An empirical study into the effects of private automated vehicles on drivers' parking location choice

An application to the city of The Hague

Master thesis

D.E.M. van den Hurk

An empirical study into the effects of private automated vehicles on drivers' parking location choice

An application to the city of The Hague

By

Daphne Elisabeth Maria van den Hurk

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Student number:	4369580	
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Thesis committee:	Prof. dr. ir. B. van Arem	Chairman, TU Delft (CiTG)
	Dr. D. Milakis	Supervisor, TU Delft (CiTG)
	Dr. E.J.E. Molin	Supervisor, TU Delft (TPM)
	Ir. J. Loijen	External supervisor, Goudappel Coffeng

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PREFACE

The aim of this master thesis is to gain insight into the effects of private highly automated vehicles on drivers' parking location choice using an empirical framework. This study is conducted on behalf of Goudappel Coffeng in association with the Delft University of Technology. With this thesis, I conclude my master program *Transport, Infrastructure and Logistics* at the faculty of Civil Engineering and Geosciences at the Delft University of Technology.

I would like to express my gratitude to everyone who helped me during my master thesis. First of all, I would like to thank my graduation committee for their guidance and feedback. I would like to thank prof. dr. ir. Bart van Arem, the chairman of my committee, for bringing me in contact with Goudappel Coffeng and for his extensive knowledge about automated vehicles. I would like to thank dr. Dimitris Milakis, the daily supervisor of my committee, for his contribution on the spatial impacts of automated vehicles. I would like to thank dr. Eric Molin, the daily supervisor of my committee, for helping me with the modelling aspects in this research that proved to be a challenge for me. I would like to thank ir. Jeroen Loijen, the company supervisor, for his help with the policy related aspects and his support during this entire master thesis.

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Third, I would like to thank everyone who participated in the brainstorm sessions for constructing the conceptual framework of this research. Special thanks go to Arjen Reijneveld and Diede Labots from the municipality of The Hague for their insights into the implementation of the system in The Hague and for their directions for the policy advice. Furthermore, I would like to thank all persons who filled in the online questionnaire in order to get the data for this research.

Last but not least, I would like to thank my parents Eric and Henriette for their support during my entire study in Eindhoven and Delft. Furthermore, I would like to thank my boyfriend Hans for his support in me and for his help with constructing the animated introduction movie for the online survey. In addition, I would like to thank my friends, brothers and sister for distracting me when I needed it.

I really enjoyed my bachelor *Architecture* at the Eindhoven University of Technology and my master *Transport, Infrastructure and Logistics* at the Delft University of Technology. The interest and the obtained knowledge on the combination of spatial planning and transport proved to be of great importance in this research. I am proud of what I have accomplished during this graduation process, a period of discovering interesting results while at the same time meeting new people. After this intensive process, I am happy that I am able to change my status as an intern at Goudappel Coffeng to a consultant in mobility and urban planning and become a 'Goudappelaar' myself.

Daphne van den Hurk
Amsterdam, 2017

EXECUTIVE SUMMARY

Automated vehicles (AVs) have been receiving increased attention all over the world, since the first fully AVs are already operating on the public road network. AVs could not only have a tremendous impact on the urban environment but also on human travel behaviour. With the capability of AVs to ride and park themselves instead of being operated by a human driver, it is likely that parking choice behaviour will change when conventional vehicles (CVs) are replaced by AVs. In order to make investment decisions, it is important for governments to gain insight into the impacts of AVs. The objective of this research is to find the importance of different factors and constraints that could influence drivers' parking location choice for a future situation in which private highly AVs will become available for passenger transport. The results of this study have been used to provide guidelines for governments on how to develop their parking policy for this future situation. The main research question of this thesis is formulated as follows:

'' What is the effect of private highly automated vehicles on drivers' parking location choice, based on parking constraints? ''

AVs can either be privately used or shared with others. This research is focused on the private use of AVs. A schematic overview of a trip with a private highly AV is visualised in Figure i.1. The trip with a private highly AV starts from the 'passenger origin' and develops in the direction of the 'passenger destination'. Space to drop-off the passenger is needed to avoid congestion caused by dropping-off passengers on the road itself. On-street parking space is used for the drop-off manoeuvre. When the passenger is dropped-off at a drop-off point, the passenger walks to the destination. Simultaneous to this walking leg, the private highly AV drives empty from the drop-off point to a parking facility. The two considered parking locations are 1) parking in the inner city (PIC) and 2) parking at the edge of the city (PEC), both at off-street parking facilities. When the passenger's activity has ended, he/she walks to a pick-up point. On-street parking space is used for the pick-up manoeuvre. Simultaneously, the private highly AV drives empty from the parking facility to the pick-up point. When the passenger and the private highly AV have both arrived at the pick-up point, the vehicle trip from the pick-up point to the passenger's home or to another destination starts.

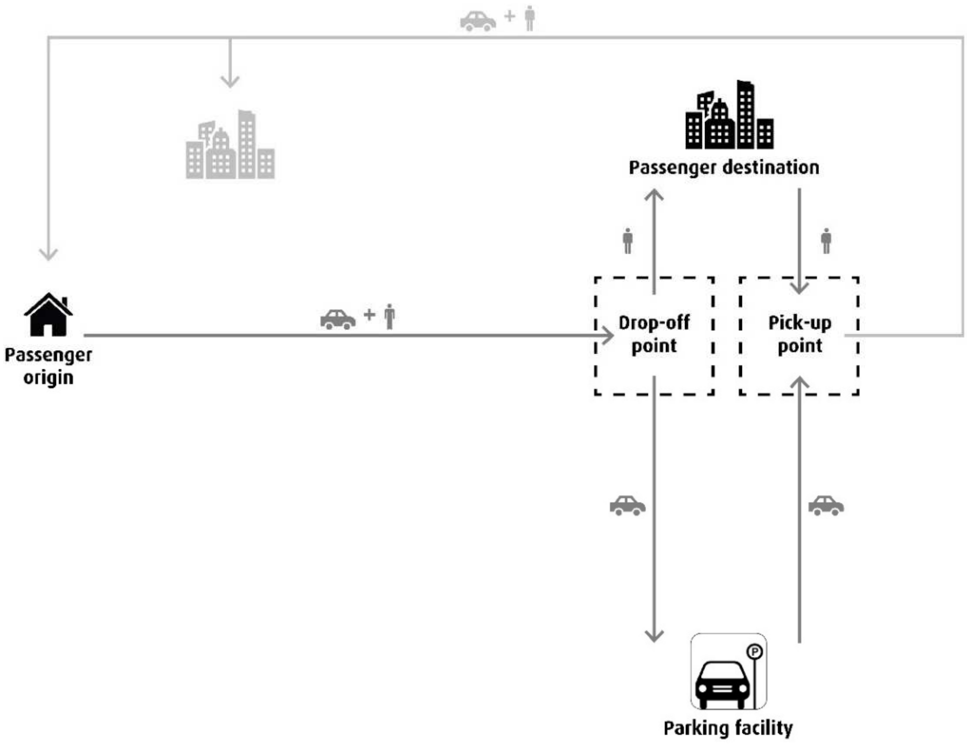

Figure i.1 Schematic overview of the different steps of a trip with a private highly AV

A literature review and brainstorm sessions with experts were conducted to define factors and constraints that could influence drivers' parking location choice. Factors and constraints for the Stated Preference (SP) experiment were selected by means of a Multi-Criteria Analysis (MCA). The selected factors and constraints can be divided into different categories: context factors, attributes, perceptions and exogenous variables. A SP data collection method was used in this research to examine which factors and constraints, and to which extent, influence a driver's parking location choice. Private highly AVs as described in this study are not operating on the public road network yet, which makes the need for hypothetical choice situations necessary. SP data is based on individuals' reactions to hypothetical situations: it is asked what an individual would choose in a specific situation. In this research the environmental conditions, road network configuration and parking constraints of the city of The Hague are used specifically, however, the generic methodology applied in this study could be applied to any large scale city.

Two pilot surveys were conducted in order to design the final questionnaire. An orthogonal design was used to create the hypothetical choice situations for both pilot surveys, because there is no information on prior parameter values. The aim of both pilot surveys was to test if the respondents understood the questionnaire and the concept of automated driving. Furthermore, the results of both pilot surveys were used to find prior parameter values. A final survey was made, based on the results of both pilot surveys. The final survey consists of introduction questions, hypothetical choice situations (part 1), statements on automated driving (part 2) and general questions on personal characteristics (part 3). In the introduction questions, respondents' fill in the trip characteristics (trip purpose, trip duration and trip reimbursement) of their most recent trip to the inner city of The Hague. The trip characteristics are the context factors that apply for the hypothetical choice situations which were asked in the first part of the survey. Preferences regarding the attributes were collected via the different hypothetical choice situations. Attributes included in the design are: 'parking cost', 'surveillance of the parking facility', 'risk of extra waiting time' and 'risk of parking fee'. The two latter attributes are new concepts for individuals, describing respectively the result of the vehicle arriving too early at the pick-up point and the vehicle arriving too late at the pick-up point. An efficient design was used to create the hypothetical choice situations, because the pilot survey provided information on the prior parameter values. In the second part of the survey, statements were presented in order to receive information on respondents' perceptions on automated driving. Information about respondents' exogenous factors was collected via general questions in the third part of the survey.

In total, 421 respondents filled in the online questionnaire. 388 responses were valid and used for the data analysis. Results of the descriptive analysis showed that 16.2% of the respondents have a fixed preference for PIC, compared to 11.6% of the respondents that have a fixed preference for PEC. Trip characteristics explain the fixed preference for either PIC or PEC. Results of the Multinomial logit (MNL) model estimation on the hypothetical choice situations show that all attributes are significant, which means that these attributes are of influence on drivers' parking location choice. From the results of the hypothetical choice situations, it can be concluded that in general PIC is preferred over PEC. The 'parking cost', the 'risk of extra waiting time' and the 'risk of parking fee' have a negative influence on drivers' parking location choice. 'Personnel surveillance' has a positive influence on drivers' parking location choice. The parameter for 'camera surveillance' is not significant, which means that individuals are not sensitive for the presence of cameras in a parking facility. Personal characteristics (exogenous factors), trip characteristics (context factors) and perceptions resulting from the MCA were included in the MNL model as interaction effects to test if these characteristics affect the attributes that influence drivers' parking location choice. Results of the MNL model estimation on the interaction effects showed that only a few interaction effects are significant. Despite their significance, several of these interaction effects are based on a small sample and others cannot be explained. The following interaction effects are based on a large sample and can be explained:

- Individuals with a high income are more sensitive for 'risk of extra waiting time'. This was expected, since the research pointed out that on average, individuals with a higher income have a higher Value of Time (VoT) and Value of Reliability (VoR).
- Individuals with a relatively high purchase value of the car are less sensitive for 'risk of extra waiting time'. A reason for this might be that individuals with a high purchase value of the car find it more important that the car arrives safely at the passenger's destination. In this case, the individual accepts the 'risk of extra waiting time'.
- Individuals who consider safety during the empty vehicle trip to be important, are less sensitive for the 'risk of extra waiting time' and the 'risk of parking fee'. Apparently, these individuals care more about the safety circumstances during the empty vehicle trip than about extra time and costs.

When a large amount of interaction effects do not play a role, a more generic model can be estimated that works for the same conditions. Therefore, it was chosen to conduct the scenario analysis based on a model without interaction variables. This means that the same model applies for individuals with different characteristics, trip purposes and perceptions.

The results of the scenario analysis are visualised in Figure i.2. From the results of the scenario analysis can be concluded that **individuals are most sensitive for a change in direct costs**, i.e. **the 'parking cost' at the parking facility and the 'parking fee' for temporary parking the highly AV at an on-street parking place near the passenger's destination.** When the parking cost in the inner city is decreased with €1 per hour, parking demand will increase with 11%. Furthermore, it could be expected that when the parking cost in the inner city will be increased with €1 per hour, parking demand will decrease with 8%. When there are no parking costs for parking at the edge of the city, parking demand will remain the same. When the parking cost at the edge of the city will be increased from €4 per day to €8 per day or €12 per day, it is expected that parking demand will drastically decrease with 15% and 45% respectively. When a parking fee of €20 is implemented for temporary parking the highly AV at an on-street parking place near the passenger's destination, parking demand at the edge of the city will decrease with 19%. This has the same effect as increasing the parking cost at the edge of the city from €4 to approximately €8.50 per day. From the results of the scenario analysis can be concluded that **individuals are less sensitive for 'personnel surveillance' and 'risk of extra waiting time'**. The presence of personnel surveillance has a positive influence on drivers' parking location choice. When personnel surveillance will be available at a parking facility, parking demand will increase with 6% in the inner city, compared to 3% at the edge of the city. From the results of the model, it was concluded that camera surveillance is not significant, which means that camera surveillance is valued the same as no surveillance. This means that when the parking facility is supervised by means of cameras, it is expected that this will not lead to an increase or decrease in parking demand. The risk of extra waiting time (for 10 minutes) during the off-peak period is 1 out of 10 times. When no separated lanes for highly AVs exist, the risk of extra waiting time during the peak period is likely to be higher. When the risk of extra waiting time is increased to 3 out of 10 times or 5 out of 10 times during the peak period, and no separated lanes for highly AVs are available, the parking demand at the edge of the city will decrease to 5% and 9% respectively.

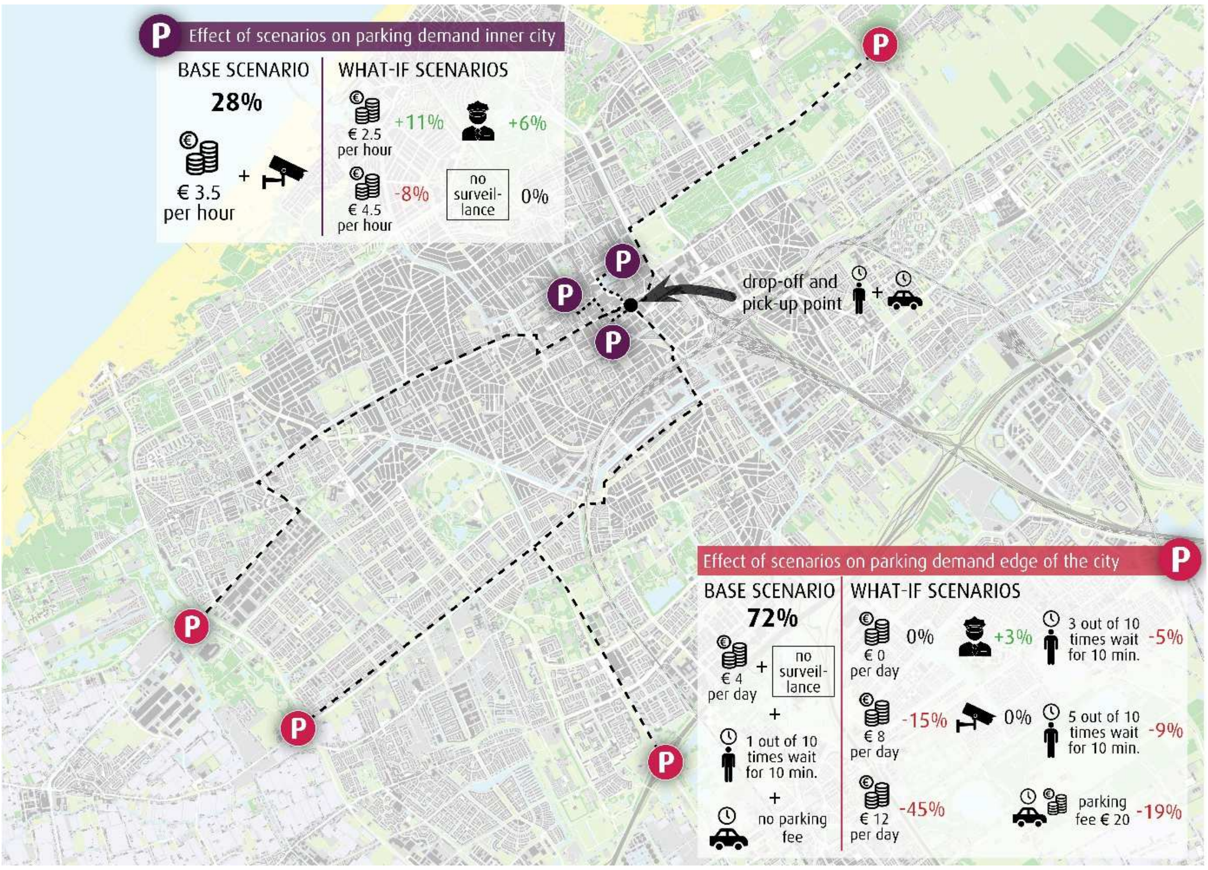

Figure i.2 The influence of the what-if scenarios on the distribution of parking demand

Directions for parking policies are related to different topics regarding parking regime, parking price and parking capacity. The directions for parking policies are visualised in Figure i.3. First, in order to reduce the number of on-street parking spaces, it is advised to forbid the parking of highly AVs at on-street parking spaces. Consequently, released space could be used for drop-off and pick-up manoeuvres. It is not expected that all on-street parking space is needed for drop-off and pick-up manoeuvres. Similar to the current situation, it might be considered that inhabitants of the city of The Hague are allowed to park their highly AV on-street with a parking permit. Furthermore, released on-street parking space could be used for greenery or extra space for bicyclists and pedestrians. Second, in order to minimize the number of empty vehicle kilometres, it is advised to stimulate short term parking of highly AVs in the inner city and stimulate long term parking of highly AVs at the edge of the city. This could be done by increasing the parking cost of parking at the edge of the city from €4 to €10 per day. Consequently, approximately 55% of the individuals would park their highly AV in the inner city, compared to 28% that parked their highly AV in the inner city in the base scenario. Third, it is advised to implement a dynamic pricing strategy for the parking fee that is asked for temporary parking the highly AV at an on-street parking place near the passenger's destination, when the highly AV arrives too early. When implementing a dynamic pricing strategy, the municipality is able to 1) control supply and demand, 2) account for competitor pricing and 3) account for external factors (e.g. peak periods). When a parking fee of €20 is implemented, approximately 47% of the individuals would park their highly AV in the inner city, compared to 28% that parked their highly AV in the inner city in the base scenario. Fourth, when more parking capacity is needed, it is advised to invest in flexible parking facilities at the edge of the city near distributor roads. When the parking facility is supervised by personnel, parking demand will only increase with 3%. To increase the attractiveness of parking highly AVs at the edge of the city, it is advised to reserve space for additional services (e.g. pick-up point for groceries and day-care). Further research is needed to examine which services positively influence drivers' parking location choice. Recent studies show that automated vehicles could induce an increase of travel demand due to changes in destination choice, mode choice and mobility (Milakis, Arem, & Wee, 2017). Hence, more parking capacity might be required. Furthermore, the level of sharing and the penetration rate of AVs should be taken into account when making policy decisions, because these developments might have an influence on the number of parking spaces required.

This research succeeded in capturing the change of drivers' parking location choice in the case when private highly AVs will become available for passenger transport. As a result of choices made by respondents in the hypothetical choice situations, insight was gained in individuals' preferences and trade-offs. The presented results and guidelines can be used in future research on the effects of highly AVs on parking location choice where, at the same time, it can be used by governments to develop their parking policy for this future situation.

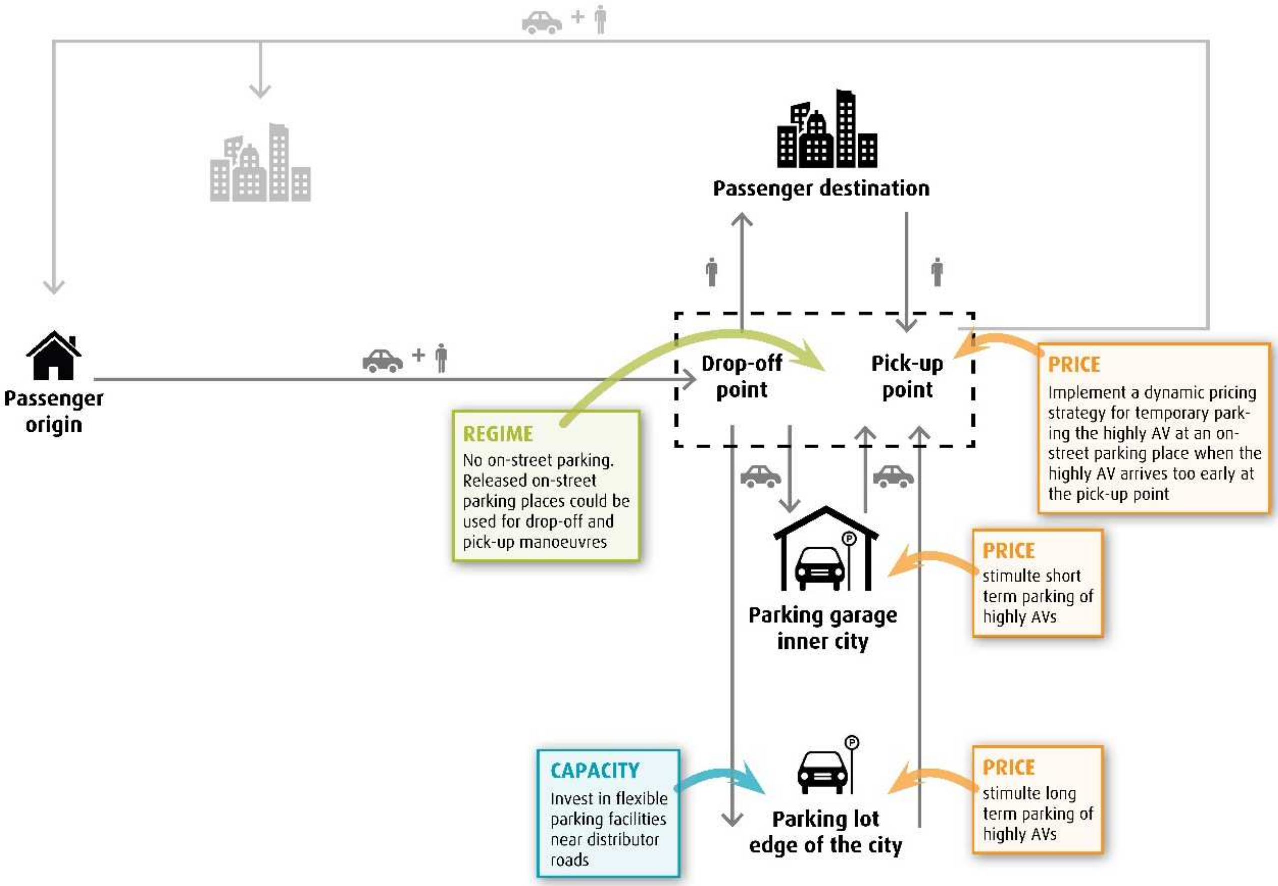

Figure i.3 Visualisation of the directions for promising parking policies

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LIST OF ABBRIVIATIONS

ASC	Alternative Specific Constant
ADS	Automated Driving System
AV	Automated vehicle
CV	Conventional vehicle
DCM	Discrete Choice Modelling
DDT	Dynamic Driving Task
MCA	Multi-Criteria Analysis
MNL	Multinomial Logit
ODD	Operational Design Domain
OEDR	Object and Event Detection and Response
PEC	Parking at the Edge of the City
PIC	Parking in the Inner City
pwu	part-worth utility
SAV	Shared AV
SAVs	Shared AVs
STAD	Spatial and Transport impacts of Automated Driving
SP	Stated Preference
RP	Revealed Preference
VoT	Value of Time
VoR	Value of Reliability

1
INTRODUCTION

Automated vehicles (AVs) have been receiving increased attention all over the world, since the first fully AVs are already operating on the public road network. AVs could not only have a tremendous impact on the urban environment but also on human travel behaviour. Implications of automated driving can be expected in many different fields: travel cost, road capacity, travel choices, vehicle ownership and sharing, location choices and land use, transport infrastructure, energy consumption and air pollution, safety, social equity, economy and public health (Milakis, Arem, & Wee, 2017).

This thesis describes the effects of AVs on drivers' parking location choice. With the capability of AVs to ride and park themselves instead of being operated by a human driver, it is likely that parking choice behaviour will change when conventional vehicles (CVs) are replaced by AVs. Parking spaces within walking distance from the passenger's destination might no longer be needed, as cars have the ability to park themselves in more remote areas where land is less valuable and parking is cheaper. Unnecessary parking spaces in the city centre could be removed due to the relocation of cars. As a result, released space can be redeveloped for more valuable uses such as commercial and leisure activities or extra space for cycle and pedestrian enhancements (WSP | Parsons Brinckerhoff, Farrells, 2016).

Several studies have examined the effects of shared automated vehicles (SAVs) on urban parking in different scenarios. International Transport Forum (2015) built an agent-based model to test the implementation of a shared automated fleet size in a mid-sized European city (Lisbon, Portugal) in different scenarios. They concluded that there is an excessively large potential to reduce both on-street and off-street parking. On-street parking could be eliminated completely and approximately 80% of the off-street parking can be removed. However, in the scenario of shared and fully AVs in combination with private CVs and the absence of bus services, even more parking spaces are needed to meet the parking demand (International Transport Forum, 2015).

Fagnant & Kockelman (2013) also introduced agent-based model scenarios to test the travel and environmental implications of SAVs. They concluded that each SAV has the ability to replace nearly 12 privately owned vehicles. Consequently, almost 11 parking spaces can be eliminated for each SAV (Fagnant & Kockelman, 2013).

Zhang et al. (2015) concluded that the total daily parking demand is positively correlated with a SAV fleet size. Overall results show that approximately 90% of parking demand for the participating clients can be reduced once the SAV system is implemented. After adding the ridesharing scenario, 91% of the parking demand can be reduced. When also adding 5-min empty vehicle cruising, 92 or 93% of the parking demand can be reduced (Zhang, Guhathakurta, Fang, & Zhang, 2015).

From the results of these studies it is clear that in almost all scenarios parking demand in the city will drastically reduce with the implementation of a SAV fleet size. However, it has been demonstrated that sharing a vehicle with strangers is an attitudinal problem that is hard to overcome (Correia, de Abreu e Silva, & Viegas, 2013). The study of Correia et al. (2013) concluded that it is difficult to change from an acquaintance-based carpooling (household or employer) to a system where strangers share their rides. Therefore, it is interesting to focus on the effects of private AVs scenarios. Little research has been conducted on the effects of private AVs on urban parking. The study of Correia & van Arem (2016) is the first study that focused on modelling trips with privately owned AVs to a road network in which they also implemented different prices for parking in their model framework. They concluded that free parking at the edge of the city is not as attractive as parking in the inner city because of the extra kilometres that need to be driven. However, if the value of travel time is lower, AVs could replace CVs while 1) maintaining the same level of trip satisfaction and 2) the advantage of completely freeing the city centre of parked cars (Correia & Arem, 2016).

1.1 PROBLEM IDENTIFICATION

From a scientific point of view, it can be concluded that (the distribution of) parking demand will change with the implementation of AVs, in both the shared and the private AV scenarios. The capability of AVs to park themselves instead of being parked by the driver, will result in a change of parking choice behaviour compared to the use of CVs. The driver is able to put restrictions on the car to park itself at a vacant parking spot either close to his/her destination or further away based on different factors that influence the driver's parking location choice. The **problem** arises that it is unknown which factors influence to what extent drivers' parking location choice. Insight in these factors is needed in order to guide parking policies for a future situation in which private AVs will become available for passenger transport.

From a societal point of view, it can be seen that new vehicles are more and more equipped with automated features. Vehicles with (limited) automated features, e.g. adaptive cruise control, lane assistance and self-parking capabilities, are available in the stores and operate on the road network. AVs which are able to drive without a human driver, e.g. the WEpod, are now developed and tested on several public roads (TNO, Royal HaskoningDHV, 2016). Hence, possibilities for remote parking in the urban area arise. In order to make investment decisions, it is important for governments to gain insight in the impacts of AVs (Puylaert, Snelder, Nes, & Arem, 2016).

This research fills the gap in literature as it captures the change of drivers' parking location choice in the case for a future situation in which private AVs will become available for passenger transport. The results of this study will be used to provide guidelines for governments on how to develop their parking policy for this future situation.

1.2 SCOPE OF THE RESEARCH

This research is focused on the user's perspective and only implies trips that are made by private car users. A possible increase in traffic due to the use of AVs is not considered in this research (i.e. a modal shift from public transport to private AVs and an increase in trips with private AVs).

1.2.1 Level of driving automation 4: High Driving Automation

SAE International (2016) defines 6 levels of driving automation, ranging from level 0 to level 5. The levels and definitions of driving automation are listed in Appendix A. In the ladder of automation, level 0 is the conventional car with no assistive features available. Levels 1, 2 and 3 need humans for emergency backup, where level 4 and 5 operate without human assistance. This research is focused on level of driving automation 4, **High Driving Automation**:

''The sustained and Operational Design Domain (ODD)-specific performance by an Automated Driving System (ADS) of the entire Dynamic Driving Task (DDT) and Dynamic Driving Task fallback, without any expectation that a user will respond to a request to intervene'' (SAE International, 2016)

The automated capability of level 4 is fixed to certain geographic and environmental conditions (the ODD) which distinct this level from level 5, where the car is able to drive in all conditions. Achieving level 5 will be very difficult and requires breakthroughs in software engineering and signal processing (Shladover, 2016). The large-scale operation of level of automation 4 vehicles is more likely to become a reality in the future. In this research, facilities in the network area are needed to make sure that automated driving is done well in a technically correct way to facilitate level 4 vehicles. The infrastructural requirements for the operation of SAE level 4 vehicles is discussed in section 4.2.

1.2.2 Privately used AVs

AVs can either be privately used or shared with others. Sharing a vehicle can be done in sharing time and space resources where travellers travel in the same vehicle simultaneously (ride sharing system) or in sharing only time resources where travellers travel in the same car sequentially (car sharing system) (International Transport Forum, 2015). A research of TNS NIPO (2014) among the Dutch population showed that approximately 1% of the Dutch population participate in one or more forms of car sharing. This corresponds to approximately 0.02% of the total number of car trips in the Netherlands (KiM, 2015). Sharing a vehicle simultaneously or sequentially with strangers might be a disutility for people when they are used to have their own vehicle. Even when a shared fleet of AVs operates on the road network, there are always individuals who would like to have their own AV (WSP | Parsons Brinckerhoff, Farrells, 2016). Goodwin (2008) defines *habit* as ''a resistance to changing a currently adopted pattern of behaviour: that resistance is unlikely to be infinitely strong – it will give way to some countervailing pressure, but only if that pressure is strong enough to overcome some hurdle or threshold'' (Goodwin, 2008). This research is therefore focussed on **privately used AVs**. After the private highly AV has dropped-off the passenger(s), the AV needs to find a vacant parking spot. Only parking at public parking facilities is taken into account, parking at private parking facilities is not included in this research.

1.3 RESEARCH OBJECTIVE AND QUESTIONS

The **objective** of this research is to find the importance of different factors that could influence drivers' parking location choice. The results are used to give advice on promising parking policies in the case when private highly AVs will become available for passenger transport. In this study, theoretical expectations are examined with an empirical framework to get conclusions on the medium- and long term impacts of highly AVs on drivers' parking location choice. In order to contribute to the research objective, several research questions will be answered.

The **main research question** of this thesis is formulated as follows:

'' What is the effect of private highly automated vehicles on drivers' parking location choice, based on parking constraints? ''

To answer the main research question, several **sub research questions** need to be answered which are formulated as follows:

1. Which factors and constraints could influence drivers' parking location choice in the case of private highly automated vehicles?
2. To what extent do different personal characteristics, trip characteristics and perceptions on highly automated driving have an effect on factors and constraints that influence drivers' parking location choice?
3. What are promising parking policies in the case when private highly automated vehicles will become available for passenger transport?

1.4 CONTRIBUTION TO SCIENCE AND SOCIETY

Scientifically, more insight is obtained in drivers' parking location choice in the case of private highly AV use. To the best of the author's knowledge, no empirical research on the influence of private highly AVs on drivers' parking location choice has been examined. Therefore, the methodology to use Discrete Choice Modelling (DCM) to investigate the effects of private highly AVs on drivers' parking location choice contributes to science.

Socially, the results of this study can be used by policy makers when developing parking policies for the situation when private highly AVs will become available for passenger transport. ''An understanding of people's behaviour when making transportation choices is important when planning changes in public policy'' (Lambre, 1996).

Furthermore, this study contributes to the **STAD-project**: Spatial and Transport impacts of Automated Driving. This project studies implications of automated driving in a broader spatial and temporal scope than research that has already been conducted. The project is conducted by different research groups (Delft University of Technology (consortium leader), Free University of Amsterdam, Erasmus University Rotterdam, Eindhoven University of Technology and Rotterdam University of Applied Sciences) in close cooperation with different knowledge institutes, provinces, municipalities, consultancies and public transport operators (TU Delft, 2016). Goudappel Coffeng is one of the participating parties in de STAD-project. All participants in the STAD-project are able to use the results from this study.

1.5 RESEARCH METHODOLOGY

The research methodology which is used in this study is described below and visualised in Figure 1.1.

- Problem identification: The problem and objective were identified in the first phase of this study. In addition, the different research questions that will be answered in this study were formulated.

- Literature review: The literature review consists of three parts. First, a literature review was conducted in order to define factors that could influence drivers' parking location choice for CVs. It was examined which factors could also apply for the parking location choice in the case of AVs. Second, a literature review was conducted in order to identify perceptions on automated driving which could be of influence for when making the choice for a parking location. Third, a literature review on DCM in general was conducted. The information which was gained from the literature review was used as input for the conceptual framework.

- Conceptual framework: The conceptual framework describes the different stages of a trip with a private highly AV and factors that could be of influence for the parking location choice related to each stage of the trip. The list with factors that could influence drivers' parking location choice in the case of AVs resulting from the literature study was extended by the factors resulting from *expert consulting*. In expert consulting, different experts were asked to define factors that could influence drivers' parking location choice in the case of AVs. In order to limit the number of factors, a selection process is done by means of a *Multi-Criteria Analysis* (MCA). In the MCA, different factors that could influence drivers' parking location choice were selected based on different selection criteria.

- Case study - The Hague: The city of The Hague was used as a case study in order to quantify the selected factors that could influence drivers' parking location choice and to create *what-if scenarios*. These factors were used to create the Stated Preference (SP) survey. The generic methodology which is applied in this study could be applied to any other large scale city, but the environmental conditions, road network configuration and parking constraints of the city of The Hague are used in this research.

- Stated Preference survey design: A SP survey design was used to examine which parking location –among alternatives- drivers would choose based on factors that influence their decision for the parking location. First, two SP *pilot surveys* were conducted to test if respondents understood the questionnaire and to find prior values for the attributes in the hypothetical choice situations. The prior parameter values were used to make the SP *final survey* design. The self-completion online survey was sent to a panel in order to collect data for the data analysis and model estimation.

- Data analysis and model estimation: Descriptive data analysis and inferential data analysis were done with the collected data from the SP survey. Descriptive statistics are used to describe the sample and observations. Inferential statistics are used to draw conclusions on the collected data. A Multinomial Logit Model (MNL model) was estimated to gain insight in which factors influence to what extent drivers' parking location choice. In addition, interaction effects were incorporated in the MNL model to examine if and to what extent personal characteristics, trip characteristics and perceptions on automated driving have an influence on drivers' parking location choice.

- Conclusions, discussion and recommendations: The aim of the conclusion is to provide an answer on the main research question formulated in this study. The discussion reflects on the model estimation. In addition, recommendations for science and society are presented.

1.6 THESIS OUTLINE

In Chapter 1, the problem and objective were identified and research questions were formulated. Chapter 2 focusses on the literature review in three parts: factors that could influence drivers' parking location choice in the case of CVs, perceptions on automated driving and discrete choice models in general. The conceptual framework is shown and explained in Chapter 3. Chapter 4 describes the case study which is used in this research. Chapter 5 shows the design of the stated preference survey. The data analysis and estimated models are described in Chapter 6. Finally, Chapter 7 presents the conclusions, discussion and recommendations.

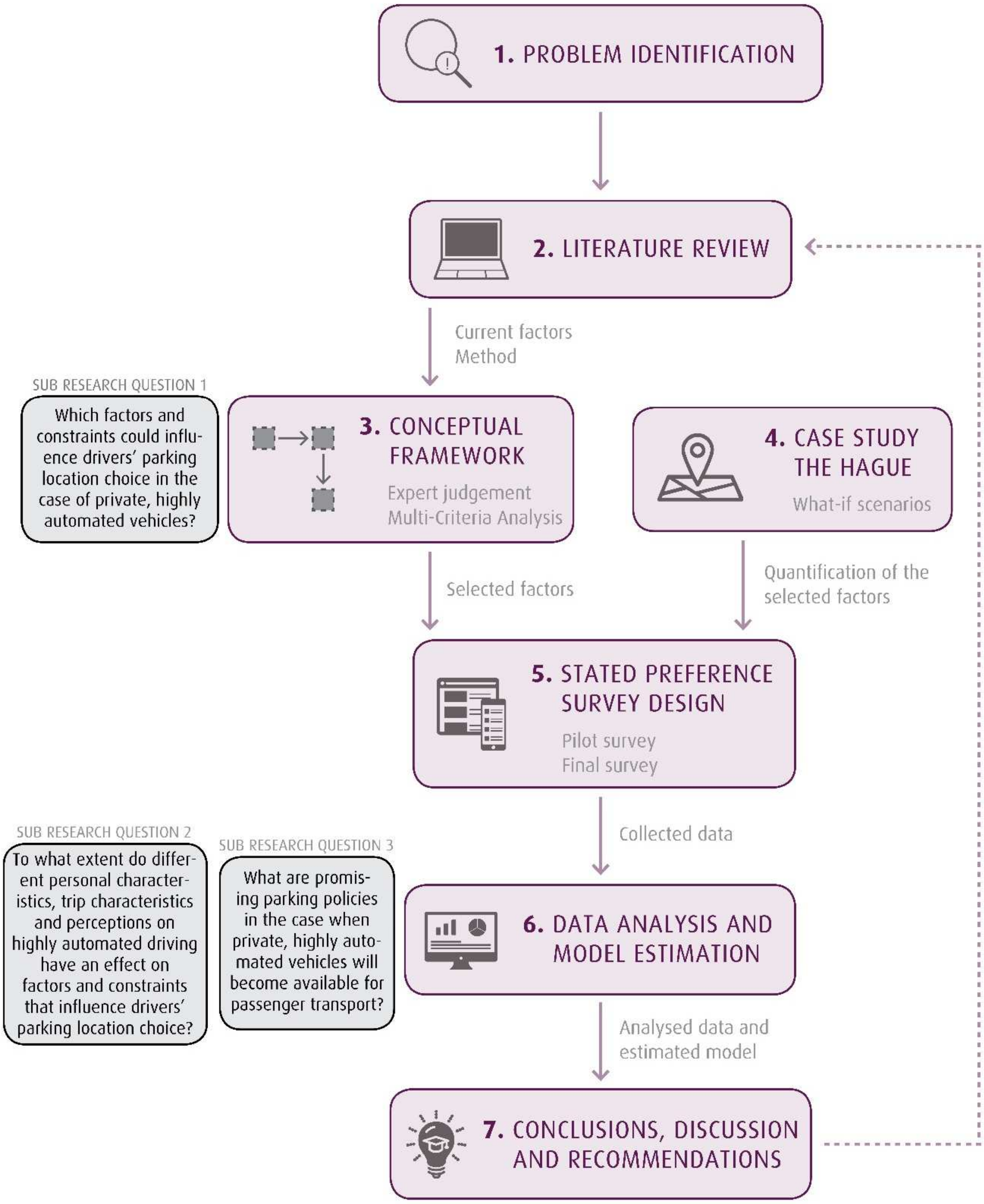

Figure 1.1 Visualisation of the research methodology (source icons: the noun project)

2
STATE OF THE ART

This chapter describes the state of the art in 1) parking choice behaviour, 2) perceptions on automated driving and 3) discrete choice modelling. The output of this chapter will be used as input for the conceptual framework that is described in Chapter 3. Section 2.1 describes parking of CVs and AVs in general, followed by factors that could influence the choice for a parking location and type of parking in section 2.2. Section 2.3 gives insight in perceptions on automated driving which might influence drivers' parking location choice. General information on stated preference data and the concept of discrete choice modelling is given in section 2.4. The chapter ends with a conclusion in section 2.5.

