MARISSA JANINE DEKKER

RIDING A SELF-DRIVING BUS TO WORK

INVESTIGATING HOW TRAVELLERS PERCEIVE ADS-DVS ON THE LAST MILE

Riding a self-driving bus to work

Investigating how travellers perceive ADS-DVs on the last mile

by

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Preface

This thesis has been written as part of the graduation assessment for the masters degree in Transport, Infrastructure and Logistics at the Delft University of Technology (TU Delft). The work is created from a collaboration between the TU Delft and the Metropoolregio Rotterdam Den Haag (MRDH) as part of the Spatial and Transport impacts of Automated Driving (STAD) project, a joint research project about the implications of future accessibility and spatial development of mobility with respect to autonomous driving technologies. The MRDH is a governmental agency that is responsible for the development of mobility and transportation policies in collaboration with multiple municipalities in the Rotterdam - The Hague area.

During the process of developing a research topic, conducting a stated preference survey and choice modelling analysis and writing this thesis my four committee members were always available for feedback or discussion on my work. First, I would like to thank Bart for his ever-lasting enthusiasm that has guided me during the course of my masters programme through several subjects, the organisation of a study tour, an internship and the writing of this thesis. Next my gratitude goes out to Eric for always being critical on the analyses and my writing so that I was able to improve my work each time. During the first phase of my research I had difficulties to find the topic that would suit my interests. I would like to thank Dimitris for patiently taking the time to go over several of my research proposals and guiding me in the right direction during our meetings. From the MRDH my appreciation goes out to my previous supervisor Gert de Visser for supporting my decision to change topics and switch from the EV department to the VA department. And last but certainly not least, I thank Lodewijk for agreeing to be my supervisor at VA on such short notice and for all our weekly meetings discussing everything related and unrelated to my thesis.

Additionally I would like to thank everyone else who has been a part of my graduation process. First all the people from municipalities, interest groups and the MRDH that have given feedback to improve my survey and helped to distribute it to respondents. Next all the guys from the *hok* at Civil Engineering for offering distraction and a good laugh in hours of need. And finally I would like to thank Gilles for supporting me through all the highs and lows of this past period without ever complaining.

Marissa Dekker
Delft, 23 April 2017

Summary

About 8 million of the 16.8 million inhabitants of the Netherlands live in a 8.200 square kilometre region known as the Randstad. In this area the four largest cities of the country are situated and linked trough a vast network of municipalities and roads and rail infrastructure. During the rush hour long traffic jams are presented on a large share of the Dutch road network, mainly in the Randstad area. The government has opted for policies to decrease the pressure on the roads by attempting to make public transportation more attractive. By improving the quality of public transportation and offering high subsidies to lower fare prices more travellers made use of public transportation. However, these measures are not expected to be sufficient to handle the traffic increase caused by the projected population growth of 700.000 inhabitants in the Randstad area up to 2025. Additional measures are needed to further influence the growing share of public transportation in the modal split of work-related travel. In a search for affordable land prices companies have situated their offices at the edge of cities in business park clusters. These business parks are often poorly accessible by public transportation but do offer good connections to the regional and national highway network. The travel demand patterns on business park locations are difficult for public transport operators to respond to. During the morning and evening peak the demand is very high while during the day the demand is very low. Offering a service would require many vehicles and drivers during the rush hours, while the vehicles and drivers remain idle during the rest of the day. Because the operational costs of such a service are very high, operators decide to offer limited frequencies or no service at all. The previously mentioned measures of the government cannot increase the share of public transportation use if on such locations no proper connections are available on the *last mile*, from the final public transportation station to the final destination of the traveller. Therefore other approaches are needed to first improve the accessibility of business parks by public transportation.

Current developments in the automotive sector could offer solutions to make public transportation service on such last mile locations affordable. Automated vehicles (AVs) are vehicles that can take over parts of the driving task from a human or even take over completely. If vehicles would be used that do not require drivers a significant part of the operational costs of a public transportation system could be reduced. During rush hours more vehicles could be used, while during low demand the vehicles numbers could be decreased and even operate *on-demand*. Making use of multiple smaller vehicles and letting travellers determine their own timetables can also improve the quality of the transportation service offered. Currently already one such system is in operation at the Rivium business park in Capelle a/d IJssel and together with the ambition of the Dutch Minister of Infrastructure and the Environment, Melanie Schultz van Haegen, to be the leader in the development of automated vehicles the use of such systems in the Netherlands could increase. Two main types of AVs can be distinguished: (1) automated vehicles for personal use and (2) shared automated vehicles. Furthermore, AVs can be categorised based on the level of automation of the driving task as proposed by the Society of Automotive Engineers (SAE). The traditional car is on SAE level 0 and a fully automated vehicle on SAE level 5. The focus in this study is on shared vehicles that can operate without the presence of a driver for all regular trips. This type of AV is referred to as an *Automated Driving System - Dedicated Vehicle* (ADS-DV). ADS-DVs can operate on level 4 or level 5. On level 4 the ADS-DV can operate without a driver in a restricted area: the operational design domain (ODD). The level 5 ADS-DV can operate without a driver on any road a human driver could navigate and thus has no restriction of ODD. The ParkShuttle in Rivium is a level 4 ADS-DV that operates on its own dedicated lane. ADS-DVs could also operate amongst other traffic on both level 4 and level 5. However, current systems need to operate on dedicated lanes to ensure traffic safety. Many researches and pilots are being conducted to improve the capability of ADS-DVs. It is expected that the first permanently operational ADS-DV amongst other traffic (level 4) will operate in Rivium from 2020.

From an operational perspective the introduction of ADS-DVs on last mile locations seems feasible. The main focus of research is on the technological developments (e.g. sensors, recognition software) to make the systems safer and cheaper and on the interaction of such vehicles with other road users like pedestrians and cyclists. The question whether *users* would want to make use of these systems however has remained largely unanswered. It is assumed that individuals that are more accustomed with AVs or automation features in

cars would be less hesitant of travelling with an ADS-DV. No study has however explicitly studied whether individuals that have more experience with ADS-DVs would be more positive towards such systems.

To be able to get some insight in whether ADS-DVs would be a feasible solution on last mile locations from a traveller's perspective and whether the level of experience an individual has with ADS-DVs has influence on their preferences and perceptions of ADS-DVs the following main research question is answered in this study: *"How do travellers perceive ADS-DVs on last mile connections and are travellers that have experience with ADS-DVs more positive towards such systems?"*. The position of the main research question in the context of the proposed policy measure is visualised in figure 1.

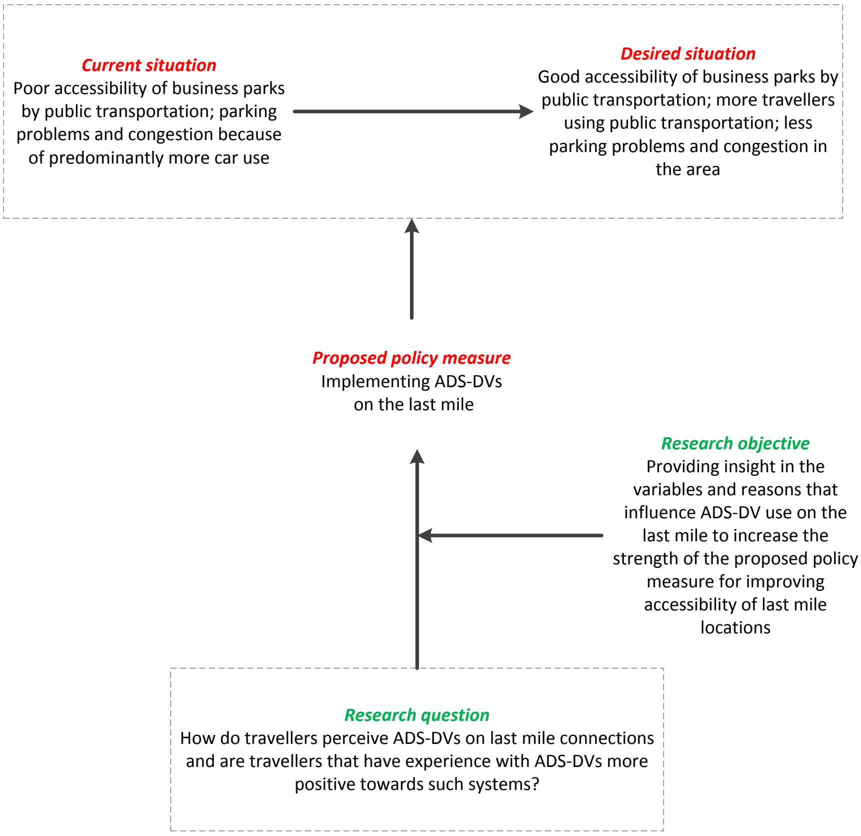


Figure 1: Position of research question within policy measures

The main research question is guided by sub-questions investigating the instrumental and psychological factors that influence travellers preferences for ADS-DVs, the effect of experience with ADS-DVs on the preferences and exploring some reasons for travellers to want to make use or not want to make use of ADS-DVs. The service type, surveillance in the vehicle and the configuration of the system are considerd specific attributes for ADS-DVs. ADS-DVs can operate via fixed stops or can offer a door-to-door service to travellers. Furthermore, surveillance methods like a camera or supervisor in the vehicle can be deployed for safety and security purposes. In this study a distinction is made between ADS-DVs that operate on a dedicated lane and ADS-DVs that operate amongst other traffic. To answer the research questions a stated preference survey is used to collect data for a discrete choice modelling analysis. The survey consisting of statements on ADS-DVs, choice sets to derive mode choices and questions on socioeconomic characteristics is distributed at locations where an ADS-DV is present (Rivium, Capelle a/d IJssel) and at locations where no ADS-DV is present (Beatrixkwartier, The Hague and Plaspoelpolder, Broekpolder and Hoornwijck in Rijswijk). About 200 completed surveys are collected and processed using SPSS and Biogeme. The answers to the statements are used as indicator variables in a Factor Analysis to derive the latent variable *trust in ADS-DVs*. The composite score of the latent variable and a variable indicating whether an individual has experience with ADS-DVs are included in the choice model. A Mixed Logit model is used to account for panel effects and taste heterogeneity effects on the model estimation. The influence of the attributes *travel cost, travel time, waiting time, service type* and the type of *surveillance in an ADS-DV* on the mode choice are determined and compared based on the level of experience an individual has with ADS-DVs and the level of trust he or she has in such vehicles. Additionally participants are asked to reflect on the possibility to make use of an ADS-DV in their region and provide reasons to make use or not to make use of such systems.

The results from the choice modelling analysis indicate that travel costs, travel time and waiting time have a negative effect on the preference for an ADS-DV, increasing values lead to lower appreciation of the modes. Travellers were found to react more positive towards ADS-DVs when a form of surveillance (camera or supervisor) was present in the vehicle or when the ADS-DV operated door-to-door instead of making use of fixed stops. The appreciation for a camera system in an ADS-DV was found to be slightly higher than the appreciation for a supervisor. In general individuals prefer to make use of an ADS-DV on the last mile compared to the not specified 'another method to travel the final 1.5 kilometres'. Travellers have a slight preference for an ADS-DV on a dedicated lane over an ADS-DV that operates amongst other traffic. For both the preference of ADS-DV type and surveillance in an ADS-DV heterogeneity is considered present in the population. The amount of heterogeneity for ADS-DV type is more widespread than for surveillance. This means that individuals have more different opinions on the preferred ADS-DV than on the preferred type of surveillance. Still individuals were found to prefer ADS-DVs over the 'alternative mode' option, but preferences for the type differ. In the case of surveillance less heterogeneity is present, most travellers prefer a camera over a supervisor in the vehicle. However, the presence of any type of surveillance is found not to be important to some individuals. The observed heterogeneity could be explained by the amount of trust that an individual has in ADS-DVs. Travellers that have a higher level of trust in ADS-DVs than average are more positive about ADS-DVs in general (and ADS-DVs that operate amongst other traffic in specific) and value surveillance in the vehicle as less important than individuals that have lower level of trust in ADS-DVs. Individuals that have higher levels of trust in ADS-DVs are predominantly male and/or have an ADS-DV in operation in their work area. The amount of use experience that an individual has with ADS-DV is not found to have an influence on the preference for ADS-DVs or preference or the importance of surveillance in the vehicle. To be able to compare the importance of the different attributes of ADS-DVs the willingness-to-pay is calculated. In general travellers are prepared to pay more to have a type of surveillance in the vehicle or to be able to travel door-to-door instead of being bound to fixed stops, table 1.

Table 1: Individuals willingness-to-pay for attributes of ADS-DV

Attribute	**Value**	**Unit**
Travel time	-0.21	€/minute
Waiting time	-0.63	€/minute
Surveillance: camera	0.69	€
Surveillance: supervisor	0.51	€
Service type: door-to-door	0.53	€

In the survey potential routes were shown for the specific work area of the participant. The participants then indicated whether they would be interested to make use of one of the suggested ADS-DV trajectories or prefer another method to travel to their work. 63.6% of all respondents stated that they would make use of the ADS-DVs. When asked to clarify their decision most respondents stated that the most important reasons to make use of an ADS-DV were the on-demand aspect of an ADS-DV (42.7%) and the expectation that they would arrive faster at their destination using an ADS-DV (41.1%). For respondents that indicated not to want to make use of the proposed ADS-DVs 42.3% stated that the shown lines were irrelevant to them, 28.2% of respondents stated that they would prefer to make use of their own transportation mode instead and 23.9% stated to prefer to walk or cycle from the station to their work. Respondents were allowed to select multiple reasons to explain their answer. Respondents that currently do not make (much) use of public transportation to travel to their work were asked whether they would be interested to do so if the accessibility by public transport to their work area would be improved. 37.5% of respondents indicated to be interested to make (more) use of public transportation to travel to their work if the accessibility would be improved.

It can be concluded that travellers are positive towards the use of ADS-DVs on last mile connections. Especially the on-demand aspect and the possibility to travel door-to-door appeal to travellers. The level of use experience that a traveller has does not influence their preferences for an ADS-DV or need for surveillance. The level of trust an individual has in ADS-DV does influence these factors. Individuals with a higher level of trust in ADS-DVs than average are more positive towards ADS-DVs that operate amongst other traffic and are

less in need of a camera or supervisor in the vehicle. From these findings it can be concluded that ADS-DVs are perceived by travellers as a feasible solution to improve accessibility of business parks.

Based on the conclusions from this study both ADS-DVs on dedicated lanes and those that operate amongst other traffic are both accepted as transportation methods for the last mile. In designing ADS-DV systems a supervisor is not considered necessary as a camera will offer sufficient surveillance. Policy makers are advised to focus on the level of trust that individuals have in ADS-DVs rather than on the level of use experience when trying to determine support for ADS-DVs in the population. Before focusing on policy measures that try to increase the acceptance for ADS-DVs by increasing the level of trust in ADS-DVs of travellers, a study confirming the assumed causal effect needs to be conducted. This study could be linked to the current Automated Vehicles on the Last Mile (AVLM) project of the Metropoolregio Rotterdam Den Haag (MRDH). The levels of trust in ADS-DVs and support for ADS-DVs before the introduction of ADS-DVs in the region could be compared to the levels of trust in ADS-DVs and support for ADS-DVs for the same individuals after the introduction of ADS-DVs in the region. In case the causal effect of more trust in ADS-DV on the level of support can be confirmed measures to increase trust in ADS-DVs like making travellers known with automated transportation modes by for example first introducing automated trams and metros before introducing ADS-DVs. An additional advantage that rises from the lack of influence of experience on ADS-DV preference is that in forming sample groups for studies involving ADS-DV the sample does not need to represent a significant number of individuals that have experience with ADS-DVs. Conducting any research on ADS-DV is therefore more manageable as the tough requirement of sufficient individuals with experience can be lifted.

The feasibility of ADS-DVs on last mile location is only considered from the perspective of the traveller in this study. Therefore aspects as the financial and technological feasibility of such systems are mainly left out of the scope of this thesis. Current technological developments only allow for ADS-DVs to operate on dedicated lanes to ensure traffic safety. The implementation costs of ADS-DV systems on dedicated lanes is much higher because infrastructure needs to be build to accommodate the system. To bridge this gap on the short-term the possibility of integrating ADS-DVs on dedicated lanes for traditional buses and trams could be investigated. Another approach would be to offer dedicated lane ADS-DV services in developmental areas. When over time more companies and housing is available and the demand for travel in the area increases the ADS-DV dedicated lane could re-purposed for use of traditional buses or tram, ensuring the investment costs stretch over a longer period of time and operational costs can be kept low during the time of limited travel demand. An even more interesting opportunity would be to reassign the ADS-DVs from the newly developed area (where they have been replaced by bus or tram services) to another developing area with low demand. Keeping the vehicles in the cycle for multiple years also results in a better return on investment of implementation costs. To advance technological developments of ADS-DVs that operate amongst other traffic (level 4 and level 5) an integrated approach of policy makers, public transportation operators, vehicle developers, research institutes and users is advised like is currently done in the Spatial and Transport impacts of Automated Driving (STAD) project.

It must be noted that the focus in this study is on the acceptance of ADS-DVs themselves, therefore little comparison is made between ADS-DVs and alternative modes. From the results of this study it is assumed that ADS-DVs are considered quite similar to other public transportation modes. Only features like on-demand travel and door-to-door services could distinguish the ADS-DV from other alternatives in a positive manner. Especially the comparison of an ADS-DV to a shuttle bus or 'belbus' could be interesting, as both modes could offer the same advantages (on-demand and door-to-door services) as ADS-DVs. The only difference would be the presence of a driver. From the results of this study it is assumed that the traveller's mode choice would in such case be primarily based on instrumental factors like travel time and travel costs rather than the presence of a human in the vehicle. In that case the operational costs for public transportation operators would be more important in determining the transportation service offered. To confirm this assumption policy makers are advised to conduct a study to determine the exact place of the ADS-DV in the transportation market. Such a study could be done by a stated preference survey with multiple mode options on the last mile or even combined with full trips or by conducting a revealed preference study on a location after an ADS-DV has been introduced.

The use of ADS-DVs is assumed to be most beneficial in areas where the travel demands are not too high. In a situation with high transport demand the number of vehicles would be so high that public transport operators could better rely on mass transit public transportation systems (e.g. trams, traditional buses and metros) to ensure punctuality of the services. Besides last mile locations the use of ADS-DVs in rural areas could be investigated. The population numbers in these areas are steadily declining over the years and the average age of the population is rising. The declining population numbers are reason for public transportation operators to discontinue bus services in the area, however the rising average age is resulting in more people that are not able to drive cars and dependent on other means of transportation. The use of ADS-DVs (that operate amongst other traffic) might help reduce the operational costs of transportation services for operators. However, because of longer distances and an expected lower number of travellers per day it is assumed that less advantages of ADS-DVs are present in rural areas than on last mile locations.

From the perspective of the traveller ADS-DVs offer a feasible solution to improve the accessibility of last mile connections in business parks. The support for ADS-DVs indicates that the systems could be taken into account when comparing possible measures to increase the share of public transportation users and decrease the share of car users in business parks. When comparing measures the technical and financial feasibility of each measure needs to be determined and further research into the causal effects of each measures on the amount of congestion on the road network in the Randstad area must be proven before implementation.

Policymakers are advised to always let the demand for transportation guide the implementation of ADS-DVs. Take ADS-DVs into account when comparing several transportation alternatives, but only implement an ADS-DV system if it is considered the best solution to the problem.

Samenvatting

Ongeveer 8 miljoen van de 16.8 miljoen inwoners van Nederland leven in een gebied ter grootte van 8.200 vierkante kilometer dat ook wel bekend staat als de Randstad. De vier grootste steden (Amsterdam, Utrecht, Den Haag en Rotterdam) die in deze regio liggen zijn met elkaar verbonden door een complex netwerk van wegen en rail-infrastructuur. Gedurende de spits vormen zich lange files op het Nederlandse wegennet en voornamelijk in de Randstad. De overheid probeert al langere tijd om de filedruk op wegen aan te pakken door te investeren in beter openbaar vervoer (OV). Met subsidies worden de ritprijzen laag gehouden en de kwaliteit van het vervoer verbeterd om reizigers van de auto naar het OV te krijgen. Met een projectie van de stijging van het aantal inwoners in de randstad met 700.000 tot 2025 wordt er echter aan getwijfeld of deze maatregelen voldoende zullen zijn. Het takenpakker zal met andere maatregelen moeten worden uitgebreid om invloed uit te oefenen op gebieden waar het percentage OV-reizigers op werkgerelateerde trips nog laag is. In de zoektocht naar betaalbare grondprijzen hebben veel bedrijven zich gevestigd aan de rand van steden in bedrijvenparken. Deze bedrijvenparken zijn vaak slecht bereikbaar met openbaar vervoer maar bieden goede uitvalswegen naar het regionale en nationale wegennet. HEt aanbieden van vervoersdiensten in deze regio's is lastig doordat de vervoersvraag in de ochtend- en avondpiek heel hoog ligt, terwijl gedurende de rest van de dag de vraag laag is. Voor het aanbieden van een OV dienst zijn veel voertuigen en chauffeurs nodig in de piekuren, maar zijn veel daarvan overbodig tijdens de rest van de dag. De operationale kosten van dit soort dienst zijn erg hoog, waardoor aanbieders besluiten geringe frequenties aan te bieden of zelfs helemaal geen dienst in het gebied. De eerdergenoemde beleidsmaatregelen van de overheid om het aantal OV-reizigers toe te laten nemen zal niet effectief zijn wanneer geen diensten beschikbaar zijn op deze *last mile* verbindingen. De last mile is het laatste stuk van de trip van het laatste station naar de uiteindelijke bestemming van de reiziger. Een andere aanpak is nodig om eerst de bereikbaarheid van bedrijvenparken per openbaar vervoer te verbeteren.

De huidige ontwikkelingen in de automobiel sector zouden oplossingen kunnen brengen om het aanbieden van openbaar vervoer op last mile locaties betaalbaar te maken. Automatische voertuigen (AVs) zijn voertuigen die delen van de besturing van een voertuig kunnen overnemen, of zelfs de volledige rijtaak op zich nemen. Wanneer voertuigen worden ingezet waar geen bestuurders in nodig zijn kan een significant gedeelte van de operationele kosten worden bespaard. Tijdens de spits kunnen meerdere voertuigen worden ingezet en tijdens de daluren kan het aantal voertuigen worden gereduceerd en zelfs *on-demand* (op afroep) opereren. Door gebruik te maken van meerdere kleinere voertuigen en reizigers hun eigen dienstregeling te laten bepalen kan de kwaliteit van de openbaar vervoersdienst zelfs worden verbeterd. Op dit moment is een systeem met AVs actief op het bedrijvenpark Rivium in Capelle a/d IJssel en samen met de ambitie van Minister Schultz van Haegen, ministerie van Infrastructuur en Milieu, om Nederland de leider te maken op het gebied van automatisch vervoer kan het gebruik van zulke systemen in Nederland fors toenemen. Globaal kan onderscheid gemaakt worden tussen twee typen AVs: (1) automatische voertuigen voor prive gebruik en automatische voertuigen voor gedeeld gebruik. Dan kan er nog onderscheid gemaakt worden in het niveau van automatisering in het voertuig op basis van de standaarden zoals voorgesteld door de Society of Automotive Engineers (SAE). De traditionale auto zonder automatische functies bevindt zich op SAE niveau 0 and volledig automatische voertuigen op SAE niveau 5. The focus in dit onderzoek is op gedeelde automatische voertuigen die zonder bestuurder kunnen opereren op alle reguliere ritten. Dit type automatisch voertuig wordt aangeduid als een *Automated Driving System - Dedicated Vehicle* (ADS-DV). ADS-DVs kunnen opereren op level 4 en level 5. Een level 4 systeem kan zonder bestuurder in een voorgeprogrammeerd gebied rijden: het operational design domain (ODD). Level 5 voertuigen kunnen zonder bestuurder rijden op elke weg waarop een menselijke bestuurder ook kan rijden en heeft dus geen restricties van het ODD. De ParkShuttle in Rivium is een voorbeeld van een level 4 ADS-DV dat op een eigen baan opereert. ADS-DVs van level 4 en level 5 zouden ook tussen ander verkeer kunnen worden ingezet, maar huidige systemen zijn alleen in gebruik op een eigen baan om de verkeersveiligheid te kunnen garanderen. Veel onderzoeken en pilots worden uitgevoerd om de functionaliteit van ADS-DVs te verbeteren. Naar verwachting zal in 2020 de eerste permanent functionerende ADS-DV tussen ander verkeer (level 4) gaan rijden in Rivium.

Vanuit operationeel perspectief lijkt de invoering van ADS-DVs op last mile locaties vrij haalbaar. De focus van de meeste onderzoeken over automatische voertuigen ligt op technologische ontwikkelingen (sensors, herkenningssoftware) om de systemen veiliger en goedkoper te maken en op de interactie van zulke voertuigen met andere verkeersdeelnemers zoals voetgangers en fietsers. De vraag of *gebruikers* ADS-DVs zouden willen gebruiken om te reizen is grotendeels onbeantwoord gebleven. Het wordt aangenomen dat personen die meer bekend zijn met AVs of automatische functies in auto's positiever zullen staan tegenover het gebruik van ADS-DVs dan personen die hier niet bekend mee zijn. Geen onderzoek heeft dit verband echter nog expliciet aangetoond.

Om inzicht te kunnen krijgen in de haalbaarheid van ADS-DVs als oplossing voor last mile locaties vanuit het perspectief van de reiziger en of de hoeveelheid ervaring die een persoon heeft invloed heeft op zijn of haar voorkeuren en percepties van ADS-DVs is de volgende onderzoeksvraag beantwoord: *"Hoe ervaren reizigers ADS-DVs op last mile locaties en staan reizigers die ervaring hebben met ADS-DVs positiever tegenover dit soort systemen?"*. De inpassing van de onderzoeksvraag in de context van de genoemde beleidmaatregel is gevisualiseerd in figuur 2.

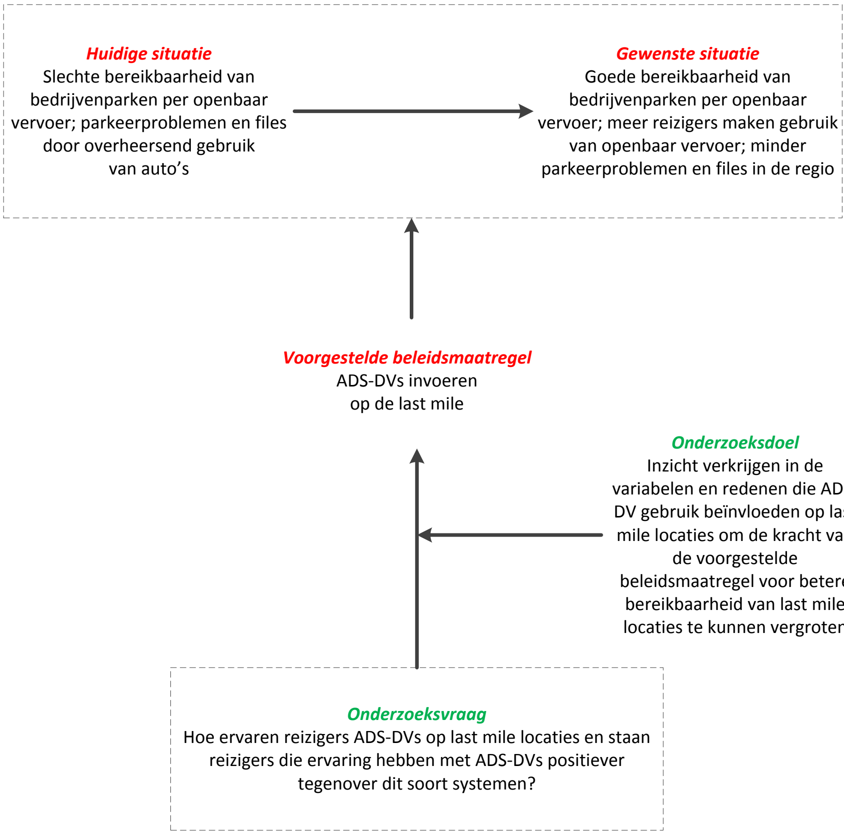


Figure 2: Positie van onderzoeksvraag binnen beleidsmaatregel

De hoofdonderzoeksvraag wordt ondersteund door verschillende sub-vragen om inzicht te krijgen in de instrumentel en psychologische factoren die invloed hebben op de voorkeuren van reizigers voor ADS-DVs, het effect van ervaring met ADS-DVs op de voorkeuren en welke redenen reizigers hebben om wel of geen gebruik te willen maken van ADS-DVs. Het service type, methoden van toezicht zoals een camera of toezichthouder in het voertuig en de configuratie van het system worden gezien als specifieke attributen voor ADS-DVs. ADS-DVs kunnen rijden via vaste haltes of een deur-tot-deur dienst aanbieden aan reizigers. De toezichtmethoden camera en toezichthoude kunnen door een OV aanbieder worden ingezet om de verkeersveiligheid en veiligheid van de reiziger te garanderen. In dit onderzoek is een onderscheid gemaakt tussen voertuigen die op een eigen baan rijden en voertuigen die tussen ander verkeer rijden. Om de onderzoeksvragen te beantwoorden is een *stated preference survey* gebruikt om data te verzamelen voor een *discrete choice modelling* analyse. The questionnaire bestaande uit stellingen over ADS-DVs, keuzesets om voertuigkeuzes te bepalen en vragen over socioeconomische karakteristieken van deelnemers is verspreid op een locatie waar een ADS-DV in gebruik is (Rivium, Capelle a/d IJssel) en op locaties waar geen ADS-DV in gebruik is (Beatrixkwartier, Den Haag en Plaspoelder, Broekpolder en Hoornwijck in Rijswijk). Ongeveer 200 ingevulde questionnaires zijn verzameld verwerkt met SPSS en Biogeme software. De antwoorden op de stellingen zijn gebruikt als indicator variabelen in een Factor Analyse om de latente variabele *vertrouwen in ADS-DVs* te bepalen. De composiet score van de latente variabele en een variabele om aan te geven hoeveel ervaring een persoon heeft met ADS-DVs zijn meergenomen in het keuzemodel. Een Mixed Logit model is gebruik om rekening te kunnen houden met panel effecten en heterogeniteit op de model schatting. De invloed van de attributen *reiskosten, reistijd, wachttijd, service type* en het type *toezicht in een ADS-DV* op de modaliteitskeuze zijn bepaald en vergeleken gebaseerd op het niveau van ervaring dat een persoon heeft met ADS-DVs en de hoeveelheid vertrouwen dat hij of zij heeft in zulke voertuigen. Aanvullend hebben deelnemers vragen beantwoord om te reflecteren op de mogelijkheid om gebruik te maken van een ADS-DV in hun regio en aangegeven om welke redenen zij wel of niet gebruiken zouden willen maken van ADS-DVs.

De resultaten van de choice modelling analyse geven aan dat reiskosten, reistijd en wachttijd een negatief effect hebben op de voorkeur voor een ADS-DV, wanneer de waarden van de variabelen toenemen wordt de waardering van de modaliteit lager. Reizigers blijken positiever te reageren op ADS-DV wanneer een vorm van toezicht aanwezig is in het voertuig (camera of toezichthouder) of wanneer het voertuig via een deur-tot-deur dienst rijst in plaats van via vaste haltes. De waardering voor een camera systeem in een ADS-DV is iets hoger dan de waardering voor een toezichthouder. In het algemeen maken reizigers liever gebruik van een ADS-DV op de last mile dan van een niet gespecificeerd 'ander reisalternatief voor de laatste 1.5 kilometer'. Reizigers hebben een lichte voorkeur voor een ADS-DV op een eigen baan ten opzichte van een ADS-DV die tussen ander verkeer rijdt. In de voorkeur voor ADS-DV type en in de voorkeur voor het soort toezicht in het voertuig blijkt heterogeniteit aanwezig te zijn in de populatie. De heterogeniteit voor het type ADS-DV is meer verspreid dan de heterogeniteit voor het type toezichthouder. Dit houdt in dat personen meer verschillen in mening over het voorkeurstype ADS-DV dan het voorkeurstype toezicht. Nog steeds hebben personen een voorkeur voor een ADS-DV over het 'andere alternatief', maar de voorkeuren voor het specifieke type ADS-DV verschillen. In het geval van toezicht is minder heterogeniteit aanwezig, de meeste reizigers verkiezen een camera over een toezichthouder in het voertuig. Maar de aanwezigheid van toezicht in het voertuig blijkt niet belangrijk te zijn voor iedere reiziger. De geobserveerde heterogeniteit zou verklaard kunnen worden door de hoeveelheid vertrouwen die een persoon heeft in ADS-DVs. Reizigers die gemiddeld gezien meer vertrouwen hebben in ADS-DVs zijn positiever over ADS-DVs in het algemeen (en over ADS-DVs die tussen ander verkeer rijden specifiek) en waarderen toezich in het voertuig als minder belangrijk dan personen die een minder vertrouwen hebben in ADS-DVs. Personen met meer vertrouwen in ADS-DVs zijn overheersend mannen en/of hebben een ADS-DV in gebruik in hun werk regio. The hoeveelheid gebruikservaring die een persoon heeft met ADS-DVs blijkt geen invloed te hebben op de voorkeuren voor ADS-DVs of de voorkeur of het belang van toezicht in het voertuig. Om het belang van de verschillende attributen van ADS-DVs te kunnen vergelijken is de *willingess-to-pay* (WTP), de betalingsbereidheid, voor elk attribuut bepaald. Over het algemeen zijn reizigers bereid meer te betalen voor een vorm van toezicht in het voertuig of om deur-tot-deur te kunnen reizen in plaats van via vaste haltes, zie tabel 2.

Table 2: Betalingsbereidheid voor attributen van ADS-DV

Attribuut	**Waarde**	**Eenheid**
Reistijd	-0.21	€/minuut
Wachttijd	-0.63	€/minuut
Toezicht: camera	0.69	€
Toezicht: toezichthouder	0.51	€
Service type: deur-tot-deur	0.53	€

In de questionnaire zijn aan elke deelnemer verschillende potentiële routes voor ADS-DVs in zijn of haar werkgebied getoond. Elke deelnemer heeft vervolgens aangegeven of hij of zij geïnteresseerd zou zijn om gebruik te maken van een van de voorgestelde ADS-DV verbindingen of liever op een andere manier naar het werk zou reizen. 63.3% van de reizigers gaf aan interesse te hebben in het gebruik van de ADS-DVs. Als toelichting bij hun keuze gaf 42.7% aan dat het on-demand aspect van ADS-DVS hun erg aansprak en stelde 41.1% de verwachting dat zij sneller op hun werk zouden aankomen wanneer zij gebruik maakten van een ADS-DV belangrijk te vinden. Van de respondenten die aangaven geen gebruik te willen maken van de ADS-DVs gaf 42.3% aan dat de getoonde routes niet relevant voor hen waren, gaf 28.2% aan dat zij liever gebruik maakten van een eigen vorm van vervoer om naar hun werk te reizen en gaf 23.9% aan om liever te willen lopen of fietsen vanaf het station. Respondenten konden in de questionnaire meerder redenen aangeven om hun keuze te onderbouwen. Deelnemers die op dit moment weinig of geen gebruik maken van OV om naar hun werk reizen werden gevraagd om aan te geven of zij interesse hadden om dit wel te doen wanneer de bereikbaarheid per openbaar vervoer naar hun werk regio zou worden verbeterd. 37.5% van de respondenten gaf aan dit te willen doen.

Op basis van dit onderzoek kan worden geconcludeerd dat reizigers positief staan tegenover het gebruik van ADS-DVs op last mile locaties. Met name het on-demand aspect en de mogelijkheid om deur-tot-deur te reizen spreken reizigers aan. De mate van gebruikservaring dat een persoon heeft met ADS-DVs heeft geen invloed op de voorkeuren voor een ADS-DV of het soort toezicht in het voertuig. De mate van vertrouwen dat een persoon heeft in ADS-DVs heeft wel invloed op deze factoren. Personen die gemiddeld gezien meer vertrouwen hebben in ADS-DVs staan positiever tegenover ADS-DV die tussen ander verkeer rijden en hebben minder behoefte aan een camera of toezichthouder in het voertuig. Op basis van deze bevindingen kan worden geconcludeerd dat ADS-DVs door gebruikers worden ervaren als een mogelijke oplossing om de bereikbaarheid van bedrijvenparken te verbeteren.

Gebaseerd op de conclusies van dit onderzoek zijn zowel ADS-DVs op een eigen baan als ADS-DVs tussen ander verkeer geaccepteerde transportmethoden op de last mile. Bij het ontwerp van ADS-DV systemen kan een toezichthouder als onnodig worden beschouwd indien er een camera systeem wordt geplaatst. Beleidsmakers wordt geadviseerd om te focussen op de mate van vertrouwen die reizigers hebben in ADS-DVs in plaats van op de mate van gebruikservaring wanneer de acceptatie in de populatie wordt gepeild. Voordat echter wordt gefocust op beleidsmaatregelen om het vertrouwen in ADS-DVs in de populatie te vergroten om zo ook het draagvlak voor ADS-DVs the vergroten, wordt geadviseerd om een onderzoek te doen om dit causale verband aan te tonen. De dergelijk onderzoek zou verbonden kunnen worden aan het Automatisch Vervoer op de Last Mile (AVLM) project van de Metropoolregio Rotterdam Den Haag (MRDH). De mate van vertrouwen in ADS-DVs en het bijbehorende draagvlak kunnen voor de invoering en na de invoering van een ADS-DV systeem in de regio worden vergeleken voor dezelfde personen. In het geval dat het causale effect hiermee kan worden bevestigd kunnen maatregelen worden ingezet om het vertrouwen in ADS-DVs te verhogen, zoals reizigers bekendheid maken met automatische systemen door bijvoorbeeld eerst geautomatiseerde trams en metro's te introduceren voordat ADS-DVs worden geintroduceerd. Een bijkomend voordeel van het feit dat gebruikservaring geen invloed heeft op voorkeuren voor ADS-DVs is dat sample groepen for onderzoeken naar ADS-DVs niet hoeven worden toegespitst op een significant aantal ervaren gebruikers. Het uitvoeren van een onderzoek over ADS-DVs wordt hierdoor eenvoudiger te realiseren.

De haalbaarheid van ADS-DVs op last mile locaties is alleen bekeken vanuit het perspectief van de reiziger in dit onderzoek. Daardoor zijn de financiële en technologische haalbaarheid van dergelijke systemen grotendeels uit de scope gelaten. Huidige technologiache ontwikkelingen ondersteunen alleen ADS-DVs die op een eigen baan rijden vanuit veiligheidsoverwegingen. De implementatiekosten van ADS-DV systemen op een eigen baan zijn veel hoger doordat nieuwe infrastructuur moet worden aangelegd voor het systeem. Om dit probleem op korte termijn te kunnen overbruggen kan worden gekeken naar de mogelijkheid om ADS-DVs te integreren op eigen banen van trams en traditionele bussen. Een ander aanpak zou kunnen zijn om ADS-DVs op een eigen baan in te zetten als transportmethode in gebieden die nog worden ontwikkeld. Als na gedurende tijd meer huizen worden gebouwd en bedrijven zich vestigen en de transportvraag stijgt kan de eigen baan ADS-DV worden verwachten door een traditionele bus of tram. Op deze manier kunnen de investeringskosten van een eigen baan over een langere periode worden verspreid en blijven de operationele kosten voor een transportsysteem laag gedurende de periode van beperkte vraag. Een nog interessantere toepassing zou het hergebruiken van de ADS-DVs (die zijn vervangen voor een bus of tram) in een nieuwe ontwikkelingsregio zijn. Door de voertuigen op deze manier in gebruik te houden voor meerdere jaren kunnen de implementatiekosten nog verder worden gereduceerd. Om de ontwikkeling van ADS-DVs die tussen ander verkeer rijden (niveau 4 en niveau 5) te bevorderen wordt geadviseerd een integrale aanpak aan te houden met beleidsmakers, openbaar vervoer aanbieders, voertuigontwikkelaars, onderzoeksinstellingen en gebruikers zoals wordt gedaan in het Spatial and Transport impacts of Automated Driving (STAD) project.

Gezien de focus van dit onderzoek ligt op de waardering van ADS-DVs zelf zijn de vergelijkingen met andere modaliteiten beperkt. Op basis van de resultaten van dit onderzoek wordt verondersteld dat ADS-DVs gelijkwaardig worden ervaren aan andere openbaar vervoersmethodes. Alleen aspecten zoals on-demand reizen en deur-tot-deur services zouden de ADS-DV op een positieve manier kunnen onderscheiden van alternatieven. In het bijzonder de vergelijking van een ADS-DV met een shuttlebus of een belbus zou interessant kunnen zijn, gezien bij modaliteiten dezelfde voordelen bieden (on-demand en deur-tot-deur service). Het enige verschil zou de aanwezigheid van een chauffeur zijn. Op basis van de resultaten van dit onderzoek wordt verwacht dat de keuze van de reiziger in dat geval voornamelijk afhankelijk is van instrumentele factoren zoals reiskosten en reistijd in plaats van de aanwezigheid van een persoon in het voertuig. In dat geval zouden de operationele kosten voor openbaar vervoer aanbieders een belangrijkser rol spelen in het besluit van de aan te bieden modaliteit. Om deze aanname te bevestigen worden beleidsmakers geadviseerd onderzoek uit te voeren om de exacte plek van ADS-DVs in de transportmarkt te bepalen. Dit onderzoek kan worden uitgevoerd door middel van een stated preference survey met meerdere alternatieven op de last mile en volledige trip alternatieven. Een andere optie is het uitvoeren van een revealed preference studie op een locatie nadat een ADS-DVs is ingevoerd (en voldoende alternatieven aanwezig zijn).

De toepassing van ADS-DVs wordt verondersteld het effectiefst te zijn in gebieden waar de transportvraag niet te hoog is. In een situatie met een hoge transportvraag zou het aantal benodigde voertuigen zo hoog zijn dat openbaar vervoer aanbieders beter mass transit public transportation systemen kunnen aanbieden (zoals trams, traditionele bussen en metro's) om de punctualiteit van diensten te garanderen. Het gebruik van ADS-DVs in rurale gebieden zou eventueel nog potentie kunnen hebben. De bevolkingsaantallen in deze gebieden nemen geleidelijk af terwijl de gemiddelde leeftijden stijgen. De afnemende bevolkingsaantallen zijn reden voor openbaar vervoer aanbieders om buslijnen in landelijk gebied op te heffen, terwijl juist de vergrijzing ervoor zorgt dat steeds meer mensen geen gebruik meer kunnen maken van een eigen auto en zijn aangewezen op openbaar vervoer. Het gebruik van ADS-DVs (die tussen ander verkeer rijden) zou kunnen helpen om de operationele kosten van de aanbieders in deze gebieden te verlagen. Door de langere afstanden en de verwachting dan minder reizigers per dag gebruik zullen maken van de dienst wordt echter verwacht dat de voordelen van ADS-DV in rurale gebieden niet zo groot zullen zijn als die op last mile locaties.

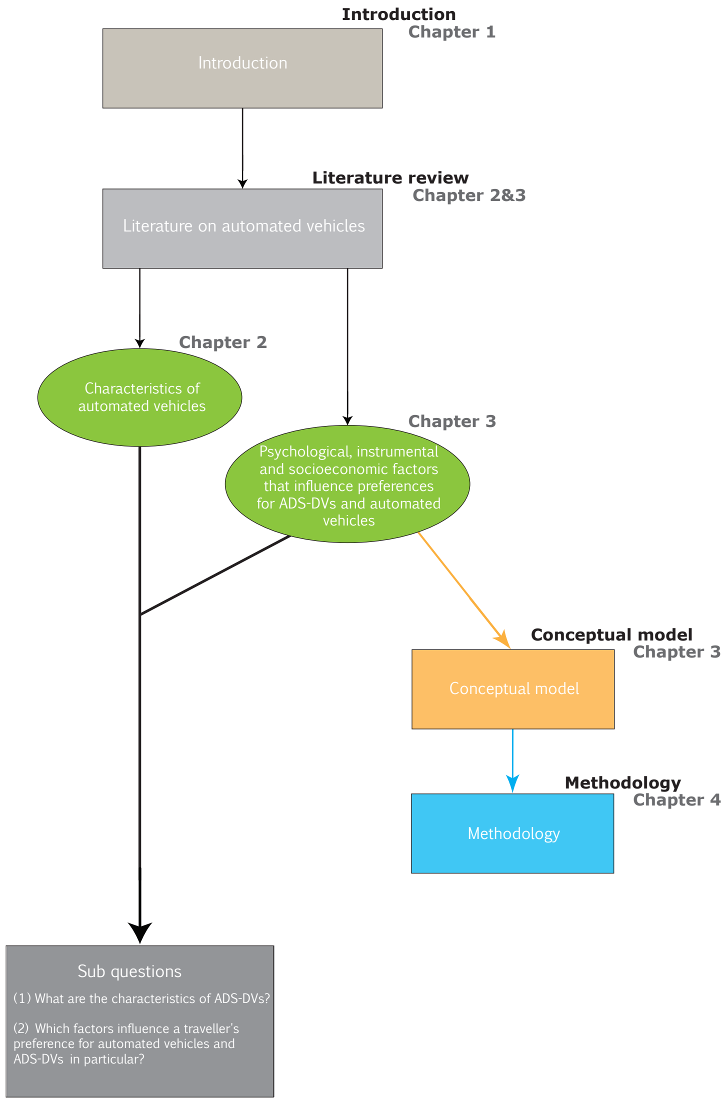
Vanuit het perspectief van de reiziger bieden ADS-DVs een haalbare oplossing om de bereikbaarheid van last mile locaties in bedrijvenparken te verbeteren. Het draagvlak voor ADS-DVs geeft aan dat de toepassing van dit soort systemen moet worden meegenomen wanneer maatregelen om het aandeel OV reizigers te verhogen en het aandeel autogebruikers in bedrijvenparken te verlagen worden vergeleken. Bij het vergelijken van maatregelen moeten de technische en financiële haalbaarheid van elke maatregel worden bepaald en aanvullend onderzoek naar de causale effecten van de maatregelen op de congestie van het wegennetwerk in de Randstad moeten worden bewezen voordat tot implementatie wordt overgegaan.

Beleidsmakers wordt geadviseerd om altijd de vraag naar transport centraal te stellen bij de implementatie van ADS-DVs. Neem ADS-DVs mee wanneer verschillende alternatieven worden vergeleken, maar implementeer alleen een ADS-DV systeem wanneer dit als beste oplossing voor het probleem wordt beschouwd.

Contents

I

Introduction & theoretical framework



1 Introduction

The Randstad area is the most densely populated area in the Netherlands. It is situated in the Central-Western region of the country, where the four largest cities (Amsterdam, The Hague, Rotterdam and Utrecht) are linked in a vast network of municipalities and smaller cities. In 2014 the 8.200 square kilometre area was home to 7.8 million inhabitants (950 inhabitants per square kilometre). and the city of The Hague topped the bill with a density of 6.300 inhabitants per square kilometre in 2016. In comparison, the population densities of Hong Kong and Singapore in 2015 were respectively 6.950 and 7.800 inhabitants per square kilometre. According to the **?**] the Randstad area will face a significant population growth of 700.000 inhabitants between 2010 and 2025 increasing the density in the area even further. Organising transportation in such dense areas is a difficult task. Especially during rush hour commuters make use of a broad variety of modes to reach their destinations. Although public transportation is generally more refined in densely populated areas, there are areas that are still difficult to reach. Business parks created at the edge of cities offer affordable land prices and more space but often have poor connections to public transportation networks. This results in higher car shares and a lot of congestion especially during rush hours. To improve traffic conditions on the road infrastructure (e.g. decrease congestion) and reduce emissions, the Dutch Government makes effort to persuade commuters to make more use of public transportation [1]. However, increasing the public transportation share in an area with poor accessibility of public transportation is difficult. High demand during rush hours and no/low demand outside peak hours makes it difficult for public transport operators to start up a service or increase the number of vehicle trips in the area. It is a costly operation where multiple drivers and vehicles are needed to serve the area in the morning peak, then drive around with empty vehicles or wait to finally serve the evening peak.

Opportunities lie with the ambition of the Dutch Minister of Infrastructure and the Environment to be the leader in the development of automated vehicles [2]. The use of automated vehicles offers possibilities for public transportation operators to accurately serve areas with specific demand patterns. During rush hours more vehicles could be used, while during low demand the vehicle numbers could be decreased and even operate on-demand. Financial advantages lie with the possibility to cater specifically to demand by using smaller vehicles *without drivers*. On the last mile connections (connection between a train / metro station and the final destination of a traveller) additional benefits consist of lower waiting times for travellers due to on-demand services and smaller more frequently available vehicles. Furthermore, automated vehicle systems, at the level of full automation, can offer a better competitive position of public transportation compared to car commuting due to increased accessibility of the area.

The focus of this thesis is on such Automated Driving System - Dedicated Vehicles (ADS-DVs), sometimes referred to as self-driving buses. Their value is expected to be high in rural areas and as access or egress mode to public transportation. In the case of access or egress (to stations) ADS-DVs can be an affordable alternative to increase the accessibility of an area by public transportation. The Kennisinstituut voor Mobiliteitsbeleid (KiM), the Dutch research institute for transport policies, recently published a report on innovations in general public transportation: Savelberg et al. [3] state that automated vehicles will be introduced to the mobility market in phases, depending on available technologies, market demand and resolved knowledge gaps. The three main bottlenecks for automated transportation on last mile connections (using ADS-DVs) that are mentioned in the report are (1) realising sufficient trust in and acceptance of ADS-DVs among travellers, (2) solving liability issues involving both passengers and other road users and (3) decide whether ADS-DVs would even have any market potential if self-driving (personal) vehicles would be available on a large scale. This thesis primarily addresses the first bottleneck and leaves the other topics for further research. The third topic is briefly addressed in section 2.3.

User acceptance is of major importance for implementing any transport system. Factors influencing mode choice decisions of travellers need to be understood in order to accustom public transport to users' needs. In the past governments focused primarily on instrumental factors (e.g. fare price or travel time) to influence travellers to make use of public transportation. Research by Vredin Johansson et al. [4] however state that the government has more incentives available to attract travellers to public transportation apart from cost and travel time. They looked into the effects of attitudes and personality traits on mode choice, and found that attitudes on environmental considerations and perceptions of safety, comfort, convenience and flexibility also have an effect on the individual's mode choice. Moreover, Mokhtarian et al. [5] stress that solely focusing on economic motivators can lead to underestimating the demand for travel or even lead to unexpected resistance to policies or technologies. Therefore it is important to take both instrumental factors and psychological factors (e.g. attitudes or perceptions) into account when investigating the stimuli for travellers' mode choices. As ADS-DVs are only scarcely available worldwide the variables influencing mode choice for these systems have not been thoroughly investigated yet. A recently published report on present knowledge gaps for automated vehicle systems, with regards to human interaction, concludes that most research is focused on the interaction of drivers with driving automation features and the interaction of automated vehicle systems with other road users [6]. Moreover, Voorsluijs [6] states that little attention is paid to the perspective of the actual *users of shared automated transportation systems*. She states that especially research questions involving (factors that influence) acceptance, attitudes and behaviour and the valuation of automated vehicles with regards to other travel modalities should be investigated.

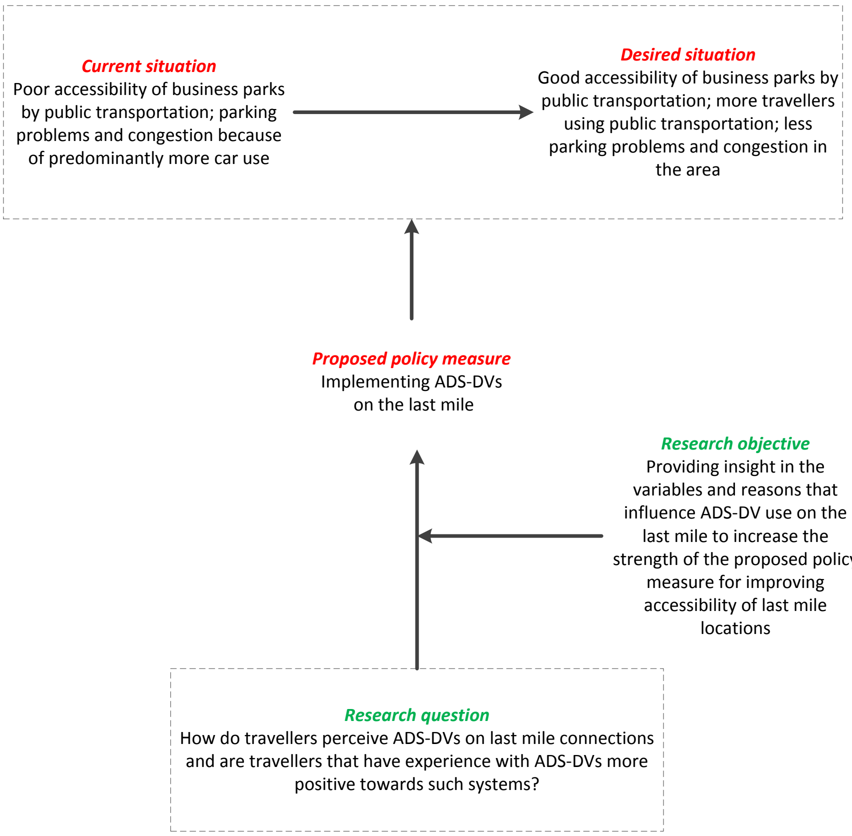


Figure 1.1: Position of research objective within policy measures

The Netherlands has an unique advantage over other countries by having an ADS-DV in operation as regular public transportation for over fifteen years. The ParkShuttle operates as a last mile connection between metro station Kralingse Zoom and business park Rivium in the municipality of Capelle aan den IJssel, near Rotterdam. This configuration offers the rare possibility to derive information from a travellers' perspective

and investigate actual *users'* preferences for ADS-DVs. By additionally comparing ParkShuttle users and travellers that have no experience with ADS-DVs, an insight can be derived in potentially different enablers and barriers for ADS-DVs between users and non-users. Bansal et al. [7] state that perceptions and expected or stated behavioural responses to vehicle-based technologies are likely to change rapidly as communities and individuals create a larger understanding of connected automated vehicles and autonomous vehicles. In line with Bansal et al. [7] it is assumed that as the level of experience with an ADS-DV increases different enablers and barriers are of importance and in general acceptance for ADS-DVs will increase.
This thesis helps to give an indication as to whether potential users would be interested in using ADS-DVs on last mile connections and to give recommendations on implementation strategies for such systems from a travellers' perspective. Comparing preferences of users and non-users of an ADS-DV will help governmental agencies to respond to travellers' needs in a region and address their perceived barriers accordingly. Figure 1.1 schematically shows the position of the research objective within the prospective policy measure.

This thesis is guided by the following main research question and accompanying sub questions: *How do travellers perceive ADS-DVs on last mile connections and are travellers that have experience with ADS-DVs more positive towards such systems?*
Sub questions:

1. What are the characteristics of ADS-DVs?
2. Which factors influence a traveller's preference for automated vehicles and ADS-DVs in particular?
3. Which instrumental and psychological factors influence the traveller's preferences for an ADS-DV, and to what extend?
4. Are travellers that have experience with an ADS-DV more favourable of an ADS-DV on the last mile?
5. What relations can be found between socioeconomic factors (age, education level, income, gender, current transport mode) and positive / negative perceptions of ADS-DVs?
6. What groups based on socioeconomic factors (age, education level, income, gender, current transport mode) are most positive towards ADS-DVs?
7. Could an ADS-DV be a feasible alternative on the last mile from the travellers' perspective?
8. What are the most important reasons for travellers to want to make use/not want to make use of ADs-DVs?

Table 1.1 summarises the scientific and the practical relevance of this thesis.

Table 1.1: Scientific & practical relevance

Scientific	**Practical**
• First study involving experienced (long-term) users of ADS-DV	• Indication of public support for ADS-DVs on last mile locations
• One of the first studies to involve psychological factors in an ADS-DV mode choice study	• Conclusions from this study can feed ADS-DV policies on last mile connections

This thesis is divided in three parts and nine chapters. Chapters 2-4 are part I: introduction & theoretical framework, chapters 5-7 are part II: data collection & analysis and part III addresses the results in chapter 8 and 9. Chapter 2 provides an overview of the current state-of-the-art on automated vehicles and in particular shared systems. A differentiation is made between two types of ADS-DVs: buses on dedicated lanes and buses that operate amongst other traffic. In chapter 3 travel behaviour is viewed from econometric and psychological worldviews and relevant factors that are expected to influence preferences for ADs-DVs are included in a conceptual model. Chapter refers to the methodology used in this study and explains in short the considerations for this approach. Chapter 5 introduces the survey design, sample group and discusses first results from the final survey. Chapter 6 describes the choice models used in this study and the results. Chapter 7 discusses the statistical methods used to process the final survey data. Conclusions and recommendations on are discusses in chapter 8. The thesis concludes with the discussion and reflection that can be found in chapter 9. The overall structure of the thesis is visualised in figure 1.2.

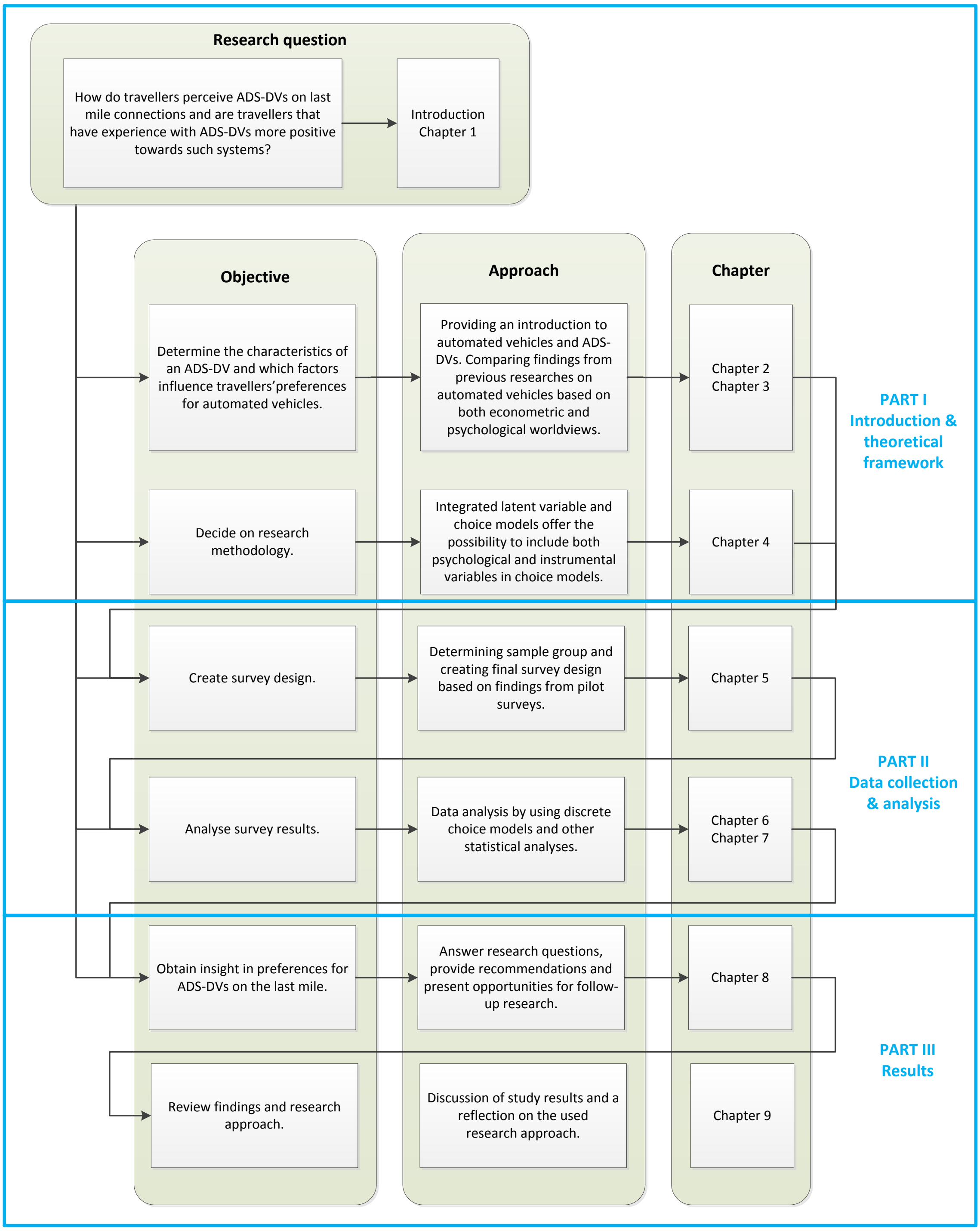


Figure 1.2: Flow diagram of thesis

2

Automated vehicles

This chapter introduces automated vehicles from its definition (2.1). Then current developments in vehicle automation for personal use (2.2), the current status of available vehicle automation in public transportation (2.3) and several ADS-DVs in operation (2.4) are discussed. In section 2.5 a recent survey on the user satisfaction of the ADS-DV *ParkShuttle* is briefly addressed.

2.1. Definition of an automated vehicle

Including automation (features) to vehicles is an important development in vehicle technology. In all areas (e.g. research institutions, car manufacturers, governmental agencies, start-ups) the topic is placed high on the agenda, mostly due to the prospected improvement opportunities it will bring in traffic safety. An automated vehicle can be defined as a vehicle that has one or more automated features that can assist the driver or can take over driving (tasks) completely. A widely used categorisation standard for automation in vehicles was developed by the Society of Automotive Engineers (SAE) and distinguishes between six levels: from *no driving automation* to *full driving automation* [8]. The six levels are displayed in figure 2.1. With the increase of each level the *dynamic driving task* (DDT) shifts gradually from the human driver to the system. At level 5 a human driver is not required to operate the vehicle at any given moment. This level of full driving automation allows for vehicles operating without any human present, solely relying on a computer system to operate the vehicle. Vehicles that are designed to operate exclusively with a level 4 or level 5 *automated driving system* (ADS) for all trips are referred to as *ADS-dedicated vehicles* (ADS-DV). ADS-DVs distinguish themselves from other ADS for no conventional or remote driver is required during routine operation. This allows for designing the vehicle without any user interfaces, such as a steering wheel or brakes. From figure 2.1 it can be noticed that for both level 4 and level 5 ADS-DVs the *object and event detection and response* (OEDR) and DDT fallback (DDT in case of main system failure) are handled by the system. In the latter case the system relies on back-up computing modules to achieve a minimal risk situation. A level 4 ADS-DV is designed to operate exclusively on certain roads or fixed routes, it cannot operate outside its *operational design domain* (ODD). The level 5 ADS-DV can operate on all roads that would be navigable by a human driver. The automated vehicles referred to in this thesis belong to both level 4 and level 5 ADS-DV.