2.1 PARKING OF CONVENTIONAL VEHICLES AND AUTOMATED VEHICLES

In literature on CVs, parking choice behaviour -by means of discrete choice modelling- is analysed at two levels of scale: macroscopic level and microscopic level. Macroscopic level implies the choice for parking location and the type of parking (on-street or off-street). On-street parking means that the vehicle is parked on the street, on or along the curb. Off-street parking implies parking in or at a parking facility. Microscopic level implies the decision of which parking spot within the parking facility is chosen. This research is focused on the macroscopic level.

Appendix B gives an overview of the models, alternatives and attributes that are used in the several studies on macroscopic (Axhausen & Polak, 1991); (Hunt & Teply, 1993); (Lambre, 1996); (Thompson & Richardson, 1998); (Bonsall & Palmer, 2004); (Ruisong, Meiping, & Xiaoguang, 2009); (Chaniotakis, 2014); (van der Groot, 1982) and microscopic (van der Waerden, Borgers, & Timmermans, 2003) levels of scale. The main question in those models is: *''where do travellers park their car?''*

In literature on AVs, it is found that it is possible to let the AV being parked in more remote areas, with the advantage of low parking costs and without the disutility of travelling from the parking facility to the passenger's destination in the inner city with another mode of transport. In literature on AVs, no empirical framework is found that examines drivers' parking location choice. Studies on AVs that examine parking demand make use of agent-based models. The main question in those models is: *''where will the AV be parked?''*

By combining the reviewed literature studies mentioned above on both CVs and AVs, parking locations and types are determined where AVs are able to park. Figure 2.1 is created where the choice for parking a highly AV is shown by combining the choice framework for parking CVs and opportunities for parking AVs. It should be noted that for parking the vehicle at the edge of the city, only off-street parking is considered. This thesis focusses on highly AVs and it is assumed that these vehicles cannot operate on all roads in the network. This will be further explained in Chapter 4.

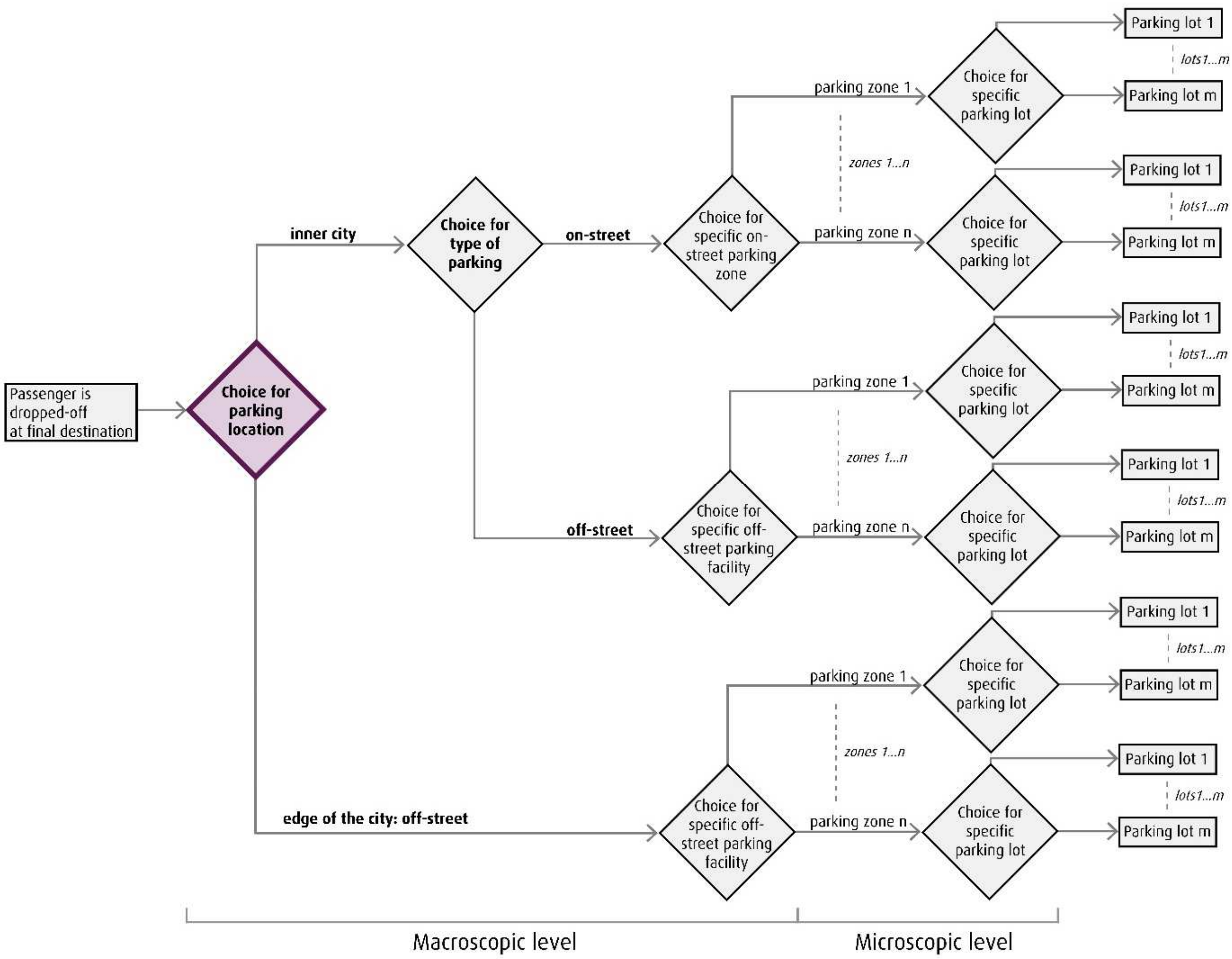

Figure 2.1 Choice framework for parking location and type of parking

2.2 FACTORS INFLUENCING PARKING CHOICE BEHAVIOUR

To be best of the author's knowledge, no study has been conducted in order to determine factors that could influence drivers' parking location choice in the case of private highly AVs. However, there are various studies available in which factors are defined that describe parking choice behaviour in the case of CVs. Parking choice behaviour in this context is defined as the type of parking (on-street or off-street) and the location of the parking facility.

Chaniotakis (2014) reviewed 11 articles in his master thesis on *the application of Smart Parking Applications* and listed factors that could influence parking choice behaviour in the case of CVs for every study. Six of these studies fit within the scope of this research and are reviewed again. The results (study [1] until [6]) are shown in Table 2.1. It should be noted that some factors were eliminated and some factors were added with respect to the results of the reviewed studies by Chaniotakis. Chaniotakis' study is denoted by [7] in Table 2.1 . The study of van der Groot (1982) is a valuable addition to this list and therefore results of this study were added ([8]).

Ruisong, Meiping and Xiaoguang (2009) conclude the following with respect to the categorization of the influencing factors on parking choice behaviour: factors that influence drivers' choice of parking locations involve three aspects, namely: 1) the travellers' characteristics, 2) the parking location characteristics and 3) the trip characteristics. For every study reviewed in this research, it is possible to allocate the influencing factors within one of these categories. In this study, the term 'personal characteristics' is used for 'travellers' characteristics' and 'parking constraints' is used for 'parking location characteristics'. The results of the literature review on factors that could influence parking choice behaviour in the case of CVs are shown in Table 2.1.

Table 2.1 Factors that could influence drivers' parking choice behaviour in the case of CVs

Factors	Study [1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	Sign factor	Significance factor
Personal characteristics										
Age						x			-	No
Gender						x			-	No
Parking constraints										
Cost	x	x	x	x	x	x	x	x	-	Yes
Egress (walking)	x	x	x	x	x	x	x	x	-	Yes
Access (driving)	x	x	x	x	x		x		-	Yes
Search	x	x		x					-	Yes
Typology		x					x		+	Yes
Ill. Fine / expected fine	x			x					-	Yes
PGI usage					x				-/+ *	Yes
Safety						x			+	No
Occupancy								x	+	Depends on purpose group
Probability							x		+	Yes
Capacity		x							+	Yes
Parking surface		x							+	Yes
Accessibility factor								x	+	Depends on purpose group
Parking duration				x					+	Yes
Trip characteristics										
Reimbursement						x			+	No
Parking time restriction								x	+	Depends on purpose group

* 'FULL' sign: - '# spaces' sign: +

Where: [1] (Axhausen & Polak, 1991)*; [2]* (Hunt & Teply, 1993)*; [3]* (Lambre, 1996)*; [4]* (Thompson & Richardson, 1998)*; [5]* (Bonsall & Palmer, 2004)*; [6]* (Ruisong, Meiping, & Xiaoguang, 2009)*; [7]* (Chaniotakis, 2014)*; [8]* (van der Groot, 1982)

The definitions of the different factors that could influence parking choice behaviour are listed below:

- **Cost.** The fee for parking the vehicle.
- **Egress (walking).** The walking time from the parking space to the passenger's destination.
- **Access (driving).** The total travel time from the origin to the beginning of the search time.
- **Search.** The total time for searching and queuing for the parking space.
- **Typology.** On-street parking (parking on the street) or off-street parking (parking in a garage or at a lot).
- **Illegal fine.** Extra fine for the passenger when he /she parks at a spot where he / she is not allowed to park.
- **PGI usage (Parking, Guiding and Information).** Via roadside variable message signs at some distance from the parking facilities, offer drivers real-time information on parking space availability and help them to make more informed choices.
- **Safety.** Off-street parking is valued safer than on-street parking.
- **Occupancy.** ''The group of parking places under consideration as a percentage of the number of places officially available and that within 4 min from the time the visitor arrived at the parking place'' (van der Groot, 1982).
- **Probability.** The chance of finding a vacant parking spot at a specific parking facility.
- **Capacity.** The number of parking lots in/at a specific parking facility.
- **Parking surface.** The type and condition of the parking surface at the specific location (dirt, gravel or pavement; smooth, potholes or rough breaks).
- **Accessibility factor.** The attractiveness and accessibility to a certain visitor.
- **Parking duration.** Maximum permitted parking time at a specific parking destination.
- **Reimbursement.** Declaration of the parking costs
- **Parking time restriction.** Difference between the intended parking time before the actual choice of a parking space is made, and the maximum permitted parking time.

From the literature review on factors that could influence parking choice behaviour in the case of CVs can be concluded that most important attributes are categorized as parking constraints. The importance of parking cost, egress time (walking) and access time (driving) is confirmed. However, egress time (walking) and access time (driving) no longer exist when highly AVs are considered that are able to park themselves. Therefore, these factors are not included in the conceptual framework. In general, an attribute that is significant in a particular study, is significant under the circumstances provided by the levels in that study. A non-significant attribute in one study does not mean that it is non-significant in another study (Kløjgaard, Bech, & Søgaard, 2012). Therefore, all factors from the literature review that apply for CVs and which could also be applied for private highly AVs will be considered for this research. These factors are: *age, gender, cost, typology, safety, occupancy, probability, capacity, parking surface, parking duration, reimbursement* and *parking time restriction*.

2.3 PERCEPTIONS ON AUTOMATED DRIVING REGARDING EMPTY VEHICLE DRIVING TRIP

Perceptions on automated driving might influence drivers' parking location choice. The question arises which and if different perceptions on automated driving might influence the choice for parking a highly AV in the inner city or at the edge of the city. The main difference between these two alternatives regarding perceptions on automated driving is the length of the empty vehicle driving trip from the passenger's destination in the inner city to the parking facility in the inner city compared to the parking facility at the edge of the city. The aim of this section is therefore to examine which perceptions on automated driving regarding the empty vehicle driving trip might influence drivers' parking location choice.

Different studies have examined the public opinion about automated driving on varying topics related to e.g. safety, legal issues, software hacking, joy of riding, and privacy (Yap, Correia, & Arem, 2016) (König & Neumayr, 2016) (Kyriakidis, Happee, & Winter, 2015) (Bazilinksyy, Kyriakidis, & Winter, 2015). The main difference of the perceptions described in the reviewed studies and this study is the presence of the driver in the AV. The reviewed studies assume that the driver is present in the vehicle where in this study the focus is on the empty vehicle driving trip. Eventually, drivers will decide where to park their high AV and therefore it is important to examine drivers' perceptions on automated driving during the empty vehicle driving trip.

The following statements result from the reviewed studies and can be related to different perceptions on the empty vehicle driving trip:

- I am afraid that the AV will malfunction[a]
- I trust that a computer can drive the cybercar with no assistance from me[a]
- I believe a computer-operated car would drive better than the average human driver on populated streets[a]
- I am afraid that the AV will not be fully aware of what is happening around him[a]
- An AV could cause legal liability issues for the driver / owner when a crash is caused by AV[b]
- An AV could be confused in unexpected / unprecedented situations[b]
- An AV could cause safety consequences triggered by technical error[b]
- An AV could be dangerous while there are also human-operated cars on the streets[b]
- An AV may not drive as well as human drivers do[b]

In these statements, [a] is adapted from (Yap, Correia, & Arem, 2016) and [b] is adapted from (König & Neumayr, 2016).

All statements can be related to the **trust in the system** during the empty vehicle driving trip. When the trust in the system is low, people are more afraid of risk of damage during the empty vehicle driving trip. König & Neumayr (2016) concluded in their study: ''the most apparent result is the prevalent lack of trust across all sub-groups in the functioning of the technology'' (König & Neumayr, 2016). When passengers think that there is a chance of damage during the empty vehicle driving trip, passengers might not opt for the option to park the vehicle at the edge of the city. The formulated statements in this section were combined where possible and reformulated for the empty vehicle driving trip in order to test them in the SP survey.

2.4 STATED PREFERENCE DATA

SP data was used to estimate discrete choice models in this research. The motivation to use SP data is described first (paragraph 2.4.1). Next, it is explained how discrete choice theory is used to describe the parking location choice (paragraph 2.4.2).

2.4.1 Stated preference data versus revealed preference data

Two types of data collection paradigms can be used to estimate choice models: Revealed Preference (RP) data and Stated Preference (SP) data. **Revealed Preference data** is based on individual's behaviour that is revealed: it is observed or asked what an individual did in a specific situation. **Stated Preference data** is based on the individual's reaction to hypothetical situations: it is asked what an individual would choose in a specific situation (Sanko, 2010).

As was described in the methodology, the SP data collection method was used in this research. Private highly AVs as described in this study are not available in the market, which makes the need for hypothetical choice situations necessary. However, with currently existing concepts that resemble the concept of automated driving, situations can be created where opportunities arise for RP data collection. Valet parking is one of these examples where an external driver takes over the private vehicle from the passenger after he/she has reached his/her destination and parks the car somewhere else, most of the time in a more remote area (Centralparking, 2016). However, perceptions on automated driving during the empty vehicle driving trip cannot be captured within this construction. In addition, the costs for RP data collection are high and the timeframe of this research is limited. As a result, it is not possible to collect RP data for this study. The main advantage of collecting SP data is that it is economical compared to collecting RP data that requires a lot of time and cost. One serious disadvantage of SP data is the reliability of the data. In SP, the individual reacts to a hypothetical choice situation. Consequently, there is a possibility that the response does not correspond with the individual's actual behaviour (Sanko, 2010).

2.4.2 Discrete choice theory

This study considers the discrete choice for parking a private highly AV either in the inner city (off-street parking garage) or at the edge of the city (off-street parking lot). ''To understand and be able to forecast transportation and its effects, you have to understand and be able to forecast choices'' (Chorus, SPM4612 Choice models - basics and recent advances, 2015). Since 1970, Discrete Choice Models (DCMs) are used worldwide to describe decision-makers' choices among different alternatives. DCMs derive the underlying preferences of individuals by using the observed choices between different alternatives. The weights that individuals attach to different characteristics (factors or attributes) of the alternatives can be estimated with DCMs (Chorus, Random Regret-Based Discrete Choice Modeling: A Tutorial, 2012). Knowledge about the weights of different factors can be used to provide guidelines for governments on how to develop their parking policy for a future situation in which private highly AVs will become available for passenger transport.

Each DCM has an assumed systematic component (V_{ij}) and an assumed random component (ε_{ij}). The random component represents the unobserved part of the behaviour. The systematic component (the decision rule) translates individuals' preferences in combination with the factors of the alternatives into predicted choice patterns. Most of the DCMs are based on utility maximization, i.e. the decision-maker chooses the alternative that has the highest total utility (gain). DCMs that are based on utility maximization are called Random Utility Maximization-models (Chorus, Random Regret-Based Discrete Choice Modeling: A Tutorial, 2012). The utility theory is presented in Equation 2.1 and 2.2.

$$U_{ij} = V_{ij} + \varepsilon_{ij} \tag{2.1}$$

$$V_{ij} = \Sigma\, \beta_k X_{ijk} \tag{2.2}$$

Where:
U_{ij} = total utility (i = individual, j = alternative)
V_{ij} = systematic component of the utility
ε_{ij} = random component of the utility
β_k = model parameter to be estimated (k = attribute)
X_{ijk} = attribute level

2.5 CONCLUSION

This chapter discussed several aspects on the state of art in 1) factors that could influence parking choice behaviour in the case of CVs, 2) perceptions on automated driving regarding the empty vehicle driving trip and 3) SP data.

The two alternatives that result from the literature review on parking choice behaviour are 1) parking in the inner city and 2) parking at the edge of the city, both at off-street parking facilities. No factors that could influence drivers' parking location choice in the case of AVs were found in literature. Therefore, a literature review was conducted to define factors that influence parking choice behaviour in the case of CVs. All factors resulting from the literature review that apply for CVs and which could also be applied for private highly AVs were selected. These factors are: *age, gender, cost, typology, safety, occupancy, probability, capacity, parking surface, parking duration, reimbursement* and *parking time restriction*. This list of factors will be extended with the use of expert consulting. Furthermore, perceptions on automated driving might influence drivers' parking location choice. A SP experiment will be used to test which factors influence to what extent drivers' parking location choice when private highly AVs will become available for passenger transport. Private highly AVs as described in this study are not operating on the public road network yet and therefore RP methods cannot be used. MNL models are used in the reviewed literature on parking choice behaviour and therefore it is justified to use MNL models in this study as well for a first insight in the effects. The next chapter will discuss the results of the brainstorm session in expert consulting and the selected factors that might influence drivers' parking location choice.

3
CONCEPTUAL FRAMEWORK

This chapter describes the conceptual framework for this research and provides an answer to the first sub-research question: *''Which factors and constraints could influence drivers' parking location choice in the case of private highly automated vehicles?''* The output of this chapter will be used as input for the stated choice preference survey which is described in Chapter 5. Section 3.1 describes the trip with a private highly AV. Section 3.2 shows the conceptual framework with factors that could influence drivers' parking location choice. Based on a selection process with predefined criteria, a selection of these factors will be made which is discussed in section 3.3. The chapter ends with a conclusion in section 3.4.

3.1 CONCEPT DESCRIPTION: A TRIP WITH A PRIVATE HIGHLY AUTOMATED VEHICLE

A trip with a private highly AV does not yet exist as described in this context. Therefore, the current concept of Valet parking, that has similarities with the concept of AVs, is first described (paragraph 3.1.1). Lessons from this concept are used to describe the trip with a private highly AV. Second, the different steps of a trip with an AV are described (paragraph 3.1.2). Third, the drop-off and pick-up points are described in more detail (paragraph 3.1.3).

3.1.1 The concept of Valet Parking

The concept of a trip with a private highly AV is closely related to the currently existing concept of Valet parking. The main difference between the concept of an AV and the concept of Valet Parking is that the AV is able to drive itself instead of being operated by humans. The similarity in both concepts is that remote parking is possible, where the parking manoeuvre is not operated by the owner of the vehicle itself. With Valet parking, an external human driver takes over the private vehicle from the passenger after he/she has reached his/her destination and parks the car somewhere else, most of the time in a more remote area (Centralparking, 2016). Valet Parking is amongst others applied in the cases of: restaurants, hospitals, airports, casinos, shopping malls or in crowded urban areas. The advantage of using Valet Parking is that the access time to a parking area, the search time for a parking spot and the egress time from the parking area to the passenger's destination are eliminated from the passenger's travel time. This is also the case when a private highly AV would be used: the access time to a parking facility, the search time for a parking spot and the egress time from the parking facility to the passenger's destination are taken out of the loop.

3.1.2 The different steps of a trip with an AV

In order to define factors that could influence the driver's parking location choice, it is important to notice that the trip with a private highly AV can be divided in different sequential and simultaneous steps. During every step, different factors are related to the driver's parking location choice. Figure 3.1 shows a schematic overview of the different steps, with an explanation provided below.

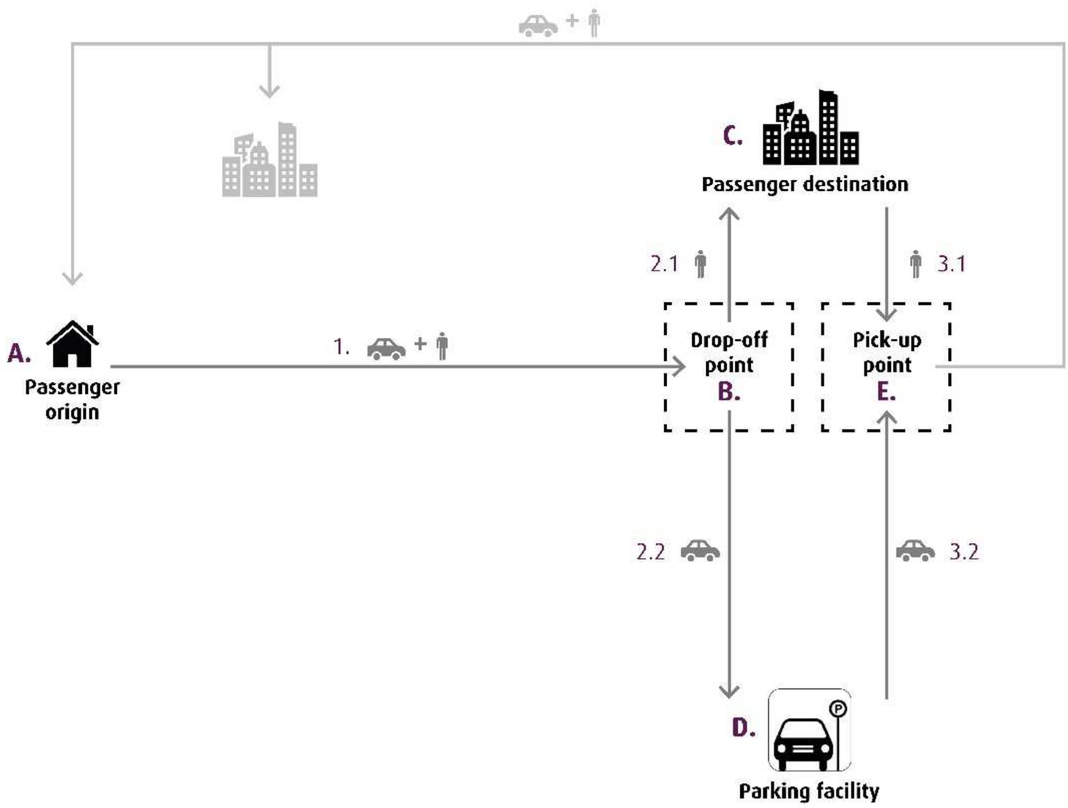

Figure 3.1 Schematic overview of the different steps of a trip with a private highly AV

Where:
1. Car trip from the passenger's origin to the drop-off point
2.1. Walking leg from the drop-off point to the passenger's destination
2.2. Empty car trip from the drop-off point to the parking facility
3.1. Walking leg from the passenger's destination to the pick-up point
3.2. Empty car trip from the parking facility to the pick-up point
4. Car trip from the pick-up point back to the passenger's origin or to another destination

The passenger origin (A) is, in general, the passenger's home from where the trip with the private highly AV starts. The passenger already made the choice for using the highly AV and starts the trip from the origin in the direction of his/her destination (1).

The drop-off point (B) is the closest area near the passenger's destination where space exists to drop-off the passenger. Space to drop-off the passenger is needed to avoid congestion caused by dropping-off passengers on the street itself. It is not always possible to reach the passenger's destination by car, especially in inner cities where car-free areas exist. Dropping-off the passenger can be compared to current *kiss-and-ride* and *taxi* concepts. In these concepts, separate lanes exist for dropping-off passengers. However, in inner cities -where space is already scarce- it is hard to implement these lanes. Reserved on-street parking places might be used for such manoeuvres. This will be further explained in the next paragraph.

When the passenger is dropped-off at the drop-off point, he/she has to walk to his/her destination. The walking leg from the drop-off point to the passenger's destination (2.1) should be as short as possible because this walking leg is perceived as a disutility (Ruisong, Meiping, & Xiaoguang, 2009). Simultaneously to the walking leg, the empty private AV starts to drive from the drop-off point to either an off-street parking facility in the inner city or to an off-street parking facility at the edge of the city (2.2), based on the passenger's parking location choice.

The passenger destination (C) is the destination of the passenger where the passenger's activity starts.

The parking facility (D) is either an off-street parking facility in the inner city or an off-street parking facility at the edge of the city, both with different characteristics.

The pick-up point (E) is the closest area near the passenger's destination where space exists to pick-up the passenger. The passenger needs to walk from his/her destination to the pick-up point (3.1) and the empty vehicle needs to drive from the parking facility to the pick-up point (3.2). When the passenger and the vehicle have both arrived at the pick-up point, the car trip from the pick-up point to the passenger's home or to another destination starts.

Points (B), (C) and (E) could be the same location. Access and egress time in terms of the walking leg are not considered, because these are the same for both alternatives. As was mentioned earlier, this walking leg should be minimized.

3.1.3 Drop-off and pick-up points

As was already mentioned earlier, there is no need to park the vehicle as close as possible to the passenger's destination when cars are able to ride and park themselves. On-street parking can therefore be removed and vehicles can be relocated to off-street parking facilities. Released on-street parking space can be used for other developments.

One of these developments can be dedicated to drop-off and pick-up manoeuvres. Drop-off and pick-up points can be defined as the closest on-street parking spot used in the same manner as the kiss-and-ride concept.

Allocating (part of the) on-street parking spaces to drop-off and pick-up points means that there is always a benefit for passengers compared to the current system when walking times are minimized. Assuming that a passenger is able to reach a destination as close as possible, different scattered and dedicated parking spots are needed. A policy implication is needed that forbids to park a highly AV on-street. In addition, active management is necessary to reserve these on-street parking spaces for drop-off and pick-up manoeuvres.

3.2 FACTORS THAT INFLUENCE DRIVERS' PARKING LOCATION CHOICE

The aim of this paragraph is to create a list of factors that could influence drivers' parking location choice in the case of private highly AVs. Brainstorm sessions with experts were conducted to define factors that could influence drivers' parking location choice in addition to the factors that were found in the literature study.

A conceptual framework is constructed based on literature review and expert consulting. Factors that could influence drivers' parking location choice were linked to the several stages of the automated driving trip described in section 3.1. The factors that could influence drivers' parking location choice can be divided in different categories:

- Personal characteristics
- External conditions
- Route characteristics
- Passenger destination characteristics (trip characteristics)
- Parking facility characteristics
- Pick-up point related characteristics

All factors that could influence drivers' parking location choice when drivers make use of a private highly AV are visualized in Figure 3.2. Hypotheses for every factor are described in Appendix C.

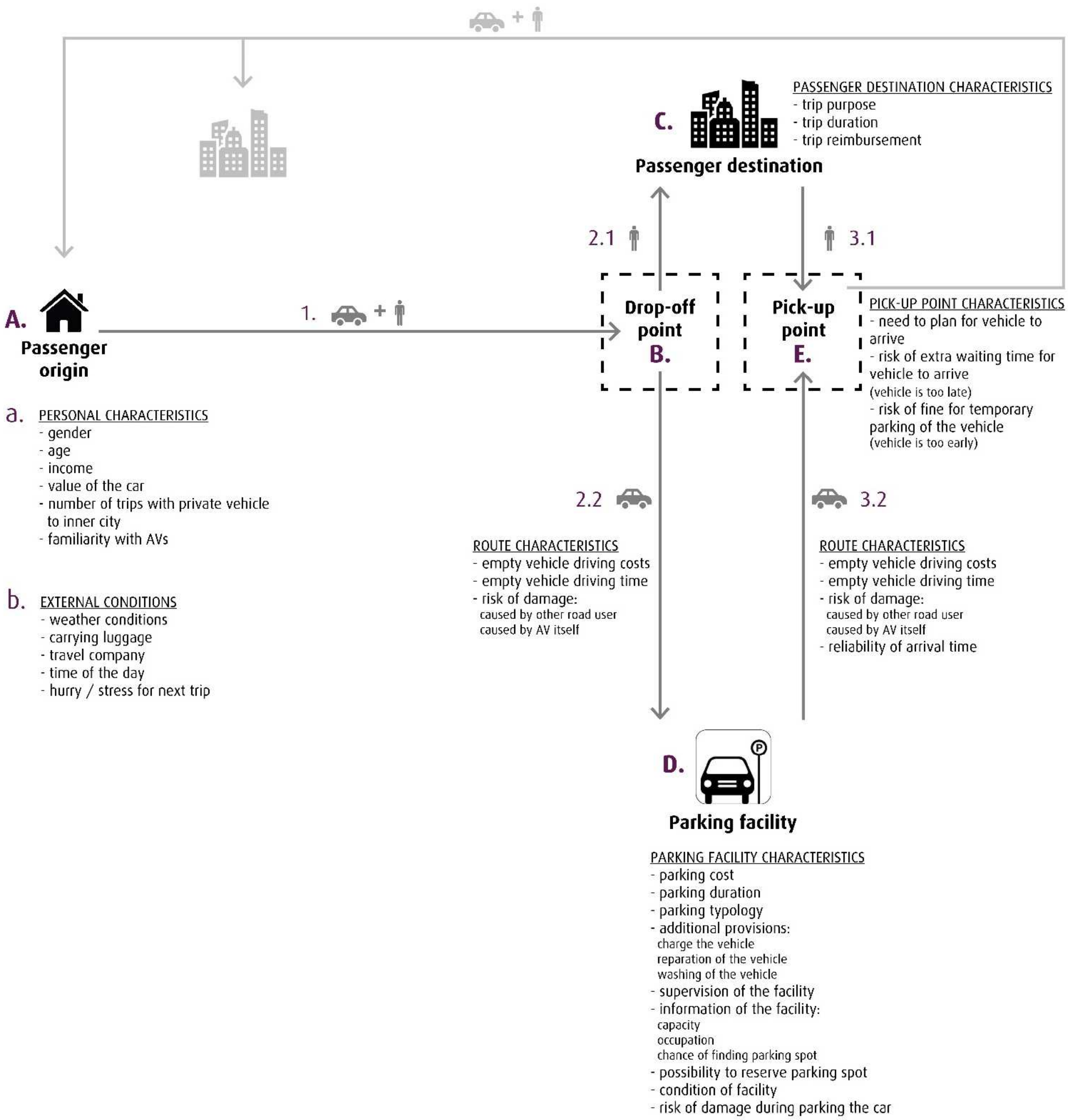

Figure 3.2 Factors that could influence drivers' parking location choice

3.3 SELECTION OF FACTORS THAT INFLUENCE DRIVERS' PARKING LOCATION CHOICE

This section describes the selected factors that could influence drivers' parking location choice. The selected factors can be divided in different categories: exogenous variables (paragraph 3.3.1), attributes (paragraph 3.3.2), context factors (paragraph 3.3.3) and perceptions (paragraph 3.3.4).

Bourguignon (2015) used different criteria to describe the influence of the choice for the type of passport control at Schiphol airport (Bourguignon, 2015). The following criteria were adapted from this study in order to determine which factors that could influence drivers' parking location choice need to be selected for the SP experiment:

1. Expected influence of the factor
   For every factor, the expected influence on the driver's parking location choice was determined based on literature review and expert consulting. Factors of which it is expected that the influence on parking location choice is high, are more important than factors of which it is expected that there is only a minor influence on parking location choice.

2. Measurability of the factor
   For every factor, it was determined whether this factor is measurable with a stated choice preference survey. Factors that are not measurable with SP were eliminated.

3. Manageability of the factor
   The manageability of the factor is relevant for policy or design. In order to give directions to new parking policies, it is important to know if the factor is manageable by the municipality.

The values of the selection criteria and the selection of the factors by use of a MCA are presented in Appendix C. Factors can be incorporated in the SP as exogenous variables, attributes, context factors or perceptions.

3.3.1 Exogenous variables (personal characteristics)

An exogenous variable is an external, independent variable which affects the model, but is not affected by the model (The Law Dictionary, n.d.). It can be expected that socio-demographic characteristics influence preferences and therefore it can be expected that these factors also influence the parking location choice (Bonsall & Palmer, 2004). In this study, personal characteristics (amongst other socio-demographic characteristics) are exogenous variables. For all indicated personal characteristics in Figure 3.2, it was expected that they could influence drivers' parking location choice. Therefore, all personal characteristics were selected as exogenous variables.

The following exogenous variables (personal characteristics) are selected for the SP survey:

- Gender
- Age
- Income
- Value of the car
- Number of trips with private vehicle to inner city
- Familiarity with AVs

3.3.2 Attributes

Attributes are ''the independent or predictor variables'' (Molin, SPM4612: An introduction to stated choice experiments, 2015a). The number of attributes that can be used in a SP experiment is limited. Pearmain et all (1991) advises to use an upper limit of 6 or 7 attributes to avoid confusing the respondents (Pearmain, Swanson, Kroes, & Bradley, 1991). This number might be lower if some attributes are unfamiliar to respondents or if the definition of the attributes is too complex. Molin (2015a) advises to ''include as few attributes as possible and as many attributes as you need to realistically describe the alternatives'' (Molin, SPM4612: An introduction to stated choice experiments, 2015a). The number of attributes in the conceptual framework described in section 3.2 is too large. Therefore, a selection of the attributes is needed which can be used in the SP experiment.

The following seven attributes are selected for the SP survey:

- Empty vehicle driving costs. The driving cost for the empty vehicle driving trip from the passenger's destination to the parking facility and from the parking facility back to the passenger's destination.
- Empty vehicle driving time. The driving time of the empty vehicle driving trip from the passenger's destination to the parking facility and from the parking facility back to the passenger's destination.
- Parking cost. The cost for parking the private highly AV at the specific parking facility.
- Surveillance of the parking facility. The type of control which is offered by the parking facility.
- Need to plan for vehicle to arrive. When the private highly AV is parked in the *inner city*, the passenger has the option to call for his/her vehicle to pick him/her up or has the option to walk to the parking facility to pick-up the vehicle.

- **Risk of extra waiting time.** When the private highly AV is parked at the *edge of the city*, it is possible that the vehicle is not back at the exact predefined point of time the passenger wanted the vehicle to be back. The possibility arises that he/she needs to wait for his/her vehicle to arrive.
- **Risk of fine.** When the private highly AV is parked at the *edge of the city*, it is possible that the vehicle is earlier at the passenger's destination than the passenger. As it is forbidden to temporarily park the vehicle near the passenger's destination, the passenger has to pay a fine for the vehicle arriving too early.

Three of the above mentioned attributes are currently unfamiliar to respondents and rather complex to explain. These are 1) the need to plan for vehicle to arrive, 2) risk of extra waiting time and 3) risk of fine. In the SP pilot survey, it will be tested if respondents understand these attributes. It might be considered to eliminate attributes if the choice sets are too complex for respondents. It should be noted that the empty vehicle driving time and costs are also new concepts for respondents. However, these attributes can be interpreted easily as extra driving costs and time.

In the concept described in this study -where the highly AV is parked further away and the passenger needs to recall for his/her vehicle- there is an uncertainty of the arrival time of the vehicle back to the passenger. In this research, it is assumed that parking the vehicle in the inner city results in a perfect match between the vehicle and the passenger because of the short distance between the passenger's destination and the parking facility. In case of parking the vehicle at the edge of the city, the distance becomes larger. As a result, the match between the vehicle and the passenger might be not perfect. Two scenarios are possible: either the vehicle is too late or the vehicle is too early. In the first, there is a 'risk of extra waiting time' for the passenger at the pick-up point. In the latter, the vehicle needs to wait at the pick-up point. The vehicle remains at the pick-up point until the passenger has arrived at his/her vehicle. In order to discourage parking at the pick-up point, a fine needs to be paid for the vehicle to wait. The 'risk of extra waiting time' and the 'risk of fine' are two attributes that are the result of unreliable travel times from the parking facility to the passenger's destination. It is allowed to measure both attributes in the same choice situation because these are probabilities and do not necessary take place. Reliability is in this case operationalized as risk of waiting time and risk of fine. Furthermore, another scenario is possible, in which the passenger is too late. This cannot be measured with SP because this delay is caused by the passenger.

3.3.3 Context factors

A context is a condition that is applicable for all choice situations (Molin, SPM4612 Lecture 5 - Coding in Ngene & context-dependent experiments, 2015b). Context factors in this study are external conditions and passenger's destination characteristics resulting from the conceptual framework presented in Figure 3.2.

The following context factors are selected for the SP survey:

- Trip purpose
- Trip duration
- Trip reimbursement

Context factors in this study are likely to play a vital role, as respondents might chose for another parking location if another context applies. The three selected context factors are all trip related characteristics. The main trade-off between the two alternatives Parking in the Inner City (PIC) and Parking at the Edge of the City (PEC) is a high parking price and a high reliability of the vehicle to arrive for the PIC alternative in contrast to a low parking price and a lower reliability of arrival time of the vehicle for the PEC alternative. The Value of Reliability (VoR) and Value of Time (VoT) are therefore of great importance when choosing between PIC and PEC. Passengers with a different VoT and VoR might choose a different parking location. The VoT and VoR differ for different trip purposes; the VoT and VoR for recreational purposes and work purposes are approximately the same, however, for business purposes, the VoT and VoR are higher (KiM, 2013). Next to this, it should be noted that the VoT and VoR are also different for every person, independent of the trip purpose.

The ideal situation would be to vary the context factors for each respondent to measure intra-person variation. This means that every choice situation needs to be presented in different contexts. Consequently, every respondent needs to fill in more choice situations. The choice situations in this study are rather complex because of new attribute concepts. Therefore, it is chosen to ask for only one context per person in order to reduce complexity.

Many studies state that the reliability of the results in a SP experiment will increase when choice situations are presented to respondents that are familiar for them (Swierstra, Molin, & Nes, 2016). Therefore, it is chosen to use an existing city as case study and ask respondents who have ever visited this city with their own vehicle for the trip characteristics of their most recent trip to this city. The context factors: trip purpose, parking duration and trip reimbursement of respondents' most recent trip to the inner city with their private vehicle -with the assumption that this vehicle is a self-driving vehicle- will be asked in the beginning of the survey. Respondents needed to fill in the hypothetical choice situations in the SP experiment for this context.

3.3.4 Perceptions on automated driving

Perceptions on automated driving were already discussed in section 2.3. All statements discussed in section 2.3 were related to the drivers' trust in the system during the empty vehicle driving trip. The trust in the system is again related to the risk of damage during the empty vehicle driving trip resulting from the conceptual model.

Based on the selection process and the insights from section 2.3, risk of damage is selected as a perception for the SP survey. The driver's perception on the risk of damage during the empty vehicle driving trip could influence their parking location choice.

The selected factors for the SP experiment that could influence drivers' parking location choice when they make use of a private highly AV are shown in Figure 3.3.

3.4 CONCLUSION

This chapter first discussed the concept of a trip with a private highly AV. Next, a conceptual framework was presented in which different factors that could influence drivers' parking location choice regarding the different stages of the trip were shown. These factors were obtained by a literature study and expert consulting. By means of a MCA, a selection of the factors for the SP experiment was made.

It is important to note that the selected factors that could influence drivers' parking location choice need to be implemented differently in the SP experiment. Information about respondents' exogenous factors will be collected via general questions. Preferences regarding the attributes will be collected via different choice situations. It should be noted that there are new attribute concepts in this study which makes it necessary to conduct a pilot survey in which it is tested if respondents understand the attribute concepts before conducting the final survey. Setting the context factors will be done via questions where the respondents fill in the trip characteristics of their most recent trip to the inner city with their own vehicle. Perceptions regarding automated driving during the empty vehicle driving trip will be tested via statements. The next chapter will discuss the quantification of the attributes for the case study of this research. The results of Chapter 3 and Chapter 4 will be used to design the stated choice preference survey which will be discussed in Chapter 5.

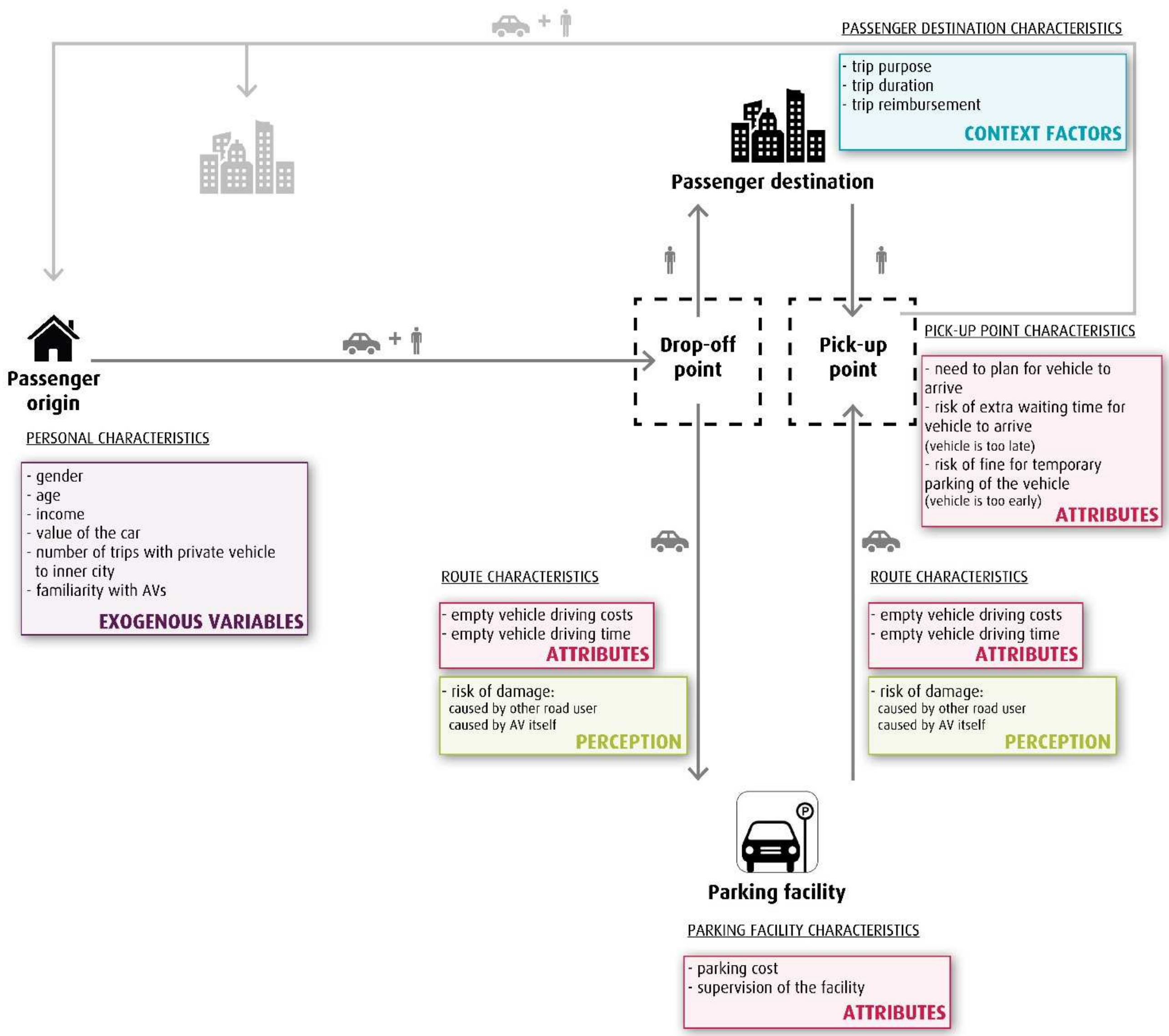

Figure 3.3 Selected factors that could influence drivers' parking location choice for the SP experiment

4

CASE STUDY: THE HAGUE

This chapter describes the case study of this research: the city of The Hague. The empirical framework that is applied in this research could be applied to any other large scale city similar to The Hague. However, the environmental conditions, road network configuration and the parking constraints of the city of The Hague are used for this research. The output of this chapter will be used as input for the stated choice preference survey which is described in Chapter 5. Section 4.1 describes the motivation of this case study followed by the infrastructural requirements in section 4.2. The quantification of the attributes is described in section 4.3. Section 4.4 presents the what-if scenarios. The social costs and benefits once the system would be implemented are presented in section 4.5. The chapter ends with a conclusion in section 4.6.

4.1 THE CITY OF THE HAGUE

The Hague is the capital city of the province of South Holland, located in the Netherlands. With more than 520,000 inhabitants (Gemeente Den Haag, 2016), it is the third largest city of the Netherlands, after Amsterdam and Rotterdam.

The city of The Hague was chosen for this research because of several reasons. First, The Hague is a large sized city, with distances from the inner city to the edge of the city of approximately 8-10 km (GoogleMaps, n.d., b). This results in significantly different 'empty vehicle driving time's and costs between the choice for parking the vehicle in the inner city or parking the vehicle at the edge of the city. Second, land in the inner city of The Hague is scarce and opportunities for other developments than parking exist. Third, on-street parking in the inner city of The Hague is scarce whereas off-street parking is under-utilized. With the implementation of AVs, opportunities exist for relocating on-street parked vehicles to off-street parking garages. Last, parking prices in the inner city of The Hague are high compared to parking prices at the edge of the city.

This research focusses on the two parking alternatives: parking in the inner city and parking at the edge of the city. The inner city and the edge of the city in this case study are visualized in Figure 4.1.

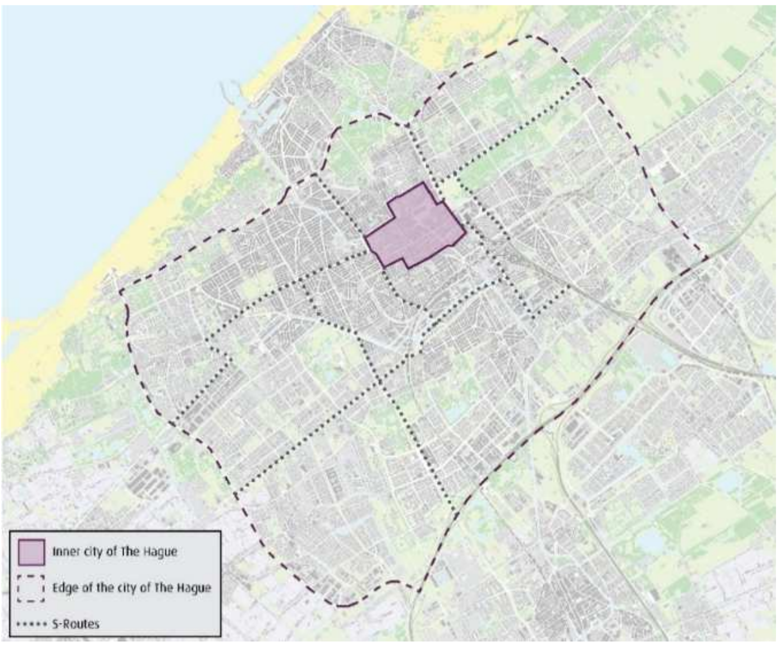

Figure 4.1 Visualisation of the inner city and the edge of the city of The Hague with the indicated s-routes

4.2 INFRASTRUCTURAL REQUIREMENTS

This section gives an indication of the infrastructural requirements when private highly AVs (SAE level 4) will become available for passenger transport. It should be noted that this study does not assume that only SAE level 4 vehicles operate on the road network; it is assumed that a mix of different SAE level vehicles operates in the environment.

No large infrastructural changes are needed in order to implement the system that is described in this research. With the assumption that different SAE level vehicles operate on the same roads, it is inevitable that CVs need the fundamentals of the urban streetscape for a safe and comfortable condition (TNO, Royal HaskoningDHV, 2016) (WSP | Parsons Brinckerhoff, Farrells, 2016).

At roads where cars are subordinate to slow traffic, interactions between AVs and slow traffic is the determining factor for a safe and comfortable environment (Parkin, Clark, Clayton, Ricci, & Parkhurst, 2016). At residential roads, cars are subordinate to slow traffic in contrary to distributor roads. At distributor roads, there is less interaction between fast and slow traffic and therefore, safe and comfortable conditions are less related to road traffic interactions between slow traffic and highly AVs. Therefore, it is more convenient to assume that highly AVs operate at the distributor roads between the inner city of The Hague and the edge of the city. These distributor roads are roads with priority sections, traffic lights and roundabouts.

However, in this research it is assumed that all roads (distributor and residential roads) in the inner city are accessible for highly AVs, because then passengers can be dropped-off near their destination. In addition, it is assumed that the distributor roads -the so called s-routes- that connect the ringroad of the inner city to the ringroad of the edge of the city will be ready for AVs. These roads are indicated in Figure 4.1.

TNO and Royal Haskoning DHV (2016) have constructed an overview of the most important findings for infrastructural changes in a mixed SAE level vehicles condition. The most important aspects for **distributor roads** are listed below (TNO, Royal HaskoningDHV, 2016):

- Improve the quality of the physical markings and lane boundaries. The markings and boundaries must be visible by in-car sensors and by human drivers. Application of uniform markings will improve the detection by the AVs.
- Change the surface condition of the roads in order that it corresponds with the comfort requirements of AVs.
- Improve the visibility of traffic signs so that they are easily readable by in-car camera systems.
- Invest in communication and cooperation at intersections.
- Separate fast and slow traffic (and public transport) at intersections where possible.

Optional for roads with many lanes:

- Consider to reserve lanes for AVs only. The width of the roads for AVs can in this case be smaller. However, it is important to stay flexible with the layout of the roads.

To prepare for the situation where private highly AVs will become available for passenger transport and will drive empty on distributor roads between the passenger's destination in the inner city and the parking facility at the edge of the city, the municipality should consider the above mentioned infrastructural changes.

4.3 QUANTIFICATION OF THE ATTRIBUTES

The selected attributes resulting from the conceptual model described in Chapter 3 need to be quantified for the stated choice experiment. The quantification of the selected attributes is described in this section.

The selected attributes resulting from the conceptual model are divided in the following three main categories:

- **Empty vehicle driving trip characteristics**
  - Empty vehicle driving time
  - Empty vehicle driving costs

- **Parking facility characteristics**
  - Parking cost
  - Surveillance of the parking facility

- Pick-up point related characteristics
  - Need to plan for vehicle to arrive
  - Risk of extra waiting time
  - Risk of fine

The quantification of the attributes for the case study of The Hague is described in the subsequent paragraphs.

4.3.1 Empty vehicle driving trip characteristics

The 'empty vehicle driving time' is the time needed for the private highly AV to drive from the passenger's destination to the parking facility and back from the parking facility to the passenger's destination to pick-up the passenger when his/her activity at the destination has ended.

When the private highly AV is parked in a parking facility in the inner city of The Hague, it is assumed that the empty vehicle driving trip (retour) takes approximately 10 minutes (GoogleMaps, n.d., a).

When the private highly AV is parked at a parking facility at the edge of the city of The Hague, it is assumed that the empty vehicle driving trip (retour) takes approximately 40 minutes during the off-peak period (GoogleMaps, n.d., b). The time to park the private highly AV once the AV has reached the parking facility is not taken into account.

The 'empty vehicle driving costs' are dependent on 1) the empty vehicle driving distance between the passenger's destination and the parking facility and 2) the costs for charging the vehicle.

When the private highly AV is parked in a parking facility that is located in the inner city of The Hague, it is assumed that the empty vehicle driving distance between the passenger's destination and the parking facility is approximately 3 km for a retour trip (GoogleMaps, n.d., a). The cost for electricity is approximately 12 cent per km (ANWB, n.d.). The 'empty vehicle driving costs' for parking the private highly AV in the inner city are therefore approximately €0.40.

When the private highly AV is parked at a parking facility at the edge of the city, 'empty vehicle driving costs' are significantly higher. The distance between the passenger's destination in the inner city and the parking facility at the edge of the city is approximately 16-20 km for a retour trip (GoogleMaps, n.d., b). The 'empty vehicle driving costs' for parking the private highly AV at the edge of the city are therefore approximately €2.

4.3.2 Parking facility characteristics

The 'parking cost' for parking the private highly AV in an off-street parking facility in the inner city of The Hague are shown in Table 4.1. From this table, it can be concluded that the costs for parking vary from €3 to €4 per hour with a maximum of €25 to €48 per day. On average, the cost for parking is €3.50 per hour.

Table 4.1 Parking characteristics of parking garages in the inner city of The Hague

Off-street parking garage	Capacity [# parking lots]	Price [€]	Price per hour [€]	Maximum price per day [€]
City Parking	300	4.00 / 60 min	4	30
Grote markt	400	4.00 / 60 min	4	30
Helicon	230	3.00 / 60 min	3	26
Lutherse Burgwal	320	4.00 / 60 min	4	30
Torengarage	300	3.00 / 60 min	3	26
Veerkaden	1000	4.00 / 60 min	4	30
Muzenplein	343	4.00 / 60 min	4	30
Noordeinde	87	2.00 / 30 min	4	30
Stadhuis	350	3.00 / 60 min	3	30
Markthof	62	4.00 / 60 min	4	48
Pleingarage	536	1.00 / 15 min	3	30
Wijnhaven Centrum	540	3.00 / 60 min	3	25

Source: Parkeren-denhaag.nl / Vries Excel / prettigparkeren.com

The 'parking cost' for parking the private highly AV at an off-street parking lot at the edge of the city of The Hague are assumed to be the same as the current Park and Ride facility costs. The cost for using a Park and Ride facility are €4 per day. Therefore, the costs for parking the private highly AV are set to €4 per day.

The 'surveillance of the parking facility' for an on-street parking garage in the inner city of The Hague are cameras. There is no supervision at the off-street parking lots at the edge of the city.

4.3.3 Pick-up point related characteristics

The pick-up point related characteristics do not exist in the current situation. Therefore, assumptions were made on the quantification of these attributes which are applicable for the city of The Hague.

The 'need to plan for vehicle to arrive' indicates whether or not the passenger needs to plan for the vehicle to arrive at the passenger's destination when the activity has ended. There are three concepts for this term. First, the passenger plans for the vehicle in advance for a predefined point of time to pick him/her up. There is no extra waiting time and no walking time. Second, the passenger recalls for the vehicle at the moment when his/her activity has ended. This means that there is an extra waiting time for the vehicle to arrive. Third, the passenger does not 'need to plan for vehicle to arrive', because the passenger walks to the parking facility and picks-up the vehicle. This implies walking time to the parking facility. The 'need to plan for vehicle to arrive' cannot be quantified in numbers, instead it will be indicated with text and icons in the choice sets.

The 'risk of extra waiting time' is the result of unreliable travel times for the empty vehicle driving trip from the parking facility back to the passenger's destination. Optimizing the reliability of the travel times means decreasing the unexpected delays (Kouwenhoven, et al., 2015). Municipalities are able to optimize their traffic system in order to minimize the 'risk of extra waiting time' by minimizing congestion and maximizing smooth traffic flows. Risk is defined as the chance that a scenario occurs multiplied by the impact of the scenario. In stated choice experiments, either the chance or the impact of the attribute is varied. In this experiment, the chance that the passengers needs to wait is varied. Quantification of a chance in stated choice experiment can be difficult to understand for respondents. It is found that '1 out of several times' is the best way to formulate the chance in order that respondents understand the different scenarios (Peters, et al., 2006). After using expert consulting, it is decided that the waiting time will be fixed to 10 minutes. This will be tested in the pilot survey.

The 'risk of fine' is, next to the 'risk of extra waiting time', the result of unreliable travel times for the empty vehicle driving trip from the parking facility back to the passenger's destination. It is not likely that municipalities optimize their traffic system in order to minimize the 'risk of fine'. However, the municipality is able to manage the height of the fine that needs to be paid when the vehicle needs to park and wait at the passenger's destination.

An overview of the quantification of the attributes is shown in Table 4.2.

Table 4.2 Quantification of the attributes for the SP experiment

Attributes	Alternative 1: Parking inner city (PIC) Parking garage - indoors	Alternative 2: Parking edge of the city (PEC) Parking lot - open air
Empty vehicle driving costs (to and from parking facility)	€0.40	€2
Empty vehicle driving time (to and from parking facility)	10 minutes	40 minutes
Parking cost	€ 3.50 per hour *(€30 per day)*	€4 per day
Surveillance of the parking facility	Cameras	None
Need to plan for vehicle to arrive	Yes: in advance Yes: at specific moment* No: passenger picks-up vehicle in parking facility**	Yes: in advance
Risk of extra waiting time	Perfect match passenger / vehicle	1 out of ... times + 10 min
Risk of fine	Perfect match passenger / vehicle	1 out of 20 times + € ...

** implies extra waiting time of 5 minutes; ** implies extra walking time of 5 minutes; '...' means to be defined*

4.4 SCENARIOS

The aim of the scenarios is to create a framework on how the results of the choice experiment could be applied to the estimated model. The base scenario (paragraph 4.4.1) applies for every choice situation whereas the what-if scenarios (paragraph 4.4.2) are used to investigate the effects of new parking policies.

4.4.1 Base scenario

The base scenario applies for every choice situation in the stated choice experiment. The base scenario consists of the assumptions that are listed below for 1) highly AVs and 2) the concept of sending the private highly AV to the parking facility and recall for the vehicle. An overview of all assumptions in this study is listed in Appendix D.

- Highly AVs:
  - Everyone is able to drive a highly AV: the passenger does not need to have a driver licence.
  - A highly AV has the same price as a CV; different price classes of AVs exist based on type of vehicle, size of the vehicle, etc. (The Boston Consulting Group, 2016).
  - A mixed traffic scenario is assumed, which means that vehicles of different SAE levels operate on the road network.
  - All highly AVs that operate on the road network are electric.

- Concept of sending the private highly AV to the parking facility and recall for the private highly AV:
  - The passenger pays automatically via his smartphone when he/she recalls for the vehicle to pick him/her up.
  - Locking the AV is done automatically when the passenger has left the vehicle.

4.4.2 What-if scenarios

The aim of the what-if scenarios in this study is to investigate how the estimated model could be implemented. In this research, the current parking constraints are considered for the possible future situation and opportunities for parking policies will be considered by varying the attribute levels.

- Scenario 1: Vary the parking cost
  What if the 'parking cost' for parking the highly AV at the parking facility are increased or decreased? The 'parking cost' for parking the vehicle in the inner city and at the edge of the city are varied with €1 per hour and €4 per day respectively.
- Scenario 2: Vary the surveillance of the parking facility
  What if the circumstances in the parking facility are safer or less safe? Are more people willing to park their car in a specific parking facility because of safer circumstances? The 'surveillance of the parking facility' is varied by 'no surveillance', 'camera surveillance' and 'personnel surveillance'.
- Scenario 3: Vary the need to plan for vehicle to arrive
  What if different options for the 'need to plan for vehicle to arrive' exist? The options for the 'need to plan for vehicle to arrive' were already described in paragraph 4.3.3.
- Scenario 4: Vary the chance of waiting time (vehicle is too late)
  What if the reliability of the route becomes higher by sophisticated technologies or separated lanes for AVs? In this scenario, the 'risk of extra waiting time' is varied by varying the chance that a person needs to wait for the vehicle to arrive.
- Scenario 5: Vary the height of the parking fine (vehicle is too early)
  What if the fine for temporary parking the vehicle at the passenger's destination is higher or lower? Currently, the fine for not paying (enough) parking cost or parking without a parking permit in The Hague is €61 plus the parking tariff per hour (Gemeente Den Haag, 2017). The passenger is responsible for the fine because of his/her wrong behaviour. In this what-if scenario -where the vehicle drives back empty from the parking facility to the passenger's destination- the passenger is not responsible for the fine because the passenger has no influence on the circumstances on the road network. Therefore, the fine in this what-if scenario is set to half of the current fine, thus: €30. This fine is varied in height in this what-if scenario.

4.5 SOCIAL COSTS AND BENEFITS

Social costs and benefits related to the system of private highly AVs operating in the city of The Hague can be of great importance for the directions of the policy advice. This section provides an overview of the consequences of the system described in this research in terms of social costs and benefits. Although AVs will lead to a broad spectrum of social costs and benefits (e.g. risk of the system, reduce driver stress, social equity, etc.) this research only focusses on the social costs and benefits in terms of parking and on the road network where the vehicles operate in.

Social costs:

- The system presented in this research will lead to 'empty vehicle driving time' and cost. The highly AV drives to the inner city to drop-off the passenger at the destination. Next, the highly AV drives empty from the passenger's destination to a parking facility and from the parking facility back to the passenger's destination. Consequently, the system may cause extra congestion and safety problems because of the empty vehicle driving trips between the passenger's destination and the parking facility. The empty vehicle driving trips result in extra vehicle kilometres on the road network compared to the current situation.
- The municipality needs to invest in the road network when it is desired that highly AVs can safely operate in the environment. The requirements for the road network were described in section 4.2.
- The liveability and attractiveness in some neighbourhoods may decrease due to empty vehicle driving trips. However, when highly AVs are only designated to several (distributor) roads on the network, the impact on liveability and attractiveness in neighbourhoods might be small.

Social benefits:

- Highly AV owners do not need to search for a parking space anymore due to the self-parking capability of AVs. Nowadays, around 30%-45% of city centre traffic are drivers searching for parking places (WSP | Parsons Brinckerhoff, Farrells, 2016). Consequently, this could lead to emission reductions, congestion improvements and a safer environment in terms of less accidents on the road.
- Highly AVs can be distributed over the parking garages in the inner city. Underutilized parking garages can be used when the capacity of a certain parking garage is reached.

The balance between the short-term and long-term costs and benefits is uncertain. In accordance, Milakis et al. (2015) stated in their research on policy and society related implication of automated driving: ''although the benefits of AVs in the short term are expected to be important, the long-term implications are uncertain and highly dependent on the evolution of vehicle travel demand ''(Milakis, Arem, & Wee, 2017).

4.6 CONCLUSION

This chapter discussed the case study of this research: the city of The Hague. Because of the growing number of visitors to the city centre of The Hague by car, the high amount of search traffic within the inner city, the good accessibility of the city by car and the innovation of AVs, it is of great importance that cities start to examine the effects of this new technology.

In order to prepare for the situation where private highly AVs will be available for passenger transport and will drive empty via distributor roads between the passenger's destination in the inner city and the parking facility at the edge of the city, the road authorities should take into account the following infrastructural requirements:

- Improve the quality of the physical markings and lane boundaries
- Change the surface condition of the roads
- Improve the visibility of traffic signs
- Separate fast and slow traffic (and public transport) at intersections where possible

The empirical framework that is applied in this research could be applied to any other large scale city similar to The Hague. However, the environmental conditions, the road network configuration and the parking constraints of the city of The Hague are used for this research. All attributes resulting from the conceptual framework were quantified in order to implement the attributes in the stated choice experiment, which will be discussed in the next chapter.

5

DESIGN OF THE STATED CHOICE PREFERENCE SURVEY

This chapter describes the design of the stated choice preference survey. The goal of a stated choice preference survey is to observe choices between different series of hypothetical choice alternatives. The output of this chapter will be used as input for the data analysis and model estimation, which is described in Chapter 6. Section 5.1 provides an overview of the alternatives, attributes and attribute levels in the stated preference (SP) survey. Section 5.2 and 5.3 present the SP pilot survey and the SP final survey respectively. The chapter ends with a conclusion in section 5.4.

5.1 ALTERNATIVES, ATTRIBUTES AND ATTRIBUTE LEVELS

This section provides an overview of the alternatives (paragraph 5.1.1), the attributes (paragraph 5.1.2) and the attribute levels (paragraph 5.1.3) which are used in the SP survey.

5.1.1 Alternatives

In this stated choice experiment, respondents were asked to choose between two alternatives: **Parking in the Inner City** (PIC) and **Parking at the Edge of the City** (PEC). Both alternatives are labelled, which means that ''alternatives have a label with which attributes are associated that are not varied in the experiment'' (Molin, SPM4612 Lecture 2 - Orthogonal experimental designs, 2015c). In the case of labelled alternatives, an Alternative Specific Constant (ASC) can be estimated. The ASC denotes the base difference in utility between the two labelled alternatives. This difference is based on preferences that are not captured by the attributes that are present in the alternatives.

No base alternative is included in the SP design. The author is interested in what trade-offs are made between PIC and PEC, given that a person owns a highly AV and that this vehicle needs to be parked somewhere. This operational decision means that respondents are forced to park their vehicle at a public parking facility -either in the inner city or at the edge of the city- while in reality they might opt for other alternatives. For example, respondents might also consider parking at a private facility, sending and parking the vehicle at home or to let the vehicle cruise empty (the vehicle drives empty on the road network, until the passenger needs the vehicle again). In order to make the design not too complex by including too many alternatives and to get enough responses for PIC and PEC, only these two alternatives were chosen for the SP design. Both PIC and PEC have advantages and disadvantages, based on heterogeneity in respondents' preferences and choices.

5.1.2 Attributes

Attributes can either be generic or specific over the alternatives. Attributes are **generic** if they have the same parameter β. Attributes are **specific** when 1) the attribute is only present in one of the alternatives or 2) if the parameter β of the attribute differs in both alternatives. Table 5.1 indicates for every attribute present in the SP design if the attribute is generic of specific.

The attributes 'empty vehicle driving costs' and 'empty vehicle driving time' are generic for PIC and PEC. The first attribute is expressed in euros and the second attribute is expressed in minutes. However, the attribute level is fixed and therefore these attributes do not have a parameter value β. These attributes are added to the SP design because otherwise respondents might make their own assumptions on the levels of these attributes.

The attributes 'parking cost' and 'surveillance' are present in both PIC and PEC. However, it is doubtful whether the parameter values β for both attributes are the same for PIC and PEC. 'Parking cost' is only a generic attribute if the respondent takes parking time into account: 'parking cost' for PIC is represented in euros per hour in contrast to PEC, where 'parking cost' is represented in euros per day. Surveillance is only a generic attribute if surveillance of the parking facility is experienced the same for PIC and PEC. Surveillance might differ for both alternatives, which means that the attribute might be specific. For example, a passenger might rate surveillance of the parking facility at the edge of the city higher, because parking at the edge of the city is facilitated at a more remote area. In general, if it is not certain if parameters are generic of specific, it is best to indicate the attributes as alternative-specific (ChoiceMetrics, 2014).

The attribute 'need to plan for vehicle to arrive' is only present in the PIC alternative. This indicates that the attribute is specific for PIC. The attributes 'risk of extra waiting time' and 'risk of fine' are only present in the PEC alternative, which indicates that these attributes are specific for PEC.

Table 5.1 Generic and specific attributes

Generic attributes for PIC and PEC	Specific attributes for PIC	Specific attributes for PEC
Empty vehicle driving costs*	Need to plan for vehicle to arrive	Risk of extra waiting time
Empty vehicle driving time*	Parking cost**	Risk of fine
	Surveillance**	Parking cost**
		Surveillance**

** attribute level is fixed (no parameter value); ** attribute is present in both alternatives, however parameter β might differ*

5.1.3 Attribute levels

Table 5.2 gives an overview of the attributes and their levels which were used in the SP experiment. The levels are resulting from the quantification of the attributes, which was described in section 4.3. Seven attributes vary in three levels. With the application of three levels for every attribute, the design is able to test for non-linear effects.

Table 5.2 Attributes and their levels which are used for the SP pilot survey

Attribute	Alternative 1: PIC Parking garage - indoors	Level	Alternative 2: PEC Parking lot - open air	Level
Empty vehicle driving costs	€0.40	Fixed	€2	Fixed
Empty vehicle driving time	10 minutes	Fixed	40 minutes	Fixed
Parking cost	€ 2.50 per hour *(€20 per day)* € 3.50 per hour *(€30 per day)* € 4.50 per hour *(€40 per day)*	0 1 2	€0 per day €4 per day €8 per day	0 1 2
Surveillance	None Cameras Personnel	0 1 2	None Cameras Personnel	0 1 2
Need to plan	Yes: in advance Yes: at specific moment* No: passenger picks-up vehicle in parking facility**	0 1 2	Yes: in advance	Fixed
Risk of extra waiting time	No risk of extra passenger waiting time	Fixed	1 out of 10 times + 10 min 3 out of 10 times + 10 min 5 out of 10 times + 10 min	0 1 2
Risk of fine	No risk of fine	Fixed	1 out of 20 times + €20 1 out of 20 times + €30 1 out of 20 times + €40	0 1 2

** implies extra waiting time of 5 minutes, ** implies extra walking time of 5 minutes*

The attribute levels of 'empty vehicle driving costs' and 'empty vehicle driving time' are fixed. As was already mentioned before, no parameter value can be estimated when the attribute level is fixed. However, the attributes are included in the SP design because otherwise respondents might make their own assumptions with respect to the level of these attributes.

The attribute levels of 'parking cost' are based on the 'parking cost' in the current situation and vary in lower and higher costs for parking the vehicle at the parking facility. The values of the attribute levels are chosen in such a way, that trade-offs can be made for realistic price situations.

The attribute levels of 'surveillance' are based on three possible types of 'surveillance of the parking facility': 'no surveillance', 'camera surveillance' and 'personnel surveillance'.

The attribute levels for 'need to plan for vehicle to arrive' were discussed in section 4.3. The possibility exists that the passenger needs to plan for the vehicle in advance (implies no waiting time and no walking time) or at the specific moment (implies an extra waiting time). In addition, there is the possibility that it is not needed to plan for the vehicle to arrive (implies an extra walking time to the parking facility to pick-up the vehicle).

The attribute levels for 'risk of extra waiting time' imply a fixed extra waiting time for the vehicle being 10 minutes too late, in which the probability of extra waiting time is varied.

The attribute levels for 'risk of fine' have a fixed probability for the vehicle being too early, where the height of the fine is varied in every level.

5.2 PILOT SURVEY DESIGN AND RESULTS

This section first discusses the design (paragraph 5.2.1) and results (paragraph 5.2.2) of the first SP pilot survey. The first SP pilot design was improved and a second SP pilot survey was conducted. The design (paragraph 5.2.3) and results (paragraph 5.2.4) of the second SP pilot survey are presented.

Three main steps have to be taken in order to create a stated choice experiment (ChoiceMetrics, 2014):

1. Model specification
2. Generation of the experimental design
3. Construction of the questionnaire

The different steps in creating a stated choice experiment are described below.

<u>STEP 1: MODEL SPECIFICATION</u>

In creating stated choice experiments, the first step is to specify the model. For the model specification, it needs to be decided 1) which alternatives and 2) which attributes for each alternative need to be included (ChoiceMetrics, 2014). When an attribute has two levels, one parameter is estimated. When an attribute has three levels, two parameters are estimated. For both labelled alternatives and related attributes, described in section 5.1, the utility functions are specified in Equation 5.1 and 5.2.

$$U_{PIC} = asc + \beta_{COSTI1} * COSTI1 + \beta_{COSTI2} * COSTI2 + \beta_{PSI} * PERS\_SURV\_I + \beta_{CSI} * CAM\_SURV\_I + \beta_{PLAN\_IA} * PLAN\_IA + \beta_{PLAN\_ASM} * PLAN\_ASM + \varepsilon \tag{5.1}$$

$$U_{PEC} = \beta_{COSTE1} * COSTE1 + \beta_{COSTE2} * COSTE2 + \beta_{PSE} * PERS\_SURV\_E + \beta_{CSE} * CAM\_SURV\_E + \beta_{WAIT1} * WAIT1 + \beta_{WAIT2} * WAIT2 + \beta_{FINE1} * FINE1 + \beta_{FINE2} * FINE2 + \varepsilon \tag{5.2}$$

Where:

U_{PIC}	= utility of alternative: parking in the inner city
U_{PEC}	= utility of alternative: parking at the edge of the city
asc	= alternative specific constant
β_{COSTI1}	= alternative specific parameter for the first component of 'parking cost' in the inner city (COSTI1)
β_{COSTI2}	= alternative specific parameter for the second component of 'parking cost' in the inner city (COSTI2)
β_{PSI}	= alternative specific parameter for the variable 'personnel surveillance' in the inner city (PERS_SURV_I)
β_{CSI}	= alternative specific parameter for the variable 'camera surveillance' in the inner city (CAM_SURV_I)
β_{PLAN_IA}	= alternative specific parameter for the variable 'need to plan for vehicle to arrive in advance' (PLAN_IA)
β_{PLAN_ASM}	= alternative specific parameter for the variable 'need to plan for vehicle at specific moment' (PLAN_ASM)
β_{COSTE1}	= alternative specific parameter for the first component of 'parking cost' at the edge of the city (COSTE1)
β_{COSTE2}	= alternative specific parameter for the quadratic component of 'parking cost' at the edge of the city (COSTE2)
β_{PSE}	= alternative specific parameter for the variable 'personnel surveillance' at the edge of the city (PERS_SURV_E)
β_{CSI}	= alternative specific parameter for the variable 'camera surveillance' in the inner city (CAM_SURV_E)
β_{WAIT1}	= alternative specific parameter for the linear component of 'risk of extra waiting time' (WAIT1)
β_{WAIT2}	= alternative specific parameter for the quadratic component of 'risk of extra waiting time' (WAIT2)
β_{FINE1}	= alternative specific parameter for the linear component of 'risk of fine' (FINE1)
β_{FINE2}	= alternative specific parameter for the quadratic component of 'risk of fine' (FINE2)
ε	= random error component

As can be seen in Equation 5.1 and 5.2, all attributes are alternative-specific, where the same attributes have different parameters (β) for both alternatives. 'I' and 'E' correspond to parking in the Inner city and parking at the Edge of the city respectively.

Next, the model type has to be chosen. As was discussed in section 2.6, the MNL model is suitable for the stated choice experiment. When the model has been specified, the experimental design can be generated. The generation of the experimental design is explained in the next step.

STEP 2: GENERATION OF THE EXPERIMENTAL DESIGN

The second step in creating stated choice experiments is to generate the experimental design, in which hypothetical choice situations are created (ChoiceMetrics, 2014). There are two types of experimental designs: orthogonal designs and efficient designs. An **orthogonal design** minimizes correlation between attributes and an **efficient design** minimizes standard errors (Molin, SPM4612 Lecture 2 - Orthogonal experimental designs, 2015c). It is more desirable to use efficient designs because these designs are able to outperform orthogonal designs, as they are able to maximize information from every choice situation. However, efficient designs require prior parameter estimates (ChoiceMetrics, 2014). Priors are the best guesses on the attribute parameters (Molin, SPM4612 Lecture 3 - Foldover designs & Ngene, 2015d). Information on prior parameter estimates is not available in this case. Therefore, an orthogonal design is chosen for the SP pilot survey which assumes that the attribute levels are not correlated.