2.2. Personal vehicle automation

Before 2010 Google was the main player in self-driving vehicles, but as of the beginning of 2016 many parties have invested in vehicle automation. At this moment, many car manufactures (e.g. Tesla, Honda, Volvo, Audi, BMW, Ford) are known to work on vehicle automation. At the Consumer Electronics Show (CES) in Las Vegas in January 2017 vehicle automation dominated the event [9, 10]. All companies seem to develop automated features to make car driving more comfortable, and most show off their prototypes of automated cars that according to their makers should be self-driving and available to customers in only a couple of years [11]. Tesla brought cars to the market that can offer high automation (SAE level 3) on high ways [12]. Note that drivers are still requested to stay focused and be ready to take over the steering wheel at any time. That this first step towards full automation is available on high way stretches first can be explained by the relatively 'simple' traffic situations that occur. Traffic situations in urban areas are less predictable than on high ways and current technology is not yet reliable enough to be able to guarantee traffic safety. Next to Tesla, Google,

Level	Name	Narrative definition	DDT		DDT fallback	ODD
			Sustained lateral and longitudinal vehicle motion control	OEDR		
Driver performs part or all of the *DDT*						
0	No Driving Automation	The performance by the *driver* of the entire *DDT*, even when enhanced by *active safety systems*.	*Driver*	*Driver*	*Driver*	n/a
1	Driver Assistance	The *sustained* and *ODD*-specific execution by a *driving automation system* of either the *lateral* or the *longitudinal vehicle motion control* subtask of the DDT (but not both simultaneously) with the expectation that the *driver* performs the remainder of the *DDT*.	*Driver* and *System*	*Driver*	*Driver*	Limited
2	Partial Driving Automation	The *sustained* and *ODD*-specific execution by a *driving automation system* of both the *lateral* and *longitudinal vehicle motion control* subtasks of the *DDT* with the expectation that the *driver* completes the *OEDR* subtask and *supervises* the *driving automation system*.	***System***	*Driver*	*Driver*	Limited
ADS ("*System*") performs the entire *DDT* (while engaged)						
3	Conditional Driving Automation	The *sustained* and *ODD*-specific performance by an *ADS* of the entire DDT with the expectation that the *DDT fallback-ready user* is *receptive* to *ADS*-issued *requests to intervene*, as well as to *DDT performance-relevant system failures* in other *vehicle* systems, and will respond appropriately.	*System*	***System***	*Fallback-ready user (becomes the driver during fallback)*	Limited
4	High Driving Automation	The *sustained* and *ODD*-specific performance by an *ADS* of the entire *DDT* and *DDT fallback* without any expectation that a *user* will respond to a *request to intervene*.	*System*	*System*	***System***	Limited
5	Full Driving Automation	The *sustained* and unconditional (i.e., not *ODD*-specific) performance by an *ADS* of the entire *DDT* and *DDT fallback* without any expectation that a *user* will respond to a *request to intervene*.	*System*	*System*	*System*	**Unlimited**

Figure 2.1: Levels of vehicle automation as defined by SAE International in SAE standard J3016 [8]

nuTonomy and Uber are testing with self-driving cars in urban areas [13–16] to improve their software to be completely reliable in any situation, the main challenge for the development of full automation at this moment (although especially Uber experiences difficulties from legislative origin [17, 18]). It must be noted that all of the pilots with self-driving cars are conducted with 'safety drivers' on board that can intervene in case of emergency. In the area of public transportation some systems are already available that offer full automation, see section 2.4.

2.3. Impact of automated vehicles on public transportation

The impact of the introduction of previously discussed fully automated personal vehicles on a large scale may have great impact on public transportation. Full automation offers opportunities to combine the advantages of travelling by public transportation and those of travelling by a personal vehicle. In a fully automated vehicle (SAE level 5) the 'driver' has the possibility to use the in-vehicle time for work or relaxation just like in current public transportation systems. However, the driver also benefits from the flexibility, comfort and convenience of on-demand travel that is common to a personal vehicle [19]. What will happen to public transportation in this scenario? Bhat [19] suggests that public transportation usage will decrease in favour of personal (or shared) vehicles. The demand for those vehicles increases even more by shifts from walking and bicycling shares and the improved accessibility of elderly and disabled. This prospected drastic collapse of current public transportation can be questioned, mainly because of capacity issues of the road network. If most transportation would be done in small on-demand vehicles, most areas would result in gridlock, as was found by Boesch and Ciari [20] using simulation models. As no driver would be needed to operate the vehicle, empty vehicles will be on the streets heading for parking places or even home after dropping-off the traveller, leading to more traffic than is currently about in the transport system.

Krumm [21] approaches the future of public transportation in a different manner. By placing route types and travel types on separate axes, different demands and supply for transportation arise, figure 2.2. In the past flexible routes were only addressable by individual modes like personal cars, and collective transportation would remain on fixed routes with fixed time tables in the form of mass transit public transport. As a strategy and innovation employee in the field of public transportation Krumm states that full automation will open up new markets catering to the need for flexibility using micro transit: on-demand (public) transportation. However, such car/trip sharing is only expected to succeed on a small scale or in less densely populated areas. In large cities similar gridlocks as described before would still occur. Therefore it is expected that mass transit public transport will still be needed to service the large transport demand in those areas.

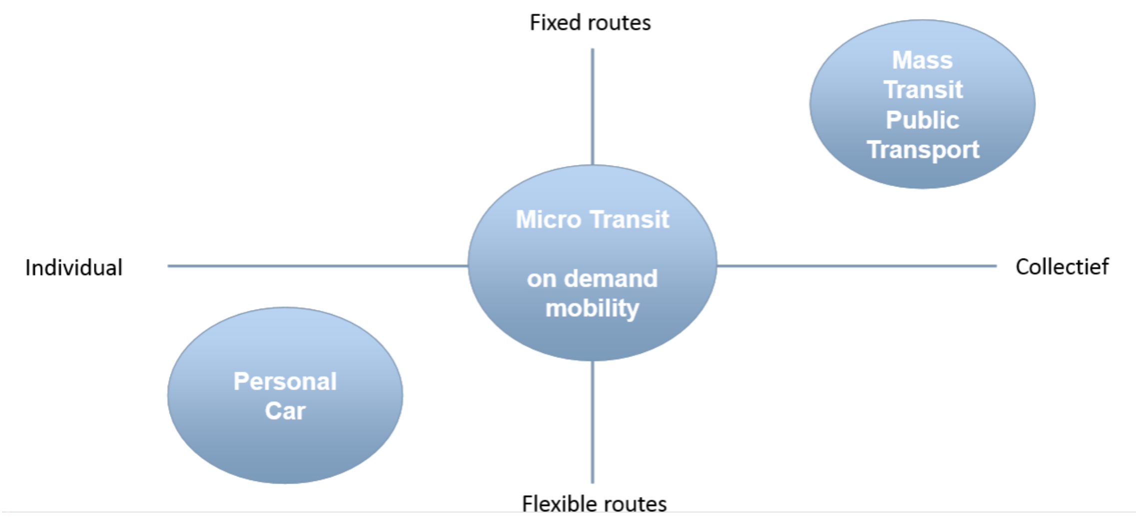


Figure 2.2: Demand and supply of transportation derived from Krumm [21]

In line with the micro transit modes that Krumm mentioned, CyberCars (CC), Personal Rapid Transit (PRT), Group Rapid Transit (GRT) and High Tech Buses (HTB) are being developed. Alessandrini et al. [22] define these Automated Road Transit Systems (ARTS) as follows (although it must be noted that some definitions are interchangeably used in literature and practise):

- *CyberCars* (CC): Automated road vehicles ranging from 4-20 passengers that perform a taxi service, passengers share a vehicle and can have different origins and destinations that are reached on a lane that can be segregated or not segregated;
- *Personal Rapid Transit* (PRT): individual vehicles offering space to 4 passengers maximum, carrying passengers form origin to destination without intermediate stops on dedicated lanes;
- *Group Rapid Transit* (GRT): the larger version of PRT offering space for up to 25 passengers;
- *High Tech Buses* (HTB): vehicles that offer mass transport using infrastructure that could either be private or shared with other road users, automation can be available in the form of driver assistance or in full automation and platooning.

Based on the ADS-DV definition all above mentioned systems could in theory operate at either level 4 or level 5 (high tech buses could also operate on lower levels of driving automation). However systems currently available operate at a maximum of level 4. May et al. [23] used a predictive modelling method to investigate the impacts of CC, PRT and HTB systems. They found that PRT systems in cities mostly drew in travellers from mainly public transportation modes, walking and cycling as to traditional car users, which is a negative development from a sustainability perspective. The financial cost benefit ratios were often positive, due to low operational costs (no driver), especially in areas with previously poor levels of service and cities with high fare regimes. The researchers state that in order to make automated vehicles feasible they will have a role to play in certain niche markets in a city, that will differ from location to location. In general the use of CC or PRT as feeder services to conventional high speed public transport routes offer a particularly promising starting point in cities with high public transport fares and on locations with poor levels of public transport service.

2.4. ADS-DVs in operation

To give the development of automated vehicles a boost, back in 2014 the Netherlands decided to invest in research and pilot studies [2]. In the Randstad area (the most densely populated area in the Netherlands) the governmental agency responsible for an integrated approach of traffic and transportation in the Rotterdam - The Hague area, Metropoolregio Rotterdam Den Haag (MRDH) started a project focusing on last mile connections: *Automated Transportation on the Last Mile* (AVLM). A collaboration of several municipalities work on innovative solutions for first and last mile connections in order to improve the accessibility of business parks and knowledge institutions, increase the use of public transportation and increase awareness of automated transportation. In the AVLM project first and last miles are taken into account as connections between metro/train stations and business parks or knowledge institutions. The connections should be addressed by level 4 or level 5 ADS-DVs that offer space to about 12 persons.

Table 2.1: ADS-DV types

	Dedicated lane	**Amongst other traffic**
Level	ADS-DV Level 4	ADS-DV Level 4 or Level 5
Configuration	Separated lane	Integrated with other traffic
Service	Fixed stops	Fixed stops / Door-to-door service
Example	ParkShuttle	WEpods (level 4)

The current state-of-the-art in vehicle automation of collective automated vehicles includes several systems in operation and many pilot studies. The main difference lies in the configuration of the system. Since it is easier to predict traffic situations for systems operating on dedicated lanes, than systems amongst other traffic, the first are found in operation, while the latter are only in pilot stage. Throughout this thesis a distinction is made between the two types. Labelling the first system as a system on a *dedicated lane* (ADS-DV level 4) and the second as a system operating *amongst other traffic* (ADS-DV level 4/level 5), table 2.1. Systems not bound to a dedicated lane offer the advantage to be able to operate as a door-to-door service, while systems on a dedicated lane can only service fixed stops. Worldwide four *dedicated lane* ADS-DV systems are in operation to transport passengers from their origin along a number of stops to their destination. Differences exist between the characteristics of the systems, the most important being *at grade/levelled operation* and *crossings with other traffic/full separation of other traffic*. Three systems function on private facilities such as an airport (London Heathrow 2011), university campus (Morgantown, USA 1975) and in Masdar City (UAE 2010). The ParkShuttle connects a subway station to a business park (Rotterdam, the Netherlands 1999) [24]. The ParkShuttle is operated as public transportation to overcome last mile transit for commuters. Figure 2.3 shows the ParkShuttle. From the summary in table 2.2 it can be seen that the ParkShuttle is the only system currently operating as public transport at grade with (protected) crossings with other traffic and charging fare costs to its travellers. Worldwide multiple examples of rail-based automated people mover systems exist. However, these systems are left out of the scope of this thesis for they are not ADS-DVs.

Table 2.2: Operational systems on a dedicated lane (ADS-DV level 4) based on ATRA [24]

	Morgantown PRT	**ParkShuttle**	**CyberCab**	**ULTra PRT**
Location	Morgantown, USA	Capelle a/d IJssel, Netherlands	Masdar City, UAE	London, UK
Facility	University campus	Public transport	Underground city transport	Airport terminal
Vehicle supplier	Boeing Aerospace Co	2getthere	2getthere	ULTra PRT
Start of operation	1975	1999	2010	2013
# of stops	5	5	2	3
Length of track	13.2 km	1.8 km	1.5 km	3.8 km
At grade	No	Yes	No	No
Crossings	No	Yes	No	No
Fare price	No	Yes	No	No
Type	ADS-DV level 4	ADS-DV level 4	ADS-DV level 4	ADS-DV level 4

Figure 2.3: Rivium ParkShuttle, derived from 2getthere [25]

Systems operating *amongst other traffic* (ADS-DV level 4/level 5) offer advantages over the dedicated lane system. Door-to-door services allow the traveller to stop right at their destination and infrastructure needs for ADS-DVs are lower, lowering investment costs. Disadvantages of buses amongst other traffic include higher chances of accidents and higher chances of delays caused by congestion. To guarantee the safety of travellers and other traffic participants the speed of vehicles currently has to remain low (approx. 15 km/h - in comparison the new model of the ParkShuttle is designed to operate at 40 km/h). It is assumed that speeds will increase when features like obstacle recognition can be improved. Several projects are ongoing to test the potential of these vehicles in practise. In the Netherlands the WEpods project in Ede-Wageningen and the automated vehicles pilot in Appelscha (Friesland) are two examples [26][27], see 2.4. The aim of the projects is to test current technology and increase awareness and acceptance of ADS-DVs. Globally several projects are run with similar aims, like the CyberCars, EDICT and CityMobil projects executed by the European Union [28]. There are currently no examples of ADS-DV level 5 systems.

Figure 2.4: Appelscha (l), derived from DagbladvanhetNoorden [29] and WEpod (r), derived from WEpods [30]

2.5. User satisfaction of the ParkShuttle

The municipality of Capelle aan den IJssel has assessed user satisfaction of the ParkShuttle and bus line in the area in both 2000 (one year after introduction) and 2016. Travellers were presented several questions on mode use and instrumental factors and were asked to provide improvement opportunities. Although the results show that the ParkShuttle is in general rated better in 2016 than in 2000 and given lower scores (which is in this case better) than the conventional bus (figure 2.5), conclusions must be drawn with caution. The surveys did not represent follow-up results under the same group of respondents and no socioeconomic data are available of respondents to be able to compare the results. Moreover, improvements of the ParkShuttle system over the past 15 years have not been taken into account when comparing the ratings of both surveys (e.g. higher vehicle speeds and less system failures). Despite the impossibility to draw firm conclusions, the data can be used to give an indication of factors that might be influenced by experience. Most variables have scored better in 2016 compared to the 2000 results. Especially the reliability of the ParkShuttle scores a lot better in 2016 than in 2000. Similarly the waiting times have been rated better in 2016. However, the walking distance from the stop to the destination is perceived a lot more negative in 2016 compared to 2000.

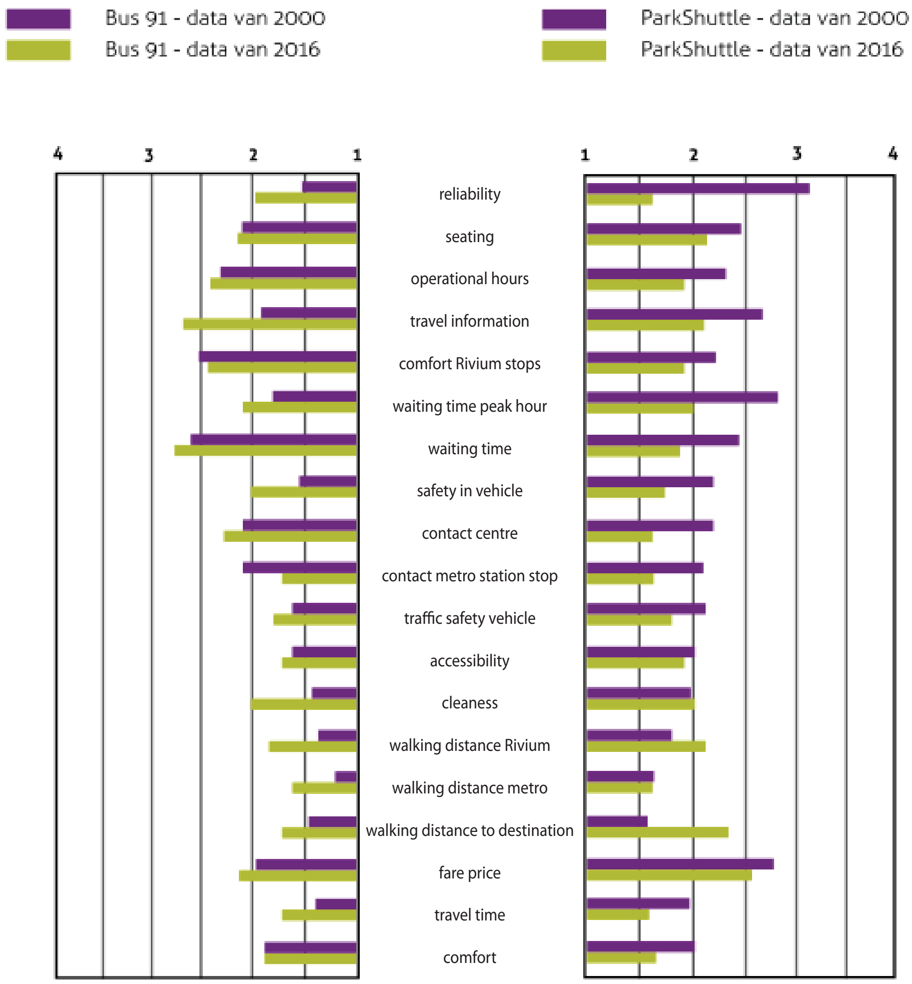


Figure 2.5: Survey results bus/ParkShuttle satisfaction 2000-2016 (1=high, 4=low), derived from Except [31] (translated)

3

Travel behaviour

This chapter gives an introduction into travel behaviour, and in specific travel behaviour of travellers choosing a mode. First the four stage model of travel behaviour is introduced (3.1). Next, several conceptual notions and paradigms are discussed (3.2). Section 3.3 goes in depth with research on travel behaviour with regard to automated vehicles. The chapter concludes with a conceptual model providing an overview of the factors that are considered important for this thesis (3.4).

3.1. Four stages of travel behaviour

The decision to travel and how to travel is built up in sequential questions. First an individual determines he or she is to *make a trip* to fulfil some kind of need (e.g. go to work or do shopping). Next he or she has to decide *where* the trip will be headed (e.g. supermarket or bakery). When the destination is decided on it must be decided *how* to reach it. The traveller compares available modes and chooses the one that he or she thinks fits the trip best (e.g. bicycle, bus or car). Finally the traveller decides *what route* to take (e.g. scenic route or shortest route) and departs for the trip. Ortúzar and Willumsen [32] represent these choices in a schematic four-stage model of travel behaviour:

1. **Trip generation** the decision to make a trip. Travellers also define the purpose of the trip in this stage;
2. **Trip distribution** offers the available origins and destinations available to the traveller to choose from;
3. **Mode choice** the traveller decides which modes suit his planned trips;
4. **Route choice** the final decision for the traveller is the route the traveller will take to reach his or her determined destination.

Sometimes a fifth stage is included that lets the traveller decide at *what time* he or she will travel (e.g. during peak hour or in the weekend). It must be noted that these stages are not completely independent and sequential. For example the destination can also be dependent on the modes available to the traveller. Although all stages are part of the travel decision of travellers, this thesis focuses primarily on the third stage *mode choice* and the factors that influence the traveller to choose a certain mode. The decision to make a trip is assumed as given in this thesis, travellers have a work-related trip purpose to travel from home to work. Furthermore, as the focus is restricted to last mile connections, only a selection of modes is taken into account. Route choice is partially linked with mode choice and is included where mode and route are considered integrated.

3.2. Travel behaviour research based on different schools of thought

Throughout the years travel behaviour has been addressed from many different points of view. An indication of different scholars and their matching paradigms is shown in 3.1 (note that the figure only shows a selection of possible modelling methods). In the traditional econometric approach an individual is thought of as a black box, with predetermined wants and needs for which the individual tries to maximise his or her utility. Utility maximisation theory has first been introduced by McFadden [33] in 1980. A recent development is the theory of Regret Minimisation as introduced by Chorus [34]. This theory proposes that (some) individuals are more likely to minimise the regret in a certain situation than to maximise their utility. An essential aspect for both approaches that differentiates the econometric worldview from others is the assumption that the individual makes rational choices: he or she is fully aware of all available alternatives and their values (e.g. travel time or travel cost). The assumption that travellers are fully aware of all information on alternatives and their values is a simplification of reality. Often individuals deal with *bounded rationality*: limitations in information or time to make a decision. Furthermore, only observable factors are included in the research (e.g. travel time or travel cost) as these can easily be quantified. Latent variables as attitudes and perceptions are difficult to determine and hard to quantify, therefore these are excluded from econometric research.

Conceptual notion(s)	Modelling paradigm
Econometric: Travel behaviour is the outcome of a (rational) choice process	Discrete choice models, latent class discrete choice model
Psychological: Travel behaviour is determined by psychological factors (habits, social norms, attitudes), e.g. Theory of Planned Behaviour	Structural equation models
Marketing: Travel behaviour is a reflection of generic/holistic mobility styles, life styles or worldviews.	Cluster analysis, latent class analysis
Geographical: Travel behaviour is determined by the built environment, residential self-selection.	Regression models, multi-level models, structural equation models
Biographical: Travel behaviour is dynamic and evolves in tandem with household/employment biographies.	Logit models, regressions models, (latent) transition (Markov) models
Sociological: Travel behaviour is embedded in social practices, institutions and discourses. Focus on social structures instead of individuals, e.g. social practice theory	Usually non-quantitative models, i.e. qualitative research

Figure 3.1: Six conceptual notions of travel behaviour, derived from Kroesen [35]

The simplified approach of utility theory has often been criticised by behavioural scientists. Important idiosyncratic aspects of behaviour are neglected and the theory cannot handle irrational decisions [36]. From the school of psychological research many studies have shown that psychological factors such as attitudes, norms, perceptions, affects and beliefs have a significant and sometimes even larger influence on travel behaviour than observable variables [37–39]. Including such psychological factors into research is believed to cater for some of the differences between decision makers and their sensitivities that cannot be grasped using an utility theory approach and thus lead to better explained and predicted choices. This thesis focuses only on the two paradigms from those shown in figure 3.1.
Data collection for both psychological and econometric funded research often makes use of surveys. In stated preference (SP) surveys respondents are asked what they would do in a hypothetical choice situation. In revealed preference (RP) surveys the data is based on *observed choices* that are made by individuals. RP studies are generally favoured over SP studies as the choices are real choices made in a real context. However, the limited availability of automated vehicles has lead researchers of both fields to make extensive use of SP surveys in this context.

Most published researches on automated vehicles focus on personal vehicles, like cars with full driving automation (features) or cars with automated assistance features. The number of papers focused solely on shared automated vehicles and ADS-DV systems is limited. Therefore the literature for this thesis is expanded to include studies on automated vehicles in general. It is assumed that many factors that influence choices for automated vehicles found in personal automated vehicle studies can also apply for shared systems. The literature review is based on the work by Nordhoff et al. [41] who have conducted a thorough review of available literature in the field.

3.3. Literature review on travel behaviour

This thesis reviews 22 studies which are briefly discussed in this section. The studies have made use of psychological, econometric and integrated approaches. In the most common econometric theory (utility maximisation) the traveller solely acts to maximise his or her needs. Each alternative has a certain amount of utility for an individual in fulfilling their needs. This viewpoint is the core of *Choice Modelling*. Since its first introduction the paradigm is expanded to allow for psycho-physical randomness by including a random error. Although still not directly taking psychometric data into account this *Random Utility Model* does allow for more realistic results than its predecessor. The psychological worldview includes unobservable factors

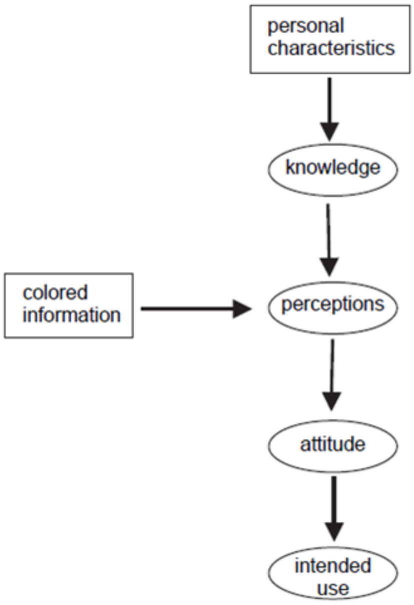


Figure 3.2: Influence of latent constructs on intended use, derived from Molin [40]

(e.g attitudes, beliefs and perceptions) in their models to explain and predict travel behaviour, see for example figure 3.2. A common approach deals with the concept of *acceptance*. Adell et al. [42] proposed the definition of acceptance as the degree to which an individual uses an alternative or if the alternative is not (yet) available, intends to use it. Over the past decades efforts have been made to expand choice models with latent variables. A small number of studies have been conducted recently in the field of transportation. The study of Yap et al. [43] is included in this review as one of the first focusing on automated vehicles.

The remainder of this section addresses the most important findings from the reviewed studies on automated vehicles (AV). Findings from studies that specifically focused on ADS-DVs are shown in *italic*. An overview of all reviewed papers can be found in appendix A.

3.3.1. Instrumental factors

Traveller's choices for automated vehicles are influenced by the instrumental factors that define the systems, like travel costs and travel time.

Travel costs *ADS-DV: Pilot studies with an ARTS reviewed by Gorris and Kievit [44] showed that on average travellers were willing to pay a little less than €2 to make use of the system.* Krueger et al. [45] found that travel costs have a strong negative influence on the preference for shared AVs. Although many studies showed that travellers could be interested in using automated vehicles, often respondents are concerned about costs [46] or even state not wanting to pay extra for the technology (in a personally owned AV) [47]. Additionally König and Neumayr [48] found that most respondents would find the idea of using an AV more attractive than buying an AV.

Travel time / waiting time Both travel time and waiting time were found to have a strong negative influence on the preference for shared AVs [45].

Travel time enrichment Conflicting results were found on the influence of travel time enrichment (the possibility for travellers to spend the in-vehicle time in other ways than driving, e.g. working or sleeping). In the study by König and Neumayr [48] respondents rated the possibility to engage in other activities than driving as one of the most important benefits of AVs. *ADS-DV: The study by Yap et al. [43] found however that travel time enrichment was experienced more negatively than driving a vehicle manually. Yap et al. [43] argue that the short distance of the last mile trips in their study might have caused this effect.*

Configuration *ADS-DV: In the studies by [22, 49] it was found that individuals have a relatively higher prefer-*

ence for an ADS-DV for trips on a major facility. Most respondents in the study by Louw and Merat [50] stated to prefer vehicles on dedicated lanes over shared configuration. Furthermore, respondents showed a preference for clear demarcations such as zebra crossings and marked lanes. In the study 80% of respondents also stated to be unfamiliar with automated vehicles, which might affect respondents preferences.

Automation aspects *ADS-DV: the study by Site et al. [51] found that the preference for an automated bus is slightly higher than for a regular minibus when scenario attributes and level-of-service attributes are the same, suggesting that additional attributes specifically related to automation play a role.*

Presence of transit employee *ADS-DV: A recent study by Dong et al. [52] showed that two-thirds of respondents stated to be willing to ride a self-driving bus when a transit employee is present, while only 13% would agree to ride the bus without a transit employee aboard. The lack of a driver or other type of transit employee present in the vehicle was also stated as a concern in studies by Louw and Merat [50], Voge and McDonald [53].*

Information *ADS-DV: In the research by Louw and Merat [50] 50% of the respondents stated that they would not need information on traffic detection and movement during the trip.*

Vehicle speed *ADS-DV: The slow vehicle speed of AVs was found to be regarded as a concern among respondents [50, 53].*

Instrumental factors are important factors that can distinguish alternatives in a mode choice study. *Travel cost, travel time* and *waiting time* are included in generally every choice model to be able to represent realistic alternatives in a SP survey. Although *travel time enrichment* could be one of the most radical changes when introducing full driving automation to personal vehicles, the impact when compared to public transportation is limited. Since passengers already can use their time freely in current modes, this factor is excluded form this study. From literature it was found that travellers prefer the *configuration* of ADS-DV systems to be on dedicated lanes or areas. Furthermore, clear demarcations of the route of ADS-DV systems amongst other traffic were stated as important. As previous studies only included participants that had no to limited experience with such systems and several participants in this study have long term experience with the ParkShuttle (level 4 ADS-DV) the findings might be different. It is expected that travellers with long term experience are more in favour of ADS-DVs amongst other traffic than are non experienced travellers. *Automation aspects* were found to have a positive effect on use intention. This effect is not specifically studied in this thesis as both level 4 and level 5 ADS-DV operate with full driving automation. The *presence of a transit employee* was found to have a large positive influence on the use intention of ADS-DV systems. This factor is therefore included in this study. It is expected to find a stronger positive influence for the presence of an employee for travellers that have no or little experience with ADS-DVs than for long-term users of the ParkShuttle. Louw and Merat [50] found that *information* on traffic detection and movement during the trip was not considered necessary for 50% of their respondents. This low amount for a study with in-depth interviews of which 80% of respondents were unfamiliar with AVs would give reason to believe that information would not have a strong influence on the choice to make use of ADS-DV systems. A slow *vehicle speed* was mentioned as a concern for respondents in the same study by Louw and Merat [50]. Slow speeds might make a ADS-DV feel silly and not a real competitor to faster travel modes. However, as modes can best be compared based on travel time and developments of ADS-DV systems keep increasing speeds, this factor is not included in this study.

3.3.2. Psychological factors

Psychological factors include information about an individual that is not directly observable, e.g. attitudes, beliefs and perceptions. This type of variable is often indirectly measured using psychometric constructs like Likert scales (scales for the level of agreement, first used by Likert [54]).

Trust in AVs The lack of trust in an AV is mentioned as a large influence on individuals to reject AVs [46, 55, 56]. Generally younger people and those familiar with automated car features are found to have higher levels of trust in AVs. Respondents stated that the possibility to take over driving the vehicle whenever they wanted would help reduce concerns users might have regarding AVs [48]. Rudin-Brown and Parker [57] found that drivers' trust in automated cruise control (ACC) increased significantly after using the system. *ADS-DV: For ADS-DVs it was found that trust plays an important role in the attractiveness of this type of AVs as well [43, 50].*

Safety & security General safety concerns are mentioned by Zmud et al. [46] as a major concern for (intentional) non-users of AVs. Furthermore, individuals that believe AVs will reduce crash risk are more likely to make use of these vehicles [46]. In multiple studies travellers mentioned to be afraid of possible attacks from hackers on the vehicle [47, 48, 58] and to be concerned that the AV would not perform as well as a human driver [47]. In the study by König and Neumayr [48] the risk that automated vehicles might not drive as well as human drivers was valued as the least concern, whereas in the study by Schoettle and Sivak [47] it was mentioned as the highest concern of respondents. *ADS-DV: Studies about shared AVs found similar concerns on safety present in respondents [50, 52].*

Performance expectancy *ADS-DV: Madigan et al. [59] found that the expected performance of an ARTS system strongly influences the use intention of the system. Respondents of the survey of Voge and McDonald [53] rated the vehicle and system performance highly after participating in a vehicle demonstration.*

Ease of use Individuals believing that the use of an automated vehicle would be easy stated to be more likely to use an AV [46]. One of the largest concerns mentioned for using a personal automated vehicle involves the handling of legal issues [48, 58]. *ADS-DV: Similar to findings of personal AVs, Madigan et al. [59] conclude that the perception of how difficult the system is strongly influences the decision to use an ARTS system.*

Social recognition People are believed to adapt their behaviour to the opinions of their friends and family. Respondents stating that their peers would like/use AVs too were found to have a higher intention to use AVs [7, 46]. Most respondents do not believe an automated vehicle would give them social recognition [48]. *ADS-DV: Influences of other people also are found to play a role in the choice to make use of an ARTS system [59].*

Usefulness Choi and Ji [56] found that the perceived usefulness of an AV has a large positive influence on the use intention of such vehicles. Many respondents value the improved accessibility for elderly and disabled persons as the main advantage of AVs [48]. König and Neumayr [48] found that most respondents do not believe that AVs would yield shorter travel times. Use intention for automated vehicles is found to be highest in stressful and monotonous driving conditions, however not in areas with busy traffic [60]. An explanation could be the lack of trust in an AV to perform as well as a human driver. *ADS-DV: 60% of the respondents in the study by Louw and Merat [50] did not see a benefit of ARTS systems over existing public transport.*

Enjoyment Individuals that stated they would enjoy driving an AV were found to be more likely to use such a vehicle [46]. Individuals thinking that they would not enjoy the experience of driving an AV are less willing to pay for them [58]

Sustainability *ADS-DV: Yap et al. [43] conclude that the sustainability aspect of electrical AVs plays an important role in the attractiveness of AVs.*

Technology focus Multiple studies found that respondents that are technology prone are more likely to make use of AVs [7, 46].

Sensation-seeking Choi and Ji [56] did not find a significant effect of sensation-seeking on intention to use an AV. Payre et al. [60] however did find positive correlations between sensation-seeking and the use intention of full automated driving.

Locus of control Respondents with an external locus of control are more likely to use an AV than those with an internal locus of control [56].

Psychological factors are not often combined (yet) in choice models concerning ADS-DVs. However, from other studies indications on the expected effects of these latent variables can be derived. Furthermore, Yap et al. [43] have already shown that psychological factors indeed play a role in the decision to make use of an automated vehicle. It is assumed that differences between the perceptions of ADS-DVs of travellers that have experience with the ParkShuttle are expected to be more positive than the perceptions of travellers that do not have experience with an ADS-DV. In this thesis the perceptions of *trust in AVs, safety, security, performance expectancy* and *ease of use* are considered. Especially these four are expected to play a role when deciding to make use of an (unknown) mode. *Social recognition* is thought to be less relevant in the context of last mile connections and therefore excluded. *Enjoyment* is expected to be less present in the case of ADS-DVs compared to personal automated vehicles and is therefore excluded from this study. *Usefulness* is expected to be hard to measure and in the context of home-work trips to be irrelevant. It is assumed that any transportation mode that would enable the traveller to reach its work destination would be considered as useful. The focus in this thesis is on travellers' *perceptions* of ADS-DVs not on an individual's attitudes. Therefore an individual's attitude towards *sustainability* is not taken into account in this study even though Yap et al. [43] found that sustainability plays an important role in the attractiveness of AVs. Furthermore, other psychological factors like *technology focus, sensation-seeking* and *locus of control* are not included as these do not deal with perceptions and are less relevant to policy makers to focus transportation policies on.

3.3.3. Socioeconomic factors

Socioeconomic factors are observable variables of individuals, e.g. age, gender, household income or vehicle ownership.

Age *ADS-DV: Dong et al. [52] found that younger individuals (18-34 year old) are more willing to use ADS-DVs. Voge and McDonald [53] found similar positive reactions of younger age groups towards ARTS systems.* Krueger et al. [45] found that young individuals are more likely to adopt shared automated vehicles. Although according to a study by König and Neumayr [48] most respondents would see benefits for the elderly and disabled in using an AV, again young people (18-30 years of age) are found to be more positive about AV use than those in higher age groups.

Gender *ADS-DV: Dong et al. [52] found that males were more likely to ride a driverless bus than females.* Multiple studies have similarly indicated that males are in general more willing to make use of automated vehicles than are females [7, 46–48, 60]. Furthermore, Bansal et al. [7] found that males have a higher willingness-to-pay than females.

Household income Bansal et al. [7] found that especially male respondents with a high income have more interest in AVs and a higher willingness-to-pay. Zmud et al. [46] found that households with lower incomes (lower than $25.000 on a yearly basis) are less likely to make use of AVs, middle income households ($25.000-$50.000) are more likely to use AVs and respondents with higher incomes are equally likely and unlikely to use AVs.

Vehicle miles travelled Individuals driving more are found to be more likely to pay for automated vehicles [7]. A strong positive correlation was found between respondents that drive more and their willingness-to-pay for automated vehicles [58].

Vehicle ownership Currently owning or leasing a vehicle was not found to have an effect on the individual's intention to use an AV [46].

Current travel mode *ADS-DV: Current users of public transportation in general were found to react more positive towards ARTS systems than other mode users [53]. Additionally, Yap et al. [43] found that first class train travellers prefer small AVs over bicycle or bus/tram/metro as egress mode.* Zmud et al. [46] found that commuters that currently are vehicle drivers are slightly less likely to make use of AVs than those travelling by other modes. Krueger et al. [45] found that individuals with multimodal travel patterns were more likely to adopt shared AVs.

Crash experience Respondents having more crash experience are typically more interested in AVs and have a higher willingness-to-pay than other respondents [7].

Experience *ADS-DV: Dong et al. [52] found that respondents having prior knowledge on AVs were more willing to ride a driverless bus. Gorris and Kievit [44] reviewed six pilot studies conducted in the CityMobil research program. They found that ease of use of the system was best perceived by test-users, whereas the satisfaction of usefulness, reliability, integration with other systems, safety and the perceived level of privacy were all valued as average. The studies of Voge and McDonald [61] and Voge and McDonald [53] surveyed respectively a group unfamiliar with ARTS vehicles and a group that made a trip in a ARTS vehicle. The first group reported concerns* *on safety which were less present in the responses from the second study. It must be noted that respondents of both studies however were not the same individuals.* Multiple studies found that people having a higher familiarity with AVs (having heard of them) [48] or are familiar with automated car features [46, 58] did have significantly more positive intentions towards AVs. Furthermore, respondents stated that offering free test rides and sharing of comprehensive information on AVs were on the top of the list to reduce concerns about AVs [48].

Disability Individuals suffering of any physical condition that prohibits them from driving were found to have a higher intention to use AVs [46]. Additionally, 71% of respondents in the study by Payre et al. [60] stated to be willing to make use of AVs when impaired.

Motion sickness Diels and Bos [62] found that motion sickness can negatively effect acceptance of automated vehicles.

Socioeconomic factors are useful to categorise participants into several groups and to determine specific travel preferences for those groups. This study is however mainly focused on instrumental and psychological factors in the choice modelling part. Only *experience* is included in the choice model to be able to distinguish in preferences for travellers that have experience with an ADS-DV and travellers that do not have experience. The factors *age, gender, household income* and *current travel mode* are used to compare the sample group to the population and to be able to draw some conclusions with additional statistical analyses. Factors that are mainly focused on car drivers (*vehicle miles travelled, vehicle ownership* and *crash experience*) are not expected to have a strong effect in the case of ADS-DVs and are therefore not included. *Disability* is not taken into account for this study as the ADS-DV is considered as part of a multi-modal trip. Transfers are expected to limit the potential for the disabled to make use of ADS-DVs on last mile connections. Diels and Bos [62] considered the effects of *motion sickness* in personal AVs especially when used as living room or office environments. No problems with motion sickness are reported from the ParkShuttle or other ADS-DV studies leading to the conclusion that motion sickness is not relevant in this study.

3.3.4. Overview of factors

Each of the previously discussed factors is included in table 3.1 stating the effect on use intention of AVs found in literature, whether the factor is included in this thesis and if so, what effect is expected to be found with regards to ADS-DVs.

Table 3.1: Influences of factors found in literature

	effect as found in literature	included in thesis?	expected effect	references
Instrumental factors				
Travel costs	negative	yes	negative	[45–47]
Travel time	negative	yes	negative	[45]
Waiting time	negative	yes	negative	[45]
Travel time enrichment	unclear	no, not relevant	-	[43, 48]
Configuration	preference dedicated lane/area	yes	preference dedicated lane (more experience: more in favour of amongst other traffic)	[22, 49, 50]
Automation aspects	positive	ADS-DV are fully automated	-	[51]
Presence of transit employee	positive	yes	positive	[50, 52, 53]

Table 3.1: Influences of factors found in literature

	effect as found in literature	included in thesis?	expected effect	references
Information	unclear	no	-	[50]
Vehicle speed	negative	no	-	[50, 53]
Psychological factors				
Technology focus	positive	no	-	[7, 46]
Sensation-seeking	unclear	no	-	[56, 60]
Locus of control	respondents with an external locus of control are more likely to make use of AVs	no	-	[56]
Sustainable attitude	positive	no	-	[43]
Perception of...				
Trust in AVs	positive	yes	positive	[43, 46, 48, 50, 55, 56]
Safety	positive	yes	positive	[46]
Performance expectancy	positive	yes	positive	[59]
Ease of use	positive	yes	positive	[46, 59]
Social recognition	respondents with peers that would be positive about AVs have a higher use intention	no	-	[7, 46, 59]
Usefulness	positive	no	-	[56]
Enjoyment	positive	no	-	[46, 58]
Socioeconomic factors				
Age	negative	not in DCM	negative	[45, 48, 52, 53]
Gender	males more positive than females	not in DCM	males more positive than females	[7, 46–48, 52, 60]
Household income	positive	not in DCM	positive	[7, 46]
Vehicle miles travelled	positive	no	-	[7, 58]
Vehicle ownership	no effect found	no	-	[46]
Current travel mode	PT users tend to be more positive towards ADS-DVs	not in DCM	PT users expected to be more positive towards ADS-DVs	[45, 46, 53]
Crash experience	positive	no	-	[7]
Experience	positive	yes	positive	[46, 48, 52, 53, 58]
Disability	positive	no	-	[46, 60]
Motion sickness	negative	no	-	[62]

3.4. Conceptual model: integrating econometric and psychological worldviews

Based on the reviewed literature on both personal AVs and ADS-DVs, a conceptual model is constructed, figure 3.3. The psychological factors *trust in ADS-DV, traffic safety, security, ease of use* and *performance expectancy* are selected for their assumed strong influence on mode choice decision and the assumption that these variables are different for differing levels of experience. The instrumental factors consist of general factors often used in mode choice studies using discrete choice modelling like *travel costs, travel time* and *waiting time*. The instrumental factors are complemented with specific factors of ADS-DVs: *configuration of ADS-DV* and *presence of transit employee on board*. The number of socioeconomic factors has deliberately been limited given the focus on psychological and instrumental factors and to keep the respondent burden in the survey manageable. The conceptual model shows the expected direction (positive/negative) of each factor's influence on the preferences for ADS-DVs.

Based on the reviewed literature, multiple studies have found that experience with AVs (either having heard of them and/or performed a test ride) has a positive effect on use intention and preferences for such vehicles. Furthermore, indications have been given by Gorris and Kievit [44] and Voge and McDonald [53, 61] that after experiencing an automated vehicle some concerns were less present than before, in particular safety concerns. It must be noted however that in none of the studies, respondents were surveyed before and after experiencing an AV and nor did the respondents ever have more experience than a test ride. In this thesis the influence of long-term experience with an ADS-DV on preferences and perceptions is investigated.

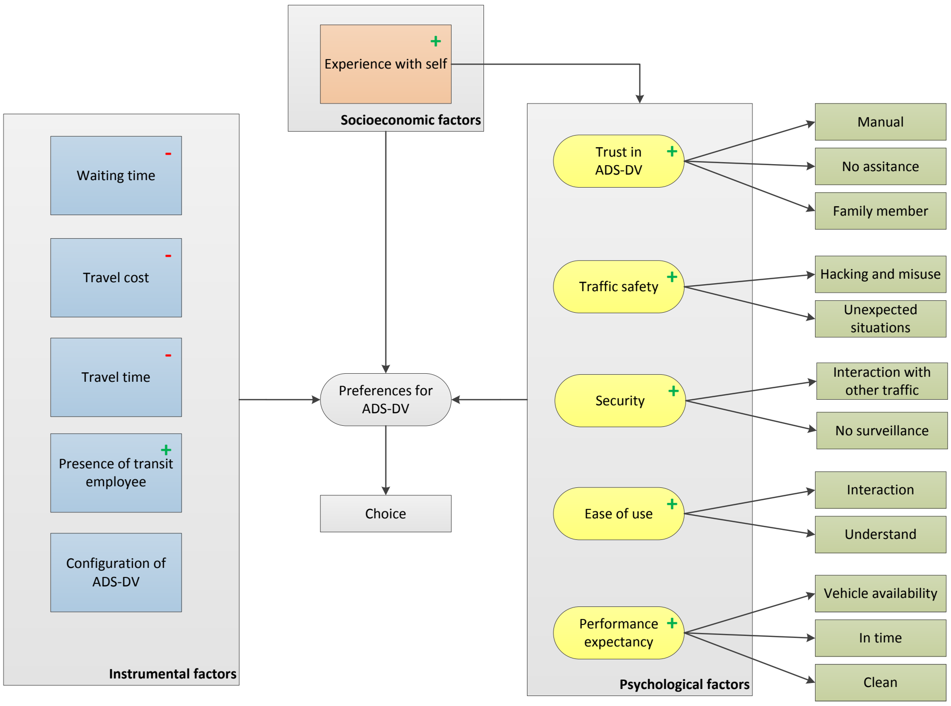


Figure 3.3: Conceptual model

4 Methodology

To get insight in how travellers perceive ADS-DVs it is necessary to collect data of representative respondents in the research. Empirical research allows for data collection from observations and experiences in practice, in a quantitative and/or qualitative manner to reveal direct and indirect effects between variables. In the context of this thesis variables that influence the use of ADS-DVs are identified and their impacts analysed. A quantitative approach is used for both data collection and analysis, by means of respectively a survey and statistical models. Surveys allow for the simultaneous gathering of large amounts of data by presenting a sample group with questionnaires. It is of importance that the sample group represents the target population well to be able to generalise the findings to the population at large. This chapter discusses briefly surveys for data collection (4.1) and discrete choice models and other statistical models (respectively section 4.2 and section 4.3) for data analysis.

4.1. Surveys

The ADS-DV in the Rivium business park offered the opportunity to investigate differences in preferences and perceptions between (long-term) users and non-users of ADS-DVs and comparing the data to other business parks without the availability of ADS-DVs. To fully capture the causal effect of experience repetitive data collection of the same respondents would be preferred. However, due to time constraints in this thesis a cross-sectional approach is used. In order to compensate for the lack in longitudinal data, several groups are distinguished that represent different levels of experience with ADS-DVs. In order to be able to draw conclusions on the causal effect of experience, all groups need to be significantly similar on several relevant socioeconomic factors. Since only respondents of Rivium have the possibility to use an ADS-DV to travel to work and no suitable alternatives are offered to the travellers, it is impossible to conduct a revealed preference study. For these reasons it was decided to conduct a stated preference study instead.

Limitations of surveys

Using stated preference surveys can cause results to be affected by hypothetical biases (e.g. respondents might give socially accepted answers or turn out not to use the stated alternatives in real life) [63]. Some solutions include conducting the surveys anonymously or letting the respondents fill out the survey without supervision. By distributing the survey online some of these problems can be overcome. However, contextual biases can pose a problem in this thesis. These can occur specifically in surveys that include mode choices of which one or more are non-existent to (a part of) the respondents. There are several ways to try to deal with this type of biases, such as using virtual reality or serious gaming [64]. This thesis is limited mainly in time, making it impossible to design virtual reality or serious gaming tools to accompany the survey methods. The use of videos and pictures for explanatory purposes can help familiarising respondents with ADS-DVs. However for this thesis the effect of this hypothetical bias must still be taken into account when analysing the results.

4.2. Discrete choice modelling

The aim of this research is to determine the factors that influence travellers to make use of ADS-DVs. The factors included in the thesis are mainly instrumental and psychological. In order to include psychological factors in the choice model an integrated approach is needed. The psychological factors cannot directly be measured and thus are addressed using psychometric indicators. From the socioeconomic factors only *experience with an ADS-DV* is included in the choice model. Experience is assumed to have a positive influence on ADS-DV choice and individuals that have use experience with ADS-DVs are expected to have more positive perceptions of ADS-DVs than individuals that do not have use experience.

The concept of discrete choice theory

The explanation of the theory is based on Ben-Akiva and Lerman [65], to which the reader is referred for further reading on the topic. To be able to make statements about the travel behaviour of large numbers of individuals it is necessary to look at the individual choices that underlie aggregated travel behaviour. This econometric theory assumes that individuals make rational decisions based on the believed desired outcomes. The core of discrete choice theory (of the random utility maximisation variation) is the calculation of *utilities* for each alternative and the assumption that an individual selects the alternative with the highest utility. Each alternative has several *attributes* that can increase or decrease the utility of that alternative. The collection of available alternatives at a decision moment is referred to as the *choice set*. The *decision maker* compares explicitly or implicitly the different attributes of all alternatives in the choice set and will select the alternative with the highest utility. A set of functions is used to support the calculation of the utilities. Equation 4.1 shows an example of an (structural) utility function for an alternative.

$$V_i = \beta_1 t_1 + \beta_2 t_2 \tag{4.1}$$

where V_i represents the (structural) utility of an alternative i, t_1 and t_2 attributes of the alternative and β_1 and β_2 the parameter values of the attributes.

The parameter values (β) represent the sensitivity of the decision makers to the specific attributes. Generally speaking, a higher (absolute) value would indicate that this attribute has more influence (is more important) in the decision making process than other attributes with lower (absolute) values. This function is not able to deal with any of the following types of randomness: (1) unobserved attributes, (2) unobserved taste variations and (3) measurement errors and imperfect information. In other words, the function does not take all possible attributes of an alternative into account, not all decision makers are completely the same and the function would not suit irrational behaviour or measurement errors. To address these problems the *probability* that an alternative is chosen is calculated and an error term is included in the function, resulting in the basic function as represented in equation 4.2.

$$U_i = V_i + \epsilon_n \tag{4.2}$$

where V represents the observed components of equation 4.1 and error term ϵ accounts for the randomness of unobserved components to the total utility.

Assuming that the random utilities are *independently and identically distributed* (IID), each error term has a similar probability distribution and all are mutually independent, a simple model can be constructed. In this case the choice probability of an alternative is only a function of the *differences* between other alternatives.

Model types

Several models have been proposed to predict choices and to calculate travellers' willingness-to-pay for several attributes of alternatives. A couple of the most applied are briefly addressed in this paragraph. First *Multinomial Logit* (MNL) and *Mixed Logit* (ML) are introduced and then some more advanced models are briefly discussed.

MNL models represent the simplest random utility models and are most widely used in discrete choice modelling, because of the easy approach and short calculation times. The MNL model assumes that the error terms are *Independent and Identically Distributed* (IID) as a Gumbel variable for all alternatives. In other words, unobserved utility components (disturbances) are uncorrelated over the alternatives and have a similar variance for all alternatives. Alternatives are assumed not to share unobserved characteristics and the error terms determine the utility to the same extent. The probability that individual n selects alternative i is represented with equation 4.3. The model parameters for each of the alternatives attributes are determined using maximum likelihood estimation based on observed choices. *Maximum likelihood estimation* searches for parameter values in the population that make the observed sample values most probable.

$$P_n(i) = \frac{e^{V_{in}}}{\sum_{j \epsilon c_n} e^{V_{jn}}} \tag{4.3}$$

where C_n is the choice set of j alternatives of individual n and e is the base number for a natural logarithm.

Since a MNL model assumes homogeneity in preferences for all individuals, (and one of the aims in this thesis is to analyse whether differences exist between travellers that have experience with ADS-DVs and travellers that do not have experience) the MNL model needs adjustments. When introducing the socioeconomic factor *experience* in the model as an interaction effect different parameter values for both *segments* can be derived. In case the parameters are different and significant for the segments, it can be concluded that differences in preferences between the two groups exist. Furthermore, by comparing the model fit to a base model (MNL model without interaction effects) it can be verified if the model would indeed better explain choice behaviour.

A more complex method to integrate heterogeneity is to use a *Mixed Logit* (ML) model. A ML model allows for randomness in taste variation by estimating a standard deviation accompanying the parameter value average. In case the standard deviation is significant, it may be assumed that heterogeneity indeed is present. ML models could also be used to account for *nesting effects* (alternatives that have correlations between unobserved attributes) and *panel data* (data including multiple choice made by per individual) [66].

In this thesis two alternatives represent types of ADS-DVs and are thus quite similar. To determine whether the two alternatives are nested a *Nested Logit* (NL) model is estimated. In case a nest of ADS-DVs is present, nesting effects need to be taken into account using a ML model. Even more complex types of models for heterogeneity are left out of the scope of this research (e.g. Latent Class Models) as the focus on integrating latent variables in choice models in thought of more importance in the context of ADS-DVs.

MNL models assume that choices by the same individual are not correlated. However in stated choice experiments the consecutive choices made by individuals generally are correlated, resulting from correlation of tastes and preferences across time (e.g. tastes for attributes and mode preferences). This property of the MNL could lead to underestimating the standard errors of parameters and thus overestimating t-values, leading to the conclusion that parameters are significant while in fact they are not [66]. To account for these panel effects a ML model can be used to check whether the use of a simpler MNL would be justified.

The psychological factors included in this study *trust in ADS-DVs, traffic safety, security, ease of use* and *performance expectancy* as mentioned in section 3.4 are sometimes referred to as latent variables, unmeasurable variables. Integrating latent variables in choice models has been evolving over past decades [36]. First attempts bluntly included indicators directly into choice models. This approach however has many disadvantages, as the indicators are used as error-free explanatory predictors of choice, see figure 4.1(a). This would assume a direct causal relationship with choice. An improvement of the method is first creating latent variables using Factor Analysis and subsequently including the composite factor scores in the utility functions of the choice model, see figure 4.1(b). This method does recognise that the choice and response to the indicator questions are both driven by the same underlying latent variable, but still the latent estimates are considered inefficient, i.e. they are only derived from the attitudinal information, not from the actual choices that the respondent has made. A possible and state-of-the-art method to address this issue is using an *Integrated Choice and Latent Variable* model (ICLV), see figure 4.1(c). ICLV models determine the latent variables based on exploratory variables and indicator variables. Model estimation can be done sequentially or simultaneous (full-information). The reader is referred to appendix B for more information on ICLV models. The complexity and time consuming process of ICLV model estimation combined with the expectation that (sequential) ICLV estimations might not lead to significant different results have lead to the decision to make use of the composite factors for this study instead.

To answer sub questions *(3) Which instrumental and psychological factors influence the traveller's preferences for an ADS-DV, and to what extend?* and *(4) Are travellers that have experience with an ADS-DV more favourable of an ADS-DV on the last mile?* in this study first an MNL model is estimated as a base model. Next the possible presence of a nest is checked using NL modelling. In case a nest is present the effects need to be addressed in the ML model. Otherwise the ML model is solely used to account for the effects of panel data. The influence of experience is taken into account by including interactions effects for all relevant parameters (variables for which differences between individuals with and without use experience with ADS-DVs is expected). Latent variables are included by first determining the factor scores with a Factor Analysis. the factor scores for all latent variables are then included in the choice model as composite scores.

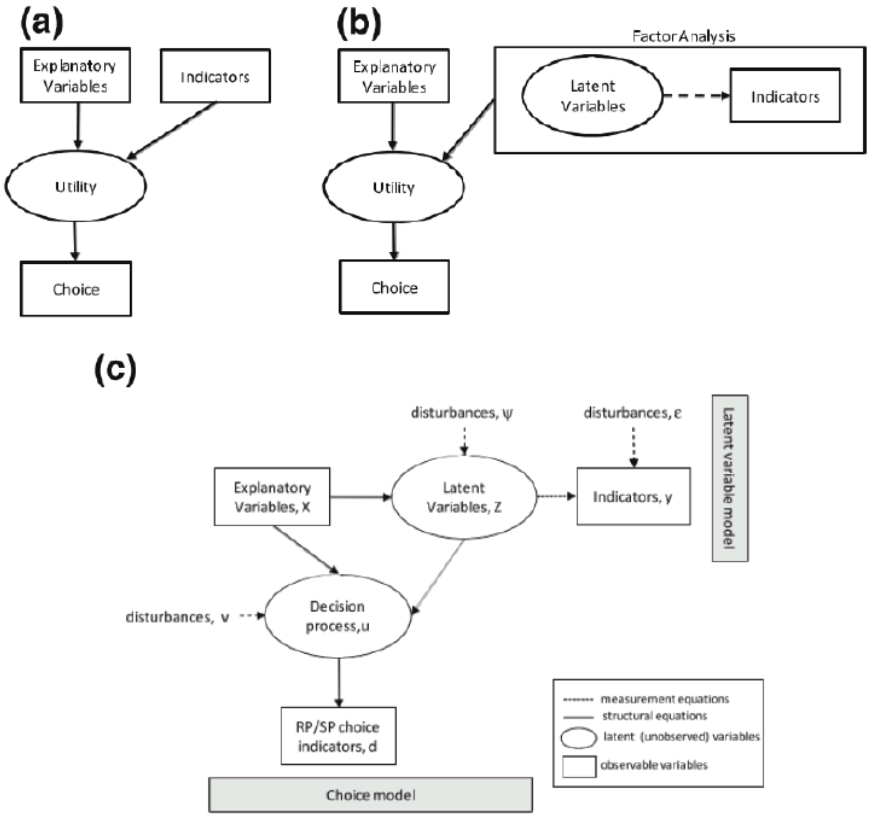


Figure 4.1: Possibilities to include latent variables in choice models, derived from Daly et al. [36]

4.3. Additional statistical analyses

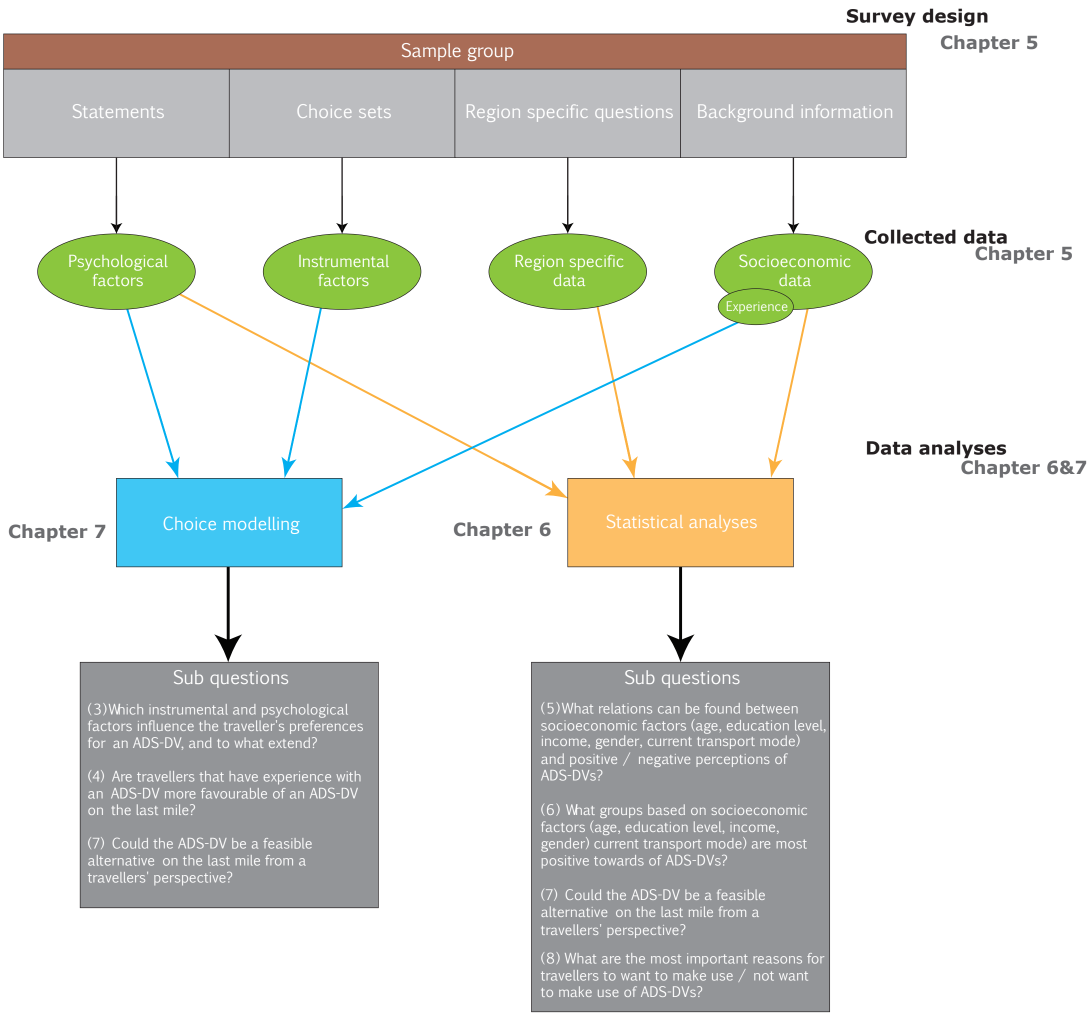
Some sub questions relevant to this study cannot be answered with choice modelling. To be able to provide full answers to the questions *(5) What relations can be found between socioeconomic factors (age, education level, income, gender, current transport mode) and positive / negative perceptions of ADS-DVs?; (6) What groups based on socioeconomic factors (age, education level, income, gender, current transport mode) are most positive towards ADS-DVs?; (7) Could an ADS-DV be a feasible alternative on the last mile from the travellers' perspective?* and *(8) What are the most important reasons for travellers to want to make use/not want to make use of ADs-DVs?* additional analyses are needed.

Statistical tests can be used to identify relations and/or differences between certain variables in the data. The specific analyses to use depend on the measurement scale of the variables. For example, tests fit for categorical variables are for example *cross tables* and the *chi-square tests.* Cross tables are used to determine whether a variable consisting of two or more groups differs in the distribution of the categories used for another variable [67]. This test is used to determine how the gender is divided over the levels of experience with ADS-DV. The Chi-square test is used to determine if differences found between two groups are significant. If this is the case, the differences found in the sample group would be valid for the population (not caused by sample peculiarities). When comparing the average values of three or more groups (independent variable) with the dependent variable of interval or ratio scale, the *One-way ANOVA* variance analysis is used. In the context of this study this test is used to determine whether significant differences in statement scores are present for different levels of experience with ADS-DVs.

Sub questions 7 and 8 are answered based on the results from the choice models and additional questions in the survey. These questions focus on the specific reasons behind the use intentions of individuals for ADS-DV systems and provide a context to position the modelling results in.

II

Data collection & analysis



5

Survey design

This chapter provides an overview of the survey that is used for data collection and describes the sample group. The case study locations used in this study are introduced in section 5.1. The lay-out of the survey is as follows: respondents are first informed on the topic of the study using a video. The video explains how to use an ADS-DV and introduces both an ADS-DV on a dedicated lane (example: ParkShuttle) and an ADS-DV amongst other traffic (example: WEpod). The first section consists of statements that are used to determine the latent variables (section 5.2). In the second section respondents are asked to choose between two types of ADS-DVs (section 5.3). Next respondents are presented a region specific question where several (possible) trajectories of an ADS-DV are shown in their region (section 5.5). The survey concludes with a final section containing questions on personal characteristics of respondents (section 5.4). At the end of this chapter some additional considerations and the first results of the final survey are discussed (sections 5.6 and 5.7). The final survey itself can be found in appendix C. More in depth information on the considerations for the survey design can be found in appendix D.

The final survey design is based on two pilot surveys. Pilot survey 1 was made using the Google forms tool and was distributed online. Pilot survey 2 and the final survey were created in Typeform and again distributed online. In Typeform four versions of the survey were created: two versions of choice sets and in Dutch and English languages. By splitting English and Dutch, the amount of text provided in instructions, questions and answers was minimised in order to make this relatively intense survey less overwhelming to respondents and thus increase the completion rate. More information on the pilot surveys and the detailed survey design process can be found in appendix E. The second pilot survey can be found in appendix F. The results from the pilot surveys can be found in appendices G and H.

Note: in this thesis the definition *ADS-DV* is used. However with the focus on respondents unfamiliar with ADS-DVs the expression *self-driving bus* is used to improve clarity in the survey.

5.1. Sample group: case study locations

The presence of an ADS-DV in the Rivium business park offers the opportunity to investigate the differences in preferences and perceptions between users and non-users. Furthermore, by comparing the survey data gathered in Rivium with data from other business parks without the availability of an ADS-DV the differences between region are investigated. In this study respondent data from three areas in the Netherlands has been collected, figure 5.1. In this chapter first the general sample group is described, followed by a case study description of each location.

Sample group

The research is constructed in such a manner that relationships found between variables in the sample groups provide information on the relationships present in the Dutch (office) labour force. Preferably a research into the effect of experience would be done with longitudinal studies, first gathering data on travellers without any knowledge of the system and later gathering data from the same individuals after long-term use of the system. However, this situation is impossible to replicate in the time span of this thesis. Another possibility to derive information, includes comparing multiple groups that have a different level of experience with ADS-DVs. In order to be able to draw conclusions, all groups need to be sufficiently similar on all relevant variables. "Sufficiently similar on all relevant variables" means that the groups need to be similar on

Figure 5.1: Case study locations

Table 5.1: Definition of experience in sample group

Experience	
Users	Frequent use of ParkShuttle (weekly) Have used ParkShuttle once/multiple times
Non-users	Seen or read something about ADS-DVs Never heard of ADS-DVs before this study

(socioeconomic) factors that are expected to have influence on the mode choice decision of travellers, e.g age, gender. Furthermore, all participants are handed the same survey to ensure consistency. Finally, to replicate similar socioeconomic factors, the survey is handed out at three business park locations: Rivium in Capelle aan den IJssel, Beatrixkwartier in The Hague and in Rijswijk: Plaspoelpolder, Broekpolder and Hoornwijck. The socioeconomic factors of the groups are compared statistically. Based on experience, the following distinction between users and non-users is made, see table 5.1.

Capelle aan den IJssel: Rivium

The Rivium ParkShuttle is the only example of a permanently operational ADS-DV in the Netherlands. In the current situation the ParkShuttle system, operated by Connexxion, uses six vehicles to shuttle between metro station Kralingse Zoom in Rotterdam and Rivium 4e straat in Capelle aan den IJssel. The area is also accessible by bus from the metro station Capelsebrug in Rotterdam. RET operates one busline that addresses all stops counter clockwise until 16:00 and clockwise from 14:00. Between 14:00 and 16:00 the line is operated in both directions. Connexxion operates the area between 06:00 and 21:00 and RET from 06:30 until 18:30, both lines are only serviced on weekdays. The area is also accessible by private means of transportation such as car, bicycle or by foot. Figure 5.2 shows the current ParkShuttle and RET bus lines in the Rivium area.