The total number of hypothetical choice situations is defined by L^A combinations (Molin, SPM4612 Lecture 2 - Orthogonal experimental designs, 2015c) where 'L' represents the number of attribute levels (three in this case) and 'A' represents the number of attributes (seven in this case). The use of a **full** factorial design results in 2187 choice situations (=3^7), which are way too many to show to the respondents. It is therefore needed to use a specific selection of the full factorial design in which the number of choice situations is reduced. In an orthogonal **fractional** factorial design only 18 choice situations are needed. When using an orthogonal fractional design, it not possible to estimate interaction effects. Only main effects can be estimated.

The software package *Ngene* was used to create hypothetical choice alternatives or profiles for the SP pilot survey. Ngene is able to generate designs with any number of choice situations, alternatives, attributes and attribute levels (ChoiceMetrics, 2014). The Ngene model, which was created to generate the choice situations for the SP pilot survey, is included in Appendix E. The choice situations resulting from the Ngene syntax file are shown in Table 5.3. The code of the levels can be found in Table 5.2 in paragraph 5.1.3. When the experimental design is generated, the questionnaire can be constructed. The construction of the questionnaire is described in the next step.

Table 5.3 The 18 choice situations for the SP pilot survey

Choice situation	Alternative 1: PIC			Alternative 2: PEC				Block
	Parking cost	Surveillance	Need to plan	Parking cost	Surveillance	Risk of extra waiting time	Risk of fine	
1	0	0	0	0	0	0	0	1
2	1	1	1	1	1	1	0	1
3	2	2	2	2	2	2	0	1
4	2	1	1	2	0	0	1	1
5	0	2	2	0	1	1	1	1
6	1	0	0	1	2	2	1	1
7	2	0	2	1	0	1	2	1
8	0	1	0	2	1	2	2	1
9	1	2	1	0	2	0	2	1
10	0	2	1	1	0	2	0	2
11	1	0	2	2	1	0	0	2
12	2	1	0	0	2	1	0	2
13	1	2	0	2	0	1	1	2
14	2	0	1	0	1	2	1	2
15	0	1	2	1	2	0	1	2
16	1	1	2	0	0	2	2	2
17	2	2	0	1	1	0	2	2
18	0	0	1	2	2	1	2	2

STEP 3: CONSTRUCTION OF THE QUESTIONNAIRE
Each row in Table 5.3 represents a choice situation, which needs to be transformed into choice situations which are understandable for respondents. The choice situations that were presented to respondents are explained in the subsequent paragraphs. The online survey program *Typeform* was used to create the SP pilot survey. Typeform is able to create any type of survey by using a drag-and-drop interface (Typeform, 2016). The SP pilot survey was constructed in Dutch and was only distributed to Dutch respondents. Two SP pilot surveys were conducted, which are discussed in the subsequent paragraphs.

5.2.1 First pilot survey design
The aim of the first SP pilot survey is to test if respondents 1) understand the concept of sending the private vehicle - under the assumption that the vehicle is able to drive itself- to a parking facility either in the inner city or at the edge of the city, 2) switch between the different choice situations and 3) understand the questionnaire. The first SP pilot survey consists of an introduction followed by three parts.

INTRODUCTION
The aim of the introduction questions is to set the context for the choice situations. Respondents were asked to fill in the trip purpose, trip duration and trip reimbursement of their most recent trip. These three context factors were derived from the conceptual framework. In addition, two extra questions were asked: the parking location and parking cost of their most recent trip.

PART 1: CHOICE SITUATIONS
The goal of the first part of the SP pilot survey is to observe choices between series of hypothetical choice alternatives. A short animated movie of approximately 2 minutes was shown to respondents, in which the concept of highly AVs, the empty vehicle driving trip and the choice for the parking location was explained. The aim of the animated movie is to minimize hypothetical bias in SP. The hypothetical choice situations are visualized by showing two mobile phones, resembling the two choices: PIC and PEC. At the top of each mobile phone, a map of The Hague is shown. It is decided to show a map where respondents are familiar with, enabling them to obtain a better feeling with the presented distances. The corresponding attributes and levels for each alternative are shown below the map. A visualisation of a choice situation in the first SP pilot survey is included in Appendix E.

PART 2: STATEMENTS
The goal of the second part of the SP pilot survey is to capture perceptions of automated driving which cannot be captured in the attributes within the choice situations. Perceptions on automated driving are latent and were therefore asked via statements. The statements do not overlap with the attributes in the choice sets. Three main subjects were tested with the statements: 1) safety and trust in system during empty driving trip, 2) responsibility of the AV and 3) use of the system. Three statements were formulated for every main subject.

PART 3: GENERAL QUESTIONS
General questions about respondents' personal characteristics were asked to divide the respondents into different classes or segments. It was analysed if different personal characteristics have an influence on drivers' parking location choice.

5.2.2 First pilot survey results
The first pilot survey was distributed via email to family and friends of the author. In total, 10 respondents filled in the self-completion online survey and provided feedback on this first pilot survey.

All respondents indicated that they understood the concept of AVs and the principle of sending their private vehicle empty to a public parking facility. They indicated that the animated movie was really helpful in order to understand the concept and the two alternatives.

Respondents switched between the alternatives with varying attributes, indicating that one alternative does not outperform the other and that there is heterogeneity in respondents' preferences and choices.

Not all parts of the survey were understood by the respondents. The hypothetical choice alternatives in part 1 of the survey were not clear to almost all respondents. They indicated that they had the problem to choose between the two alternatives. They indicated that there are too many attributes and they did not understand all attributes, especially the 'risk of fine' was difficult to understand. Some respondents indicated that this was caused by the absence of a legend of the icons. Half of the respondents indicated that they did not understand some questions about the responsibility of the car. They did not understand that, instead of human responsibility, a car can be held responsible for the actions. Half of the respondents indicated that the survey took more time than the indicated time of 15 minutes. This could also be caused by the fact that they had to give feedback on the survey.

The first pilot survey was updated according to the given feedback, resulting in the realization of a second SP pilot survey. The adaptions are described in the subsequent paragraph.

5.2.3 Second pilot survey design

The aim of the second pilot survey was to test if 1) respondents understand the questionnaire and 2) to find prior parameter values. The first pilot survey was updated according to the given feedback. The main adjustments are described below.

UPDATE PART 1: CHOICE SITUATIONS

An explanation of every attribute is presented for every choice situation. This operational decision means that respondents have to read more text in the situations. As a result, respondents might understand the attributes better, resulting in more realistic observations. In order to compare the attributes for both alternatives, it is chosen to place the attributes next to each other, resulting in the elimination of the image of the mobile phone. An example of the updated design of the choice situation is included in Appendix E.

UPDATE PART 2: STATEMENTS

It is chosen to eliminate the statements about the responsibility of the AV.

UPDATE PART 3: GENERAL QUESTIONS

Only minor changes in the construction of the sentences were made.

5.2.4 Second pilot survey results

Data was collected using a self-completion online survey. The second pilot survey was distributed via email to employees of Goudappel Coffeng and the municipality of The Hague. It was explicitly mentioned that the survey is only meant for people who own a car and have ever visited the inner city of The Hague with this car. Two different surveys were required because the orthogonal fractional factorial design is blocked. Not blocking the design would mean that every respondent needs to fill in 18 choice situations, which are considered to be too many. In total, 46 respondents completed the survey: 23 respondents in block 1 and 23 respondents in block 2. The socio-demographic characteristics of the respondents that completed the second pilot survey are shown in Table 5.4.

Table 5.4 Statistics of the respondents on personal characteristics second SP pilot survey

Number of respondents:	Block 1: **23**, Block 2: **23**, Total: **46**
Age:	**28%** 0-30 years, **70%** 31-60 years, **2%** more than 61 years
Gender:	**80%** male, **20%** female
Income (net monthly):	**0%** less than €1,000, **9%** €1,000-€2,000, **41%** €2,000-€3,000, **39%** more than €3,000, **11%** I don't know/I don't want to tell
Value of the car:	**22%** less than €5,000, **28%** €5,000-€10,000, **20%** €10,000-€15,000, **11%** €15,000-€20,000, **15%** more than €20,000, **4%** I don't know/I don't want to tell
# trips with private vehicle to inner city:	**2%** one or more trip per day, **4%** several trips per week, **17%** several trips per month, **44%** several trips per year, **33%** less than 1 trip per year
Familiarity with AVs:	No knowledge/no experience: **0%** Knowledge/no experience: **76%** Knowledge/experience: **24%**
	Professionally active: **44%** Not professionally active/interested: **39%** Not professionally active/not interested: **13%** Other: **4%**

A majority of the respondents provided feedback on the SP pilot survey. The overall feedback of the respondents on the SP pilot survey includes the following aspects: 1) the scenarios are too complex, which makes it hard to choose between the two alternatives, 2) it was not clear which attributes changed and which were fixed over the scenarios and 3) the concept of 'risk of fine' was not clear in the introduction movie and in the scenarios. These insights were taken into account during the generation of the SP final design.

The open source freeware *Biogeme* was used to estimate the MNL model (Bielaire, 2003). A data file and a model file are essential for the estimation of the MNL model in Biogeme (Molin, Handleiding Biogeme, 2015e). The data file (.dat) contains the data presented on the individual level. The model file (.mod) contains the specification of the model that needs to be estimated. The Biogeme model file is presented in Appendix E. The values of the estimated MNL model in Biogeme are shown in Table 5.5.

The aim of the second SP pilot survey is to find prior parameter values. The context factors -trip purpose, trip duration and trip reimbursement- are not considered in the estimation of the MNL model for the SP pilot survey. Furthermore, linearity effects are not discussed in this phase of the research.

It should be noted that 43.5% of the respondents have a fixed preference for either parking in the inner city or parking at the edge of the city. 32.6% (15/46) of the respondents have a fixed preference for parking in the inner city and 10.9% (5/46) of the respondents have a fixed preference for parking at the edge of the city. After a small analysis where context effects were taken into account, it can be concluded that the fixed preference can be related to the short trip duration (1-3 hours). This short trip duration might be the cause why some respondents always choose for parking in the inner city and not sending their vehicle to the edge of the city.

Table 5.5 Values model estimation: second SP pilot survey

	Parameter name	Parameter component	Parameter estimate	Robust Std err	Robust t-test	p-value
PIC	asc	asc	0.386	0.106	3.63	0.00*
	Parking cost	β_{COSTI_L}	-0.449	0.147	-3.05	0.00*
		β_{COSTI_Q}	0.00288	0.147	0.02	0.98
	Surveillance	β_{PSI}	-0.113	0.145	-0.78	0.44
		β_{CSI}	0.328	0.157	2.09	0.04*
	Need to plan	β_{PLAN_IA}	0.213	0.156	1.37	0.17
		β_{PLAN_ASM}	0.0307	0.147	0.21	0.83
PEC	Parking cost	β_{COSTE_L}	-0.448	0.158	-2.83	0.00*
		β_{COSTE_Q}	0.180	0.148	1.22	0.22
	Surveillance	β_{PSE}	0.121	0.147	0.82	0.41
		β_{CSE}	-0.178	0.156	-1.15	0.25
	Risk of extra waiting time	β_{WAIT_L}	-0.360	0.156	-2.31	0.02*
		β_{WAIT_Q}	0.121	0.148	0.82	0.41
	Risk of fine	β_{FINE_L}	-0.0878	0.158	-0.55	0.58
		β_{FINE_Q}	-0.0301	0.147	-0.21	0.84

* *Significant on a 95% confidence interval ($p < 0.05$)*

First, it is evaluated if the **parameter is significant** on a 95% confidence interval ($p < 0.05$). It might be considered to leave out the non-significant parameters in the final survey design. Parameters indicated with a * in Table 5.5 are significant on a 95% confidence interval.

The following five parameters are significant on a 95% confidence interval: the alternative specific constant (asc), 'parking cost' PIC (linear component), 'camera surveillance' PIC, 'parking cost' PEC (linear component) and 'risk of extra waiting time' (linear component). The reason why not all parameters are significant can be caused by the low number of respondents (N=46) or because respondents indicated that the choice situations were too complex. As a result of the latter, respondents might not take all factors into account while making decisions.

From literature, it can be concluded that 'parking cost' is the most important factor for drivers' parking location choice (section 2.2). The parameters for 'parking cost' for both PIC and PEC are significant. The parameters for 'risk of fine' are not significant, while this attribute also has a direct cost aspect. It is decided to keep the attribute 'risk of fine' in the SP design and to provide a better explanation of this factor to respondents.

In addition, the parameters for 'camera surveillance' for both PIC and PEC and 'personnel surveillance' for PEC are not significant. It might be the case that respondents did not take surveillance into account because they had to consider many (and complex) attributes.

The parameters for 'need to plan for vehicle to arrive' are also not significant. It is possible that respondents did not understand the concept of 'need to plan for vehicle to arrive', because in the introduction movie it was stated that they *must* recall for their vehicle to pick them up again and therefore it seemed that they always have to plan for their vehicle to arrive.

Second, it is evaluated if the parameter sign is logical. When the parameter has an unexpected sign, the value of the parameter is set to 0 in the Ngene syntax for the final SP survey. All parameters are effect coded, which means that every attribute level has a unique code consisting of ones, zeros and minus ones. The advantage of effect coding is that it provides a nice interpretation of the *asc* and it gives no problems in estimating interaction effects (Molin, SPM4612 Lecture 4 - Efficient designs & coding, 2015f). All attributes in the pilot survey have three attribute levels. A general effect coding scheme for an attribute with three levels is shown in Table 5.6. The highest attribute level is coded with {1 0}, the middle attribute level is coded with {0 1} and the lowest attribute level is coded with {-1 -1}. When the lowest attribute level is coded with {-1 -1}, the parameter values match with the expected parameter signs. An example for the effect coding schemes for 'parking cost' for PIC is shown in Table 5.7. The effect coding schemes for all attributes are included in Appendix E.

Table 5.6 General effect coding scheme for an attribute with 3 levels

Levels	Variable 1	Variable 2
Level 2	1	0
Level 1	0	1
Level 0	-1	-1

Table 5.7 Example effect coding scheme 'parking cost' PIC

Parking cost (PIC)	COSTI1	COSTI2
Level 2: €4.50	1	0
Level 1: €3.50	0	1
Level 0: €2.50	-1	-1

By calculating the part-worth utility (pwu), utility differences between the attribute levels can be determined and the parameter signs and values for all attribute levels can be defined. The pwu is calculated by the parameter estimate * the attribute value (=coding). For example, the pwu for PIC €4.50 = -0.449 * 1 + 0.00288 * 0 = -0.449. The sum of the part-worth utilities for one attribute always equals 0. The parameter sign and value is equal to the pwu for the attribute level which is coded with a 1.

The pwu for the attribute levels is shown in Table 5.8. A negative sign indicates that utility decreases, where a positive sign indicates that utility increases. For example, if the 'parking cost' for PIC are €4.50, utility decreases by 0.449 utils and if free parking at the edge of the city is surveyed by personnel, utility increases by 0.121 utils.

The *asc* was included in the utility function of PIC. Therefore, the *asc* denotes the average utility that is derived from all PIC alternatives presented in the experiment compared to PEC. A positive value of the *asc* indicates that in general PIC is preferred over PEC, not taken into account the attributes.

In Table 5.8, it is also indicated if the signs are as expected. It can be concluded that almost all parameter signs are as expected. Three parameter signs are not as expected: 1) personnel surveillance for PIC, 2) camera surveillance for PEC and 3) no surveillance for PEC.

In short, five parameters are significant in the SP pilot survey. The significant parameters in the SP pilot survey are the following: the asc, the first parameter for 'parking cost' PIC, 'camera surveillance' PIC, the first parameter for 'parking cost' PEC and the first parameter for 'risk of extra waiting time'. However, it is more interesting to look at the parameter signs. All parameter signs are as expected, except for 'personnel surveillance' for PIC, and 'camera surveillance' and 'no surveillance' for PEC. Therefore, the prior parameter values for surveillance for PIC and PEC are set to 0 in the Ngene syntax for the final survey design. Linearity will be tested for the results of the final survey, because there are not enough respondents in the pilot survey to test for linearity effects.

Table 5.8 Signs and estimates utility parameters second SP pilot survey

	Attribute name	Attribute level	pwu	Sign as expected?
PIC	asc		+0.386	Unknown
	Parking cost	€4.50 per hour	-0.449	Yes
		€3.50 per hour	+0.00288	Unknown
		€2.50 per hour	+0.446	Yes
	Surveillance	Personnel	-0.113	**No**
		Camera	+0.328	Yes
		None	-0.215	Yes
	Need to plan	Yes, in advance (no walking, no waiting)	+0.213	Yes
		Yes, at moment (waiting)	+0.0307	Yes
		No (walking)	-0.2437	Yes
PEC	Parking cost	€8.00 per day	-0.448	Yes
		€4.00 per day	+0.180	Unknown
		€0.00 per day	+0.268	Yes
	Surveillance	Personnel	+0.121	Yes
		Camera	-0.178	**No**
		None	+0.057	**No**
	Risk of extra waiting time	5 out of 10 times: 10 min	-0.360	Yes
		3 out of 10 times: 10 min	+0.121	Unknown
		1 out of 10 times: 10 min	+0.239	Yes
	Risk of fine	1 out of 20 times: €40	-0.0878	Yes
		1 out of 20 times: €30	-0.0301	Unknown
		1 out of 20 times: €20	+0.1179	Yes

5.3 FINAL SURVEY DESIGN

The SP pilot survey was improved based on the feedback from the respondents. First, the improvements are discussed (paragraph 5.3.1). Second, the design of the SP final survey is shown (paragraph 5.3.2).

5.3.1 Improvements from SP pilot survey

As was already discussed in the previous section, respondents provided feedback on the second pilot survey. The main feedback of the respondents on the SP pilot survey includes the following aspects: 1) the scenarios are too complex which makes it hard to choose between the two alternatives, 2) it was not clear which attributes changed and which were fixed over the scenarios and 3) the concept of 'risk of fine' was not clear in the introduction movie and in the scenarios. The SP pilot survey is improved based on the feedback from the respondents. Three main improvements in the choice situations were made.

First, the attribute 'need to plan for vehicle to arrive' is eliminated from the choice situations. Eliminating one attribute will not have an effect on the parameter values for the other attributes, because an orthogonal design is used for the generation of the choice situations. Because the SP pilot survey includes seven attributes of which three new attribute concepts ('risk of extra waiting time', 'risk of fine' and 'need to plan for vehicle to arrive'), the choice sets might be too complex for respondents. Therefore, it is decided to leave out one of these new attributes in the final SP survey, which is the attribute 'need to plan for vehicle to arrive'.

Second, it is indicated in the example question which attributes are fixed and which attributes are changing in the choice situations. In the choice situations, the fixed attributes are marked in grey and in the title the fixed aspect of the attributes is included. Respondents who filled in the SP pilot survey indicated that they had difficulties with the distinction between the fixed and changing attributes.

Third, the attribute 'risk of fine' is changed to 'parking fee'. It turned out that the term and explanation of 'risk of fine' is hard to understand for respondents and that a 'fine' might not be the correct definition for the relationship with the vehicle arriving too early. In fact, it is not a fine because passengers are not responsible for the vehicle arriving too early because of unreliable arrival times. It is therefore decided that if the vehicle arrives too early, people might have to pay a fee for temporary parking the vehicle on-street as close as possible to their final destination. There should be a mechanism that prevents people of always calling for their vehicle too early, which has been found in the so-called parking fee.

Next, the attribute levels for the 'parking fee' need to be defined. The fine in the SP pilot survey was set to a price of €20, €30 and €40. For a fine, these prices are realistic. However, for a parking fee, the prices are out of proportion where they resemble the maximum daily parking cost in a parking garage in the inner city of The Hague. Parking the vehicle on-street at a public parking spot in the centre of The Hague is in some places forbidden and in the places where it is allowed to park the vehicle on-street, the costs are between €2.15 and €2.65 per hour (Prettig Parkeren, 2017). On-street parking places in the inner city of The Hague are scarce and places need to be reserved for drop-off and pick-up manoeuvres. Limited spaces for parking are available and therefore the passenger has to pay for temporary parking the vehicle on-street. Therefore, it is decided to set a price for temporary parking which is higher than the parking costs. The author is interested if passengers are sensitive for the implementation of this price system and to what extent. The effect of the price system will be tested with this attribute which will be explained in the animated introduction movie which respondents will watch before filling in the survey.

5.3.2 Design of the SP final survey

The attributes and the attribute levels which are used in the SP final experiment are shown in Table 5.9. The attribute levels for the Ngene syntax are coded with either a 0, 1 of 2.

Table 5.9 Attributes and their levels which are used for the SP final survey

Attributes	Alternative 1: PIC Parking garage - indoors	Level	Alternative 2: PEC Parking lot - open air	Level
Empty vehicle driving costs	€0.40	Fixed	€2	Fixed
Empty vehicle driving time	10 minutes	Fixed	40 minutes	Fixed
Parking cost	€ 2.50 per hour *(max. €20 per day)* € 3.50 per hour *(max. €30 per day)* € 4.50 per hour *(max. €40 per day)*	0 1 2	€0 per day €4 per day €8 per day	0 1 2
Surveillance of the parking facility	None Cameras Personnel	0 1 2	None Cameras Personnel	0 1 2
Risk of extra waiting time	No risk of extra waiting time	Fixed	1 out of 10 times + 10 min 3 out of 10 times + 10 min 5 out of 10 times + 10 min	0 1 2
Risk of parking fee	No risk of parking fee	Fixed	Yes: €20 No	1 0

The number of choice situations can be determined with Equation 5.3 (ChoiceMetrics, 2014).

$$\#\,\text{choice situatios} = \frac{\#\,\text{parameters}}{(\#\text{alternatives} - 1)} = \frac{12}{(2-1)} = 12 \tag{5.3}$$

In ChoiceMetrics (2014), the number of parameters is called 'number of attributes'. This is correct if linearity is assumed and one parameter value is estimated for one attribute. In this case linearity is not assumed and some attributes have two parameter values. Therefore, the number of parameters is used instead of the number of attributes. In this case, there are 12 parameters: 5 attributes have 2 parameters. 1 attribute has 1 parameter and the asc as a parameter.

The Ngene syntax for the final survey is included in Appendix F. Because there is information on the prior parameter values, an efficient design can be generated. The design with the lowest D-error is chosen. The design was checked for dominance and the MNL utilities were recalculated by hand. The resulting 12 choice situations are shown in Table 5.10. This experimental design contains attribute level balance, which means that all attribute levels are shown an equal number of times to the respondents. When there is no attribute level balance, the standard errors of some parameters might be higher or lower.

Table 5.10 The 12 choice situations for the SP final survey

Choice situation	Alternative 1: PIC		Alternative 2: PEC			
	Parking cost	Surveillance	Parking cost	Surveillance	Risk of extra waiting time	Risk of parking fee
1	1	2	0	1	1	0
2	1	1	0	0	2	0
3	2	2	1	1	1	1
4	0	2	2	0	2	0
5	0	1	0	0	0	1
6	0	1	1	2	2	1
7	1	0	2	2	0	1
8	2	0	2	0	1	1
9	0	0	1	1	0	0
10	2	0	0	2	2	1
11	2	1	2	1	0	0
12	1	2	1	2	1	0

The complete SP final survey in Dutch and English is included in Appendix F. At the start of the survey, respondents were informed about the approximate completion time of 10 minutes. The survey consists of five introduction questions, followed by three parts. The five introduction questions consider the respondents' most recent trip to the inner city of The Hague, to define the context for the 12 hypothetical choice situations in the first part of the survey. An example of a choice situation (choice situation 4) is visualized in Figure 5.1. The respondents' answers on the first five questions are presented above each choice situation in the SP survey. The second part of the survey consists of the six statements about AVs. The third part consists of 12 questions on personal characteristics and preferences. Respondents were guaranteed of anonymity and confidentiality.

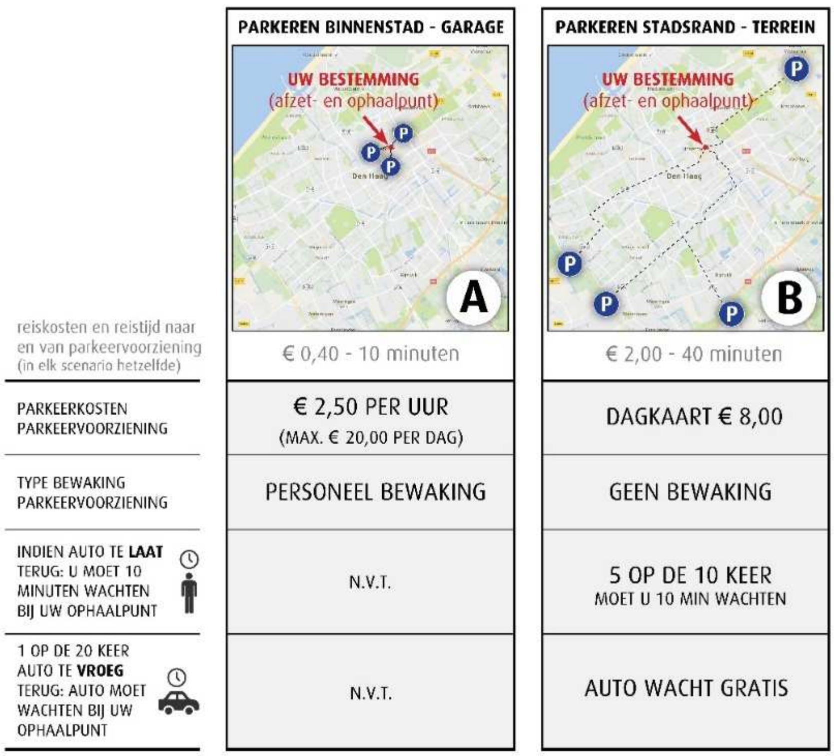

Figure 5.1 Example of a choice situation (4) in the SP final survey (pictures from Google Maps (Google maps, n.d., c))

5.4 CONCLUSION

This chapter described the designs and results of two SP pilot surveys and the design of the SP final survey. The two alternatives in this stated choice experiment are 1) Parking in the Inner City (PIC) and 2) Parking at the Edge of the City (PEC). Two pilot surveys were conducted in order to design the final questionnaire. An orthogonal design was used to create the choice situations for both pilot surveys, because there is no information on prior parameter values. In the first pilot survey, it was tested whether respondents understood the concept of automated driving and the questionnaire. In the second pilot survey, the main aim was to find prior parameter values.

A final survey was made, based on the results of both pilot surveys. The final survey consists of five introduction questions, followed by three parts: choice situations (part 1), statements (part 2) and general questions (part 3). In the introduction questions, respondents' have to fill in the trip characteristics of their most recent trip to the inner city of The Hague. The trip characteristics are the context factors that apply for the hypothetical choice situations which were asked in the first part of the survey. An efficient design was used to create the choice situations because the pilot survey provided information on the prior parameter values. In the second part of the survey, statements were presented in order to receive information on respondents' perceptions on automated driving. In the third part of the survey, respondents' have to fill in some personal characteristics.

The final survey will be send to an online Panel. With respect to the results of the final survey, it is expected that:

- The parameter values are more reliable, because of a larger sample
- A certain percentage of the respondents has a fixed preference for either PIC or PEC
- Personal characteristics, trip characteristics and perceptions on automated driving have an influence on drivers' parking location choice

The next chapter will discuss the results of the SP final survey.

6

DATA ANALYSIS & MODEL ESTIMATION

This chapter describes the data analysis and model estimation and gives an answer on sub-research question 2: *''To what extent do different personal characteristics, trip characteristics and perceptions on highly automated driving have an effect on factors and constraints that influence drivers' parking location choice?''* and sub research question 3: *''What are promising parking policies in the case when private highly automated vehicles will become available for passenger transport?''* Section 6.1 discusses the sampling method for the data collection. Section 6.2 describes the descriptive statistics. The MNL model estimation is described in section 6.3 followed by the MNL model estimation with the implemented interaction variables in section 6.4. Section 6.5 describes the scenario analysis followed by a description on the directions for parking policies in section 6.6. The chapter ends with a conclusion in section 6.7.

6.1 SAMPLING METHOD

This section describes the sampling method in which an online panel was used for the data collection (paragraph 6.1.1) and the requirements for the online panel (paragraph 6.1.2).

6.1.1 Data collection: online panel

Data was collected by means of an online panel. Data collection via the Internet is fast and relatively cheap compared to conducting (in-depth) interviews. As a consequence, the quality of the data might be lower. However, the use of an online panel is an appropriate manner to collect data for a first insight in the passenger behaviour in the case when respondents assume that their own vehicle is a highly AV.

Data was collected during the period of 13th till 16th February in 2017. Respondents were recruited via *PanelClix,* which has been managing and building an online international panel since 1999. Because of the large panel size in combination with the extensive participants' profiles, PanelClix is able to compile every desired sample (PanelClix, 2017). PanelClix rewards respondents with a small fee (€0.70) for filling in the questionnaire. In order to facilitate the research, Goudappel Coffeng compensated the costs for launching the online survey. It should be noted that there is a risk that respondents only complete the questionnaire to receive the fee, while they do not fill in the questionnaire in a serious manner. This should be taken into account when drawing conclusions. Because of the large sized panel, it is expected that enough respondents can be collected to use the city of The Hague as a case study.

The minimum number of respondents can be determined with Equation 6.1 (Hess, 2015).

$$minimum\ \#\ respondents\ (N) = 500 * \frac{\mathrm{I}}{\mathrm{J} * \mathrm{S}} = \frac{3}{(2 * 12)} = 62.5 \qquad (6.1)$$

Where:

I = highest number of levels for any attribute

J = number of alternatives

S = number of rows in the experimental design

Based on this formula, the minimum number of respondents for this stated choice experiment would be 63. Based on some insignificant parameters in the pilot survey and to get enough responses for the different trip characteristics, it is desired to recruit more respondents. Furthermore, a higher number of respondents will lead to more reliable results and parameter estimates. Based on the given budget for this research, it is possible to recruit 400 respondents.

6.1.2 Requirements for the online panel

Respondents need to meet some specific requirements in order to conduct the questionnaire. Instead of using a probability sampling method that involves random selection respondents, a non-probability sampling method was used, which means that respondents were not randomly selected.

The following requirements apply for the panel:

- Respondents need to own a car and a driver's licence.
- Respondents have visited the inner city of The Hague with their own car during the last year. This is required because respondents need to remember their most recent trip to the inner city of The Hague to fill in the choice situations.
- Participants cannot have their place of residence in the city of The Hague. When a respondent lives in The Hague and travels to the inner city, the option for parking the vehicle at the edge of the city might become irrelevant because he/she could also opt for the option to send the vehicle home and park for free or for a lower fee than parking the vehicle in the inner city.

PanelClix incorporated selection questions in the questionnaire for the recruitment of respondents. To have a higher probability that respondents have ever visited the inner city of The Hague with their own vehicle during the last year, respondents were recruited from areas within a radius of 30 kilometres from the city of The Hague. This area approximately resembles the province of South Holland.

6.2 DESCRIPTIVE STATISTICS

Descriptive statistics were used to describe the sample and observations. First, it is explored whether the sample is representative for the population of South Holland (paragraph 6.2.1). Second, the exploration of respondents' answers to the questions in the survey is presented (paragraph 6.2.2). Third, descriptive statistics regarding the fixed preference for PIC and PEC are presented (paragraph 6.2.3).

In total, 421 respondents filled in the self-completion online questionnaire with an average completion time of 8 minutes and 44 seconds. Different devices were used to complete the questionnaire. A majority of the respondents used a computer or laptop (343), some respondents used a tablet (44) or a smartphone (35). From the 421 respondents who completed the questionnaire, 33 were excluded from the dataset because of the following reasons:

- Respondents who completed the survey within three minutes. It already takes two minutes to watch the introduction movie which is needed to understand the concept and choice alternatives.
- Respondents who did not fulfil the requirements stated in paragraph 6.1.2. Despite the fact that selection questions were added at the start of the survey to filter out respondents who do not fulfil the requirements, it appeared that some respondents who did not meet the requirements completed the questionnaire.

In total, there are 388 valid responses in the dataset.

6.2.1 Frequency distribution and representativeness of the sample

The personal characteristics of the respondents were obtained from the third part of the survey. The frequency distribution of the variables on the personal characteristics are included in Appendix G. To obtain statistically significant results, the different segment groups for every personal characteristic cannot be too small. Therefore, it is checked if every category consists of at least 30 respondents. When it was possible, segments with less than 30 respondents were combined for the subsequent analysis.

The representativeness of the sample was checked in order to examine if the sample does not deviate too much of the population of South Holland. Even though a non-probability sampling method was used, this does not mean that the sample cannot be representative for the population. From the results, it can be concluded that the sample is fairly representative for the population of South Holland. Although the sample is fairly representative for the province of South Holland, results should be interpreted with care because there is a selective bias as a result of the use of an online panel.

6.2.2 Exploration of respondents' answers

The **context factors** were obtained from the introduction questions of the survey. The frequency distribution of respondents' answers on these introduction questions is visualised in Figure 6.1.

First, the trip purpose was asked. As can be seen in the figure, most respondents (79%) indicated that their most recent trip to the inner city of The Hague was for a recreational purpose. The Hague is a city with many recreational services, which explains the high frequency distribution of recreational trips. A minority of the respondents indicated that their most recent trip to the inner city of The Hague was for a business purpose (13%) or a work purpose (6%). Some respondents (2%) indicated that their most recent trip to the inner city of The Hague was not for business, work or recreational purposes. These respondents indicated that their most recent trip to the inner city of The Hague was to pick-up an online ordered purchase or to visit the hospital.

Second, the trip reimbursement was asked. Most respondents (74%) answered that their parking costs were not reimbursable, followed by not applicable (15%) and reimbursable parking costs (11%). The high frequency of no reimbursable parking costs is in line with the high number of respondents that visited the city for recreational purposes, where parking costs are (most of the time) not reimbursable.

Third, the parking duration during respondents' most recent trip to the inner city of The Hague was asked. Most respondents (74%) indicated that they parked their car for 2-4 hours during their most recent trip to the inner city of The Hague. This is in line with the conclusions in the report 'consumentenonderzoek Den Haag' (2012), where it is stated that an average trip to the inner city of The Hague for recreational purposes takes 2-4 hours (SmartAgent, 2012).

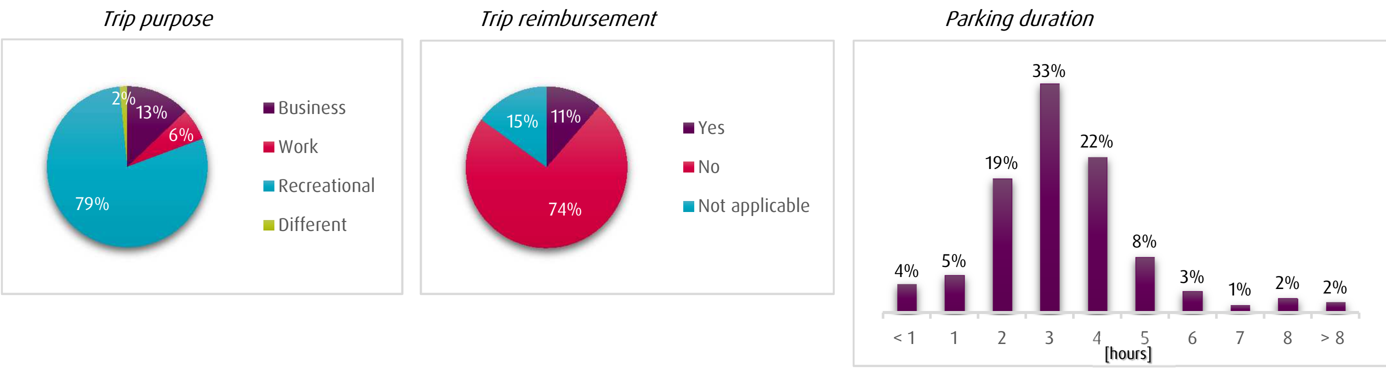

Figure 6.1 Frequency distributions of respondents' answers on the introduction questions: context factors

The answers on the **choice situations** were obtained from the first part of the survey. The distribution of the answers on these questions is visualised in Figure 6.2. For every choice situation (1 – 12) and the total the percentage of the sample choosing PIC and choosing PEC is visualized. From the figure, it can be seen that the answers on the choice situations are quite evenly distributed. A small majority of the respondents choose for PEC in the first (1-3) and last (9-12) choice situations. A small majority choose for PIC in the other choice situations (4-8).

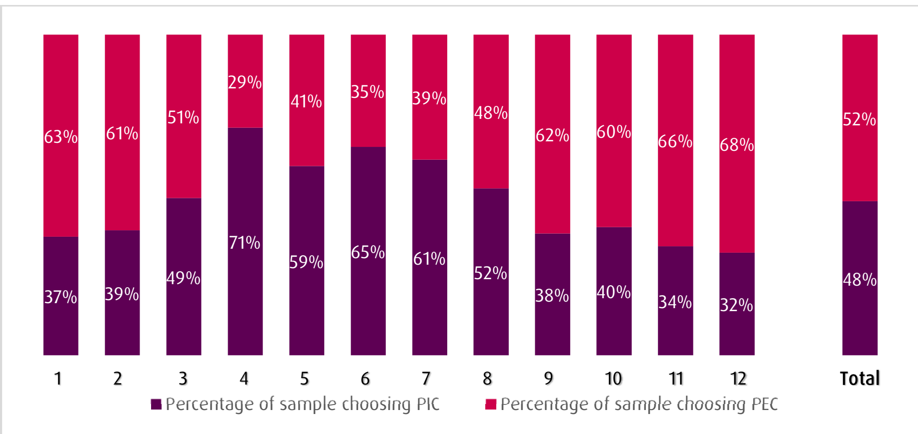

Figure 6.2 Frequency distribution of respondents' answers on the first part of the survey: choice situations

The answers on the **statements** were obtained from the second part of the survey. The distribution of the answers on these questions is visualised in Figure 6.3. The mean score and standard deviation for every statement is shown in Table 6.1. A higher value for the mean score on a statement, means more agreement on that specific statement (1 = strongly disagree and 5 = strongly agree). The numbers of the statements ([1] – [6]) in the figure correspond with the numbers of the statements in the table.

Regarding the statements on the 'trust of the system' (statements [1], [3] and [5]), statements that were negatively formulated ([1] and [5]) have a higher mean score, where the statement that was positively formulated ([3]) has an average mean score. This means that a more negative opinion can be seen for the statements on the trust of the system.

For the statements on the 'use of the system' (statements [2], [4] and [6]), the statement that was negatively formulated ([2]) has a lower mean score, where the statements that positively formulated ([4] and [6]) have a higher mean score. This points out that a more positive opinion can be seen for the statements on the use of the system.

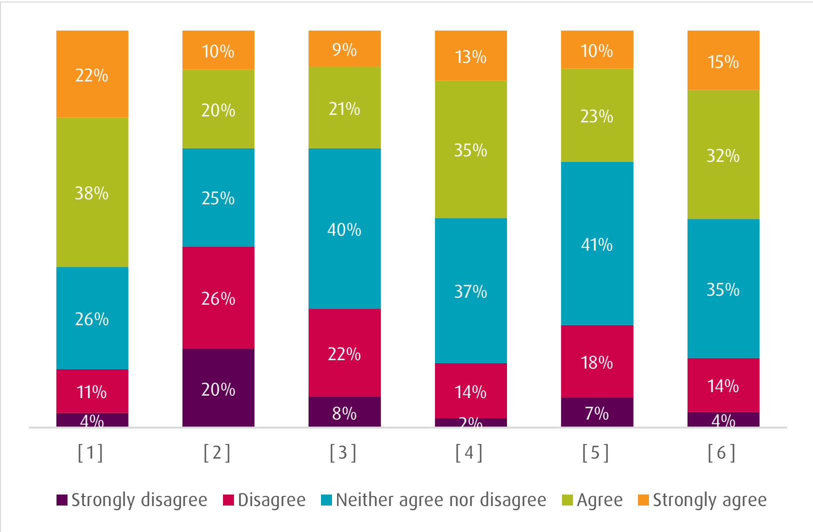

Figure 6.3 Frequency distribution of respondents' answers on the second part of the survey: statements

Table 6.1 Statements with their corresponding mean score and standard deviation

	Statement	Mean score	SD
[1]	I am afraid that dangerous situations may arise when my self-driving car drives between other traffic on the road, such as human-operated cars, bicycles and pedestrians	3.63/5	1.054
[2]	I think it would be difficult to understand how to use my smartphone or laptop to park my self-driving car and plan for the car to arrive	2.74/5	1.256
[3]	I trust the technology of the self-driving car during the empty vehicle trip	3.01/5	1.049
[4]	I think it would be easy to understand how to use a self-driving car	3.41/5	0.956
[5]	I think a self-driving vehicle may not drive as well as a car with a human driver during the empty vehicle trip	3.09/5	1.045
[6]	I like to make use of the latest technology systems	3.41/5	1.024

The higher the mean score, the more strongly agree [1 = strongly disagree, 5 = strongly agree]

6.2.3 Fixed preferences for PIC or PEC

Several respondents have a fixed preference for either PIC or PEC, meaning that they are not influenced by the factors shown in the choice situations. 27.8% (108/388) of the respondents have a fixed preference for either parking in the inner city or parking at the edge of the city. 16.2% (63/388) of the respondents have a fixed preference for parking in the inner city and 11.6% (45/388) of the respondents have a fixed preference for parking at the edge of the city. By means of the program *SPSS*, it was tested if respondents with a fixed preference have personal characteristics, trip characteristics or perceptions in common.

First, it was checked if **personal related characteristics** have a significant influence on the fixed preference for either PIC or PEC. The results of the chi-square tests that were performed for every personal related characteristic to test if the results are significant are shown in Table 6.2. From this table, it can be seen that none of the personal related characteristics give significant results (p-value is always > 0.05). Therefore, it can be concluded that personal related characteristics have no significant influence on the fixed preference for either PIC or PEC.

Table 6.2 Results Chi-square test for personal related characteristics

Personal related characteristic	Pearson Chi-Square	p-value
Gender	0.257	0.880
Age	11.584	0.072
Income	5.316	0.981
Education	9.785	0.134
Purchase value of the car	6.350	0.785
Number of trips	7.009	0.536
Use of automated features	12.411	0.134
Knowledge / experience	2.269	0.686
Interest	3.888	0.692
Parking preference	4.341	0.362
Consider AV for parking	7.660	0.105

Second, it was checked if **trip related characteristics** have a significant influence on the fixed preference for either PIC or PEC. Table 6.3 shows the results of the chi-square tests that were performed for the trip related characteristics: trip purpose, trip duration and trip reimbursement.

The observed counts (O) are the number of respondents that were actually observed for the specific trip characteristic. The expected counts (E) are the expected number of respondents that would be observed for the specific trip characteristic if there is no relation between the fixed preference and the trip characteristics. For example, it is observed that 13 respondents who have a fixed preference for PIC had business as a trip purpose. If there is no relation between the trip purpose and the fixed preference, it would be expected that there are 8.1 respondents with a fixed preference for PIC who have business as a trip purpose. As can be seen in Table 6.3, the observed counts differ from the expected counts. The Chi-square test helps to determine if the observed counts are different enough for the association to be significant. From the Chi-square test results, it can be seen that trip related characteristics have significant influence on the fixed preference for either PIC or PEC ($p < 0.05$). It is observed that individuals with a business trip more often have a fixed preference for PIC. In addition, it is observed that individuals with a recreational trip more often have a fixed preference for PEC. Furthermore, it is observed that the number of fixed preferences for PIC is higher for individuals with a short trip duration compared to a lower number of fixed preferences for PEC. In addition, it can be seen that individuals with a reimbursable trip more often have a fixed preference for PIC. However, results have to be interpreted with care, because the chi-square assumption is violated: there are too many cells with expected count less than 5.

Table 6.3 Results Chi-square test for trip related characteristics

Fixed preference		Trip purpose				Trip duration			Trip reimbursement			Total # respon-dents
		Business	Work	Recreation	Different	Short (≤ 3 hours)	Medium (4–5 hours)	Long (6 ≥ hours)	Yes	No	Not applicable	
PIC	(O)	13	4	42	4	46	10	7	13	44	6	63
	(E)	8.1	4.1	49.8	1.0	39.0	19.2	4.9	7.1	46.4	9.4	
	(%)	20.6%	6.3%	66.7%	6.3%	73.0%	15.9%	11.1%	20.6%	69.8%	9.5%	
PEC	(O)	2	3	39	1	20	18	7	2	32	11	45
	(E)	5.8	2.9	35.6	0.7	27.8	13.7	3.5	5.1	33.2	6.7	
	(%)	4.4%	6.7%	86.7%	2.2%	44.4%	40.0%	15.6%	4.4%	71.1%	24.4%	
No fixed preference	(O)	35	18	226	1	174	90	16	29	210	41	280
	(E)	36.1	18.0	221.5	4.3	173.2	85.2	21.6	31.8	206.4	41.9	
	(%)	12.5%	6.4%	80.7%	0.4%	62.1%	32.1%	5.7%	10.4%	75.0%	14.6%	
		Pearson Chi-Square = 19.201 df = 6 p = 0.004 5 cells (41.7%*) have expected count less than 5.				Pearson Chi-Square = 15.460 df = 4 p = 0.004 2 cells (22.2%*) have expected count less than 5.			Pearson Chi-Square = 11.130 df = 4 p = 0.025 0 cells (0%*) have expected count less than 5.			

* *If higher than 20%, then assumption chi-square is violated*

Third, it was checked if **perceptions on the risk of damage during the empty vehicle driving trip** have a significant influence on the fixed preference for either PIC or PEC. Three statements in the survey tested respondents' perceptions on automated driving regarding the empty vehicle driving trip (which is different for parking in the inner city and parking at the edge of the city). All statements that were negatively formulated were reversed, making all statements positively formulated. The mean scores for every statement for the fixed preference for PIC, PEC and for no fixed preference were calculated and shown in Table 6.4. A higher mean score indicates a higher trust in the empty vehicle driving trip.

For every statement in Table 6.4, the mean score for the fixed preference for PEC is higher than for PIC. In this table it can be seen that respondents who have a fixed preference for PEC have a slightly higher trust in the empty vehicle driving trip than respondents with a fixed preference for PIC. In addition, it can be seen that respondents with no fixed preference have a slightly higher trust in the empty vehicle driving trip than respondents with a fixed preference for PIC and PEC. An ANOVA (analysis of variances) test in *SPSS* was conducted to test if the results between the three groups are significant. The p-values are listed in Table 6.4. From these values, it can be concluded that the results are not significant. Therefore, it can be concluded that perceptions on AV regarding the empty vehicle driving trip have no significant influence on the fixed preference for either PIC or PEC.

Table 6.4 Mean scores for trust in the empty vehicle driving trip for respondents with a fixed preference

Fixed preference	Mean score statement 1 I am not afraid that dangerous situations may arise when my self-driving car drives between other traffic on the road, such as human-operated cars, bicycles and pedestrians	Mean score statement 3 I trust the technology of the self-driving car during the empty vehicle trip	Mean score statement 5 I think a self-driving vehicle drive as well as a car with a human driver during the empty vehicle trip
PIC	2.14	2.79	2.68
PEC	2.36	2.96	2.80
No fixed preference	2.42	3.07	2.98
	p = 0.166	p = 0.161	p = 0.102

6.3 MODEL ESTIMATION

Respondents' answers on the choice situations in the first part of the questionnaire were used as input for the model estimation, which is discussed in this section. With the data collected from the choice situations, the influence of the different attributes on drivers' parking location choice can be estimated. First, a short description of the Multinomial Logit (MNL) model and the motivation for using the MNL model is described (paragraph 6.3.1). Second, different MNL models are estimated (paragraph 6.3.2). Third, the results of the best MNL model are interpreted (paragraph 6.3.3).

6.3.1 Multinomial Logit Model

In discrete choice theory, the Multinomial Logit (MNL) Model is the most widely used model. As was discussed in section 2.1 and Appendix B, reviewed research on CVs used mainly MNL models to predict drivers' parking behaviour (e.g. (Axhausen & Polak, 1991) (Bonsall & Palmer, 2004)). Therefore, the MNL model will also be used in this research to predict drivers' parking location choice in the case of private highly AVs. A MNL model states the probability that an individual i chooses alternative j (Equation 6.2). A disadvantage of MNL models is that they assume homogeneity in preferences. This can be overcome by including characteristics that might be of influence on drivers' parking location choice as interaction variables in the models. This will be further explained in section 6.4.

$$p_{ij} = \frac{e^{V_{ij}}}{\sum_{m \in S_i} e^{V_{im}}} \tag{6.2}$$

Where:
p_{ij} = probability that an individual i chooses alternative j
V_{ij} = utility of individual i to choose alternative j
S_i = the choice set of m alternatives of individual i

For discrete choice models, the *likelihood ratio index* is often used to measure how well the models fit the data. The value of the likelihood ratio index indicates how well the estimated model performs, compared to a model in which all parameters are zero. The likelihood ratio index is based on the value of the log-likelihood of the estimated model and the value of the log-likelihood of the null model. This ratio can be calculated with Equation 6.3. The higher the final log-likelihood, the better the model fits the data (Train, 2002).

$$\rho^2 = 1 - \frac{LL\,(\beta)}{LL\,(0)} \tag{6.3}$$

Where:

ρ^2 = likelihood ratio index
LL (β) = final log-likelihood (value log-likelihood of the estimated model)
LL (0) = init log-likelihood (value log-likelihood of the null model)

6.3.2 MNL model estimations

Different MNL models were estimated using the *Biogeme* software to find the model that fits the data the best. The results of the MNL model estimations are included in Appendix G.

In Table 5.5, the attributes and their levels are shown which were used in the SP final survey. 'Parking cost' and 'risk of extra waiting time' are continuous variables. The real attribute level values were used in the MNL model estimation. The parameters for these attributes can therefore be interpreted as follows: if parking price increases one unit, utility increases with the parameter value.

'Surveillance of the parking facility' and 'risk of parking fee' have nominal attribute levels. As a result, the parameter values cannot be interpreted in the same manner as continuous variables. The nominal attributes are coded as dummy variables, where one attribute level is coded as the reference attribute level. The parameters represent the utility difference with respect to the reference level. When dummy coding is used, L levels are coded by L-1 indicator variables (Molin, SPM4612 Lecture 4 - Efficient designs & coding, 2015f). 'Surveillance of the parking facility' has three attribute levels: the highest attribute level is coded with {1 0}, the middle attribute level is coded with {0 1} and the lowest attribute level is coded with {0 0}. Two parameters (indicator variables) are estimated for this attribute. 'Risk of parking fee' has two attribute levels: the highest attribute level is coded with {1} and the lowest attribute level is coded with {0}. One parameter (one indicator variable) is estimated for this attribute. The dummy coding schemes for the 'surveillance of the parking facility' and 'risk of parking fee' are shown in Table 6.5 and Table 6.6 respectively.

Table 6.5 Dummy coding scheme for 'surveillance of the parking facility'

Levels	SURV_PERS	SURV_CAM
Level 2: personnel surveillance	1	0
Level 1: camera surveillance	0	1
Level 0: no surveillance	0	0

Table 6.6 Dummy coding scheme for 'risk of parking fee'

Levels	FEE
Level 1: parking fee	1
Level 0: no parking fee	0

The goodness of fit of the models was checked with the value of ρ^2. However, not all models have the same number of parameters. When it is desired to compare different models, the adjusted ρ^2 can be used, that corrects for the number of parameters (Louviere, Henscher, & Swait, 2000). The highest adjusted rho-square is 0.044, which is a low value. The low model fit might be the result of unobserved attributes or because the model does not test for heterogeneity. In section 6.4, heterogeneity is considered in the MNL model estimation by including personal characteristics, trip characteristics and perceptions on automated driving as interaction variables in the MNL model. It is expected that the model fit will increase by the implementation of these aspects. Furthermore, it is important that the model has sufficient significant parameters, is understandable and is logical.

The MNL model with the inclusion of all alternative specific parameters and quadratic parameter components for all continuous variables has the best model fit (i.e. the highest final log-likelihood and the highest adjusted rho-square). However, in this model only 4 out of 12 parameters are significant and not all parameters have a logical parameter value. The MNL model where 1) all parameters are significant, 2) has logical parameter values but 3) has a slightly lower final log-likelihood, is chosen as the model that explains the data the best. Although the model fit is low, all parameters are significant. This means that all attributes influence drivers' parking location choice. However, results are varying substantial per individual. This model will be further explained in the subsequent paragraph.

6.3.3 Interpretation of the best MNL model

The model that explains the data the best, only consists of significant parameters. When a parameter is significant, it is possible to generalize the results for the population. For the PIC alternative, the linear alternative specific parameter component for 'parking cost' and the alternative specific parameter for 'personnel surveillance' are incorporated. For the

PEC alternative, the alternative specific parameter for the linear and quadratic components, the alternative specific parameter for 'personnel surveillance', the alternative specific parameter for the linear component for 'risk of extra waiting time' and the alternative specific parameter for 'risk of parking fee' are incorporated. The utility functions for the PIC and PEC alternatives for the best MNL model are presented in Equation 6.4 and 6.5.

$$U_{PIC} = asc + \beta_{COSTI} * COSTI + \beta_{PSI} * PERS\_SURV\_I + \varepsilon \tag{6.4}$$

$$U_{PEC} = \beta_{COSTE\_L} * COSTE + \beta_{COSTE\_Q} * COSTE^2 + \beta_{PSE} * PERS\_SURV\_E + \beta_{WAIT} * WAIT + \beta_{FEE} * FEE + \varepsilon \tag{6.5}$$

Where:

U_{PIC} = utility of alternative: parking in the inner city
U_{PEC} = utility of alternative: parking at the edge of the city
asc = alternative specific constant
β_{COSTI} = alternative specific parameter for the variable 'parking cost' in the inner city (COSTI)
β_{PSI} = alternative specific parameter for the variable 'personnel surveillance' in the inner city (PERS_SURV_I)
β_{COSTE_L} = alternative specific parameter for the linear component of 'parking cost' at the edge of the city (COSTE)
β_{COSTE_Q} = alternative specific parameter for the quadratic component of 'parking cost' at the edge of the city ($COSTE^2$)
β_{PSE} = alternative specific parameter for the variable 'personnel surveillance' at the edge of the city (PERS_SURV_E)
β_{WAIT} = alternative specific parameter for the variable 'risk of extra waiting time' (WAIT)
β_{FEE} = alternative specific parameter for the variable 'risk of parking fee' (FEE)
ε = random error component

The Biogeme model file that was needed to run the model in *Biogeme* is included in Appendix G. The results and the values of the estimated model with all parameters are shown in Table 6.7 and Table 6.8 respectively.

Table 6.7 Results model estimation: model with all parameters

Model:	Multinomial logit
Number of estimated parameters:	8
Number of observations:	4656
Number of individuals:	4656
Null log-likelihood	-3227.293
Cte log-likelihood	-3223.497
Init log-likelihood	-3227.293
Final log-likelihood	-3077.152
Likelihood ratio test	300.283
Rho-square	0.047
Adjusted rho-square	0.044

Table 6.8 Values model estimation: model with all parameters

	Parameter name	Parameter	Parameter estimate	Robust Std err	Robust t-test	p-value
PIC	asc	asc	0.672	0.155	4.32	0.00*
	Parking cost	β_{costi}	-0.484	0.0401	-12.07	0.00*
	Surveillance of the parking facility	β_{psi}	0.248	0.0755	3.29	0.00*
PEC	Parking cost	β_{coste_l}	0.0808	0.0371	2.18	0.03*
		β_{coste_q}	-0.0202	0.00449	-4.50	0.00*
	Surveillance of the parking facility	β_{pse}	0.184	0.0736	2.50	0.01*
	Risk of extra waiting time	β_{wait}	-0.100	0.0207	-4.84	0.00*
	Risk of parking fee	β_{fee}	-0.806	0.0708	-11.39	0.00*

* *Significant on a 95% confidence interval ($p < 0.05$)*

First, it should be noted that **all parameters are significant** on a 95% confidence interval ($p < 0.05$). When a parameter is significant, it is possible to generalize the results for the population. As was already mentioned in section 6.2, the sample is not completely representative for the population. Therefore, results should be interpreted with care.

Second, it should be noted that **all parameters have a logical sign**. 'Parking cost' (PIC), 'risk of extra waiting time' and 'risk of parking fee' have a negative parameter estimate, which indicates that utility will decrease if the attribute level increases. 'Personnel surveillance' (PIC and PEC) has a positive parameter estimate, which indicates that utility will increase if the attribute level increases. The asc has a positive sign, which means that parking in the inner city is preferred if all nominal attributes have reference levels and all continuous attributes have an attribute level of 0. The first parameter for 'parking cost' (PEC) has a positive value, which means that utility first starts to increase. The second parameter for 'parking cost' (PEC) has a negative value, which means that the decrease in utility is getting larger when the 'parking cost' is getting higher.

Third, the parameter estimates are interpreted. The parameter estimates have to be compared with each other, because the estimates are relative values.

First, the parameter estimates for the PIC alternative are interpreted. The estimate for the asc denotes the utility of the PIC alternative, in which all nominal attributes have reference levels and in which all continuous attributes have an attribute level of 0. This scenario shows that parking in the inner city is preferred over parking at the edge of the city. The parameter estimate for 'parking cost' in the PIC alternative is -0.484 which indicates that when the 'parking cost' in the inner city will be increased with €1 per hour, utility will decrease with 0.484 utils. Because utility decreases linearly with the increasing 'parking cost', it means that when 'parking cost' in the inner city are decreased with €1 per hour, utility increases with 0.484 utils. The parameter estimate for 'personnel surveillance' is 0.248, which indicates that when 'personnel surveillance' is available in the parking facility located in the inner city, utility increases with 0.248 utils. The parameter estimate for 'camera surveillance' is not significant, meaning that 'camera surveillance' is valued in the same manner as 'no surveillance'.

Second, the parameter estimates for the PEC alternative are interpreted. The estimated parameters for the linear and quadratic components of 'parking cost' are 0.0808 and -0.0202 respectively. Utility does not increase linearly with the increase in 'parking cost' at the edge of the city, because the parameter for the quadratic component is significant. The quadratic component has a negative value, thus the curve for 'parking cost' at the edge of the city is concave down. This means that utility will decrease faster when the 'parking cost' is further increased. The parameter estimate for 'personnel surveillance' is 0.184, which indicates that when 'personnel surveillance' is available in the parking facility located at the edge of the city, utility increases with 0.184 utils. It was expected that utility of 'personnel surveillance' at the edge of the city would be higher than the utility of 'personnel surveillance' in the inner city, because the parking facility at the edge of the city is located in a more remote area. The parameter estimate for 'camera surveillance' is not significant, which means that 'camera surveillance' is valued in the same manner as 'no surveillance'. The parameter estimate for 'risk of extra waiting time' is -0.100, which indicates that when the 'risk of extra waiting time' increases with 1 out of 10 times, utility will decrease with 0.100 utils. The 'risk of waiting time' can, for example, increase when there is more congestion on the distributor roads between the edge of the city and the inner city. Utility decreases linearly with the increasing 'risk of extra waiting time', which means that when the 'risk of extra waiting time' decreases with 1 out of 10 times, utility increases with 0.100 utils. The 'risk of extra waiting time' can, for example, decrease when the chance of congestion reduces or when separate lanes for AVs are implemented between the inner city and the edge of the city. The parameter estimate for the 'risk of parking fee' is -0.806, which indicates that when a fee of €20 is implemented for temporary parking the vehicle near the final passenger's destination, utility will decrease with 0.806 utils.

6.4 INFLUENCE OF PERSONAL CHARACTERISTICS, TRIP CHARACTERISTICS AND PERCEPTIONS

MNL models assume homogeneity in preferences. However, different individuals might have different preferences (under different circumstances) in a systematic way. In this this section, heterogeneity is taken into account by including personal characteristics (paragraph 6.4.1), trip characteristics (paragraph 6.4.2) and perceptions on automated driving (paragraph 6.4.3) as interaction variables in the MNL model. The effects of the characteristics on the attributes that influence drivers' parking location choice is estimated. An interpretation of the effects of the characteristics is included in this section (paragraph 6.4.4).

All interaction variables were effect coded. This means that the segments in the categories were coded with {-1}, {0} and {1}. For every characteristic, the effect coding scheme is given in the corresponding paragraph. When using effect coding for the variables, a parameter can be estimated for every segment in the category. When dummy coding would be used, every parameter needs to be interpreted with the reference level, which is not convenient for explaining the interaction effect. The personal characteristics, trip characteristics and perceptions may affect the alternative specific constant and the alternative specific attribute parameters. Therefore, an interaction effect was estimated on the constant and on the attribute parameters. To find the effect of each characteristic, the variables of the personal characteristics, trip characteristics and perceptions were incorporated sequentially in the MNL model which was estimated in section 6.3. Although the parameter for 'camera surveillance' was not significant in the MNL model that was described in section 6.3, it is expected that 'camera surveillance' might have interaction effects with the characteristics described above. Therefore, the alternative specific parameter for 'camera surveillance' was included in the interaction models. It was tested if the parameters of the interaction effects are significant on a 95% confidence interval.

6.4.1 Model results of the interaction with personal characteristics

Individuals might have different preferences for the parking location choice. The aim of this paragraph is to examine if, and to what extent, different personal characteristics have an effect on factors that influence drivers' parking location choice. The personal characteristics were obtained from the general questions in the questionnaire. Examples of the utility functions for the PIC and PEC alternative where gender is incorporated in the MNL model are presented in Equations 6.6 and 6.7. The effect coding scheme for the personal characteristics is shown in Table 6.9.

$$U_{PIC} = asc + \beta_{gender} * GENDER + \beta_{COSTI} * COSTI + \beta_{PSI} * PERS\_SURV\_I + \beta_{CSI} * CAM\_SURV\_I + \beta_{genderCOSTI} * COSTI * GENDER + \beta_{genderPSI} * PERS\_SURV\_I * GENDER + \beta_{genderCSI} * CAM\_SURV\_I * GENDER + \varepsilon \tag{6.6}$$

$$U_{PEC} = \beta_{COSTE\_L} * COSTE + \beta_{COSTE\_Q} * COSTE^2 + \beta_{PSE} * PERS\_SURV\_E + \beta_{CSE} * CAM\_SURV\_E + \beta_{WAIT} * WAIT + \beta_{FEE} * FEE + \beta_{genderCOSTEL} * COSTE * GENDER + \beta_{genderCOSTEQ} * COSTE^2 * GENDER + \beta_{genderPSE} * PERS_{SURV_E} * GENDER + \beta_{genderCSE} * CAM\_SURV\_E * GENDER + \beta_{genderWAIT} * WAIT * GENDER + \beta_{genderFEE} * FEE * GENDER + \varepsilon \tag{6.7}$$

Table 6.9 Effect coding scheme for the personal characteristics

Gender	**GENDER**			
Female	1			
Male	-1			
Age	**AGE1**	**AGE2**	**AGE3**	
65 ≥ (≤ 1951)	1	0	0	
45 – 64 (1971 – 1952)	0	1	0	
25 – 44 (1991 – 1972)	0	0	1	
18 – 24 (1992 ≤)	-1	-1	-1	
Income	**INC1**	**INC2**	**INC3**	
€60,000 >	1	0	0	
€40,000 - €60,000	0	1	0	
€20,000 - €40,000	0	0	1	
< €20,000	-1	-1	-1	
Education	**EDU1**	**EDU2**	**EDU3**	
WO	1	0	0	
HBO	0	1	0	
MBO	0	0	1	
Primary / secondary school	-1	-1	-1	
Purchase value of the car	**PURC1**	**PURC2**	**PURC3**	**PURC4**
€20,000 >	1	0	0	0
€15,000 - €20,000	0	1	0	0
€10,000 - €15,000	0	0	1	0
€5,000 - €10,000	0	0	0	1
< €5,000	-1	-1	-1	-1
Average number of trips to inner city with own car	**NTRIP1**	**NTRIP2**	**NTRIP3**	**NTRIP4**
One or several trips per day	1	0	0	0
One or several trips per week	0	1	0	0
One or several trips per month	0	0	1	0
One or several trips per year	0	0	0	1
Less than one trip per year	-1	-1	-1	-1
Use of automated features	**AF1**	**AF2**	**AF3**	
Use of advanced automated features	1	0	0	
Use of limited automated features	0	1	0	
Use of very limited automated features	0	0	1	
No use of automated features	-1	-1	-1	
Knowledge / experience	**KNEX1**	**KNEX2**		
Knowledge / experience	1	0		
Knowledge / no experience	0	1		
No knowledge / no experience	-1	-1		
Interest	**INT1**	**INT2**		
Professionally active	1	0		
Interested	0	1		
Not interested	-1	-1		

As an example, the Biogeme model file for the interaction with gender is included in Appendix G. The parameter values of the estimated interaction model are shown in Table 6.10. The parameters for the interaction effects indicate the change in the main parameter due to the personal characteristics. For example, the interaction effect of the personal characteristic 'income' (€60,000 >) with the 'risk of extra waiting time' is -0.101. The negative parameter for the interaction effect (on the already negative main parameter) indicates that individuals with a high income are more sensitive for the 'risk of extra waiting time'. The values for the robust standard error, t-test and p-values are listed in Appendix G.

Table 6.10 Interaction effects on personal characteristics

	PIC				PEC					
	asc	Parking cost	Personnel surveillance	Camera surveillance	Parking cost	Parking cost²	Personnel surveillance	Camera surveillance	Risk of extra waiting time	Risk of parking fee
Gender										
Main parameter	0.548*	-0.499*	0.301*	0.110	0.102*	-0.0235*	0.117*	-0.116	-0.110*	-0.849*
Female	-0.255	0.0119	0.0683	0.0904	-0.0257	0.00289	0.0537	0.0111	-0.0135	-0.0791
Male	0.255	-0.0119	-0.0683	-0.0904	0.0257	-0.00289	-0.0537	-0.0111	0.0135	0.0791
Age										
Main parameter	0.499*	-0.505*	0.348*	0.151	0.0845	-0.0214*	0.133*	-0.0998	-0.111*	-0.847*
18 – 24 (1992 ≥)	-0.17157	-0.0578	0.004	0.2132	-0.1231	0.01242	-0.0317	0.0754	-0.0297	-0.1148
25 – 44 (1991 – 1972)	-0.00423	0.0760	-0.110	-0.0893	-0.0158	0.00200	-0.0662	0.0136	0.0130	0.0625
45 – 64 (1971 – 1952)	0.245	-0.0707	-0.118	-0.0418	0.0605	-0.00802	-0.0121	-0.0638	-0.0176	-0.0787
65 ≥ (≤ 1951)	-0.0692	0.0525	0.224	-0.0821	0.0784	-0.00640	0.110	-0.0252	0.0343	0.131
Income										
Main parameter	0.592*	-0.509*	0.304*	0.0949	0.0987*	-0.0245*	0.0943	-0.128	-0.113*	-0.822*
< €20,000	-0.1986	0.0258	0.3057	0.1359	0.0316	-0.00601	-0.0078	-0.0061	0.0335	0.0922
€20,000 – €40,000	0.0886	0.0137	-0.0824	-0.0103	-0.0249	0.00671	0.0281	0.0644	0.0456	0.111
€40,000 - €60,000	0.309	-0.0283	-0.0483	-0.0488	0.0707	-0.0108	-0.101	0.0292	0.0219	-0.0972
€60,000 >	-0.199	-0.0112	-0.175	-0.0768	-0.0774	0.0101	0.0807	-0.0875	-0.101*	-0.106
Education										
Main parameter	0.554*	-0.483*	0.283*	0.116	0.0960*	-0.0231*	0.118*	-0.105	-0.109*	-0.817*
Primary / secondary school	0.0456	0.0284	0.0635	0.12763	0.0176	0.00222	0.0269	-0.0819	0.0282	0.0361
MBO	-0.0736	-0.0456	0.0168	0.0769	0.0110	0.000350	0.0157	-0.0657	0.00172	-0.0661
HBO	0.142	-0.0763	0.0447	-0.203	0.0224	-0.00535	-0.0297	0.0326	-0.0237	-0.117
Bachelor / Master WO	-0.114	0.0935	-0.125	-0.00153	-0.0510	0.00278	-0.0129	0.115	-0.00622	0.147
Purchase value of the car										
Main parameter	0.608*	-0.504*	0.286*	0.0998	0.109*	-0.0248*	0.103	-0.103	-0.109*	-0.798*
< €5,000	-0.2845	0.0322	0.2092	0.3869	-0.14143	0.01256	0.0556	0.05958	0.009	0.035
€5,000 - €10,000	0.00340	-0.0882	0.0622	-0.0660	0.0268	-0.00526	0.0474	-0.0701	-0.0275	-0.211
€10,000 - €15,000	0.0205	-0.0131	-0.124	-0.104	0.0291	-0.00239	0.0297	-0.0489	-0.0344	-0.177
€15,000 - €20,000	0.293	0.0121	-0.174	-0.186	0.0935	-0.0100	-0.149	0.0666	0.114*	0.201
€20,000 >	-0.0324	0.0570	0.0266	-0.0309	-0.00797	0.00509	0.0163	-0.00718	-0.0611	0.152
Average number of trips to inner city with car										
Main parameter	0.527*	-0.462*	0.302*	0.122	0.102	-0.0231*	0.139*	-0.131	-0.0863*	-0.789*
Less than one trip per year	-0.745	-0.0247	0.02083	0.2583	-0.16209	0.01535	0.07997	-0.0295	0.0726	-0.274833
One or several trips per year	0.154	-0.109	0.00377	-0.0371	0.0430	-0.00561	-0.0429	0.0235	-0.0412	-0.110
One or several trips per month	0.127	-0.0197	-0.0678	-0.0344	-0.0644	0.00697	-0.00647	0.0328	-0.0474	-0.0352
One or several trips per week	-0.241	0.0905	0.138	-0.0588	0.00649	-0.00191	-0.0417	-0.0102	-0.0283	-0.000967
One or several trips per day[a]	0.705	0.0629	-0.0948	-0.128	0.177	-0.0148	0.0111	-0.0166	0.0443	0.421
Use automated features while driving										
Main parameter	0.733*	-0.521*	0.443*	0.306	0.135	-0.0271*	0.0768	-0.158	-0.132*	-0.819*
No use of AF**	-0.1449	-0.0175	-0.159	-0.172	-0.0438	0.00256	-0.004	0.0183	0.03908	-0.166
Use of very limited AF**	-0.0661	0.00240	-0.270	-0.315	-0.0309	0.00587	0.122	0.120	0.00909	0.241
Use of limited AF**	0.106	-0.0341	0.171	-0.234	0.0467	-0.00350	0.121	-0.0538	0.00603	-0.438*
Use of advanced AF**	0.105	0.0492	0.258	0.721	0.0280	-0.00493	-0.239	-0.0845	-0.0542	0.363
Knowledge / Experience										
Main parameter	0.425	-0.315*	0.359	0.317	0.0162	-0.0117	0.0725	0.0478	-0.00265	-0.744*
No knowledge / no experience	0.268	-0.203	-0.2391	-0.384	0.1503	-0.0174	0.1355	-0.285	-0.129	-0.114
Knowledge / no experience	0.140	-0.203	-0.0409	-0.209	0.0877	-0.0125	0.0355	-0.166	-0.115	-0.117
Knowledge / experience[a]	-0.408	0.406*	0.280	0.593	-0.238	0.0299	-0.171	0.451	0.244*	0.231
Interest in AVs										
Main parameter	1.01	-0.496*	0.269	0.0818	0.209	-0.0307	0.220	-0.122	-0.0288	-0.877*
Not interested	-0.626	0.0624	0.114	0.04827	-0.100	0.00844	-0.1984	0.0515	-0.0607	-0.0035
Interested	-0.328	-0.0475	-0.0348	0.00873	-0.119	0.00676	-0.0276	-0.0276	-0.0993	0.0515
Professionally active[a]	0.954	-0.0149	-0.0792	-0.0570	0.219	-0.0152	0.226	-0.0239	0.160	-0.0480

** Significant on a 95% confidence interval ($p < 0.05$); [a] N < 30; AF** = automated features*

From the results presented in Table 6.10, it can be seen that four parameters for the interaction effects are found to be significant on a 95% confidence interval:

- Income (€60,000 ≥) - 'risk of extra waiting time': Individuals with a high income are more sensitive for 'risk of extra waiting time'.
- Purchase value car (€15,000-€20,000) – 'risk of extra waiting time': Individuals with a relatively high purchase value of the car are less sensitive for 'risk of extra waiting time'.
- Use of automated features while driving (use of limited automated features) – 'risk of parking fee': Individuals which use limited automated features while driving are more sensitive to the 'risk of parking fee'. Examples of limited automated features are anti-lock braking system and sensors that measure distances to objects.
- Interest in AVs (knowledge/experience) – 'parking cost' (PIC): Individuals who have driven in an AV before are less sensitive for the 'parking cost' in the inner city.

It should be noted that in some cases the parameter for the interaction effect is significant while the main parameter is not. This means that the effect only plays a role under specific circumstances and is not the same for every individual.

6.4.2 Trip characteristics

As was discussed in section 3.3, individuals might have different preferences for different trip characteristics. The aim of this paragraph is to examine if and to what extent trip characteristics, presented in the conceptual framework, have an effect on factors that influence drivers' parking location choice. The trip purpose, trip duration and trip reimbursement were obtained from the introduction questions in the questionnaire. Examples of the utility functions for the PIC and PEC alternative where the trip purpose is incorporated in the MNL model are presented in Equations 6.8 and 6.9. The effect coding scheme for trip purpose and trip reimbursement is shown in Table 6.11. The real attribute levels are used for the trip duration.

$$\begin{aligned} U_{PIC} = {} & asc + \beta_{business} * BUSINESS + \beta_{work} * WORK + \beta_{recreational} * RECREATIONAL \\ & + \beta_{COSTI} * COSTI + \beta_{PSI} * PERS\_SURV\_I + \beta_{CSI} * CAM\_SURV\_I \\ & + \beta_{businessCOSTI} * COSTI * BUSINESS + \beta_{workCOSTI} * COSTI * WORK + \beta_{recreationalCOSTI} * COSTI * RECREATIONAL \\ & + \beta_{businessPSI} * PERS\_SURV\_I * BUSINESS + \beta_{workPSI} * PERS\_SURV\_I * WORK + \beta_{recreationalPSI} * PERS\_SURV\_I * RECREATIONAL \\ & + \beta_{businessCSI} * CAM\_SURV\_I * BUSINESS + \beta_{workCSI} * CAM\_SURV\_I * WORK + \beta_{recreationalCSI} * CAM\_SURV\_I * RECREATIONAL \\ & + \varepsilon \end{aligned} \tag{6.8}$$

$$\begin{aligned} U_{PEC} = {} & \beta_{COSTE\_L} * COSTE + \beta_{COSTE\_Q} * COSTE^2 + \beta_{PSE} * PERS\_SURV\_E + \beta_{CSE} * CAM\_SURV\_E + \beta_{WAIT} * WAIT + \beta_{FEE} * FEE \\ & + \beta_{businessCOSTEL} * COSTE * BUSINESS + \beta_{workCOSTE} * COSTE * WORK + \beta_{recreationalCOSTE} * COSTE * RECREATIONAL \\ & + \beta_{businessCOSTE\_Q} * COSTE^2 * BUSINESS + \beta_{workCOSTE\_Q} * COSTE^2 * WORK + \beta_{recreationalCOSTE\_Q} * COSTE^2 * RECREATIONAL \\ & + \beta_{businessPSE} * PERS\_SURV\_E * BUSINESS + \beta_{workPSE} * PERS\_SURV\_E * WORK + \beta_{recreationalPSE} * PERS\_SURV\_E * RECREATIONAL \\ & + \beta_{businessCSE} * CAM\_SURV\_E * BUSINESS + \beta_{workCSE} * CAM\_SURV\_E * WORK + \beta_{recreationalCSE} * CAM\_SURV\_E * RECREATIONAL \\ & + \beta_{businessWAIT} * WAIT * BUSINESS + \beta_{workWAIT} * WAIT * WORK + \beta_{recreationalWAIT\_L} * WAIT * RECREATIONAL \\ & + \beta_{businessFEE} * FEE * BUSINESS + \beta_{workFEE} * FEE * WORK + \beta_{recreationalFEE} * FEE * RECREATIONAL \\ & + \varepsilon \end{aligned} \tag{6.9}$$

Table 6.11 Effect coding scheme for the trip characteristics

Trip purpose	TRIPPB	TRIPPW	TRIPPR
Business	1	0	0
Work	0	1	0
Recreation	0	0	1
Different	-1	-1	-1
Trip reimbursement	**TRIPRY**	**TRIPRN**	
Yes	1	0	
No	0	1	
Not applicable	-1	-1	

As an example, the Biogeme model file for the interaction with trip purpose is included in Appendix G. The parameter values of the estimated interaction model are shown in Table 6.12. The parameters for the interaction effects indicate the change in the main parameter due to the trip characteristics. The values for the robust standard error, t-test and p-values are included in Appendix G.