Figure 5.2: Last mile connections Rivium Businesspark, derived from Except [31]

However, as the RET busline has a poor performance rate RET decided to discontinue the service in the near future. In the meantime the municipality of Capelle aan den IJssel has looked into opportunities to make better use of the current availability of public transportation in the area. The ParkShuttle's current main purpose is to transport commuters during rush hour, resulting in full vehicles heading for Rivium in the morning with empty returns to the metro station, while in the afternoon the phenomenon is the other way around. As part of the AVLM project the region will be developed in a public transportation hub in collaboration with the MRDH. It will support links between the metro, ParkShuttle and nearby Waterbus stops and introduce GoBike facilities. To connect metro and Waterbus the trajectory of the ParkShuttle will be extended. Furthermore, the ParkShuttle will service the two stops in Rivium currently addressed by bus line 95. Where the ParkShuttle makes use of a dedicated separate lane in current configuration, the extension will require the ParkShuttle to operate amongst other traffic. Guidance of the system will be done by magnets in the concrete as is done in the current trajectory. The future public transportation hub is expected to be operational in 2020. Further expansions of the service are in development and are expected to include access to the Erasmus University Brainpark and door-to-door connections in Capelle-West. Figure 5.3 shows the plans for the new transportation hub in Rivium. Recently funding has been awarded for the implementation of the ParkShuttle extention including an update of the ParkShuttle vehicles. With the completion of the new trajectory in 2019/2020 the Dutch company 2getthere will be the first company in the world to operate ADS-DVs amongst other traffic. It must be noted however that the system is still a level 4 ADS-DV, as it operates within a fixed operational design domain (ODD).

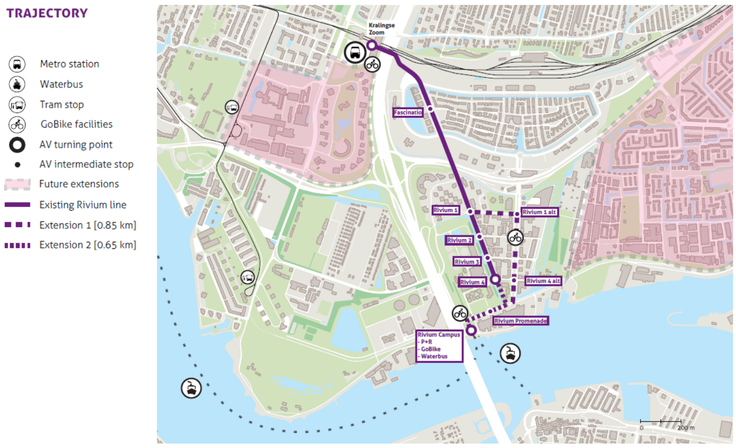


Figure 5.3: Extension of ParkShuttle in Rivium and transportation-hub, derived from the AVLM project MRDH [68]

Rijswijk: Plaspoelpolder, Broekpolder & Hoornwijck

Rijswijk is situated between Rotterdam and The Hague and houses three strategically positioned business parks: Plaspoelpolder, Broekpolder and Hoornwijck. The areas together offer space to 3.200 companies and 32.000 jobs. Accessibility by car to these areas is well organised with direct connections to important highways. The downside of good accessibility by car is expressed by parking problems and congestion. The Plaspoelpolder area is adjacent to a train station, but both Broekpolder and Hoornwijck are postioned at a larger distance. Broekpolder can be reached by tram from the nearby station and Hoornwijck is connected to the train stations of neighbouring cities by another tram line. In practise mostly employees of companies in a radius of 500-700 meters from the Rijswijk station travel by public transportation, whereas employees in other areas mostly opt for transportation by car [68]. To stimulate the use of public transportation the municipality of Rijswijk is investigating the possibility to connect the Rijswijk train station with the business parks by ADS-DVs.

The municipality of Rijswijk also takes part in the AVLM project. It investigates whether ADS-DVs could improve the accessibility of the Plaspoelpolder, Broekpolder and Hoornwijck areas. Several options for trajectories in the region are shown in figure 5.4 (Plaspoelpolder is situated on the left, Broekpolder in the middle and Hoornwijck on the right hand side of the canal). The project is still in an exploratory phase and no follow-up dates have been announced up to present.

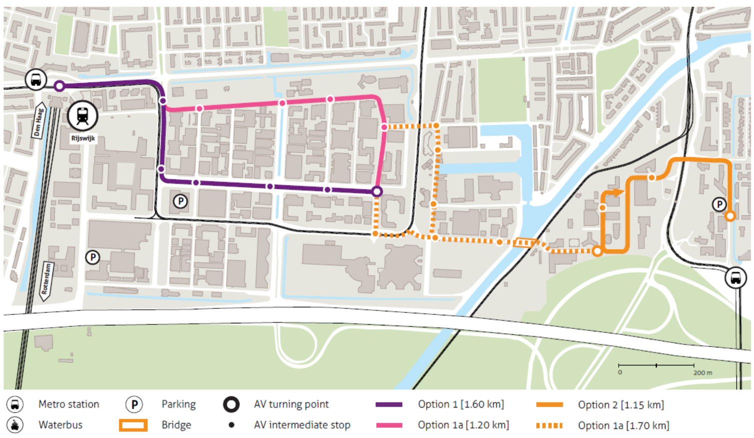


Figure 5.4: Potential self-driving bus conenctions in Rijswijk, derived from the AVLM project MRDH [68]

Den Haag: Beatrixkwartier

The third area included in this study is located in The Hague. Unlike the other two areas the Beatrixkwartier is not (yet) planning to incorporate an ADS-DV in the area's transportation system. However, the area does struggle with congestion and parking problems caused by a large share of car travellers. A regional interest group of companies located in the area, the Stichting Green Business Club Beatrixkwartier, collaborates to simulate sustainable development in the area. One of the goals is to improve the mobility of the Beatrixkwartier in a sustainable manner [69]. The interest group represents about 8000 employees.

The Beatrixkwartier is situated between two train stations, but offers limited public transportation possibilities in the area itself. Furthermore, walking distances were perceived as too long and unclear to employees in the area leading to low numbers of public transportation use. Recently the Green Business Club invested in signage to improve the area's accessibility by foot, figure 5.5.

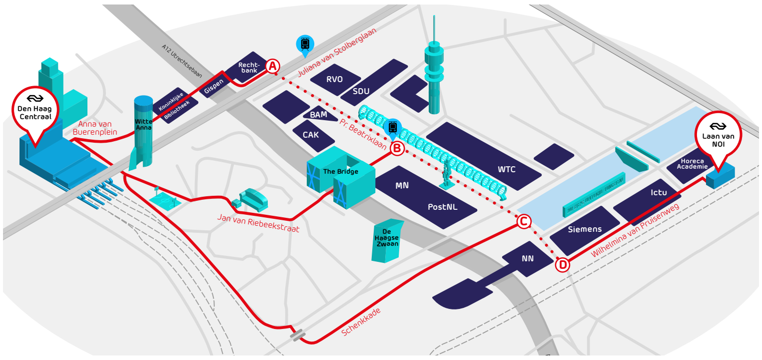


Figure 5.5: Walking routes introduced in at Beatrixkwartier, derived from Beatrixkwartier [70]

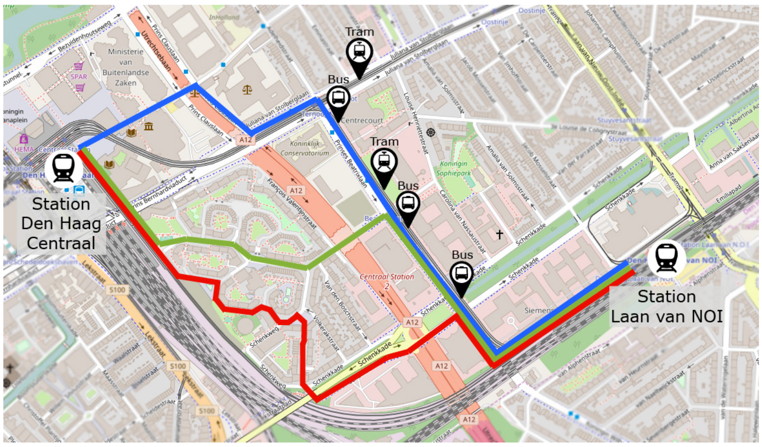


Figure 5.6: Possible ADS-DV trajectories in Beatrixkwartier, designed for the purpose of this study

The Beatrixkwartier is not part of the AVLM project and no plans for ADS-DVs in the area are currently being developed by the municipality. However in theory an opportunity to improve the accessibility to the area could be to invest in ADS-DVs that penddle between the The Hague Central and Laan van NOI train stations. For the purpose of this study several trajectories for ADS-DVs were drawn up. Figure 5.6 shows the trajectories that were based on the shortest walking routes of figure 5.5. In designing the routes it was taken into account that the vehicles did not operate on sidewalks or pedestrians only areas.

5.2. Statements

In order to determine latent variables, indicators are needed that indirectly show their values. To quantify the indicator values generally two approaches are used in transportation related researches. The first and traditional approach makes use of psychometric scales (often Likert [54]), providing the respondent with statements and asking to rate the amount of agreement with each statement [4, 71–74]. Advantages of this method include: a better insight beforehand what the construct will measure and possibility to build on previous findings by using the same psychometric constructs [75]. The second approach first asks respondents to provide three adjectives that they perceive related to a mode and ask a second group of respondents to indicate their ratings for each of the grouped adjectives on both a discrete and a continuous scale ([76, 77] as cited in Glerum and Bierlaire [78]). Glerum and Bierlaire [78] state that the psychometric scales that are used in many studies are subjective to the researchers design of the phrases which could prevent the researcher from completely seizing the representation of the persons attitude or perception.

In this thesis Likert scale constructs are used to determine the latent variables. The statements are based on previously used psychometric constructs in related automated vehicle studies: [43, 47, 48, 55, 58, 59]. The advantage of pre-validated constructs and the possibility to use the constructs in follow-up research is decided to be of more value than the disadvantage of subjectivity. In the survey each respondent is shown twelve statements in alternating positive and negative phrasing. For each statement the respondent is asked to indicate their level of agreement on the five-point Likert scale. Statements are used in the final survey to indicate the latent variables of *trust in ADS-DVs, traffic safety, security, ease of use* and *performance expectancy*. The statements used in the first pilot survey were slightly revised to decrease the presence of any possible ambiguity. Some statements were transformed from positive to negative to better balance the directions of the indicators within the assumed latent constructs. This process is described in appendix E. The following statements (in order of appearance) were included in the final survey:

1. I trust a self-driving bus can drive itself without any assistance from a human. (*trust in ADS-DV*)
2. I think it is hard to understand how to use a self-driving bus. (*ease of use*)
3. I think that I will arrive late at my destination when I take a self-driving bus. (*performance expectancy*)
4. I think there will be a self-driving bus available for the return trip to the station. (*performance expectancy*)
5. I would let a close family member ride a self-driving bus. (*trust in ADS-DV*)
6. I am concerned about riding a self-driving bus with strangers. (*security*)
7. I believe that a self-driving bus can safely handle unexpected situations. (*traffic safety*)
8. I am concerned about the interaction of a self-driving bus with other traffic, like human drivers, pedestrians and cyclists. (*traffic safety*)
9. I expect that the interior of a self-driving bus will be dirty. (*performance expectancy*)
10. I think I would find it easy to inform a self-driving bus of my destination. (*ease of use*)
11. I believe a self-driving bus would drive safer than the average human driver. (*trust in ADS-DV*)
12. The potential risks of software hacking or other forms of misuse of self-driving buses worry me. (*security*)

For each statement the latent construct is mentioned (between brackets) for which it was included in the survey. However, as the perceptions of *trust, safety* and *performance expectancy* overlap in certain areas, it is expected that new latent constructs might be derived from the survey data. A *Factor Analysis* performed on the first pilot survey data already gave some indications for this possibility. In the light of the study such an outcomeis not problematic. The aim of this thesis is to indicate whether perceptions play a role in determining the utility for ADS-DVs and whether there are differences in perceptions between individuals that have experience with ADS-DVs and individuals that do not have experience. It can therefore be stated that the presence of latent constructs is more important than the specific latent constructs themselves.

5.3. Choice sets

An instruction video was included at the start of the choice set section to point out that respondents were expected to make trade-offs between all the properties of the presented buses when deciding on their preferred alternative. Discrete choice modelling forms an integral part of this research to investigate travellers preferences for ADS-DVs on last mile connections. The choice modelling questions in the survey are presented as choice sets. A choice set shows all alternatives a respondent can choose from and provides information on attribute values (e.g. travel times, travel costs) in order for the respondents to make a rational decision on their preferred alternative. This study focuses on two ADS-DV types, operating on a dedicated lane and operating amongst other traffic. Respondents are asked to choose their preferred alternative on the last mile. To reduce the choice set complexity each decision is split up in two levels. At the first level respondents are asked to make a choice between two ADS-DVs, at the second level respondents are asked to decide whether they would want to make use of an ADS-DV or not (c.q. choose the alternative 'another method to travel the 1.5 kilometres'). The number of alternatives in the final survey was deliberately reduced to three alternatives. In the first pilot survey the range of alternatives included public transportation (regular bus), a shuttle bus, a bike (own or rented) and walking. In focusing solely on last mile alternatives, full trip modes like car were not taken into account. The choice set with six alternatives turned out to be to complex for respondents. As the main focus was on ADS-DVs it was decided to drop the other alternatives. For a detailed description of this process the reader is referred to E. An example of the choice sets as used in the final survey is shown in figure 5.7. Respondents were asked to compare the alternatives on *travel costs, waiting time, travel time in-vehicle, service type* and *surveillance in bus*. Note that a bus operating on a dedicated lane cannot offer the service type *door-to-door* since it cannot leave the lane. All other attributes and levels are available for both alternatives. Table 5.3 shows the attributes and attribute levels as used in the final survey.

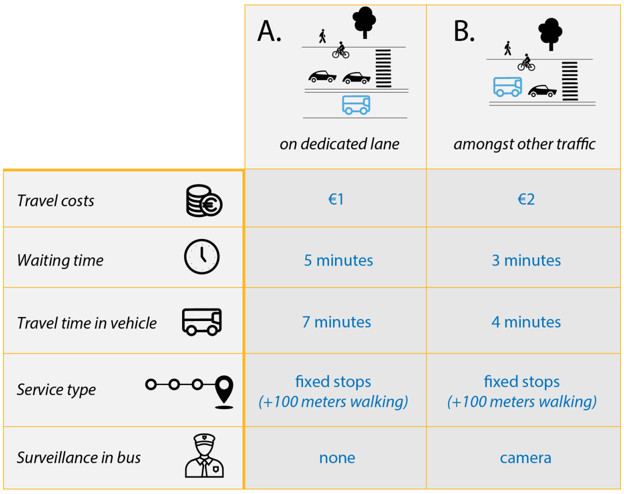


Figure 5.7: Choice set example final survey

Table 5.3: Attribute and attribute levels final survey

Attribute	Level 1	Level 2	Level 3
Travel costs	€1	€1,5	€2
Waiting time	1 minute	3 minutes	5 minutes
Travel time in-vehicle	4 minutes	5,5 minutes	7 minutes
Service type	scheduled stops	door-to-door	
	(+100 meters walking)	*(+0 meters walking)*	
Surveillance in bus	none	camera	supervisor

Note: Service type 'door-to-door' is only available for alternative 'bus amongst other traffic'

In determining what combinations of attribute levels need to be presented in the choice sets and the combination of choice sets themselves an efficient design was generated in Ngene [79].An efficient design uses *prior indicators* values to determine which levels need to be combined to maximise the information that can be derived from the choice sets. In other words, information on which parameters were considered important to individuals is used to create the choice set designs. This prior information can be collected from pilot surveys or can be based on parameter values from other studies. The prior indicator values used to determine the efficient design were derived from the pilot surveys. The reader is referred to appendix E for more information on the detailed process. Each respondent was asked to make decisions for multiple choice sets. In the efficient design twelve choice sets were generated. To reduce the number of choice sets each respondent had to choose from, *blocking* was used. Blocking allows the researcher to divide the total number of choice sets over multiple respondents. In this case two blocks of six choice sets were constructed with Ngene. A downside of this approach is that the number respondents needs to be higher in order to retrieve the same amount of data. Since the complete survey was already quite lengthy it was decided that blocking was needed to reduce the respondent burden.

5.4. Socioeconomic data

Socioeconomic data is used to be able to generalise the relationships found in the sample group to the population. In the last section of the survey respondents were asked to provide information on:

- Their year of birth;

- Their gender;
- Their monthly income;
- Their level of education;
- Whether the respondent receives travel cost reimbursement;
- Their most used modes to travel to work;
- Whether the respondent would switch to public transportation from another mode if the accessibility of their work area by public transportation would improve;
- Which case study area the respondent works in;
- Their experience with an ADS-DV.

The first four questions are asked to be able to compare the sample groups of different locations. Whether a respondent receives travel cost reimbursement (from) his or her employer could influence the importance of the travel cost attribute in the choice sets. The information what modes the respondent currently uses to travel to work can provide insight in what travellers might be more interested in using ADS-DVs and whether the respondent would we susceptible to switch to public transportation if accessibility of the area by means of public transportation would improve. The question related to the area the respondent works in allows for categorisation per area providing detailed information. The question about experience with an ADS-DV (using ParkShuttle on a weekly basis, used ParkShuttle once, have heard of or seen something about self-driving buses, never heard of self-driving buses before this survey) allows for the determination of the level of a respondents experience with ADS-DVs.

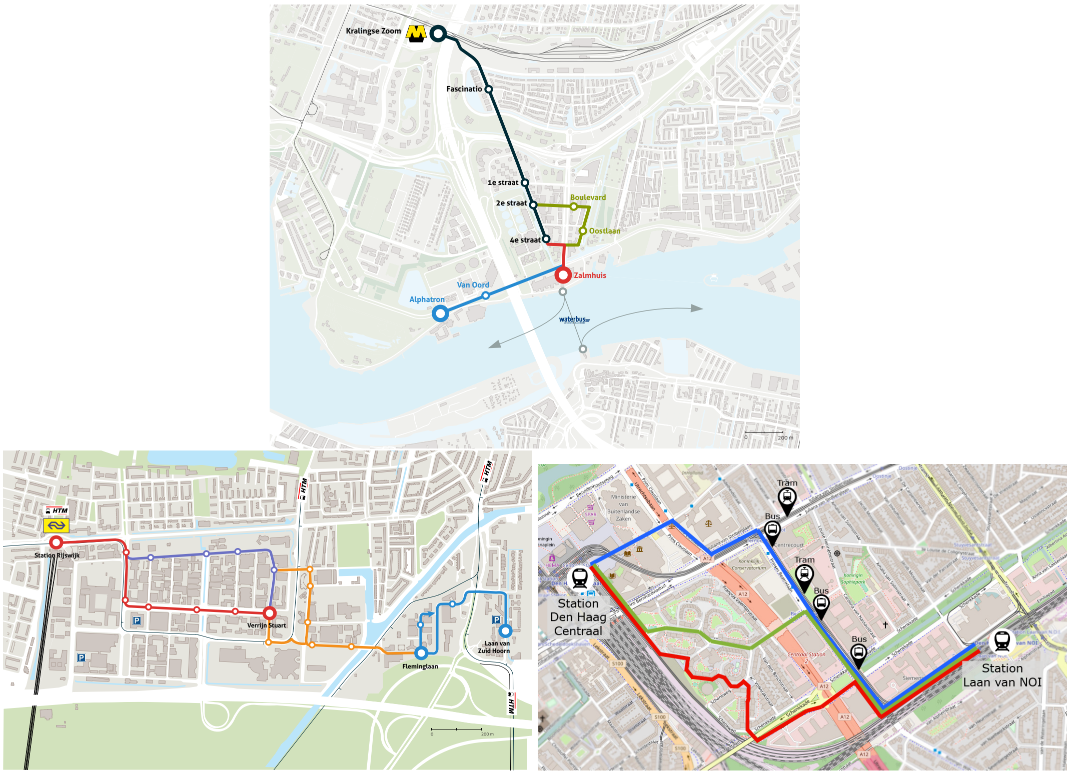


Figure 5.8: Region specific questions: Capelle a/d IJssel (t); Rijswijk (l); The Hague (r)

5.5. Region specific questions

After respondents had finished the choice sets each respondent was asked to indicate in which region their office is situated: Capelle a/d IJssel: Rivium; Rijswijk: Plaspoelpolder, Broekpolder & Hoornwijck or The Hague: Beatrixkwartier. Based on the answer a map of selected area was presented showing several possible routes for an ADS-DV. Respondents were asked to indicate which (if any) of the routes they would use in case these were available to them. Based on their reply (yes/no/maybe) each respondent was asked to explain their answer. Several reasons were predetermined for respondents to choose from and respondents had the opportunity to add their own reasons in a text field. Answers to these questions are believed to give practical information for each region/municipality and allow for insight in the considerations of respondents to make use of ADS-DVs in a realistic environment. The maps for the questions are shown in figure 5.8.

5.6. Survey design considerations

Respondent fatigue and the prospected length of a survey influence the quantity and quality of the gathered data. A study by Caussade et al. [80] investigated the effect of design dimensions on respondents fatigue and indirect influence on choice. It was concluded that the number of attributes has a negative effect and the number of alternatives has an inverse U-shape effect with the optimum on four alternatives. While the number of choice sets also showed an inverse U-shape pattern with the optimum around 9-10 choice sets, the researchers state that this effect on choice is lower than the first mentioned variables. In this study the choice sets consist of five attributes, two alternatives and six choice sets. Since all five attributes were needed to provide a realistic choice situation (travel time, travel cost and waiting time) and provide insight in the specific characteristics of ADS-DVs (service type, surveillance and configuration). The configuration of an ADS-DV was included in the alternative type to reduce the number of attributes and to be able to make a distinction for the attribute service type. Since the attribute levels for an ADS-DV on a dedicated and an ADS-DV amongst other traffic vary it is more convenient to make use of two ADS-DV alternatives. Blocking was used to reduce the number of choice sets from twelve to six given that the statements section also asks relative effort from the respondents. Other considerations for the survey design are described in appendix D.

5.7. First results: representativeness of survey data

The survey was distributed in Beatrixkwartier and Rivium from February 6th 2017 and from February 14th 2017 in Plaspoelpolder, Broekpolder and Hoornwijck. Data was collected over a period of five weeks.

The minimal number of respondents needed for the discrete choice modelling analysis is determined with the formula in equation 5.1 as described by Orme [81].

$$N = 500 * \frac{I^*}{J * S} = 500 * \frac{3}{2 * 12} = 62.5 = 63 \tag{5.1}$$

in which the minimum sample size N is determined by the highest number of levels for any attribute I^*, the number of alternatives J and the number of rows in the experimental design S.

Since the choice sets are divided over two surveys by means of blocking, the total number of respondents must be multiplied by 2. Therefore the minimum number of respondents is 126. For this thesis a total of 198 completed surveys have been collected.

After importing the data into SPSS all variables were named and all data was recoded to eliminate the language differences between the English and Dutch responses. Furthermore, the variables *BIRTHYEAR, INCOME* and *EDUCATION* were recoded to represent the age of respondents and to categorise the variables on three and two levels respectively. Before the analyses were done the completion times of respondents were checked. Most people completed the survey between 5 and 10 minutes. Three respondents took less than 5 minutes to fill out the survey. Given the fact that respondents were asked to watch a video, it seems unlikely that these respondents did actually watch the video or spent enough time to answer the questions properly. These three cases were removed from the data set. The total number of valid cases in this study is 195.

The distribution of socioeconomic variables like gender, age, income etc. in the sample are shown in table 5.4. For each variable the distribution in the sample is compared to statistics on the Dutch labour force from the Centraal Bureau voor de Statistiek (CBS). The CBS data is derived from Statline over 2016 and in the case of income over 2014 [82]. The available data from CBS is not perfect as business parks consists predominantly of office buildings and are not directly representative for all job types. In general such companies employ relatively more men, have a higher educated workforce and offer higher salaries. In comparing the sample data to that of CBS these considerations need to be taken into account. Overall, it can be concluded that there is a predominant share of male participants in this survey. Although this was expected from the type of jobs offered at business parks, this should be taken into account when analysing the results. Furthermore, as expected the income and educational level are both higher than the CBS average. The distribution of age over the sample group is more or less similar to the averages of the CBS. The sample group is therefore considered quite representative. From the sample group about halve of the respondents make use of public transportation and the other halve makes use of private modes (e.g. car, bike). The distribution of participants over the region with an ADS-DV and the regions without an ADS-DV is equal (99 vs. 96) which is good for comparison purposes. Furthermore, the distribution of experience with ADS-DVs shows that in the sample about 35.3% have made use of an ADS-DV, the largest share 44.6% has read of or seen something about ADS-DVs and 20% stated to never have heard of ADS-DVs before participating in this survey. To conclude, the sample is thought to be representative for the the purpose of this study.

Table 5.4: Distribution of socioeconomic variables over sample group

Socioeconomic variable	**Category**	**Sample share**	**Population share**
Gender	Male	69.3%	53.7%
	Female	30.7%	46.3%
	Total number (=100%)	*192*	
Age	18-35	39.8%	35.6%
	36-55	44%	45.5%
	>55	16.2%	18.9%
	Total number (=100%)	*191*	
Education level	Low/middle	22.3%	63.1%
	High	77.7%	35.7%
	Total number (=100%)	*188*	
Nett monthly household income	<2200	19.4%	40%
	2200-4000	50.3%	40%
	>4000	30.3%	20%
	Total number (=100%)	*165*	
Public transport use for home-work travel	Yes	50.8%	
	No	49.2%	
	Total number (=100%)	*195*	
Region	Capelle a/d IJssel: Rivium	50.8%	
	The Hague: Beatrixkwartier	30.3%	
	Rijswijk: Plaspoelpolder, Broekpolder & Hoornwijck	18.9%	
	Total number (=100%)	*195*	
Experience with ADS-DVs	No experience	20%	
	Read/seen	44.6%	
	Little experience	21.5%	
	Weekly experience	13.8%	
	Total number (=100%)	*195*	

5.7.1. Experience: relevant socioeconomic variables

This study focuses on travellers preferences and perceptions towards ADS-DVs and whether differences in experience with ADS-DVs would lead to different preferences and perceptions. To be able to draw conclusions based on experience, it is useful to know the distribution of socioeconomic variables over the several groups. An important aspect in this study is to be able to compare respondents of different experience levels and of different locations. Cross tables were created in SPSS accompanied by Chi-square tests to determine whether the groups were similar on some socioeconomic variables. The full analysis can be found in appendix K. From the significant Chi-square values in the cross tables (table 5.5 and table 5.6) it can be concluded that the variables *experience* and *income* and *experience* and *age* are not independent of each other. This means that differences exist in the level of experience with ADS-DVs based on income and age. Individuals with higher incomes have less experience with ADS-DVs. Furthermore, Individuals in higher age groups also have less experience with ADS-DVs. This could be explained by the fact that the ParkShuttle operates as public transportation and often individuals with higher incomes make less use of public transportation and in average higher incomes are available at higher ages. For other socioeconomic variables (gender, education level and public transport use) no significant differences were found. In interpreting the results from the choice models for experience this dependency must be taken into account.

Table 5.5: Cross table experience and income

Income	Experience No experience	Experience with ADS-DVs	Total number (=100%)
< 2000 euro	46.9%	53.1%	32
2000 - 4000 euro	63.9%	36.1%	83
> 4000 euro	78%	22%	50
Total	64.8%	35.2%	165

Chi^2=8.365; df=2; p=0.015

Table 5.6: Cross table experience and age

Age	Experience No experience	Experience with ADS-DVs	Total number (=100%)
18-35	51.3%	48.6%	76
36-55	67.9%	32.1%	84
>55	87.1%	12.9%	31
Total	64.4%	35.6%	191

Chi^2=13.078; df=2; p=0.001

5.7.2. Experience: insight in statement responses

To give a first indication if there could be differences in the answers to the statements based on groups with different levels of experience with ADS-DVs *One-way ANOVA* tests were conducted. First the negative statements were recoded into positive statements. This is easier to interpret as now high values represent positive reactions for all statements. First the distribution of the statements was checked. Histograms of the distribution of the answers to the statements can be seen in figure 5.9. From the histograms it can be derived that overall the reactions to the statements were found to be on average positive as all means were higher than 3 (scale: 1 = very negative, 2 = slightly negative, 3 = neutral, 4 = slightly positive, 5 = very positive).

Table 5.7: Variable names for statements

Variable name	Statements
TRUST1	I trust a self-driving bus can drive without any assistance from a human.
TRUST2	I would let a close family member ride a self-driving bus.
TRUST3	I believe a self-driving bus would drive safer than the average human driver.
PERFROMANCE1	I think that I will arrive late at my destination when I take a self-driving bus.
PERFORMANCE2	I think there will be a self-driving bus available for the return trip to the station.
PERFORMANCE3	I expect that the interior of a self-driving bus will be dirty.
TRAFFICSAFETY1	I am concerned about the interaction of a self-driving bus with other traffic, like human drivers, pedestrians and cyclists.
TRAFFICSAFETY2	I believe that a self-driving bus can safely handled unexpected situations.
SECURITY1	I am concerned about riding a self-driving bus with strangers.
SECURITY2	The potential risks of software hacking or other forms of misuse worry me.
EASEOFUSE1	I think it is hard to understand how to use a self-driving bus.
EASEOFUSE2	I think I would find it easy to inform a self-driving bus of my destination.

The *One-way ANOVA* test were used to check for differences between mean values of statements based on the level of experience with ADS-DVs that an individual has. The variable EXPERIENCE categorised in four levels *no experience; have read or seen something about ADS-DVs; have tried ParkShuttle once or a few times* and *use on a weekly basis* is used for this analysis. Table 5.7 shows the variable names for all statements.

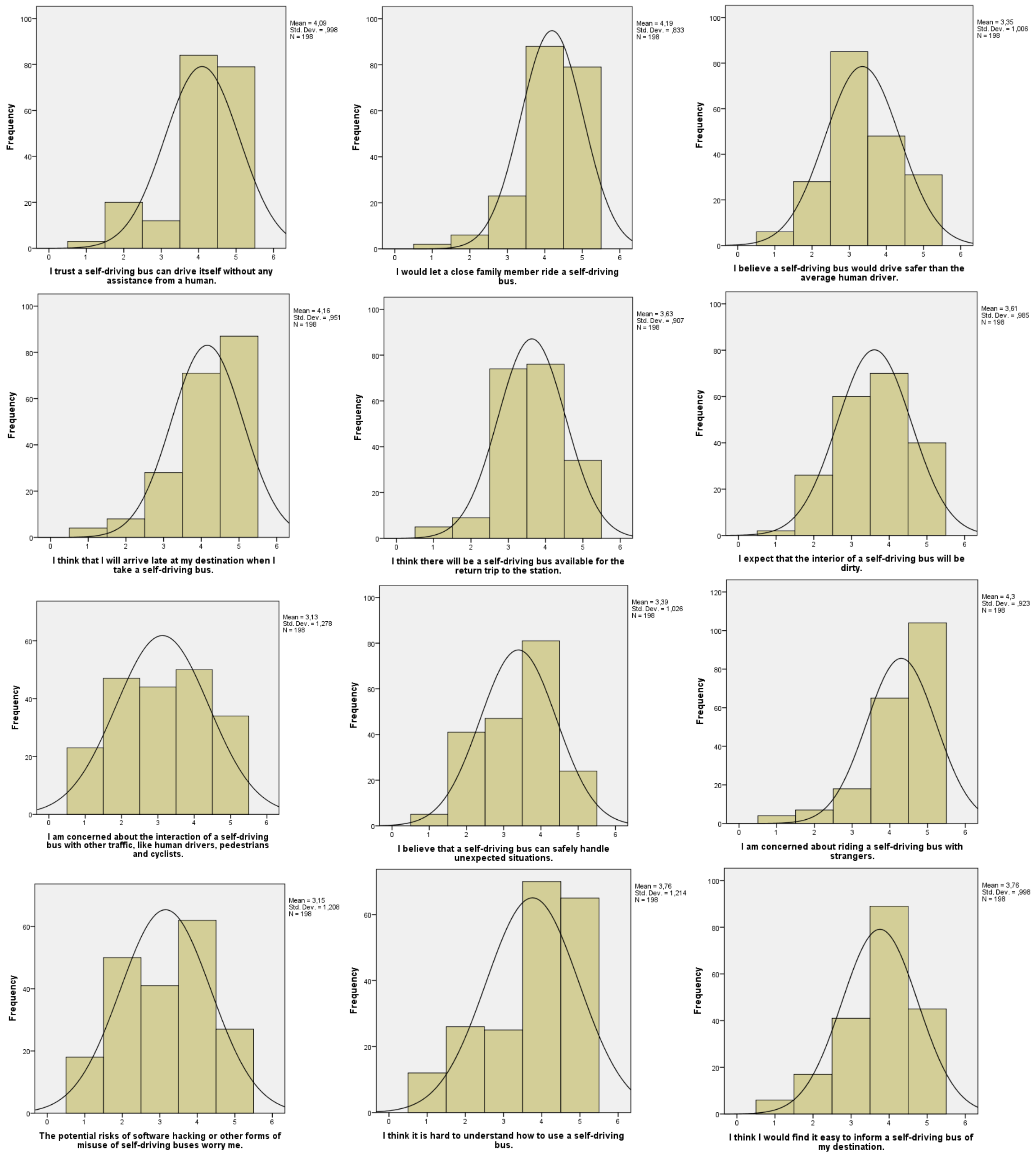


Figure 5.9: Distribution statement variables on scale from 1 (negative) to 5 (positive)

From table 5.8 the average positions on the statement scale are 2.62 (no experience), 3.05 (read or seen something about ADS-DVs), 3.45 (little experience with ADS-DVs) and 3.56 (use on a weekly basis). From the One-way ANOVA analysis it can be concluded that significant differences exist in statement answers in the population for the statement *I am concerned about the interaction of a self-driving bus with other traffic, like human drivers, pedestrians and cyclists* (TRAFFICSAFETY1) based on the level of experience. From the post hoc Bonferroni test it became clear that only significant differences between individuals that have no experience and individuals that have higher levels of experience (little exp and weekly exp).

It can be concluded that individuals that have made use of an ADS-DV (once or on a daily basis) are less concerned about the interaction of ADS-DV with other traffic, than are those that had never heard of ADS-DVs. Furthermore, individuals that have read or seen something about ADS-DVs have are not more or less concerned about the interaction of ADS-DVs with other traffic than individuals with no experience or more experience.

Table 5.8: Mean values TRAFFICSAFETY1 and experience (One-way ANOVA)

	distribution			**p (Post hoc Bonferroni)**		
TRAFFICSAFETY1	average	Std.dev.	N	read/seen	once/few times	weekly exp
no exp	2.62	1.248	39	0.452	0.018	0.018
read/seen	3.05	1.275	87	-	0.510	0.394
once/few times	3.45	1.310	42	-	-	0.308
weekly exp	3.56	1.050	27	-	-	-

F=4.307; p=0.006

Using the Kruskal-Wallis test the differences in ranking of a variable between groups can be analysed. In the case of the statement *I think it is hard to understand how to use a self-driving bus* (EASEOFUSE1) it was found that individuals that have lower levels of experience with ADS-DVs (no experience or only read or seen something about ADS-DVs) perceive the understanding of ADS-DVs harder than those individuals that have actually made use of an ADS-DV before, see table 5.9.

Table 5.9: Differences in EASEOFUSE1 statements based on experience levels (Kruskal-Wallis)

	Experience	N	average ranking
EASEOFUSE1	No exp	39	99.78
	Read/seen	87	84.21
	Little exp	42	110.12
	Weekly exp	27	121.02
	total	195	

Chi^2=12.712; df=3; p=0.005

Although there were differences found in the sample group in the average values for the statements based on the level of experience an individuals has, see tabel 5.10, no significant differences were found between groups for the other statements. The other differences found in the sample group can therefore not be proven to be unaffected by chance. In appendix L the details of the performed analyses can be found.

Table 5.10: Mean values for all statements based on level of experience (sample group)

Statements	**Experience** no exp	read/seen	little exp	weekly exp	overall
TRUST1	3.95	4.02	4.38	4.00	4.08
TRUST2	3.95	4.17	4.33	4.37	4.19
TRUST3	3.46	3.15	3.64	3.41	3.35
PERFROMANCE1	4.31	4.07	4.40	3.81	4.15
PERFORMANCE2	3.54	3.57	3.76	3.74	3.63
PERFORMANCE3	3.77	3.37	3.74	3.81	3.59
TRAFFICSAFETY1	2.62	3.05	3.45	3.56	3.12
TRAFFICSAFETY2	3.05	3.47	3.48	3.41	3.38
SECURITY1	4.28	4.21	4.40	4.41	4.29
SECURITY2	3.36	3.05	3.26	2.93	3.14
EASEOFUSE1	3.85	3.44	4.02	4.19	3.75
EASEOFUSE2	3.69	3.62	3.64	3.41	3.76

Note that for all statements 1 represents a low value, 3 a neutral and 5 a high value

To conclude, the levels of experience are evenly distributed over the socioeconomic variables gender, education level and *public transport use*. Individuals that have lower ages or lower incomes in general were found to have more experience with an ADS-DV than those individuals that have respectively higher ages or higher incomes. The individuals that have experience with an ADS-DV make use or have made use of the ParkShuttle in Rivium. The ParkShuttle operates as public transportation system which could explain than in general those with higher incomes make more use of personal transportation modes like cars than those with lower incomes. Those with higher incomes are in general also of higher age groups. In interpreting the results from the choice modelling for experience this distribution must be taken into account.

From the first tests of statements responses not many significant differences were found between the answers based on the level of experience. Only for the statements *I am concerned about the interaction of a self-driving bus with other traffic, like human drivers, pedestrians and cyclists* and *I think it is hard to understand how to use a self-driving bus* differences were found. As was expected the individuals that have more experience with ADS-DVs respond more positive towards ADS-DVs than those that have lower levels of experience. However, the fact that for only two statements this effect is found to be significant could indicate that the effect of experience on perceptions of ADS-DVs might not be as strong as was expected.

6

Discrete choice modelling

This chapter discusses the data analysis by use of discrete choice modelling. In section 6.1 the preparation of the survey data for the models and the alternatives and variables are discussed. In the next section several types of choice models are described and their estimation results discussed (6.2). The chapter concludes with the application of the final choice model on two choice sets for illustrative purposes in section 6.3.

6.1. Data preparation

In order to process the survey data with choice models the data needs to be presented in the correct format. The model estimation is done using Biogeme [83]. The data file indicates all variables for which parameters need to be estimated, the choice sets that were shown to the respondent and the choice the respondent has made.

6.1.1. Alternatives

In the final survey the choice set were split in two questions. First respondents were asked to select their preferred ADS-DV and then respondents were asked whether they would be interested in using this particular ADS-DV on a last mile trip of 1.5 kilometres. Given this set-up it is possible to estimate preferences for ADS-DVs even in the case that only few respondents would select to use an ADS-DV. This approach was used as it was unclear beforehand whether respondents might select the "no-use" option too often, leading to the impossibility to estimate a model. Based on the collected data sufficient respondents have indicated that they would use the selected ADS-DVs. Therefore the data is recoded to three alternatives: alternative 1: *bus on dedicated lane*; alternative 2: *bus amongst other traffic* and alternative 3: *no bus* (c.q. "another method to travel the 1.5 kilometres).

Both alternatives with an ADS-DV have five attributes (*travel time in-vehicle, travel costs, waiting time, service type* and *surveillance in bus*. For all attributes parameter values are estimated that indicate the importance of the variables in the decision making process. The third alternative (no bus) has no attribute values. The alternative suggests that a respondent would opt for another mode on the last mile, but since no other modes are specified no information can be given on what kind mode that would be and which accompanying attribute values.

An *Alternative Specific Constant* (ASC) for each alternative can be estimated to determine the relative preference of each alternative. The ASC is calculated relative to one base alternative. In other words, the ASC shows the preference of a specific alternative over another. A positive value indicates that the alternative is preferred over the base alternative, while a negative value indicates that the base alternative is preferred. A base alternative is often the 'no mode' alternative or in case this was not available in the choice set the ASC of one of the alternatives can be fixated on zero. In this study the 'no bus' alternative is selected as base alternative. In the model estimation the ASC is therefore fixated at zero.

At the start of this study it was unclear whether the ADS-DV would be chosen enough to derive any information on this mode when introducing to many other alternatives. The ADS-DV was chosen very often in this survey therefore it is advised to include multiple alternatives (e.g. regular bus, shuttle bus, bike, walking) in a follow-up study to determine the relative position of an ADS-DV in the transport network (preferences for ADS-DV with regard to other modes).

6.1.2. Variables

The data of the attributes *travel costs, travel time in-vehicle* and waiting time can directly be used in the model estimation for these are numerical values. In the case of the attributes *service type* and *surveillance in bus* the values are presented in categorical form. Such values need to be recoded before these can be understand by Biogeme. The recoding can be done with *dummy coding* or *effect coding*. In the first case the values are recoded using zeros and ones. While in the second case minus one, plus one and zeros are used. The interpretation of dummy coding is generally easier as the parameter values indicate the relative difference from a base level. In other words, it can be derived which level of the attribute value is preffered in general. In the case of effect coding no the difference with a base level is determined, but the difference with the *average* value. The clear interpretation of the dummy variable is favoured for this study. Table 6.1 shows the dummy coding used for the attributes *service type* and *surveillance in bus*.

Table 6.1: Dummy coding used for attribute levels of *service type* and *Surveillance in bus*

Attribute	Category	Indicator variable I	Indicator variable II
Service type	Fixed stops	0	
	Door-to-door	1	
Surveillance in bus	None	0	0
	Camera	0	1
	Supervisor	1	0
Experience	No	-1	
	Yes	1	

Note: Attribute 'service type' is only coded for alternative 'bus amongst other traffic'

6.1.3. Interaction variable: Experience with ADS-DVs

Besides attribute values from the choice sets socioeconomic variables can be included in the model. Since the level of experience a individual has with ADS-DVs is measured as a categorical value it needs to be recoded before it can be estimated in the model. In this thesis it is hypothesised that individuals that have more experience with ADS-DVs are more positive towards ADS-DVs of both level 4 and level 5, than individuals that do not have experience with ADS-DVs. Furthermore, individuals that have experience with ADS-DVs are believed to value the surveillance in an ADS-DV as less important that individuals that have less experience with ADS-DVs. To investigate whether a significant difference exists between the two groups for these variables, interaction effects were coded. In the data set the variable *experience* was coded as 1 for respondents that have use experience with an ADS-DV and coded as -1 for respondents that indicated to have no use experience with ADS-DVs, table 6.2.

The variable has been introduced in the model syntax as an *interaction variable*. The parameter for an interaction variable is coded in the syntax as the level of the interaction variable (1 or -1) multiplied by a relevant attribute. The value of this parameter can be interpreted based on the sign of the parameter. The interpretation of the interaction parameter for *surveillance in bus* with *experience* is 'positive' for individuals *with* use experience and 'negative' for individuals *without* use experience with ADS-DVs. To clarify, if the parameter value for the interaction variable is negative it means that this variable is relatively *less* important to those that have experience with ADS-DVs. At the same time *surveillance in bus* is more important to those individuals that have no use experience with ADS-DVs. A similar approach is used to determine the difference in preference between the two groups for the ADS-DV on a dedicated lane and the ADS-DV amongst other traffic by multiplying the *experience* with the constant for both ADS-DV on a dedicated lane and ADS-DVs amongst other traffic.

6.1.4. Latent variables

An indication of the influence of latent variables is determined by incorporating the factor scores into the choice model. Via Factor Analysis latent variables are determined from the indicators (statements). The factor scores for each individuals are included directly as component scores in the choice model.

Table 6.2: Variables for experience

Attribute	Category	Indicator variable I	Survey data
Experience	Users	1	Frequent use of ParkShuttle (weekly) Have used ParkShuttle once/multiple times
	Non-users	-1	Seen or read something about ADS-DVs Never heard of ADS-DVs before this study

Factor Analysis

Reducing many indicators in a few variables can be done in multiple ways and for multiple purposes. Two common methods are the *Principal Component Analysis* (PCA) and the *Principal Factor Analysis* (PFA). The main difference between the two is that PCA combines variables into new variables in such a manner that the variance can be retained. This approach is solely a mathematical technique to reduce data. The PFA however assumes that correlations between the indicators are caused by underlying latent variables. This technique explains the correlations between indicators with the derived factor scores **??**. As in this study the assumption is made that answers to similar statements (indicators) would help to identify unmeasurable latent variables, it is clear that the second approach is needed.

A factor analysis can be conducted *exploratory* or *confirmatory*. In the *exploratory* case, factors (latent variables) are created based on the communalities of each indicator statements with the latent variables. In the case of *confirmatory* Factor Analysis, a pre-determined model is checked. From the Factor Analysis of the first pilot survey it was found that some of the statements might overlap (especially for *trust in ADS-DV, safety, security* and *performance expectancy* and it is yet unclear which latent variables are can be derived from the data. Therefore an *exploratory* Factor Analysis was used rather than a *confirmatory* Factor Analysis.

All indicator variables loaded primarily on one factor. This would suggest that one overall latent variable like an 'attitude towards ADS-DVs' could be derived from the statements. However, the communalities were not found high enough to indicate the presence of one overall latent variable. Because the indicators all loaded primarily on the same factor it was impossible to derive multiple independent latent variables. During the analysis the indicators that scored lower than 0.25 on communalaties were removed systematically. These indicators did not have sufficient in common with the other indicators to form one latent variable together. In the end five indicators remained and formed one latent variable, table 6.3. The indicators *TRUST1, TRUST2, TRUST3, TRAFFICSAFETY1* and *TRAFFICSAFETY2* form one latent variable that is from now on addressed as *trust in ADS-DVs*. From the *Kaiser-Meyer-Olkin Measure of Sampling Adequacy* (KMO MSA) and indication can be given of the strength of the factor (latent variable). Values below 0.50 are unacceptable, > 0.50 is poor, > 0.60 mediocre, > 0.70 average, > 0.80 good and 1 is perfect. From table 6.3 it can be seen that the MSA value is 0.770, this indicates that the factor analysis resulted in a suitable factor. The reader is referred to table 6.4 for the statements the variables refer to. Detailed information on the factor analysis can be found in appendix M.

Table 6.3: Results Factor Analysis

	Factor scores	Communalities
TRUST1	0.568	0.322
TRUST2	0.583	0.340
TRUST3	0.630	0.397
TRAFFICSAFETY1	0.527	0.278
TRAFFICSAFETY2	0.687	0.471

KMO MSA = 0.770

After determining which indicators load on which factors, a method can be chosen to derive the factor score of the latent variable and the corresponding values for each individual. The simplest approach would be to determine which indicator variables load on the same factor and calculate the average value of all indicators combined. This method is however not very refined as it does not take the weights of each indicator into account and does not strive for uncorrelated factor scores. The advantage however is that the interpretation of the latent variable is more intuitive. A more refined method to calculate factor score is the calculation of Regression Scores. This method produces factor scores (of the indicator variables) that are highly correlated with the latent variable to obtain unbiased estimates of the true (latent variable) factor scores leading to higher validity of the factors.

Table 6.4: Variable names for statements

Variable name	Statements
TRUST1	I trust a self-driving bus can drive without any assistance from a human.
TRUST2	I would let a close family member ride a self-driving bus.
TRUST3	I believe a self-driving bus would drive safer than the average human driver.
PERFROMANCE1	I think that I will arrive late at my destination when I take a self-driving bus.
PERFORMANCE2	I think there will be a self-driving bus available for the return trip to the station.
PERFORMANCE3	I expect that the interior of a self-driving bus will be dirty.
TRAFFICSAFETY1	I am concerned about the interaction of a self-driving bus with other traffic, like human drivers, pedestrians and cyclists.
TRAFFICSAFETY2	I believe that a self-driving bus can safely handled unexpected situations.
SECURITY1	I am concerned about riding a self-driving bus with strangers.
SECURITY2	The potential risks of software hacking or other forms of misuse worry me.
EASEOFUSE1	I think it is hard to understand how to use a self-driving bus.
EASEOFUSE2	I think I would find it easy to inform a self-driving bus of my destination.

The factor scores for each individual for the latent variable *trust in ADS-DVs* are calculated as regression scores. The regression scores of the latent variable is standardised to a mean of 0 and a variance of 1. This means that the mean of 0 indicates the average score of all individuals for *trust in ADS-DVs*. One must not that this is *not* the same as an average score on a scale of the variable *trust in ADS-DVs* itself. In other words, a negative score for the variable *trust in ADS-DVs* does not indicate that an individual has a negative perception of trust in ADs-DVs, but it indicates that an individuals has a *more* negative perception of trust in ADS-DVs *compared to other individuals*. To give a sense for the distribution of the latent variable *trust in ADS-DVs* a simple graph of the average of the indicator scores is shown in figure 6.1. For illustrative purposes a graph showing the distribution of the regression scores was included as well. Note that for the choice modelling, the more refined regression scores are used. The reader is referred to DiStefano et al. [84] for more information on calculations of factor scores.

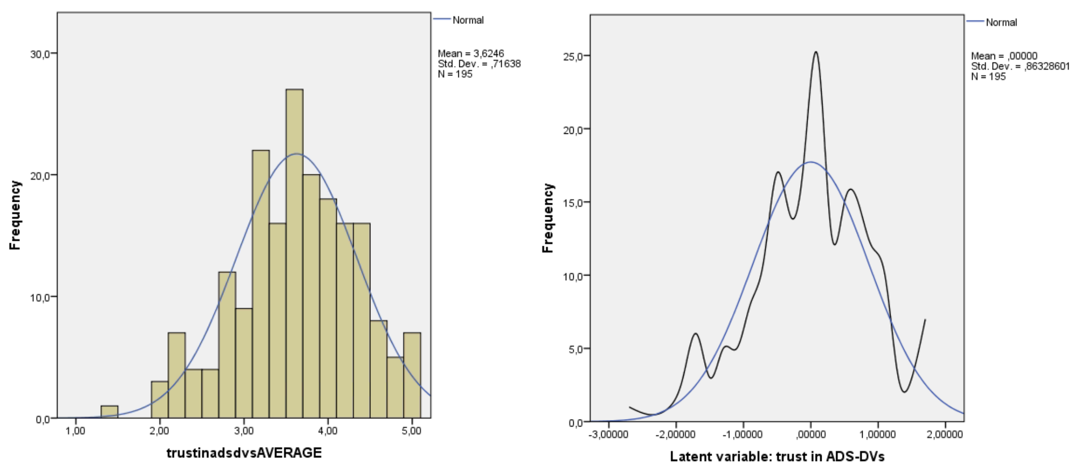


Figure 6.1: Indication of distribution latent variable *trust in ADS-DVs*: averaged indicator scores (l) and regression scores (r)

Choice model with latent variable: trust in ADS-DVs

The factor scores for each individual as derived from the Factor Analysis are used in the choice model directly. It is expected that a higher level of trust in ADS-DVs would result in a more positive intention to use ADS-DVs. For both ADS-DV types the latent variable is included. Furthermore, it is expected that the level of trust in ADS-DVs might also have some effects on the preferred type of surveillance. For both ADS-DV functions an interaction effect between *surveillance* and *trust in ADS-DVs* is included. In the model syntax the value for *trust in ADS-DVs* is multiplied with the attribute *surveillance in bus* and with the constant for each alternative.

A positive value for *trust in ADS-DVs* indicates that an individual has a more positive perception of trust in ADS-DVs than average.

6.2. Choice model variations & results

A base MNL model was estimated to act as a reference to the more advanced models that include interaction effects and latent variables. The syntax of the model is quite similar to that of the second pilot survey, however with inclusion of the *no bus* alternative. Eleven parameters were estimated and the variables *travel costs, travel time in-vehicle* and *waiting time* are checked on linearity. Table 6.5 shows all estimated models and the variables included in each variation. The reader is referred to chapter for more information over the different variations of choice models. The quadratic coefficients for *travel time* and *waiting time* were found to be not significant for every model variation and were therefore excluded from the final models. Detailed Biogeme syntax and output for the choice models are available in appendix N.

Table 6.5: Parameters that are included in different variations of choice models

	Parameter	MNL base model	MNL model exp & trust	MNL model trust	ML panel trust	ML heterogeneity & panel trust
1.	*Constant for bus amongst other traffic (ASC)*	X	X	X	X	X
2.	*Constant for bus on dedicated lane (ASC)*	X	X	X	X	X
3.	*β Service type*	X	X	X	X	X
4.	*β Travel cost linear*	X	X	X	X	X
5.	*β Travel cost quadratic*	X	X	X	X	X
6.	*β Supervisor*	X	X	X	X	X
7.	*β Camera*	X	X	X	X	X
8.	*β Travel time linear*	X	X	X	X	X
9.	*β Travel time quadratic*	-*	-*	-*	-*	-*
10.	*β Waiting time linear*	X	X	X	X	X
11.	*β Waiting time quadratic*	-*	-*	-*	-*	-*
12.	*β Camera experience*	-	X*	-	-	-
13.	*β Supervisor experience*	-	X*	-	-	-
14.	*β Experience amongst other traffic*	-	X*	-	-	-
15.	*β Experience dedicated lane*	-	X*	-	-	-
16.	*β Camera trust in ADS-DVs*	-	X	X	X	X
17.	*β Supervisor trust in ADS-DVs*	-	X	X	X	X
18.	*β Trust in ADS-DVs amongst other traffic*	-	X	X	X	X
19.	*β Trust in ADS-DVs dedicated lane*	-	X	X	X	X
20.	*SIGMA1 panel*	-	-	-	X	-
21.	*SIGMA2 panel*	-	-	-	X	-
22.	*SIGMA DL*	-	-	-	-	X
23.	*SIGMA AT*	-	-	-	-	X
24.	*SIGMA Camera*	-	-	-	-	X
25.	*SIGMA Supervisor*	-	-	-	-	X
# of parameters		9	17	13	15	17

An asterisk (*) marks parameters that were found not to be significant

6.2.1. Multinomial Logit model

A base MNL model is estimated to act as a reference to the more advanced models that include interaction effects and latent variables. The syntax of the model is similar to that of the second pilot survey, however with inclusion of the *no bus* alternative.

6.2.2. Nested and Mixed Logit models

In the context of this study a Mixed Logit (ML) model would be preferred. A ML model can handle nesting effects of alternatives, take into account taste effects and address panel data.

Nesting effects

The alternatives *bus on dedicated lane* and *bus amongst other traffic* could have characteristics in common that are not captured in the attributes of the current models. Not taking these effects into account could lead to an overestimation of preferences for these alternatives. In order to check whether such a nest is present a Nested Logit (NL) was estimated. From the results in table 6.6 it can be concluded that no significant correlation between non-observed utilities of *bus on dedicated lane* and *bus amongst other traffic* are present. In other words the NL model is not significantly different from the MNL model.

Table 6.6: Nested logit

Nest	Alternatives	Coeff. estimate	Robust Asympt. std.error	t-stat	p-value
NEST1	Bus on dedicated lane	2.19	1.35	0.88	0.38*
	Bus amongst other traffic				
NEST2	No bus	1.0	fixed		

Panel effects

MNL models do not correct for the influence of panel effects. These effects can occur (and often do) when each individual is given multiple choice sets. Each individual has certain preferences or perceptions that are not included in the choice model as parameters but do influence the decision. A MNL model assumes that each choice is independent from another, while a ML panel model can address the errors that influence the model. By indicating which choices are made by the same person the 'peculiarities' can be filtered from the model results. In practice the parameter values might be slightly altered. In the ML model the coefficient *SIGMA1* and *SIGMA2* were added to correct for these correlated error terms in each utility function. Two sigma's were added as the bus-alternative do not represent one nest. Each sigma represents an *individual specific error component* containing the individual's specific preferences and perceptions. Both sigma's were found to be significant. Therefore it can be concluded that panel effects are indeed present in the data set.

Taste heterogeneity

Mixed Logit models can also correct for taste heterogeneity of individuals. Where the results of an MNL model represent the parameter values as homogeneous (i.e. all parameter values are the same for all individuals) an ML model can handle taste heterogeneity. Instead of estimating a parameter value as one value, the parameter is represented as a range. Often this is represented with a normal distribution. The parameter itself is represented by the average value and the sigma respresents the standard deviation. When testing for taste heterogeneity it can be checked whether the parameter value has a small or large range. A small range would for example indicate that for most people the importance of a certain variable (or attribute) is similar, while a large range indicates that differences in importance of the variable are present among individuals.

It is assumed that individuals with different levels of experience with ADS-DVs and those that have different level of trust in ADS-DV have more positive preferences for ADS-DVs and might perceive surveillance in the vehicle as less important than those that have less experience with ADS-DVs or lower levels of trust in ADS-DVs. The MNL model estimates ASC values that indicate that all individuals would have similar preferences for ADS-DVs. In testing for taste heterogeneity for ASC parameters it can be checked if some individuals have different preferences for the ADS-DV alternatives. In a similar manner the taste heterogeneity for the attribute *surveillance in bus* can be tested. In this case two sigma parameters were added to the model (one for camera and one for supervisor).

Table 6.7: Model fit

Model	# of parameters	Adjusted ρ-square	Final loglikelihood	LRS
Null	0	-	-1285.376	-
MNL base model	9	0.122	-1118.979	332.795
MNL model exp & trust	17	0.138	-1090.706	389.341
MNL model trust	13	0.140	-1091.888	386.976
ML panel trust	15	0.243	-956.283	658.187
ML heterogeneity ASC & panel trust	15	0.244	-956.660	657.433
ML heterogeneity ASC surveillance & panel trust	17	0.246	-952.598	665.556

6.2.3. Model fit and likelihood ratio test

It is assumed that a model fits the data better as the log likelihood gets closer to zero. This is also expressed in the $\bar{\rho}^2$ value. A higher $\bar{\rho}^2$ value indicates a better model fit. In general a value from 0.10 up indicates an acceptable model fit. Adding variables to the model usually improves the log likelihood and therefore the $\bar{\rho}^2$. To determine whether an extended model would actually better fit the data and not only have a better score on the $\bar{\rho}^2$ due to extra parameters, the *Likelihood ratio test* is used. This test determines whether a better fit of a model is solely because of sample peculiarities. The base MNL model has a $\bar{\rho}^2$ value of 0.122 as is presented in table 6.7.

The null model has a loglikelihood of -1285.376 (assuming all variables have a value of 0). The final log likelihood is -1118.979. The calculation of the Likelihood ratio test value (LRS) is shown in equation 6.1. To be statistically certain that the improvement of the model fit is not due to the additional of more parameters the value is checked in the *Chi square distribution table.* In the table of figure 6.2 the minimal needed LRS value is shown for different significance levels. This means that if the value of the LRS is higher than the shown values for the number of added variables (degrees of freedom) it can be concluded that the model has a better fit. In this case the base model with the parameters as shown in table 6.5 is an improvement of the null model.

$$LRS = -2 * (LL_{null} - LL_{MNLbase}) = -2 * (-1285.376 - -1118.979) = 332.794 \tag{6.1}$$

Critical Values of the χ^2 Distribution

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

Figure 6.2: Chi square distribution table

The MNL base model was extended with *experience* and the latent variable *trust in ADS-DVs*, adding 8 parameters to the model. To determine whether the model fits better than the base model the LRS is calculated in equation 6.2. The LRS value is 56.546. From the chi square distribution table in figure 6.2 it can be concluded that the model does fit significantly better than the base model with a $\bar{\rho}^2$ value of 0.138.

$$LRS = -2 * (LL_{MNLbase} - LL_{MNLtrustexp}) = -2 * (-1118.979 - -1090.706) = 56.546 \tag{6.2}$$

However no significant effects were found for the 'experience'-parameters, indicating that based on the data no differences exist in preferences for ADS-DVs based on experience or for the level of surveillance preferred by the groups. The Biogeme model syntax and output can be found in appendix **??**.

The model was re-estimated without the non-significant parameters for *experience* to see whether the model fit would improve. This time the MNL base model was only extended with the latent variable *trust in ADS-DVs*, adding 4 parameters. The LRS value is 54.182, see equation 6.3. From the chi square distribution table in figure 6.2 it can be concluded that the model again does fit significantly better than the base model. To determine whether the model with *experience*-parameters would result in an improved fit over the extended MNL extended only with parameters for *trust* the LRS value between the two model was calculated. From the LRS value of 2.364 it can be concluded that the inclusion of *experience*-parameters does not lead to a significant better fit of the model. Therefore the parameter for *experience* were excluded from the model.

$$LRS = -2 * (LL_{MNLbase} - LL_{MNLtrust}) = -2 * (-1118.979 - -1091.888) = 54.182 \tag{6.3}$$

$$LRS = -2 * (LL_{MNLtrust} - LL_{MNLtrustexp}) = -2 * (-1091.888 - -1090.706) = 2.364 \tag{6.4}$$

6.2.4. Panel effects & taste heterogeneity

Several Mixed Logit models were estimated to determine what effects are present in the data: ML model for panel effects, ML model for panel effects and taste heterogeneity for ASC and a ML model with panel effects, taste heterogeneity for ASC and taste heterogeneity for surveillance in bus. From the first model it was concluded that panel effects were indeed present in the data. From table **??** it can be seen that the model has significant sigma's (p-value: 0.00 and 0.00) for both alternatives and a $\bar{\rho}^2$ value of 0.243. Both models correcting for taste heterogeneity return significant sigma values indicating that for both the alternative specific constant and *surveillance in bus* taste heterogeneity exists. The $\bar{\rho}^2$ values for these models are respectively 0.244 and 0.246.

Table 6.8: Model fit

ML Model	Adjusted ρ -square	Parameters	Values	p-value
Panel	0.243	SIGMA1	-2.12	0.00
		SIGMA2	2.00	0.00
Panel & heterogeneity ASC	0.244	ASC dedicated lane	9.03	0.00
		SIGMA dedicated lane	-2.13	0.00
		ASC amongst other traffic	7.59	0.00
		SIGMA amongst other traffic	-1.94	0.00
Panel & heterogeneity ASC & surveillance	0.246	Camera	1.15	0.00
		SIGMA camera	0.964	0.00
		Supervisor	0.799	0.00
		SIGMA supervisor	0.950	0.00
		ASC dedicated lane	10.4	0.00
		SIGMA dedicated lane	2.18	0.00
		ASC amongst other traffic	8.86	0.00
		SIGMA amongst other traffic	1.95	0.00

All Mixed Logit models have $\bar{\rho}^2$ values that are over 0.1 point higher than those of the MNL models. Since all sigma values are found to be significant the model including both panel effects anad taste heterogeneity for ASC and *surveillance in bus* is preferred. From this model most information can be derived. The LRS value of 278.58 (equation 6.5) confirms that the model is indeed an improvement over the MNL model.

$$LRS = -2 * (LL_{MNLtrust} - LL_{MLtrust}) = -2 * (-1091.888 - -952.598) = 278.58 \tag{6.5}$$

6.2.5. Interpretation of parameter values

The ML model for panel effects and heterogeneity effect with extra parameters for *trust in ADS-DVs* is chosen as the most suitable model for this study. The summary statistics of the final model with 17 parameters are summarised in table 6.9. The model fit ($\bar{\rho}^2$) is 0.246. The model fit of the MNL base model without the latent variable *trust in ADS-DVs* was 0.122.

Table 6.9: Panel model summary statistics

Summary statistics		
Number of observations = 1170		
$\mathcal{L}(0)$	=	-1285.376
$\mathcal{L}(c)$	=	-1158.808
$\mathcal{L}(\hat{\beta})$	=	-952.598
$-2[\mathcal{L}(0)-\mathcal{L}(\hat{\beta})]$	=	665.556
ρ^2	=	0.259
$\bar{\rho}^2$	=	0.246

Parameter values can be interpreted as the gained/lost utility for an increase of one unit of the attribute. So, high values indicate that more utility is gained or lost with an increase of the attribute value, these parameters can be considered more important in the decision making process of individuals as they can largely influence the tipping point between alternatives. This is sometimes explained as that individuals are more sensitive to changes in attributes with higher parameter values.