Table 6.12 Interaction effects on trip characteristics

	PIC				PEC					
	asc	Parking cost	Personnel surveillance	Camera surveillance	Parking cost	Parking cost^2	Personnel surveillance	Camera surveillance	Risk of extra waiting time	Risk of parking fee
Trip purpose										
Main parameter	0.985	-0.416*	0.314	0.0810	0.00279	-0.00967	0.0851	-0.0472	-0.0527	-0.590*
Business	0.970	-0.201	-0.187	-0.254	0.200	-0.0281	-0.119	-0.0842	-0.0610	0.146
Work[a]	-1.01	-0.00290	0.642	0.709*	-0.0835	0.00871	0.207	-0.112	0.0441	0.0476
Recreation	-0.603	-0.0930	-0.0591	0.0213	0.108	-0.0151	0.0490	-0.0752	-0.0705	-0.375
Different[a]	0.643	0.2969	-0.3959	-0.4763	-0.2245	0.03449	-0.137	0.2714	0.0874	0.1814
Trip duration										
Main parameter	0.887	-0.344*	0.0526	-0.0639	0.0341	-0.0177	0.170	-0.136	-0.115	-0.386
Trip duration	-0.0751	-0.0381	0.0589	0.0380	0.0166	-0.00149	-0.0123	0.00440	0.000649	-0.111*
Trip reimbursement										
Main parameter	0.537*	-0.432*	0.306*	0.0957	0.0734	-0.0186*	0.142*	-0.123	-0.101*	-0.752*
Yes	0.322	0.156	0.0625	-0.0639	-0.0173	0.00534	0.00818	0.0437	0.0278	0.315
No	0.0668	-0.115	-0.00651	0.00768	0.0514	-0.00870	-0.0375	0.00603	-0.0171	-0.160
Not applicable	-0.3888	-0.041	-0.05599	0.05622	-0.0341	0.00336	0.02932	-0.04973	-0.0107	-0.155

** Significant on a 95% confidence interval ($p < 0.05$); [a] N < 30*

From the results presented in Table 6.12, it can be seen that two parameters for the interaction effects are found to be significant on a 95% confidence interval:

- **Trip purpose (work) – 'camera surveillance':** Individuals who go to the inner city to work, prefer a parking facility with camera surveillance.
- **Trip duration – 'risk of parking fee':** Individuals who have a longer trip duration are more sensitive for 'risk of parking fee'.

6.4.3 Perceptions on the risk of damage during the empty vehicle driving trip

As was discussed in section 3.3, individuals with a different perception on the risk of damage during the empty vehicle driving trip might have different preferences for the parking location. The aim of this paragraph is to examine if and to what extent the perception on risk of damage has an effect on factors that influence drivers' parking location choice. The risk of damage was obtained from the statements in the questionnaire. Examples of the utility functions for the PIC and PEC alternative where the perception is incorporated in the MNL model are presented in Equation 6.10 and 6.11.

$$\begin{aligned} U_{PIC} = asc + \beta_{riskofdamage} * RDAM + \beta_{COSTI} * COSTI + \beta_{PSI} * PERS\_SURV\_I + \beta_{CSI} * CAM\_SURV\_I \\ + \beta_{riskofdamageCOSTI} * COSTI * RDAM + \beta_{riskofdamagePSI} * PERS\_SURV\_I * RDAM + \beta_{riskofdamageCSI} * CAM\_SURV\_I * RDAM + \varepsilon \end{aligned} \tag{6.10}$$

$$\begin{aligned} U_{PEC} = \beta_{COSTE\_L} * COSTE + \beta_{COSTE\_Q} * COSTE^2 + \beta_{PSE} * PERS\_SURV\_E + \beta_{CSE} * CAM\_SURV\_E + \beta_{WAIT} * WAIT + \beta_{FEE} * FEE \\ + \beta_{riskofdamageCOSTEL} * COSTE * RDAM + \beta_{riskofdamageCOSTQ} * COSTE^2 * RDAM + \beta_{riskofdamagePSE} * PERS\_SURV\_E * RDAM \\ + \beta_{riskofdamageCSE} * CAM\_SURV\_E * RDAM + \beta_{riskofdamageWAIT} * WAIT * RDAM + \beta_{riskofdamageFEE} * FEE * RDAM + \varepsilon \end{aligned} \tag{6.11}$$

Three statements were formulated in the questionnaire that measure respondents' perceptions on the risk of damage during the empty vehicle driving trip. Respondents were asked to indicate to what extent they agree or disagree with every presented statement. An underlying factor is assumed within the three statements, namely the perception on the risk of damage during the empty vehicle driving trip. A factor analysis was performed in *SPSS,* where the scores on the three statements were combined into one score: the factor score. The aim of the factor analysis is to find the underlying common aspects (latent variables). The factor loadings on the three statements are shown in Table 6.13. The negative factor loading of statement 3 means that the statement is formulated in the opposite direction: statements 1 and 5 are negatively formulated and statement 3 is positively formulated.

Table 6.13 Factor loadings on the three statements

Statement	Risk of damage empty vehicle driving trip	Factor loading
1	I am afraid that dangerous situations may arise when my self-driving car drives between other traffic on the road, such as human-operated cars, bicycles and pedestrians	0.806
3	I trust the technology of the self-driving car during the empty vehicle trip	-0.595
5	I think a self-driving vehicle may not drive as well as a car with a human driver during the empty vehicle trip	0.617

Extraction Method: Principal Axis Factoring. (1 factors extracted. 16 iterations required.)

The factor loadings of statement 3 and 5 are lower than statement 1. Statements 3 and 5 are related to the risk of damage caused by the technology of the automated vehicle itself whereas in statement 1 the cause of the risk of damage might be the result of factors in the environment. This separation was already shown in the conceptual model. An additional factor analysis with only statement 3 and 5 was performed to check if the factor loadings are higher. The factor loadings are presented in Table 6.14.

Table 6.14 Factor loadings on the two statements

Risk of damage (regarding AV itself)	Factor loading
I trust the technology of the self-driving car during the empty vehicle trip	-0.604
I think a self-driving vehicle may not drive as well as a car with a human driver during the empty vehicle trip	0.604

Extraction Method: Principal Axis Factoring. (1 factors extracted. 8 iterations required.)

The factor loadings are not higher than in the previous factor analysis. Therefore, all three factors were combined and a factor variable was created in *SPSS,* which was implemented as an interaction variable in the MNL model. The higher the factor variable, the more afraid is the respondent for risk of damage during the empty vehicle trip.

The Biogeme model file that was needed to run the MNL interaction model in Biogeme is presented in Appendix G. The parameter values of the estimated interaction model are shown in Table 6.15. The parameters for the interaction effects indicate the change in the main parameter due to the perception on the risk of damage. The values for the robust standard error, t-test and p-values are included in Appendix G.

Table 6.15 Interaction effects on perception risk of damage

	PIC				PEC					
	asc	Parking cost	Personnel surveillance	Camera surveillance	Parking cost	Parking cost²	Personnel surveillance	Camera surveillance	Risk of extra waiting time	Risk of parking fee
Perception										
Main parameter	0.569	-0.497*	0.298*	0.106	-0.103*	-0.0235*	0.116*	-0.117	-0.108*	-0.843*
Perception risk of damage	0.00102	0.00125	0.000467	0.000448	0.000140	0.00	-0.000533	0.000929	0.000748*	0.00209*

** Significant on a 95% confidence interval ($p < 0.05$)*

From the results presented in Table 6.15, it can be seen that two parameters for the interaction effects are found to be significant on a 95% confidence interval:

- **Perception risk of damage – 'risk of extra waiting time':** Individuals who are more afraid for risk of damage during the empty vehicle trip are less sensitive for 'risk of extra waiting time'.
- **Perception risk of damage – 'risk of parking fee':** Individuals who are more afraid for risk of damage during the empty vehicle trip are less sensitive for 'risk of parking fee'.

6.4.4 Interpretation of the interaction effects

The model fit of almost all interaction models with personal characteristics slightly decrease with respect to the MNL model without the implementation of the interaction variables. The model fit of the interaction models with trip characteristics and perceptions slightly increases with respect to the MNL model without the implementation of the interaction variables. However, as can be seen from the results in paragraph 6.4.1, 6.4.2 and 6.4.3, only a few interaction parameters are significant on a 95% confidence interval.

Significant parameters

Individuals with a high income are more sensitive for the 'risk of extra waiting time'. This was also expected, where the research pointed out that on average, individuals with a higher income have a higher VoR. Individuals with a relatively high purchase value of the car are less sensitive for the risk of extra waiting time. It could be expected that individuals with a high purchase value of the car also have a high income. Therefore, respondents with an expensive car would be more sensitive for 'risk of extra waiting time'. However, it might be that individuals with a high purchase value of the car find it more important that the car arrives safe at the passenger's destination. In this case, the individual accepts the 'risk of extra waiting time'. Individuals which use limited automated features while driving are more sensitive to the 'risk of parking fee'. Further research is required to understand why individuals with use of limited automated features are more sensitive for the risk of parking fee. Individuals who have driven in an AV before are less sensitive for the 'parking cost' in the inner city. Although this interaction effect is significant, there are only 11 observations for knowledge/experience within the sample. Therefore, it is not possible to draw conclusions on this interaction effect.

Individuals who go to the inner city to work, prefer a parking facility with camera surveillance. When these individuals use the parking facility on a regular base, a more secure parking environment is preferred. Although this interaction effect is significant, there are only 25 observations for work within the sample. Therefore, conclusions on this interaction effect should be interpreted with care. Individuals who have a longer trip duration are more sensitive for 'risk of parking fee'. Further research is required to understand why individuals who have a longer trip duration are more sensitive for the 'risk of parking fee'.

Individuals who consider safety during the empty vehicle trip to be important, are less sensitive for the 'risk of extra waiting time' and the 'risk of parking fee'. Apparently, these individuals care more about the safety circumstances during the empty vehicle trip than about extra time and costs.

Non-significant parameters

From the results on the interaction effects presented in Table 6.10, Table 6.12 and Table 6.15, is can be seen that many interaction effects are not significant. When an interaction effect is not significant, it means that the interaction effect does not play a role. From the results of the MCA, it was expected that more interaction effects would be of influence on drivers' parking location choice. When interaction effects do not play a role, a more generic model can be estimated that works for the same conditions. In this case, only a few interaction effects are significant. Despite their significance, several of these interaction effects were based on a small sample and others cannot be explained. Therefore, it is chosen to conduct the scenario analysis based on the model without the implementation of the interaction variables. This model was presented and discussed in section 6.3.

6.5 MODEL INTERPRETATION

This section describes the model interpretation with the use of the base scenario and the what-if scenarios that were described in section 4.4. The model interpretation is based on the estimated model described in section 6.3, which is the model without the implementation of interaction variables on personal characteristics, trip characteristics and perceptions. First, the base scenario and what-if scenarios are described (paragraph 6.5.1), followed by changes in utilities for different attribute levels (paragraph 6.5.2). Last, the influence of the different what-if scenarios on the distribution of parking demand is described (paragraph 6.5.3).

6.5.1 Base scenario and what-if scenarios

This paragraph discusses the base scenario and the what-if scenarios which were described in section 4.4 in more detail.

Base scenario

In the base scenario, the attribute levels are considered which are present in the current situation. As was described in Chapter 4, the parking costs are €3.5 per hour for parking a vehicle in the inner city and €4 per day for parking a vehicle at the edge of the city. There is camera surveillance available in the parking garages in the inner city in contrast to no surveillance for parking lots at the edge of the city. Assumptions for the 'risk of extra waiting time' and the 'risk of parking fee' are needed because these factors do not exist in the current situation. During off-peak periods, it is assumed that the risk of extra waiting time (10 minutes) is 1 out of 10. Furthermore, it is assumed that no parking fee is asked for temporary parking the private highly AV at an on-street parking place near the passenger destination.

What-if scenarios

The aim of the what-if scenarios is to create a framework on how the results of the estimated model could be used to guide parking policies for the future situation.

- What-if scenario 1: Increase or decrease the parking cost to (de)stimulate a parking facility
  What if the parking cost for parking the private highly AV at a parking facility is increased or decreased? Results from the literature review confirmed that individuals are very sensitive for a change in direct costs. Changing the parking cost is a way to (de)stimulate a certain parking facility. In this scenario, it is examined how sensitive individuals are for an increase or decrease in parking cost. Furthermore, it is explored how the distribution of parking demand will change when the parking cost at both parking facilities is varied.

- **What-if scenario 2: Invest in personnel surveillance at the parking facility**
  What if the circumstances in the parking facility are safer? In this scenario, it is examined how the distribution of parking demand will change when personnel surveillance is available in a parking garage in the inner city or at a parking lot at the edge of the city.
- **What-if scenario 3: Decrease the chance of the vehicle arriving too late**
  What if the reliability of the empty vehicle driving trip is higher and the chance of the vehicle arriving too late is decreased? The reliability of the arrival time will increase when separated lanes for AVs are available. In this scenario, the 'risk of extra waiting time' is varied by varying the chance that a person needs to wait for the vehicle to arrive.
- **What-if scenario 4: Implement a parking fee for the vehicle arriving too early**
  What if a parking fee is asked for temporary parking the private highly AV at an on-street parking place near the passenger's destination? On-street parking places in the inner city of The Hague are scarce and places need to be reserved for drop-off and pick-up manoeuvres. Limited spaces for parking are available and therefore the passenger has to pay for temporary parking the vehicle at an on-street parking place. In this scenario, it is examined how sensitive individuals are for paying a parking fee for temporary parking the private highly AV at an on-street parking place near their destination.

What-if scenarios 1 and 2 are related to the parking facilities and are applicable for both parking in the inner city and parking at the edge of the city. What-if scenarios 3 and 4 are related to the vehicle arriving too early or the vehicle arriving too late at the pick-up point respectively. These scenarios are only applicable for parking at the edge of the city because the reliability of arrival time might be low due to circumstances during the empty vehicle driving trip between the parking facility at the edge of the city and the passenger's destination in the inner city. A visualisation of the attributes present in the what-if scenarios is shown in Figure 6.4.

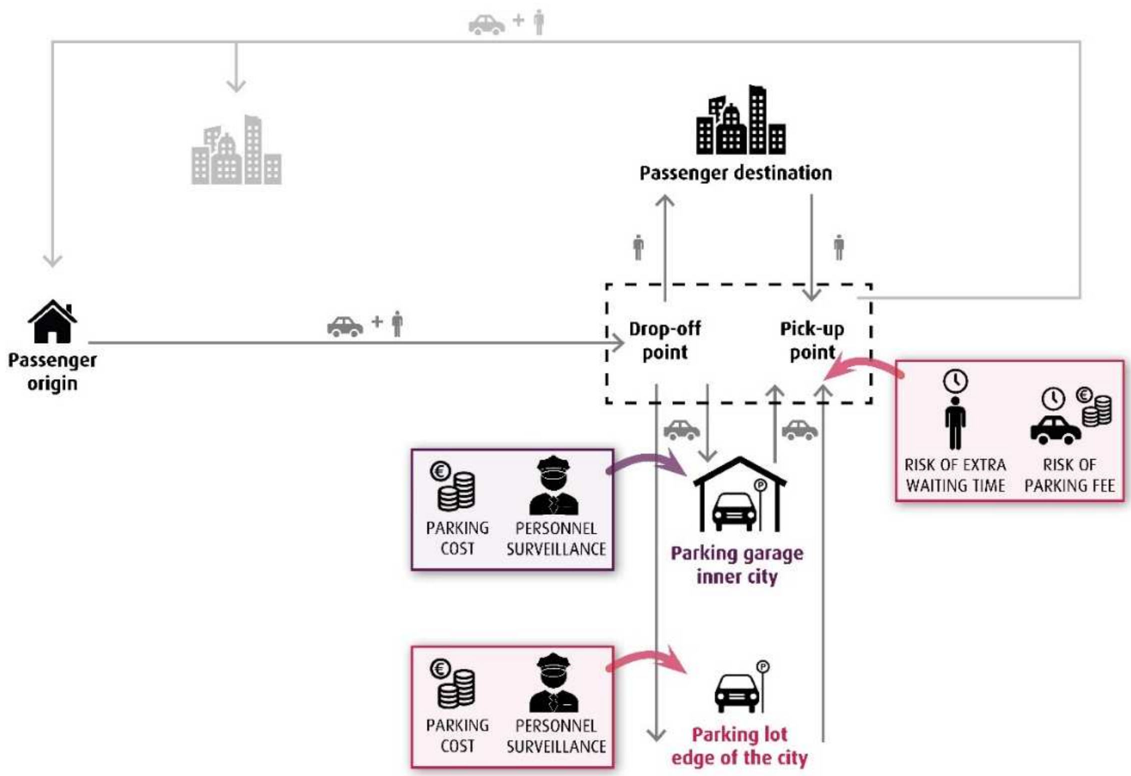

Figure 6.4 Attributes related to the different stages of a trip with a private highly AV

6.5.2 Changes in utilities

The parameter outcomes from the model estimation were used to calculate the changes in utilities when different attribute levels are applicable. An overview of the changes in utilities when attribute levels are varied in the PIC and PEC alternatives are shown in Table 6.16 and Table 6.17 respectively. The results are visualised Figure 6.5 and indicate how sensitive individuals are for a change in the attribute levels.

Table 6.16 Changes in utilities for different attribute levels (PIC)

Parking cost [per hour]	utility
€ 0	0.000
€ 1	-0.484
€ 2	-0.968
€ 3	-1.452
€ 4	-1.936
€ 5	-2.420
€ 6	-2.904
€ 7	-3.388
€ 8	-3.872

Surveillance	utility
No surveillance	0.000
Personnel surveillance	0.248

Table 6.17 Changes in utilities for different attribute levels (PEC)

Parking cost [per day]	utility
€ 0	0.000
€ 1	0.061
€ 2	0.081
€ 3	0.061
€ 4	0.000
€ 5	-0.101
€ 6	-0.242
€ 7	-0.424
€ 8	-0.646
€ 9	-0.909
€ 10	-1.212
€ 11	-1.555
€ 12	-1.939
€ 13	-2.363
€ 14	-2.828
€ 15	-3.333

Surveillance	utility
No surveillance	0.000
Personnel surveillance	0.184

Risk of extra waiting time	utility
0 out of 10	0.000
1 out of 10	-0.100
2 out of 10	-0.200
3 out of 10	-0.300
4 out of 10	-0.400
5 out of 10	-0.500
6 out of 10	-0.600
7 out of 10	-0.700
8 out of 10	-0.800
9 out of 10	-0.900
10 out of 10	-1.000

Fee	utility
No fee	0.000
Fee of €20	-0.806

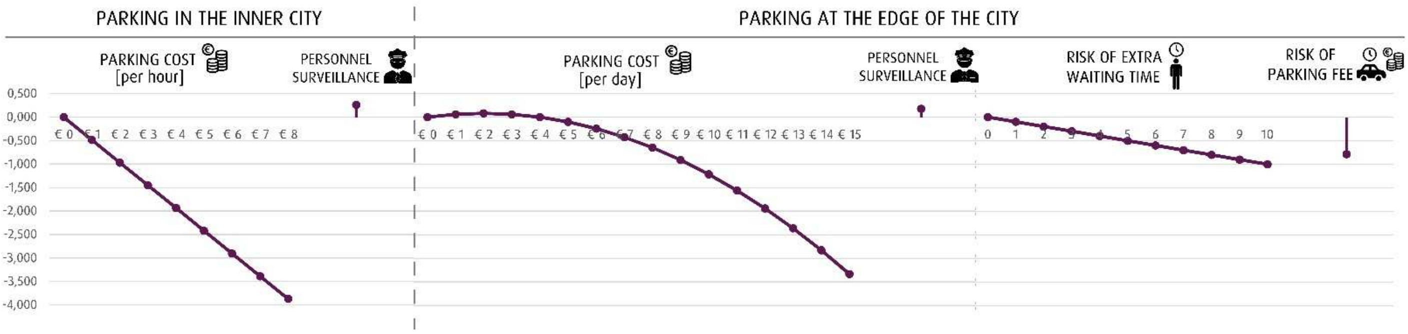

Figure 6.5 Changes in utilities for different attribute levels for PIC and PEC

From the results in Figure 6.5, it can be seen that utility for parking in the inner city will decrease linearly when parking cost is increased compared to a quadratic relationship for parking at the edge of the city since utility will decrease faster when the parking cost at the edge of the city is further increased. The parking cost at the edge of the city where the highest utility is achieved is around €2 per day. Utility decreases when there are no parking cost at the edge of the city. One explanation for this effect might be that passengers do not trust the parking facility at the edge of the city when their highly AV is parked there for free. Personnel surveillance has a small positive effect on drivers' parking location choice. When the risk of extra waiting time is decreased, it has a negative influence on drivers' parking location choice. When a parking fee for temporary parking the private highly AV at an on-street parking place near the passenger's destination is implemented, utility will drastically decrease.

6.5.3 Influence on the distribution of parking demand

The changes in utilities were used to calculate the distribution of the parking demand for parking the private highly AV in a parking garage in the inner city or at a parking lot at the edge of the city. For the base scenario, the utilities for the PIC and PEC alternatives and the choice distribution were calculated. The calculation is presented below and is based on Equation 6.2, 6.4 and 6.5.

$$U_{PIC} = asc + \beta_{COSTI} * COSTI + \beta_{PSI} * PERS\_SURV\_I + \varepsilon$$
$$U_{PIC} = 0.672 - 0.484 * 3.5 + 0 = -1.022$$

$$U_{PEC} = \beta_{COSTE\_L} * COSTE + \beta_{COSTE\_Q} * COSTE^2 + \beta_{PSE} * PERS\_SURV\_E + \beta_{WAIT} * WAIT + \beta_{FEE} * FEE + \varepsilon$$
$$U_{PEC} = 0.0808 * 4 - 0.0202 * 4^2 + 0 - 0.100 * 1 + 0 = -0.100$$

$$p_{ij} = \frac{e^{V_{ij}}}{\sum_{m \in s_i} e^{V_{im}}}$$

$$p_{ij} = \frac{e^{-1.022}}{e^{-1.022} + e^{-0.1}} = 28.45\%$$

In the base scenario, with the attribute levels described above, 28% of the individuals would choose for the parking facility in the inner city. Hence, 72% of the individuals would choose for the parking facility at the edge of the city. For the what-if scenarios, the percentages of the individuals choosing PIC and PEC are calculated in the same manner as for the base scenario. The distribution of parking demand for PIC and PEC in the base scenario and the what-if scenarios are shown in Table 6.18. For every what-if scenario, the increase or decrease in parking demand with respect to the base scenario is given. For every what-if scenario, the increase or decrease in the distribution of parking demand is visualised in Figure 6.6.

Table 6.18 Distribution of parking demand for PIC and PEC for the different what-if scenarios

Scenario		PIC		PEC				Distribution of parking demand [%]	
		Parking cost	Type of surveillance	Parking cost	Type of surveillance	Risk of extra waiting time	Risk of parking fee	PIC	PEC
Base scenario		€3.5 per hour	Camera surveillance	€4 per day	No surveillance	1 out of 10 times 10 min.	No risk of parking fee	28	72
What-if scenarios		€2.5 per hour	Camera surveillance	€4 per day	No surveillance	1 out of 10 times 10 min.	No risk of parking fee	39 Δ 11	61
		€4.5 per hour	Camera surveillance	€4 per day	No surveillance	1 out of 10 times 10 min.	No risk of parking fee	20 ∇ 8	80
		€3.5 per hour	Camera surveillance	€0 per day	No surveillance	1 out of 10 times 10 min.	No risk of parking fee	28	72 0
		€3.5 per hour	Camera surveillance	€8 per day	No surveillance	1 out of 10 times 10 min.	No risk of parking fee	43	57 ∇ 15
		€3.5 per hour	Camera surveillance	€12 per day	No surveillance	1 out of 10 times 10 min.	No risk of parking fee	73	27 ∇ 45
		€3.5 per hour	Personnel surveillance	€4 per day	No surveillance	1 out of 10 times 10 min.	No risk of parking fee	34 Δ 6	66
		€3.5 per hour	Camera surveillance	€4 per day	Personnel surveillance	1 out of 10 times 10 min.	No risk of parking fee	25	75 Δ 3
		€3.5 per hour	Camera surveillance	€4 per day	No surveillance	3 out of 10 times 10 min.	No risk of parking fee	33	67 ∇ 5
		€3.5 per hour	Camera surveillance	€4 per day	No surveillance	5 out of 10 times 10 min.	No risk of parking fee	37	63 ∇ 9
		€3.5 per hour	Camera surveillance	€4 per day	No surveillance	1 out of 10 times 10 min.	Risk of parking fee	47	53 ∇ 19

Δ and ∇ indicate the increase and decrease in parking demand with respect to the base scenario

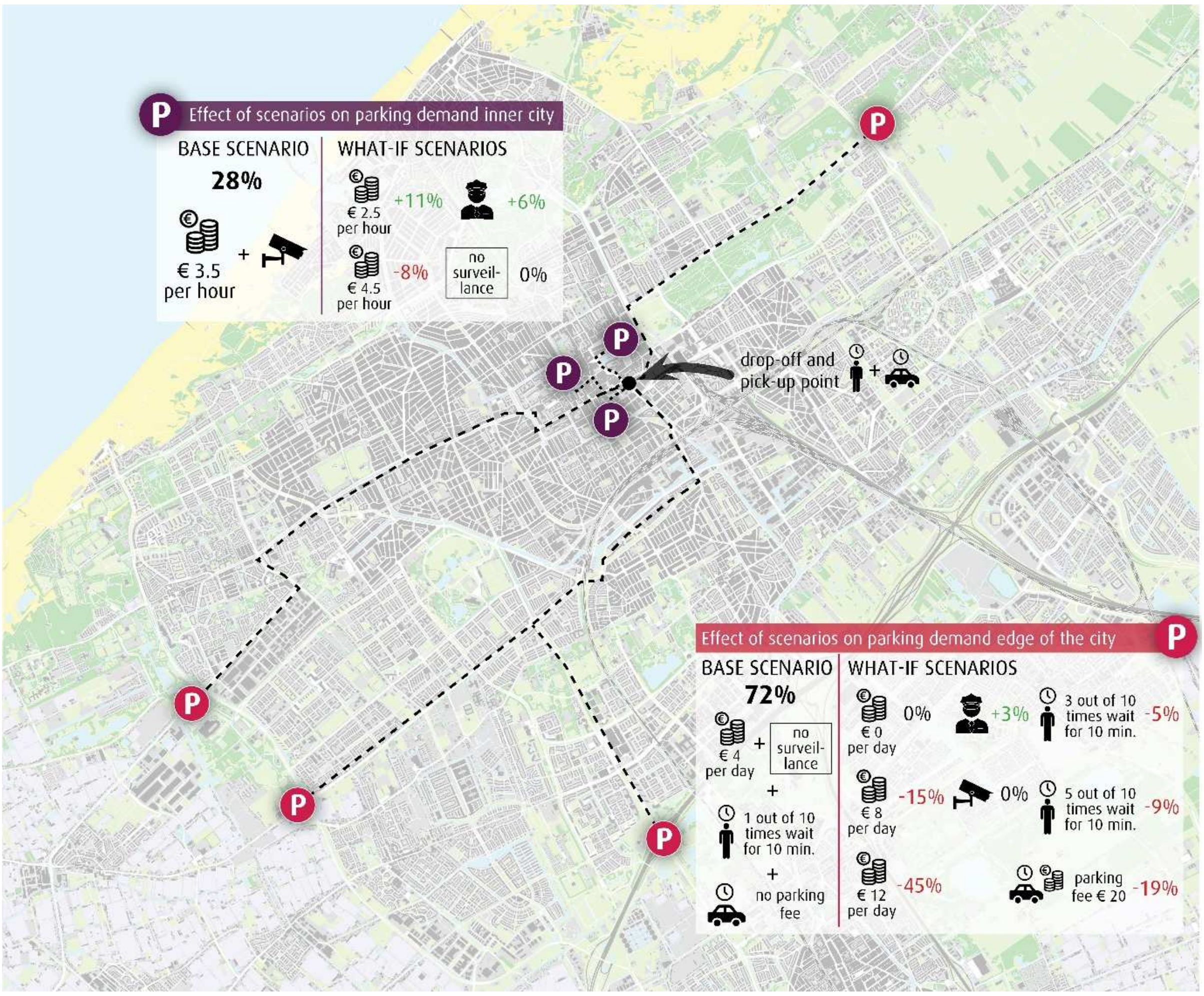

Figure 6.6 The influence of the what-if scenarios on the distribution of parking demand

The first what-if scenario that is tested with the model is a decrease and increase in parking cost. From the results, it could be expected that when the parking cost in the inner city will be decreased with €1 per hour, parking demand will increase with 11%. Furthermore, it could be expected that when the parking cost in the inner city will be increased with €1 per hour, parking demand will decrease with 8%. When there are no parking costs for parking at the edge of the city, parking demand will remain the same. When the parking cost at the edge of the city will be increased from €4 per day to €8 per day or €12 per day, it is expected that parking demand will drastically decrease with 15% and 45% respectively.

The second what-if scenario that is tested with the model is an investment in personnel surveillance at the parking facility. From the results, it can be seen that individuals are more sensitive for personnel surveillance in the inner city compared to personnel surveillance at the edge of the city. The presence of personnel surveillance has a positive influence on drivers' parking location choice. When personnel surveillance will be available at a parking facility, parking demand will increase with 6% in the inner city, compared to 3% at the edge of the city. From the results of the model, it was concluded that camera surveillance is not significant, which means that camera surveillance is valued the same as no surveillance. This means that when the parking facility is supervised by means of cameras, it is expected that this will not lead to an increase or decrease in parking demand.

The third what-if scenario that is tested with the model is the risk of extra waiting time for the passenger at the pick-up point. It is assumed the risk of extra waiting time (for 10 minutes) during the off-peak period is 1 out of 10 times. When no separated lanes for highly AVs exist, the risk of extra waiting time during the peak period is likely to be higher. When the risk of extra waiting time is increased to 3 out of 10 times or 5 out of 10 times during the peak period, and no separated lanes for highly AVs are available, the parking demand at the edge of the city will decrease to 5% and 9% respectively.

The fourth what-if scenario that is tested with the model is the risk of parking fee for temporary parking the vehicle at an on-street parking place near the passenger's destination. When a parking fee of €20 is implemented for temporary parking the highly AV at an on-street parking place near the passenger's destination, parking demand at the edge of the city will decrease with 19%. This has the same effect as increasing the parking cost at the edge of the city from €4 to approximately €8.50 per day.

Further research is necessary in order to be able to examine the effect of combined what-if scenarios. With the model, it was not tested if interaction effects between attributes would play a role which might lead to different results.

From the results of the scenario analysis can be concluded that **individuals are most sensitive for a change in direct costs, i.e. the 'parking cost' at the parking facility and the 'parking fee' for temporary parking the highly AV at an on-street parking place near the passenger's destination.** Furthermore, is can be concluded that **individuals are less sensitive for 'personnel surveillance' and 'risk of extra waiting time'**.

6.6 DIRECTIONS FOR PARKING POLICY

This section presents directions for parking policies for a future situation in which private highly AVs will become available for passenger transport. Directions for parking policies are discussed in different topics related to parking regime (paragraph 6.6.1), parking price (paragraph 6.6.2) and parking capacity (paragraph 6.6.3).

An interview with the policy makers of the municipality of The Hague was conducted to gain insight in the vision of the municipality with respect to directions for promising parking policies when private highly AVs will become available for passenger transport. The main wish of the municipality of The Hague is to **minimize the number of empty vehicle kilometres** in the city of The Hague. In addition, it is desired to **reduce the number of on-street parking spaces**, because the streetscape of The Hague is dominated by the presence of parked cars (Gemeente Den Haag, 2009).

6.6.1 Parking regime

With the self-parking capability of highly AVs, there is no need to park the highly AV at an on-street parking place close the passenger's destination. However, space is needed to drop-off and pick-up the passenger near his/her destination. One of the main elements described in the conceptual framework is the reservation of on-street parking space -which is no longer needed for parking the highly AV- for drop-off and pick-up manoeuvres. The municipality confirmed the need for a dedicated place for drop-off and pick-up manoeuvres in order to avoid that highly AVs will be stopping on the public roads to drop-off and pick-up passengers. When it is **forbidden to park (highly automated) vehicles at on-street parking spaces, released space could be used for drop-off and pick-up manoeuvres**. The municipality is able to forbid on-street parking. It is not expected that all on-street parking space is needed for drop-off and pick-up manoeuvres. Similar to the current situation, it might be considered that inhabitants of the city of The Hague are allowed to park their (highly automated) vehicle on-street with a parking permit. Furthermore, released on-street parking space could be used for greenery, bicycle parking or extra space for bicyclists and pedestrians. Further research is necessary to examine how many on-street parking places are needed for drop-off and pick-up manoeuvres.

It should be noted that in the current situation, parking revenues mainly result from visitors that park their vehicle at an on-street parking place. When it is forbidden to park the vehicle on-street, the municipality will miss these revenues. A price mechanism that compensates for these missing revenues will be discussed in the subsequent paragraph.

6.6.2 Parking price

In order to minimize the number of empty vehicle kilometres, it is advised to stimulate the parking of private highly AVs in parking garages in the inner city. Consequently, the number of empty vehicle trips between the passenger's destination in the inner city and the parking facility at the edge of the city will be limited. When the occupation rates of all parking garages in the inner city will have reached a certain level (e.g. 90% to account for a buffer), it is desired to stimulate the parking of private highly AVs at the edge of the city.

It should be monitored that the parking garages in the inner city are not occupied by long term parked highly AVs, where a parking place could be more efficiently used by multiple cars that are parked on that spot for a short term. Therefore, to reduce the number of empty vehicle kilometres, it is advised to **stimulate short term parking in parking garages in the inner city**. The results of the chi square test already showed that trip duration has a significant influence on the fixed preference for either parking the private highly AV in the inner city or parking the private highly AV at the edge of the city. It is shown that most of the individuals with a fixed preference for parking the private highly AV in the inner city have a short parking duration (≤ 3 hours). In facilitating short term parking in the inner city for individuals with no fixed preference, parking prices for parking the private highly AV in the inner city must be lower for a short trip duration than the parking price for parking the highly AV at the edge of the city. Furthermore, it is advised to **stimulate long term parking at parking lots at the edge of the city**. Parking prices for parking the private highly AV at the edge of the city must be lower than parking prices for parking the private highly AV in the inner city in case of a long parking duration (6 ≥ hours). The municipality of The Hague is able to change the parking cost for the parking facilities at the edge of the city. However, the municipality is not able to change the parking cost for parking the vehicle in a parking garage in the inner city because most of the parking facilities in the inner city are owned by the private company Qpark. When the price for parking the highly AV at the edge of the city is increased from €4 per day to €10 per day (which resembles the parking cost for 3 hours parking in the inner city), approximately 55% of the individuals will park their highly AV in the inner city, compared to 28% that will park their highly AV in the inner city in the base scenario. Further research is required to examine which distribution of parking demand will lead to an occupation rate in parking garages of approximately 90%.

Results of the MNL model estimation show that **implementing a parking fee for temporary parking the vehicle near the passenger's destination is an effective way to influence drivers' parking location choice**. Implementing a parking fee for temporary parking the vehicle at the pick-up point is necessary because otherwise all individuals would recall for their vehicle a long time in advance. In addition, when no parking fee is implemented, all on-street parking would constantly be occupied with parked cars. When **a dynamic pricing strategy** is chosen for implementing the parking fee, the municipality is able to:

- *Control supply and demand.* In the previous paragraph, it was described that it is desired to let as many highly AVs being parked in the inner city to minimize the number of empty vehicle kilometres. When a certain occupation rate is reached, it is desired to let the highly AVs being parked at parking facilities at the edge of the city. In the base scenario, approximately 28% of the individuals parks his/her highly AV in the inner city. When a parking fee of €20 is implemented, this number increases to 47%. Further research is required to examine how sensitive individuals are for different parking fees in order to implement a dynamic pricing strategy.
- *Account for competitor pricing.* On-street parking space is reserved for temporary parking the private highly AV, which means that the municipality of The Hague is able to set the price for the parking fee. The municipality of The Hague receives the revenues of the implementation of the parking fee. The off-street parking facilities are owned by the private company Qpark. When Qpark changes the parking price, the municipality is able to anticipate by changing the parking fee for temporary parking the highly AVs on-street. For example, when Qpark decides to increase the parking cost with €1, 8% of the individuals will switch from parking in the inner city to parking at the edge of the city. Hence, 20% of the individuals will park their private highly AV in the inner city compared to 80% of the individuals who will park their vehicle at the edge of the city. This will lead to an increase in empty vehicle kilometres compared to the base scenario. When a parking fee of €20 is implemented for temporary parking the highly AV at an on-street parking space near the passenger's destination, this will lead to a shift of 19% of the individuals who parked their highly AV at the edge of the city and will now park their highly AV in the inner city. Hence, the number of empty vehicle kilometres is drastically reduced.
- *Account for external factors.* It is desired that the number of empty vehicle driving trips between the inner city and the edge of the city is minimalised during the peak period in order to avoid congestion. When a higher parking fee is asked for trips during the peak, it is discouraged to recall for the vehicle during the peak period. Further research is required to examine how sensitive individuals are for a different parking fee.