All parameters estimated from the model have the expected sign and are highly significant (t-values » 1.96), see table 6.10. Higher *travel costs, travel times* and *waiting times* lead to lower utilities and more *surveillance* and a more convenient *service type* lead to higher utilities. Furthermore, both the constant for the *bus amongst other traffic* and the *bus on dedicated lane* have positive values (respectively 8.86 and 10.4), indicating that both alternatives provide utility over *no bus* ('another method to travel the last mile distance'). The value for the alternative *no bus* was fixed at 0.00.

Table 6.10: Parameter values ML model for panel & taste heterogeneity effects with latent variable *trust in ADS-DVs*

Parameter number	Description	Coeff. estimate	Robust Asympt. std. error	t-stat	p-value
1	Constant for ADS-DV amongst other traffic	8.86	1.70	5.20	0.00
2	Constant for ADS-DV on dedicated lane	10.4	1.77	5.85	0.00
3	β Service type	0.874	0.224	3.90	0.00
4	β Travel cost linear	-6.53	2.07	-3.15	0.00
5	β Travel cost quadratic	1.66	0.676	2.45	0.01
6	β Supervisor	0.799	0.187	4.27	0.00
7	β Camera trust in ADS-DVs	-0.874	0.208	-4.21	0.00
8	β Camera	1.15	0.207	5.56	0.00
9	β Supervisor trust in ADS-DVs	-0.719	0.214	-3.36	0.00
10	β Travel time linear	-0.334	0.0649	-5.15	0.00
11	β Trust in ADS-DVs amongst other traffic	1.39	0.302	4.61	0.00
12	β Trust in ADS-DVs dedicated lane	0.900	0.331	2.72	0.01
13	β Waiting time linear	-0.487	0.0666	-7.31	0.00
14	β SIGMA amongst other traffic	1.95	0.278	7.02	0.00
15	β SIGMA camera	0.964	0.276	3.49	0.00
16	β SIGMA dedicated lane	2.18	0.286	7.61	0.00
17	β SIGMA supervisor	0.950	0.324	2.93	0.00

Since the parameters for *travel time, travel cost* and *waiting time* are measures on different ranges and/or different measurement scales the parameter values cannot be compared directly. *Travel cost* was found to have a negative influence on the utilities of the alternatives (-6.53), indicating that the coefficient of *travel cost* is not linear. That the value of the quadratic component is positive (1.66) means that the higher the price is the less the utility decreases when the price increases. In other words the negative influence of *travel cost* on the utility of an alternative decreases as the travel costs increase. It can be noted that *travel time quadratic* and *waiting time quadratic* are not present in the table. During the process of improving the model these values were removed as their coefficients were found to be very small and not significant. The parameters for *travel time in-vehicle* and *waiting time* were found to be significant and linear. The negative signs (respectively -0.334 and -0.487) indicate that higher travel and waiting times make alternatives less attractive.

Since the parameter for *surveillance* and *service type* all have been dummy coded the measurement scale is similar and the parameter values may be compared. C.q, a one unit increase can represent (1) from no surveillance to camera, (2) from no surveillance to supervisor or (3) from fixed stops to door-to-door service. Based on the parameter values it can be concluded that *surveillance in bus* and *service type* both have large influences on the mode choice decision of the individual. The fact that the parameter value for *service type* has a positive sign indicates that travellers prefer door-to-door service over fixed stops (dummy coded). For *surveillance in bus* dummy coding was used to be able to estimate the relative influence of 'camera' and 'supervisor' presence in the bus on utility. Both 'camera' and 'supervisor' have positive and significant parameters indicating that individuals derive utility from both types of surveillance in the bus compared to 'no surveillance'. The parameter value (0.874) for *service type* is about as high as the value for 'supervisor' (0.799) indicating that both are similarly influential in determining the utility of an alternative. However 'camera' is found to be most important for individuals given the highest parameter value (1.15)

From table 6.10 it can be seen that both the interaction effect of *trust in ADS-DVs* with the alternative specific constants positive and significant. Individuals that have more trust in ADS-DVs have higher preferences for both types of ADS-DVs, and especially for ADS-DV amongst other traffic, compared to individuals with lower levels of trust in ADS-DVs. The parameter values are respectively 1.39 for *bus amongst other traffic* and 0.900 for *bus on dedicated lane*. Furthermore, it is interesting to see that the interaction between *surveillance camera* and *trust in ADS-DVs* has negative parameter values (−0.874 and −0.719). This indicates that the higher the level of trust in ADS-DVs an individual has the less the surveillance in the bus is of importance to an individual.

The significant values for the SIGMA parameters indicates that the estimation with the Mixed Logit model for panel effects and taste heterogeneity confirms that panel effects and heterogeneity for parameters is present. Graph 6.3 shows the distributions for ASC dedicated lane, ASC amongst other traffic and the camera and supervisor parameter for *surveillance in bus*. For the estimation of the ML model a normal distribution was assumed for the parameters. The coefficient values represent the mean value and the accompanying sigma the standard deviation.

It can be noticed that the distribution of the ASC parameters (blue lines) is more widespread than the distribution of the *surveillance in bus* parameter (green lines). This means that more heterogeneity is present for the ASC than for *surveillance in bus*. The distribution for both ASC parameters is on the positive x-axis indicating that all parameter values are positive. All individuals are found to prefer the ADS-DV alternatives over the 'no bus' alternatives, although the strength of the preference differs greatly. Although the bus on a dedicated lane is has a higher preference on average, the distribution of the function is more widespread than the distribution for the ASC for the bus amongst other traffic.

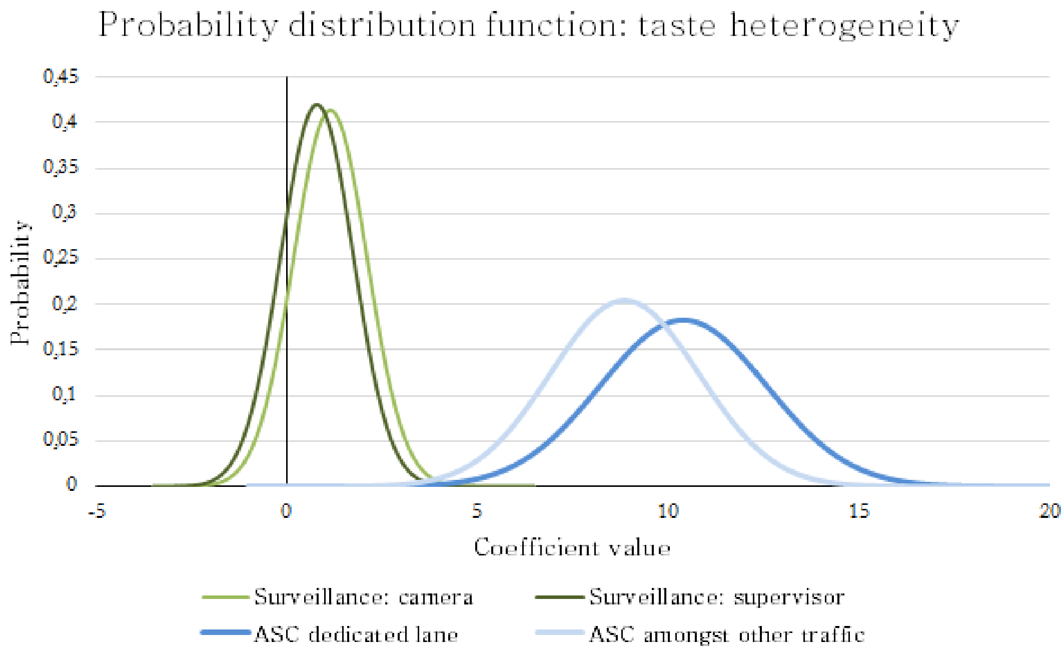


Figure 6.3: Probability density functions for ASC and Surveillance in bus

The distribution for the parameters *camera* and *supervisor* show a steeper curve, indicating that individuals are more in agreement over the importance of surveillance in an ADS-DV. The use of a normal distribution for the estimation of parameter values can result in undesirable (in this case) negative coefficient values. Notice that part of the curve lies on the negative side of the x-axis. A negative coefficient value would indicate that an individual would perceive the presence of a camera or a supervisor as dis-utility, c.q. surveillance would have a negative influence on the attractiveness of an alternative. One could image that this would, with exception of a few individuals, probably not be the case. Using cumulative probability density functions the probability that a parameter is negative can be calculated. The probability on a negative value for camera and supervisor are respectively 11.8% and 20.3%. As it can still be concluded that not all individuals value the type of surveillance in an ADS-DV similarly, most prefer to have some type of surveillance while others do not derive utility from a camera or supervisor, the negative values are not considered a problem for the purpose of this study. When conducting a more in-depth research into the exact distribution for the coefficient of surveillance in ADS-DVs one might consider negative values to be a problem. In order to prevent negative coefficient values one could make use of a different distribution function, like for example the log-normal distribution.

To conclude: no significant relationships between level of experience an individual has and preference for ADS-DV type (bus on dedicated lane versus bus amongst other traffic). No significant difference between level of experience and importance of surveillance in bus. Individuals that have higher levels of trust in ADS-DVs are slightly more positive about ADS-DVs amongst other traffic that individuals that have lower levels of trust in ADS-DVs. Additionally, the surveillance in the ADS-DV (both on a dedicated lane and amongst other traffic) is less of importance to individuals with higher levels of trust in ADS-DVs than to those that have lower levels of trust. Estimating the model using panel effects significantly improves the model fit by taking into account individual peculiarities that are not considered in the other parameters. Taste heterogeneity exists in preferences for ADS-DV, all individuals have a preference for ADS-DVs but the amount of preference differs greatly between individuals. Taste heterogeneity is also present for the level of surveillance in an ADS-DV. Although most individuals derive utility from a camera or supervisor in an ADS-DV, some do not seem to consider these attributes important. This could be related to the level of *trust in ADS-DV* that an individual has, where surveillance was considered as less important to those individuals that have higher levels of trust in ADS-DV than average. Other factors that are not considered in this study could also be of influence on the heterogeneity of *surveillance in bus*, like whether individuals are in need of route information (asking the supervisor) or the time of day that an individual makes use of the ADS-DV (nighttime could be considered more dangerous).

6.2.6. Willingness-to-pay

Individuals willingness-to-pay can be calculated from choice models to validate the model results and to give an indication of the amount of money individuals would be willing to pay for certain attributes of alternatives. An advantage of this method is that for attributes that are not measured in the same measurement scale or range can be compared [66]. For calculative purposes the final ML model was re-estimated assuming a linear parameter for *travel costs*. Table 6.11 shows the estimated parameter values of both models. Note that the estimated values are slightly different from the model with non-linear travel costs. However the relative importance of parameters is still consistent and therefore the calculation of willingness-to-pay is considered valid.

A validation of the results was done by calculating the willingness-to-pay for individuals that could be derived from the model. From equations 6.6 and 6.7 it can be derived that the willingness-to-pay is equal to 11.79 €/hour. Kouwenhoven et al. [85] stated that the value of time (willingness-to-pay for a decrease of one hour of travel time) in the Netherlands is €9.75 and €13.50 for respectively commuters and business employees in general. Given that the value of 12.38 that was calculated with the data of the survey lies within this range, therefore it may be concluded that the parameters found with the model are quite representative.

$$WTP_{perminutetraveltime} = \frac{\beta traveltimein-vehicle}{\beta travelcost} = \frac{-0.328}{-1.59} = 0.206 \tag{6.6}$$

$$WTP_{\frac{euro}{hour}} = 0.206 * 60 minutes = 12.38 \frac{euro}{hour} \tag{6.7}$$

In a similar manner the willingness to pay for an hour decrease of waiting time and an indication of the willingness to pay for door-to-door services and surveillance types can be calculated. Table 6.12 shows the average values that an individual is willing to pay for increase/to pay to prevent a decrease in these variables.

Table 6.11: Parameter values ML model for panel & taste heterogeneity effects with latent variable *trust in ADS-DVs* - linear travel costs assumed

Param. nr.	Description	*Linear* Coeff. estimate	Robust Asympt. std. error	t-stat	p-val.	*Non-linear* Coeff. estimate
1	Constant for ADS-DV amongst other traffic	5.52	0.801	6.88	0.00	8.86
2	Constant for ADS-DV on dedicated lane	7.00	0.867	8.08	0.00	10.4
3	β Service type	0.834	0.218	3.83	0.00	0.874
4	β Travel cost linear	-1.59	0.277	-5.74	0.00	-6.53
5	β Travel cost quadratic	-.	-.	-.	-.	1.66
6	β Supervisor	0.808	0.182	4.43	0.00	0.799
7	β Camera trust in ADS-DVs	-0.864	0.204	-4.23	0.00	-0.874
8	β Camera	1.09	0.207	5.27	0.00	1.15
9	β Supervisor trust in ADS-DVs	-0.712	0.214	-3.33	0.00	-0.719
10	β Travel time linear	-0.328	0.0624	-5.25	0.00	0.334
11	β Trust in ADS-DVs amongst other traffic	1.39	0.303	4.58	0.00	1.39
12	β Trust in ADS-DVs dedicated lane	0.902	0.333	2.71	0.01	0.900
13	β Waiting time linear	-0.499	0.0661	-7.55	0.00	-0.487
14	β SIGMA amongst other traffic	1.95	0.281	6.97	0.00	1.95
15	β SIGMA camera	0.979	0.281	3.49	0.00	0.964
16	β SIGMA dedicated lane	2.19	0.288	7.60	0.00	2.18
17	β SIGMA supervisor	0.903	0.325	2.78	0.01	0.950

Note that travel time and waiting time are expressed in €/minute paid for an decrease. Surveillance is expressed in the discount in euro an individual would like to receive in case no camera or supervisor is aboard the ADS-DV. Similarly service type represents the discount in euro an individual would like to receive in case fixed stops are offered instead of a door-to-door service.

Table 6.12: Individuals willingness-to-pay for attributes

Attribute	**Value**	**Unit**
Travel time	0.21	€/minute
Waiting time	0.63	€/minute
Surveillance: camera	-0.69	€
Surveillance: supervisor	-0.51	€
Service type: door-to-door	-0.53	€

6.3. Application of choice model

This section is added to illustrate the working of choice models. For two choice sets from the survey the probabilities that an alternative is chosen are calculated. The utility for each alternative is determined by the alternative specific utility function. Next the MNL model is used to determine the choice probabilities. For each choice set three alternatives are available: (1) bus on dedicated lane, (2) bus amongst other traffic and (3) no bus/other travel method on the last mile. The utility function for the third alternative is fixed at zero. The utility function for the other two alternatives are represented in equation 6.8 and equation 6.10. Note that in each second equation the parameter values for the attributes have already been filled in.

$$\begin{aligned} UtilityDL = ASC_{DL} &+ \beta_{trustdedicatedlane} * trust + \beta_{travelcostlinear} * TC + \beta_{travelcostquad} \\ &* TC + \beta_{waitingtime} * WT + \beta_{traveltime} * TT + \beta_{camera} * camera + \beta_{supervisor} \\ &* supervisor + \beta_{camera-trust} * camera * trust + \beta_{supervisor-trust} * supervisor * trust \end{aligned} \tag{6.8}$$

$$\begin{aligned} UtilityDL = 10.4 + 0.900 * trust - 6.53 * TC + 1.66 * TC - 0.487 * WT - 0.334 * TT + 1.15 * camera \\ + 0.799 * supervisor - 0.874 * camera * trust - 0.719 * supervisor * trust \end{aligned} \tag{6.9}$$

$$UtilityAT = ASC_{AT} + \beta_{trustamongsttraffic} * trust + \beta_{travelcostlinear} * TC + \beta_{travelcostquad} * TC + \beta_{waitingtime} * WT + \beta_{traveltime} * TT + \beta_{camera} * camera + \beta_{supervisor} * supervisor + \beta_{camera-trust} * camera * trust + \beta_{supervisor-trust} * supervisor * trust + \beta_{servicetype} * service \tag{6.10}$$

$$UtilityAT = 8.86 + 1.39 * trust - 6.53 * TC + 1.66 * TC - 0.487 * WT - 0.334 * TT + 1.15 * camera + 0.799 * supervisor - 0.874 * camera * trust - 0.719 * supervisor * trust + 0.874 * service \tag{6.11}$$

The probability functions for each alternative are determined with the MNL formula in equation 6.12.

$$P_i = \frac{exp(V_i)}{\sum_{j=1..J} exp(V_j)} \tag{6.12}$$

where P_i represents the probability of alternative i, V_i the utility of alternative i and j all alternatives in the choice set.

In this example the choice probabilities for two choice sets are calculated. Figure 6.4 shows the available alternatives with their accompanying attribute values. The third alternative 'no bus/other travel method on the last mile' has no attributes and is therefore not shown explicitly in the figure. Table 6.13 shows for each alternative the choice probability. Note that for each choice sets the level of trust that an individual has in ADS-DVs is varied from low (latent variable *trust in ADS-DVs* value of -1.5) to high (1.5). The average of 0 indicates that the individual has an average level of trust in ADS-DVs compared to other individuals.

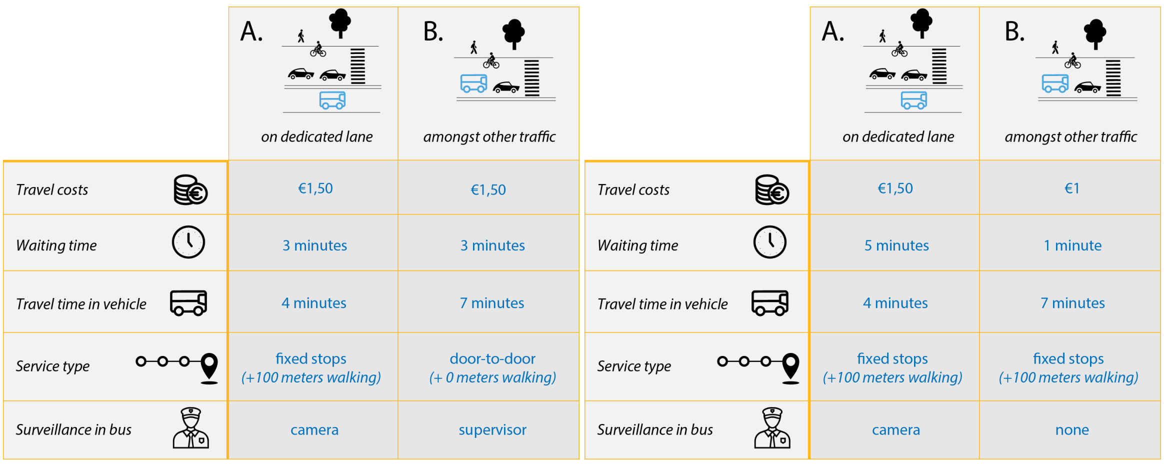


Figure 6.4: Choice set 1 (l) and 2 (r); note that the third alternative 'no bus/other travel method on the last mile' is not visualised

In the first case both ADS-DV alternatives have some form of surveillance (and from the parameter values it could be noticed that camera results in a slightly higher utility than supervisor). The travel costs and waiting time are similar for both alternatives. The travel time of the bus amongst other traffic is higher resulting in more dis-utility. However, the door-to-door service does increase the utility of the alternative. For the second choice set the travel costs and waiting time for the bus on a dedicated lane are higher and the travel time is lower than for the bus amongst other traffic, resulting in more dis-utility for the dedicated lane alternative for travel cost and waiting time and more dis-utility for the alternative amongst other traffic for travel time. Both alternatives operate on fixed stops where no utility is derived for either alternative. The bus on a dedicated lane has a camera for surveillance, while the second alternative does not have a form of surveillance. From the camera utility is derived for the bus on a dedicated lane, while for the bus amongst other traffic no utility is derived.
Notice that in the case of the first choice set the probability that the bus on the dedicated lane will be chosen is largest no matter the level of trust an individual has in ADS-DVs. For the second choice set however it can be notices that individuals that have lower levels of trust in ADS-DVs would be more likely to choose the bus on a dedicated lane or the no bus alternative than individuals that have higher levels of trust for ADS-DVs than

Table 6.13: Choice probabilities for alternatives; highest probabilities shown in **bold**

Choice set	Alternative	Level of trust in ADS-DVs		
		low (-1.5)	average (0)	high (1.5)
1	Bus on dedicated lane	**77.2%**	**73.1%**	**63.5%**
	Bus amongst other traffic	3.9%	9.7%	22.2%
	No bus/other travel method	18.9%	17.2%	14.3%
2	Bus on dedicated lane	**52.5%**	27.6%	5.9%
	Bus amongst other traffic	13.5%	**55.2%**	**90.6%**
	No bus/other travel method	34%	17.2%	3.5%

average. For an average level of trust the choice probability increases to 55.2% and for high levels of trust even to 90.6%. The fact that the choice probabilities differ more for the second choice set than for the first choice set can foremost be explained by the attribute values for surveillance in the second choice set. The level of trust that an individual has in ADS-DVs influences strongly the utility that is derived from the presence of a camera or supervisor in the bus. Individuals that have higher levels of trust than average were found to not derive much utility from surveillance. Furthermore, the general preference for ADS-DVs is slightly increased for individuals that have higher levels of trust. These aspects combined result in a shift from the importance of the attribute surveillance towards attributes like service type and travel cost and thus resulting in different levels of utility for the alternatives and different choice probabilities.

7

Statistical analyses

This chapter addresses several statistical analyses that are conducted using SPSS software to better understand and support the results of the choice models from chapter 6. First section 7.1 discusses the dependencies of the variable *trust in ADS-DVs* and several socioeconomic variables. Then section 7.2 reviews additional relevant data needed to answer other sub questions in this thesis. For all statistical tests conducted in this study a confidence interval of 95% is used with a significance level of 0.05. This means that for every test it can be said with 95% certainty that the findings of the sample are present in the population.

7.1. Socioeconomic variables and latent variable: trust in ADS-DVs

The choice model analysis in chapter 6 indicated that individuals that have higher levels of trust in ADS-DVs are more positive towards these modes and perceive the surveillance as less important than individuals that have lower levels of trust in ADS-DVs. To get some insight in the characteristics of individuals with higher or lower levels of trust in ADS-DVs one statistical analyses are conducted. The independent samples T-test and *One-way ANOVA* are used to compare for several socioeconomic variables if the mean value for the variable trust in ADS-DVs differs for groups within the socioeconomic variables. For example, the test compares if males and females have different mean values for trust in ADS-DVs. An independent samples T-test is used in case the independent socioeconomic variable has two levels, otherwise the One-way ANOVA is used. Several independent samples T-tests and One-way ANOVA tests were conducted for socioeconomic variables *gender, age, income, education level, public transport use, region* and *experience with ADS-DVs*. Detailed output of the analyses can be found in appendix O. From the analyses it can be concluded that only *gender* and *region* indicate significant differences in the mean values for the *trust in ADS-DVs* as can be seen in the results tables 7.1 and 7.2. Males were found to have more trust in ADS-DVs than females, mean values of 0.116 and -0.258 respectively. This difference is found to be significant and thus it can be concluded that this difference is present in the population. Furthermore, the mean values of the latent variable *trust in ADS-DVs* were found to be higher in a region where an ADS-DV is in operation (0.143) than in regions where no ADS-DV is present (-0.147). From the significant value in the T-test it can be concluded that this difference is present in the population. For the variables *age, income, education level, public transport use* and *experience* no significant differences were found in the mean values of *trust in ADS-DVs.*

Table 7.1: Differences in mean values of latent variable trust in ADS-DVs based on gender (independent samples T-test)

	average	**std.dev.**	**N**
Males	0.116	0.838	133
Females	-0.258	-0.258	59
	difference	**T**	**p(2-tailed)**
t-test	0.375	2.819	0.005

To conclude, those that have more trust in ADS-DVs (and are therefore more positive towards ADS-DVs) are most likely male and have a job in a region where an ADS-DV is in operation. Note that trust is not directly

Table 7.2: Differences in mean values of latent variable trust in ADS-DVs based on region (independent samples T-test)

	average	**std.dev.**	**N**
Region with ADS-DV	0.143	0.763	99
Region without ADS-DV	-0.147	0.937	96
	difference	**T**	**p(2-tailed)**
t-test	0.290	2.375	0.019

related to experience although one might assume so. In the sample group results individuals that had never heard of ADS-DVs had the least trust in ADS-DVs (-0.246) and individuals that had made use of an ADS-DV once or a few times were most positive (0.258). However the One-way ANOVA indicated that no differences in mean values for the groups of experience were present on the 0.05 significance level, table 7.3 . The value of 0.05 does imply a that an less powerful relation could be present. Also note that this possible relation is based on a difference in mean value for the 'No' and the 'Yes, I have made use of the ParkShuttle once / a few times', not for those that have long-term experience with ADS-DVs (use on weekly basis). In this study the relation is not clear enough to draw a firm conclusion whether those with higher levels of experience in general have more trust in ADS-DVs than those with lower levels of experience. It is therefore advised to conduct a longitudinal research to determine the effect of experience on trust in ADS-DVs.

Table 7.3: Mean values trust in ADS-DVS for experience (One-way ANOVA)

	distribution			**p (Post hoc Bonferroni)**		
trust in ADS-DVs	average	Std.dev.	N	read/seen	once/few times	weekly exp
no exp	-0.246	0.921	39	1.000	0.051	0.538
read/seen	-0.0511	0.906	87	-	0.329	1.000
once/few times	0.258	0.812	42	-	-	1.000
weekly exp	0.118	0.585	27	-	-	-

F=2.646; p=0.050

7.2. Additional analyses

Additional data was collected with the surveys that was not used for the choice models and aforementioned analyses. For every region an indication was made of the interest in possible ADS-DV trajectories by travellers. In addition respondents were asked for their reasons to make use or not to make use of the proposed ADS-DV system. Respondents were asked to indicate whether they would be willing to make (more) use of public transport to travel to their work in the future. Note that the information in this section is meant for *exploratory purposes* and no firm conclusions can be drawn from the results.

7.2.1. Socioeconomic variables and ADS-DV preference

In addition to the choice modelling analyses it was investigated whether groups based on socioeconomic variables chose more or less often to make use of an ADS-DV instead of another transportation method on the last mile from the choice sets. Using several *independent samples T-tests* and *One-way ANOVA* tests it was concluded that no significant differences between the groups could be found based on *gender, age, income, education level, public transport use, region* and *experience with ADS-DVs*. The detailed output of the analyses can be found in appendix P.

7.2.2. Interest in ADS-DVs per region

Respondents of every region were shown several possible ADS-DV trajectories and were asked to indicate whether they would want to make use these. Figures 7.1 show maps of the ADS-DV trajectories as used in the survey.

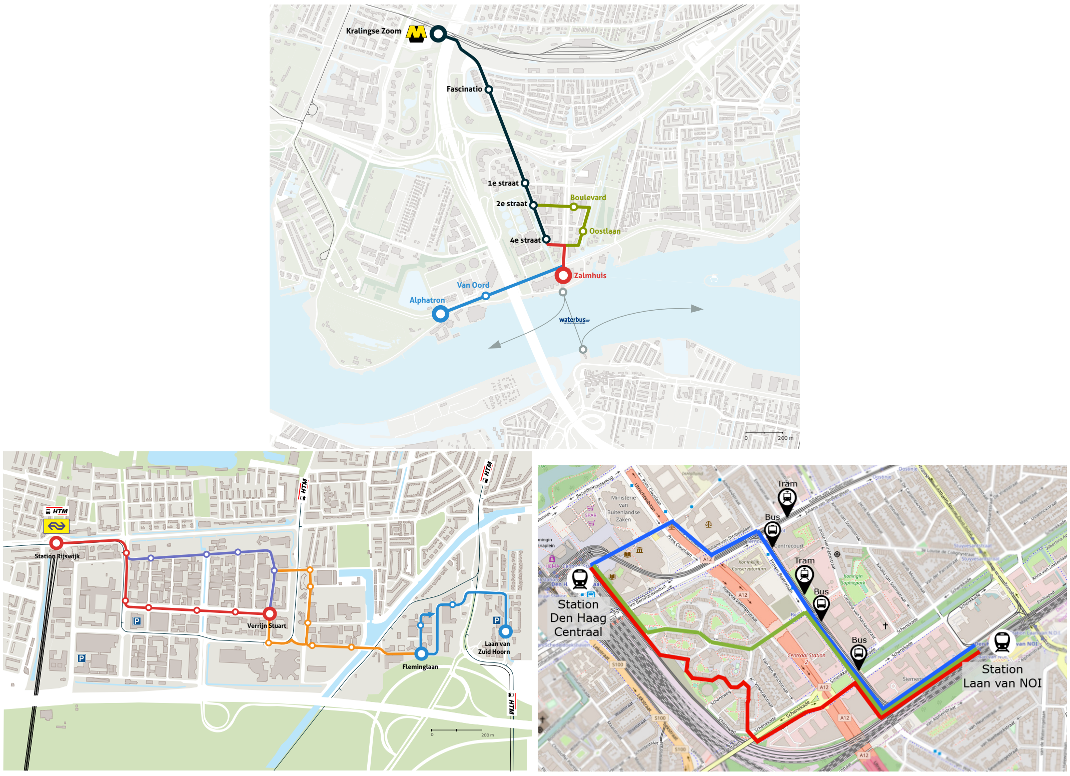


Figure 7.1: ADS-DV trajectories per region: Rivium (t); Rijswijk (l); Beatrixkwartier (r)

All respondents had to select the region their work was situated in: Capelle a/d IJssel, Rivium; The Hague: Beatrixkwartier or Rijswijk: Plaspoelpolder, Broekpolder and Hoornwijck. In the following question the respondent was asked to indicate if he/she would want to make use of the ADS-DV service and if yes, which line would be preferred. Table 7.4 shows the responses per region and in total. It can be noticed that for all regions the largest group states to want to make use of one of the ADS-DV lines. In total 63.6% of 195 respondents states that they would be intereseted in using an ADS-DV in their region. Which lines would be preferred in each region can be derived from table 7.5. For Capelle a/d IJssel the current ParkShuttle line was chosen most often (68.8% of respondents). In Beatrixkwartier the blue line was favourite (70.5%) and in Rijswijk 81.3%

picked the red line. Also note that the willingness-to-use an ADS-DV is relatively high in the regions where such a system is not available currently (74.5% in Beatrixkwartier and 43.3% in Rijswijk).

Table 7.4: ADS-DV choice per region

Region	**ADS-DV choice** No	Maybe	Yes	Total number (=100%)
Capelle a/d IJssel	27.3%	8.1%	64.6%	99
Beatrixkwartier	15.3%	10.2%	74.5%	59
Rijswijk	35.1%	21.6%	43.3%	37
Total	25.1%	11.3%	63.6%	195

Table 7.5: Preferred ADS-DV lines per region

Region	**Preferred line**	**Percentages**
Capelle a/d IJssel	Yes, current ParkShuttle trajectory	68.8%
	Yes, red line	15.6%
	Yes, green line	7.8%
	Yes, blue line	7.8%
# of respondents (=100%)		64
Beatrixkwartier	Yes, blue line	70.5%
	Yes, red line	11.4%
	Yes, green line	18.2%
# of respondents (=100%)		44
Rijswijk	Yes, red line	81.3%
	Yes, purple line	12.5%
	Yes, orange line	0%
	Yes, blue line	6.2%
# of respondents (=100%)		16
Total		
# of respondents (=100%)		124

Reasons to make use/not make use of an ADS-DV

Each respondent was asked to explain why they would make use or would not make use of the suggested ADS-DV lines. Table 7.6 shows all reasons that were shown as options to the respondents. In case a respondent chose to make use of the ADS-DV the four 'Y' reasons were shown and a fifth option were the respondent could add another reason. In case a respondent indicated that he/she would not make use of the suggested routes the seven 'N' reasons were shown and similarly respondents had the possibility to fill in an additional reason. Respondents were asked to select the most important reasons that applied to their decision and thus had the option to pick multiple answers. Table 7.7 shows the distribution of respondents over the possible reasons. In general most respondents stated to want to make use of an ADS-DV because of the 'on-demand' aspect of an ADS-DV (42.7%) and the expectation that they would arrive faster at their destinations using an ADS-DV (41.1%). For about a quarter of the respondents the green image and the preference for new technologies also played a role, respectively 26.6% and 25%.

From the respondents that had indicated that they would not make use of the suggested ADS-DV trajectories, most people stated that the shown lines were irrelevant to them (42.3%). Furthermore, 28.2% of respondents stated that they would prefer to make use of their own transportation mode instead and just under a quarter of respondents stated to prefer to walk or cycle from the station to their work (23.9%). However, compared to other public transport only 1.4% stated to prefer other types of public transport over an ADS-DV. Moreover, only a few respondents selected reasons that would indicate that they were hesitant of making use of an ADS-DV: to first see the ADS-DV in operation (5.6%) and preference for a shuttle bus with a human driver (2.8%). Moreover, none of the respondents stated to never want to make use of an ADS-DV (N6).

Some respondents in Capelle a/d IJssel stated to select the ADS-DV as there is no alternative means of transportation available. Other additional reasons provided to make use of an ADS-DV included that the 'ADS-DV would be their preferred alternative in case of bad weather', 'no specific preference for an ADS-DV over other transportation types' and 'ADS-DVs are part of the technologies currently shaping the world'. The only two additional reasons stated to not make use of the proposed ADS-DVs included 'a preference for a direct ADS-DV connection from a train station (instead of metro) to the final destination' and that 'the home-work distance would make it inconvenient to travel by means of public transportation'.

Table 7.6: Reasons to make use or not to make use of ADS-DVs

	Reasons
Yes	
Y1	I think I would arrive faster at my destination than with other means of transportation.
Y2	An electric self-driving bus is more environmental friendly than other types of (public) transportation.
Y3	The fact that the self-driving bus operates 'on-demand' appeals to me.
Y4	I like to make use of new technologies.
No/maybe	
N1	The routes shown are irrelevant to me.
N2	I would want to see the self-driving bus performing well before I am willing to make use of it.
N3	I would prefer travelling with another type of public transportation.
N4	I would prefer walking or cycling from the station.
N5	I would prefer travelling from home to work using my own transportation mode.
N6	I would never want to make use of a self-driving bus.
N7	A shuttle bus with a human driver would have my preference.

Table 7.7: Percentages use intention of suggested ADS-DV lines per region

	Yes				**N**			
	Y1	Y2	Y3	Y4				
Capelle a/d IJssel	53.1%	21.8%	42.2%	15.6%	64			
Beatrixkwartier	31.8%	27.3%	38.6%	27.3%	44			
Rijswijk	18.8%	43.8%	56.3%	56.3%	16			
All regions	41.1%	26.6%	42.7%	25%	124			
	No/maybe							**N**
Region	N1	N2	N3	N4	N5	N6	N7	
Capelle a/d IJssel	42.9%	2.9%	2.9%	8.6%	40%	0%	2.7%	35
Beatrixkwartier	33.3%	6.7%	0%	40%	26.7%	0%	6.7%	15
Rijswijk	47.6%	9.5%	0%	38.1%	9.5%	0%	0%	21
All regions	42.3%	5.6%	1.4%	23.9%	28.2%	0%	2.8%	71

Note that respondents could select multiple reasons

Willingness to make use of public transport in the future

An additional question was used in the survey to get some insight in the willingness of the respondents to switch to public transportation modes in general. Respondents that stated not to make use of public transportation on more than two days per week to travel to their work were asked if they would be interested in doing so in case the accessibility of their work area by public transportation would be improved. From this group 37.5% states to be willing to make (more) use of public transportation and 26.1% stated they might do so. From these groups respectively 82.9% and 83.3% currently travel by car. An overview of the results can be found in table 7.8. Note that this does not conclude that improving the accessibility to business parks would make 31.1% (82.9% of 37.5) of individuals that currently travel by car to switch to public transportation. It merely gives an indication that potential for measures improving public transportation connections is present. Follow-up research would be needed to determine how strong the effect of each measure would be.

Table 7.8: Cross table region and future public transport use

Region	Future PT use No	Maybe	Yes	Total number (=100%)
Capelle a/d IJssel	36.4%	27.3%	36.4%	66
Beatrixkwartier	52.9%	11.8%	35.3%	17
Rijswijk	15.4%	38.5%	46.2%	13
Total	36.4%	26.1%	37.5%	96

7.2.3. General reactions towards ADS-DVs and AVs

During the process of handing out flyers (in the Beatrixkwartier in The Hague and Plaspoelpolder, Broekpolder and Hoornwijck in Rijswijk) respondents already stated some of their opinions on both ADS-DVs and AVs. Speaking to many people on the street about ADS-DVs gave a general positive overview of the public opinion on automated vehicles. Most people were eager to talk about the subject, either to learn more about AVs and the current state-of-the-art or to share their visions on how such technologies change the world and could be beneficial. Only a few of the about 500 individuals that were approached indicated that they were concerned about the development of automated vehicles. Some stated that they would not have problems with systems that operate without a driver as long as they are bound to a rails. They would however have problems with an ADS-DV operating amongst other traffic or even on a dedicated lane. Another issue that was brought up was the concern for such technologies to increase unemployment as no drivers would be needed to operate the ADS-DVs.

Additional thoughts respondents shared in the survey (open question) included the concern about vandalism when there is no additional passenger in the vehicle. However, again respondents were mostly positive towards the introduction of ADS-DVs. Furthermore, questions arise whether a distance of 1.5 kilometres would be to short for an ADS-DV alternative, and that low fare costs and short waiting times would be needed to balance this. The personalised 'on-demand' aspect of ADS-DVs appeals to travellers. The context of an office area or connection of Rotterdam The Hague Airport to the metro are mentioned as appealing applications of ADS-DVs. To ease the implementation process some suggest to start with the introduction of automated trams to make the transfer to ADS-DVs a smaller step for the general public.

To conclude on this section, in general most respondents were positive towards the introduction of ADS-DV systems. One must note that the results and opinions shared represent those of 195 respondents and multiple individuals that were present in the regions during flyering-sessions. As self-selection might have played a role in any survey based study one must be careful with overestimating the conclusions from a study. Therefore the results presented in this section are purely exploratory and call for further research before any firm conclusions can be drawn.

III

Results

8

Conclusions & Recommendations

This chapter concludes on ADS-DVs from a travellers' perspective. Section 8.1 answers the main research question and sums up the conclusions of this study. Section 8.2 discusses the findings in relation to the policy perspective of the increased accessibility of the last mile in business parks.

8.1. Conclusions

Recent technological developments have increased the interest in several types of automated vehicles (AVs). Both AVs for personal use and for shared use are considered as a potential integral part of future transportation networks. The main focus in current research is primarily on the technical aspects; the interaction of the driver with the automated driving function and the interaction of AVs with other traffic, like other vehicles, pedestrians and cyclists. Not much is known so far about how *users* perceive such automated modes. To address the knowledge gap surrounding demand for ADS-DVs and feasibility of such transportation systems on last mile locations, this study answers the following research question: *How do travellers perceive automated driving systems - dedicated vehicles (ADS-DVs) on last mile connections and are travellers that have experience with ADS-DVs more positive towards such systems?*

In general travellers are found to react positive towards ADS-DVs on last mile connections. Especially the *on-demand* aspect and the possibility to travel door-to-door appeal to travellers. The level of experience that a traveller has is not found to influence their preferences for ADS-DV type or need for surveillance. The level of trust an individuals has in ADS-DV however is found to do influence these factors. Individuals with a higher level of trust in ADS-DVs than average are found to be more positive towards ADS-DVs that operate amongst other traffic and to be less in need of a camera or supervisor in the vehicle. From these findings it can be concluded that ADS-DVs are perceived by travellers as a feasible solution to improve accessibility of business parks.

Vehicle attributes & perceptions

- The heterogeneity in ADS-DV preferences is very large indicating that individuals have very different preferences for ADS-DV type. Therefore it is concluded that although on average a system operating on a dedicated lane is preferred over an ADS-DV operating amongst other traffic the preferences for both types of ADS-DV could be considered fairly equal;
- As expected higher travel costs and longer travel times and waiting times have a negative effect on the use intention of ADS-DVs. Travellers are willing to pay about €0.20 and €0.65 for a one-minute decrease in respectively travel time and waiting time;
- Offering a door-to-door service instead of operating along fixed stops increases the attractiveness of an ADS-DV significantly. Travellers would expect to get a discount of at least €0.55 in the ADS-DV only serves fixed stops;
- Surveillance in an ADS-DV by means of a camera or supervisor is found to be of value to travellers. A camera is considered sufficient for most travellers as the presence of a supervisor in the vehicle was not valued higher than a camera by most people. Travellers were found to be willing to pay €0.70 and €0.50 for surveillance by respectively a camera and a supervisor;
- In line with earlier studies the amount of trust an individual has in ADS-DVs, is found to positively influence their preference for ADS-DVs. Individuals that have higher levels of trust in ADS-DVs are more

positive about both types of ADS-DVs (dedicated lane/amongst other traffic) on last mile connections than those that have lower levels of trust in ADS-DVs. The preference for an ADS-DV that operates among other traffic is slightly higher for individuals with more trust in ADS-DVs. Taste heterogeneity for surveillance in ADS-DVs indicates that not all individuals value a camera or supervisor in the ADS-DV as equally important. This matches the finding that individuals that have higher levels of trust in ADS-DVs consider the presence of surveillance in ADS-DVs as less important than do individuals with lower levels of trust in ADS-DVs;

- Higher levels of trust in ADS-DVs have been found for males than for females, which is in line with earlier studies. Additionally it can be concluded that individuals that work in an area where an ADS-DV system is in operation have higher levels of trust in ADS-DVs than those that work in areas where no ADS-DV system is present. The level of experience an individuals has with ADS-DVs is not directly found to have a relation with the amount of trust an individual has in ADS-DVs;
- From previous studies it was assumed that individuals with higher levels of experience with ADS-DVs would be more positive towards ADS-DVs. However, individuals that have more experience were not found to have different preferences for ADS-DV type or surveillance in an ADS-DV. An explanation could be that not the *personal* use experience that an individual has with ADS-DVs is important for determining whether an individual has a positive use intention for ADS-DVs, but that latent variables like the trust an individual has in ADS-DVs are more important in the decision making process;
- An advantage from concluding that the level of experience an individual has with ADS-DVs is less important than the level of trust in ADS-DV leads to easier possibilities to set up research designs. Researchers do no explicitly need participants that have experience with ADS-DVs in order to draw conclusions about ADS-DV use intentions. More important is to review the perceptions that individuals have with regard to ADS-DVs.

Feasibility & reasons to make use of an ADS-DV

- In the survey ADS-DV trajectories were shown to the respondents according to their work area. 63.6% stated that they would make use of an ADS-DV one one of the routes if it would be available;
- The *on-demand* aspect, that an ADS-DV can be ordered whenever the traveller wants to make use of it instead of fixed timetables, appeals to travellers. Additionally travellers expect that they would arrive faster at their destination using an ADS-DV than by other means of transportation on the last mile;
- Some participants stated that although they chose to make use of the ADS-DV they had no specific preference for ADS-DVs over other transportation types. This could indicate that ADS-DVs are considered not very different from traditional public transportation modes (that are operated by a driver).

The conclusions are based on the answers to the sub questions to which the reader is referred for a more in-depth explanation of the results.

Answers to sub questions

1. What are the characteristics of ADS-DVs?

Automated Driving Systems - Dedicated Vehicles (ADS-DVs) are vehicles that can operate completely automated on all regular trips. No (external) driver is needed for daily operation, however most systems have an operator in place to monitor the processes. ADS-DVs can operate on SAE level 4 which allows for automated driving in a predefined area (operational design domain - ODD) or on SAE level 5 at which an ADS-DV is able to navigate all roads a human driver could navigate. In the latter case no restrictions are present for the ODD. The vehicles are often used in shared driving systems and offer room for 2 to 25 passengers on each trip.

2. Which factors influence a traveller's preference for automated vehicles and ADS-DVs in particular?

Earlier studies concluded that instrumental, socioeconomic and psychological factors influence travellers' preferences for ADS-DV and automated vehicles (AVs). In general *travel time, travel cost* and *waiting time* influence any mode choice and were found to play a role for ADS-DVs as well. More interesting are the factors mentioned in literature that specifically apply to AVs and ADS-DVs. The *configuration* of a system (on a dedicated lane or amongst other traffic) and the interaction with other traffic were considered important. Travellers were found to have a preference for systems on dedicated lanes or dedicated areas or would require clear demarcations on the road otherwise. The *presence of a transit employee* aboard an ADS-DV was considered to have a positive effect on the use intention of such vehicles. About half of the travellers unknown with AVs stated however that information on the vehicle performance would not be interesting to them during the trip. For AVs that would replace personal vehicles *travel time enrichment* can play an important role. Since travellers do not have to focus on the driving task anymore, extra time becomes available for example to work or to relax. In the case of ADS-DVs this advantage does not apply as in conventional public transportation modes travellers are not required to perform the driving task. Based on socioeconomic characteristics like *gender*, males were found to be more in favour of AVs than were females in multiple studies. Furthermore, younger individuals (up to 34 years of *age*) are generally more positive towards AVs. *Household income* was not found to have a specific direction, as middle income individuals are more positive about AVs than are those with lower or higher incomes. Individuals that *drive long distances* or have more *crash experience* were also found to be more likely to make use of AVs. Multiple studies found that *public transportation users* are in general more positive about using AVs and ADS-DVs than those that are vehicles drivers. Based on several studies involving individuals that had different levels of *experience* with AVs indications were stated that the more experience an individual has with AVs, ADS-DVs or automated features in cars the more positive they are towards AVs and ADS-DVs and the lower the number of concerns about such systems they have. Additional to the instrumental and socioeconomic factors, researchers concluded that psychological factors play an important role in the adoption of AVs and ADS-DVs. Perceptions about an AV or ADS-DV like *trust in AVs, safety, security, performance* and *ease of use* are thought to greatly influence the decision to make use of such an (unknown) mode. More positive perceptions about these factors are expected to increase the use intentions of travellers for AVs and ADS-DVs.

3. Which instrumental and psychological factors influence the traveller's preferences for an ADS-DV, and to what extend?

Based on the choice model analysis it was found that travellers perceive both types of ADS-DVs (on a dedicated lane and amongst other traffic) more positive than an alternative method to travel on the last mile. Overall a slight preference for ADS-DVs on a dedicated lane was found on average. However, there exists a lot of heterogeneity for preference of ADS-DV type, indicating that travellers have different preferences. Providing a door-to-door service or surveillance measures like a camera or supervisor in an ADS-DV have positive influence on the decision of travellers to make use of ADS-DVs. A camera in the ADS-DV derives slightly more utility in general than the presence of a supervisor. Like with other modes *travel costs, travel time in-vehicle* and *waiting time* have a negative influence on choosing that mode. Travellers that have higher levels of *trust in ADS-DVs* than average were found to be more positive towards ADS-DVs. Their preference for ADS-DVs amongst other traffic was found to be slighty higher than that of individuals with lower levels of trust. Furthermore, both variations of surveillance in the bus are found to be less important to travellers that have higher levels of trust in ADS-DVs.

Table 8.1 summarises the effects of variables found in literature, the expected effects and the results from the choice modelling analysis in this study. Most results are similar to previous findings and are as expected. It can be concluded however that a camera in an ADS-DV can offer a very good alternative to a supervisor. From the financial point of view of the vehicle operator this could significantly reduce the costs of vehicle operation.

Table 8.1: Influences of factors on travel behaviour

	effect as found in literature	**references**	**expected effect**	**effect found in study**
Instrumental factors				
Travel costs	negative	[45–47]	negative	negative
Travel time	negative	[45]	negative	negative
Waiting time	negative	[45]	negative	negative
Configuration	preference dedicated lane/area	[22, 49, 50]	preference dedicated lane in general (more experience: more in favour of amongst other traffic)	slight preference for dedicated lane, individuals with more trust in ADS-DVs are more positive about operation amongst other traffic

Table 8.1: Influences of factors on travel behaviour

	effect as found in literature	references	expected effect	effect found in study
Presence of transit employee	positive	[50, 52, 53]	positive	*presence of transit employee slightly less important than camera in ADS-DV*
Psychological factors				
Trust in AVs/ADS-DVs	positive	[43, 46, 48, 50, 55, 56]	positive	positive
Socioeconomic factors				
Experience	positive	[46, 48, 52, 53, 58]	positive	*no effect found*

4. Are travellers that have experience with an ADS-DV more favourable of an ADS-DV on the last mile?

Travellers that have experience with ADS-DVs (having used an ADS-DV on one occasion or making use of it on a weekly basis) were not found to have different preferences for ADS-DVs than those that have no experience or only have read or heard something about ADS-DVs. Furthermore inexperienced users were not found to have a need for more surveillance and/or the presence of a supervisor in the bus. This finding is different from the expected effect and assumptions from literature as can be seen in table 8.1. An explanation could be that not the *personal* use experience that an individual has with ADS-DVs is important for determining whether an individual has a positive use intention for ADS-DVs, but that latent variables like the trust an individual has in ADS-DVs are more important in the decision making process.

5. What relations can be found between socioeconomic factors (age, education level, income, gender, current transport mode) and positive/negative perceptions of ADS-DVs?

Males were found to have significantly higher levels of trust in ADS-DVs than females. Furthermore, travellers in regions where an ADS-DV is already in operation also have higher levels of trust in ADS-DVs than travellers in regions where currently no ADS-DVs are present. No significant differences have been found based on age, education level, income or whether someone currently travels by public transport.

6. What groups based on socioeconomic factors (age, education level, income, gender, current transport mode) are most positive towards ADS-DVs?

No differences in ADS-DV preference over other transportation methods were found based on gender, age, income, education level, public transport use, region with or without ADS-DV and the level of experience with ADS-DVs.

7. Could an ADS-DV be a feasible alternative on the last mile from the travellers' perspective?

This study shows that ADS-DVs can be a feasible alternative on the last mile from the perspective of the traveller. From the choice models it can be concluded that travellers perceive both types of ADS-DVs in a positive way. Especially the 'door-to-door' and 'on-demand' aspects are highly valued. In 83.9% of the choice sets that were presented to the travellers an ADS-DV was chosen. In addition to the choice modelling analysis, respondents were presented survey questions showing potential ADS-DV connections in their own work area. 63.6% stated that they would make use of the ADS-DV if it would be available. This number is also interesting since only 49.2% of respondents currently does not make use of public transportation (on more than half of their trips to work), indicating that potentially not public transport users would be willing to make use of public transport instead. Additionally, 37.5% of this group stated that they would want to make use of public transportation in the future if the accessibility to their work area would be improved and 26.1% stated they might do so. Note that these numbers represent the *stated* use of an ADS-DV. Whether an ADS-DV would actually be used is influenced by multiple factors and therefore firm conclusions cannot be drawn from these numbers that are meant for exploratory purposes. Other factors that could for instance influence the actual use of an ADS-DV system include frequency of service, operational hours, walking distance from stops, ordering process of ADS-DV or other available modes.

8. What are the most important reasons for travellers to want to make use/not want to make use of ADS-DVs?

In general most respondents stated that the most important reasons to make use of an ADS-DV were the 'on-demand' aspect of an ADS-DV (42.7%) and the expectation that they would arrive faster at their destination using an ADS-DV (41.1%). For about a quarter of the respondents the green image and the preference for new technologies also played a role, respectively 26.6% and 25%. Most respondents that had indicated that they would not make use of the suggested ADS-DV trajectories stated that the shown lines were irrelevant to them (42.3%). Furthermore, 28.2% of respondents stated that they would prefer to make use of their own transportation mode instead and just under a quarter of respondents stated to prefer to walk or cycle from the station to their work (23.9%). However, compared to other public transport only 1.4% stated to prefer other types of public transport over an ADS-DV. Moreover, only a few respondents selected reasons that indicated that they were hesitant to make use of an ADS-DV: to first see the ADS-DV in operation (5.6%) and preference for a shuttle bus with a human driver (2.8%). Moreover, none of the respondents stated to never want to make use of an ADS-DV. Some respondents in Capelle a/d IJssel stated to select the ADS-DV as there is no alternative means of transportation available. Other reasons provided included that the ADS-DV would be their preferred alternative in case of bad weather, no specific preference for an ADS-DV over other transportation types and that ADS-DVs are part of the technologies currently shaping the world. The only two additional reasons to not make use of the proposed ADS-DVs included a preference for a direct ADS-DV connection from a train station (instead of metro) to the final destination and that the home-work distance would make it inconvenient to travel by means of public transportation.

8.2. Recommendations

Based on the findings from the choice models, additional analyses and supplementary data of specific regions it can be concluded that ADS-DV systems provide a suitable alternative on last mile connections from the perspective of the traveller. Policy makers can be advised take ADS-DV systems into account when considering transportation policies. The key aspects for successful ADS-DV systems include the 'on-demand' and 'door-to-door' services that greatly appeal to travellers. Furthermore, the level of trust that travellers have in the systems plays a big role in developing support for ADS-DVs.

Vehicle attributes & perceptions

- In designing ADS-DV systems camera systems in the vehicle are sufficient for surveillance purposes. Since supervisors are not considered more important (even slightly less) than camera systems, vehicle operators can reduce operating costs considerably by only placing cameras;
- Considering that the *use* experience an individual has with an ADS-DV does not influence the preference for ADS-DVs or the preferred type of surveillance in an ADS-DV, the purposes of showcases and pilots with such vehicles should be reconsidered. The goal should not be to let people *experience* an ADS-DV with the intention to increase the use intention for ADS-DVs of those individuals;
- Individuals with higher level of trust in ADS-DVs are found to be more positive towards ADS-DVs. It could be assumed that by increasing the level of trust an individual has in ADS-DVs the individual would become more positive towards ADS-DVs. However, such a causal relationship can only be assumed, not confirmed from the results of this study. Before investing in measures to increase the perception of trust in ADS-DVs in the population MRDH and other governmental agencies are advised to conduct a follow-up research into the causal effect of trust and use intention of ADS-DVs. Causality could be investigated by conducting a longitudinal study comparing individuals' levels of trust and use intention of ADS-DVS in a region before and after the implementation of an ADS-DV system. It is proposed to integrate this research with locations in the Automated Vehicles on the Last Mile (AVLM) project of the MRDH;
- After confirming the causal effect that increasing trust in ADS-DVs leads to higher use intentions, MRDH is advised to look into opportunities to accustom individuals with AVs and ADS-DVs or other automated driving systems. Automation features in cars or automated trams/metros could for example increase the level of trust in such systems in the general population.

Feasibility & reasons to make use of an ADS-DV

- Besides public support of ADS-DV systems the technological and financial aspects play a large role in the actual realisation of such transportation solutions. Especially investing in the infrastructure needed to accommodate dedicated lane ADS-DVs is very expensive. Technological developments are not advanced enough on the current day and legislation is not yet in place to allow for ADS-DVs that can operate amongst other traffic. A short-term solution for the implementation of ADS-DVs is the integration of the system with existing dedicated lanes for trams and conventional buses. Another approach would be to offer dedicated lane ADS-DV services in developmental areas. When over time more companies and housing are available and the demand for travel in the area increases the ADS-DV dedicated lane could re-purposed for use of traditional buses or tram, ensuring the investment costs stretch over a longer period of time and operational costs can be kept low during the time of limited travel demand. An even more interesting opportunity would be to reassign the ADS-DVs from the newly developed area (where they have been replaced by bus or tram services) to another developing area with low demand. Keeping the vehicles in the cycle for multiple years also results in a better return on investment of implementation costs. To advance technological developments of ADS-DVs that operate amongst other traffic (level 4 and level 5) an integrated approach of policy makers, public transportation operators, vehicle developers, research institutes and users is advised like is currently done in the Spatial and Transport impacts of Automated Driving (STAD) project;
- It must be noted that the focus in this study is on the acceptance of ADS-DVs themselves, therefore little comparison is made between ADS-DVs and alternative modes. From the results of this study it is assumed that ADS-DVs are considered quite similar to other public transportation modes. Only features like on-demand travel and door-to-door services could distinguish the ADS-DV from other alternatives in a positive manner. Especially the comparison of an ADS-DV to for example a shuttle bus or 'belbus' could be interesting, as both modes could offer the same advantages (on-demand and door-to-door services) as ADS-DVs. The only difference would be the presence of a driver. From the results of this study it is assumed that the traveller's mode choice would in such case be primarily based on instrumental factors like travel time and travel costs rather than the presence of a human in the vehicle. In that case the operational costs for public transportation operators would be more important in determining the transportation service offered. To confirm this assumption policy makers are advised to conduct a study to determine the exact place of the ADS-DV in the transportation market. Such a study could be done by a stated preference survey with multiple mode options on the last mile or even combined with full trips or by conducting a revealed preference study on a location after an ADS-DV has been introduced;
- This study focused primarily on last mile connections at business parks. Other potential use cases for ADS-DVs could be in rural areas. As in rural areas the average age increases, less people are able to drive their car, therefore the need for public transportation rises. However, since the population numbers in these areas declined steadily over the past decades, it is very costly for public transportation operators to manage connections on a frequent basis. In these areas the improved accessibility for elderly and other people that are not able to make use of a car could be a big advantage. A follow-up study could be done to investigate whether potential users in rural areas would be interested in using ADS-DVs. The use of ADS-DVs (that operate amongst other traffic) might help reduce the operational costs of transportation services for operators. However, because of longer distances and an expected lower number of travellers per day it is assumed that less advantages of ADS-DVs are present in rural areas than on last mile locations;
- An interesting difficulty for ADS-DVs that operate amongst other traffic is to maintain high punctuality. ADS-DVs on public roads can suffer from congestion just like any other vehicle increasing the travel times and waiting times. In this study the congestion aspect was purposely excluded as it made the choice set very complex for participants and it was assumed that the delays on the short distances of the last mile business park locations would not have a large influence on the overall travel time. In scenarios where the ADS-DVs would operate on larger distances or areas with more dense traffic the increase in travel time could have a large negative influence on the utility of ADS-DV amongst other traffic and lead to a decrease in travellers' use intentions in these situations. It is advised to take this aspect into account when considering studies about ADS-DVs that operate amongst traffic, for example in rural areas or more dense traffic situations. Simulation models (e.g. discrete event) could be used to investigate the effect of congestion on ADS-DVs and to be able to compare ADS-DVs on dedicated lanes to ADS-DVs amongst other traffic. Furthermore, the effect of potential delays could be investigated to

get better insight in the expected negative influence that uncertainty in travel times has on ADS-DV mode choice decisions. This aspect could be investigated using choice modelling.

From the perspective of the traveller ADS-DVs offer a feasible solution to improve the accessibility of last mile connections in business parks. The support for ADS-DVs indicates that the systems could be taken into account when comparing possible measures to increase the share of public transportation users and decrease the share of car users in business parks. When comparing measures the technical and financial feasibility of each measure needs to be determined and further research into the actual effects of the measures on the amount of congestion on the road network in the Randstad area must prove causality of measures and results before implementation.

Policymakers are advised to always let the demand for a transportation system guide the implementation of ADS-DVs. Take ADS-DVs into account when comparing several transportation alternatives, but only implement the ADS-DV if it is considered the best solution to the problem.

9

Discussion & Reflection

This chapter concludes the report on ADS-DVs from a travellers' perspective. Some critical notes on the study are discussed in section 9.1 and a reflection on the study is presented in section 9.2.

9.1. Discussion

While conducting any study limitations, simplifications and considerations affect the results of the study. In this section several aspects that apply to this study are discussed.

Power

In testing hypotheses with statistical tests type I and type II errors could occur. Respectively the chance of concluding that a relationship is present in the population while in fact there *is no* relationship and the chance of concluding that no relationship exist in the population while in fact there *is* a relationship present. The type II error is related to the power of testing a hypothesis (β): power = 1 - chance of incorrectly assuming the null hypothesis (concluding there is no relationship in the population while it does exist). The power for a research should be at least 80%. Aspects that influence the power are the sample size, the value of the coefficient and the size of the significance level (α). A larger sample size, high coefficient value and low value for α improve the power. In this study the α has been set at 0.05, which is a common value in statistics. The sample size of 195 is above the minimum number of 126 that was needed for the choice model. Furthermore, the sample size is not as large that very weak relationships would become significant. Stating that preferably between 15 and 20 respondents represent each parameter, 9.75 - 13 coefficients could be estimated based on the sample with sufficient power. In the final model 13 parameters (and 4 sigmas) were estimated. It can therefore be concluded that the sample size is large enough to give the study sufficient power, although a higher number of respondents would have been preferred.

Self-selection of participants

A problem that occurs often with surveys is self-selection. Some individuals are more likely to fill out a certain questionnaire than are other. This could be the case because they are more interested in the topic, are more positive about the topic or simply like to fill out questionnaires. In general this could effect the results of a study an lead to different or even more positive reactions. Of course such effects could have played a role during this study as well. Based on the general positive reactions that people gave when addressed about this topic in person, it is likely that the positive attitude towards ADS-DVs that can be concluded from this study is in fact present in the population of business parks. However, since it cannot be ruled out that some of those individuals also participated in the survey the positive reaction towards ADS-DVs could still be overestimated in the study.

Socioeconomic variable: household income

The socioeconomic variable *nett household income* was derived from the answers of the respondents. However the comparison of the socioeconomic variable over individuals is difficult as no information is available on the type of household, number of persons in the household and whether multiple incomes are earned. To make a fair comparison between individuals this information would be necessary. In this thesis the variable did not play a central role and as such it is not considered to have influenced the results. However, for follow-up research it is advised to ask additional information on household configuration.

Choice set design

Given the design of the choice sets that were used in the choice model, the ADS-DVs could also be chosen over other modes more often because the other mode were combined in the option 'other transportation method'. Representing other modes as a combined group without any specifications could influence participants to pick the more clear alternatives of ADS-DVs. However, it was clearly stated in the question and answer that the trip entails a 1.5 kilometre journey from a train station to their work location. Therefore it is likely to assume that travellers were able to imagine other (conventional) transportation methods themselves and provide an indication of accompanying costs, travel times, waiting times and additional aspects. This indicates that travellers do consider ADS-DVs as possible alternatives on the last mile. However, to get better insight in how ADS-DVs compare to other types of last mile alternatives it is advised to conduct a follow up research purely based on *which* mode travellers would prefer on the last mile and why. Furthermore, it is advised to include the aspects of 'on-demand' and 'door-to-door' travelling into the ADS-DV alternative as travellers state the importance of these features. An additional advantage from concluding that the level of experience an individual has with ADS-DVs is less important than the level of trust in ADS-DV leads to easier possibilities to set up research designs. Researchers do no explicitly need participants that have experience with ADS-DVs in order to draw conclusions about ADS-DV use intentions. More important is to review the perceptions that individuals have with regard to ADS-DVs.

Multiple latent variables

In the Factor Analysis in this study the indicator variables loaded on three factors. However it is assumed that due to too much correlation between indicators it was impossible to derived multiple separate factors. Additionally the indicators that loaded on the first factor did not have high enough communalities to be combined into one factor. The perceptions of ADS-DVs based on *trust, safety, security, performance* and *ease of use* as initially defined by the used statements have too much in common to be used in one study. To be able to investigate the effect of security, performance and ease of use researchers are advised to make use of even more specific statements, assume more indicator per variable or investigate the latent variables in seperate studies.

Factor score calculation of trust in ADS-DVs

For the Factor Analysis regression scores were calculated for each individual. A disadvantage of the used of regression scores is that the mean value 0 represents the *average* level of trust an individual has in ADS-DVs. This is not similar to an average level of trust for ADS-DVs. The interpretation of the latent variable is therefore less intuitive. A positive value for an individual represents that this individual has more trust in ADS-DVs than average. One could imagine that an interpretation where a positive value indicate that an individual has trust in ADS-DVs and a negative value that an individual does not have trust in ADS-DVs is easier. In that case the results from the choice model regarding the latent variable could be interpreted in a similar manner. The average for the variable is around 3.6 providing multiple individuals that have a positive level of trust with a negative regression score in the current model. One can expect that the parameter values might be stronger when a negative score value represents a negative perception of trust in ADS-DVs.

Effect of experience on the level of trust in ADS-DVs

From independent T-tests and One-way ANOVA tests it was derived that those that have more trust in ADS-DVs (and are therefore more positive towards ADS-DVs) are most likely male and have a job in a region where an ADS-DV is in operation. Not relation between experience and the level of trust an individual has in ADS-DVs was found although one might assume so. The One-way ANOVA was not significant with a p-value of 0.05. The value of 0.05 could imply a that an less powerful relation could be present. In this study the relation is not clear enough to draw a conclusion whether those with higher levels of experience with ADS-DVS have more trust in ADS-DVs than those with lower levels of experience. It is therefore advised to conduct a follow-up research to determine whether a less powerful effect of experience on trust in ADS-DVs is present.