6.6.3 Parking capacity

In the current situation, there are only a limited amount of parking lots located at the edge of the city compared to the amount of parking garages in the inner city. Parking at the edge of the city is a good alternative when parking facilities in the inner city are almost occupied and on-street parking in the inner city is not desired. This study provides no insight in the number of parked vehicles either in the inner city or at the edge of the city when private highly AVs will become available for passenger transport. Hence, no conclusions can be drawn on the number of parked vehicles at the parking facilities. It might be the case that supply does not meet demand and new parking facilities are needed. Space in the inner city is scarce and there is not many space for extra off-street parking garages. However, space is available at the edge of the city to build new parking lots with the advantage of freeing on-street parking spaces in the inner city but with the disadvantage of extra empty vehicle kilometres between the inner city and the edge of the city. When supply does not need demand and new parking lots at the edge of the city are needed, these parking lots should be located next to distributor roads. Decreasing the parking cost for parking at the edge of the city has not many influence on drivers' parking location choice. When the parking cost for parking the private highly AV at the edge of the city is decreased from €4 per day to €2 per day -where the attractiveness is the highest- 1% of the individuals will switch from parking in the inner city to parking at the edge of the city. When personnel surveillance is available at a parking facility at the edge of the city, its attractiveness slightly increases which results in an increased parking demand of 3%. When more services would be available at the parking facility, its attractiveness is likely to further increase. Hence, it is advised to **invest in flexible parking facilities at the edge of the city near distributor roads where space is reserved for extra services that make a parking facility more attractive** (e.g. pick-up point for groceries and day-care). It should be taken into account that every vehicle that is parked at the edge of the city instead of in the inner city, generates 13 to 17 extra empty vehicle kilometres.

The above described directions for promising parking policies when private highly AVs will become available for passenger transport are visualised in Figure 6.7.

When private highly AVs will become available for passenger transport, an increase in travel demand and parking requirements might be expected. Milakis, van Arem and van Wee (2017) reviewed several studies on policy and society related implications of automated driving. They state that most reviewed studies show that ''automated vehicles could induce an increase of travel demand by between 3-27%, due to changes in destination choice (i.e. longer trips), mode choice (i.e. modal shift from public transport and walking to car) and mobility (i.e. more trips)'' (Milakis, Arem, & Wee, 2017). Results of the agent-based model scenarios in the study conducted by International Transport Forum (2015) suggest that ''shared and self-driving fleets operating with private conventional cars fleets may lead to even higher parking requirements than today in the absence of bus services'' (International Transport Forum, 2015). Hence, when private highly AVs are assumed, even more parking requirements might be needed. The results of these studies should be considered when making policy decisions because it affects parking demand.

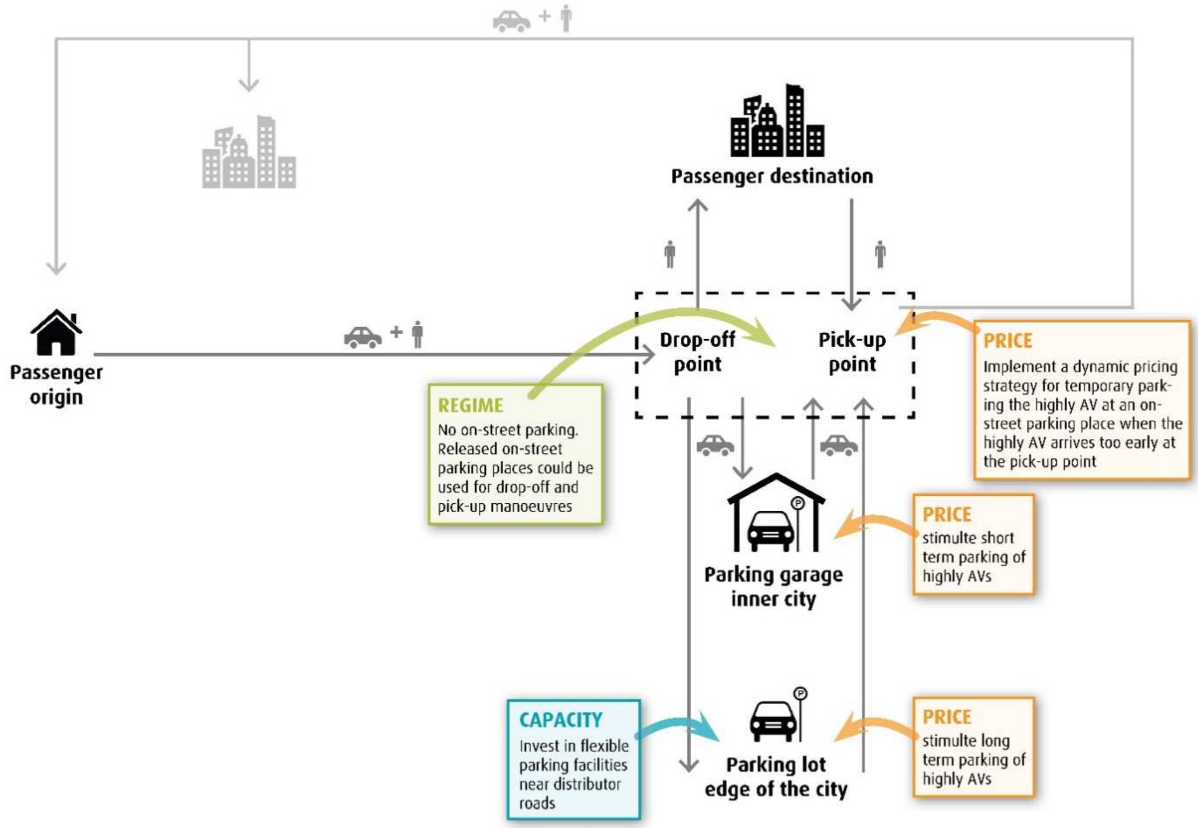

Figure 6.7 Visualisation of the directions for promising parking policies

Furthermore, the level of sharing and the penetration rate of AVs should be taken into account when making policy decisions. First, from results of studies on shared AVs, it is clear that parking demand in the city will drastically reduce in all scenarios with the implementation of shared AVs. These studies show that one shared AV could replace 11 to 14 conventional vehicles, indicating that 10 to 13 parking spaces could be eliminated for each shared AV (International Transport Forum, 2015) (Zhang, Guhathakurta, Fang, & Zhang, 2015) (Fagnant & Kockelman, 2013). Second, it is important to take into account the penetration rate of AVs. In a mixed traffic condition, conventional vehicles also operate on the road network. In this study, it is assumed that it is forbidden to park highly AVs at on-street parking places and in order to minimize the empty vehicle kilometres, it is advised to stimulated to park these highly AVs in off-street parking facilities in the inner city. Consequently, this will have an influence on the number of parking spaces in parking garages in the inner city. Furthermore, this will influence the search time of conventional drivers for a vacant parking place.

6.7 CONCLUSION

This chapter described the data analysis and the model estimation. The influence of the four attributes 'parking cost', 'surveillance of the parking facility', 'risk of extra waiting time' and 'risk of parking fee' on drivers' parking location choice was tested by means of a MNL model estimation. In addition, the influence of 1) personal characteristics, 2) trip characteristics and 3) perception on the risk of damage during the empty vehicle driving trip, on drivers' parking location choice was examined.

In total, 421 respondents filled in the self-completion online questionnaire. 388 responses are valid and were used for the data analysis. From the results of the descriptive statistics, it can be concluded that the sample is fairly representative for the population of South Holland. Although the sample is fairly representative for the province of South Holland, results should be interpreted with care because a selective bias occurs as a result of the use of an online panel.

Results of the descriptive analysis show that 16.2% of the respondents have a fixed preference for parking in the inner city, compared to 11.6% of the respondents that have a fixed preference for parking at the edge of the city. Respondents with a fixed preference are not influenced by the changes of the attribute levels. **Trip characteristics explain the fixed preference for either PIC or PEC.** Personal related characteristics and perceptions on the risk of damage during the empty vehicle driving trip have no significant influence on the fixed preference for either PIC or PEC.

Results of the MNL model estimation show that most of the parameter values for the four attributes are significant. This means that the four attributes 'parking cost', 'surveillance of the parking facility', 'risk of extra waiting time' and 'risk of parking fee' are of influence on drivers' parking location choice. However, the model fit of the MNL model is low, meaning that the values vary substantial per individual. Personal characteristics, trip characteristics and perceptions on the risk of damage during the empty vehicle driving trip were included in the MNL model as interaction effects to test if these characteristics affect the attributes that influence drivers' parking location choice. Results of the model estimation on the interaction effects show that only a few interaction effects are significant. Despite their significance, several of these interaction effects are based on a small sample and others could not be explained. Therefore, it was chosen to conduct the scenario analysis based on the model without interaction variables. This means that the same model applies for individuals with different characteristics, trip purposes and perceptions.

Based on the model interpretation, it can be concluded that **individuals are most sensitive for a change in direct costs, which are the 'parking cost' at the parking facility and the 'parking fee' for temporary parking the highly AV at an on-street parking place near the passenger's destination.** In addition, it can be concluded that **individuals are less sensitive for 'personnel surveillance' and the 'risk of extra waiting time'**.

The main wish of the municipality of The Hague is to minimize the number of empty vehicle kilometres and to reduce the number of on-street parking spaces.

First, in order to reduce the number of on-street parking spaces, it is advised to forbid the parking of (highly automated) vehicles at on-street parking spaces. Consequently, released space could be used for drop-off and pick-up manoeuvres. It is not expected that all on-street parking space is needed for drop-off and pick-up manoeuvres. Similar to the current situation, it might be considered that inhabitants of the city of The Hague are allowed to park their (highly automated) vehicle on-street with a parking permit. Furthermore, released on-street parking space could be used for greenery or extra space for bicyclists and pedestrians.

Second, in order to minimize the number of empty vehicle kilometres, it is advised to stimulate short term parking of highly AVs in parking garages in the inner city and stimulate long term parking of highly AVs at parking lots at the edge of the city. This could be done by increasing the parking cost of parking at the edge of the city from €4 to €10 per day. Consequently, approximately 55% of the individuals would park their highly AV in the inner city compared to 28% that parked their highly AV in the inner city in the base scenario.

Third, it is advised to implement a dynamic pricing strategy for the parking fee that is asked for temporary parking the highly AV at on-street parking place near the passenger's destination when the highly AV arrives too early. When a dynamic pricing strategy will be implemented, the municipality is able to 1) control supply and demand, 2) account for competitor pricing and 3) account for external factors (e.g. peak periods). When a parking fee of €20 is implemented, approximately 47% of the individuals would park their highly AV in the inner city compared to 28% that parked their highly AV in the inner city in the base scenario.

Fourth, it is advised to invest in flexible parking facilities at the edge of the city near distributor roads when more parking capacity is needed in the future situation. When the parking facility is supervised by personnel, parking demand will only increase with 3%. To increase the attractiveness of the parking the highly AV at the edge of the city, it is advised to reserve space for additional services (e.g. pick-up point for groceries and day-care). Further research is needed to examine which services positively influence drivers' parking location choice.

The next chapter will describe the conclusion, discussion and recommendations resulting from this research.

7

CONCLUSIONS, DISCUSSION AND RECOMMENDATIONS

This research focused on the effects of private highly automated vehicles (AVs) on drivers' parking location choice. In this research the environmental conditions, road network configuration and parking constraints of the city of The Hague are used specifically, however, the generic methodology applied in this study could be applied to any large scale city. This chapter first describes the conclusion in section 7.1, by answering the sub research questions and main research question. Section 7.2 contains a discussion of the results of this research, followed by the recommendations for science and society that are described in section 7.3. The chapter end with a personal reflection upon the graduation process in section 7.4.

7.1 CONCLUSIONS

The objective of this research was to find the importance of different factors that could influence drivers' parking location choice for a future situation, in which private highly AVs will become available for passenger transport. As a result of choices made by respondents in the hypothetical choice situations, insight was gained in individuals' preferences and trade-offs. The presented results and guidelines could be used in future research on the effects of highly AVs on parking location choice where, at the same time, it could be used by governments to develop their parking policy for this future situation. This section provides answers to the sub research questions and the main research question of this research.

7.1.1 Possible influencing factors and constraints (sub research question 1)

The first sub research question is formulated as follows:

1. *Which factors and constraints could influence drivers' parking location choice in the case of private highly automated vehicles?*

To be best of the author's knowledge, no study has been conducted in order to determine factors and constraints that could influence drivers' parking location choice in the case of private highly AVs. However, there are various studies available in which factors are defined that describe parking choice behaviour in the case of conventional vehicles (CVs). These factors were listed and it was examined which factors and constraints could also apply in the case of highly AVs. Brainstorm sessions with experts were conducted to define factors and constraints that could influence drivers' parking location choice, in addition to the factors that were found in the literature study. In order to reduce complexity, a selection of the factors was made by means of a Multi-Criteria Analysis (MCA). The selected factors and constraints are shown in Figure 7.1. The selected factors and constraints can be divided in different categories: context factors, exogenous variables, attributes and perceptions. Every category of factors and constraints was implemented differently in the SP experiment. First, context factors in this study are likely to play a vital role, as respondents might chose for another parking location if another context applies. The three selected context factors are all trip related characteristics. Second, it can be expected that exogenous variables influence preferences and therefore it can be expected that these factors also influence the parking location choice (Bonsall & Palmer, 2004). Third, the attributes are defined as ''the independent or predictor variables'' (Molin, SPM4612: An introduction to stated choice experiments, 2015a). The levels of the attributes were varied in the hypothetical choice situations to test if, and to what extent, these factors and constraints influence drivers' parking location choice. Last, drivers' perception on the risk of damage during the empty vehicle driving trip could influence drivers' parking location choice.

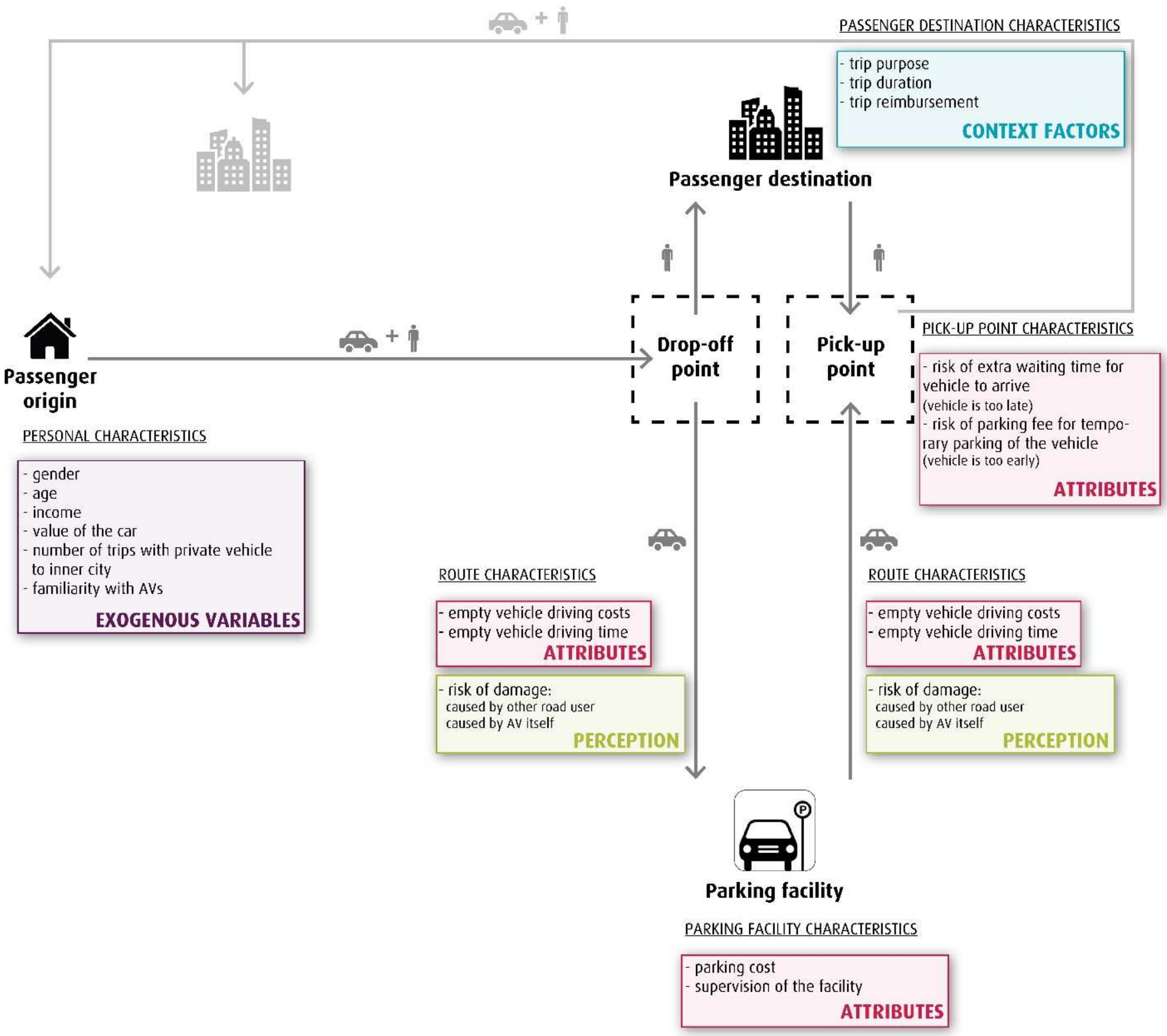

Figure 7.1 Selected factors and constraints that could influence drivers' parking location choice

7.1.2 Influence of personal characteristics, trip characteristics and perceptions (sub research question 2)

The second sub research question is formulated as follows:

2. *To what extent do different personal characteristics, trip characteristics and perceptions on highly automated driving have an effect on factors and constraints that influence on drivers' parking location choice?*

First, it was examined if individuals with a **fixed preference** for parking in the inner city or parking at the edge of the city, have corresponding personal characteristics, trip characteristics and perceptions. It can be concluded that personal related characteristics and perceptions on automated driving regarding the empty vehicle driving trip have no significant influence on the fixed preference for either PIC or PEC. It can be concluded that **trip related characteristics have significant influence on the fixed preference for either PIC or PEC**. It was observed that individuals with a business trip more often have a fixed preference for PIC. In addition, it was observed that individuals with a recreational trip more often have a fixed preference for PEC. Furthermore, it was observed that the number of fixed preferences for PIC is higher for individuals with a short trip duration, compared to a lower number of fixed preferences for PEC. In addition, it can be seen that individuals with a reimbursable trip more often have a fixed preference for PIC. However, results have to be interpreted with care, because the chi-square assumption is violated.

Second, it was examined if individuals with **no fixed preference** for parking in the inner city or parking at the edge of the city -and with different personal characteristics, trip characteristics and perceptions- are sensitive for different factors and constraints that influence drivers' parking location choice. Results of the MNL model estimation on the interaction effects show that only a few interaction effects are significant. Despite their significance, several of these interaction effects are based on a small sample and others could not be explained. The following interaction effects are based on a large sample and can be explained:

- Individuals with a high income are more sensitive for 'risk of extra waiting time'. This was expected, since the research pointed out that on average, individuals with a higher income have a higher Value of Time (VoT) and Value of Reliability (VoR).
- Individuals with a relatively high purchase value of the car are less sensitive for 'risk of extra waiting time'. A reason for this might be that individuals with a high purchase value of the car find it more important that the car arrives safely at the passenger's destination. In this case, the individual accepts the 'risk of extra waiting time'.
- Individuals who consider safety during the empty vehicle trip to be important, are less sensitive for the 'risk of extra waiting time' and the 'risk of parking fee'. Apparently, these individuals care more about the safety circumstances during the empty vehicle trip than about extra time and costs.

7.1.3 Directions for promising parking policies (sub research question 3)

The third sub research question is formulated as follows:

3. *What are promising parking policies in the case when private highly automated vehicles will become available for passenger transport?*

Directions for parking policies are related to different topics regarding parking regime, parking price and parking capacity. The directions for parking policies are visualised in Figure i.3.

First, in order to reduce the number of on-street parking spaces, it is advised to forbid the parking of highly AVs at on-street parking spaces. Consequently, released space could be used for drop-off and pick-up manoeuvres. It is not expected that all on-street parking space is needed for drop-off and pick-up manoeuvres. Similar to the current situation, it might be considered that inhabitants of the city of The Hague are allowed to park their highly AV on-street with a parking permit. Furthermore, released on-street parking space could be used for greenery or extra space for bicyclists and pedestrians.

Second, in order to minimize the number of empty vehicle kilometres, it is advised to stimulate short term parking of highly AVs in the inner city and stimulate long term parking of highly AVs at the edge of the city. This could be done by increasing the parking cost of parking at the edge of the city from €4 to €10 per day. Consequently, approximately 55% of the individuals would park their highly AV in the inner city, compared to 28% that parked their highly AV in the inner city in the base scenario.

Third, it is advised to implement a dynamic pricing strategy for the parking fee that is asked for temporary parking the highly AV at an on-street parking place near the passenger's destination, when the highly AV arrives too early. When implementing a dynamic pricing strategy, the municipality is able to 1) control supply and demand, 2) account for competitor pricing and 3) account for external factors (e.g. peak periods). When a parking fee of €20 is implemented, approximately 47% of the individuals would park their highly AV in the inner city, compared to 28% that parked their highly AV in the inner city in the base scenario.

Fourth, when more parking capacity is needed, it is advised to invest in flexible parking facilities at the edge of the city near distributor roads. When the parking facility is supervised by personnel, parking demand will only increase with 3%. To increase the attractiveness of parking highly AVs at the edge of the city, it is advised to reserve space for additional services (e.g. pick-up point for groceries and day-care). Further research is needed to examine which services positively influence drivers' parking location choice. Recent studies show that automated vehicles could induce an increase of travel demand due to changes in destination choice, mode choice and mobility (Milakis, Arem, & Wee, 2017). Hence, more parking capacity might be required. Furthermore, the level of sharing and the penetration rate of AVs should be taken into account when making policy decisions, because these developments might have an influence on the number of parking spaces required.

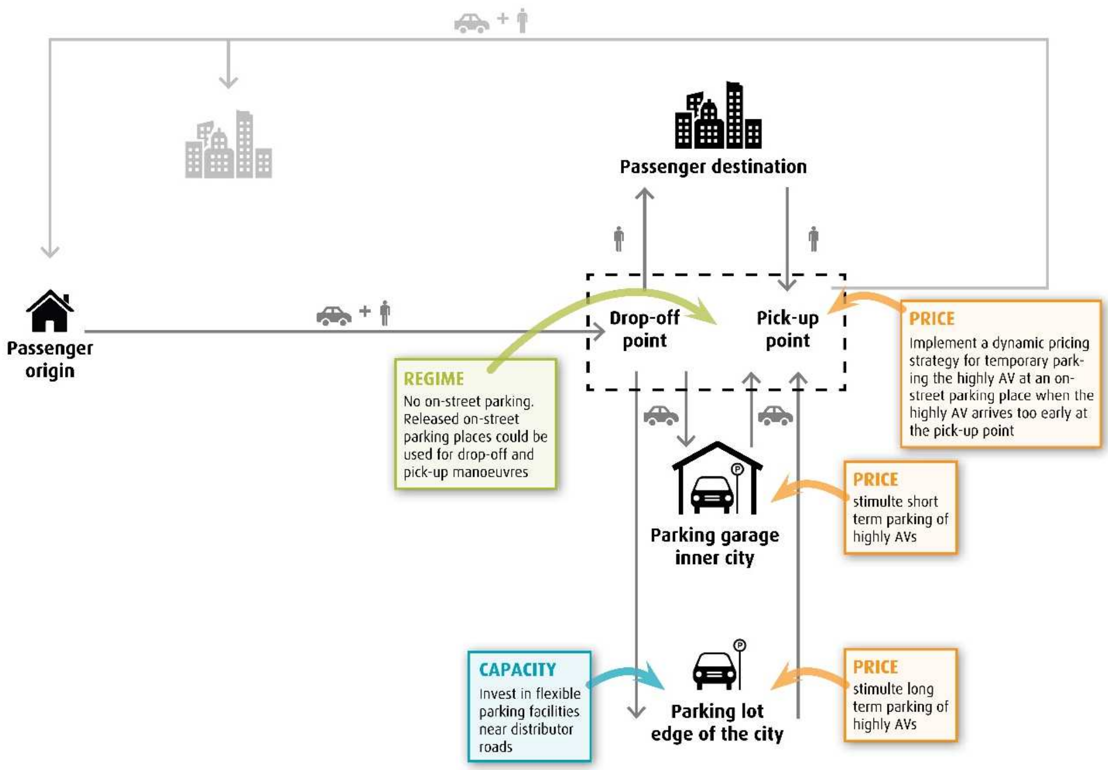

Figure 7.2 Visualisation of the directions for promising parking policies

7.1.4 Effect of private highly AVs on drivers' parking location choice (main research question)

The main research question is formulated as follows:

'' What is the effect of private highly automated vehicles on drivers' parking location choice, based on parking constraints? ''

This study considers the discrete choice for parking a private highly AV either in the inner city (off-street parking garage) or at the edge of the city (off-street parking lot). On-street parking is not considered, where there is no need to park the vehicle as close as possible to the passenger's destination when private highly AVs are able to ride and park themselves. Released on-street parking space will be used for drop-off and pick-up manoeuvres in order to prevent private highly AVs of stopping on the roads to drop-off and pick-up passengers.

Factors that could influence drivers' parking location choice are determined from literature review and brainstorm sessions with experts. Results from the literature review show that 'parking cost' has a large influence on drivers' parking location choice. The other factors and constraints that could influence drivers' parking location choice are derived from brainstorm sessions with experts. When individuals need to recall for their vehicle to pick them up, there is a possibility that the vehicle is not back at the predefined point of time. Two scenarios are possible: either the vehicle is too late or the vehicle is too early. In the first, there is a 'risk of extra waiting time' for the passenger at the pick-up point. In the latter, the vehicle needs to wait at the pick-up point either for free or against a 'parking fee' for temporary parking the private highly AV at an on-street parking place. In addition, it is expected that the ́surveillance of the parking facility' might have an effect on drivers' parking location choice. The four attributes are varied in hypothetical choice situations to test their influence on drivers' parking location choice. Different personal characteristics, trip characteristics and perceptions are considered.

16.2% of the respondents have a fixed preference for parking in the inner city compared to 11.6% of the respondents have a fixed preference for parking at the edge of the city. Respondents that have a fixed preference for parking in the inner city or parking at the edge of the city are not influenced by the changes of the attribute levels. Trip characteristics (trip purpose, trip duration and trip reimbursement) explain the fixed preference for either parking in the inner city or parking at the edge of the city.

It was tested if personal characteristics, trip characteristics and/or perceptions affect the attributes that influence drivers' parking location choice. Results showed that many of them are not significant. Hence, **personal characteristics, trip characteristics and perceptions on automated driving during the empty vehicle driving trip do not affect the attributes that influence drivers' parking location choice.** When a large amount of interaction effects do not play a role, a more generic model can be estimated that works for the same conditions. Therefore, it was chosen to conduct the scenario analysis based on a model without interaction variables. This means that the same model applies for individuals with different characteristics, trip purposes and perceptions.

Table 7.1 Distribution of parking demand for PIC and PEC for the different what-if scenarios

Scenario		PIC		PEC				Distribution of parking demand [%]	
		Parking cost	Type of surveillance	Parking cost	Type of surveillance	Risk of extra waiting time	Risk of parking fee	PIC	PEC
Base scenario		€3.5 per hour	Camera surveillance	€4 per day	No surveillance	1 out of 10 times 10 min.	No risk of parking fee	28	72
What-if scenarios		€2.5 per hour	Camera surveillance	€4 per day	No surveillance	1 out of 10 times 10 min.	No risk of parking fee	39 Δ 11	61
		€4.5 per hour	Camera surveillance	€4 per day	No surveillance	1 out of 10 times 10 min.	No risk of parking fee	20 ∇ 8	80
		€3.5 per hour	Camera surveillance	€0 per day	No surveillance	1 out of 10 times 10 min.	No risk of parking fee	28	72 0
		€3.5 per hour	Camera surveillance	€8 per day	No surveillance	1 out of 10 times 10 min.	No risk of parking fee	43	57 ∇ 15
		€3.5 per hour	Camera surveillance	€12 per day	No surveillance	1 out of 10 times 10 min.	No risk of parking fee	73	27 ∇ 45
		€3.5 per hour	Personnel surveillance	€4 per day	No surveillance	1 out of 10 times 10 min.	No risk of parking fee	34 Δ 6	66
		€3.5 per hour	Camera surveillance	€4 per day	Personnel surveillance	1 out of 10 times 10 min.	No risk of parking fee	25	75 Δ 3
		€3.5 per hour	Camera surveillance	€4 per day	No surveillance	3 out of 10 times 10 min.	No risk of parking fee	33	67 ∇ 5
		€3.5 per hour	Camera surveillance	€4 per day	No surveillance	5 out of 10 times 10 min.	No risk of parking fee	37	63 ∇ 9
		€3.5 per hour	Camera surveillance	€4 per day	No surveillance	1 out of 10 times 10 min.	Risk of parking fee	47	53 ∇ 19

Δ and ∇ indicate the increase and decrease in parking demand with respect to the base scenario

From the results of the scenario analysis can be concluded that **individuals are most sensitive for a change in direct costs, i.e. the 'parking cost' at the parking facility and the 'parking fee' for temporary parking the highly AV at an on-street parking place near the passenger's destination.** When the parking cost in the inner city is decreased with €1 per hour, parking demand will increase with 11%. Furthermore, it could be expected that when the parking cost in the inner city will be increased with €1 per hour, parking demand will decrease with 8%. When there are no parking costs for parking at the edge of the city, parking demand will remain the same. When the parking cost at the edge of the city will be increased from €4 per day to €8 per day or €12 per day, it is expected that parking demand will drastically decrease with 15% and 45% respectively. When a parking fee of €20 is implemented for temporary parking the highly AV at an on-street parking place near the passenger's destination, parking demand at the edge of the city will decrease with 19%. This has the same effect as increasing the parking cost at the edge of the city from €4 to approximately €8.50 per day. From the results of the scenario analysis can also be concluded that **individuals are less sensitive for 'personnel surveillance' and 'risk of extra waiting time'**. The presence of personnel surveillance has a positive influence on drivers' parking location choice. When personnel surveillance will be available at a parking facility, parking demand will increase with 6% in the inner city, compared to 3% at the edge of the city. From the results of the model, it was concluded that camera surveillance is not significant, which means that camera surveillance is valued the same as no surveillance. This means that when the parking facility is supervised by means of cameras, it is expected that this will not lead to an increase or decrease in parking demand. The risk of extra waiting time (for 10 minutes) during the off-peak period is 1 out of 10 times. When no separated lanes for highly AVs exist, the risk of extra waiting time during the peak period is likely to be higher. When the risk of extra waiting time is increased to 3 out of 10 times or 5 out of 10 times during the peak period, and no separated lanes for highly AVs are available, the parking demand at the edge of the city will decrease to 5% and 9% respectively.

7.2 DISCUSSION

This section discusses several aspects of this research. First, a comparison of the results of this research with results that were found in literature is given (paragraph 7.2.1). Second, aspects that are related to the online questionnaire are discussed (paragraph 7.2.2). Third, the implications of the used model are discussed (paragraph 7.2.3). Fourth, trends and developments in society which might influence the results of this research are presented (paragraph 7.2.4). Last, the limitations of this research are presented (paragraph 7.2.5).

7.2.1 Comparison results research with results in literature

To be best of the author's knowledge, no study has been conducted in order to determine factors that could influence drivers' parking location choice in the case of private highly AVs. However, there are various studies available in which factors are defined that describe parking choice behaviour in the case of CVs. All factors from the literature review that apply for CVs and which also apply for private highly AVs were considered for this research. Several factors were selected by means of a Multi-Criteria Analysis and were tested by means of a Stated Preference experiment. The sign and significance of the factors obtained from literature and the factors resulting from this research are shown in Table 7.2.

Table 7.2 Comparison of the results from this research with results found in literature

Factors	LITERATURE		THIS RESEARCH	
	Sign factor	Significance factor	Sign factor	Significance factor
Personal characteristics				
Age	-	No	-/+	No
Gender	-	No		No
Parking constraints				
Cost	-	Yes	-	Yes
Trip characteristics				
Reimbursement	+	No	+	No

In Table 7.2, it can be seen that age and gender were not significant from results obtained from literature and resulting from this research. This means that age and gender do not have an effect on drivers' parking location choice. The same applies for the trip reimbursement. It can be seen that parking cost is both significant in results found in literature and within this research. In this research, it was concluded that the parameters with direct costs ('parking cost', 'risk of parking fee') have the most effect (high parameter values) on drivers' parking location choice. This effect could also be seen in literature on CVs, where the importance of parking cost is confirmed (Bonsall & Palmer, 2004).

The rho-square and adjusted rho-square of this research are 0.047 and 0.044 respectively, which are a low values. The low model fit might be the result of unobserved attributes or because the model does not test for heterogeneity. When interaction effects are implemented in the model, the adjusted rho-square slightly increases to a maximum of 0.054. The rho-square and adjusted rho-square of this study and the reviewed literature studies are shown in Table 7.3. In this table, it can be seen that the model fit of the reviewed studies are higher. The lower model fit of this study might be the result of new attribute concepts presented in this study. Furthermore, individuals are not used to AV in the current situation. Hence, when individuals will be more familiar with AVs and when more research is done on the factors that might influence drivers' parking location choice, the model fit is likely to increase in further research on this topic.

Table 7.3 Rho-square and adjusted rho-square of this research compared with results from literature

Study	Rho-square	Adjusted rho-square
(Axhausen & Polak, 1991)	0.2258 – 0.3791	
(Bonsall & Palmer, 2004)	0.15 – 0.42	0.05 – 0.36
(Ruisong, Meiping, & Xiaoguang, 2009)	0.4147 – 0.6862	0.4147 – 0.5083
(Chaniotakis, 2014)	0.116	0.114
This research	**0.047**	**0.044**

7.2.2 Online questionnaire
This paragraph discusses aspects that are related to the online questionnaire.

Improvement of the question on the trip reimbursement
In the introduction questions of the online questionnaire, it was asked if the parking costs of the most recent trip to the inner city of The Hague were reimbursable. There were three options: yes, no and not applicable. The option for 'not applicable' was meant for those respondents who did not have parking costs. However, also respondents who did have parking costs sometimes choose this answer. It would be better to only ask the question of reimbursable parking cost to those respondents who indicated that they have made parking costs in their most recent trip.

Quality of the data
Respondents received a fee for filling in the online questionnaire. Consequently, it should be noted that there is a risk that respondents only complete the questionnaire to receive the fee, while they do not fill in the questionnaire in a serious manner. Furthermore, respondents were asked to fill in 12 choice situations, which might result in response fatigue. On the other hand, the chance is higher that respondents complete the survey because they only receive the fee when the survey is finished. Together, this might reduce the quality of the data.

Hypothetical bias in stated choice experiments
There is a hypothetical bias in stated choice experiments: respondents might have misunderstood the concept of AVs, choice situations or statements. The risk of the presence of a hypothetical bias is minimized by including an introduction movie in which the concept of private highly AVs and the alternatives were explained. All the information that is provided in the introduction movie was also presented in textual information, because respondents might not watch the introduction movie. In order to further reduce the risk of a hypothetical bias, two questions were included in the survey where respondents were able to give comments. One open question was presented after the choice situations and one open question was presented at the end of the questionnaire.

7.2.3 Model
This paragraph discusses the model which is used in this research to predict drivers' parking location choice.

Multinomial logit Model
The Multinomial Logit Model is used in this research to predict drivers' parking location choice. For a first insight in choice behaviour, the MNL model is an efficient model to use. Reviewed research on CVs also used mainly MNL models to predict drivers' parking behaviour. A disadvantage of using a MNL model is that the model assumes homogeneity in preferences. In this research, it is possible that heterogeneity in preferences plays a role. For example, some individuals might have a strong preference for 'personnel surveillance' where other individuals might not. Individuals' preferences neutralize when using an MNL model. Panel effects are not taken into account in the MNL model. One way to take heterogeneity into account is to estimate interaction effects in the MNL model. However, when it is desired to get insight in heterogeneity, it is also possible to use more advanced models such as the Mixed Logit Model. Another advanced model that takes heterogeneity into account is the Latent Class Model.

High percentage of recreational trip purposes in the model
79% of the respondents indicated that their most recent trip to the inner city of The Hague was for a recreational trip purpose. Consequently, 79% of the respondents filled in the hypothetical choice situations for a recreational trip, which might have an effect on the results of the MNL model estimation.

7.2.4 Society
This paragraph discusses the most important trends and developments in society that might have an effect on the results of this research.

Development of the pedestrian zone in the inner city of The Hague
The pedestrian zone in the inner city of The Hague is already large and there are plans to enlarge the pedestrian zone. The pedestrian zone that is located in the inner city of The Hague is not accessible by car. Dropping-off and picking-up passengers can therefore not be done within the pedestrian zone. The results that were found in the literature study

confirmed the importance of egress time (walking) from the parking facility to the passenger's destination. When the passenger's destination is located in (the core of) the pedestrian zone, walking distances are relevant. When the pedestrian zone in the inner city of The Hague will be enlarged, walking distances from the drop-off and pick-up points to the passenger's destination will become larger. It might be the case that parking the vehicle at the edge of the city and transferring to tram, bus or bike will be faster, where the individual is able to reach the core of the inner city with these modes.

Shared AVs

AVs can either be privately used or shared with others. Sharing a vehicle simultaneously or sequentially with strangers might be a disutility for people, because they are used to have their own vehicle. However, when sharing vehicles is stimulated, by for instance decreasing the costs, more individuals might be willing to share a vehicle. Shared AVs will have different consequences for the system. For example, shared vehicles may enter the pedestrian zone in the inner city as they would function as public transport. Furthermore, less space is needed in parking facilities and drop-off and pick-up points, because less cars are needed in order to serve the same number of passengers. It can be concluded that when more AVs are shared, other implications could be expected.

Road pricing

When road pricing will be implemented in cities, the cost for the empty vehicle driving trip will become more important for drivers. When the costs for the empty vehicle driving trip will be higher due to road pricing, drivers' might chose more often for parking their highly AV in the inner city. Furthermore, when road pricing is only implemented during peak hours, this might have an effect on the moment when individuals recall for their vehicle. In addition, this could have a positive effect on congestion on the road network.

7.2.5 Limitations of this research

This paragraph describes the limitations of this research.