Sample group: experience

The individuals within the sample group that stated to have use experience with ADS-DVs were generally of lower ages (18-35) and had lower household incomes. From literature it would be expected that younger individuals would be more positive towards ADS-DVs than those of higher age groups. From the choice modelling analysis it was found however that no differences were present in preferences for ADS-DVs for individuals that have experience and individuals that do not have experience. Since the effect of age was expected to enhance the positive effect of experience and no effect was found, it is assumed that the difference in average age between the groups has not influenced the results of the study. Similarly, since no effects are expected of household income on the preference for ADS-DVs the differences in average household income between the groups are not considered to have influenced the results.

Configuration of ADS-DVs

It must be noted that the conclusion drawn about a slight preference for ADS-DVs on a dedicated lane over ADS-DVs that operate amongst traffic in general and the conclusion that individuals that have higher levels of trust in ADS-DVs than average are more positive about ADS-DVs that operate amongst other traffic than individuals with lower levels of trust are not based on the isolated effect of vehicle configuration. The attribute of configuration was included as a label in the choice set not as a separate attribute value. This means that the preferences found in this study are not based solely on the aspect of vehicle configuration but are influenced by the error term of all aspects not considered in the choice model. Since it is assumed that the main effect of the alternative specific constant is in this case influenced by the configuration, the conclusions were addressed to that attribute. However, to be able to confirm the actual influence of the configuration of the ADS-DV on the decision making process the attribute should be included as an attribute in a follow-up study.

Travel expenses

The value of time found in this study is relatively high (12.38€/hour). This can be explained by the fact that 82.1% of participants receive refunds for (part of) their travel expenses. Different values of time couold be calculated for the groups. However, in this study it was decided not to calculate separate values as (1) the percentage of travellers that do not receive refunds is quite small and (2) considering that this study investigates work-related travellers only it is assumed acceptable that the value of time is higher. When interpreting the willingness-to-pay for the other attributes (waiting time, type surveillance in the ADS-DV and service type) it must be taken into account that these values are also higher than average. In other words, the willingness-to-pay for the attributes of ADS-DVs could be lower for other trips, and the values can therefore not directly be transferd to designing and pricing ADS-DVs for other purpose trips, e.g. shopping or leisure.

95% confidence interval

In this study the working of the choice model was illustrated by calculating the probabilities that each alternative would be chosen. To give more a better estimation the 95% confidence interval for each probability could have been calculated. A confidence interval represents the range in which the probability value falls for the whole population. The 95% confidence interval provides a range with a 95% chance that the actual probability for the population is within that range instead of implying that the model can calculate the exact probability for each alternative.

Comparison to other studies

Findings from the explorative study into preferences for AVs by Yap et al. [43] concluded that first class train travellers have a preference for AVs on last mile connections while second class train travellers do not. From this study however it can be concluded that ADS-DVs on the last mile are favoured in general independent of the current mode. Explanations for this difference can be that (1) in this study no distinction was made between first and second class train travellers. However, the strong conclusion that first class train travellers are more positive towards AVs that Yap et al. bring forward could also be influenced by the set up of the choice set. First class train travellers were offered a discount (even up to 70%) on the AV fare. Therefore the pure preference of the AV itself is hard to determine. (2) The choice sets in this study did only focus on last mile connections and do not offer a full trip alternatives, whereas Yap et al. consider full trips. (3) A different type of AV was presented in both studies. Yap et al. introduced 'cybercars' that can be shared with *a few* passengers or be private and could be driven manually or automated. This system is different from the ADS-DV used in this study that operates automated on all trips and offers room to up to 10 passengers.

Both studies are in agreement on the strong influence of trust in the system on the utility of the AV/ADS-DV. Higher trust results in higher utilities. To conclude, this study states that an overall interest is present for the use of ADS-DVs on last mile connections and questions whether the actual preferences for AVs of first and second class train travellers are as distinct as presented by Yap et al. It is advised to conduct a follow-up research with ADS-DVs including multiple mode alternatives (both on the last mile and full trip) in the choice set without any fare discounts (for first class train travellers).

Bunschoten [86] concluded that in regions were a tram was present as travel mode, the preferences for this mode were higher than in regions where no tram was available. In this study it was found that travellers in a region with an ADS-DV available did not directly have higher preferences for ADS-DVs, however the trust in ADS-DVs was found to be slightly higher. Moreover, travellers that have higher levels of trust in ADS-DVs do have a slightly higher preference for ADS-DVs and are more willing to make use of ADS-DVs that operate amongst other traffic. Furthermore, younger individuals were found to have higher levels of trust independent of the region that they work in. Therefore it can be concluded that the ’tram bonus’ of Bunschoten [86] is not present as such, however individuals in areas where ADS-DVs are in operation do have higher levels of trust and therefore are indirectly more positive towards ADS-DVs.

In this study it is concluded that the different levels of experience an individual has with ADS-DVs does not lead to different preferences for ADS-DV types or different perceptions about ADS-DVs. Earlier studies found that individuals that have more knowledge on ADS-DVs/AVs lead to increased willingness to use such systems [48, 52]. Furthermore, Vöge and MacDonald [53, 61] stated that individuals with experience with riding an automated vehicle did have less concerns about such systems. The difference in conclusions can be explained by the fact that in previous studies only pilot vehicles were used, no long-term permanent systems. All participants to this study were informed of the existence of the ParkShuttle ADS-DV in Capelle a/d IJssel that has been in operation for over 15 years. This might transform the concept of a *self-driving bus* from a future mode to a present day alternative, influencing individuals’ perceptions of ADS-DVs and their use intentions for such systems.

Winter et al. [87] stated that the mode preference for automated vehicles had to do with the aspect of vehicle automation. Individuals that were categorised as early adopters of mobility trends were more positive towards the shared autonomous vehicles, than were those that are categorised as normal and late adopters. The latter categories even showed a clear aversion towards shared autonomous vehicles. In this research however individuals were all found to be positive towards ADS-DVs no matter the level of experience with ADS-DVs. Explanations for this difference in findings can be based on (1) the type of vehicles: ADS-DVs are a ’proven’ technology, while the shared autonomous vehicles in Winter et al. [87] are not yet available, (2) alternative modes: Winter et al. have included alternative modes in the choice sets which which represents more realistic choice options than were used in this study, perhaps the preference for ADS-DVs would also be lower if clear alternatives were present or (3) self-selection: this survey was distributed under employees of business parks on a voluntarily basis, while the survey of Winter et al. was distributed through a survey company, therefore it is possible that participants in this survey are be more positive towards AVs in general than those in the study by Winter et al.

9.2. Reflection

Writing a thesis is the final examination of your masters programme, completing the curriculum of various courses, group projects and excursions. The first phase of the thesis is one of the hardest, looking for a topic that combines several (sometimes contradictory) aspects: the topic needs to be (1) state-of-the-art in science, (2) relevant to the collaboration company and (3) needs to suit your personal interests. After some struggles I managed to find a topic that fitted all three of the requirements and kicked-off my final project. Besides some small hurdles the progress of the thesis went rather smoothly. Until the moment I reached the distribution of my survey. This did not go as planned beforehand. It turned out that the distribution of the survey via interest groups was quite unsuccessful. From Rijswijk and Beatrixkwartier combined only 15 responses were collected this way. For Rivium there were direct email addresses available of about 300 employees in the area. These individuals had participated in a programme of the Municipality Capelle a/d IJssel to increase business interaction in the region. Distribution through this channel was very successful: in Rivium 101 surveys were completed. Still, it was essential to increase the number of respondents in the areas without an ADS-DV. Extra reminders via the interest groups did not lead to higher response rates and some companies replied not to be interested in distributing any survey, which could indicate that more companies had not distributed the survey to their employees. A different approach was needed to collect sufficient respondents. I decided the only option to gather more participants without getting to far behind on schedule was to start handing out flyers. I designed small flyers that could attract the attention of travellers in the regions. Via a QR-code or (short) URL on the flyer respondents could easily access the on-line survey. I distributed a total of 500 flyers by handing them out at main tram and train stations and I left several at lunch rooms and coffee bars. The handing out of flyers in Beatrixkwartier and Rijswijk resulted in an additional 85 responses to the survey. An unexpected effect of flyering was the nice conversations I had with the people I addressed and the great support and feedback you receive from talking about your work with strangers.

Looking back at the whole process of the project I believe that unexpected disruptions can give a refreshing new view on your own work. I would advise however not to rely on companies to distribute your survey. When companies prevent their employees from deciding on their own whether they want to participate no responses can be gathered. People are very willing to fill out surveys if you approach them in the right way, so I recommend to make use of direct email addresses, flyers or even get help from survey distribution companies. All-in-all I would argue that a thorough planning and being able to cut yourself some slack if things do not work out as planned are the building blocks of good thesis.

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Appendices

A

Detailed literature overview

This appendix discusses relevant literature used in the theoretical framework of this thesis in more details. Table A.1 refers to McFadden [88] on psychological and econometric worldviews. Table A.2 summarises the literature on personal automated vehicles and table A.4 summarises the literature on shared vehicles with a psychological research approach. Similarly tables A.3 and A.5 summarise the literature from a econometric worldview for respectively personal and shared automated vehicles. Additionally tables A.6 and table A.7 give additional information on choice modelling in general and on integrated choice and latent variable models.

Table A.1: Literature on psychological & econometric worldviews for choice behaviour

Reference	Method	Most important findings	Remarks
McFadden [88]	psychology vs. traditional economics	Information and experience are, together with emotions, the key determinants of preference formation according to the standard behavioural choice model	

Table A.2: Literature on personal automated vehicles - psychological worldview

Reference	Method	Most important findings	Remarks
König and Neumayr [48]	questionnaire & regression analyses	Higher familiarity with AVs (having heard of them) leads to significantly more positive attitudes towards AVs. Young people and men where found to have more positive attitudes. Using an AV was found more attractive than buying an AV. The benefits of improved accessibility and the possibility to engage in other activities than driving were rated as most valuable by the respondents. Most respondents did not feel that a self-driving car would give them social recognition nor did they trust that self-driving cars would yield shorter travel times. Concerns were highly rated than benefits in general, with legel issues and possible attacks from hackers. Furthermore a lack of trust was found in all respondent groups, although younger people and those familiar with automated features showed a not significant lower value of concern. The threat of job loss and the risk that self-driving cars might not drive as well as human drivers were seen as the least concerns. In asking respondents how they would like to see strategic implications to overcome concerns towards self-driving cars, the possibility to take over driving whenever wanted, offering free test rides and comprehensive information in the showroom were ranked at the top. Least valued were tax incentives to promote sale of self-driving cars, special lanes for the vehicles and the involvement in the development process.	Sample selected by convenience sampling in the light of an exploratory study, however, this might leads to biases in the results.

Table A.2: Literature on personal automated vehicles - psychological worldview

Reference	Method	Most important findings	Remarks
Zmud et al. [46]	survey & face-to-face interviews & regression model	Division of respondents over use intention for AVs was split 50-50. 18% were strong rejectors, while 34% were labelled as enthusiasts. The most important concerns influencing the non-users were concerns about lack of trust, safety and costs. Males are more likely to use than females, lower income house holds are less likely and middle income ($25,000-$50,000) are more likely to use AVs. Individuals with higher incomes were equally likely and unlikely to use. Currently owning or leasing a vehicle was not found to have an effect on an individual's intent to use. Respondents that were familiar with automated car features were more likely to be enthusiasts than those unfamiliar. Of commuters that currently are vehicle drivers 48% were likely to use AVs, while of other modes 57% stated to be likely to use AVs. No significant effect for age were found. The profile of individuals with a higher level of intent to use AVs includes the belief that AVs reduce crash risk, AVs would be fun, AVs will be easy to use, less concern on data privacy, technology prone, believe their peers would like AVs too and might have any physical conditions that prohibit them from driving.	Sample group of Austin, Texas
Bazilinskyy et al. [55]	categorising positive and negative statements of three previously conducted surveys	Public opinion on FAD is split with significant numbers of positive and negative attitudes. A share of the respondents does not trust automated vehicles and prefers to driver manually. Inhabitants of higher-income countries were more likely to express negative comments on automated driving than those of lower-income countries.	Surveys were conducted on CrowdFlower platform which are argued to not represent the entire population of stakeholders of future FAD vehicles. These respondents generally have low incomes, neglecting the share of more wealthy people who are likely to be the earliest adopters of such technologies.
Choi and Ji [56]	survey & partial least squares	Perceived usefulness and trust are of major influence on the use intention of autonomous vehicles. Trust is found to have a negative influence on perceived risk. Sensation-seeking was not found to have a significant effect on use intention, while locus of control does have significant effect.	
Diels and Bos [62]		Motion sickness can negatively affect user acceptance of automated vehicles. Designs of self driving cars need to consider perceptual mechanisms, where these cannot simply be though of as living rooms, offices and entertainment venues on wheels.	

Table A.2: Literature on personal automated vehicles - psychological worldview

Reference	Method	Most important findings	Remarks
Schoettle and Sivak [47]	survey	Most respondents were familiar with the term self-driving vehicles and had a positive opinion about them. The highest levels of concern were found in security issues related to the vehicles and the risk of the vehicle not performing as well as a human driver. Furthermore, concerns were found about the omitting of driver controls, vehicles driving while unoccupied and commercial self-driving vehicles, buses and taxis. Most respondents stated they would be interested to have the technology in their cars, however most were unwilling to pay extra for the technology. Females were found to be more reluctant towards the benefits of self-driving vehicles and had more concerns than did males.	Sample groups in UK, US and Australia
Kyriakidis et al. [58]	questionnaire & correlation analyses	Respondents are most concerned about software hacks, misuse, legal issues and data transmitting. Mileage and current ACC use have strong positive correlations with willingness-to-pay for automated vehicles. Division between respondents in favour of fully automated vehicles and respondents thinking it will not provide an enjoyable experience and are not willing to pay for it.	Worldwide sample group
Payre et al. [60]	questionnaire & confirmatory factor analysis & ANOVA	Respondents attitude of sensation-seeking correlates positively with use intention of full automated driving (FAD). FAD use intention is highest in stress-full and monotonous driving conditions, except in built-up areas. 71% of respondents state they would use FAD when impaired. Men have more positive attitudes towards FAD than women.	All French respondents. Unbalanced gender proportion in sample group.
De Jong and Van de Riet [89]			
Rudin-Brown and Parker [57]	experiment	Drivers trust in ACC increased significantly after using the system.	

Table A.3: Literature on personal automated vehicles - econometric worldview

Reference	Method	Most important findings	Remarks
Bansal et al. [7]	survey & univariate OP estimations (regression)	AV adoption rates depend on adoption rates of friends and neighbours. 'high-income, tech-savvy males, living in urban areas and having greater crash experience have more interest in and a higher WTP for these new technologies, with less dependence on friends' adoption rates.' Respondents that drive more have a higher WTP.	Sample group of Austin, Texas

Table A.4: Literature on shared automated vehicles - psychological worldview

Reference	Method	Most important findings	Remarks
Madigan et al. [59]	pilot & questionnaire & multiple regression model	The decision to use an ARTS is strongly influenced by the performance expectancy of the system, influences of other people and the perception of how difficult the system is to use.	
Louw and Merat [50]	in-depth interviews (26 participants)	80% unfamiliar with AV. 60% did not see a benefit of automated road transportation system (ARTS) over existing public transport. Preference for dedicated vehicles over shared configuration, trust in the system was present however concerns were present about safety. Respondents showed a preference for clear demarcations, e.g. zebra crossings and marked lanes. 50% said no information on detection and movement would be necessary during the trip. Other concerns include slow vehicle speed, the lack of a driver and the fear of unreliable technology.	
Gorris and Kievit [44]	demonstrations and pilots of ARTS & questionnaires	Over six locations, ease of use of an ARTS was best perceived by travellers. Average satisfaction of usefulness, reliability, integration with other systems, perception of safety and the perceived level of privacy were found. The average price travellers would pay for the trip was a little less than €2.	
Voge and McDonald [53]	demonstration of AV & questionnaire	Vehicle and system performance where highly rated. Slight concerns arise over increased travel times due to low vehicle speeds and personal safety due to the absence of a driver. Positive responses to the use automated urban transportation systems (AUTS) were found, especially for younger age groups and users of public transportation. Some concerns mentioned in **?**] were less represented in this study, suggesting that these were mainly due to unfamiliarity and lack of experience with AVs.	Respondents of this study are not similar to those in **?**], for this reason assumptions on causalities regarding experience need to be handled with care.
?]	focus groups & individual interviews	Expected advantages of AV as reported by end-user respondents: increased traffic safety and environmental benefits. Requirements: on-demand services with waiting times not exceeding 5 min. vehicle speeds up to 80 km/h and integration with other modes of transport.	

Table A.5: literature on shared automated vehicles - econometric worldview

Reference	Method	Most important findings	Remarks
Yap et al. [43]	survey & discrete choice model	First class train travellers prefer AVs over bicycle or bus/tram/metro as egress mode. In-vehicle time in AV is experienced more negatively than in-vehicle time in manual driven cars. Trust and sustainability play an important role in the attractiveness of AVs.	The AVs are presented as small vehicles without trip sharing.
Alessandrini et al. [49]	questionnaire & three binomial logit models	Preferences for an automated minibus within a major facility were found, similar to **?**].	

Table A.5: literature on shared automated vehicles - econometric worldview

Reference	Method	Most important findings	Remarks
Dong et al. [52]	survey & mixed logit modeling framework	Two-thirds of respondents state a willingness to ride a driver-less bus when a transit employee is aboard the vehicle, while only 13% would agree to ride a bus without a transit employee. Males and 18-34 years old are more willing to ride a driver-less bus. The probability of being unwilling to make use of a driver-less bus is lower for respondents that who have prior knowledge of automated vehicles. Vehicle operational and personal safety are the most common concerns under respondents.	mixed logit framework conducted with Likert scales, not choice modelling
Krueger et al. [45]	survey & stated choice model	Service attributes like travel cost, travel time and waiting time have strong influence on SAV preference. Young individuals and individuals with multimodal travel patterns may be more likely to adopt SAVs.	
Alessandrini et al. [22]	questionnaire & logit model	Relatively higher preference for ARTS where it is implemented inside a major facility.	Only explanatory variables are taken into account (waiting time, riding time, fare and personal characteristics)
Site et al. [51]	two questionnaires & logit model	The preference for the automated bus is found higher than for the regular minibus while scenario and level-of-service attributes being the same. The ASC for the automated bus is higher than for the minibus, suggesting that additional attributes specifically related to automation play a role.	Buses offered as free shuttle service to connect a fair with a car park.

Table A.6: Literature on mode choice modelling

Reference	Topic	Most important findings	Remarks
Dziekan and Kottenhoff [90]	mode choice in general	Travellers like at-stop real-time information on transit services and have positive attitudes towards it.	
Martínez and Comejo [91]	mode choice in general	Fare price has a negative influence on mode choice, while service frequency and modal comfort have a positive influence.	
Cervero [92]	mode choice in general	In general travellers are approximately twice as sensitive to changes in travel time as to changes in fares. Increased travel costs for car will have significantly higher effect to increase transit usage than to lower or free transit fares.	
Taylor et al. [93]	mode choice in general	Regional geography, household income, car possession and political preference are of influence on public transit usage and transit policies changing fares and service frequency make significant difference.	
Schwanen and Mokhtarian [94]	mode choice in general	Dissonant urban residents and suburbanites leads to a higher use of private vehicles	

Table A.6: Literature on mode choice modelling

Reference	Topic	Most important findings	Remarks
Vilimek and Keinath [95]	electric vehicles		

Table A.7: literature on Integrated Choice and Latent Variable models in transportation

Reference	Topic	Latent variables	Method	Most important findings	Remarks
Correia et al. [73]	car pooling	positive/ negative attitude towards carpooling	survey & ICLV model: SEM + discrete choice model	A positive attitude towards car pooling plays an important role in the decision to participate in a car pooling group. An effect that could only be taken into account using ICLV modelling.	
Bolduc et al. [74]	new technology features for cars	environmental concern/ appreciation of new car features	survey & ICLV model: SEM + discrete choice model	The authors state that including perceptions and attitudes in the model allows for a more realistic modelling of choice behaviour and gives a better description of the profile of the consumers an their adoption.	
Yáñez et al. [72]	effect of latent variables on mode choice	reliability/ comfort&safety/ accessibility	survey & ICLV model: SEM + discrete choice model	The hybrid choice model was found to have a better fit than the models without latent variables.	Endogeneity issues can arise as both perceptions of modes and attributes representing those modes are included in the choice model.
Daziano and Bolduc [96]	green automobile technologies	environmental concern	survey & ICLV model: SEM + discrete choice model	The model is found to outperform standard discrete choice models as it includes pro-environmental features as well as providing a tool to create a profile of environmentally-conscious consumers.	
Fleischer et al. [71]	impact of fear of flying on flight choice	fear of flying (FOF)	survey & ICLV model: SEM + discrete choice model	Significant differences were found in choices of individual that have a high level of FOF than those that have a low level.	
Fernández-Heredia et al. [97]					
Fernández-Heredia et al. [98]	bicycle use intention	convenience/ pro-bike/ physical determinants/ external restrictions	survey & ICLV model: SEM + discrete choice model	Bicycle use intention model? Combinint use intention and choice modelling?	

Table A.7: literature on Integrated Choice and Latent Variable models in transportation

Reference	Topic	Latent variables	Method	Most important findings	Remarks
Vredin Johansson et al. [4]	mode choice in general	mode choice	survey & ICLV model	Attitudes towards flexibility and comfort, and being pro-environmentally inclined influences mode choice.	

B

Methodology: ICLV in depth

The name Integrated Choice and Latent Variable (ILCV) model was first mentioned by Bolduc et al. [99] but earlier work on the topic dates back to Ben-Akiva et al. [100], Walker [101] and Walker and Ben-Akiva [102]. The first intentions to combine choice models and latent variables even dates back to McFadden [103] and Train et al. [104] in 1986/1987. Much progress has been made in the development of these models. Their advantages over the traditional choice model include greater explanatory power of the choice model, reduced parameter biases and a better model fit [105]. The ICLV modelling technique (also known as Hybrid Choice Modelling) has been used in multiple transportation researches to explain travel choices through personal traits, attitudes and perceptions [4, 71–74, 96–98].

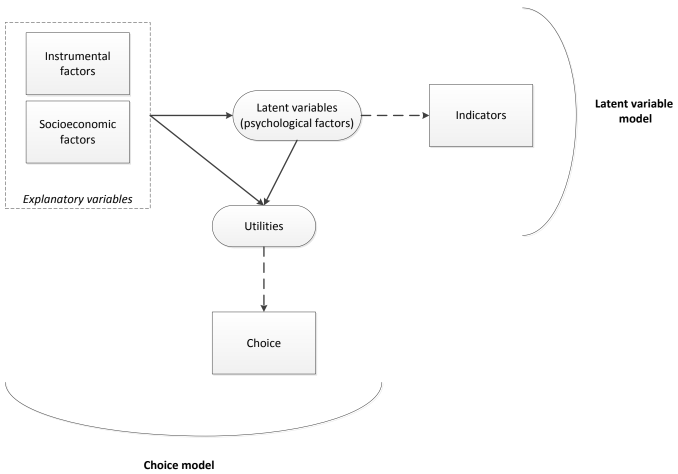


Figure B.1: Integrated Choice and Latent Variable framework, derived from Ben-Akiva et al. [100] - *edited*

An example of framework as presented by Ben-Akiva et al. [100] is shown in figure B.1. Underlying the framework is the extended structural utility equation B.1 [105]. Where U_n represents the utility that an individual (n) tries to maximise, which consists of a systematic part: $V(X_n, X_n^*; \beta)$ and an error part: ε_n. The systematic utility V is a function of a set of observable explanatory variables of the individual (x_n) and a set of unobservable explanatory variables of the individual (x_n^*). B and ` are model parameters denoting sensitivities to the observable and latent variables, respectively. Error part (ε_n) is the vector of random disturbances, which is distributed $\varepsilon_n \sim D(\theta_\varepsilon)$, where θ_ε are unknown parameters.

$$U_n = Bx_n + `x_n^* + \varepsilon_n \tag{B.1}$$

The latent variables are represented by X_n^* for which equation B.3 hold. A is the model parameter denoting a structural relationship between latent variables and observable variables and υ_n a random disturbance term.

$$x_n^* = Ax_n + \upsilon_n \tag{B.2}$$

The indicators used to measure the latent variables are included in the model as i_n, which is assumed to show deviations from the mean, equation **??**. D represents the model parameters denoting the sensitivities of the measurement indicators to the latent variables and η_n is the random disturbance term. Stochastic components $\varepsilon_n, \upsilon_n$ and η_n are assumed to be mutually independent.

$$i_n = Dx_n^* + \eta_n \tag{B.3}$$

The Random Utility Model assumes utility maximisation which means that the decision-maker n chooses alternative j if and only if the utility of that alternative is the highest, equation B.4.

$$y_{nj} = \{ \begin{matrix} 1 & \text{if } u_{nj'} \text{ for } j' \in \{1,...,J\} \\ 0 & \text{otherwise} \end{matrix} \tag{B.4}$$

The improvement of ICLV models over traditional choice models is that it describes how perceptions and attitudes affect choices and use both information on observed choices and indicator questions to inform the estimation of these latent variables. This advanced method is in recent studies performed both sequentially [4, 106] and simultaneously [102, 106–108]. In the first case the latent variable model and choice model are calculated separately, while in the second case the models are estimated jointly. Bolduc et al. [99] states that consistency can be achieved using the sequential approach while the simultaneous estimation adds efficiency.

The construction of latent variables from indicators is often performed by Structural Equation Modelling (SEM) [109] or Factor Analysis. SEM models allow for testing of *indirect* effects besides *direct* effects between variables, furthermore, the silmutaneous estimation of the measurement model and the structural model leads to a correction of the measurement error [**?**].

An ICLV model can be estimated with full information (*simultaneous*) or *sequential*. In chapter it is discussed in more detail that although the simultaneous estimation method would lead to more efficient results, the increased complexity and mathematical workload of the model have been decisive to estimate a sequential model in this thesis. The sequential framework that is applied is shown in B.2.

B.1. Multiple Indicator Multiple Causes Model

A Multiple Indicator Multiple Causes Model (MIMIC) is a special case of SEM that consists of two parts, a *measurement model* which defines the relations between the latent variable and its indicators and a *structural model* which specifies the causal relationships among latent variables and explains latent effects Jöreskog and Sörbom [110]. First the latent variables are determined and estimated in the measurement model using *Exploratory Factor Analysis* (EFA) and then the structural model is estimated using *Structural Equation Modelling* (SEM).

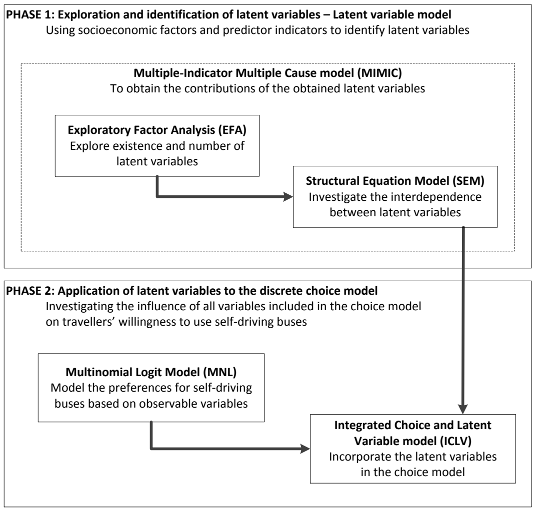


Figure B.2: Lay-out of ICLV approach

B.1.1. Factor Analysis

The result from the factor analysis in section 6.1.4 also apply for the ICLV. However, althoug the same latent variable *trust in ADS-DVs* is used in the Structural Equation Model, the values are recalculated.

B.1.2. Structural Equation Model

SEM is used to check theories that are expressed in relationships among measured variables and latent constructs (variates). SEM will assess how well the theory fits the reality as represented by the data. SEM analyses involve testing both measurement theory (how the constructs are represented) and structural theory (how the constructs relate to each other). In this research the Multiple Indicators Multiple Causes (MIMIC) approach is used [111]. In order to prevent endogeneity in the choice model, the indicators need to be chosen to have none or minimal overlap with the explanatory variables.

Examining impact of (covariates) personal characteristics on constructs/factors and the impact of one construct on the other...

B.2. Choice model

For the choice model part of the ICLV, again a ML model is estimated. The latent variable values that were estimated in the latent variable model (MIMIC) are included in the MNL base model as composite factors.

B.3. Software

The reader is referred to the report by Bierlaire [112] for information on the estimation of choice models with laten variables in Biogeme.

B.4. Criticism on Integrated Choice and Latent Variable models

Even though latent variables as attitudinal and perceptional variables are often used in current research to improve the explanatory power of choice modelling, Chorus and Kroesen [113] urge to use latent variables with caution for travel demand determination and transport policies. They argue that the endogenous character with respect to travel behaviour of latent variables and the cross-sectional collection of data do not support causal effects of latent variables on travel behaviour in individuals. In other words, the travel behaviour itself can influence perceptions and attitudes of individuals, and only provided with cross-sectional data a researcher cannot conclude on the effect of changing an individuals perceptions and attitudes on travel behaviour. Although a large focus in this thesis is on the *observable* variable experience, excluding the variable from the aforementioned criticism, it must be taken into account that no conclusions can be drawn with respect to changing individual values of perception on mode choice due to the cross-sectional setup of this study (c.q. the assumption of causal effects of policy measures to change perceptions of travellers and therefore their preferences for ADS-DVs cannot be proven thoroughly in this thesis and such assumptions should be addressed with care).

A recent paper by Vij and Walker [105] stresses that the advantages of ICLV models are only valid under certain circumstances. A researcher is wise to check whether the study objective can benefit from the use of more complex ICLV models over traditional choice modelling. In most cases the model fit will not be improved by inclusion of latent variables. The model's prediction leads to more or less similar results and influence factors in both ICLV and traditional choice models. This can be explained by the assumed causal relation between explanatory (observable) variables and latent variables. However, in case these variables are merely correlated (instead of causaly related) a different outcome may be expected. Furthermore, the use of ICLV models offers the opportunity to decompose the influence of explanatory and latent variables. In this thesis especially the latter advantage is relevant, as it offers the possibility to identify the separate influences of psychological and instrumental factors and insight in the direct and indirect effects of experience on mode choice.

C

Final survey design

In this appendix the full design of the final survey is included. Note that for several questions *logic jumps* are integrated in the on-line survey, this enables that respondents are presented questions according to previously given answers.

Bussen die tussen ander verkeer kunnen rijden zijn nog in ontwikkeling, zoals de WEpod in Ede-Wageningen

Buses that can operate between other traffic are still in development, like the WEpod in Ede-Wageningen

Met een zelfrijdende bus naar werk?

Would you ride a self-driving bus to work?

De enquête is relevant voor u ongeacht op welke manier u nu naar het werk reist. Als u nu geen gebruik maakt van het OV ben ik juist ook benieuwd welke redenen u daarvoor heeft en of u mogelijk wel geïnteresseerd zou zijn om gebruik te maken van een zelfrijdende bus.

Your opinion is relevant regardless of how you currently travel to your work. If you do not make use of public transportation I would like to find out for what reasons you prefer other modes and whether you might still be interested to make use of a self-driving bus.

Bekijk de video voordat u verder gaat naar de enquête (geluid niet nodig)

Please watch the video before you continue to the survey (no sound required)

continue press ENTER

1 → In welke taal wilt u deze enquête invullen?
*Please select your preferred survey language**

A Nederlands B English

This survey is part of my graduation research at the Delft University of Technology and the Metropoolregio Rotterdam Den Haag as part of the STAD project (stad.tudelft.nl).

The research is focused on how travellers value *self-driving buses* on their trip from home to work. Knowledge on this topic is still limited and with your contribution we hope to get new insights. Even if you currently make use of your own transportation to travel to work, your opinion is valuable to this research.

After participation you can voluntarily leave your e-mail address at the final page to take part in a prize lottery to win one of the five €20 'bol.com' vouchers.

All information provided in this survey will be used for research purposes exclusively and will not be shared with any third parties. The survey will take about 7-10 minutes to complete (30 questions). It is **not** possible to save your answers and resume later.

I hope you would like to participate and I look forward to your contribution!

Kind regards,
Marissa Dekker

For questions or remarks you can contact me at: mj.dekker@mrdh.nl

Marissa Dekker

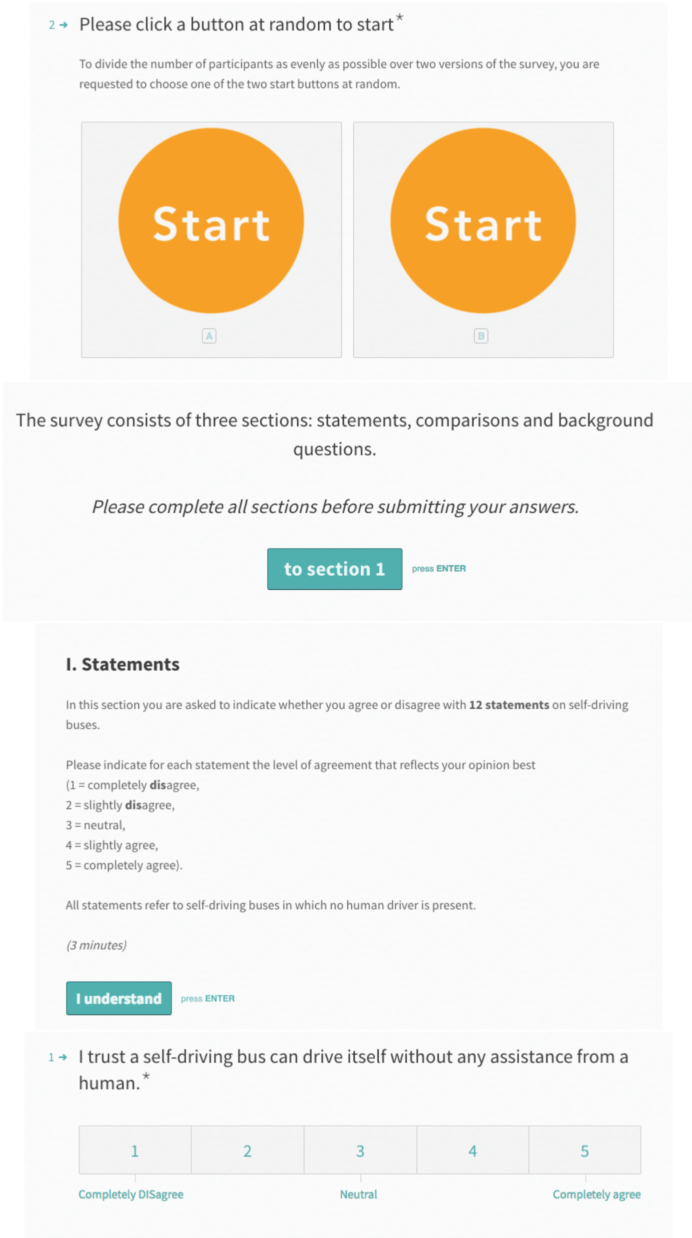
TU Delft MRDH METROPOOLREGIO ROTTERDAM DEN HAAG Spatial and Transport Impacts of Automated Driving

Continue press ENTER

" Note: this survey is meant for employees of the following regions:
Beatrixkwartier in Den Haag (The Hague)
Plaspoelpolder, *Broekpolder* en *Hoornwijck* in Rijswijk
and *Rivium* in Capelle a/d IJssel **including** the *Schaardijk* in Rotterdam.

Please make sure that your office is located in one of the mentioned regions before you continue the survey.

Continue press ENTER


2 → Please click a button at random to start*
To divide the number of participants as evenly as possible over two versions of the survey, you are requested to choose one of the two start buttons at random.
Start
A
Start
B
The survey consists of three sections: statements, comparisons and background questions.
Please complete all sections before submitting your answers.
to section 1
press ENTER
I. Statements
In this section you are asked to indicate whether you agree or disagree with 12 statements on self-driving buses.
Please indicate for each statement the level of agreement that reflects your opinion best
(1 = completely disagree,
2 = slightly disagree,
3 = neutral,
4 = slightly agree,
5 = completely agree).
All statements refer to self-driving buses in which no human driver is present.
(3 minutes)
I understand
press ENTER
1 → I trust a self-driving bus can drive itself without any assistance from a human.*
1
2
3
4
5
Completely DISagree
Neutral
Completely agree

2→ I think it is hard to understand how to use a self-driving bus.*

1	2	3	4	5
Completely DISagree		Neutral		Completely agree

3→ I think that I will arrive late at my destination when I take a self-driving bus.*

1	2	3	4	5
Completely DISagree		Neutral		Completely agree

4→ I think there will be a self-driving bus available for the return trip to the station.*

1	2	3	4	5
Completely DISagree		Neutral		Completely agree

5→ I would let a close family member ride a self-driving bus.*

1	2	3	4	5
Completely DISagree		Neutral		Completely agree

6→ I am concerned about the interaction of a self-driving bus with other traffic, like human drivers, pedestrians and cyclists.*

1	2	3	4	5
Completely DISagree		Neutral		Completely agree

7→ I am concerned about riding a self-driving bus with strangers.*

1	2	3	4	5
Completely DISagree		Neutral		Completely agree

8→ I believe that a self-driving bus can safely handle unexpected situations. *

1	2	3	4	5
Completely DISagree		Neutral		Completely agree

9→ I expect that the interior of a self-driving bus will be dirty.*

1	2	3	4	5
Completely DISagree		Neutral		Completely agree

10→ I think I would find it easy to inform a self-driving bus of my destination.*

1	2	3	4	5
Completely DISagree		Neutral		Completely agree

11→ I believe a self-driving bus would drive safer than the average human driver.*

1	2	3	4	5
Completely DISagree		Neutral		Completely agree

12 → The potential risks of software hacking or other forms of misuse of self-driving buses worry me.*

1	2	3	4	5
Completely DISagree		Neutral		Completely agree

“ End of section **I. Statements**

continue press ENTER

II. Travelling from home to work (comparisons)

In this section you are asked to compare two variations of self-driving buses for each question. What trade-offs do you make between *waiting time, travel time, travel costs, service type* and *surveillance* when deciding to travel?

Please first watch the video before continuing to the questions (no sound needed).

I have watched the video press ENTER

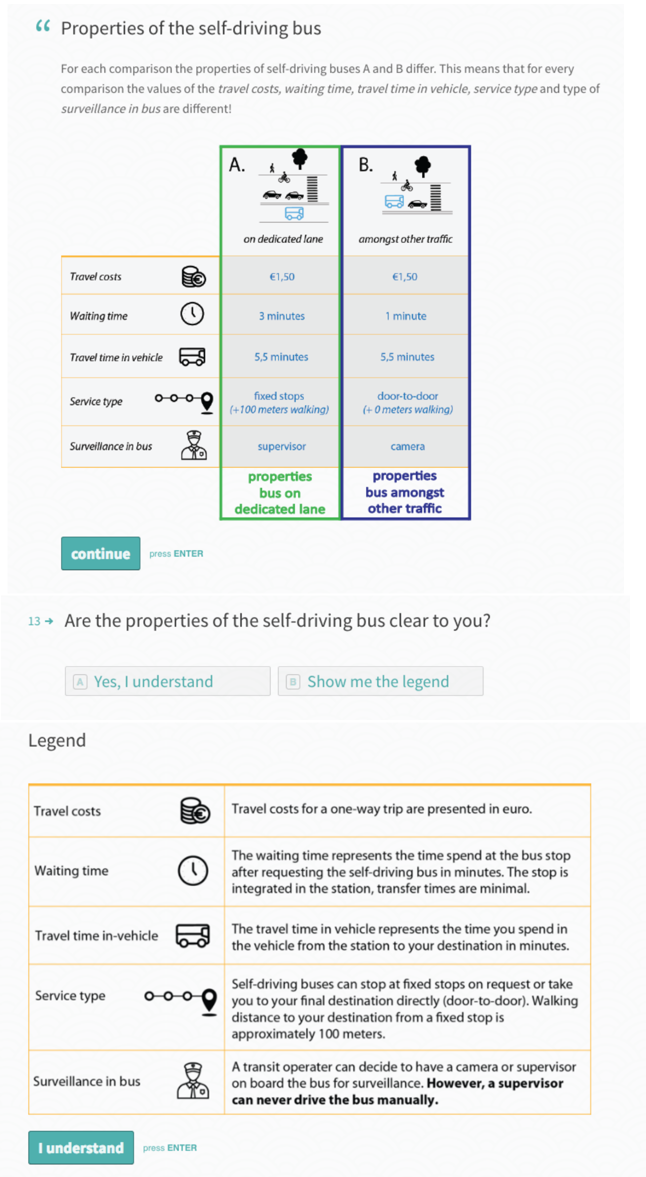
“ *Imagine you would travel to work by train. From the station nearest to your work you have the possibility to transfer to a self-driving bus.*

You will be shown **6 comparisons** of two self-driving buses. For each comparison self-driving bus A and B have different properties. Please indicate for all comparisons which bus would have your preference and whether you would like to make use of this bus.

(5 minutes)

You will be shown an example comparison before being asked to answer the questions.

to the example press ENTER



Properties of the self-driving bus

For each comparison the properties of self-driving buses A and B differ. This means that for every comparison the values of the *travel costs, waiting time, travel time in vehicle, service type* and type of *surveillance in bus* are different!

	A. on dedicated lane	B. amongst other traffic
Travel costs	€1,50	€1,50
Waiting time	3 minutes	1 minute
Travel time in vehicle	5,5 minutes	5,5 minutes
Service type	fixed stops (+100 meters walking)	door-to-door (+ 0 meters walking)
Surveillance in bus	supervisor	camera
	properties bus on dedicated lane	properties bus amongst other traffic

continue press ENTER

13 → Are the properties of the self-driving bus clear to you?

A Yes, I understand

B Show me the legend

Legend

Travel costs	Travel costs for a one-way trip are presented in euro.
Waiting time	The waiting time represents the time spend at the bus stop after requesting the self-driving bus in minutes. The stop is integrated in the station, transfer times are minimal.
Travel time in-vehicle	The travel time in vehicle represents the time you spend in the vehicle from the station to your destination in minutes.
Service type	Self-driving buses can stop at fixed stops on request or take you to your final destination directly (door-to-door). Walking distance to your destination from a fixed stop is approximately 100 meters.
Surveillance in bus	A transit operater can decide to have a camera or supervisor on board the bus for surveillance. **However, a supervisor can never drive the bus manually.**

I understand press ENTER

14 → Comparison 1

a. Which variation of the self-driving bus would you prefer?*

Take note: the values of the bus properties vary for each question!

	A.  *on dedicated lane*	B.  *amongst other traffic*
Travel costs	€1	€2
Waiting time	5 minutes	3 minutes
Travel time in vehicle	7 minutes	4 minutes
Service type	fixed stops *(+100 meters walking)*	fixed stops *(+100 meters walking)*
Surveillance in bus	none	camera

A bus on dedicated lane

B bus amongst other traffic

b. You chose the self-driving *bus on dedicated lane.*

The distance from the train station to your work is **1.5 kilometers**.

Would you make use of this bus **including** its specific properties to travel this distance?*

A Yes

B No, I would make use of another method to travel these 1.5 kilometers

15 → Comparison 2

a. Which variation of the self-driving bus would you prefer?*

Take note: the values of the bus properties vary for each question!

	A.  *on dedicated lane*	B.  *amongst other traffic*
Travel costs	€2	€1
Waiting time	1 minute	5 minutes
Travel time in vehicle	5,5 minutes	5,5 minutes
Service type	fixed stops *(+100 meters walking)*	fixed stops *(+100 meters walking)*
Surveillance in bus	supervisor	camera

A bus on dedicated lane

B bus amongst other traffic

b. You chose the self-driving *bus on dedicated lane.*

The distance from the train station to your work is **1.5 kilometers**.

Would you make use of this bus **including** its specific properties to travel this distance?*

- A Yes
- B No, I would make use of another method to travel these 1.5 kilometers

16 → Comparison 3

a. Which variation of the self-driving bus would you prefer?*

Take note: the values of the bus properties vary for each question!

	A.  on dedicated lane	B.  amongst other traffic
Travel costs	€1	€2
Waiting time	5 minutes	1 minute
Travel time in vehicle	4 minutes	7 minutes
Service type	fixed stops *(+100 meters walking)*	door-to-door *(+ 0 meters walking)*
Surveillance in bus	none	camera

- A bus on dedicated lane
- B bus amongst other traffic

b. You chose the self-driving *bus on dedicated lane.*

The distance from the train station to your work is **1.5 kilometers**.

Would you make use of this bus **including** its specific properties to travel this distance?*

- A Yes
- B No, I would make use of another method to travel these 1.5 kilometers

17 → Comparison 4

a. Which variation of the self-driving bus would you prefer?*

Take note: the values of the bus properties vary for each question!

	A. *on dedicated lane*	B. *amongst other traffic*
Travel costs	€1,50	€1,50
Waiting time	3 minutes	3 minutes
Travel time in vehicle	4 minutes	7 minutes
Service type	fixed stops *(+100 meters walking)*	door-to-door *(+ 0 meters walking)*
Surveillance in bus	camera	supervisor

A bus on dedicated lane

B bus amongst other traffic

b. You chose the self-driving *bus on dedicated lane.*

The distance from the train station to your work is **1.5 kilometers**.

Would you make use of this bus **including** its specific properties to travel this distance?*

A Yes

B No, I would make use of another method to travel these 1.5 kilometers

18 → Comparison 5

a. Which variation of the self-driving bus would you prefer?*

Take note: the values of the bus properties vary for each question!

	A. *on dedicated lane*	B. *amongst other traffic*
Travel costs	€2	€1
Waiting time	1 minute	5 minutes
Travel time in vehicle	7 minutes	4 minutes
Service type	fixed stops *(+100 meters walking)*	door-to-door *(+ 0 meters walking)*
Surveillance in bus	camera	none

A bus on dedicated lane

B bus amongst other traffic

b. You chose the self-driving *bus on dedicated lane.*

The distance from the train station to your work is **1.5 kilometers**.

Would you make use of this bus **including** its specific properties to travel this distance?*

- A Yes
- B No, I would make use of another method to travel these 1.5 kilometers

19 → Comparison 6

a. Which variation of the self-driving bus would you prefer?*

Take note: the values of the bus properties vary for each question!

	A.  *on dedicated lane*	B.  *amongst other traffic*
Travel costs	€1,50	€1,50
Waiting time	3 minutes	1 minute
Travel time in vehicle	5,5 minutes	5,5 minutes
Service type	fixed stops *(+100 meters walking)*	door-to-door *(+ 0 meters walking)*
Surveillance in bus	supervisor	camera

- A bus on dedicated lane
- B bus amongst other traffic

b. You chose the self-driving *bus on dedicated lane.*

The distance from the train station to your work is **1.5 kilometers**.

Would you make use of this bus **including** its specific properties to travel this distance?*

- A Yes
- B No, I would make use of another method to travel these 1.5 kilometers

20 → How do you feel about a self-driving bus in your own region?

In this final part of section II you are asked to answer **4 questions** about possible self-driving bus lines in the region you work in.

(2 minutes)

a. In which region do you work?*

- A Capelle a/d IJssel: Rivium (+ Rotterdam: Schaardijk)
- B The Hague: Beatrixkwartier
- C Rijswijk: Plaspoelpolder, Broekpolder or Hoornwijck
- D Other

→ Imagine that the following self-driving bus lines would be available. Would you like to make use of any of these self-driving bus lines?*

The extended ParkShuttle connection could make use of several routes. Each route is shown by a different colour. All buses shuttle between metro station Kralingse Zoom and the final destinations of the line, shown by a large circle. The smaller circles indicate fixed stops on the routes.

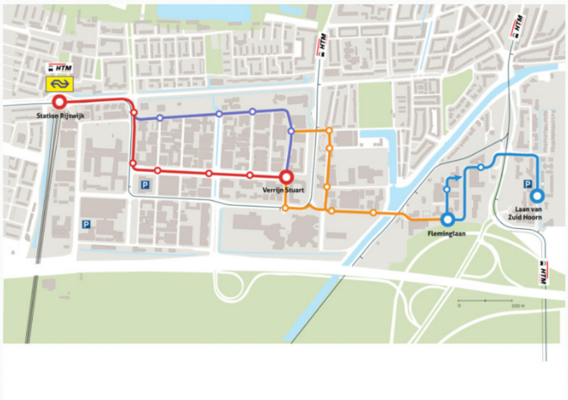
N.b. the shown self-driving bus routes are solely illustrative for this research. No rights can be derived from this figure.

- A Yes, current ParkShuttle trajectory (black line)
- B Yes, red line
- C Yes, green line
- D Yes, blue line
- E No
- F Maybe

→ Imagine that the following self-driving bus lines would be available. Would you like to make use of any of these self-driving bus lines?*

The self-driving bus would drive a fixed route along the shown lines. Each route is shown by a different colour. All buses shuttle between train station Rijswijk and the final destinations of the line, shown by a large circle. The smaller circles indicate fixed stops on the routes. The current HTM tram lines are shown on the map.

N.b. the shown self-driving bus routes are solely illustrative for this research. No rights can be derived from this figure.

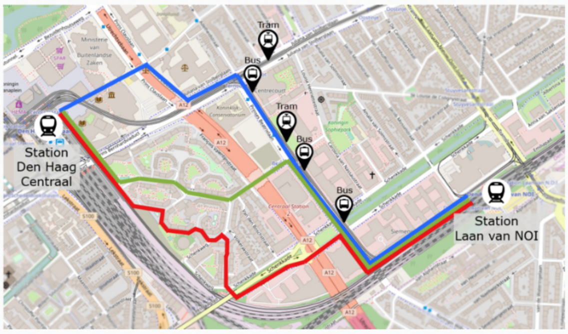


- A Yes, purple line
- B Yes, red line
- C Yes, orange line
- D Yes, blue line
- E No
- F Maybe

→ Imagine that the following self-driving bus lines would be available. Would you like to make use of any of these self-driving bus lines?*

The self-driving bus would drive a fixed route along the shown lines. Each route is shown by a different colour. All buses shuttle between train station Den Haag Centraal and train station Laan van NOI. The current tram and regular bus stops are shown on the map.

N.b. the shown self-driving bus routes are solely illustrative for this research. No rights can be derived from this figure.



- A Yes, blue line
- B Yes, green line
- C Yes, red line
- D No
- E Maybe

→ What are the most important reasons for you to make use of a self-driving bus?*

Choose as many as you like

- A I think I would arrive faster at my destination than with other means of transportation
- B An electric self-driving bus is more environmental friendly than other types of (public) transportation
- C The fact that the self-driving bus operates 'on-demand' appeals to me
- D I like to make use of new technologies
- E Other

→ Could you please explain your answer?*

Choose as many as you like

- [A] The routes shown are irrelevant to me
- [B] I would want to see the self-driving bus performing well before I am willing to make use of it
- [C] I would prefer traveling with another type of public transportation
- [D] I would prefer walking or cycling from the station
- [E] I would prefer traveling from home to work using my own transportation mode
- [F] I would never want to make use of a self-driving bus
- [G] A shuttle bus with a human driver would have my preference
- [H] Other

21 → Were you familiar with the self-driving bus before you started this survey?*

- [A] No
- [B] Yes, I have read or seen something about self-driving buses earlier
- [C] Yes, I have made use of the ParkShuttle once / a few times
- [D] Yes, I make use of the ParkShuttle on a weekly basis

“ End of section **II. Travelling from home to work (comparisons)**

continue press **ENTER**

III. Background information

This is the final section of the survey. Background information helps to be able to create profiles of different types of travelers and their preferences. *All answers provided are treated confidentially.*

Final 8 questions (2 minutes)

continue press **ENTER**

22 → What is your year of birth?

23 → What is your gender?

- A Male
- B Female

24 → What is the nett monthly income of your household?

- A < 1000 euro
- B 1000 - 1599 euro
- C 1600 - 2199 euro
- D 2200 - 2799 euro
- E 2800 - 3399 euro
- F 3400 - 3999 euro
- G 4000 - 4599 euro
- H 4600 - 5200 euro
- I > 5200 euro
- J I prefer not to say

25 → What is the highest degree you received?

- A Primary education
- B Secondary education
- C Higher National Diploma
- D Undergraduate degree
- E Graduate Degree or higher
- F Other

26 → Does your employer refund your home-work travel expenses?*

- A Yes
- B No
- C Partially

27 → Do you make use of public transportation *more than 2 times a week* on (a part of) your trip from home to work?*

- A Yes
- B No

28 → Which travel itinerary is most applicable to you?*

The part of the trip from your home to a train-/ metro station is referred to as *pre-transport*

- A Pre-transport + train / metro + tram
- B Pre-transport + train / metro + bus
- C Pre-transport + train / metro + ParkShuttle
- D Pre-transport + train / metro + (OV) bike
- E Pre-transport + train / metro + walking
- F Only tram
- G Only bus
- H Only ParkShuttle
- I Other

28 → How do you travel to your work?*

- A Private car
- B Company car / lease car
- C Carpooling
- D Motor
- E Scooter
- F Bike / e-bike
- G Walking
- H Other

29 → Would you consider to make (more) use of public transportation to travel to your work *if the accessibility of your work region (by public transportation) would be improved?**

A Yes | B No | C Maybe

30 → Could you please explain your answer?

To add a paragraph, press **SHIFT + ENTER**

31 → Do you have any more thoughts on self-driving vehicles or this research?

To add a paragraph, press **SHIFT + ENTER**

32 → Would you like to take part in the prize lottery to win a *bol.com* voucher?

Y Yes

N No

33 → In case you would like to participate in the prize lottery for the *bol.com* vouchers, please fill in your e-mail address below (*otherwise leave blank and click 'ok'*).

Marissa Dekker

TU Delft

MRDH METROPOOLREGIO ROTTERDAM DEN HAAG

Spatial and Transport Impacts of Automated Driving

Done! All your answers are submitted.
Thank you for participating in this survey.

Please remind your colleagues to fill in the survey by forwarding this link: https://zelfrijdendebus.typeform.com/to/nI8RNm

D

Considerations for survey design

In order create a survey that allows for proper data collection and a high level of user-friendliness several considerations have been made for the survey design. In designing the survey the book “Questionnaire Design” by Brace [75] was consulted.

General

- Closed pre-coded answers are used to reduce work load
- For all questions it was checked that answers are *mutually exclusive, as exhaustive as possible and as precise as necessary*
- Questions not directly related to the study were removed in order to reduce the *respondent burden* and reduce the *drop-out rate*
- Technical terms and jargon have been transformed into clear language to ensure clarity
- The order of questions in the survey is deliberately from more general questions on the *working* of self-driving buses (statements section) to more specific questions relating to *properties* of self-driving buses (choice sets section)
- Short introduction and instruction films were included to explain the *concept* (opening page) and *properties* (intro of choice sets section) of self-driving buses to respondents
- The introduction page informs respondents on the length of the survey in both number of questions and approximate time needed for completion
- The introduction page also includes as short description of the survey goal, the organisations conducting the survey and that all provided information will be handled confidentially
- At the introduction page the target audience is clearly stated. No additioanl screening questions are used in the survey as the survey is distributed at companies that are situated at the sample locations. In case someone might end up filling in the survey but is not working in one of the three regions, he or she will be filtered out after the choice sets with the "In which region do you work?" question
- It will be determined afterwards if these responses provide valuable information to the study (based on for example the total number of responses or the number of respondents that are not part of the sample locations)
- The survey has been set up bilingual for it is expected that a large number of respondents will not be sufficiently familiar with the Dutch language to complete the survey in Dutch
- Answers needed for analysis generally force the respondent to answer by a built in *required* function that does not let the respondent continue to the next section before all mandatory questions are filled in
- Questions solely needed for cross-sectional analysis (mostly socioeconomic) are not mandatory to be answered before completion in order to prevent unnecessary *drop-out*
- *Social Desirability Bias* is expected to be low as most questions are not to personal and sensitive questions on socioeconomic information are not mandatory, furthermore results are filled in anonymously in an online survey (c.q. the respondent can be alone when filling in the answers)

Statements

- Statements are kept short and direct, are checked for ambiguity and checked for double denial

- The used Likert scale starts with ‘disagree’ on left hand side to counteract the *order effect* (tendency to pick first available option) with the *acquiescence effect* (tendency of respondents to agree rather than to disagree)
- Positive and negative statements are alternated in order to prevent boredom and *pattern answering*
- Statements of all constructs are mixed to prevent *pattern answering*
- A five-point Likert scale is used, as is believed that it is not necessary to provide more detail in the level of agreement (c.q. no seven-point scale needed)
- The scales are balanced, as neutral opinions are seemed plausible in this study
- No “don’t know” option is provided as it is expected that respondents will understand all statements and will have an opinion or choose “neutral”
- All questions in this section are mandatory

Choice sets

- An example question was included to explain how to answer the questions: which properties belong to which bus and where the respondent can record his or her choice
- Icons for each property were included in the choice sets in order to support the clarity
- All icons shown in the choice sets were deliberately used in the instruction film (at the beginning of the choice set page) to familiarise respondents with the properties
- The title of the choice set section "Variations of the self-driving bus" was chosen as “Choice sets” would not be clear and intuitive to respondents
- The number of choice sets presented to the respondent has been limited to six, as to reduce the *respondent fatigue* and as such prevent *drop-out*
- The section concludes with a question to determine the working location of the respondent (e.g. Capelle a/d IJssel / Rijswijk / Den Haag / other) to be able to provide the respondent with a region specific question on self-driving buses. By providing a map of the region with a possible self-driving bus trajectory respondents are believed to better relate to the situation and give a more accurate / reliable insight in their use intention for self-driving buses.
- Furthermore, by allowing respondents to give multiple pre-coded answers it is believed that respondents reasoning can be captured. As it is possible that the reason the respondent has in mind is not included in the pre-coded answers the “other” option is included with a mandatory open fill-in box where the respondent can explain their choice.
- All questions in this section are mandatory

Socioeconomic data » Background information

- The title “Background information” was chosen to be less intimidating to respondents than “Personal information” and more clear than the technical term “Socioeconomic data”
- At the beginning of the section respondents are reminded that all data is processed confidentially in order to increase the respondents willingness to fill in all socioeconomic questions
- Sensitive questions like on *income* are presented with answer options in categories to increase the chance that a respondent will answer the question
- In case the answers to the question are believed not to be exhaustive the “other” option is included. In case it is relevant to know specifically what the respondent would have answered, “other” is complemented with a fill-in box. Otherwise, selecting “other” is sufficient.
- *Primacy* (selecting one of the first answers of a list) and *recency* (selecting one of the last answers of a list) are not expected to have a large effect as most questions offer only a couple of possible answers
- Answers are provided in a fixed sequence in case ordering of the answers would make more sense to the respondent (e.g. "Yes", "Maybe", "No" or the clustering of transportation modes). In such cases it is assumed that the *primacy* and *recency effects* will not play a role
- Only for the question on reasons to make use/not make use of an ADS-DV the answer options a presented at random to respondents to counter *primacy* and *recency effects*.
- Answering most of the questions in this section is left to the choice of the respondent
- Only the answer to the question on *experience with a self-driving bus* is mandatory, as this is an important variable in the study

E

Survey design process

This appendix discusses the process of the survey design and the analyses the pilot surveys created for this study in four sections. Section E.1 and section E.2 address respectively the design and results of the first pilot survey. Section E.3 discusses the second pilot survey and section E.4 the final survey design and results. In general the lay-out of the survey is as follows: respondents are first informed on the topic of the study using an introduction text and picture of the ParkShuttle or a video. The second part consists of statements needed to determine the latent variables. In the third part respondents are asked to choose between two types of ADS-DVs. The survey concludes with questions on personal characteristics of respondents. Pilot survey 1 was made using the Google forms tool and was distributed online. Pilot survey 2 and the final survey were created in Typeform and again distributed online. Note: in this thesis the expression *ADS-DV* is used. However with the focus on respondents unfamiliar with ADS-DVs the expression *self-driving bus* is used to improve clarity in the survey.

E.1. Pilot survey 1

This section describes in detail all parts of the survey design.

E.1.1. Psychological constructs

In order to determine latent variables, indicators are needed that indirectly show their values. To quantify the indicator values generally two approaches are used in transportation related researches. The first and traditional approach makes use of psychometric scales (often Likert [54]), providing the respondent with statements and asking to rate the amount of agreement with each statement [4, 71–74]. Advantages of this method include: a better insight beforehand what the construct will measure and possibility to build on previous findings by using the same psychometric constructs [75]. The second approach first asks respondents to provide three adjectives that they perceive related to a mode and ask a second group of respondents to indicate their ratings for each of the grouped adjectives on both a discrete and a continuous scale ([76, 77] as cited in Glerum and Bierlaire [78]). Glerum and Bierlaire [78] state that the psychometric scales that are used in many studies are subjective to the researchers design of the phrases which could prevent the researcher from completely seizing the representation of the persons attitude or perception.

In this thesis Likert scale constructs are used to determine the latent variables. The statements are based on previously used psychometric constructs in related automated vehicle studies: [43, 47, 48, 55, 58, 59]. The advantage of pre-validated constructs and the possibility to use the constructs in follow-up research is decided to be of more value than the disadvantage of subjectivity. In the survey each respondent is shown eleven statements in alternating positive and negative phrasing. For each statement the respondent is asked to indicate their level of agreement on the seven-point Likert scale. The following statements are used in the pilot survey to indicate the latent variables of *Trust in ADS-DVs, Safety, Ease of use* and *Performance expectancy*.

Trust in self-driving buses

1. I believe a computer-operated bus would drive better than the average human driver on populated streets
2. I trust that a computer can drive an automated bus with no assistance from a human driver

3. I would be comfortable entrusting the safety of a close family member to an automated bus

Safety

1. The idea that fully automated driving systems may be introduced on a widespread scale worries me because of potential software hacking, or other forms of misuse
2. I am more concerned of riding an automated bus with people I do not know than riding a regular bus
3. I am concerned of the interaction of an automated bus with other traffic, like cars, pedestrians and cyclists

Ease of use

1. I would find it easy to get an automated bus to do want I want it to do
2. I think it would be easy to understand how to use an automated bus

Performance expectancy

1. I am afraid there would be no automated bus available when I would like to make use of it
2. I am afraid I will not arrive in time at my destination while travelling with an automated bus
3. I am afraid that an automated bus will not be clean

E.1.2. Choice sets

Discrete choice modelling forms an integral part of this research to investigate travellers preferences for ADS-DVs on last mile connections. The choice modelling questions in the survey are presented as choice sets. The study focuses on the preferences for ADS-DV types, operating on a dedicated lane and operating amongst other traffic. Respondents are asked to choose their preferred mode on the last mile. To reduce the choice set complexity each decision is split up in two levels. At the first level respondents are asked to make a choice between two ADS-DVs, at the second level respondents are asked to decide on their top three of last mile options. The range of options available for last mile connections consists of public transportation (regular bus), a shuttle bus, a bike (own or rented) and walking. In focusing solely on last mile alternatives, full trip modes like car are not taken into account. Full trip modes are excluded from the study in order to maintain a smaller choice set that solely focuses on the last mile. Attribute values of the ADS-DVs at the first level vary for each question, offering different scenarios. The attributes and their levels are shown in tabel **??**. Attributes of the other alternatives at the second level of the question are fixed in order to minimise the choice complexity for respondents.

Table E.1: Attribute and attribute levels pilot survey 1

Attribute	Level 1	Level 2
Travel costs	€1	€2
Waiting time	1 minute	4 minutes
Travel time in-vehicle	4 minutes	6 minutes
Extra travel time	in 3 of 10 times + 3 min.	in 6 of 10 times + 3 min.
Service type	scheduled stops	door-to-door
Presence of transit employee	yes	no

The number of choice sets that are shown to the respondent are determined using an experimental design. The simplest experimental design (*full factorial design*) includes all possible option-attribute combinations, however the number of choice sets would be very large and some options would offer unrealistic values. Fractional factorial designs allow for the possibility to construct a subset of choice sets from the full factorial.

Orthogonal designs are a form of fractional factorial design and ensure that within the subset of choice sets the attribute levels are balanced. *Attribute level balance* ensures that respondents are presented with an even amount of high and low values for each attribute. Orthogonal designs were often used for stated choice experiments, as they allow for an independent estimation of the influence of each attribute on choice. However as the design is focused on linear models and discrete choice models are often not linear, their suitability has been questioned by several researchers: Bunch et al. [114], Kuhfeld et al. [115], Huber and Zwerina [116] as cited in Bliemer and Rose [117]. In the case of discrete choice models orthogonality can only be preserved from the design onto the data in exceptional circumstances, decreasing the use of these models for choice modelling, for more details the reader is referred to ChoiceMetrics [79]. The researchers aimed at minimising the standard errors of the parameter estimators with improves their reliability [117]. The designs generated from this progress are known as *efficient designs*. The advantage of using an efficient design includes the possibility to decrease the number of choice sets that need to be presented to the respondents. However, in order to generate efficient designs prior parameter values are needed. In this thesis the prior estimators are retrieved by first conducting a pilot survey using an orthogonal design. With these prior estimators an efficient design is constructed for the final survey. Ngene software has been used to configure the choice set designs. The Ngene syntax and resulting orthogonal design can be found in appendix G. The orthogonal design of the pilot survey resulted in twelve choice sets.

E.1.3. Socioeconomic data

The last section of the survey consists of questions on personal characteristics. Respondents are asked to provide information on:

- Their year of birth
- Their gender
- Their monthly income
- Their level of education
- Whether the respondent receives travel cost reimbursement
- Their most used modes to travel to work
- Whether the respondent would switch to public transportation from another mode if the accessibility of their work area by public transportation would improve
- Which case study area the respondent works in
- Their experience with an ADS-DV

The first four questions are asked to be able to compare the sample groups of different locations. Whether a respondent receives travel cost reimbursement (from) his or her employer could influence the importance of the travel cost attribute in the choice sets. The information what modes the respondent currently uses to travel to work can provide insight in what travellers might be more interested in using ADS-DVs and whether the respondent would we susceptible to switch to public transportation if accessibility of the area would improve. The question related to the area the respondent works in allows for categorisation per area providing detailed information. To conclude, the question about experience with an ADS-DV (using ParkShuttle on a weekly basis, used ParkShuttle once, have heard of or seen something about self-driving buses, never heard of self-driving buses before this survey) allows for the determination of a respondents experience with ADS-DVs.

E.1.4. Respondent fatigue

Respondent fatigue and the prospected length of a survey influence the quantity and quality of the gathered data. A study by Caussade et al. [80] investigated the effect of design dimensions on respondents fatigue and indirect influence on choice. It was concluded that the number of attributes has a negative effect and the number of options has an inverse U-shape effect with the optimum on four alternatives. While the number of choice sets also showed an inverse U-shape pattern with the optimum around 9-10 choice sets, the researchers state that this effect on choice is lower than the first mentioned variables. Comparing to the proposed choice sets of six attributes, two options and twelve choice sets, the influence of the survey design on respondent fatigue is not ideal. The number of choice sets in the pilot survey exceeds the ideal number. Although it would be possible to use blocking and distribute two version of the survey with each six choice sets, it was chosen not to use block as the number of respondents also needed to be doubled in that case. The number of choice sets in the final design is reduced to six choice sets in an efficient design, as the statements also ask some effort from the respondents.

E.2. Results pilot survey 1

This section discusses briefly the results from the pilot survey. The questionnaire was completed by 24 respondents, however multiple other respondents mentioned they did not finish the survey because they found it too complex and time consuming. Unfortunately the Google form tool does not allow for partial completion, as such their data is not included in this analysis.

E.2.1. Statements

Several respondents indicated that some of the statements used to measure the latent variables were unclear to them and suggested rephrasing. Furthermore, some respondents noted that it would be possible to misinterpret some statements when they are presented in a negative form. Comparing the responses on indicators of similar psychological constructs, it can be noticed that not all respondents answered similarly (all high/all low) on grouped indicators, figure E.1. Especially statement 3 *"I believe a computer-operated bus would drive better than the average human driver on populated streets"* leads in some cases to different values than the other two statements for Trust (generally lower). A similar divergence can be seen for statement 4 *"I am concerned of the interaction of an automated bus with other traffic, like cars, pedestrians and cyclists"* and the other two indicators of Safety. Different valuation of statements could mean that the statements do not indicate a similar latent variable. In the case of safety it is assumed that the statements could better be split up over two latent variables: *traffic safety* and *security*.

	Trust	Trust	Trust	Safety	Safety	Safety	Ease of use	Ease of use	Performance	Performance	Performance
	Q3	Q5	Q7	Q4	Q10	Q11	Q1	Q9	Q2	Q6	Q8
	High	High	High	Low	Low	Low	High	High	Low	Low	Low
ID	Op drukke st	Ik zou er gee	Ik vertrouw e	Ik maak me z	Ik maak me r	Het idee dat	Ik verwacht I	Ik verwacht I	Ik ben bang d	Ik ben bang d	Ik ben bang d
1	2	7	6	5	1	2	5	7	1	2	5
2	5	5	5	5	5	3	5	5	2	3	3
3	5	6	6	6	5	5	7	7	1	1	4
4	4	4	4	3	4	4	4	4	3	4	4
5	2	4	3	5	3	5	7	7	5	3	1
6	4	5	5	5	1	5	6	6	5	5	1
7	4	7	2	2	2	5	6	6	1	2	5
8	1	6	6	6	2	1	6	7	2	2	5
9	3	7	6	4	1	2	6	6	2	2	2
10	4	7	2	6	2	2	6	6	3	4	2
11	3	4	3	6	2	5	7	7	4	1	1
12	6	6	6	6	2	2	6	6	2	2	2
13	7	7	7	6	1	2	6	7	5	7	2
14	4	4	4	6	2	5	6	6	4	4	1
15	4	3	5	3	3	3	6	6	3	3	3
16	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*
17	3	7	7	2	1	1	7	7	1	1	2
18	2	3	4	4	5	5	4	4	3	3	3
19	5	7	7	6	2	4	4	6	1	2	4
20	2	7	6	5	4	2	5	6	1	5	4
21	1	7	4	6	1	2	6	5	2	7	6
22	6	7	5	3	2	3	4	5	2	3	2
23	6	3	6	4	5	6	5	6	6	3	6
24	5	3	4	6	5	5	3	4	5	5	5

Figure E.1: Review answers on statements in pilot survey

For the final survey all statements have been revised:

Trust in ADS-DVs

1. I believe a self-driving bus would drive safer than the average human driver
2. I trust a self-driving bus can drive itself without any assistance from a human
3. I would be comfortable if a close family member rides a self-driving bus

Traffic safety

1. The potential risks of software hacking or other forms of misuse of self-driving buses worry me
2. I am concerned that a self-driving bus gets confused in unexpected situations

Security

1. I am concerned about riding a self-driving bus with strangers
2. I am concerned about the interaction of a self-driving bus with other traffic, like human drivers, pedestrians and cyclists

Ease of use

1. I think I would find it easy to inform a self-driving bus of my destination
2. I expect it is easy to understand how to use a self-driving bus

Performance expectancy

1. I am concerned there would be no self-driving bus available for the return trip to the station
2. I am concerned I will not arrive at my destination in time if I take a self-driving bus
3. I am concerned that the interior of a self-driving bus will not be clean

E.2.2. Choice sets: qualitative evaluation

Respondents indicating that the survey was complicated mostly referred to the 'scenarios' section (choice sets). The two-level question confused some respondents and especially the second level (choosing from multiple alternatives on the last mile) turned out to be hard. The fact that the values of the ADS-DV chosen at the first level were not visible at the second level and the limitation of attributes of the other alternatives to *travel time* and *travel cost* made the question unclear (e.g "Am I supposed to compare the self-driving bus on all attributes or just on travel time and travel cost?"). Furthermore, the decision to use fixed attribute values for the alternative modes to reduce the respondents fatigue did not work. Most respondents did not realise that the values in the second level did not variate (even though it was mentioned in the question). Moreover, some respondents thought that some values in the first level were fixed. To make the scenario section more clear, the second level is reduced to only indicating whether a respondent would use the chosen bus or not. Furthermore introduction pictures were added for the second pilot survey and an instruction video explaining the different attributes was added in the final survey.

E.2.3. Choice sets: quantitative evaluation

Biogeme software, open source freeware designed for the maximum likelihood estimation of parametric models developed by Michel Bierlaire [83], was used to calculated the prior indicator values. The syntax of the model specification file and the data file can be found in appendix H.

Prior indicators

The prior estimator values indicate that *travel costs* are the most influential significant attribute in choosing an ADS-DV type, see table E.2. The value is negative as was expected (higher travel costs lead to a lower probability of choosing that alternative).

Only the attribute *steward* is found not to be significant in the pilot survey with a p-value of 0.15. Which could indicate that a steward on board the vehicle is not important for the respondent group in making their decision or the attribute steward was misunderstood. From the qualitative feedback on the pilot survey it can be concluded that the function of the steward was unclear to some respondents and that the representation with ticked boxes turned out to be confusing (e.g. "I am trying to select a steward, but it does not work"). Another explanation of the low insignificant value for steward can be be due to the fact that all respondents to the pilot survey were part of the MRDH. Involvement in ParkShuttle projects might also have lead to bias, as the ParkShuttle operates without a supervisor. A possible influence of the attribute *steward* cannot be excluded, as such the attribute is kept and needs to be made more clear in the final survey by using simple "yes/no" indications to indicate its presence. Furthermore, the attribute was changed to *surveillance in bus* which could either be present with a camera or a supervisor or absent.

All other attributes are found to be significant. Attributes *travel time* and *waiting time* have the expected sign (higher values of either lead to a lower probability of choosing that alternative). However, the sign of *extra travel time* shows a positive sign where one would expect it to be negative. Extra travel time (displayed in the survey as *6 in 10 times + 3 min.* and *3 in 10 times + 3 min.*) is found to lead to a *higher* probability of choosing that alternative. Explanations could be that the attribute was unclear to respondents or not important for respondents. The latter is argued to be unlikely as the attribute for *travel time* is found to be significant with the expected negative sign. Therefore it was decided to exclude this attribute from the survey. *Service type* shows a positive sign indicating that respondents prefer door-to-door service over scheduled stops, as can be expected.

A validation of the results was done by calculating the willingness-to-pay for individuals that could be derived from the model. From equations E.1 and E.2 it can be derived that the willingness-to-pay is equal to 10.76 €/hour. Kouwenhoven et al. [85] stated that the value of time (willingness-to-pay for a decrease of one hour of travel time) in the Netherlands is €/hour 9.75 and €13.50/hour for respectively commuters and business employees in general. Comparing the calculated value of 10.76 shows that the value found in the model estimation lies within this range. Therefore it may be concluded that the priors found with the model are quite representative.

Table E.2: Prior estimator values

Parameter number	Description	Coeff. estimate	Robust Asympt. std. error	t-stat	p-value
1	Constant for Bus amongst other traffic	-1.94	0.349	-5.55	0.00
2	Extra travel time	0.695	0.226	3.07	0.00
3	Service type	0.966	0.358	2.70	0.01
4	Travel cost	-1.89	0.289	-6.54	0.00
5	Steward	0.215	0.151	1.43	0.15*
6	Travel time	-0.339	0.0906	-3.75	0.00
7	Waiting time	-0.387	0.0550	-7.05	0.00

$$WTP_{perminutetraveltime} = \frac{\beta traveltimein-vehicle}{\beta travelcost} = \frac{-0.339}{-1.89} = 0.1794 \tag{E.1}$$

$$WTP_{\frac{euro}{hour}} = 0.1794 * 60 minutes = 10.76 \frac{euro}{hour} \tag{E.2}$$

Furthermore, it can be noticed from the survey data that in 66% of the cases the respondents choose the bus on a dedicated lane over the bus amongst other traffic. It can be questioned whether the attribute values of the bus on a dedicated lane are presented more favourable in most scenarios or that this finding is based on the fact that the bus operates on a dedicated lane or that perhaps other factors that are not taken into account in this study play a role (c.q. the alternative specific constant ASC). The ASC value for *bus amongst other traffic* is found to be negative and significant, indicating that this alternative is less preferred than the *bus on a dedicated lane* based on factors that are not included (yet). Including the latent variables in the ICLV model of the final survey data might result in a more clear understanding of the components of the ASC. However, for two quite similar alternatives the magnitude of the coefficient is very large (-1.94). This could mean that the complexity of the choice sets or the construction with travel time + extra time might have influenced respondents in such a way that the utilities may not have been distributed balanced over the alternatives, c.q. dominance was present. Another explanation might be that because the alternatives were only shown as figures respondents did not understand the differences between the two. In that case the ASC would not give information based on perceived differences between the two buses. It was decided to run a second pilot survey with an improved choice set design to be able to improve the prior values for the final survey design. The results of the second pilot can be found in section E.3.

E.2.4. Socioeconomic data

No major changes were made in the section on socioeconomic data. Some questions were slightly rephrased or the number of answer categories expanded (e.g. household income, current travel mode).

E.3. Pilot survey 2

Another pilot was conducted that included the new choice set design to improve the prior estimator values. This pilot only consisted of an introduction to ADS-DVs using pictures followed by 12 choice sets. Statements and socioeconomic data were not included in this pilot to limit the respondent burden and increase the number of respondent in the short time span. In Ngene an efficient design was developed using the significant priors, but excluding the ASC. Furthermore, attribute and levels were included as presented in E.3. The model estimates 10 parameters therefore at least 12 choice sets need to be constructed. Four attributes have three levels and one attribute has two levels. The Ngene syntax and efficient design are included in appendix G. An example of the new choice set as presented to the respondents is shown in E.2.

The second pilot survey was completed by 31 individuals. Although the survey did not include questions on socioeconomic data it is known that the respondents are between the ages of 25 and 66 and most respondents are employed (as opposed to students). However the largest share of respondents are in the lower age segment (25-30).

Table E.3: Attribute and attribute levels pilot survey 2

Attribute	Level 1	Level 2	Level 3
Travel costs	€1	€1,5	€2
Waiting time	1 minute	3 minutes	5 minutes
Travel time in-vehicle	4 minutes	5,5 minutes	7 minutes
Service type	scheduled stops *(+100 meters walking)*	door-to-door *(+0 meters walking)*	
Surveillance in bus	none	camera	supervisor

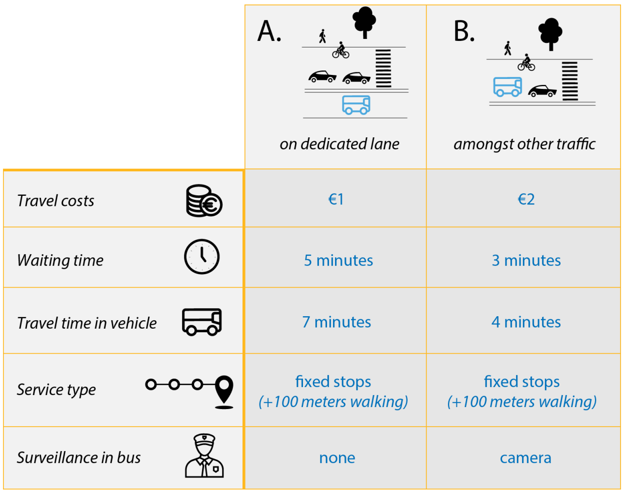


Figure E.2: Choice set example pilot survey 2

The model was estimated in Biogeme including three levels for *travel costs, waiting time, travel time in-vehicle* and *surveillance in vehicle* and two levels for *service type*. The model including linearity parameters for *travel costs, waiting time* and *travel time in-vehicle* was re-estimated without these parameters after these values were found not to be significant. In the final experimental design in Ngene the linearity parameters were not included explicitly (as the values were found not to be significant). However, based on the small sample group and the fact that the parameters were almost significant sufficient degrees of freedom were still taken into account for the final design to be able to test for linearity. The prior estimator values of the model without linearity parameters are shown in table E.3. The output of all Biogeme runs can be found in appendix H.

Parameter number	Description	Coeff. estimate	Robust Asympt. std. error	*t*-stat	*p*-value
1	Constant for Bus amongst other traffic	-0.531	0.172	-3.08	0.00
2	Service type	1.16	0.326	3.56	0.00
3	Travel cost linear	-2.16	0.355	-6.07	0.00
4	Supervisor	0.158	0.103	1.54	0.12*
5	Camera	0.396	0.134	2.96	0.00
6	Travel time linear	-0.375	0.0683	-5.49	0.00
7	Waiting time linear	-0.505	0.0630	-8.02	0.00

All prior values have the expected sign. *Travel costs, travel time* and *waiting time* all have a negative influence on the utility. While *surveillance in bus* (supervisor and camera) and *service type* both have a positive effect on the utility.

The constant for the *bus amongst other traffic* was again found to be negative (-0.531). However, compared to the prior value of the first pilot (-1.94) the value is a lot lower. Intuitively this would make sense, an ADS-DV amongst other traffic could be perceived as dangerous or slow in case it would get stuck in traffic. However, the alternative is quite related to the ADS-DV on a dedicated lane which means that many other factors that would influence utility negatively would be found in both alternatives, leading to a smaller difference in ASC values. The ASC for the bus on dedicated lane was fixed at 0.0 to operate as a base point.

Surveillance in bus was effect coded to be able to estimate the relative influence of 'camera' and 'supervisor' in the bus on utility. 'Camera' has a positive and significant parameter meaning that individuals derive utility from this type of surveillance in the bus compared to 'no surveillance'. Furthermore, 'supervisor' was found to be not significant, which would indicate that having a supervisor in the bus would not derive more utility than having a camera in the bus. Although supervisor was not found to be significant, it was decided to keep the parameter *surveillance in bus* in three levels. From literature it was found that a supervisor in the bus would have a strong influence on utility and as the second pilot overrepresented younger individuals, the parameter might still be significant in the final survey.

A validation of the results was done by calculating the willingness-to-pay for individuals that could be derived from the model. From equations E.3 and E.4 it can be derived that the willingness-to-pay is equal to 10.42 €/hour. Kouwenhoven et al. [85] stated that the value of time (willingness-to-pay for a decrease of one hour of travel time) in the Netherlands is €/hour 9.75 and €13.50/hour for respectively commuters and business employees in general. Comparing the calculated value of 10.42 shows that the value found in the model estimation lies within this range. Therefore it may be concluded that the priors found with the model are quite representative.

$$WTP_{perminutetraveltime} = \frac{\beta traveltimein-vehicle}{\beta travelcost} = \frac{-0.375}{-2.16} = 0.1736 \tag{E.3}$$

$$WTP_{\frac{euro}{hour}} = 0.1736 * 60 minutes = 10.42 \frac{euro}{hour} \tag{E.4}$$

E.4. Final survey

The final survey was created based on the feedback from both pilot surveys and can be found in appendix C. A list of all considerations for the survey design can be found in appendix **??**.

E.4.1. Final survey design

The statements used in the first pilot survey were slightly revised to decrease the presence of any possible ambiguity. Furthermore, one statement was added to support the latent construct of *security*. Moreover, some statements were transformed from positive to negative to better balance the directions of the indicators within the assumed latent constructs. The following statements (in order of appearance) were included in the final survey:

1. I trust a self-driving bus can drive itself without any assistance from a human. (*trust in ADS-DV*)
2. I think it is hard to understand how to use a self-driving bus. (*ease of use*)
3. I think that I will arrive late at my destination when I take a self-driving bus. (*performance expectancy*)
4. I think there will be a self-driving bus available for the return trip to the station. (*performance expectancy*)
5. I would let a close family member ride a self-driving bus. (*trust in ADS-DV*)
6. I am concerned about riding a self-driving bus with strangers. (*security*)
7. I believe that a self-driving bus can safely handle unexpected situations. (*traffic safety*)
8. I am concerned about the interaction of a self-driving bus with other traffic, like human drivers, pedestrians and cyclists. (*traffic safety*)
9. I expect that the interior of a self-driving bus will be dirty. (*performance expectancy*)
10. I think I would find it easy to inform a self-driving bus of my destination. (*ease of use*)
11. I believe a self-driving bus would drive safer than the average human driver. (*trust in ADS-DV*)
12. The potential risks of software hacking or other forms of misuse of self-driving buses worry me. (*security*)

For each statement the latent construct is mentioned (between brackets) for which it was included in the survey. However, as the perceptions of *trust, safety* and *performance expectancy* overlap in certain areas, it might be possible that new latent constructs might be derived from the survey data. Indications for this possibility could already be seen from the factor analysis in section E.2.1. In the light of the study this development is not seen as problematic. The aim of this thesis is to indicate whether perceptions play a role in determining the use intention for ADS-DVs and whether there are differences in perceptions between individuals that have experience with ADS-DVs and individuals that do not have experience. It can therefore be stated that the presence of latent constructs is more important than the specific latent constructs themselves.

The efficient experimental design was created in Ngene with the (significant) priors found in the second pilot survey. In appendix I the syntax and design are presented. The design consist of 12 rows in 2 blocks, allowing for 11 degrees of freedom in the model. For the best efficient design generated by Ngene all choice probabilities were found to be under 0.90. The choice set design is similar to that in the second pilot survey.

The final survey was reconstructed in the survey tool Typeform for its user friendliness and survey design possibilities exceed those of Google forms. In Typeform four versions of the survey were created: one version for each choice set block and each block was presented in Dutch and English versions. Each respondent was able to selected their preferred survey language and fill out the form in that language. By splitting English and Dutch, the amount of text provided in instructions, questions and answers was minimised in order to make this relatively intense survey less overwhelming to respondents and increase the completion rate.

The introduction to the survey was preceded by a video explaining how to use an ADS-DV and introducing both ADS-DV level 4 (example: ParkShuttle) and ADS-DV level 5 (example: WEpod). Another instruction video was included at the start of the choice set section to point out that respondents were expected to make trade-offs between all the properties of the presented buses when deciding on their preferred alternative.

The final survey was expanded with *region specific questions*. After respondents had finished the choice sets each respondent was asked to indicate in which region their office is situated: Rivium; Plaspoelpolder, Broekpolder & Hoornwijck or Beatrixkwartier. Following their answer a map of their area was presented showing several possible routes for an ADS-DV and asking the respondent to indicate which (if any) of the routes they would use in case these were available to them. Based on their answer (yes/no/maybe) each respondent was asked to explain their answer. Several reasons were predetermined for respondents to choose from and respondents had the opportunity to add their own reasons in a text field. Answers to these questions are believed to give practical information for each region/municipality and allow for considerations of respondents to make use of ADS-DVs in a realistic environment. The maps used in the questions are shown in figure E.3.

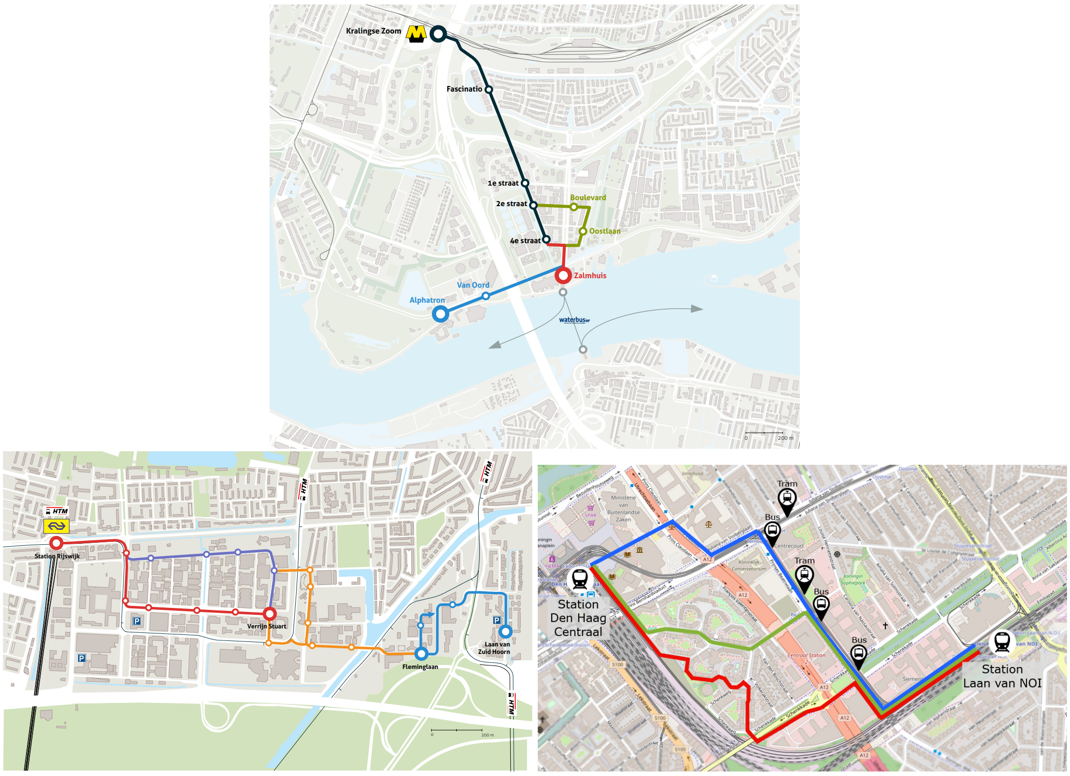


Figure E.3: Region specific questions: Rivium (t); Rijswijk (l); Beatrixkwartier (r)

E.4.2. Data collection

It was essential to increase the number of respondents in the area without an ADS-DV. Extra reminders via the interest groups did not lead to higher response rates and some companies replied not to be interested in any surveys, which could indicate that more companies did not distribute the survey to their employees. By means of handing out flyers in Beatrixkwartier and Rijswijk an additional 85 responses to the survey were collected. A total of 500 flyers were handed out at main tram and train stations and distributed via lunch rooms and coffee bars. Given the high response rate of the flyering and the positive reactions of the persons approached for the survey additionally it can be concluded that most individuals are curious about the developments in transportation and interested in the potential of automated vehicles. While flyering it is harder to reach private mode travellers than public transport users. Distribution via lunch rooms and coffee bars was done to balance the numbers of private mode users and public transportation users. The shares of public transport users per region are shown in table E.4.

Table E.4: Cross table REGION and PTUSE

	Public transport use		Total number
Region	Yes	No	(=100%)
Capelle a/d IJssel	66.6%	33.3%	99
Beatrixkwartier	28.8%	71.2%	59
Rijswijk	35.1%	64.9%	37
Total	50.8%	49.2%	195

F

Pilot survey 2

The design of the second pilot survey in shown in this appendix.

Deze pilot enquête is onderdeel van het afstudeeronderzoek van Marissa Dekker aan de TU Delft en de Metropoolregio Rotterdam Den Haag als onderdeel van het STAD project (stad.tudelft.nl/wordpress/).

In het onderzoek wordt bekeken hoe reizigers denken over busjes zonder bestuurder, zogenaamde *zelfrijdende bussen*.

start toets ENTER

1 → Hoe reis je met een zelfrijdende bus?

De foto's in deze fotocollage zijn gemaakt bij de zelfrijdende bus in Capelle a/d IJssel, de ParkShuttle.

“ Je komt met de trein aan op het station dat het dichtst bij je eindbestemming ligt. Op het treinstation bevindt zich ook de halte van de zelfrijdende bus.

volgende toets ENTER

“ Om gebruik te maken van de zelfrijdende bus, druk je bij de halte op de 'oproepknop'. Zo weet de bus dat er een reiziger is. De zelfrijdende bus rijdt altijd *on demand*: de bus komt altijd wanneer je deze aanvraagt, oftewel er zijn geen vaste vertrektijden.

“ Vervolgens komt de bus voorrijden, stap jij met andere wachtende reizigers in de bus en gebruik je je OV chipkaart om in te checken. In de bus is plaats voor 12 personen.

“ Je geeft je bestemming aan door op een van de halte knoppen te drukken of in het geval dat de bus direct naar iedereens bestemming rijdt (deur-tot-deur) geef je het adres op waar je naartoe wilt.

“ De bus rijdt zelfstandig naar de aangegeven locaties en zet onderweg passagiers af of pikt nieuwe reizigers op.

volgende toets ENTER

“ Aangekomen op je bestemming check je uit met je OV chipkaart en loop je het laatste stukje naar je werk of studie.

naar de vragen toets ENTER

2 → Wat voor soort zelfrijdende bus heeft jouw voorkeur?

Het is nog onduidelijk hoe de zelfrijdende bus wordt gewaardeerd door reizigers. Dit onderzoek moet een indruk geven welke eigenschappen van een zelfrijdende bus het belangrijkst zijn voor reizigers wanneer zij gebruik willen maken van een zelfrijdende bus.

“ Stel je bij elke vraag voor dat je met de trein naar je werk/studie reist en voor *de laatste 1500 meter vanaf het station naar je bestemming* een zelfrijdende bus wilt gebruiken.

De bedoeling is om bij elke vraag de zelfrijdende bus te kiezen die jouw voorkeur zou hebben.

Let op! Bij elke vergelijking hebben de zelfrijdende bussen andere eigenschappen.

Ga verder toets ENTER

Voorbeeld

→ Welke zelfrijdende bus zou jouw voorkeur hebben om *de laatste 1500 meter van het treinstation naar jouw bestemming* af te leggen?*

	A. *op eigen baan*	B. *tussen ander verkeer*
Reiskosten	€1	€1
Wachttijd	5 minuten	1 minuut
Reistijd onderweg	7 minuten	5,5 minuten
Service type	vaste haltes *(+100 meter lopen)*	vaste haltes *(+100 meter lopen)*
Toezicht in bus	camera	geen
	eigenschappen bus op eigen baan	**eigenschappen bus tussen ander verkeer**

A bus op eigen baan ✓ B bus tussen ander verkeer

voorbeeld keuze

Ga verder toets **ENTER**

Legenda

Een bus kan *op een eigen baan* rijden of *tussen ander verkeer* op de rijbaan, in het laatste geval deelt de bus de weg met bestuurders van auto's, fietsers of voetgangers.

Reiskosten	De kosten voor een enkele reis in de zelfrijdende bus zijn uitgedrukt in euro.
Wachttijd	De wachttijd is de tijd in minuten dat u bij de halte staat te wachten na het oproepen op de zelfrijdende bus. De bushalte bevindt zich op het station, de overstaptijd is zeer kort.
Reistijd onderweg	De reistijd onderweg is de tijd in minuten die u van het station tot aan uw bestemming in de zelfrijdende bus doorbrengt.
Service type	Zelfrijdende bussen kunnen stoppen bij een aantal vaste haltes of u direct naar uw eindbestemming brengen (deur-tot-deur). Vanaf een vaste halte moet u gemiddeld nog 100 meter lopen naar uw bestemming.
Toezicht in bus	De vervoersmaatschappij kan er voor kiezen om een camera of toezichthouder aan boord van de bus te hebben om toezicht te houden. **Een toezichthouder kan echter nooit zelf de bus besturen.**

ik snap het toets **ENTER**

a. Welke zelfrijdende bus zou jouw voorkeur hebben om *de laatste 1500 meter van het treinstation naar jouw bestemming* af te leggen?*

	A. *op eigen baan*	B. *tussen ander verkeer*
Reiskosten	€1	€1
Wachttijd	3 minuten	5 minuten
Reistijd onderweg	4 minuten	7 minuten
Service type	vaste haltes *(+100 meter lopen)*	deur-tot-deur *(+ 0 meter lopen)*
Toezicht in bus	camera	toezichthouder

A bus op eigen baan B bus tussen ander verkeer

b. Welke zelfrijdende bus zou jouw voorkeur hebben om *de laatste 1500 meter van het treinstation naar jouw bestemming* af te leggen?*

	A.  op eigen baan	B.  tussen ander verkeer
Reiskosten	€2	€1,50
Wachttijd	5 minuten	3 minuten
Reistijd onderweg	4 minuten	5,5 minuten
Service type	vaste haltes *(+100 meter lopen)*	deur-tot-deur *(+ 0 meter lopen)*
Toezicht in bus	geen	camera

- A bus op eigen baan
- B bus tussen ander verkeer

c. Welke zelfrijdende bus zou jouw voorkeur hebben om *de laatste 1500 meter van het treinstation naar jouw bestemming* af te leggen?*

	A.  op eigen baan	B.  tussen ander verkeer
Reiskosten	€1	€1,50
Wachttijd	5 minuten	1 minuut
Reistijd onderweg	5,5 minuten	4 minuten
Service type	vaste haltes *(+100 meter lopen)*	deur-tot-deur *(+ 0 meter lopen)*
Toezicht in bus	camera	geen

- A bus op eigen baan
- B bus tussen ander verkeer

d. Welke zelfrijdende bus zou jouw voorkeur hebben om *de laatste 1500 meter van het treinstation naar jouw bestemming* af te leggen?*

	A.  op eigen baan	B.  tussen ander verkeer
Reiskosten	€1,50	€2
Wachttijd	3 minuten	5 minuten
Reistijd onderweg	7 minuten	5,5 minuten
Service type	vaste haltes *(+100 meter lopen)*	deur-tot-deur *(+ 0 meter lopen)*
Toezicht in bus	toezichthouder	camera

- A bus op eigen baan
- B bus tussen ander verkeer

e. Welke zelfrijdende bus zou jouw voorkeur hebben om *de laatste 1500 meter van het treinstation naar jouw bestemming* af te leggen?*

	A. op eigen baan	B. tussen ander verkeer
Reiskosten	€1,50	€2
Wachttijd	3 minuten	1 minuut
Reistijd onderweg	4 minuten	5,5 minuten
Service type	vaste haltes *(+100 meter lopen)*	vaste haltes *(+100 meter lopen)*
Toezicht in bus	geen	toezichthouder

A bus op eigen baan   B bus tussen ander verkeer

f. Welke zelfrijdende bus zou jouw voorkeur hebben om *de laatste 1500 meter van het treinstation naar jouw bestemming* af te leggen?*

	A. op eigen baan	B. tussen ander verkeer
Reiskosten	€2	€1,50
Wachttijd	1 minuut	5 minuten
Reistijd onderweg	7 minuten	4 minuten
Service type	vaste haltes *(+100 meter lopen)*	deur-tot-deur *(+ 0 meter lopen)*
Toezicht in bus	geen	toezichthouder

A bus op eigen baan   B bus tussen ander verkeer

g. Welke zelfrijdende bus zou jouw voorkeur hebben om *de laatste 1500 meter van het treinstation naar jouw bestemming* af te leggen?*

	A. op eigen baan	B. tussen ander verkeer
Reiskosten	€1,50	€2
Wachttijd	5 minuten	3 minuten
Reistijd onderweg	5,5 minuten	4 minuten
Service type	vaste haltes *(+100 meter lopen)*	vaste haltes *(+100 meter lopen)*
Toezicht in bus	geen	toezichthouder

A bus op eigen baan   B bus tussen ander verkeer

h. Welke zelfrijdende bus zou jouw voorkeur hebben om *de laatste 1500 meter van het treinstation naar jouw bestemming* af te leggen?*

	A. *op eigen baan*	B. *tussen ander verkeer*
Reiskosten	€1,50	€2
Wachttijd	1 minuut	3 minuten
Reistijd onderweg	5,5 minuten	7 minuten
Service type	vaste haltes *(+100 meter lopen)*	deur-tot-deur *(+ 0 meter lopen)*
Toezicht in bus	toezichthouder	geen

- A bus op eigen baan
- B bus tussen ander verkeer

i. Welke zelfrijdende bus zou jouw voorkeur hebben om *de laatste 1500 meter van het treinstation naar jouw bestemming* af te leggen?*

	A. *op eigen baan*	B. *tussen ander verkeer*
Reiskosten	€2	€1
Wachttijd	1 minuut	3 minuten
Reistijd onderweg	4 minuten	7 minuten
Service type	vaste haltes *(+100 meter lopen)*	vaste haltes *(+100 meter lopen)*
Toezicht in bus	camera	geen

- A bus op eigen baan
- B bus tussen ander verkeer

j. Welke zelfrijdende bus zou jouw voorkeur hebben om *de laatste 1500 meter van het treinstation naar jouw bestemming* af te leggen?*

	A. *op eigen baan*	B. *tussen ander verkeer*
Reiskosten	€2	€1,50
Wachttijd	3 minuten	1 minuut
Reistijd onderweg	5,5 minuten	7 minuten
Service type	vaste haltes *(+100 meter lopen)*	vaste haltes *(+100 meter lopen)*
Toezicht in bus	toezichthouder	camera

- A bus op eigen baan
- B bus tussen ander verkeer

k. Welke zelfrijdende bus zou jouw voorkeur hebben om *de laatste 1500 meter van het treinstation naar jouw bestemming* af te leggen?*

	A.  op eigen baan	B.  tussen ander verkeer
Reiskosten	€1	€1
Wachttijd	1 minuut	5 minuten
Reistijd onderweg	7 minuten	4 minuten
Service type	vaste haltes (+100 meter lopen)	vaste haltes (+100 meter lopen)
Toezicht in bus	toezichthouder	camera

A bus op eigen baan
B bus tussen ander verkeer

l. Welke zelfrijdende bus zou jouw voorkeur hebben om *de laatste 1500 meter van het treinstation naar jouw bestemming* af te leggen?*

	A.  op eigen baan	B.  tussen ander verkeer
Reiskosten	€1	€1
Wachttijd	5 minuten	1 minuut
Reistijd onderweg	7 minuten	5,5 minuten
Service type	vaste haltes (+100 meter lopen)	vaste haltes (+100 meter lopen)
Toezicht in bus	camera	geen

A bus op eigen baan
B bus tussen ander verkeer

Bedankt voor het invullen!

G
Ngene pilot survey

Ngene software is used to determine the attribute values in the choice set design. This appendix shows the syntax and output of both pilot surveys.

G.1. Ngene syntax pilot 1

```
Design
;alts = busdl, busat
;rows = 12
;orth = sim
;model:
U(busat) = b0 + b1*wait[1,4] + b2*travel[4,6] + b3*extratime[0,1]
         + b4*costs[1,2] + b5*service[0,1] + b6*employee[0,1] /
U(busdl) = b1*wait + b2*travel + b4*costs + b6*employee
$
```

Figure G.1: Ngene syntax pilot study

G.2. Ngene output pilot 1

Choice situation	busat.wait	busat.travel	busat.extratime	busat.costs	busat.service	busat.employee	busdl.wait	busdl.travel	busdl.costs	busdl.employee
1	4	6	1	1	1	0	1	4	1	0
2	1	6	1	2	0	1	1	4	2	0
3	4	4	0	1	1	1	4	4	2	0
4	1	4	1	2	1	0	4	4	1	1
5	1	6	0	1	0	0	4	4	2	1
6	4	4	0	2	0	1	1	4	1	1
7	4	6	0	2	0	0	4	6	1	0
8	1	4	0	2	1	0	1	6	2	0
9	1	4	1	1	0	1	4	6	1	0
10	4	4	1	1	0	0	1	6	2	1
11	1	6	0	1	1	1	1	6	1	1
12	4	6	1	2	1	1	4	6	2	1

Figure G.2: Orthogonal design pilot study 1

Correlations (Pearson Product Moment)										
Attribute	busat.wait	busat.travel	busat.extratime	busat.costs	busat.service	busat.employee	busdl.wait	busdl.travel	busdl.costs	busdl.employee
busat.wait	1	0	0	0	0	0	0	0	0	0
busat.travel	0	1	0	0	0	0	0	0	0	0
busat.extratime	0	0	1	0	0	0	0	0	0	0
busat.costs	0	0	0	1	0	0	0	0	0	0
busat.service	0	0	0	0	1	0	0	0	0	0
busat.employee	0	0	0	0	0	1	0	0	0	0
busdl.wait	0	0	0	0	0	0	1	0	0	0
busdl.travel	0	0	0	0	0	0	0	1	0	0
busdl.costs	0	0	0	0	0	0	0	0	1	0
busdl.employee	0	0	0	0	0	0	0	0	0	1

Figure G.3: Pearson Product Moment: no correlations between attributes in the orthogonal design

G.3. Ngene syntax pilot 2

```
Design
;alts = busdl, busat
;rows = 12
;eff = (mnl,d)
;con
?;block = 2

;model:

U(busdl) = b_costs.effects[-1.89|-1.89] * travelcosts[2,1.5,1] + b_wait.effects[-0.387|-0.387] * waitingtime[5,3,1]
            + b_travel.effects[-0.339|-0.339] * traveltime [7,5.5,4] + b_surveillance.effects[0|0] * surveillance[2,1,0] /
U(busat) =  asc_at + b_costs * travelcosts + b_wait * waitingtime + b_travel * traveltime + b_service[0.966] * service[-1,1]
            + b_surveillance* surveillance

$
```

Figure G.4: Ngene syntax pilot study 2

G.4. Ngene output pilot 2

Summary statistics

D error	=	0.396799
A error	=	0.983024
B estimate	=	81.329849
S estimate	=	16.172285

Table G.1: Ngene choice probabilities - pilot 2

MNL probabilities		
Choice situation	busdl	busat
1	0.512747	0.487253
2	0.512747	0.487253
3	0.925945	0.074055
4	0.275679	0.724321
5	0.694661	0.305339
6	0.305339	0.694661
7	0.487253	0.512747
8	0.548596	0.451404
9	0.074055	0.925945
10	0.451404	0.548596
11	0.752129	0.247871
12	0.451404	0.548596

Table G.2: Prior values

Prior	b_costs(e0)	b_costs(e1)	b_wait(e0)	b_wait(e1)	b_travel(e0)	b_travel(e1)	b_surv(e0)	b_surv(e1)	asc_at	b_service
Fixed prior value	-1.89	-1.89	-0.387	-0.387	-0.339	-0.339	0	0	0	0.966
Sp estimates	2.694113	3.190547	14.275301	12.190679	12.618304	16.172285	Undefined	Undefined	Undefined	5.991392
Sp t-ratios	1.194121	1.097295	0.518756	0.561361	0.551767	0.487383	0	0	0	0.800741

Design									
Choice situation	busdl.travelcosts	busdl.waitingtime	busdl.traveltime	busdl.surveillance	busat.travelcosts	busat.waitingtime	busat.traveltime	busat.service	busat.surveillance
1	1	3	4	1	1	5	7	1	2
2	2	5	4	0	1.5	3	5.5	1	1
3	1	5	5.5	1	1.5	1	4	1	0
4	1.5	3	7	2	2	5	5.5	1	1
5	1.5	3	4	0	2	1	5.5	-1	2
6	2	1	7	0	1.5	5	4	1	2
7	1.5	5	5.5	0	2	3	4	-1	2
8	1.5	1	5.5	2	2	3	7	1	0
9	2	1	4	1	1	3	7	-1	0
10	2	3	5.5	2	1.5	1	7	-1	1
11	1	1	7	2	1	5	4	-1	1
12	1	5	7	1	1	1	5.5	-1	0

Figure G.5: Efficient design pilot study 2

H

Biogeme pilot survey 1 & 2

For the estimation of choice models Biogeme software is used. This appendix shows the syntax, input files and output of the first pilot survey and the syntax and output of the second pilot survey.

Model specification pilot survey 1

```
[ModelDescription]
"Model to determine prior estimators for pilot study with two alternatives."
"Alt1: Bus on dedicated lane, Alt2: Bus amongst other traffic"

[Beta]
// Name         Value   Lowerbound      Upperboud       Status
ASC_BUSAT       0       -1000           1000            0
B_WAIT          0       -1000           1000            0
B_TRAVEL        0       -1000           1000            0
BUSAT_EXTRA     0       -1000           1000            0
B_COST          0       -1000           1000            0
BUSAT_SERVICE   0       -1000           1000            0
B_EMPLOYEE      0       -1000           1000            0


[Choice]
CHOICE

[Utilities]
// ID   Name            Avail           Expression
1       A1_BUSDL        BUSDL_SP        B_WAIT * WT_1 + B_TRAVEL * TT_1 + B_COST * TC_1 + B_EMPLOYEE * ST_1
2       A2_BUSAT        BUSAT_SP        ASC_BUSAT * one + B_WAIT * WT_2 + B_TRAVEL * TT_2 + B_COST * TC_2
                                        + B_EMPLOYEE * ST_2 + BUSAT_EXTRA * BUSAT_ETT + BUSAT_SERVICE * BUSAT_S

[PanelData]
ID

[Expressions]
one = 1
BUSDL_SP = 1
BUSAT_SP = 1

[LaTeX]
ASC_BUSAT       "Constant for Bus amongst other traffic"
B_WAIT          "Waiting time"
B_TRAVEL        "Travel time"
BUSAT_EXTRA     "Extra travel time"
B_COST          "Travel cost"
BUSAT_SERVICE   "Service type"
B_EMPLOYEE      "Steward"

[Model]
// Multinomial Logit Model
$MNL
```

Data file pilot survey

obsIter	ID	WT_2	TT_2	BUSAT_ETT	TC_2	BUSAT_S	ST_2	WT_1	TT_1	TC_1	ST_1	**CHOICE**
1	1	4	6	1	1	1	0	1	4	1	0	**1**
2	1	1	6	1	2	0	1	1	4	2	0	**1**
3	1	4	4	0	1	1	1	4	4	2	0	**2**
4	1	1	4	1	2	1	0	4	4	1	1	**1**
5	1	1	6	0	1	0	0	4	4	2	1	**2**
6	1	4	4	0	2	0	1	1	4	1	1	**1**
7	1	4	6	0	2	0	0	4	6	1	0	**1**
8	1	1	4	0	2	1	0	1	6	2	0	**1**
9	1	1	4	1	1	0	1	4	6	1	0	**2**
10	1	4	4	1	1	0	0	1	6	2	1	**2**
11	1	1	6	0	1	1	1	1	6	1	1	**1**
12	1	4	6	1	2	1	1	4	6	2	1	**1**
13	2	4	6	1	1	1	0	1	4	1	0	**1**
14	2	1	6	1	2	0	1	1	4	2	0	**1**
15	2	4	4	0	1	1	1	4	4	2	0	**1**
16	2	1	4	1	2	1	0	4	4	1	1	**1**
17	2	1	6	0	1	0	0	4	4	2	1	**1**
18	2	4	4	0	2	0	1	1	4	1	1	**1**
19	2	4	6	0	2	0	0	4	6	1	0	**1**
20	2	1	4	0	2	1	0	1	6	2	0	**1**
21	2	1	4	1	1	0	1	4	6	1	0	**1**
22	2	4	4	1	1	0	0	1	6	2	1	**1**
23	2	1	6	0	1	1	1	1	6	1	1	**1**
24	2	4	6	1	2	1	1	4	6	2	1	**1**
25	3	4	6	1	1	1	0	1	4	1	0	**1**
26	3	1	6	1	2	0	1	1	4	2	0	**1**
27	3	4	4	0	1	1	1	4	4	2	0	**2**
28	3	1	4	1	2	1	0	4	4	1	1	**1**
29	3	1	6	0	1	0	0	4	4	2	1	**1**
30	3	4	4	0	2	0	1	1	4	1	1	**1**
31	3	4	6	0	2	0	0	4	6	1	0	**1**
32	3	1	4	0	2	1	0	1	6	2	0	**1**
33	3	1	4	1	1	0	1	4	6	1	0	**1**
34	3	4	4	1	1	0	0	1	6	2	1	**1**
35	3	1	6	0	1	1	1	1	6	1	1	**1**
36	3	4	6	1	2	1	1	4	6	2	1	**1**
37	4	4	6	1	1	1	0	1	4	1	0	**1**
38	4	1	6	1	2	0	1	1	4	2	0	**2**
39	4	4	4	0	1	1	1	4	4	2	0	**2**
40	4	1	4	1	2	1	0	4	4	1	1	**2**
41	4	1	6	0	1	0	0	4	4	2	1	**1**
42	4	4	4	0	2	0	1	1	4	1	1	**1**

Figure H.1: Biogeme data file pilot survey

43	4	4	6	0	2	0	0	4	6	1	0	**1**
44	4	1	4	0	2	1	0	1	6	2	0	**1**
45	4	1	4	1	1	0	1	4	6	1	0	**2**
46	4	4	4	1	1	0	0	1	6	2	1	**1**
47	4	1	6	0	1	1	1	1	6	1	1	**1**
48	4	4	6	1	2	1	1	4	6	2	1	**1**
49	5	4	6	1	1	1	0	1	4	1	0	**1**
50	5	1	6	1	2	0	1	1	4	2	0	**1**
51	5	4	4	0	1	1	1	4	4	2	0	**1**
52	5	1	4	1	2	1	0	4	4	1	1	**2**
53	5	1	6	0	1	0	0	4	4	2	1	**2**
54	5	4	4	0	2	0	1	1	4	1	1	**1**
55	5	4	6	0	2	0	0	4	6	1	0	**1**
56	5	1	4	0	2	1	0	1	6	2	0	**2**
57	5	1	4	1	1	0	1	4	6	1	0	**2**
58	5	4	4	1	1	0	0	1	6	2	1	**2**
59	5	1	6	0	1	1	1	1	6	1	1	**1**
60	5	4	6	1	2	1	1	4	6	2	1	**1**
61	6	4	6	1	1	1	0	1	4	1	0	**1**
62	6	1	6	1	2	0	1	1	4	2	0	**1**
63	6	4	4	0	1	1	1	4	4	2	0	**2**
64	6	1	4	1	2	1	0	4	4	1	1	**1**
65	6	1	6	0	1	0	0	4	4	2	1	**2**
66	6	4	4	0	2	0	1	1	4	1	1	**1**
67	6	4	6	0	2	0	0	4	6	1	0	**1**
68	6	1	4	0	2	1	0	1	6	2	0	**2**
69	6	1	4	1	1	0	1	4	6	1	0	**2**
70	6	4	4	1	1	0	0	1	6	2	1	**2**
71	6	1	6	0	1	1	1	1	6	1	1	**1**
72	6	4	6	1	2	1	1	4	6	2	1	**2**
73	7	4	6	1	1	1	0	1	4	1	0	**2**
74	7	1	6	1	2	0	1	1	4	2	0	**1**
75	7	4	4	0	1	1	1	4	4	2	0	**2**
76	7	1	4	1	2	1	0	4	4	1	1	**2**
77	7	1	6	0	1	0	0	4	4	2	1	**1**
78	7	4	4	0	2	0	1	1	4	1	1	**1**
79	7	4	6	0	2	0	0	4	6	1	0	**1**
80	7	1	4	0	2	1	0	1	6	2	0	**2**
81	7	1	4	1	1	0	1	4	6	1	0	**2**
82	7	4	4	1	1	0	0	1	6	2	1	**1**
83	7	1	6	0	1	1	1	1	6	1	1	**2**
84	7	4	6	1	2	1	1	4	6	2	1	**2**
85	8	4	6	1	1	1	0	1	4	1	0	**1**

86	8	1	6	1	2	0	1	1	4	2	0	**2**
87	8	4	4	0	1	1	1	4	4	2	0	**2**
88	8	1	4	1	2	1	0	4	4	1	1	**2**
89	8	1	6	0	1	0	0	4	4	2	1	**2**
90	8	4	4	0	2	0	1	1	4	1	1	**1**
91	8	4	6	0	2	0	0	4	6	1	0	**1**
92	8	1	4	0	2	1	0	1	6	2	0	**2**
93	8	1	4	1	1	0	1	4	6	1	0	**2**
94	8	4	4	1	1	0	0	1	6	2	1	**2**
95	8	1	6	0	1	1	1	1	6	1	1	**2**
96	8	4	6	1	2	1	1	4	6	2	1	**1**
97	9	4	6	1	1	1	0	1	4	1	0	**1**
98	9	1	6	1	2	0	1	1	4	2	0	**1**
99	9	4	4	0	1	1	1	4	4	2	0	**2**
100	9	1	4	1	2	1	0	4	4	1	1	**1**
101	9	1	6	0	1	0	0	4	4	2	1	**2**
102	9	4	4	0	2	0	1	1	4	1	1	**1**
103	9	4	6	0	2	0	0	4	6	1	0	**1**
104	9	1	4	0	2	1	0	1	6	2	0	**1**
105	9	1	4	1	1	0	1	4	6	1	0	**1**
106	9	4	4	1	1	0	0	1	6	2	1	**2**
107	9	1	6	0	1	1	1	1	6	1	1	**1**
108	9	4	6	1	2	1	1	4	6	2	1	**1**
109	10	4	6	1	1	1	0	1	4	1	0	**1**
110	10	1	6	1	2	0	1	1	4	2	0	**2**
111	10	4	4	0	1	1	1	4	4	2	0	**2**
112	10	1	4	1	2	1	0	4	4	1	1	**1**
113	10	1	6	0	1	0	0	4	4	2	1	**2**
114	10	4	4	0	2	0	1	1	4	1	1	**1**
115	10	4	6	0	2	0	0	4	6	1	0	**1**
116	10	1	4	0	2	1	0	1	6	2	0	**2**
117	10	1	4	1	1	0	1	4	6	1	0	**2**
118	10	4	4	1	1	0	0	1	6	2	1	**2**
119	10	1	6	0	1	1	1	1	6	1	1	**1**
120	10	4	6	1	2	1	1	4	6	2	1	**1**
121	11	4	6	1	1	1	0	1	4	1	0	**1**
122	11	1	6	1	2	0	1	1	4	2	0	**1**
123	11	4	4	0	1	1	1	4	4	2	0	**1**
124	11	1	4	1	2	1	0	4	4	1	1	**1**
125	11	1	6	0	1	0	0	4	4	2	1	**1**
126	11	4	4	0	2	0	1	1	4	1	1	**1**
127	11	4	6	0	2	0	0	4	6	1	0	**1**
128	11	1	4	0	2	1	0	1	6	2	0	**1**

129	11	1	4	1	1	0	1	4	6	1	0	**1**
130	11	4	4	1	1	0	0	1	6	2	1	**1**
131	11	1	6	0	1	1	1	1	6	1	1	**1**
132	11	4	6	1	2	1	1	4	6	2	1	**1**
133	12	4	6	1	1	1	0	1	4	1	0	**1**
134	12	1	6	1	2	0	1	1	4	2	0	**1**
135	12	4	4	0	1	1	1	4	4	2	0	**2**
136	12	1	4	1	2	1	0	4	4	1	1	**1**
137	12	1	6	0	1	0	0	4	4	2	1	**2**
138	12	4	4	0	2	0	1	1	4	1	1	**1**
139	12	4	6	0	2	0	0	4	6	1	0	**1**
140	12	1	4	0	2	1	0	1	6	2	0	**2**
141	12	1	4	1	1	0	1	4	6	1	0	**2**
142	12	4	4	1	1	0	0	1	6	2	1	**2**
143	12	1	6	0	1	1	1	1	6	1	1	**1**
144	12	4	6	1	2	1	1	4	6	2	1	**1**
145	13	4	6	1	1	1	0	1	4	1	0	**1**
146	13	1	6	1	2	0	1	1	4	2	0	**1**
147	13	4	4	0	1	1	1	4	4	2	0	**2**
148	13	1	4	1	2	1	0	4	4	1	1	**1**
149	13	1	6	0	1	0	0	4	4	2	1	**1**
150	13	4	4	0	2	0	1	1	4	1	1	**1**
151	13	4	6	0	2	0	0	4	6	1	0	**1**
152	13	1	4	0	2	1	0	1	6	2	0	**2**
153	13	1	4	1	1	0	1	4	6	1	0	**2**
154	13	4	4	1	1	0	0	1	6	2	1	**2**
155	13	1	6	0	1	1	1	1	6	1	1	**2**
156	13	4	6	1	2	1	1	4	6	2	1	**2**
157	14	4	6	1	1	1	0	1	4	1	0	**1**
158	14	1	6	1	2	0	1	1	4	2	0	**1**
159	14	4	4	0	1	1	1	4	4	2	0	**2**
160	14	1	4	1	2	1	0	4	4	1	1	**1**
161	14	1	6	0	1	0	0	4	4	2	1	**1**
162	14	4	4	0	2	0	1	1	4	1	1	**1**
163	14	4	6	0	2	0	0	4	6	1	0	**1**
164	14	1	4	0	2	1	0	1	6	2	0	**1**
165	14	1	4	1	1	0	1	4	6	1	0	**1**
166	14	4	4	1	1	0	0	1	6	2	1	**1**
167	14	1	6	0	1	1	1	1	6	1	1	**1**
168	14	4	6	1	2	1	1	4	6	2	1	**1**
169	15	4	6	1	1	1	0	1	4	1	0	**1**
170	15	1	6	1	2	0	1	1	4	2	0	**2**
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172	15	1	4	1	2	1	0	4	4	1	1	**1**
173	15	1	6	0	1	0	0	4	4	2	1	**1**
174	15	4	4	0	2	0	1	1	4	1	1	**1**
175	15	4	6	0	2	0	0	4	6	1	0	**1**
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177	15	1	4	1	1	0	1	4	6	1	0	**1**
178	15	4	4	1	1	0	0	1	6	2	1	**1**
179	15	1	6	0	1	1	1	1	6	1	1	**1**
180	15	4	6	1	2	1	1	4	6	2	1	**1**
181	16	4	6	1	1	1	0	1	4	1	0	**1**
182	16	1	6	1	2	0	1	1	4	2	0	**1**
183	16	4	4	0	1	1	1	4	4	2	0	**2**
184	16	1	4	1	2	1	0	4	4	1	1	**1**
185	16	1	6	0	1	0	0	4	4	2	1	**1**
186	16	4	4	0	2	0	1	1	4	1	1	**1**
187	16	4	6	0	2	0	0	4	6	1	0	**1**
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189	16	1	4	1	1	0	1	4	6	1	0	**1**
190	16	4	4	1	1	0	0	1	6	2	1	**1**
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192	16	4	6	1	2	1	1	4	6	2	1	**1**
193	17	4	6	1	1	1	0	1	4	1	0	**1**
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195	17	4	4	0	1	1	1	4	4	2	0	**2**
196	17	1	4	1	2	1	0	4	4	1	1	**1**
197	17	1	6	0	1	0	0	4	4	2	1	**2**
198	17	4	4	0	2	0	1	1	4	1	1	**1**
199	17	4	6	0	2	0	0	4	6	1	0	**1**
200	17	1	4	0	2	1	0	1	6	2	0	**2**
201	17	1	4	1	1	0	1	4	6	1	0	**2**
202	17	4	4	1	1	0	0	1	6	2	1	**2**
203	17	1	6	0	1	1	1	1	6	1	1	**2**
204	17	4	6	1	2	1	1	4	6	2	1	**2**
205	18	4	6	1	1	1	0	1	4	1	0	**1**
206	18	1	6	1	2	0	1	1	4	2	0	**1**
207	18	4	4	0	1	1	1	4	4	2	0	**1**
208	18	1	4	1	2	1	0	4	4	1	1	**1**
209	18	1	6	0	1	0	0	4	4	2	1	**1**
210	18	4	4	0	2	0	1	1	4	1	1	**1**
211	18	4	6	0	2	0	0	4	6	1	0	**1**
212	18	1	4	0	2	1	0	1	6	2	0	**1**
213	18	1	4	1	1	0	1	4	6	1	0	**1**
214	18	4	4	1	1	0	0	1	6	2	1	**1**

215	18	1	6	0	1	1	1	1	6	1	1	**1**
216	18	4	6	1	2	1	1	4	6	2	1	**1**
217	19	4	6	1	1	1	0	1	4	1	0	**2**
218	19	1	6	1	2	0	1	1	4	2	0	**1**
219	19	4	4	0	1	1	1	4	4	2	0	**2**
220	19	1	4	1	2	1	0	4	4	1	1	**2**
221	19	1	6	0	1	0	0	4	4	2	1	**2**
222	19	4	4	0	2	0	1	1	4	1	1	**1**
223	19	4	6	0	2	0	0	4	6	1	0	**1**
224	19	1	4	0	2	1	0	1	6	2	0	**2**
225	19	1	4	1	1	0	1	4	6	1	0	**2**
226	19	4	4	1	1	0	0	1	6	2	1	**1**
227	19	1	6	0	1	1	1	1	6	1	1	**2**
228	19	4	6	1	2	1	1	4	6	2	1	**2**
229	20	4	6	1	1	1	0	1	4	1	0	**1**
230	20	1	6	1	2	0	1	1	4	2	0	**2**
231	20	4	4	0	1	1	1	4	4	2	0	**2**
232	20	1	4	1	2	1	0	4	4	1	1	**2**
233	20	1	6	0	1	0	0	4	4	2	1	**2**
234	20	4	4	0	2	0	1	1	4	1	1	**1**
235	20	4	6	0	2	0	0	4	6	1	0	**1**
236	20	1	4	0	2	1	0	1	6	2	0	**1**
237	20	1	4	1	1	0	1	4	6	1	0	**2**
238	20	4	4	1	1	0	0	1	6	2	1	**2**
239	20	1	6	0	1	1	1	1	6	1	1	**1**
240	20	4	6	1	2	1	1	4	6	2	1	**1**
241	21	4	6	1	1	1	0	1	4	1	0	**1**
242	21	1	6	1	2	0	1	1	4	2	0	**1**
243	21	4	4	0	1	1	1	4	4	2	0	**2**
244	21	1	4	1	2	1	0	4	4	1	1	**2**
245	21	1	6	0	1	0	0	4	4	2	1	**2**
246	21	4	4	0	2	0	1	1	4	1	1	**1**
247	21	4	6	0	2	0	0	4	6	1	0	**1**
248	21	1	4	0	2	1	0	1	6	2	0	**2**
249	21	1	4	1	1	0	1	4	6	1	0	**2**
250	21	4	4	1	1	0	0	1	6	2	1	**2**
251	21	1	6	0	1	1	1	1	6	1	1	**1**
252	21	4	6	1	2	1	1	4	6	2	1	**2**
253	22	4	6	1	1	1	0	1	4	1	0	**2**
254	22	1	6	1	2	0	1	1	4	2	0	**1**
255	22	4	4	0	1	1	1	4	4	2	0	**2**
256	22	1	4	1	2	1	0	4	4	1	1	**1**
257	22	1	6	0	1	0	0	4	4	2	1	**2**

258	22	4	4	0	2	0	1	1	4	1	1	**1**
259	22	4	6	0	2	0	0	4	6	1	0	**1**
260	22	1	4	0	2	1	0	1	6	2	0	**1**
261	22	1	4	1	1	0	1	4	6	1	0	**2**
262	22	4	4	1	1	0	0	1	6	2	1	**2**
263	22	1	6	0	1	1	1	1	6	1	1	**1**
264	22	4	6	1	2	1	1	4	6	2	1	**2**
265	23	4	6	1	1	1	0	1	4	1	0	**1**
266	23	1	6	1	2	0	1	1	4	2	0	**1**
267	23	4	4	0	1	1	1	4	4	2	0	**2**
268	23	1	4	1	2	1	0	4	4	1	1	**1**
269	23	1	6	0	1	0	0	4	4	2	1	**1**
270	23	4	4	0	2	0	1	1	4	1	1	**1**
271	23	4	6	0	2	0	0	4	6	1	0	**1**
272	23	1	4	0	2	1	0	1	6	2	0	**2**
273	23	1	4	1	1	0	1	4	6	1	0	**2**
274	23	4	4	1	1	0	0	1	6	2	1	**1**
275	23	1	6	0	1	1	1	1	6	1	1	**1**
276	23	4	6	1	2	1	1	4	6	2	1	**1**
277	24	4	6	1	1	1	0	1	4	1	0	**1**
278	24	1	6	1	2	0	1	1	4	2	0	**1**
279	24	4	4	0	1	1	1	4	4	2	0	**2**
280	24	1	4	1	2	1	0	4	4	1	1	**1**
281	24	1	6	0	1	0	0	4	4	2	1	**2**
282	24	4	4	0	2	0	1	1	4	1	1	**1**
283	24	4	6	0	2	0	0	4	6	1	0	**1**
284	24	1	4	0	2	1	0	1	6	2	0	**2**
285	24	1	4	1	1	0	1	4	6	1	0	**2**
286	24	4	4	1	1	0	0	1	6	2	1	**1**
287	24	1	6	0	1	1	1	1	6	1	1	**1**
288	24	4	6	1	2	1	1	4	6	2	1	**2**

Results pilot survey 1

biogeme 2.5 [Wed, Jul 27, 2016 12:10:08 PM]

Michel Bierlaire, EPFL

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01/12/17 12:53:16

Tip: click on the columns headers to sort a table [Credits]

Model to determine prior estimators for pilot study with two alternatives.
Alt1: Bus on dedicated lane, Alt2: Bus amongst other traffic

Model: Logit for panel data
Number of estimated parameters: 7
Number of observations: 287
Number of individuals: 24
Null log likelihood: -198.933
Cte log likelihood: -184.903
Init log likelihood: -198.933
Final log likelihood: -142.296
Likelihood ratio test: 113.275
Rho-square: 0.285
Adjusted rho-square: 0.250
Final gradient norm: +9.500e-004
Diagnostic: Convergence reached...
Iterations: 77
Run time: 00:01
Variance-covariance: from finite difference hessian
Sample file: pilotsurveydat - Copy.dat

Utility parameters

Name	Value	Std err	t-test	p-value		Robust Std err	Robust t-test	p-value	
ASC_BUSAT	-1.94	0.486	-3.99	0.00		0.349	-5.55	0.00	
BUSAT_EXTRA	0.695	0.376	1.85	0.06	*	0.226	3.07	0.00	
BUSAT_SERVICE	0.966	0.399	2.42	0.02		0.358	2.70	0.01	
B_COST	-1.89	0.343	-5.51	0.00		0.289	-6.54	0.00	
B_EMPLOYEE	0.215	0.190	1.13	0.26	*	0.151	1.43	0.15	*
B_TRAVEL	-0.339	0.0988	-3.44	0.00		0.0906	-3.75	0.00	
B_WAIT	-0.387	0.0867	-4.47	0.00		0.0550	-7.05	0.00	

Utility functions

Id	Name	Availability	Specification
1	A1_BUSDL	BUSDL_SP	B_WAIT * WT_1 + B_TRAVEL * TT_1 + B_COST * TC_1 + B_EMPLOYEE * ST_1
2	A2_BUSAT	BUSAT_SP	ASC_BUSAT * one + B_WAIT * WT_2 + B_TRAVEL * TT_2 + B_COST * TC_2 + B_EMPLOYEE * ST_2 + BUSAT_EXTRA * BUSAT_ETT + BUSAT_SERVICE * BUSAT_S

Model specification pilot survey 2

```
[ModelDescription]
"Model to determine prior estimators for pilot study 2 with two alternatives."
"Alt1: Bus on dedicated lane, Alt2: Bus amongst other traffic"

[Beta]
// Name          Value    Lowerbound    Upperboud    Status
ASC_BUSAT        0        -1000         1000         0
B_COST           -1.89    -1000         1000         0
B_COSTQUAD       0        -1000         1000         0
B_WAIT           -0.387   -1000         1000         0
B_WAITQUAD       0        -1000         1000         0
B_TRAVEL         -0.339   -1000         1000         0
B_TRAVELQUAD     0|       -1000         1000         0
BUSAT_SERVICE    0        -1000         1000         0
B_SURVEILLANCE1  0        -1000         1000         0
B_SURVEILLANCE2  0        -1000         1000         0


[Utilities]
// ID    Name        Avail        Expression
1        A1_BUSDL    BUSDL_SP           B_WAIT * WT_1 + B_WAITQUAD * waitquad1
                                        + B_TRAVEL * TT_1 + B_TRAVELQUAD * travelquad1
                                        + B_COST * TC_1 + B_COSTQUAD * costquad1
                                        + B_SURVEILLANCE1 * supervisor_1
                                        + B_SURVEILLANCE2 * camera_1

2        A2_BUSAT    BUSAT_SP           ASC_BUSAT * one + B_WAIT * WT_2
                                        + B_WAITQUAD * waitquad2 + B_TRAVEL * TT_2
                                        + B_TRAVELQUAD * travelquad2 + B_COST * TC_2
                                        + B_COSTQUAD * costquad2 + B_SURVEILLANCE1 * supervisor_2
                                        + B_SURVEILLANCE2 * camera_2 + BUSAT_SERVICE * SERVICE


[Expressions]
one              = 1
BUSDL_SP         = 1
BUSAT_SP         = 1
waitquad1        = WT_1 * WT_1
travelquad1      = TT_1 * TT_1
costquad1        = TC_1 * TC_1
waitquad2        = WT_2 * WT_2
travelquad2      = TT_2 * TT_2
costquad2        = TC_2 * TC_2

[LaTeX]
ASC_BUSAT        "Constant for Bus amongst other traffic"
B_COST           "Travel cost linear"
B_COSTQUAD       "Travel cost quadratic"
B_WAIT           "Waiting time linear"
B_WAITQUAD       "Waiting time quadratic"
B_TRAVEL         "Travel time linear"
B_TRAVELQUAD     "Travel time quadratic"
BUSAT_SERVICE    "Service type"
B_SURVEILLANCE2  "Camera"
B_SURVEILLANCE1  "Supervisor"


[Choice]
CHOICE


[Model]
// Multinomial Logit Model
$MNL
```

Results pilot survey 2

biogeme 2.5 [Wed, Jul 27, 2016 12:10:08 PM]

Michel Bierlaire, EPFL

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01/26/17 15:09:48

Tip: click on the columns headers to sort a table [Credits]

Model to determine prior estimators for pilot study 2 with two alternatives.
Alt1: Bus on dedicated lane, Alt2: Bus amongst other traffic

Model:	Logit
Number of estimated parameters:	10
Number of observations:	372
Number of individuals:	372
Null log likelihood:	-257.851
Cte log likelihood:	-257.802
Init log likelihood:	-258.245
Final log likelihood:	-180.601
Likelihood ratio test:	154.499
Rho-square:	0.300
Adjusted rho-square:	0.261
Final gradient norm:	+6.645e-004
Diagnostic:	Convergence reached...
Iterations:	9
Run time:	00:00
Variance-covariance:	from analytical hessian
Sample file:	pilot2datfileeffectcoding.txt

Utility parameters

Name	Value	Std err	t-test	p-value		Robust Std err	Robust t-test	p-value	
ASC_BUSAT	-0.888	0.274	-3.25	0.00		0.274	-3.24	0.00	
ASC_BUSDL	0.00	fixed							
BUSAT_SERVICE	1.78	0.468	3.80	0.00		0.468	3.80	0.00	
B_COST	-14.6	6.35	-2.29	0.02		6.35	-2.29	0.02	
B_COSTQUAD	3.62	1.85	1.96	0.05	*	1.85	1.96	0.05	*
B_SURVEILLANCE1	0.192	0.115	1.67	0.09	*	0.115	1.66	0.10	*
B_SURVEILLANCE2	0.350	0.123	2.85	0.00		0.123	2.86	0.00	
B_TRAVEL	-3.10	1.20	-2.57	0.01		1.20	-2.58	0.01	
B_TRAVELQUAD	0.233	0.105	2.23	0.03		0.104	2.24	0.03	
B_WAIT	-1.28	0.430	-2.99	0.00		0.431	-2.98	0.00	
B_WAITQUAD	0.109	0.0626	1.74	0.08	*	0.0627	1.74	0.08	*

Utility functions

Id	Name	Availability	Specification
1	A1_BUSDL	BUSDL_SP	ASC_BUSDL * one + B_WAIT * WT_1 + B_WAITQUAD * waitquad1 + B_TRAVEL * TT_1 + B_TRAVELQUAD * travelquad1 + B_COST * TC_1 + B_COSTQUAD * costquad1 + B_SURVEILLANCE1 * supervisor_1 + B_SURVEILLANCE2 * camera_1
2	A2_BUSAT	BUSAT_SP	ASC_BUSAT * one + B_WAIT * WT_2 + B_WAITQUAD * waitquad2 + B_TRAVEL * TT_2 + B_TRAVELQUAD * travelquad2 + B_COST * TC_2 + B_COSTQUAD * costquad2 + B_SURVEILLANCE1 * supervisor_2 + B_SURVEILLANCE2 * camera_2 + BUSAT_SERVICE * SERVICE

biogeme 2.5 [Wed, Jul 27, 2016 12:10:08 PM]

Michel Bierlaire, EPFL

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01/26/17 16:22:00

Tip: click on the columns headers to sort a table [Credits]

Model to determine prior estimators for pilot study 2 with two alternatives.
Alt1: Bus on dedicated lane, Alt2: Bus amongst other traffic

Model:	Logit
Number of estimated parameters:	8
Number of observations:	372
Number of individuals:	372
Null log likelihood:	-257.851
Cte log likelihood:	-257.802
Init log likelihood:	-258.245
Final log likelihood:	-182.769
Likelihood ratio test:	150.163
Rho-square:	0.291
Adjusted rho-square:	0.260
Final gradient norm:	+8.897e-004
Diagnostic:	Convergence reached...
Iterations:	6
Run time:	00:00
Variance-covariance:	from analytical hessian
Sample file:	H:\My Documents\Afstuderen\Biogeme\Pilot survey 2\pilot2datfileeffectcoding.txt

Utility parameters

Name	Value	Std err	t-test	p-value		Robust Std err	Robust t-test	p-value	
ASC_BUSAT	-0.516	0.178	-2.89	0.00		0.172	-3.01	0.00	
ASC_BUSDL	0.00	fixed							
BUSAT_SERVICE	1.14	0.301	3.80	0.00		0.320	3.57	0.00	
B_COST	-2.11	0.333	-6.35	0.00		0.348	-6.07	0.00	
B_SURVEILLANCE1	0.161	0.108	1.49	0.14	*	0.105	1.53	0.13	*
B_SURVEILLANCE2	0.395	0.124	3.19	0.00		0.131	3.01	0.00	
B_TRAVEL	-1.17	0.779	-1.50	0.13	*	0.789	-1.48	0.14	*
B_TRAVELQUAD	0.0724	0.0709	1.02	0.31	*	0.0715	1.01	0.31	*
B_WAIT	-0.497	0.0589	-8.44	0.00		0.0620	-8.01	0.00	

Utility functions

Id	Name	Availability	Specification
1	A1_BUSDL	BUSDL_SP	ASC_BUSDL * one + B_WAIT * WT_1 + B_TRAVEL * TT_1 + B_TRAVELQUAD * travelquad1 + B_COST * TC_1 + B_SURVEILLANCE1 * supervisor_1 + B_SURVEILLANCE2 * camera_1
2	A2_BUSAT	BUSAT_SP	ASC_BUSAT * one + B_WAIT * WT_2 + B_TRAVEL * TT_2 + B_TRAVELQUAD * travelquad2 + B_COST * TC_2 + B_SURVEILLANCE1 * supervisor_2 + B_SURVEILLANCE2 * camera_2 + BUSAT_SERVICE * SERVICE

biogeme 2.5 [Wed, Jul 27, 2016 12:10:08 PM]

Michel Bierlaire, EPFL

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01/26/17 16:24:15

Tip: click on the columns headers to sort a table [Credits]

Model to determine prior estimators for pilot study 2 with two alternatives.
Alt1: Bus on dedicated lane, Alt2: Bus amongst other traffic

Model:	Logit
Number of estimated parameters:	7
Number of observations:	372
Number of individuals:	372
Null log likelihood:	-257.851
Cte log likelihood:	-257.802
Init log likelihood:	-258.245
Final log likelihood:	-183.291
Likelihood ratio test:	149.119
Rho-square:	0.289
Adjusted rho-square:	0.262
Final gradient norm:	+2.532e-004
Diagnostic:	Convergence reached...
Iterations:	4
Run time:	00:00
Variance-covariance:	from analytical hessian
Sample file:	H:\My Documents\Afstuderen\Biogeme\Pilot survey 2\pilot2datfileeffectcoding.txt

Utility parameters

Name	Value	Std err	t-test	p-value		Robust Std err	Robust t-test	p-value	
ASC_BUSAT	-0.531	0.178	-2.98	0.00		0.172	-3.08	0.00	
ASC_BUSDL	0.00	fixed							
BUSAT_SERVICE	1.16	0.303	3.83	0.00		0.326	3.56	0.00	
B_COST	-2.16	0.335	-6.44	0.00		0.355	-6.07	0.00	
B_SURVEILLANCE1	0.158	0.107	1.48	0.14	*	0.103	1.54	0.12	*
B_SURVEILLANCE2	0.396	0.124	3.18	0.00		0.134	2.96	0.00	
B_TRAVEL	-0.375	0.0692	-5.43	0.00		0.0683	-5.49	0.00	
B_WAIT	-0.505	0.0592	-8.53	0.00		0.0630	-8.02	0.00	

Utility functions

Id	Name	Availability	Specification
1	A1_BUSDL	BUSDL_SP	ASC_BUSDL * one + B_WAIT * WT_1 + B_TRAVEL * TT_1 + B_COST * TC_1 + B_SURVEILLANCE1 * supervisor_1 + B_SURVEILLANCE2 * camera_1
2	A2_BUSAT	BUSAT_SP	ASC_BUSAT * one + B_WAIT * WT_2 + B_TRAVEL * TT_2 + B_COST * TC_2 + B_SURVEILLANCE1 * supervisor_2 + B_SURVEILLANCE2 * camera_2 + BUSAT_SERVICE * SERVICE

I

Ngene design final survey

Ngene software is used to determine the attribute values in the choice set design. This appendix shows the syntax of the final survey.

I.1. Ngene syntax pilot 1

```
Design
;alts = busdl, busat
;rows = 12
;eff = (mnl,d)
;con
;block = 2

;model:

U(busdl) = b_costs[-2.16] * travelcosts[1,1.5,2] + b_wait[-0.505] * waitingtime[1,3,5]
+ b_travel[-0.375] * traveltime [4,5.5,7] + b_surveillance.effects[0|0.396] * surveillance[2,1,0] /

U(busat) = asc_at[-0.531] + b_costs * travelcosts + b_wait * waitingtime
+ b_travel * traveltime + b_service[1.16] * service[0,1] + b_surveillance* surveillance

$
```

Figure I.1: Ngene syntax pilot study

J

Icon and picture references for surveys

Icons

The survey that was used for this thesis contained several icons that were used under *creative commons* of The Noun Project (www.thenounproject.com). This online *by-users-for-users* database offers hundreds of icons under the condition that the authors are cited. In this thesis the following icons were used:

Car by Björn Andersson from the Noun Project
Euro Coins by Rockicon from the Noun Project
travel time by Arthur Shlain from the Noun Project
Waiting by Chris Homan from the Noun Project
footsteps by Lukasz M. Pogoda from the Noun Project
employees by Nikita Kozin from the Noun Project
Check Mark by Kimmi Studio from the Noun Project
Checkbox by Andreas from the Noun Project
Check Mark by Kimmi Studio from the Noun Project
Zebra Crosswalk by N.K.Narasimhan from the Noun Project
cyclist by mikicon from the Noun Project
Tree by Ecem Afacan from the Noun Project
Bus by jhon from the Noun Project
Pedestrian by Pierre-Luc Auclair from the Noun Project
clock by Barracuda from the Noun Project
distance by icon 54 from the Noun Project
Bus by Guilhem from the Noun Project
destination by Jonathan Li from the Noun Project
Driver by ProSymbols from the Noun Project
Bus by Oliviu Stoian from the Noun Project
City by Ker'is from the Noun Project
metro by anbileru adaleru from the Noun Project
Security Camera by bmijnlieff from the Noun Project
Train by Anthony Bossard from the Noun Project
map marker icon by Eliricon from the Noun Project
map marker icon by Eliricon from the Noun Project

Pictures

All pictures of the ParkShuttle and used in the surveys are of the authors private collection, except for . The pictures of the OV chipkaart and train stations were retrieved from respectively

K

Cross tables and Chi-square

Cross tables are used to compare variables of categorical measurement scale. It shows the distribution of data based on two variables. Additionaly a Chi-square test can be conducted to assess if relations exist between the selected variables. In this appendix cross tables and Chi-square test results for both the variables *experience* and *region* are included.

K.1. Experience

Experience was recoded in SPSS to *No experience* and *Experience with ADS-DVs*. The first group includes participants that had never heard of ADS-DVs before participating in this study and participants that have read of or seen something about ADS-DVs but never made use of one. The 'experience' group consists of all participants that have ever made use of the ParkShuttle. For *experience* it was found that relations are present between *age* and *experience* and between *income* and *experience*. No significant relations were found between *experience* and *gender, education level* or *current public transport use*.

rrAGE * rrEXPERIENCE

Crosstab

Count

		rrEXPERIENCE		
		No experience	Experience with ADS-DVs	Total
rrAGE	18 - 35	39	37	76
	36 - 55	57	27	84
	> 55	27	4	31
Total		123	68	191

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	13,078[a]	2	,001
Likelihood Ratio	14,076	2	,001
Linear-by-Linear Association	12,976	1	,000
N of Valid Cases	191		

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 11,04.

rrINCOME * rrEXPERIENCE Crosstabulation

Count

		rrEXPERIENCE		
		No experience	Experience with ADS-DVs	Total
rrINCOME	1,00	15	17	32
	2,00	53	30	83
	3,00	39	11	50
Total		107	58	165

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8,365[a]	2	,015
Likelihood Ratio	8,433	2	,015
Linear-by-Linear Association	8,279	1	,004
N of Valid Cases	165		

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 11,25.

rGENDER * rrEXPERIENCE

Crosstab

Count

		rrEXPERIENCE		
		No experience	Experience with ADS-DVs	Total
rGENDER	Male	90	43	133
	Female	34	25	59
Total		124	68	192

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1,802[a]	1	,179		
Continuity Correction[b]	1,390	1	,238		
Likelihood Ratio	1,778	1	,182		
Fisher's Exact Test				,194	,120
Linear-by-Linear Association	1,792	1	,181		
N of Valid Cases	192				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 20,90.

b. Computed only for a 2x2 table

rEDUCATION * rrEXPERIENCE

Crosstab

Count

		rrEXPERIENCE		
		No experience	Experience with ADS-DVs	Total
rEDUCATION	Lower level of education	26	16	42
	High level of education	97	49	146
Total		123	65	188

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	,296[a]	1	,586		
Continuity Correction[b]	,130	1	,719		
Likelihood Ratio	,293	1	,588		
Fisher's Exact Test				,586	,356
Linear-by-Linear Association	,295	1	,587		
N of Valid Cases	188				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 14,52.

b. Computed only for a 2x2 table

rPTUSE * rrEXPERIENCE

Crosstab

Count

		rrEXPERIENCE		
		No experience	Experience with ADS-DVs	Total
rPTUSE	No	63	33	96
	Yes	63	36	99
Total		126	69	195

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	,084[a]	1	,772		
Continuity Correction[b]	,020	1	,888		
Likelihood Ratio	,084	1	,772		
Fisher's Exact Test				,881	,444
Linear-by-Linear Association	,084	1	,772		
N of Valid Cases	195				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 33,97.

b. Computed only for a 2x2 table

Figure K.1: Cross tables EXPERIENCE

L Statements

L.1. Distribution histograms of statements

To get a first indication on the reactions towards the statements histograms showing the dispersion were created. For all statements the mean is higher than 3.12 placing the average response to all statements on the positive side of the scale (1 being the negative end and 5 being the positive end of the scale). Furthermore it can be noticed that on some statements agreement of the whole sample group is more present than on others. For example *EASEOFUSE2* shows a standard deviation of 0.594, with a mean of 3.76. While the standard deviation of *SECURITY2* is 1.208, with a mean of 3.14.

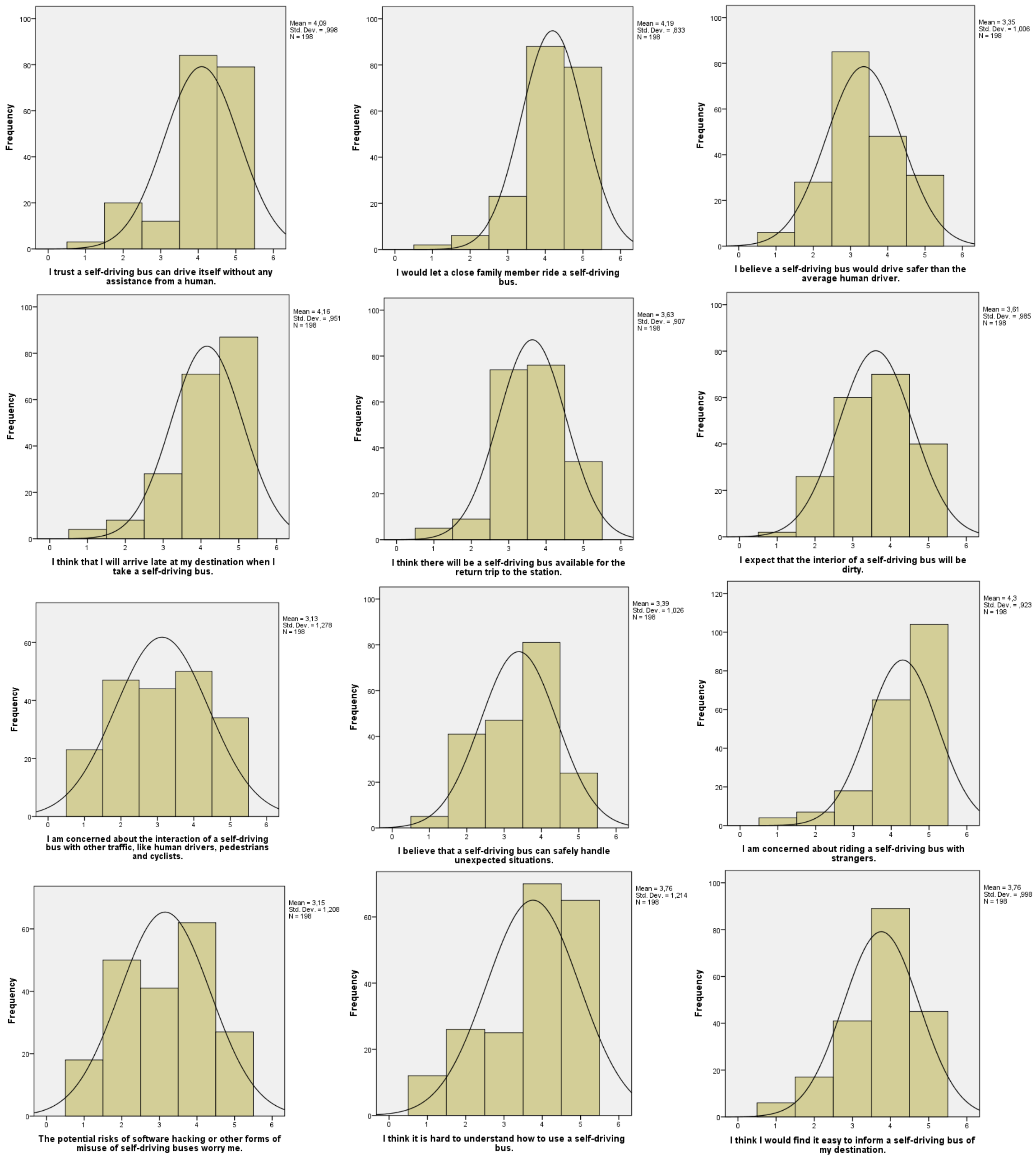

Figure L.1: Distribution statement variables on scale from 1 (negative) to 5 (positive)

L.2. One-way ANOVA

To get better insight in the differences between groups a *one-way ANOVA* test was conducted for all statement variables. Using a One-way ANOVA it can be checked whether there exist differences between the mean value of certain groups. First the *Levene's test of homogeneity* is used to check whether the variance of groups is similar to the population. From figure L.3 it can be noticed that both *PERFORMANCE2* and *EASEOFUSE1* are significant. This means that the results of the One-way ANOVA cannot be interpreted for these statements.

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
I trust a self-driving bus can drive itself without any assistance from a human.	No	39	3,95	,999	,160	3,62	4,27	1	5
	Yes, I have read or seen something about self-driving buses earlier	87	4,02	1,023	,110	3,81	4,24	2	5
	Yes, I have made use of the ParkShuttle once / a few times	42	4,38	,764	,118	4,14	4,62	2	5
	Yes, I make use of the ParkShuttle on a weekly basis	27	4,00	1,209	,233	3,52	4,48	1	5
	Total	195	4,08	1,002	,072	3,94	4,22	1	5
I think there will be a self-driving bus available for the return trip to the station.	No	39	3,54	,682	,109	3,32	3,76	2	5
	Yes, I have read or seen something about self-driving buses earlier	87	3,57	,871	,093	3,39	3,76	1	5
	Yes, I have made use of the ParkShuttle once / a few times	42	3,76	1,144	,176	3,41	4,12	1	5
	Yes, I make use of the ParkShuttle on a weekly basis	27	3,74	,944	,182	3,37	4,11	1	5
	Total	195	3,63	,912	,065	3,50	3,76	1	5
I would let a close family member ride a self-driving bus.	No	39	3,95	,887	,142	3,66	4,24	1	5
	Yes, I have read or seen something about self-driving buses earlier	87	4,17	,865	,093	3,99	4,36	1	5
	Yes, I have made use of the ParkShuttle once / a few times	42	4,33	,786	,121	4,09	4,58	2	5
	Yes, I make use of the ParkShuttle on a weekly basis	27	4,37	,629	,121	4,12	4,62	3	5
	Total	195	4,19	,831	,060	4,07	4,31	1	5
I believe that a self-driving bus can safely handle unexpected situations.	No	39	3,05	1,050	,168	2,71	3,39	1	5
	Yes, I have read or seen something about self-driving buses earlier	87	3,47	1,044	,112	3,25	3,69	1	5
	Yes, I have made use of the ParkShuttle once / a few times	42	3,48	,969	,149	3,17	3,78	2	5
	Yes, I make use of the ParkShuttle on a weekly basis	27	3,41	,931	,179	3,04	3,78	1	5
	Total	195	3,38	1,020	,073	3,24	3,52	1	5
I think I would find it easy to inform a self-driving bus of my destination.	No	39	3,69	1,030	,165	3,36	4,03	1	5
	Yes, I have read or seen something about self-driving buses earlier	87	3,62	1,014	,109	3,40	3,84	1	5
	Yes, I have made use of the ParkShuttle once / a few times	42	3,88	,942	,145	3,59	4,17	2	5
	Yes, I make use of the ParkShuttle on a weekly basis	27	4,11	,892	,172	3,76	4,46	2	5
	Total	195	3,76	,994	,071	3,62	3,90	1	5
I believe a self-driving bus would drive safer than the average human driver.	No	39	3,46	1,189	,190	3,08	3,85	1	5
	Yes, I have read or seen something about self-driving buses earlier	87	3,15	,995	,107	2,94	3,36	1	5
	Yes, I have made use of the ParkShuttle once / a few times	42	3,64	,850	,131	3,38	3,91	2	5
	Yes, I make use of the ParkShuttle on a weekly basis	27	3,41	,844	,162	3,07	3,74	2	5
	Total	195	3,35	1,002	,072	3,21	3,50	1	5
I think it is hard to understand how to use a self-driving bus.	No	39	3,85	1,065	,170	3,50	4,19	1	5
	Yes, I have read or seen something about self-driving buses earlier	87	3,44	1,291	,138	3,16	3,71	1	5
	Yes, I have made use of the ParkShuttle once / a few times	42	4,02	1,093	,169	3,68	4,36	1	5
	Yes, I make use of the ParkShuttle on a weekly basis	27	4,19	1,178	,227	3,72	4,65	1	5
	Total	195	3,75	1,220	,087	3,58	3,92	1	5
I think that I will arrive late at my destination when I take a self-driving bus.	No	39	4,31	,694	,111	4,08	4,53	3	5
	Yes, I have read or seen something about self-driving buses earlier	87	4,07	,938	,101	3,87	4,27	1	5
	Yes, I have made use of the ParkShuttle once / a few times	42	4,40	,912	,141	4,12	4,69	1	5
	Yes, I make use of the ParkShuttle on a weekly basis	27	3,81	1,241	,239	3,32	4,31	1	5
	Total	195	4,15	,951	,068	4,02	4,29	1	5

Figure L.2: One way ANOVA - Descriptives

I am concerned about the interaction of a self-driving bus with other traffic, like human drivers, pedestrians and cyclists.	No	39	2,62	1,248	,200	2,21	3,02	1	5
	Yes, I have read or seen something about self-driving buses earlier	87	3,05	1,275	,137	2,77	3,32	1	5
	Yes, I have made use of the ParkShuttle once / a few times	42	3,45	1,310	,202	3,04	3,86	1	5
	Yes, I make use of the ParkShuttle on a weekly basis	27	3,56	1,050	,202	3,14	3,97	1	5
	Total	195	3,12	1,281	,092	2,94	3,30	1	5
I am concerned about riding a self-driving bus with strangers.	No	39	4,28	,887	,142	3,99	4,57	1	5
	Yes, I have read or seen something about self-driving buses earlier	87	4,21	1,002	,107	3,99	4,42	1	5
	Yes, I have made use of the ParkShuttle once / a few times	42	4,40	,939	,145	4,11	4,70	1	5
	Yes, I make use of the ParkShuttle on a weekly basis	27	4,41	,694	,134	4,13	4,68	3	5
	Total	195	4,29	,926	,066	4,16	4,42	1	5
I expect that the interior of a self-driving bus will be dirty.	No	39	3,77	,931	,149	3,47	4,07	2	5
	Yes, I have read or seen something about self-driving buses earlier	87	3,37	,990	,106	3,16	3,58	1	5
	Yes, I have made use of the ParkShuttle once / a few times	42	3,74	,964	,149	3,44	4,04	2	5
	Yes, I make use of the ParkShuttle on a weekly basis	27	3,81	,962	,185	3,43	4,20	2	5
	Total	195	3,59	,982	,070	3,45	3,73	1	5
The potential risks of software hacking or other forms of misuse of self-driving buses worry me.	No	39	3,36	1,181	,189	2,98	3,74	1	5
	Yes, I have read or seen something about self-driving buses earlier	87	3,05	1,293	,139	2,77	3,32	1	5
	Yes, I have made use of the ParkShuttle once / a few times	42	3,26	1,191	,184	2,89	3,63	1	5
	Yes, I make use of the ParkShuttle on a weekly basis	27	2,93	,958	,184	2,55	3,30	1	5
	Total	195	3,14	1,208	,087	2,97	3,31	1	5

Figure L.3: One way ANOVA - Descriptives

From the output of the One-way ANOVA in figure L.4 it is concluded that only differences in means between groups are found for the statements *PERFORMANCE1*, *PERFORMANCE3* and *TRAFFICSAFETY1*. Looking closer at the results a post-hoc *Bonferroni* test is used. Using this test the differences in means between groups can be checked. Figure L.6 shows the output for the relevant statements. From the results it is concluded that there are no significant differences in mean values between the groups for the PERFORMANCE statements after all. However, a significant difference is found for *TRAFFICSAFETY1*. The mean values for the two groups that have made use of the ParkShuttle (use on a weekly basis and made use of ParkShuttle once or a few times) are found to be significantly higher than for the group that had never heard of ADS-DVs before participating in this survey. The mean values are respectively 0.940 and 0.837 higher that than of the no experience group. In figure L.5 a graph visualises the mean values of all groups. To conclude, although at first sight some differences could be seen between the groups was expected (also view the graph of the mean values per group, figures L.7 and L.8) almost no significant differences in mean values were found.

Both *PERFORMANCE2* and *EASEOFUSE1* did not pass the Levene's test for homogeneity. This means that equal variances cannot be assumed and the Kruskal-Wallis test needs to be performed. From the test results in figures L.9 and L.10 it can be concluded that individuals that have lower levels of experience with ADS-DVs (no experience or only read or seen something about ADS-DVs) perceive the understanding of ADS-DVs harder than those individuals that have actually made use of an ADS-DV before (EASEOFUSE1).

The results from the One-way ANOVA and Kruskal-Wallis tests indicate that except for the statements *I am concerned about the interaction of a self-driving bus with other traffic, like human drivers, pedestrians and cyclists* and *I think it is hard to understand how to use a self-driving bus* no differences are present in the population based on the levels of experience.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
I trust a self-driving bus can drive itself without any assistance from a human.	Between Groups	4,931	3	1,644	1,654	,178
	Within Groups	189,756	191	,993		
	Total	194,687	194			
I would let a close family member ride a self-driving bus.	Between Groups	4,039	3	1,346	1,979	,119
	Within Groups	129,941	191	,680		
	Total	133,979	194			
I believe a self-driving bus would drive safer than the average human driver.	Between Groups	7,673	3	2,558	2,614	,053
	Within Groups	186,911	191	,979		
	Total	194,585	194			
I think that I will arrive late at my destination when I take a self-driving bus.	Between Groups	7,298	3	2,433	2,764	,043
	Within Groups	168,087	191	,880		
	Total	175,385	194			
I think there will be a self-driving bus available for the return trip to the station.	Between Groups	1,654	3	,551	,659	,578
	Within Groups	159,761	191	,836		
	Total	161,415	194			
I expect that the interior of a self-driving bus will be dirty.	Between Groups	7,833	3	2,611	2,781	,042
	Within Groups	179,346	191	,939		
	Total	187,179	194			
I am concerned about the interaction of a self-driving bus with other traffic, like human drivers, pedestrians and cyclists.	Between Groups	20,169	3	6,723	4,307	,006
	Within Groups	298,118	191	1,561		
	Total	318,287	194			
I believe that a self-driving bus can safely handle unexpected situations.	Between Groups	5,348	3	1,783	1,732	,162
	Within Groups	196,570	191	1,029		
	Total	201,918	194			
I am concerned about riding a self-driving bus with strangers.	Between Groups	1,528	3	,509	,590	,622
	Within Groups	164,811	191	,863		
	Total	166,338	194			
The potential risks of software hacking or other forms of misuse of self-driving buses worry me.	Between Groups	4,500	3	1,500	1,028	,381
	Within Groups	278,761	191	1,459		
	Total	283,262	194			
I think it is hard to understand how to use a self-driving bus.	Between Groups	17,158	3	5,719	4,023	,008
	Within Groups	271,529	191	1,422		
	Total	288,687	194			
I think I would find it easy to inform a self-driving bus of my destination.	Between Groups	5,810	3	1,937	1,990	,117
	Within Groups	185,862	191	,973		
	Total	191,672	194			

Figure L.4: One way ANOVA - EXPERIENCE

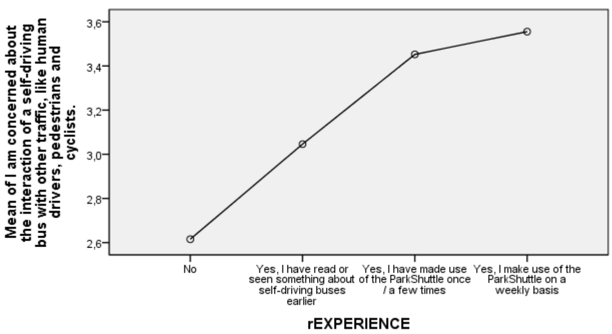

Figure L.5: Graph mean values TRAFFICSAFETY1 per group

Post Hoc Tests

Multiple Comparisons

Bonferroni

Dependent Variable	(I) rEXPERIENCE	(J) rEXPERIENCE	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
I think that I will arrive late at my destination when I take a self-driving bus.	No	Yes, I have read or seen something about self-driving buses earlier	,239	,181	1,000	-,24	,72
		Yes, I have made use of the ParkShuttle once / a few times	-,097	,209	1,000	-,65	,46
		Yes, I make use of the ParkShuttle on a weekly basis	,493	,235	,223	-,13	1,12
	Yes, I have read or seen something about self-driving buses earlier	No	-,239	,181	1,000	-,72	,24
		Yes, I have made use of the ParkShuttle once / a few times	-,336	,176	,350	-,81	,13
		Yes, I make use of the ParkShuttle on a weekly basis	,254	,207	1,000	-,30	,81
	Yes, I have made use of the ParkShuttle once / a few times	No	,097	,209	1,000	-,46	,65
		Yes, I have read or seen something about self-driving buses earlier	,336	,176	,350	-,13	,81
		Yes, I make use of the ParkShuttle on a weekly basis	,590	,231	,069	-,03	1,21
	Yes, I make use of the ParkShuttle on a weekly basis	No	-,493	,235	,223	-1,12	,13
		Yes, I have read or seen something about self-driving buses earlier	-,254	,207	1,000	-,81	,30
		Yes, I have made use of the ParkShuttle once / a few times	-,590	,231	,069	-1,21	,03
I expect that the interior of a self-driving bus will be dirty.	No	Yes, I have read or seen something about self-driving buses earlier	,401	,187	,197	-,10	,90
		Yes, I have made use of the ParkShuttle once / a few times	,031	,215	1,000	-,54	,61
		Yes, I make use of the ParkShuttle on a weekly basis	-,046	,243	1,000	-,69	,60
	Yes, I have read or seen something about self-driving buses earlier	No	-,401	,187	,197	-,90	,10
		Yes, I have made use of the ParkShuttle once / a few times	-,370	,182	,260	-,86	,12
		Yes, I make use of the ParkShuttle on a weekly basis	-,447	,213	,226	-1,02	,12
	Yes, I have made use of the ParkShuttle once / a few times	No	-,031	,215	1,000	-,61	,54
		Yes, I have read or seen something about self-driving buses earlier	,370	,182	,260	-,12	,86
		Yes, I make use of the ParkShuttle on a weekly basis	-,077	,239	1,000	-,71	,56
	Yes, I make use of the ParkShuttle on a weekly basis	No	,046	,243	1,000	-,60	,69
		Yes, I have read or seen something about self-driving buses earlier	,447	,213	,226	-,12	1,02
		Yes, I have made use of the ParkShuttle once / a few times	,077	,239	1,000	-,56	,71
I am concerned about the interaction of a self-driving bus with other traffic, like human drivers, pedestrians and cyclists.	No	Yes, I have read or seen something about self-driving buses earlier	-,431	,241	,452	-1,07	,21
		Yes, I have made use of the ParkShuttle once / a few times	-,837*	,278	,018	-1,58	-,10
		Yes, I make use of the ParkShuttle on a weekly basis	-,940*	,313	,018	-1,77	-,11
	Yes, I have read or seen something about self-driving buses earlier	No	,431	,241	,452	-,21	1,07
		Yes, I have made use of the ParkShuttle once / a few times	-,406	,235	,510	-1,03	,22
		Yes, I make use of the ParkShuttle on a weekly basis	-,510	,275	,394	-1,24	,22
	Yes, I have made use of the ParkShuttle once / a few times	No	,837*	,278	,018	,10	1,58
		Yes, I have read or seen something about self-driving buses earlier	,406	,235	,510	-,22	1,03
		Yes, I make use of the ParkShuttle on a weekly basis	-,103	,308	1,000	-,92	,72
	Yes, I make use of the ParkShuttle on a weekly basis	No	,940*	,313	,018	,11	1,77
		Yes, I have read or seen something about self-driving buses earlier	,510	,275	,394	-,22	1,24
		Yes, I have made use of the ParkShuttle once / a few times	,103	,308	1,000	-,72	,92

Figure L.6: Bonferroni test output

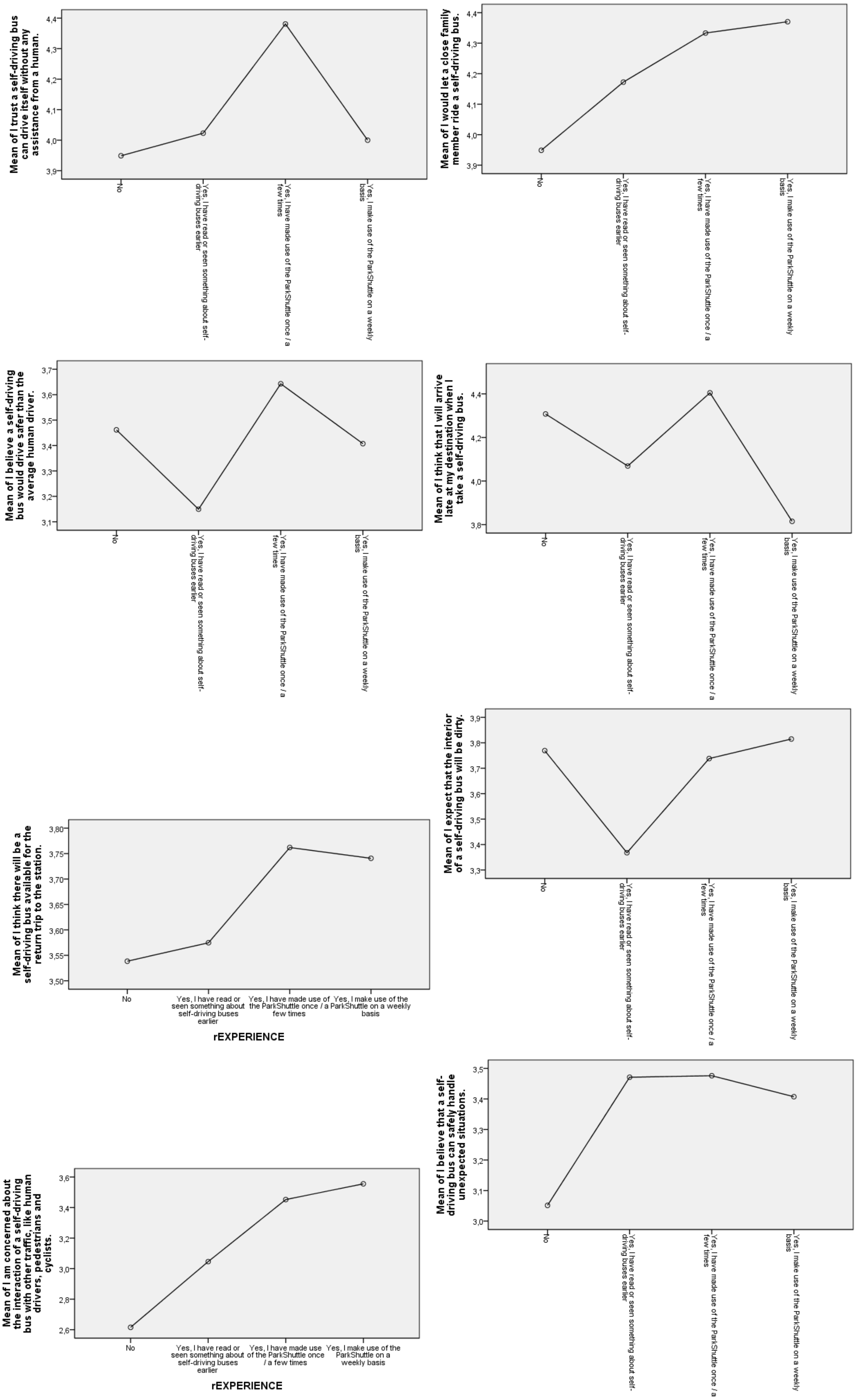

Figure L.7: Graphs mean values per group

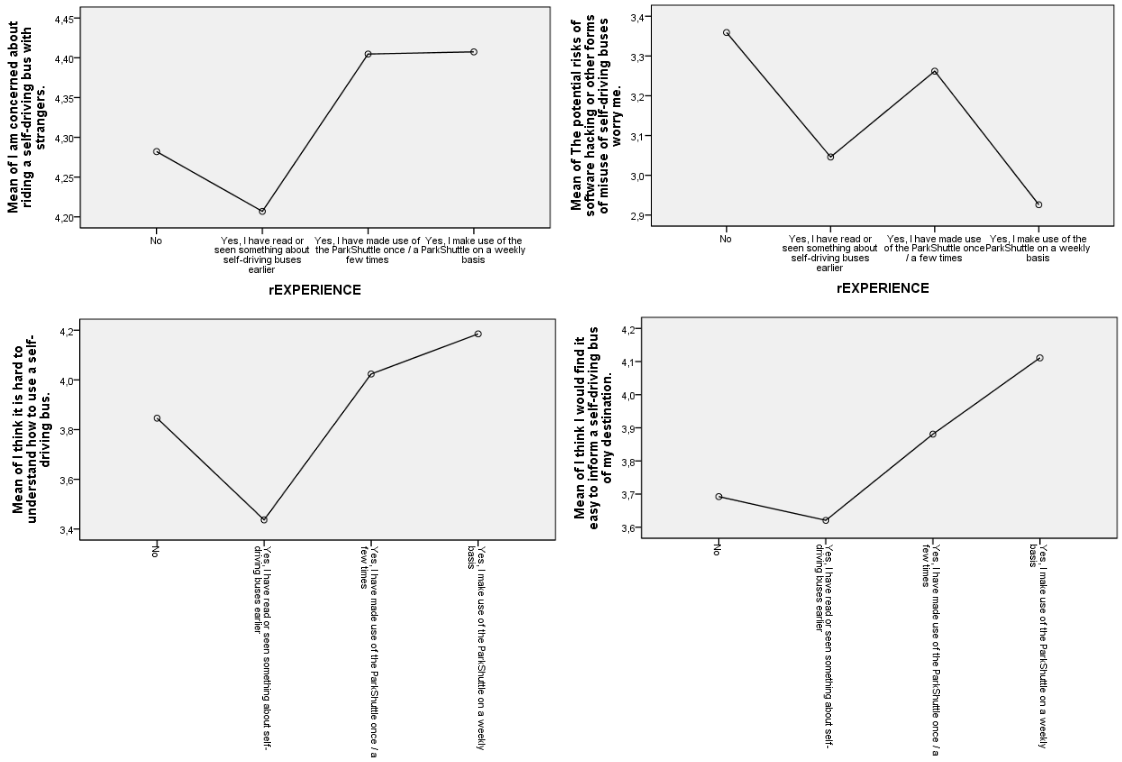

Figure L.8: Graphs mean values per group

Kruskal-Wallis Test

Ranks

	rEXPERIENCE	N	Mean Rank
I think there will be a self-driving bus available for the return trip to the station.	No	39	89,91
	Yes, I have read or seen something about self-driving buses earlier	87	94,32
	Yes, I have made use of the ParkShuttle once / a few times	42	107,54
	Yes, I make use of the ParkShuttle on a weekly basis	27	106,70
	Total	195	
I think it is hard to understand how to use a self-driving bus.	No	39	99,78
	Yes, I have read or seen something about self-driving buses earlier	87	84,21
	Yes, I have made use of the ParkShuttle once / a few times	42	110,12
	Yes, I make use of the ParkShuttle on a weekly basis	27	121,02
	Total	195	

Test Statistics[a,b]

	I think there will be a self-driving bus available for the return trip to the station.	I think it is hard to understand how to use a self-driving bus.
Chi-Square	3,394	12,712
df	3	3
Asymp. Sig.	,335	,005

a. Kruskal Wallis Test

b. Grouping Variable: rEXPERIENCE

Figure L.9: Experience > PERFORMANCE2 and EASEOFUSE1 (Kruskal-Wallis test)

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of I think there will be a self-driving bus available for the return trip to the station. is the same across categories of rEXPERIENCE.	Independent-Samples Kruskal-Wallis Test	,335	Retain the null hypothesis.
2	The distribution of I think it is hard to understand how to use a self-driving bus. is the same across categories of rEXPERIENCE.	Independent-Samples Kruskal-Wallis Test	,005	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is ,05.

Figure L.10: Experience > PERFORMANCE2 and EASEOFUSE1 (Kruskal-Wallis test)

M

Factor analysis

In order to be able to conduct a *factor analysis* several assumptions need to be checked [**?**]. First, the sample group must be at least 50 and preferrably over 100. Furthermore there need to be at least five times as much cases than variables. A minimum of $12x5 = 60$ cases is needed. This study makes use of 195 cases, and therefore meets this requirement. Then the data analysed needs to be of at least interval measurement scale, which is the case. Furthermore, sufficient correlations must be over 0.30. There is only one correlation found to be slightly under 0.30, however as all other values are over 0.30 and the indicator fits well in the latent variable this is not seen as a problem, table M.1. Then, from the *Kaiser-Meyer-Olkin Measure of Sampling Adequacy* (KMO MSA) and indication can be made of the strength of the factors (latent variable) that is found. Values below 0.50 are unacceptable, > 0.50 is poor, > 0.60 mediocre, > 0.70 average, > 0.80 good and 1 is perfect. From table **??** it can be seen that the MSA value is 0.77, this indicates that the factor analysis resulted in a suitable factor.

While conducting the analysis the communalities (the part of the variance that an indicator shares with other indicators) need to be at least 0.25. Indicators that had lower values were removed. The communalities can be seen in the communalities table of M.2. In the same figure it can be seen from the explained variance table that only one factor has an *eigenvalues* over 1. This indicates that there is only one latent variable present. This is underlined by the screeplot in figure **??**: from the moment the lines flattens no more factors are present. To conclude, the factor scores of each indicator are shown in figure **??**. The factor scores represent the correlations between the factor and the indicator. The five indicators that were found to indicate the same latent variable were previously addressed as *trust in ADS-DVs* and *traffic safety*. The fact that the indicators combined make one latent variable is not surprising as an earlier analysis in the pilot stage showed correlations between indicators. Furthermore, trust in ADS-DVs and traffic safety are related topics. The latent variable derived from this analysis is named *trust in ADS-DVs*.

Factor Analysis

Correlation Matrix

		I trust a self-driving bus can drive itself without any assistance from a human.	I would let a close family member ride a self-driving bus.	I believe a self-driving bus would drive safer than the average human driver.	I am concerned about the interaction of a self-driving bus with other traffic, like human drivers, pedestrians and cyclists.	I believe that a self-driving bus can safely handle unexpected situations.
Correlation	I trust a self-driving bus can drive itself without any assistance from a human.	1,000	,433	,356	,250	,343
	I would let a close family member ride a self-driving bus.	,433	1,000	,321	,323	,346
	I believe a self-driving bus would drive safer than the average human driver.	,356	,321	1,000	,313	,488
	I am concerned about the interaction of a self-driving bus with other traffic, like human drivers, pedestrians and cyclists.	,250	,323	,313	1,000	,407
	I believe that a self-driving bus can safely handle unexpected situations.	,343	,346	,488	,407	1,000
Sig. (1-tailed)	I trust a self-driving bus can drive itself without any assistance from a human.		,000	,000	,000	,000
	I would let a close family member ride a self-driving bus.	,000		,000	,000	,000
	I believe a self-driving bus would drive safer than the average human driver.	,000	,000		,000	,000
	I am concerned about the interaction of a self-driving bus with other traffic, like human drivers, pedestrians and cyclists.	,000	,000	,000		,000
	I believe that a self-driving bus can safely handle unexpected situations.	,000	,000	,000	,000	

Figure M.1: Correlation matrix

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,770
Bartlett's Test of Sphericity	Approx. Chi-Square	185,708
	df	10
	Sig.	,000

Communalities

	Initial	Extraction
I trust a self-driving bus can drive itself without any assistance from a human.	,256	,322
I would let a close family member ride a self-driving bus.	,264	,340
I believe a self-driving bus would drive safer than the average human driver.	,295	,397
I am concerned about the interaction of a self-driving bus with other traffic, like human drivers, pedestrians and cyclists.	,214	,278
I believe that a self-driving bus can safely handle unexpected situations.	,339	,471

Extraction Method: Principal Axis Factoring.

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Factor	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2,438	48,751	48,751	1,809	36,180	36,180
2	,812	16,230	64,981			
3	,711	14,228	79,209			
4	,546	10,929	90,138			
5	,493	9,862	100,000			

Extraction Method: Principal Axis Factoring.

Figure M.2: KMO and Bartlett's test, communalities and explained variance tables

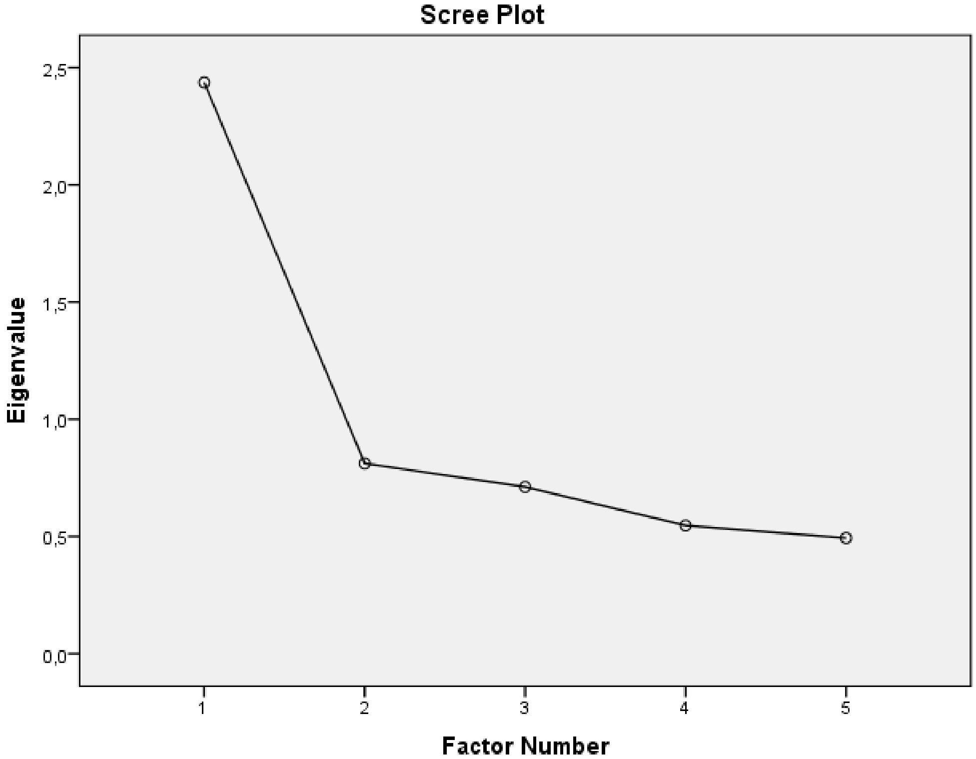

Figure M.3: Screeplot

Factor Matrix[a]

	Factor
	1
I trust a self-driving bus can drive itself without any assistance from a human.	,568
I would let a close family member ride a self-driving bus.	,583
I believe a self-driving bus would drive safer than the average human driver.	,630
I am concerned about the interaction of a self-driving bus with other traffic, like human drivers, pedestrians and cyclists.	,527
I believe that a self-driving bus can safely handle unexpected situations.	,687

Extraction Method: Principal Axis Factoring.

a. 1 factors extracted. 6 iterations required.

Figure M.4: Factor matrix

N

Biogeme choice models final survey

In this appendix the Biogeme output for several choice models is combined. The output of the MNL base model can be found in section N.1, the output for the MNL model including parameters for experience and trust are included in section N.2 and the output of the MNL model with only additional parameters for trust can be found in appendix N.3. The Nested Logit model can be found in sections N.4. The Mixed Logit panel variations are present in sections N.5 and N.6 for respectively the model with experience and trust parameters and only trust parameters. Model estimations for ML including panel and heterogeneity effects are included in sections N.7 (ASC) and N.8 (ASC & surveillance) : final model. The model with assumed linear travel costs that is used for the WTP calculations can be found in section N.9

N.1. MNL base model

Biogeme syntax

```
[Beta]
// Name          Value   Lowerbound      Upperboud       Status
ASC_BUSDL        0       -1000           1000            0
ASC_BUSAT        0       -1000           1000            0
ASC_NOBUS        0       -1000           1000            1
B_COST           0       -1000           1000            0
B_COSTQUAD       0       -1000           1000            0
B_WAIT           0       -1000           1000            0
B_WAITQUAD       0       -1000           1000            1
B_TRAVEL         0       -1000           1000            0
B_TRAVELQUAD     0       -1000           1000            1
BUSAT_SERVICE    0       -1000           1000            0
B_SURVEILLANCE1 0        -1000           1000            0
B_SURVEILLANCE2 0        -1000           1000            0


[Utilities]
// ID    Name            Avail           Expression
1        A1_BUSDL        BUSDL_SP         ASC_BUSDL * one + B_WAIT * WT_1 + B_WAITQUAD * waitquad1 + B_TRAVEL * TT_1
                                         + B_TRAVELQUAD * travelquad1 + B_COST * TC_1 + B_COSTQUAD * costquad1
                                         + B_SURVEILLANCE1 * supervisor_1 + B_SURVEILLANCE2 * camera_1

2        A2_BUSAT        BUSAT_SP         ASC_BUSAT * one + B_WAIT * WT_2 + B_WAITQUAD * waitquad2 + B_TRAVEL * TT_2
                                         + B_TRAVELQUAD * travelquad2 + B_COST * TC_2 + B_COSTQUAD * costquad2
                                         + B_SURVEILLANCE1 * supervisor_2 + B_SURVEILLANCE2 * camera_2
                                         + BUSAT_SERVICE * SERVICE

3        A3_NOBUS        NOBUS_SP         ASC_NOBUS * one

[Expressions]
one              = 1
BUSDL_SP         = 1
BUSAT_SP         = 1
NOBUS_SP         = 1

waitquad1        = WT_1 * WT_1
travelquad1      = TT_1 * TT_1
costquad1        = TC_1 * TC_1
waitquad2        = WT_2 * WT_2
travelquad2      = TT_2 * TT_2
costquad2        = TC_2 * TC_2

[LaTeX]
ASC_BUSDL        "Constant for Bus on dedicated lane"
ASC_BUSAT        "Constant for Bus amongst other traffic"
B_COST           "$\beta$ Travel cost linear"
B_COSTQUAD       "$\beta$ Travel cost quadratic"
B_WAIT           "$\beta$ Waiting time linear"
B_WAITQUAD       "$\beta$ Waiting time quadratic"
B_TRAVEL         "$\beta$ Travel time linear"
B_TRAVELQUAD     "$\beta$ Travel time quadratic"
BUSAT_SERVICE    "$\beta$ Service type"
B_SURVEILLANCE2 "$\beta$ Camera"
B_SURVEILLANCE1 "$\beta$ Supervisor"


[Choice]
CHOICE


[Model]
// Multinomial Logit Model
$MNL
```

Biogeme output

Model	:	Logit
Number of estimated parameters	:	9
Number of observations	:	1170
Number of individuals	:	1170
Null log likelihood	:	-1285.376
Cte log likelihood	:	-1158.808
Init log likelihood	:	-1285.376
Final log likelihood	:	-1118.979
Likelihood ratio test	:	332.795
Rho-square	:	0.129
Adjusted rho-square	:	0.122
Final gradient norm	:	+4.893e-007
Diagnostic	:	Convergence reached...
Iterations	:	8
Run time	:	00:01
Variance-covariance	:	from analytical hessian
Sample file	:	H:Documents3alt3alt_DUMMY.dat

Parameter number	Description	Coeff. estimate	Robust Asympt. std. error	t-stat	p-value
1	Constant for Bus amongst other traffic	5.84	1.24	4.71	0.00
2	Constant for Bus on dedicated lane	6.70	1.27	5.27	0.00
3	β Service type	0.515	0.150	3.44	0.00
4	β Travel cost linear	-4.51	1.70	-2.65	0.01
5	β Travel cost quadratic	1.19	0.565	2.10	0.04
6	β Supervisor	0.481	0.109	4.42	0.00
7	β Camera	0.679	0.109	6.23	0.00
8	β Travel time linear	-0.207	0.0376	-5.51	0.00
9	β Waiting time linear	-0.285	0.0389	-7.31	0.00

Summary statistics
Number of observations = 1170

$$\begin{aligned} \mathcal{L}(0) &= -1285.376 \\ \mathcal{L}(c) &= -1158.808 \\ \mathcal{L}(\hat{\beta}) &= -1118.979 \\ -2[\mathcal{L}(0) - \mathcal{L}(\hat{\beta})] &= 332.795 \\ \rho^2 &= 0.129 \\ \bar{\rho}^2 &= 0.122 \end{aligned}$$

N.2. MNL trust experience model

N.2.1. Distribution of ADS-DV use per experience level

For every choice set in the survey respondents were asked to indicate whether they would make use of the ADS-DV or would choose another method to travel from the train station to their destination. The number of times a respondent choose to make use of the ADS-DV was added up in the variable *SUMCS*. Figure N.1 and table N.1 show the percentages how often the ADS-DV was chosen based on the level of experience with an ADS-DV that a respondent had. It can be noticed that for every level of experience the distribution of the number of times an ADS-DV is chosen is quite similar. This could lead to the conclusion that no differences are found in the choice model with interaction effects for experience.

Table N.1: Distribution of ADS-DV use per experience group

		SUMCS							
		0	**1**	**2**	**3**	**4**	**5**	**6**	Total
rEXPERIENCE	*No*	10,3%	2,6%	0,0%	2,6%	5,1%	10,3%	69,2%	**100%**
	Yes, I have read or seen something about self-driving buses earlier	9,2%	2,3%	0,0%	1,1%	2,3%	14,9%	70,1%	**100%**
	Yes, I have made use of the ParkShuttle once / a few times	9,5%	2,4%	4,8%	0,0%	7,1%	4,8%	71,4%	**100%**
	Yes, I make use of the ParkShuttle on a weekly basis	7,4%	0,0%	0,0%	0,0%	14,8%	18,5%	59,3%	**100%**
Total		**9,2%**	**2,1%**	**1,0%**	**1,0%**	**5,6%**	**12,3%**	**68,7%**	**100%**

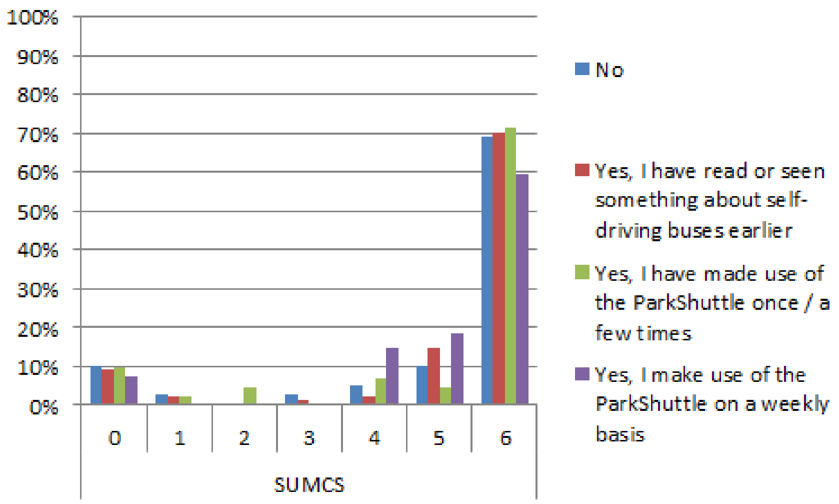

Figure N.1: Percentages of use ADS-DV in choice sets

Biogeme syntax

```
[Beta]
// Name            Value   Lowerbound      Upperboud       Status
ASC_BUSDL                  0       -10000          10000           0
ASC_BUSAT                  0       -10000          10000           0
ASC_NOBUS                  0       -10000          10000           1
B_COST                     0       -10000          10000           0
B_COSTQUAD                 0       -10000          10000           0
B_WAIT                     0       -10000          10000           0
B_WAITQUAD                 0       -10000          10000           1
B_TRAVEL                   0       -10000          10000           0
B_TRAVELQUAD               0       -10000          10000           1
BUSAT_SERVICE              0       -10000          10000           0
B_SURVEILLANCE1            0       -10000          10000           0
B_SURVEILLANCE2            0       -10000          10000           0
B_TRUSTDL                  0       -10000          10000           0
B_TRUSTAT                  0       -10000          10000           0
B_SURVEILLANCE1TRUST       0       -10000          10000           0
B_SURVEILLANCE2TRUST       0       -10000          10000           0
B_EXPDL                    0       -10000          10000           0
B_EXPAT                    0       -10000          10000           0
B_SURVEILLANCE1EXP         0       -10000          10000           0
B_SURVEILLANCE2EXP         0       -10000          10000           0


[Utilities]
// ID   Name            Avail           Expression
1       A1_BUSDL        BUSDL_SP         ASC_BUSDL [ SIGMA ] * one + B_TRUSTDL * trust + B_EXPDL * EXP + B_WAIT * WT_1
                                        + B_WAITQUAD * waitquad1 + B_TRAVEL * TT_1 + B_TRAVELQUAD * travelquad1 + B_COST
                                        * TC_1 + B_COSTQUAD * costquad1 + B_SURVEILLANCE1 * supervisor_1 + B_SURVEILLANCE2
                                        * camera_1 + B_SURVEILLANCE1TRUST * TRUSTsupervisor_1 + B_SURVEILLANCE2TRUST
                                        * TRUSTcamera_1 + B_SURVEILLANCE1EXP * EXPsupervisor_1 + B_SURVEILLANCE2EXP
                                        * EXPcamera_1

2       A2_BUSAT        BUSAT_SP         ASC_BUSAT [ SIGMA ] * one + B_TRUSTAT * trust + B_EXPAT * EXP + B_WAIT * WT_2
                                        + B_WAITQUAD * waitquad2 + B_TRAVEL * TT_2 + B_TRAVELQUAD * travelquad2 + B_COST
                                        * TC_2 + B_COSTQUAD * costquad2 + B_SURVEILLANCE1 * supervisor_2 + B_SURVEILLANCE2
                                        * camera_2 + BUSAT_SERVICE * SERVICE + B_SURVEILLANCE1TRUST * TRUSTsupervisor_2
                                        + B_SURVEILLANCE2TRUST * TRUSTcamera_2 + B_SURVEILLANCE1EXP * EXPsupervisor_2
                                        + B_SURVEILLANCE2EXP * EXPcamera_2

3       A3_NOBUS        NOBUS_SP         ASC_NOBUS * one

[Expressions]
one             = 1
BUSDL_SP        = 1
BUSAT_SP        = 1
NOBUS_SP        = 1

waitquad1       = WT_1 * WT_1
travelquad1     = TT_1 * TT_1
costquad1       = TC_1 * TC_1
waitquad2       = WT_2 * WT_2
travelquad2     = TT_2 * TT_2
costquad2       = TC_2 * TC_2

TRUSTsupervisor_1 = supervisor_1 * trust
TRUSTsupervisor_2 = supervisor_2 * trust
TRUSTcamera_1     = camera_1 * trust
TRUSTcamera_2     = camera_2 * trust


EXPsupervisor_1 = supervisor_1 * EXP
EXPsupervisor_2 = supervisor_2 * EXP
EXPcamera_1     = camera_1 * EXP
EXPcamera_2     = camera_2 * EXP

[LaTeX]
```

Biogeme output

Model	:	Logit
Number of estimated parameters	:	17
Number of observations	:	1170
Number of individuals	:	1170
Null log likelihood	:	-1285.376
Cte log likelihood	:	-1158.808
Init log likelihood	:	-1285.376
Final log likelihood	:	-1090.706
Likelihood ratio test	:	389.341
Rho-square	:	0.151
Adjusted rho-square	:	0.138
Final gradient norm	:	+2.627e-004
Diagnostic	:	Convergence reached...
Iterations	:	7
Run time	:	00:01
Variance-covariance	:	from analytical hessian
Sample file	:	H:Documents3alt LVexp3alt_DUMMY.dat

Parameter number	Description	Coeff. estimate	Robust Asympt. std. error	t-stat	p-value
1	Constant for ADS-DV amongst other traffic	5.76	1.23	4.69	0.00
2	Constant for ADS-DV on dedicated lane	6.64	1.25	5.29	0.00
3	β Service type	0.493	0.150	3.27	0.00
4	β Travel cost linear	-4.44	1.68	-2.63	0.01
5	β Travel cost quadratic	1.16	0.561	2.08	0.04
6	β Experience amongst other traffic	-0.0828	0.114	-0.72	0.47
7	β Experience dedicated lane	-0.134	0.108	-1.25	0.21
8	β Supervisor	0.525	0.113	4.66	0.00
9	β Supervisor experience	0.00852	0.102	0.08	0.93
10	β Camera trust in ADS-DVs	-0.585	0.121	-4.85	0.00
11	β Camera	0.700	0.115	6.10	0.00
12	β Camera experience	-0.0105	0.100	-0.10	0.92
13	β Supervisor trust in ADS-DVs	-0.421	0.117	-3.61	0.00
14	β Travel time linear	-0.205	0.0376	-5.45	0.00
15	β Trust in ADS-DVs amongst other traffic	0.939	0.133	7.05	0.00
16	β Trust in ADS-DVs dedicated lane	0.679	0.122	5.57	0.00
17	β Waiting time linear	-0.293	0.0399	-7.33	0.00

Summary statistics

Number of observations = 1170

$$\mathcal{L}(0) = -1285.376$$
$$\mathcal{L}(c) = -1158.808$$
$$\mathcal{L}(\hat{\beta}) = -1090.706$$
$$-2[\mathcal{L}(0) - \mathcal{L}(\hat{\beta})] = 389.341$$
$$\rho^2 = 0.151$$
$$\bar{\rho}^2 = 0.138$$

N.3. MNL trust model

Biogeme syntax

```
[Beta]
// Name           Value   Lowerbound          Upperboud        Status
ASC_BUSDL                 0       -10000           10000           0
ASC_BUSAT                 0       -10000           10000           0
ASC_NOBUS                 0       -10000           10000           1
B_COST                    0       -10000           10000           0
B_COSTQUAD                0       -10000           10000           0
B_WAIT                    0       -10000           10000           0
B_WAITQUAD                0       -10000           10000           1
B_TRAVEL                  0       -10000           10000           0
B_TRAVELQUAD              0       -10000           10000           1
BUSAT_SERVICE             0       -10000           10000           0
B_SURVEILLANCE1           0       -10000           10000           0
B_SURVEILLANCE2           0       -10000           10000           0
B_TRUSTDL                 0       -10000           10000           0
B_TRUSTAT                 0       -10000           10000           0
B_SURVEILLANCE1TRUST      0       -10000           10000           0
B_SURVEILLANCE2TRUST      0       -10000           10000           0

[Utilities]
// ID   Name           Avail           Expression
1       A1_BUSDL       BUSDL_SP         ASC_BUSDL * one + B_TRUSTDL * trust + B_WAIT * WT_1 + B_WAITQUAD * waitquad1
                                       + B_TRAVEL * TT_1 + B_TRAVELQUAD * travelquad1 + B_COST * TC_1 + B_COSTQUAD
                                       * costquad1 + B_SURVEILLANCE1 * supervisor_1 + B_SURVEILLANCE2 * camera_1
                                       + B_SURVEILLANCE1TRUST * TRUSTsupervisor_1 + B_SURVEILLANCE2TRUST * TRUSTcamera_1

2       A2_BUSAT       BUSAT_SP         ASC_BUSAT * one + B_TRUSTAT * trust + B_WAIT * WT_2 + B_WAITQUAD * waitquad2
                                       + B_TRAVEL * TT_2 + B_TRAVELQUAD * travelquad2 + B_COST * TC_2 + B_COSTQUAD
                                       * costquad2 + B_SURVEILLANCE1 * supervisor_2 + B_SURVEILLANCE2 * camera_2
                                       + BUSAT_SERVICE * SERVICE + B_SURVEILLANCE1TRUST * TRUSTsupervisor_2
                                       + B_SURVEILLANCE2TRUST * TRUSTcamera_2

3       A3_NOBUS       NOBUS_SP         ASC_NOBUS * one

[Expressions]
one              = 1
BUSDL_SP         = 1
BUSAT_SP         = 1
NOBUS_SP         = 1

waitquad1        = WT_1 * WT_1
travelquad1      = TT_1 * TT_1
costquad1        = TC_1 * TC_1
waitquad2        = WT_2 * WT_2
travelquad2      = TT_2 * TT_2
costquad2        = TC_2 * TC_2

TRUSTsupervisor_1 = supervisor_1 * trust
TRUSTsupervisor_2 = supervisor_2 * trust
TRUSTcamera_1     = camera_1 * trust
TRUSTcamera_2     = camera_2 * trust
|
[LaTeX]
ASC_BUSDL        "Constant for ADS-DV on dedicated lane"
ASC_BUSAT        "Constant for ADS-DV amongst other traffic"
B_COST           "$\beta$ Travel cost linear"
B_COSTQUAD       "$\beta$ Travel cost quadratic"
B_WAIT           "$\beta$ Waiting time linear"
B_WAITQUAD       "$\beta$ Waiting time quadratic"
B_TRAVEL         "$\beta$ Travel time linear"
B_TRAVELQUAD     "$\beta$ Travel time quadratic"
BUSAT_SERVICE    "$\beta$ Service type"
B_SURVEILLANCE2 "$\beta$ Camera"
B_SURVEILLANCE1 "$\beta$ Supervisor"

[Choice]
CHOICE


[Model]
// Multinomial Logit Model
$MNL
```

Biogeme output

Model	:	Logit
Number of estimated parameters	:	13
Number of observations	:	1170
Number of individuals	:	1170
Null log likelihood	:	-1285.376
Cte log likelihood	:	-1158.808
Init log likelihood	:	-1285.376
Final log likelihood	:	-1091.888
Likelihood ratio test	:	386.976
Rho-square	:	0.151
Adjusted rho-square	:	0.140
Final gradient norm	:	+2.655e-003
Diagnostic	:	Convergence reached...
Iterations	:	6
Run time	:	00:00
Variance-covariance	:	from analytical hessian
Sample file	:	Trustexp3alt_DUMMY.dat

Parameter number	Description	Coeff. estimate	Robust Asympt. std. error	t-stat	p-value
1	Constant for ADS-DV amongst other traffic	5.79	1.22	4.73	0.00
2	Constant for ADS-DV on dedicated lane	6.68	1.25	5.34	0.00
3	β Service type	0.490	0.150	3.26	0.00
4	β Travel cost linear	-4.45	1.68	-2.65	0.01
5	β Travel cost quadratic	1.17	0.560	2.09	0.04
6	β Supervisor	0.522	0.111	4.69	0.00
7	β Camera trust in ADS-DVs	-0.583	0.118	-4.93	0.00
8	β Camera	0.703	0.110	6.38	0.00
9	β Supervisor trust in ADS-DVs	-0.424	0.115	-3.70	0.00
10	β Travel time linear	-0.204	0.0374	-5.46	0.00
11	β Trust in ADS-DVs amongst other traffic	0.918	0.130	7.05	0.00
12	β Trust in ADS-DVs dedicated lane	0.649	0.120	5.42	0.00
13	β Waiting time linear	-0.293	0.0398	-7.36	0.00

Summary statistics

Number of observations = 1170

$$
\begin{aligned}
\mathcal{L}(0) &= -1285.376 \\
\mathcal{L}(c) &= -1158.808 \\
\mathcal{L}(\hat{\beta}) &= -1091.888 \\
-2[\mathcal{L}(0) - \mathcal{L}(\hat{\beta})] &= 386.976 \\
\rho^2 &= 0.151 \\
\bar{\rho}^2 &= 0.140
\end{aligned}
$$

N.4. NL model trust

Biogeme syntax

```
[Beta]
// Name            Value   Lowerbound      Upperboud       Status
ASC_BUSDL                  0       -10000          10000           0
ASC_BUSAT                  0       -10000          10000           0
ASC_NOBUS                  0       -10000          10000           1
B_COST                     0       -10000          10000           0
B_COSTQUAD                 0       -10000          10000           0
B_WAIT                     0       -10000          10000           0
B_WAITQUAD                 0       -10000          10000           1
B_TRAVEL                   0       -10000          10000           0
B_TRAVELQUAD               0       -10000          10000           1
BUSAT_SERVICE              0       -10000          10000           0
B_SURVEILLANCE1            0       -10000          10000           0
B_SURVEILLANCE2            0       -10000          10000           0
B_TRUSTDL                  0       -10000          10000           0
B_TRUSTAT                  0       -10000          10000           0
B_SURVEILLANCE1TRUST       0       -10000          10000           0
B_SURVEILLANCE2TRUST       0       -10000          10000           0

[Utilities]
// ID   Name            Avail           Expression
1       A1_BUSDL        BUSDL_SP         ASC_BUSDL * one + B_TRUSTDL * trust + B_WAIT * WT_1 + B_WAITQUAD * waitquad1
                                        + B_TRAVEL * TT_1 + B_TRAVELQUAD * travelquad1 + B_COST * TC_1 + B_COSTQUAD
                                        * costquad1 + B_SURVEILLANCE1 * supervisor_1 + B_SURVEILLANCE2 * camera_1
                                        + B_SURVEILLANCE1TRUST * TRUSTsupervisor_1 + B_SURVEILLANCE2TRUST * TRUSTcamera_1

2       A2_BUSAT        BUSAT_SP         ASC_BUSAT * one + B_TRUSTAT * trust + B_WAIT * WT_2 + B_WAITQUAD * waitquad2
                                        + B_TRAVEL * TT_2 + B_TRAVELQUAD * travelquad2 + B_COST * TC_2 + B_COSTQUAD
                                        * costquad2 + B_SURVEILLANCE1 * supervisor_2 + B_SURVEILLANCE2 * camera_2
                                        + BUSAT_SERVICE * SERVICE + B_SURVEILLANCE1TRUST * TRUSTsupervisor_2
                                        + B_SURVEILLANCE2TRUST * TRUSTcamera_2

3       A3_NOBUS        NOBUS_SP         ASC_NOBUS * one

[Expressions]
one             = 1
BUSDL_SP        = 1
BUSAT_SP        = 1
NOBUS_SP        = 1

waitquad1       = WT_1 * WT_1
travelquad1     = TT_1 * TT_1
costquad1       = TC_1 * TC_1
waitquad2       = WT_2 * WT_2
travelquad2     = TT_2 * TT_2
costquad2       = TC_2 * TC_2

TRUSTsupervisor_1 = supervisor_1 * trust
TRUSTsupervisor_2 = supervisor_2 * trust
TRUSTcamera_1     = camera_1 * trust
TRUSTcamera_2     = camera_2 * trust

[LaTeX]
ASC_BUSDL       "Constant for ADS-DV on dedicated lane"
ASC_BUSAT       "Constant for ADS-DV amongst other traffic"
B_COST          "$\beta$ Travel cost linear"
B_COSTQUAD      "$\beta$ Travel cost quadratic"
B_WAIT          "$\beta$ Waiting time linear"
B_WAITQUAD      "$\beta$ Waiting time quadratic"
B_TRAVEL        "$\beta$ Travel time linear"
B_TRAVELQUAD    "$\beta$ Travel time quadratic"
BUSAT_SERVICE   "$\beta$ Service type"
B_SURVEILLANCE2 "$\beta$ Camera"
B_SURVEILLANCE1 "$\beta$ Supervisor"
B_TRUSTDL       "$\beta$ Trust in ADS-DVs dedicated lane"
B_TRUSTAT       "$\beta$ Trust in ADS-DVs amongst other traffic"
B_SURVEILLANCE1TRUST "$\beta$ Camera trust in ADS-DVs"
B_SURVEILLANCE2TRUST "$\beta$ Supervisor trust in ADS-DVs"

[NLNests]
NEST1   1.0     1.0     10.0    0       1 2
NEST2   1.0     1.0     10.0    1       3

[Choice]
CHOICE


[Model]
// Multinomial Logit Model
$NL
```

Biogeme output

Model	:	Logit
Number of estimated parameters	:	13
Number of observations	:	1170
Number of individuals	:	1170
Null log likelihood	:	-1285.376
Cte log likelihood	:	-1158.808
Init log likelihood	:	-1285.376
Final log likelihood	:	-1091.888
Likelihood ratio test	:	386.976
Rho-square	:	0.151
Adjusted rho-square	:	0.140
Final gradient norm	:	+2.655e-003
Diagnostic	:	Convergence reached...
Iterations	:	6
Run time	:	00:00
Variance-covariance	:	from analytical hessian
Sample file	:	Trustexp3alt_DUMMY.dat

Parameter number	Description	Coeff. estimate	Robust Asympt. std. error	t-stat	p-value
1	Constant for ADS-DV amongst other traffic	5.79	1.22	4.73	0.00
2	Constant for ADS-DV on dedicated lane	6.68	1.25	5.34	0.00
3	β Service type	0.490	0.150	3.26	0.00
4	β Travel cost linear	-4.45	1.68	-2.65	0.01
5	β Travel cost quadratic	1.17	0.560	2.09	0.04
6	β Supervisor	0.522	0.111	4.69	0.00
7	β Camera trust in ADS-DVs	-0.583	0.118	-4.93	0.00
8	β Camera	0.703	0.110	6.38	0.00
9	β Supervisor trust in ADS-DVs	-0.424	0.115	-3.70	0.00
10	β Travel time linear	-0.204	0.0374	-5.46	0.00
11	β Trust in ADS-DVs amongst other traffic	0.918	0.130	7.05	0.00
12	β Trust in ADS-DVs dedicated lane	0.649	0.120	5.42	0.00
13	β Waiting time linear	-0.293	0.0398	-7.36	0.00

Summary statistics

Number of observations = 1170

$$\begin{aligned}
\mathcal{L}(0) &= -1285.376 \\
\mathcal{L}(c) &= -1158.808 \\
\mathcal{L}(\hat{\beta}) &= -1091.888 \\
-2[\mathcal{L}(0) - \mathcal{L}(\hat{\beta})] &= 386.976 \\
\rho^2 &= 0.151 \\
\bar{\rho}^2 &= 0.140
\end{aligned}$$

Nest	**Alternatives**	**Coeff. estimate**	**Robust Asympt. std.error**	**t-stat**	**p-value**
NEST1	Bus on dedicated lane	2.19	1.35	0.88	0.38*
	Bus amongst other traffic				
NEST2	No bus	1.0	fixed		

N.5. ML experience & trust - panel

When using variations of a Mixed Logit model the number of draws that is performed need to be determined. A higher number of draws generally leads to more stable values of the coefficients and sigma. More draws also largely increases the running time of the model. In order to find an acceptable number of draws for the model the stability of the results is compared for several runs. In general the results are considered stable when 1) the attribute values do not diverge too much from the previous run (maximum +/- 2 times the standard error) and 2) the values of the SIGMA diverge less than +/- 1 times the standard error from the value in the previous model. In this thesis each model was first run with 500 and then with 1000 draws. In comparing the results of the two models it can be concluded that in this case 1000 draws were sufficient to find stable parameter values.

Biogeme syntax

```
    [Beta]
    // Name           Value   Lowerbound        Upperboud         Status
    ASC_BUSDL                 0        -10000          10000          0
    ASC_BUSAT                 0        -10000          10000          0
    ASC_NOBUS                 0        -10000          10000          1
    B_COST                    0        -10000          10000          0
    B_COSTQUAD                0        -10000          10000          0
    B_WAIT                    0        -10000          10000          0
    B_WAITQUAD                0        -10000          10000          1
    B_TRAVEL                  0        -10000          10000          0
    B_TRAVELQUAD              0        -10000          10000          1
    BUSAT_SERVICE             0        -10000          10000          0
    B_SURVEILLANCE1           0        -10000          10000          0
    B_SURVEILLANCE2           0        -10000          10000          0
    B_TRUSTDL                 0        -10000          10000          0
    B_TRUSTAT                 0        -10000          10000          0
    B_SURVEILLANCE1TRUST      0        -10000          10000          0
    B_SURVEILLANCE2TRUST      0        -10000          10000          0
    B_EXPDL                   0        -10000          10000          0
    B_EXPAT                   0        -10000          10000          0
    B_SURVEILLANCE1EXP        0        -10000          10000          0
    B_SURVEILLANCE2EXP        0        -10000          10000          0
    ZERO                      0        -10000          10000          1
    SIGMA                     0        -10000          10000          0

    [Utilities]
    // ID   Name              Avail             Expression
    1       A1_BUSDL          BUSDL_SP           ASC_BUSDL * one + B_TRUSTDL * trust + B_EXPDL * EXP + B_WAIT * WT_1 + B_WAITQUAD * waitquad1
                                                + B_TRAVEL * TT_1 + B_TRAVELQUAD * travelquad1 + B_COST * TC_1 + B_COSTQUAD * costquad1
                                                + B_SURVEILLANCE1 * supervisor_1 + B_SURVEILLANCE2 * camera_1 + B_SURVEILLANCE1TRUST
                                                * TRUSTsupervisor_1 + B_SURVEILLANCE2TRUST * TRUSTcamera_1 + B_SURVEILLANCE1EXP
                                                * EXPsupervisor_1 + B_SURVEILLANCE2EXP * EXPcamera_1 + ZERO [ SIGMA ] * one

    2       A2_BUSAT          BUSAT_SP           ASC_BUSAT * one + B_TRUSTAT * trust + B_EXPAT * EXP + B_WAIT * WT_2 + B_WAITQUAD * waitquad2
                                                + B_TRAVEL * TT_2 + B_TRAVELQUAD * travelquad2 + B_COST * TC_2 + B_COSTQUAD * costquad2
                                                + B_SURVEILLANCE1 * supervisor_2 + B_SURVEILLANCE2 * camera_2 + BUSAT_SERVICE * SERVICE
                                                + B_SURVEILLANCE1TRUST * TRUSTsupervisor_2 + B_SURVEILLANCE2TRUST * TRUSTcamera_2
                                                + B_SURVEILLANCE1EXP * EXPsupervisor_2 + B_SURVEILLANCE2EXP * EXPcamera_2 + ZERO [ SIGMA ] * one

    3       A3_NOBUS          NOBUS_SP           ASC_NOBUS * one

    [Expressions]
    one               = 1
    BUSDL_SP          = 1
    BUSAT_SP          = 1
    NOBUS_SP          = 1

    waitquad1         = WT_1 * WT_1
    travelquad1       = TT_1 * TT_1
    costquad1         = TC_1 * TC_1
    waitquad2         = WT_2 * WT_2
    travelquad2       = TT_2 * TT_2
    costquad2         = TC_2 * TC_2

    TRUSTsupervisor_1 = supervisor_1 * trust
    TRUSTsupervisor_2 = supervisor_2 * trust
    TRUSTcamera_1     = camera_1 * trust
    TRUSTcamera_2     = camera_2 * trust

    EXPsupervisor_1 = supervisor_1 * EXP
    EXPsupervisor_2 = supervisor_2 * EXP
    EXPcamera_1     = camera_1 * EXP
    EXPcamera_2     = camera_2 * EXP
[LaTeX]
ASC_BUSDL       "Constant for ADS-DV on dedicated lane"
ASC_BUSAT       "Constant for ADS-DV amongst other traffic"
B_COST          "$\beta$ Travel cost linear"
B_COSTQUAD      "$\beta$ Travel cost quadratic"
B_WAIT          "$\beta$ Waiting time linear"
B_WAITQUAD      "$\beta$ Waiting time quadratic"
B_TRAVEL        "$\beta$ Travel time linear"
B_TRAVELQUAD    "$\beta$ Travel time quadratic"
BUSAT_SERVICE   "$\beta$ Service type"
B_SURVEILLANCE2 "$\beta$ Camera"
B_SURVEILLANCE1 "$\beta$ Supervisor"
B_TRUSTDL       "$\beta$ Trust in ADS-DVs dedicated lane"
B_TRUSTAT       "$\beta$ Trust in ADS-DVs amongst other traffic"
B_SURVEILLANCE1TRUST "$\beta$ Camera trust in ADS-DVs"
B_SURVEILLANCE2TRUST "$\beta$ Supervisor trust in ADS-DVs"
B_EXPDL         "$\beta$ Experience dedicated lane"
B_EXPAT         "$\beta$ Experience amongst other traffic"
B_SURVEILLANCE2EXP      "$\beta$ Camera experience"
B_SURVEILLANCE1EXP      "$\beta$ Supervisor experience"
SIGMA           "$\beta$ SIGMA"

[PanelData]
ID
ZERO_SIGMA

[Choice]
CHOICE

[Draws]
1000


[Model]
// Multinomial Logit Model
$MNL
```

Biogeme output

Model	:	Mixed Logit for panel data
Number of Hess-Train draws	:	1000
Number of estimated parameters	:	18
Number of observations	:	1170
Number of individuals	:	195
Null log likelihood	:	-1285.376
Cte log likelihood	:	-1158.808
Init log likelihood	:	-1285.376
Final log likelihood	:	-886.746
Likelihood ratio test	:	797.261
Rho-square	:	0.310
Adjusted rho-square	:	0.296
Final gradient norm	:	+2.111e-002
Diagnostic	:	Maximum number of iterations reached
Iterations	:	1000
Run time	:	05h 33:33
Variance-covariance	:	from finite difference hessian
Sample file	:	Trustexp3alt_DUMMY.dat

Parameter number	Description	Coeff. estimate	Robust Asympt. std. error	t-stat	p-value
1	Constant for ADS-DV amongst other traffic	8.65	1.49	5.80	0.00
2	Constant for ADS-DV on dedicated lane	9.59	1.51	6.37	0.00
3	β Service type	0.561	0.161	3.49	0.00
4	β Travel cost linear	-3.86	1.86	-2.08	0.04
5	β Travel cost quadratic	0.925	0.633	1.46	0.14*
6	β Experience amongst other traffic	-0.330	0.455	-0.73	0.47*
7	β Experience dedicated lane	-0.383	0.451	-0.85	0.40*
8	β Supervisor	0.619	0.133	4.65	0.00
9	β Supervisor experience	-0.00181	0.111	-0.02	0.99*
10	β Camera trust in ADS-DVs	-0.658	0.142	-4.65	0.00
11	β Camera	0.746	0.139	5.38	0.00
12	β Camera experience	-0.0365	0.111	-0.33	0.74*
13	β Supervisor trust in ADS-DVs	-0.500	0.134	-3.74	0.00
14	β Travel time linear	-0.221	0.0417	-5.29	0.00
15	β Trust in ADS-DVs amongst other traffic	1.89	0.560	3.38	0.00
16	β Trust in ADS-DVs dedicated lane	1.60	0.556	2.89	0.00
17	β Waiting time linear	-0.330	0.0486	-6.81	0.00
18	β SIGMA	4.64	0.761	6.10	0.00

Summary statistics

Number of observations = 1170

$$\mathcal{L}(0) = -1285.376$$
$$\mathcal{L}(c) = -1158.808$$
$$\mathcal{L}(\hat{\beta}) = -886.746$$
$$-2[\mathcal{L}(0) - \mathcal{L}(\hat{\beta})] = 797.261$$
$$\rho^2 = 0.310$$
$$\bar{\rho}^2 = 0.296$$

N.6. ML trust - panel

Biogeme syntax - travel cost linear

```
[Beta]
// Name            Value   Lowerbound      Upperboud       Status
ASC_BUSDL                  0       -10000          10000        0
ASC_BUSAT                  0       -10000          10000        0
ASC_NOBUS                  0       -10000          10000        1
B_COST                     0       -10000          10000        0
B_COSTQUAD                 0       -10000          10000        1
B_WAIT                     0       -10000          10000        0
B_WAITQUAD                 0       -10000          10000        1
B_TRAVEL                   0       -10000          10000        0
B_TRAVELQUAD               0       -10000          10000        1
BUSAT_SERVICE              0       -10000          10000        0
B_SURVEILLANCE1            0       -10000          10000        0
B_SURVEILLANCE2            0       -10000          10000        0
B_TRUSTDL                  0       -10000          10000        0
B_TRUSTAT                  0       -10000          10000        0
B_SURVEILLANCE1TRUST       0       -10000          10000        0
B_SURVEILLANCE2TRUST       0       -10000          10000        0
ZERO                       0       -10000          10000        1
SIGMA1                     0       -10000          10000        0
SIGMA2                     0       -10000          10000        0

[Utilities]
// ID   Name            Avail           Expression
1       A1_BUSDL        BUSDL_SP         ASC_BUSDL * one + B_TRUSTDL * trust + B_WAIT * WT_1 + B_WAITQUAD * waitquad1
                                        + B_TRAVEL * TT_1 + B_TRAVELQUAD * travelquad1 + B_COST * TC_1 + B_COSTQUAD
                                        * costquad1 + B_SURVEILLANCE1 * supervisor_1 + B_SURVEILLANCE2 * camera_1
                                        + B_SURVEILLANCE1TRUST * TRUSTsupervisor_1 + B_SURVEILLANCE2TRUST
                                        * TRUSTcamera_1 + ZERO [ SIGMA1 ] * one

2       A2_BUSAT        BUSAT_SP         ASC_BUSAT * one + B_TRUSTAT * trust + B_WAIT * WT_2 + B_WAITQUAD * waitquad2
                                        + B_TRAVEL * TT_2 + B_TRAVELQUAD * travelquad2 + B_COST * TC_2 + B_COSTQUAD
                                        * costquad2 + B_SURVEILLANCE1 * supervisor_2 + B_SURVEILLANCE2 * camera_2
                                        + BUSAT_SERVICE * SERVICE + B_SURVEILLANCE1TRUST * TRUSTsupervisor_2
                                        + B_SURVEILLANCE2TRUST * TRUSTcamera_2 + ZERO [ SIGMA2 ] * one

3       A3_NOBUS        NOBUS_SP         ASC_NOBUS * one

[Expressions]
one             = 1
BUSDL_SP        = 1
BUSAT_SP        = 1
NOBUS_SP        = 1

waitquad1       = WT_1 * WT_1
travelquad1     = TT_1 * TT_1
costquad1       = TC_1 * TC_1
waitquad2       = WT_2 * WT_2
travelquad2     = TT_2 * TT_2
costquad2       = TC_2 * TC_2

TRUSTsupervisor_1 = supervisor_1 * trust
TRUSTsupervisor_2 = supervisor_2 * trust
TRUSTcamera_1     = camera_1 * trust
TRUSTcamera_2     = camera_2 * trust

[LaTeX]
ASC_BUSDL        "Constant for ADS-DV on dedicated lane"
ASC_BUSAT        "Constant for ADS-DV amongst other traffic"
B_COST           "$\beta$ Travel cost linear"
B_COSTQUAD       "$\beta$ Travel cost quadratic"
B_WAIT           "$\beta$ Waiting time linear"
B_WAITQUAD       "$\beta$ Waiting time quadratic"
B_TRAVEL         "$\beta$ Travel time linear"
B_TRAVELQUAD     "$\beta$ Travel time quadratic"
BUSAT_SERVICE    "$\beta$ Service type"
B_SURVEILLANCE2  "$\beta$ Camera"
B_SURVEILLANCE1  "$\beta$ Supervisor"
B_TRUSTDL        "$\beta$ Trust in ADS-DVs dedicated lane"
B_TRUSTAT        "$\beta$ Trust in ADS-DVs amongst other traffic"
B_SURVEILLANCE1TRUST "$\beta$ Camera trust in ADS-DVs"
B_SURVEILLANCE2TRUST "$\beta$ Supervisor trust in ADS-DVs"
SIGMA1           "$\beta$ SIGMA1 dedicated lane"
SIGMA2           "$\beta$ SIGMA2 amongst other traffic"

[PanelData]
ID
ZERO_SIGMA1
ZERO_SIGMA2

[Choice]
CHOICE

[Draws]
1000


[Model]
// Multinomial Logit Model
$MNL
```

Biogeme output - travel cost linear

Model	:	Mixed Logit for panel data
Number of Hess-Train draws	:	1000
Number of estimated parameters	:	14
Number of observations	:	1170
Number of individuals	:	195
Null log likelihood	:	-1285.376
Cte log likelihood	:	-1158.808
Init log likelihood	:	-1285.376
Final log likelihood	:	-958.551
Likelihood ratio test	:	653.651
Rho-square	:	0.254
Adjusted rho-square	:	0.243
Final gradient norm	:	+3.342e-003
Diagnostic	:	Convergence reached...
Iterations	:	187
Run time	:	22:07
Variance-covariance	:	from finite difference hessian
Sample file	:	Trustexp3alt_DUMMY.dat

Parameter number	Description	Coeff. estimate	Robust Asympt. std. error	t-stat	p-value
1	Constant for ADS-DV amongst other traffic	5.18	0.712	7.28	0.00
2	Constant for ADS-DV on dedicated lane	6.59	0.767	8.58	0.00
3	β Service type	0.740	0.195	3.79	0.00
4	β Travel cost linear	-1.46	0.244	-6.00	0.00
5	β Supervisor	0.797	0.157	5.06	0.00
6	β Camera trust in ADS-DVs	-0.828	0.177	-4.68	0.00
7	β Camera	1.07	0.180	5.94	0.00
8	β Supervisor trust in ADS-DVs	-0.714	0.189	-3.79	0.00
9	β Travel time linear	-0.302	0.0553	-5.46	0.00
10	β Trust in ADS-DVs amongst other traffic	1.36	0.300	4.53	0.00
11	β Trust in ADS-DVs dedicated lane	0.947	0.310	3.05	0.00
12	β Waiting time linear	-0.466	0.0593	-7.86	0.00
13	β SIGMA1 dedicated lane	-2.14	0.256	-8.35	0.00
14	β SIGMA2 amongst other traffic	2.01	0.246	8.18	0.00

Summary statistics

Number of observations = 1170

$$\begin{aligned}
\mathcal{L}(0) &= -1285.376 \\
\mathcal{L}(c) &= -1158.808 \\
\mathcal{L}(\hat{\beta}) &= -958.551 \\
-2[\mathcal{L}(0) - \mathcal{L}(\hat{\beta})] &= 653.651 \\
\rho^2 &= 0.254 \\
\bar{\rho}^2 &= 0.243
\end{aligned}$$

Biogeme output - travel cost quadratic

Model	:	Mixed Logit for panel data
Number of Hess-Train draws	:	1000
Number of estimated parameters	:	15
Number of observations	:	1170
Number of individuals	:	195
Null log likelihood	:	-1285.376
Cte log likelihood	:	-1158.808
Init log likelihood	:	-1285.376
Final log likelihood	:	-957.409
Likelihood ratio test	:	655.935
Rho-square	:	0.255
Adjusted rho-square	:	0.243
Final gradient norm	:	+5.300e-003
Diagnostic	:	Convergence reached...
Iterations	:	216
Run time	:	25:43
Variance-covariance	:	from finite difference hessian
Sample file	:	Trustexp3alt_DUMMY.dat

Parameter number	Description	Coeff. estimate	Robust Asympt. std. error	t-stat	p-value
1	Constant for ADS-DV amongst other traffic	5.38	0.717	7.50	0.00
2	Constant for ADS-DV on dedicated lane	6.73	0.768	8.76	0.00
3	β Service type	0.587	0.225	2.61	0.01
4	β Travel cost linear	-1.33	0.262	-5.07	0.00
5	β Supervisor	0.825	0.158	5.22	0.00
6	β Camera trust in ADS-DVs	-0.835	0.178	-4.69	0.00
7	β Camera	1.04	0.183	5.65	0.00
8	β Supervisor trust in ADS-DVs	-0.711	0.188	-3.78	0.00
9	β Travel time linear	-0.295	0.0555	-5.32	0.00
10	β Trust in ADS-DVs amongst other traffic	1.38	0.303	4.55	0.00
11	β Trust in ADS-DVs dedicated lane	0.949	0.309	3.07	0.00
12	β Waiting time linear	-0.878	0.244	-3.59	0.00
13	β Waiting time quadratic	0.0731	0.0435	1.68	0.09
14	β SIGMA1 dedicated lane	-2.13	0.256	-8.32	0.00
15	β SIGMA2 amongst other traffic	2.02	0.247	8.19	0.00

Summary statistics

Number of observations = 1170

$$\mathcal{L}(0) = -1285.376$$
$$\mathcal{L}(c) = -1158.808$$
$$\mathcal{L}(\hat{\beta}) = -957.409$$
$$-2[\mathcal{L}(0) - \mathcal{L}(\hat{\beta})] = 655.935$$
$$\rho^2 = 0.255$$
$$\bar{\rho}^2 = 0.243$$

N.7. ML trust - panel & heterogeneity ASC

Biogeme syntax

```
[Beta]
// Name          Value   Lowerbound      Upperboud       Status
ASC_BUSDL                0       -10000          10000       0
ASC_BUSAT                0       -10000          10000       0
ASC_NOBUS                0       -10000          10000       1
B_COST                   0       -10000          10000       0
B_COSTQUAD               0       -10000          10000       0
B_WAIT                   0       -10000          10000       0
B_WAITQUAD               0       -10000          10000       1
B_TRAVEL                 0       -10000          10000       0
B_TRAVELQUAD             0       -10000          10000       1
BUSAT_SERVICE            0       -10000          10000       0
B_SURVEILLANCE1          0       -10000          10000       0
B_SURVEILLANCE2          0       -10000          10000       0
B_TRUSTDL                0       -10000          10000       0
B_TRUSTAT                0       -10000          10000       0
B_SURVEILLANCE1TRUST     0       -10000          10000       0
B_SURVEILLANCE2TRUST     0       -10000          10000       0
SIGMA_DL                 0       -10000          10000       0
SIGMA_AT                 0       -10000          10000       0

[Utilities]
// ID   Name            Avail           Expression
1       A1_BUSDL        BUSDL_SP         ASC_BUSDL [ SIGMA_DL ] * one + B_TRUSTDL * trust + B_WAIT * WT_1
                                        + B_WAITQUAD * waitquad1 + B_TRAVEL * TT_1 + B_TRAVELQUAD * travelquad1
                                        + B_COST * TC_1 + B_COSTQUAD * costquad1 + B_SURVEILLANCE1 * supervisor_1
                                        + B_SURVEILLANCE2 * camera_1 + B_SURVEILLANCE1TRUST * TRUSTsupervisor_1
                                        + B_SURVEILLANCE2TRUST * TRUSTcamera_1

2       A2_BUSAT        BUSAT_SP         ASC_BUSAT [ SIGMA_AT ] * one + B_TRUSTAT * trust + B_WAIT * WT_2
                                        + B_WAITQUAD * waitquad2 + B_TRAVEL * TT_2 + B_TRAVELQUAD * travelquad2
                                        + B_COST * TC_2 + B_COSTQUAD * costquad2 + B_SURVEILLANCE1 * supervisor_2
                                        + B_SURVEILLANCE2 * camera_2 + BUSAT_SERVICE * SERVICE
                                        + B_SURVEILLANCE1TRUST * TRUSTsupervisor_2 + B_SURVEILLANCE2TRUST
                                        * TRUSTcamera_2

3       A3_NOBUS        NOBUS_SP         ASC_NOBUS * one

[Expressions]
one             = 1
BUSDL_SP        = 1
BUSAT_SP        = 1
NOBUS_SP        = 1

waitquad1       = WT_1 * WT_1
travelquad1     = TT_1 * TT_1
costquad1       = TC_1 * TC_1
waitquad2       = WT_2 * WT_2
travelquad2     = TT_2 * TT_2
costquad2       = TC_2 * TC_2

TRUSTsupervisor_1 = supervisor_1 * trust
TRUSTsupervisor_2 = supervisor_2 * trust
TRUSTcamera_1     = camera_1 * trust
TRUSTcamera_2     = camera_2 * trust

[LaTeX]
ASC_BUSDL       "Constant for ADS-DV on dedicated lane"
ASC_BUSAT       "Constant for ADS-DV amongst other traffic"
B_COST          "$\beta$ Travel cost linear"
B_COSTQUAD      "$\beta$ Travel cost quadratic"
B_WAIT          "$\beta$ Waiting time linear"
B_WAITQUAD      "$\beta$ Waiting time quadratic"
B_TRAVEL        "$\beta$ Travel time linear"
B_TRAVELQUAD    "$\beta$ Travel time quadratic"
BUSAT_SERVICE   "$\beta$ Service type"
B_SURVEILLANCE2 "$\beta$ Camera"
B_SURVEILLANCE1 "$\beta$ Supervisor"
B_TRUSTDL       "$\beta$ Trust in ADS-DVs dedicated lane"
B_TRUSTAT       "$\beta$ Trust in ADS-DVs amongst other traffic"
B_SURVEILLANCE1TRUST "$\beta$ Camera trust in ADS-DVs"
B_SURVEILLANCE2TRUST "$\beta$ Supervisor trust in ADS-DVs"
SIGMA_DL        "$\beta$ SIGMA dedicated lane"
SIGMA_AT        "$\beta$ SIGMA amongst other traffic"

[PanelData]
ID
ASC_BUSDL_SIGMA_DL
ASC_BUSAT_SIGMA_AT

[Choice]
CHOICE

[Draws]
1000


[Model]
// Multinomial Logit Model
$MNL
```

Biogeme output

Model	:	Mixed Logit for panel data
Number of Hess-Train draws	:	1000
Number of estimated parameters	:	15
Number of observations	:	1170
Number of individuals	:	195
Null log likelihood	:	-1285.376
Cte log likelihood	:	-1158.808
Init log likelihood	:	-1285.376
Final log likelihood	:	-956.660
Likelihood ratio test	:	657.433
Rho-square	:	0.256
Adjusted rho-square	:	0.244
Final gradient norm	:	+4.232e-001
Diagnostic	:	Maximum number of iterations reached
Iterations	:	1000
Run time	:	04h 53:21
Variance-covariance	:	from finite difference hessian
Sample file	:	Trustexp3alt_DUMMY.dat

Parameter number	Description	Coeff. estimate	Robust Asympt. std. error	t-stat	p-value
1	Constant for ADS-DV amongst other traffic	7.59	1.47	5.16	0.00
2	Constant for ADS-DV on dedicated lane	9.03	1.51	5.97	0.00
3	β Service type	0.769	0.198	3.89	0.00
4	β Travel cost linear	-5.17	1.83	-2.82	0.00
5	β Travel cost quadratic	1.25	0.603	2.08	0.04
6	β Supervisor	0.771	0.160	4.83	0.00
7	β Camera trust in ADS-DVs	-0.831	0.177	-4.68	0.00
8	β Camera	1.09	0.179	6.11	0.00
9	β Supervisor trust in ADS-DVs	-0.706	0.186	-3.80	0.00
10	β Travel time linear	-0.299	0.0564	-5.30	0.00
11	β Trust in ADS-DVs amongst other traffic	1.37	0.308	4.46	0.00
12	β Trust in ADS-DVs dedicated lane	1.02	0.319	3.20	0.00
13	β Waiting time linear	-0.447	0.0589	-7.58	0.00
14	β SIGMA amongst other traffic	-1.94	0.242	-8.00	0.00
15	β SIGMA dedicated lane	-2.13	0.255	-8.34	0.00

Summary statistics

Number of observations = 1170

$$\mathcal{L}(0) = -1285.376$$

$$\mathcal{L}(c) = -1158.808$$

$$\mathcal{L}(\hat{\beta}) = -956.660$$

$$-2[\mathcal{L}(0) - \mathcal{L}(\hat{\beta})] = 657.433$$

$$\rho^2 = 0.256$$

$$\bar{\rho}^2 = 0.244$$

N.8. ML trust & heterogeneity: surveillance

Biogeme syntax

```
  [Beta]
  // Name          Value   Lowerbound       Upperboud       Status
  ASC_BUSDL                0        -10000        10000           0
  ASC_BUSAT                0        -10000        10000           0
  ASC_NOBUS                0        -10000        10000           1
  B_COST                   0        -10000        10000           0
  B_COSTQUAD               0        -10000        10000           0
  B_WAIT                   0        -10000        10000           0
  B_WAITQUAD               0        -10000        10000           1
  B_TRAVEL                 0        -10000        10000           0
  B_TRAVELQUAD             0        -10000        10000           1
  BUSAT_SERVICE            0        -10000        10000           0
  B_SURVEILLANCE1          0        -10000        10000           0
  B_SURVEILLANCE2          0        -10000        10000           0
  B_TRUSTDL                0        -10000        10000           0
  B_TRUSTAT                0        -10000        10000           0
  B_SURVEILLANCE1TRUST     0        -10000        10000           0
  B_SURVEILLANCE2TRUST     0        -10000        10000           0
  SIGMA_C                  0        -10000        10000           0
  SIGMA_S                  0        -10000        10000           0

  [Utilities]
  // ID   Name             Avail            Expression
  1       A1_BUSDL         BUSDL_SP          ASC_BUSDL  * one + B_TRUSTDL * trust + B_WAIT * WT_1 + B_WAITQUAD * waitquad1
                           + B_TRAVEL * TT_1 + B_TRAVELQUAD * travelquad1 + B_COST * TC_1 + B_COSTQUAD * costquad1
                           + B_SURVEILLANCE1 [ SIGMA_S ] * supervisor_1 + B_SURVEILLANCE2 [ SIGMA_C ]* camera_1
                           + B_SURVEILLANCE1TRUST * TRUSTsupervisor_1 + B_SURVEILLANCE2TRUST * TRUSTcamera_1

  2       A2_BUSAT         BUSAT_SP          ASC_BUSAT  * one + B_TRUSTAT * trust + B_WAIT * WT_2 + B_WAITQUAD * waitquad2
                           + B_TRAVEL * TT_2 + B_TRAVELQUAD * travelquad2 + B_COST * TC_2 + B_COSTQUAD * costquad2
                           + B_SURVEILLANCE1 [ SIGMA_S ] * supervisor_2 + B_SURVEILLANCE2 [ SIGMA_C ] * camera_2
                           + BUSAT_SERVICE * SERVICE + B_SURVEILLANCE1TRUST * TRUSTsupervisor_2 + B_SURVEILLANCE2TRUST
                           * TRUSTcamera_2

  3       A3_NOBUS         NOBUS_SP          ASC_NOBUS * one

  [Expressions]
  one              = 1
  BUSDL_SP         = 1
  BUSAT_SP         = 1
  NOBUS_SP         = 1

  waitquad1        = WT_1 * WT_1
  travelquad1      = TT_1 * TT_1
  costquad1        = TC_1 * TC_1
  waitquad2        = WT_2 * WT_2
  travelquad2      = TT_2 * TT_2
  costquad2        = TC_2 * TC_2

  TRUSTsupervisor_1 = supervisor_1 * trust
  TRUSTsupervisor_2 = supervisor_2 * trust
  TRUSTcamera_1     = camera_1 * trust
  TRUSTcamera_2     = camera_2 * trust

[LaTeX]
ASC_BUSDL       "Constant for ADS-DV on dedicated lane"
ASC_BUSAT       "Constant for ADS-DV amongst other traffic"
B_COST          "$\beta$ Travel cost linear"
B_COSTQUAD      "$\beta$ Travel cost quadratic"
B_WAIT          "$\beta$ Waiting time linear"
B_WAITQUAD      "$\beta$ Waiting time quadratic"
B_TRAVEL        "$\beta$ Travel time linear"
B_TRAVELQUAD    "$\beta$ Travel time quadratic"
BUSAT_SERVICE   "$\beta$ Service type"
B_SURVEILLANCE2 "$\beta$ Camera"
B_SURVEILLANCE1 "$\beta$ Supervisor"
B_TRUSTDL       "$\beta$ Trust in ADS-DVs dedicated lane"
B_TRUSTAT       "$\beta$ Trust in ADS-DVs amongst other traffic"
B_SURVEILLANCE1TRUST "$\beta$ Camera trust in ADS-DVs"
B_SURVEILLANCE2TRUST "$\beta$ Supervisor trust in ADS-DVs"
SIGMA_C         "$\beta$ SIGMA camera"
SIGMA_S         "$\beta$ SIGMA supervisor"


[PanelData]
ID
B_SURVEILLANCE1_SIGMA_C
B_SURVEILLANCE2_SIGMA_S

[Choice]
CHOICE

[Draws]
1000


[Model]
// Multinomial Logit Model
$MNL
```

Biogeme output

Model	:	Mixed Logit for panel data
Number of Hess-Train draws	:	1000
Number of estimated parameters	:	17
Number of observations	:	1170
Number of individuals	:	195
Null log likelihood	:	-1285.376
Cte log likelihood	:	-1158.808
Init log likelihood	:	-1285.376
Final log likelihood	:	-952.598
Likelihood ratio test	:	665.556
Rho-square	:	0.259
Adjusted rho-square	:	0.246
Final gradient norm	:	+8.434e-002
Diagnostic	:	Maximum number of iterations reached
Iterations	:	1000
Run time	:	02h 18:13
Variance-covariance	:	from finite difference hessian
Sample file	:	Trustexp3alt_DUMMY.dat

Parameter number	Description	Coeff. estimate	Robust Asympt. std. error	t-stat	p-value
1	Constant for ADS-DV amongst other traffic	8.86	1.70	5.20	0.00
2	Constant for ADS-DV on dedicated lane	10.4	1.77	5.85	0.00
3	β Service type	0.874	0.224	3.90	0.00
4	β Travel cost linear	-6.53	2.07	-3.15	0.00
5	β Travel cost quadratic	1.66	0.676	2.45	0.01
6	β Supervisor	0.799	0.187	4.27	0.00
7	β Camera trust in ADS-DVs	-0.874	0.208	-4.21	0.00
8	β Camera	1.15	0.207	5.56	0.00
9	β Supervisor trust in ADS-DVs	-0.719	0.214	-3.36	0.00
10	β Travel time linear	-0.334	0.0649	-5.15	0.00
11	β Trust in ADS-DVs amongst other traffic	1.39	0.302	4.61	0.00
12	β Trust in ADS-DVs dedicated lane	0.900	0.331	2.72	0.01
13	β Waiting time linear	-0.487	0.0666	-7.31	0.00
14	β SIGMA amongst other traffic	1.95	0.278	7.02	0.00
15	β SIGMA camera	0.964	0.276	3.49	0.00
16	β SIGMA dedicated lane	2.18	0.286	7.61	0.00
17	β SIGMA supervisor	0.950	0.324	2.93	0.00

Summary statistics

Number of observations = 1170

$$\begin{aligned}
\mathcal{L}(0) &= -1285.376\\
\mathcal{L}(c) &= -1158.808\\
\mathcal{L}(\hat{\beta}) &= -952.598\\
-2[\mathcal{L}(0)-\mathcal{L}(\hat{\beta})] &= 665.556\\
\rho^2 &= 0.259\\
\bar{\rho}^2 &= 0.246
\end{aligned}$$

N.9. Biogeme output - travel costs linear

Model	:	Mixed Logit for panel data
Number of Hess-Train draws	:	1000
Number of estimated parameters	:	16
Number of observations	:	1170
Number of individuals	:	195
Null log likelihood	:	-1285.376
Cte log likelihood	:	-1158.808
Init log likelihood	:	-1285.376
Final log likelihood	:	-955.286
Likelihood ratio test	:	660.180
Rho-square	:	0.257
Adjusted rho-square	:	0.244
Final gradient norm	:	+2.067e-003
Diagnostic	:	Convergence reached...
Iterations	:	126
Run time	:	14:55
Variance-covariance	:	from finite difference hessian
Sample file	:	Trustexp3alt_DUMMY.dat

Parameter number	Description	Coeff. estimate	Robust Asympt. std. error	t-stat	p-value
1	Constant for ADS-DV amongst other traffic	5.52	0.801	6.88	0.00
2	Constant for ADS-DV on dedicated lane	7.00	0.867	8.08	0.00
3	β Service type	0.834	0.218	3.83	0.00
4	β Travel cost linear	-1.59	0.277	-5.74	0.00
5	β Supervisor	0.808	0.182	4.43	0.00
6	β Camera trust in ADS-DVs	-0.864	0.204	-4.23	0.00
7	β Camera	1.09	0.207	5.27	0.00
8	β Supervisor trust in ADS-DVs	-0.712	0.214	-3.33	0.00
9	β Travel time linear	-0.328	0.0624	-5.25	0.00
10	β Trust in ADS-DVs amongst other traffic	1.39	0.303	4.58	0.00
11	β Trust in ADS-DVs dedicated lane	0.902	0.333	2.71	0.01
12	β Waiting time linear	-0.499	0.0661	-7.55	0.00
13	β SIGMA amongst other traffic	1.95	0.281	6.97	0.00
14	β SIGMA camera	0.979	0.281	3.49	0.00
15	β SIGMA dedicated lane	2.19	0.288	7.60	0.00
16	β SIGMA supervisor	0.903	0.325	2.78	0.01

Summary statistics

Number of observations = 1170

$$\begin{aligned}
\mathscr{L}(0) &= -1285.376 \\
\mathscr{L}(c) &= -1158.808 \\
\mathscr{L}(\hat{\beta}) &= -955.286 \\
-2[\mathscr{L}(0) - \mathscr{L}(\hat{\beta})] &= 660.180 \\
\rho^2 &= 0.257 \\
\bar{\rho}^2 &= 0.244
\end{aligned}$$

O

Socioeconomic variables and latent variable: Trust in ADS-DVs

Several *independent samples T tests* and *One-way ANOVA* tests were conducted to investigate the underlying relationships between the latent variable *Trust in ADS-DVs* and socioeconomic variables *gender, age, income, education level, public transport use, region* and *experience with ADS-DVs.* From the analyses it turns out that *gender* and *region* both indicate significant differences in the mean values for the *Trust in ADS-DVs.* Males were found to have more trust in ADS-DVs than females and in a region where an ADS-DV is in operation individuals were found to have higher levels of trust.

T-Test

Group Statistics

	rGENDER	N	Mean	Std. Deviation	Std. Error Mean
REGR factor score 1 for analysis 1	Male	133	,1169669	,83839260	,07269786
	Female	59	-,2577820	,87514426	,11393408

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
REGR factor score 1 for analysis 1	Equal variances assumed	,030	,862	2,819	190	,005	,37474889	,13292459	,11255139	,63694640
	Equal variances not assumed			2,773	107,045	,007	,37474889	,13515159	,10682791	,64266988

Figure O.1: Independent samples T test: Gender and Trust in ADS-DVs

T-Test

Group Statistics

	rrREGION	N	Mean	Std. Deviation	Std. Error Mean
REGR factor score 1 for analysis 1	Capelle a/d IJssel	99	,1428923	,76326150	,07671067
	Other regions	96	-,1473577	,93686666	,09561855

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
REGR factor score 1 for analysis 1	Equal variances assumed	3,184	,076	2,375	193	,019	,29025002	,12220387	,04922347	,53127658
	Equal variances not assumed			2,368	183,110	,019	,29025002	,12258644	,04838649	,53211355

Figure O.2: One-way ANOVA: Region and Trust in ADS-DVs

Oneway

Descriptives

REGR factor score 1 for analysis 1

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
No	39	-,2460321	,92127149	,14752150	-,5446737	,0526096	-2,68048	1,17872
Yes, I have read or seen something about self-driving buses earlier	87	-,0511041	,90618587	,09715332	-,2442385	,1420303	-2,01946	1,64509
Yes, I have made use of the ParkShuttle once / a few times	42	,2584411	,81202155	,12529765	,0053974	,5114849	-1,75960	1,64509
Yes, I make use of the ParkShuttle on a weekly basis	27	,1180288	,58520425	,11262261	-,1134703	,3495279	-1,30512	1,03687
Total	195	,0000000	,86328601	,06182119	-,1219279	,1219279	-2,68048	1,64509

Test of Homogeneity of Variances

REGR factor score 1 for analysis 1

Levene Statistic	df1	df2	Sig.
2,046	3	191	,109

ANOVA

REGR factor score 1 for analysis 1

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5,769	3	1,923	2,646	,050
Within Groups	138,812	191	,727		
Total	144,581	194			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: REGR factor score 1 for analysis 1

Bonferroni

(I) rEXPERIENCE	(J) rEXPERIENCE	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
No	Yes, I have read or seen something about self-driving buses earlier	-,19492797	,16428185	1,000	-,6329062	,2430502
	Yes, I have made use of the ParkShuttle once / a few times	-,50447318	,18957532	,051	-1,0098842	,0009378
	Yes, I make use of the ParkShuttle on a weekly basis	-,36406089	,21342929	,538	-,9330670	,2049452
Yes, I have read or seen something about self-driving buses earlier	No	,19492797	,16428185	1,000	-,2430502	,6329062
	Yes, I have made use of the ParkShuttle once / a few times	-,30954521	,16017946	,329	-,7365864	,1174959
	Yes, I make use of the ParkShuttle on a weekly basis	-,16913292	,18780500	1,000	-,6698242	,3315584
Yes, I have made use of the ParkShuttle once / a few times	No	,50447318	,18957532	,051	-,0009378	1,0098842
	Yes, I have read or seen something about self-driving buses earlier	,30954521	,16017946	,329	-,1174959	,7365864
	Yes, I make use of the ParkShuttle on a weekly basis	,14041229	,21028789	1,000	-,4202188	,7010434
Yes, I make use of the ParkShuttle on a weekly basis	No	,36406089	,21342929	,538	-,2049452	,9330670
	Yes, I have read or seen something about self-driving buses earlier	,16913292	,18780500	1,000	-,3315584	,6698242
	Yes, I have made use of the ParkShuttle once / a few times	-,14041229	,21028789	1,000	-,7010434	,4202188

Figure O.3: One-way ANOVA: Experience and Trust in ADS-DVs

Oneway

Descriptives

REGR factor score 1 for analysis 1

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
18 - 35	76	-,0473711	,89359331	,10250218	-,2515659	,1568237	-2,68048	1,64509
36 - 55	84	-,0045583	,85545706	,09333802	-,1902038	,1810873	-1,90146	1,64509
> 55	31	,1608595	,83488903	,14995050	-,1453803	,4670993	-2,01946	1,64509
Total	191	,0052542	,86605122	,06266527	-,1183548	,1288632	-2,68048	1,64509

Test of Homogeneity of Variances

REGR factor score 1 for analysis 1

Levene Statistic	df1	df2	Sig.
,477	2	188	,621

ANOVA

REGR factor score 1 for analysis 1

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	,969	2	,485	,644	,527
Within Groups	141,539	188	,753		
Total	142,508	190			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: REGR factor score 1 for analysis 1

Bonferroni

(I) rrAGE	(J) rrAGE	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
18 - 35	36 - 55	-,04281285	,13736408	1,000	-,3746285	,2890028
	> 55	-,20823059	,18491149	,785	-,6549013	,2384401
36 - 55	18 - 35	,04281285	,13736408	1,000	-,2890028	,3746285
	> 55	-,16541773	,18234257	1,000	-,6058830	,2750475
> 55	18 - 35	,20823059	,18491149	,785	-,2384401	,6549013
	36 - 55	,16541773	,18234257	1,000	-,2750475	,6058830

Figure O.4: One-way ANOVA: Age and Trust in ADS-DVs

Oneway

Descriptives

REGR factor score 1 for analysis 1

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
< 2200	32	,0989880	,74001172	,13081683	-,1678147	,3657906	-2,68048	1,64509
2200 - 4000	83	-,0904936	,88006463	,09659964	-,2826611	,1016738	-2,01946	1,64509
> 4000	50	,1163845	,88519982	,12518616	-,1351865	,3679555	-1,90146	1,64509
Total	165	,0089447	,85731764	,06674209	-,1228399	,1407292	-2,68048	1,64509

Test of Homogeneity of Variances

REGR factor score 1 for analysis 1

Levene Statistic	df1	df2	Sig.
2,237	2	162	,110

ANOVA

REGR factor score 1 for analysis 1

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1,657	2	,829	1,129	,326
Within Groups	118,882	162	,734		
Total	120,539	164			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: REGR factor score 1 for analysis 1

Bonferroni

(I) rrINCOME	(J) rrINCOME	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
< 2200	2200 - 4000	,18948160	,17825213	,868	-,2417273	,6206905
	> 4000	-,01739657	,19393080	1,000	-,4865337	,4517405
2200 - 4000	< 2200	-,18948160	,17825213	,868	-,6206905	,2417273
	> 4000	-,20687817	,15335630	,538	-,5778617	,1641053
> 4000	< 2200	,01739657	,19393080	1,000	-,4517405	,4865337
	2200 - 4000	,20687817	,15335630	,538	-,1641053	,5778617

Figure O.5: One-way ANOVA: Income and Trust in ADS-DVs

T-Test

Group Statistics

	rEDUCATION	N	Mean	Std. Deviation	Std. Error Mean
REGR factor score 1 for analysis 1	Lower level of education	42	-,1015945	,92476789	,14269478
	High level of education	146	,0429866	,84562585	,06998449

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
REGR factor score 1 for analysis 1	Equal variances assumed	,271	,603	-,956	186	,340	-,14458109	,15123001	-,44292767	,15376550
	Equal variances not assumed			-,910	62,081	,366	-,14458109	,15893279	-,46227497	,17311280

Figure O.6: Independent samples T test: Education level and Trust in ADS-DVs

T-Test

Group Statistics

	rPTUSE	N	Mean	Std. Deviation	Std. Error Mean
REGR factor score 1 for analysis 1	No	96	,0354949	,92466568	,09437330
	Yes	99	-,0344193	,80252857	,08065716

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
REGR factor score 1 for analysis 1	Equal variances assumed	2,036	,155	,564	193	,573	,06991426	,12387478	-,17440789	,31423642
	Equal variances not assumed			,563	187,496	,574	,06991426	,12414466	-,17498554	,31481406

Figure O.7: Independent samples T test: Public transport use and Trust in ADS-DVs

P

Socioeconomic variables and ADS-DV preference

Several *independent samples T tests* and *One-way ANOVA* tests were conducted to investigate whether groups based on socioeconomic variable have chosen more or less often to make use of an ADS-DV in the choice model. The number of times a respondent has chosen an ADS-DV has been added up to a total number (*SUMCS*). The variavble *SUMCS* ranges from 0 to 6. From the analyses it turns out that no significant differences are present for the variables *gender, age, income, education level, public transport use, region* and *experience with ADS-DVs.*

Group Statistics

	rGENDER	N	Mean	Std. Deviation	Std. Error Mean
SUMCS	Male	133	4,95	2,020	,175
	Female	59	5,19	1,559	,203

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SUMCS	Equal variances assumed	4,544	,034	-,808	190	,420	-,239	,296	-,823	,344
	Equal variances not assumed			-,892	141,974	,374	-,239	,268	-,769	,291

Figure P.1: Independent samples T test: Gender and SUM choice model

Group Statistics

	rEDUCATION	N	Mean	Std. Deviation	Std. Error Mean
SUMCS	Lower level of education	42	5,36	1,445	,223
	High level of education	146	4,92	2,012	,167

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SUMCS	Equal variances assumed	6,198	,014	1,319	186	,189	,439	,333	-,218	1,096
	Equal variances not assumed			1,579	91,426	,118	,439	,278	-,113	,992

Figure P.2: Independent samples T test: Education level and SUM choice model

Group Statistics

	rPTUSE	N	Mean	Std. Deviation	Std. Error Mean
SUMCS	No	96	5,03	1,927	,197
	Yes	99	5,04	1,840	,185

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SUMCS	Equal variances assumed	,238	,626	-,034	193	,973	-,009	,270	-,541	,523
	Equal variances not assumed			-,034	191,857	,973	-,009	,270	-,542	,523

Figure P.3: Independent samples T test: Public transport use and SUM choice model

Oneway

Descriptives

SUMCS

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean: Lower Bound	95% Confidence Interval for Mean: Upper Bound	Minimum	Maximum
18 - 35	76	4,89	1,929	,221	4,45	5,34	0	6
36 - 55	84	5,00	1,988	,217	4,57	5,43	0	6
> 55	31	5,35	1,518	,273	4,80	5,91	0	6
Total	191	5,02	1,893	,137	4,75	5,29	0	6

Test of Homogeneity of Variances

SUMCS

Levene Statistic	df1	df2	Sig.
1,973	2	188	,142

ANOVA

SUMCS

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4,698	2	2,349	,653	,522
Within Groups	676,255	188	3,597		
Total	680,953	190			

Figure P.4: One-way ANOVA: Age and SUM choice model

Oneway

Descriptives

SUMCS

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean: Lower Bound	95% Confidence Interval for Mean: Upper Bound	Minimum	Maximum
< 2200	32	5,06	1,777	,314	4,42	5,70	0	6
2200 - 4000	83	5,01	1,935	,212	4,59	5,43	0	6
> 4000	50	5,02	2,035	,288	4,44	5,60	0	6
Total	165	5,02	1,925	,150	4,73	5,32	0	6

Test of Homogeneity of Variances

SUMCS

Levene Statistic	df1	df2	Sig.
,189	2	162	,828

ANOVA

SUMCS

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	,060	2	,030	,008	,992
Within Groups	607,843	162	3,752		
Total	607,903	164			

Figure P.5: One-way ANOVA: Income and SUM choice model

Oneway

Descriptives

SUMCS

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
Capelle a/d IJssel: Rivium (+ Rotterdam: Schaardijk)	99	5,19	1,712	,172	4,85	5,53	0	6
Rijswijk: Plaspoelpolder, Broekpolder or Hoornwijck	37	4,84	2,089	,343	4,14	5,53	0	6
The Hague: Beatrixkwartier	59	4,90	2,015	,262	4,37	5,42	0	6
Total	195	5,04	1,879	,135	4,77	5,30	0	6

Test of Homogeneity of Variances

SUMCS

Levene Statistic	df1	df2	Sig.
1,465	2	192	,234

ANOVA

SUMCS

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4,978	2	2,489	,703	,496
Within Groups	679,770	192	3,540		
Total	684,749	194			

Figure P.6: One-way ANOVA: Region and SUM choice model

Oneway

Descriptives

SUMCS

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
No	39	4,97	1,980	,317	4,33	5,62	0	6
Yes, I have read or seen something about self-driving buses earlier	87	5,10	1,862	,200	4,71	5,50	0	6
Yes, I have made use of the ParkShuttle once / a few times	42	4,93	2,017	,311	4,30	5,56	0	6
Yes, I make use of the ParkShuttle on a weekly basis	27	5,07	1,639	,315	4,43	5,72	0	6
Total	195	5,04	1,879	,135	4,77	5,30	0	6

Test of Homogeneity of Variances

SUMCS

Levene Statistic	df1	df2	Sig.
,776	3	191	,509

ANOVA

SUMCS

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1,068	3	,356	,099	,960
Within Groups	683,681	191	3,579		
Total	684,749	194			

Figure P.7: One-way ANOVA: Experience and SUM choice model