Stated Preference data collection method

Private highly AVs as described in this study are not available in the market. Therefore, a Stated Preference data collection method was used in this research, which means that respondents were asked to make choices for hypothetical choice situations. As a result, the findings of this study represent respondents' preferences for hypothetical choice situations. However, it is questionable whether respondents would make the same choices in real life. Furthermore, respondents had to imagine how their vehicle would empty on the roads in the city of The Hague. It is uncertain if respondents would make the same choices when they have more experience in using a highly AV.

Only two presented alternatives

Respondents were forced to choose between two alternatives in the hypothetical choice situations: parking in the inner city and parking at the edge of the city. This operational decision meant that only preferences of the two presented alternatives are observed. In reality, individuals might opt for other alternatives, e.g. parking at a private facility, sending and parking the vehicle at home or to let the vehicle cruise empty. Furthermore, no base alternative was included in the design so respondents had to make a decision between the two alternatives. It is also possible that individuals might opt for another mode of transport when the conditions in the choice sets apply.

Unobserved factors and constraints

In this research, a conceptual framework with all factors that could influence drivers' parking location choice was constructed based on literature review and expert consulting. However, this list is not complete which means that when more experts would have been questioned or more literature studies would have been read, it might be that some other factors could have been added to this conceptual framework. In addition, a selection of the presented factors in the conceptual framework was made, because it is not desired to create complex choice sets with many attributes in this stated choice experiment. Furthermore, there was one factor that could be of great influence on drivers' parking location choice but is hard to implement in the stated choice experiment, namely the context factor: 'hurry or stress for the next trip´. When individuals are in a hurry for their next trip, they might not opt for the parking location at the edge of the city because of the unreliable arrival time of the vehicle. Hurry of stress for the next trip depends on the situation itself and can even change during the trip. Therefore, this factor cannot be operationalized in the stated choice experiment, but it is expected that this factor is of great influence for the parking location choice.

7.3 RECOMMENDATIONS

This section provides an overview of the recommendations for science (paragraph 7.3.1) and society (paragraph 7.3.2) that are based on the results of this research.

7.3.1 Science

This paragraph provides an overview of the recommendations for further scientific research.

Incorporate unobserved alternatives and attributes in the SP design

In the discussion it was described that this research only examined two alternatives (PIC and PEC) and a limited amount of attributes. Further research could focus on other alternatives, e.g. parking at a private facility, sending and parking the vehicle at home or to let the vehicle cruise empty. When other alternatives are included, it is likely that parking demand and distribution will get a new dimension. Furthermore, it could be investigated how drivers' parking location choice will change if public parking facilities located between the inner city and the edge of the city are presented in addition to the currently presented hypothetical choice situations.

In the discussion, it also was described that only a limited amount of attributes is tested in order to reduce complexity. Interesting attributes related to this research are services that make parking facilities more attractive, e.g. a pick-point for groceries or a car wash. Another interesting attribute to include in a SP experiment is the 'need to plan for vehicle to arrive' that was implemented in the SP pilot survey but was excluded from the SP final survey in order to reduce complexity. When this attribute would be included in the SP design, it would be possible to test if individuals would walk to a parking facility to pick-up their vehicle or would recall for their vehicle to drive empty to the passenger's destination. When less complex attributes are implemented in the SP experiment, it is possible to include the 'need to plan for vehicle to arrive'.

Vary context factors for each respondent to measure intra-person variation

This research focused on presenting one context to one respondent. However, the same respondent could make other choices in a different context. Although the contexts were different for every respondent, the ideal situation would be to vary the context for each respondent to measure intra-person variation. When the hypothetical choice situations are less complex or when individuals are more familiar with automated driving, it is advised to vary the context per respondent to measure intra-person variation.

Vary the attribute levels of the parking fee

In this research, it is only examined how drivers' parking location choice will change if a parking fee of €20 is implemented compared to a situation where no parking fee applies. It is interesting to test how drivers' parking location choices will change when the fee for temporary parking the vehicle is lower of higher. Consequently, it is possible to test if this effect is linear. Furthermore, only a fixed level for the parking fee was presented to respondents in this research. It is interesting to test how drivers' parking location choices will change if a time aspect is added to this attribute. Here, a fixed fee for the vehicle being too early could be considered, plus a variable fee for every minute that the vehicle needs to park at an on-street parking place.

Implement the utility functions in the OmniTRANS model

It is advised to test how the results of this research would affect the current road network of The Hague. Therefore, it could be considered to implement the utility functions resulting from this research in the OmniTRANS model. Further research is required on how the new attribute concepts could be implemented in the OmniTRANS software. When the utility functions would be implemented in the OmniTRANS model, insights in road volumes and congestion could be obtained. Furthermore, it is possible to explore the effects during peak and off-peak periods.

Investigate if the results of this study are also applicable for cities similar to The Hague

As was described earlier, the generic framework that is applied in this research could be applied to other large scale cities similar to The Hague. The sample that was used in this SP experiment consisted of respondents living in South

Holland, a province in the Netherlands. It should be checked if the same results would be obtained when using other samples and other cities.

7.3.2 Society

This paragraph provides an overview of the recommendations for society. The recommendations for opportunities for promising parking policies when private highly AVs will become available for passenger transport were already described in section 6.5.

Traffic management - Traffic Centre The Hague / Municipality of The Hague

This research focussed on drivers' parking location choice in which two parking locations (alternatives) were presented: 1) parking in a garage in the inner city and 2) parking at a parking lot at the edge of the city. The driver decides, based on factors and constraints, to which parking **location** he/she will send their highly AV. It is assumed that the driver has no preference for a specific parking **facility** when the choice for the parking location (inner city or edge of the city) is made. Consequently, traffic management could be used to send private highly AVs to a specific parking facility (e.g. to an underutilized parking facility) when the choice for the parking location is made. A smart system is needed that is able to distribute the private highly AVs over the parking facilities, for example via the shortest route or via the route with the least congestion.

International Transport Forum (2015) states: ''active management is needed to lock in the benefits of freed space'' (International Transport Forum, 2015). In this research, the released on-street parking space, which is the result of the restriction for visitors to let their highly AV park in an off-street parking facility, will be used for drop-off and pick-up manoeuvres. Active management is required to reserve released on-street parking space for these drop-off and pick-up manoeuvres.

Requirements for infrastructure – Public road authorities

To prepare the environment for highly AVs, road authorities should consider the following infrastructural changes:

- Improve the quality of the physical markings and lane boundaries
- Change the surface condition of the roads
- Improve the visibility of traffic signs
- Separate fast and slow traffic (and public transport) at intersections where possible

Search for strategic locations for drop-off and pick-up points – Municipality of The Hague

It is advised to investigate where drop-off and pick-up points should be located in order to create an optimal system. First, it should be examined how many reserved on-street parking places are needed in order to match demand and supply. During peak periods, more space for drop-off and pick-up manoeuvres is required compared to off-peak periods. In addition, it is important to consider the disutility for the walking leg to the passenger's destination. Several studies confirmed the importance of minimizing the walking leg from the parking facility to the passenger's destination. Consequently, when investigating on strategic locations for drop-off and pick-up points, it is advised to distribute the drop-off and pick-up points as scattered points in the urban lay-out. Furthermore, it is necessary to make these locations recognisable for visitors as drop-off and pick-up points.

Lay-out of the parking facility - Parking facility owners

In this research, a mix of different SAE level vehicles that operate in the urban environment is assumed. When an increasing number of SAE level 4 and 5 vehicles will operate on the road network, it is possible to change the lay-out of the parking facilities. When the vehicle is able to park itself, no space is required for the passenger to leave or enter his/her vehicle in the parking facility. This means that more vehicles can be parked in off-street parking facilities. Within the off-street parking facilities, it can be considered to create dedicated areas for AVs, in order to enlarge the capacity of the parking facilities.

7.4 REFLECTION

The master thesis was performed at Goudappel Coffeng, a company with over 250 employees and 50 years of leadership in mobility engineering. I am pleased that so many 'Goudappelaars' were enthusiastic about my research and able to provide support when I needed it. Furthermore, I was privileged to join several symposia, conferences and work sessions on smart mobility (Symposium MRA Smart Mobility in Haarlem, Expert Session Smart Mobility in The Hague, Conference

Smart Mobility in Almere and two Spatial and Transport impacts of Automated Driving (STAD) meetings). These sessions provided me with new insights on the state of the art in smart mobility and more specific in automated driving. These new insights proved to be very useful for the boundaries of this research and content of this report. During the first phase of this master thesis, I organised several brainstorm sessions with experts in smart mobility. All experts were really enthusiastic about the research and eager to help me with the completion of the conceptual framework, by discussing factors that could be of influence on drivers' parking location choice. Every session gave me new and positive energy to make the conceptual framework as complete as possible.

Constructing a Stated Preference experiment with only minor in-depth knowledge about statistical methods for behavioural analysis proved to be a challenging task. Especially constructing the coding schemes and the interpretation of the results were sometimes complicated for me. In this study, the variables of the pilot survey were effect coded because I thought that effect coding was necessary in order to be able to estimate the interaction effects. However, in this stage of the research, interaction effects did not need to be estimated and this only applies for estimating interaction effects between attributes and not in the case of implementing interaction variables. It is easier to interpret dummy coded results so it could have been more convenient to use dummy coding schemes already in the pilot survey.

In the online questionnaire, respondents were able to leave comments on the survey. I was very pleased to see so many enthusiastic reactions on my research. For example: ''it was a pleasure to join in this research'' and ''interesting study, I want to participate in more studies like this''. The comments on the survey showed that next to the positive reactions on the concept of highly automated vehicles, some respondents did not like the idea, providing feedback as: ''a self-driving car sounds really scary'' and ''I want to have the control over my vehicle''.

In this master thesis, I was able to combine my interest in spatial planning, transport and smart mobility. I am proud of the process of this master thesis and its results that provide new insights in drivers' parking location choice for a future situation, where private highly automated vehicles will become available for passenger transport. I hope that these new insights will inspire others, for further research and possible applications.

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INTERVIEWS

The following list gives an overview of the interviews, discussions and brainstorm sessions that were conducted during this study in order to acquire knowledge and information on different aspects of this research.

Goudappel Coffeng

Arthur Scheltes – Consultant Public Transport & Mobility and Environment – several meetings
Different discussions regarding 1) the effects of automated vehicles on the urban environment, 2) factors that could influence drivers' parking choice behaviour and 3) the progress of this master thesis were conducted.

Jantine Bijlsma-Boxum - Consultant – 9 November 2016
Practical information about the stated choice preference survey was given. This included information on the costs for launching the survey, type of questions possible, number and type of respondents needed and the length of the survey.

Jeroen Roelands – Coordinator Parking and Area Development – 1 November 2016
Information and thoughts on the functionality of parking in general and more specific on parking functions in the inner city of The Hague were discussed.

Matthijs Dicke-Ogenia – Consultant Traffic and Transport – 9 November 2016
A brainstorm session about factors that could influence drivers' parking choice behaviour was done. The focus of this meeting was on the importance of the planning aspect during the trip.

Menno Yap – Consultant Public Transport, PhD Researcher TU Delft, department Transport & Planning – several meetings
The levels of the attributes and the set-up of the stated choice experiment was discussed.

Paul van Beek – Senior consultant – 27 September 2016
General information on panels and specific information on the panel which could be used for this research was given.

Connecting Mobility

Ilse Harms – Senior advisor human factors and traffic – 22 November 2016
Nina Schaap – Senior advisor – 22 November 2016
A brainstorm session about factors that could influence drivers' parking choice behaviour was done. The discussion was focused on the passenger's point of view where the Value of Time appears to be of excessive influence.

Connekt

Marije de Vreeze – Manager ITS Netherlands – 18 November 2016
A brainstorm session about factors that could influence drivers' parking choice behaviour was done. The focus of this meeting was on the passenger's perception as an important aspect that relates to behaviour.

DAT.Mobility

Luuk Bredereode – Consultant DAT.mobility, PhD Researcher TU Delft, department Transport & Planning –
29 September 2016 / 9 November 2016
Information on OmniTRANS models was given and the possibility to implement choice models in OmniTRANS was discussed.

Municipality of Amsterdam

Anne Blankert – Senior consultant Traffic management, Traffic and Public Space – 2 November 2016
A brainstorm session about factors that could influence drivers' parking choice behaviour was done.

Municipality of The Hague

Arjen Reijneveld – Advisor Accessibility, department Accessibility and Traffic Management
Diede Labots – Policy officer department Transport, staff Spatial Development
3 November 2016, 9 January 2017 and 3 April 2017
The first meeting was focused on parking and (desirable) parking policies in the inner city of The Hague. Furthermore, different what-if scenarios were discussed which could be applied to the inner city of The Hague when private highly automated vehicles will become available for passenger transport. The second meeting was focused on the social costs for the municipality of The Hague when the system will be implemented. During the third meeting, opportunities for policy advice were discussed.

TU Delft

Baiba Pudane – PhD Researcher TU Delft, department Technology, Policy and Management – 10 November 2016
A brainstorm session about factors that could influence drivers' parking choice behaviour was done. The focus of this meeting was on the Value of Reliability as an important factor that could influence parking choice behaviour. Furthermore, it was discussed how general information on automated vehicles could be provided to the respondents before they fill in the survey.

Konstanze Winter – PhD Researcher TU Delft, department Transport & Planning - 28 September 2016
During this meeting, the focus of this master thesis was discussed.

A

LEVELS OF DRIVING AUTOMATION

The SAE's (Society of Automotive Engineers) levels of driving automation are listed in Table A.1. These levels are descriptive and informative. The term 'system' in this table refers to the driving automation system. This thesis focusses on **Level 4: High Driving Automation**.

Table A.1 SAE's levels of driving automation (SAE International, 2016)

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

ADS: Automated Driving System; DDT: Dynamic Driving Task; ODD: Operational Design Domain; OEDR: Object and Event Detection and Response

B

LITERATURE REVIEW

An overview of the models, alternatives and attributes that were used in the reviewed studies on macroscopic (Axhausen & Polak, 1991); (Hunt & Teply, 1993); (Lambre, 1996); (Thompson & Richardson, 1998); (Bonsall & Palmer, 2004); (Ruisong, Meiping, & Xiaoguang, 2009); (Chaniotakis, 2014); (van der Groot, 1982) and microscopic (van der Waerden, Borgers, & Timmermans, 2003) levels of scale is shown in Table B.1.

Table B.1 Models, alternatives and attributes used in the reviewed studies

Study	Model	Alternatives	Attributes
Macroscopic level			
[1]	Logit	Free on-street, metered on-street, multi-story facility, off-street surface lot, illegal parking	parking cost, walking time, access time, search time, illegal fine
[2]	Nested logit	1) Choice among on-street, off-street and employer-arranged parking 2) Choice among on-street areas 3) Choice among off-street areas	parking cost, walking time, access time, search time, parking typology, parking capacity, parking surface
[3]	Probit and logit	Choice among 55 garages and parking lots when travelling to one of the 13 destinations in the city	parking cost, walking time, access time
[4]	(Nested) logit	On-street parking, off-street garage, off-street parking lot	parking cost, walking time, access time, search time, illegal fine, parking duration
[5]	Multinomial logit	Choice among 5 parking facilities. Two journey purposes: business-meeting and off-peak shopping trip	parking cost, walking time, access time, search time, PGI usage
[6]	Binary logit	On-street and off-street parking Difference between completely-informed and incompletely-informed drivers	age, gender, reimbursement, parking cost, walking time, safety
[7]	Multinomial logit, nested logit, mixed logit and random regret minimization	Two alternatives with varying attributes (characteristics of parking) in the scenarios were created	parking cost, walking time, access time, parking typology, probability
[8]	Logit	Cluster alternatives in groups: on-street, parking bays, off-street car parks, parking garage, illegal parking (22 alternatives / 6 alternatives)	parking cost, walking time, occupancy, accessibility factor, parking time restriction
Microscopic level			
[9]	Nested logit	1) Parking spot level and 2) the choice of parking space within the parking strip	For 1: status of parking space For 2: location of ticket machine, entrance and exit

Where: [1] (Axhausen & Polak, 1991)*; [2]* (Hunt & Teply, 1993)*; [3]* (Lambre, 1996)*; [4]* (Thompson & Richardson, 1998)*; [5]* (Bonsall & Palmer, 2004)*; [6]* (Ruisong, Meiping, & Xiaoguang, 2009)*; [7]* (Chaniotakis, 2014)*; [8]* (van der Groot, 1982)*; [9]* (van der Waerden, Borgers, & Timmermans, 2003)

C

MULTI-CRITERIA ANALYSIS

All factors that could influence drivers' parking location choice when drivers make use of a private highly AV were visualised in Figure 3.2. Hypotheses for the factors are defined below:

- Socio-demographic characteristics
  Gender: obtained from the literature review.
  Age: obtained from the literature review.
  Income: individuals may become less sensitive for 'parking cost' when they have a higher income.
  Number of trips with private vehicle to inner city of The Hague: individuals may have a fixed preference for a parking location when they more often visit the inner city of The Hague.
  Familiarity with AVs: individuals may become more or less sensitive for 'risk of extra waiting time' and 'risk of parking fee' when the knowledge and interest in AVs differs.
  Value of the car: individuals may become more sensitive for 'parking surveillance' when the value of their car is higher.

- External conditions
  Weather conditions: individuals may become more sensitive for 'risk of extra waiting time' in rainy and cold weather conditions because they have to wait outside at the pick-up point. Furthermore, individuals may become more sensitive for indoor / outdoor parking facilities in different weather conditions.
  Carrying luggage: individuals may become more sensitive for 'risk of extra waiting time' when they have to carry more luggage.
  Travel company: individuals may become more or less sensitive for 'risk of extra waiting time' when they are in a large travel company.
  Time of the day: individuals may become more sensitive for 'risk of extra waiting time' during the peak periods compared to off-peak periods.
  Hurry / stress for next trip: individuals may become more sensitive for 'risk of extra waiting time' when they are in a hurry for their next trip.

- Route characteristics to and from the parking facility
  Empty vehicle driving costs: empty vehicle driving costs are direct costs which add up to the total cost for parking the private highly AV.
  Empty vehicle driving time: when the empty vehicle driving time to a parking facility is higher that the trip duration, the parking facility might not be considered.
  Risk of damage by other road user: when individuals are more afraid of risk of damage by another road user during the empty vehicle driving trip, the individual might not opt for the parking facility at the edge of the city.
  Risk of damage by AV itself: when individuals are more afraid of risk of damage by the AV itself during the empty vehicle driving trip, the individual may not opt for the parking facility at the edge of the city.
  Reliability of arrival time (second part of empty trip): when the reliability of arrival time is low, the individual may not opt for the parking facility at the edge of the city.

- Passenger destination characteristics
  Trip purpose: individuals may become more sensitive for the 'risk of extra waiting time' when the trip purpose is different.
  Trip duration: the trip duration is related to the total parking cost, which means that individuals may become more sensitive for 'parking cost' when the trip duration is longer.
  Trip reimbursement: individuals may become less sensitive for 'parking cost' when their trip is reimbursed.

- Parking facility characteristics
  Parking cost: in literature, it is confirmed that individuals are very sensitive for a change in parking cost.
  Parking duration: when the trip duration is longer than the parking duration of a parking facility, the parking facility is not considered.
  Parking typology: individuals may have a preference for the parking typology. Individuals may dislike parking garages because of the tight structure. Others might want to park their car in an indoor garage instead of parking in the open air.
  Additional provisions (charge, reparation or washing the vehicle): individuals may prefer a parking facility because of the extra provided services.
  Supervision of the parking facility: individuals may prefer a parking facility that is supervised compared to an unguarded parking facility.
  Information of the parking facility (capacity, occupation, chance of finding parking spot): when information of a certain parking facility is known, the attractiveness of a certain parking facility might increase of decrease.
  Possibility to reserve a parking spot: when it is possible to reserve a parking facility, the attractiveness of a parking facility may increase.
  Condition of the facility: when the condition of a parking facility is good (bad), the attractiveness of the parking facility may increase (decrease).
  Risk of damage during parking the car: The risk of damage during parking the car may be higher in a parking garage because of the tight structure. When individuals are more afraid of risk of damage during parking the car, the individual may not opt for parking the private highly AV in a parking garage.

The values of the criteria which are used in the MCA are shown in Table C.1.

Table C.1 Criteria values MCA

Criteria		Value explanation	Value
1	Expected influence of the factor on parking choice behaviour	Rating low-high	0 to 4
2	Measurability of the factor with SP	yes	2
		hardly measurable	1
		no	0
3	Manageability of the factor by municipality	yes	1
		no	0

A factor is selected as attribute if: Criteria 1 ≥ 3; Criteria 2 = 2; Criteria 3 = 1
A factor is selected as context factor or perception if: Criteria 1 ≥ 3; Criteria 2 = 2

The results of the MCA are presented in Table C.2. Remarks regarding the marked elements (*) are presented below:

- *Hurry / stress for next trip*: this factor depends on the real time situation and is even able to change during the activity. Therefore, this factor is not measurable with SP.
- *Reliability of arrival time*: reliability of the route and therefore the reliability of arrival time of the vehicle back at the passenger results in either the passenger needs to wait or vehicle needs to wait at the pick-up point.
- *Parking facility characteristics*: only the factors for on-street parking are manageable by the municipality. The off-street parking facilities in The Hague are owned by the private company Q-park.
- *Parking duration*: parking duration of off-street parking garages is not a constraint in this research, because there is no parking time limit for off-street parking garages in The Hague.
- *Information of parking facility*: in the future situation, technology has reached a certain level where information of the parking facility is known by the operated system. It is known where empty parking spots are located and the car is able to drive to the closest empty parking spot within the facility.
- *Possibility to reserve parking spot*: when choosing for a facility to park the car, the car immediately reserves a spot where it starts to drive to. There are no extra costs for reserving the parking spot.

Table C.2 Results MCA

	Factors	Criteria 1 Expected influence	Criteria 2 Measura-bility with SP	Criteria 3 Managea-bility	Exogenous variable	Attribute	Context	Perception
a	PERSONAL CHARACTERISTICS							
	gender	2	2	0	X			
	age	2	2	0	X			
	income	3	2	0	X			
	value of the car	2	2	0	X			
	# trips with private vehicle to inner city	2	2	1	X			
	familiarity with AVs	2	2	1	X			
b	EXTERNAL CONDITIONS							
	weather conditions	2	2	0				
	carrying luggage	1	2	0				
	travel company	2	2	0				
	time of the day	2	2	0				
	hurry / stress for next trip *	4	0	0				
2.2	ROUTE CHARACTERISTICS							
	empty vehicle driving costs	3	2	1		X		
	empty vehicle driving time	3	2	1		X		
	risk of damage - by other road user - by AV	3	1	0				X
3.2	ROUTE CHARACTERISTICS							
	empty vehicle driving costs	3	2	1		X		
	empty vehicle driving time	3	2	1		X		
	risk of damage - by other road user - by AV	3	1	0				X
	reliability of arrival time *	4	1	1				
C	PASSENGER DESTINATION CHARACTERISTICS							
	trip purpose	4	2	0			X	
	trip duration	4	2	0			X	
	trip reimbursement	4	2	0			X	
D	PARKING FACILITY CHARACTERISTICS *							
	parking cost	4	2	0/1		X		
	parking duration *	3	2	0/1				
	parking typology	3	2	0				
	additional provisions - charge the vehicle - reparation of the vehicle - washing of the vehicle	2	2	0/1				
	supervision of the facility	3	2	0/1		X		
	information of parking facility * - capacity - occupation - chance of finding parking spot	3	2	0/1				
	possibility to reserve parking spot *	2	2	0/1				
	condition of the facility	1	2	0/1				
	risk of damage during parking the car	3	1	0				
E	PICK-UP POINT CHARACTERISTICS							
	need to plan for vehicle to arrive	3	2	0/1		X		
	risk of extra waiting time for vehicle to arrive (when vehicle is too late)	4	2	1		X		
	risk of temporary parking of the vehicle: penalty (when vehicle is too early)	4	2	1		X		

The numbers/letters for every category shown in Table C.2 correspond with the numbers/letters in the conceptual framework visualised in Figure 3.2.

D
LIST OF ASSUMPTIONS

Table D.1 gives an overview of the highly AV related assumptions that are made in this research. The assumptions are categorized in different subjects related to the: vehicle, network and system.

Table D.1 AV related assumptions in this research

Subject related to	Assumption
Vehicle type and functioning	• Everyone is able to drive a highly AV: the passenger does not need to have a driver licence. • A highly AV is as expensive as a CV; different price classes of AVs exist based on type of vehicle, size of the vehicle, etc. (The Boston Consulting Group, 2016). • All highly AVs which operate on the road network are electric. • A highly AV does not have more failures than a CV. • A highly AV adheres to the traffic rules. • A highly AV is able to drive in a mixed traffic condition. In case of an emergency, the highly AV is able to drive itself to a safe place (minimal risk).
Network	• A mixed traffic scenario is assumed which means that vehicles of different SAE levels operate on the road network. • All routes in the inner city are ready for highly AVs. Only distributor roads (s-routes) from inner city to edge of city are ready for highly AVs. (= predefined routes from drop-off point to a parking facility and from parking facility to pick-up point).
System	• The passenger pays automatically via his smartphone when he/she recalls for the vehicle to pick him/her up • Locking the highly AV is done automatically when the passenger has left the vehicle. • Parking the vehicle in the inner city (PIC): perfect match between vehicle and passenger at the pick-up point. • Parking the vehicle at the edge of the city (PEC): unreliable arrival times might result in a mismatch between the vehicle and the passenger at the pick-up point.

E

STATED PREFERENCE PILOT SURVEY

This appendix first describes the Ngene syntax (E.1) which is used to create the choice situations for the stated preference pilot survey. Second, an example of the choice sets in both SP pilot surveys are presented (E.2). Third, effect coding is explained (E.3). Last, the Biogeme model and results of the estimated MNL model of the pilot survey are presented (E.4).

E.1 NGENE SYNTAX: ORTHOGONAL DESIGN

An orthogonal experimental design is used for the SP pilot survey (first and second pilot survey). The following Ngene syntax is used to design the choice situations for the SP pilot survey:

ORTHOGONAL FRACTIONAL FACTORIAL DESIGN

```
Design
;alts = pic, pec
;rows = 18
;orth = sim
;block= 2
;model:
U(PIC) = b0 + b1 * parking_cost[0,1,2] + b2 * surveillance[0,1,2] + b3 * need_to_plan[0,1,2] /
U(PEC) = b4 * parking_cost[0,1,2] + b5 * surveillance[0,1,2] + b6 * risk_of_extra_waiting_time[0,1,2] + b7 * risk_of_fine[0,1,2]
$
```

In the presented Ngene syntax above, 'alts' means alternatives which are parking in the inner city (pic) and parking at the edge of the city (pec). 'rows' stands for the number of choice situations that will be generated in the experimental design. 'orth' means that the design is orthogonal and 'sim' indicates that the design is simultaneous. An orthogonal design is needed, because there is no information on the prior parameter values. Because of the labelled alternatives with alternative specific attributes, a simultaneous design is needed (Molin, SPM4612 Lecture 2 - Orthogonal experimental designs, 2015c). 'block' indicates that the design is blocked. Not blocking the design means that every respondent needs to fill in 18 choice situations (rows = 18). Because 18 choice situations are too many to fill in by one respondent, it is decided to block the design. This design has 2 blocks. A respondent is presented only one block which indicates that 9 choice situations are showed to half of the respondents and 9 choice situations are showed to the other half of the respondents. A disadvantage of blocking the design is that double of respondents are needed. 'b' followed by a number represents the parameter β. 'b0' represents the asc.

E.2 EXAMPLES CHOICE SET

Two SP pilot surveys were created. The visualisation of a choice situation (choice situation 4) in the first and second SP pilot survey are shown in Figure E.1 and E.2 respectively. In the first SP pilot survey, mainly icons were shown to the respondents, indicating the different attributes and the different stages of the trip. In the second SP pilot survey, text is used to explain the attributes. For both pilot survey, the black, blue and red parts relate to the empty vehicle driving trip, parking facility and the passenger's destination characteristics respectively.

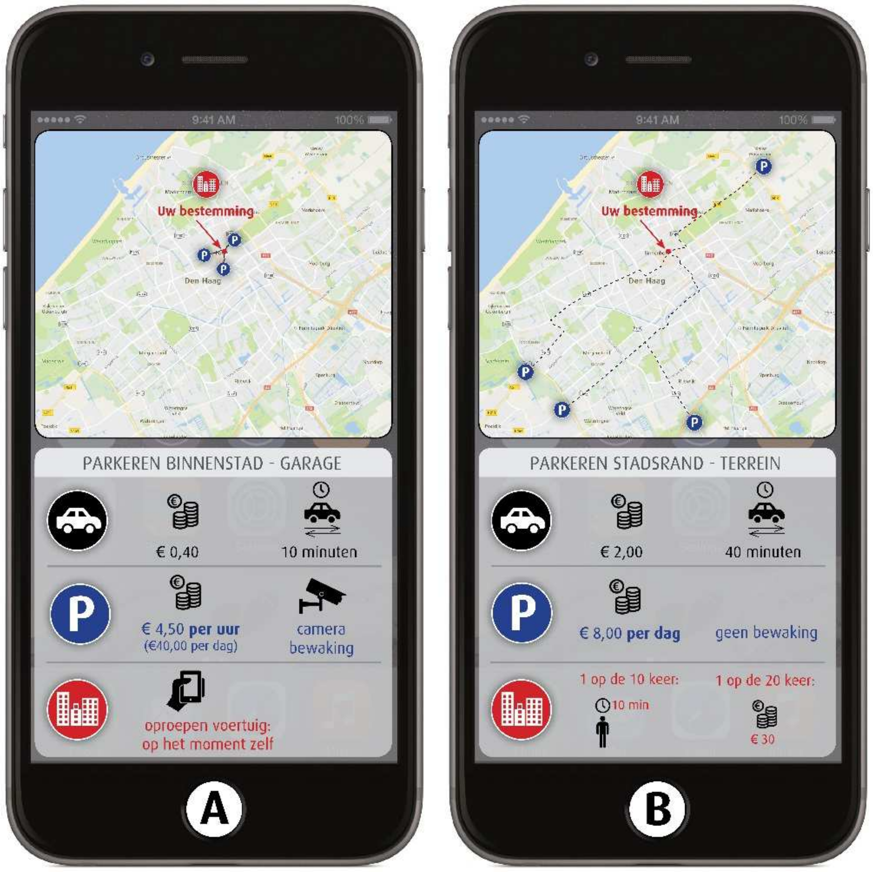


Figure E.1 Example of a choice situation in the second SP pilot survey (choice situation 4)

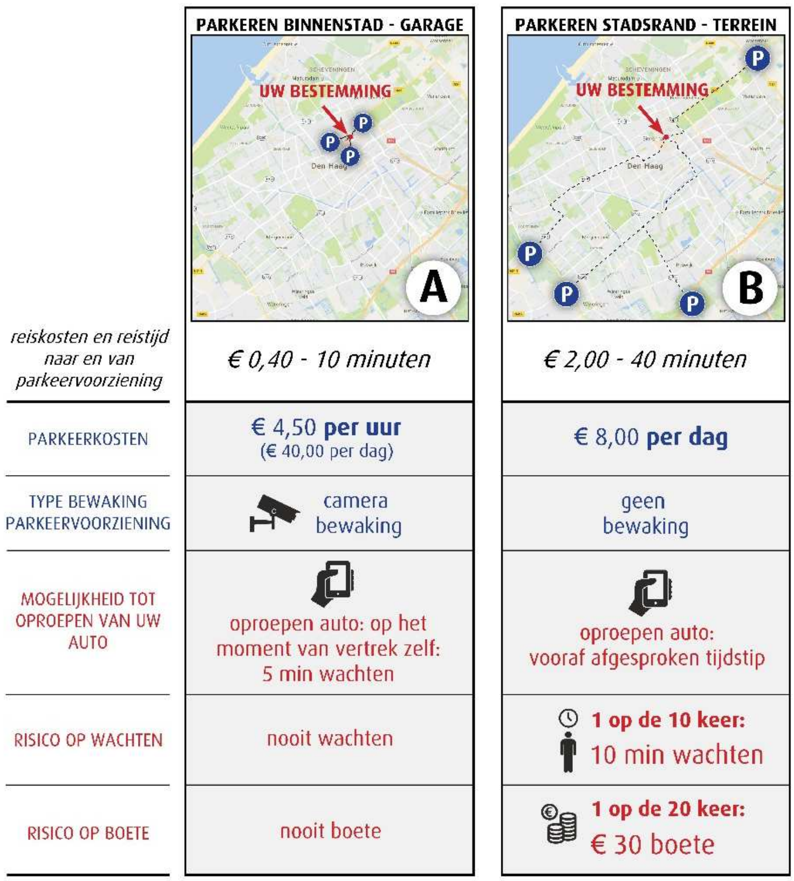


Figure E.2 Example of a choice situation in the second SP pilot survey (choice situation 4)

E.3 EFFECT CODING SCHEMES

The effect coding schemes for the parameters for parking the private highly AV in the inner city and for parking the private highly AV at the edge of the city are shown in Table E.1 and Table E.2 respectively.

Table E.1 Effect coding scheme attributes parking in the inner city

PARKING COST	COSTI1	COSTI2	SURVEILLANCE	SURVI1	SURVI2	NEED TO PLAN	PLAN1	PLAN2
€4.50	1	0	personnel	1	0	yes: advance	1	0
€3.50	0	1	camera	0	1	yes: moment	0	1
€2.50	-1	-1	none	-1	-1	no	-1	-1

Table E.2 Effect coding scheme attributes parking at the edge of the city

PARKING COST	COSTE1	COSTE2	SURVEIL-LANCE	SURVE1	SURVE2	RISK OF WAITING	WAIT1	WAIT2	RISK OF FINE	FINE1	FINE2
€0.00	1	0	personnel	1	0	5 out of 10: 10 min	1	0	1 out of 20: €40	1	0
€4.00	0	1	camera	0	1	3 out of 10: 10 min	0	1	1 out of 20: €30	0	1
€8.00	-1	-1	none	-1	-1	1 out of 10: 10 min	-1	-1	1 out of 20: €20	-1	-1

E.4 BIOGEME MODEL

The **model file (.mod)** for the SP pilot survey is constructed as follows:

BIOGEME MODEL FILE (.MOD)

```
// File PARKING.mod

[Choice]
CHOICE

[Beta]
// Name     Value   LowerBound   UpperBound   status (0=variable, 1=fixed)
asc1        0       -10000       10000        0
asc2        0       -10000       10000        1
costi1      0       -10000       10000        0
costi2      0       -10000       10000        0
survi1      0       -10000       10000        0
survi2      0       -10000       10000        0
plan1       0       -10000       10000        0
plan2       0       -10000       10000        0
coste1      0       -10000       10000        0
coste2      0       -10000       10000        0
surve1      0       -10000       10000        0
surve2      0       -10000       10000        0
wait1       0       -10000       10000        0
wait2       0       -10000       10000        0
fine1       0       -10000       10000        0
fine2       0       -10000       10000        0

[Utilities]
// Id   Name    Avail   linear-in-parameter expression (beta1*x1 + beta2*x2 + ...)
1       PIC     AV1     asc1 * CONST + costi1 * COSTI1 + costi2 * COSTI2 + survi1 * SURVI1 + survi2 * SURVI2 + plan1 * PLAN1 + plan2 * PLAN2
2 PEC       AV2     asc2 * CONST + coste1 * COSTE1 + coste2 * COSTE2 + surve1 * SURVE1 + surve2 * SURVE2 + wait1 * WAIT1
                        + wait2 * WAIT2 + fine1 * FINE1 + fine2 * FINE2

[Model]
$MNL
```

In the Biogeme model file, the two utility functions are formulated (AV1 = PIC and AV2 = PEC). In the utility functions, capital letters are used to indicate the attributes (COSTI1, COSTI2, etc..) and non-capital letters represent the parameters (costi1, costi2, etc..).

The results of the estimated MNL model for the second pilot survey are shown in Table E.3. In total, 15 parameters are estimated. These are the seven attributes who each have two parameter values (=14 parameters). In addition, the asc for parking in the inner city is estimated as a parameter. The asc for parking at the edge of the city is fixed (asc2).

Table E.3 Results model estimation second pilot survey

Model:	Multinomial logit
Number of estimated parameters:	15
Number of observations:	413
Number of individuals:	413
Null log-likelihood	-286.270
Cte log-likelihood	-280.479
Init log-likelihood	-286.270
Final log-likelihood	-265.477
Likelihood ratio test	41.585
Rho-square	0.073
Adjusted rho-square	0.020

F

STATED PREFERENCE FINAL SURVEY DESIGN

This appendix first describes the Ngene syntax (F.1) which is used to create the choice situations for the stated preference final survey. Secondly, the design of the final survey is presented in Dutch and English (F.2).

F.1 NGENE SYNTAX: EFFICIENT DESIGN

An efficient experimental design was used for the SP final survey. The following *Ngene syntax* was used to design the choice situations for the final survey:

EFFICIENT DESIGN

```
Design
;alts = pic, pec
;rows = 12
;eff = (mnl,d)
;model:
U(PIC) = b0[0.386] + b1.effects[-0.449|0.00288] * parking_cost[2,1,0] + b2.effects[0|0] * surveillance[2,1,0] /
U(PEC) = b3.effects[-0.448|0.180] * parking_cost[2,1,0] + b4.effects[0|0] * surveillance[2,1,0] + b5.effects[-0.360|0.121] *
risk_of_extra_waiting_time[2,1,0] + b6.effects[0] * risk_of_parking_fee[1,0]
$
```

In the presented Ngene syntax above, 'alts', 'rows', 'b' and 'b0' were explained in Appendix E. 'eff' means that an efficient design was used. An efficient design can be used for the SP final survey, because there is information on prior parameter values. 'mnl, d' indicates that a MNL model was used in which the efficient design with the lowest d-error was chosen for the construction of the hypothetical choice situations.

Priors that have the expected sign were implemented into the Ngene syntax. Prior values are available for: asc (b0 in the Ngene syntax), parking_cost PIC, parking_cost PEC and the risk of extra waiting time. No prior values are available for: surveillance PEC and PEC, and the risk of parking fee (this is a new introduced attribute).

F.2 DESIGN OF THE SP SURVEY

The final survey was made in Dutch because the questionnaire was only sent to respondents with a Dutch nationality. In this appendix, an English version of the survey is added and located next to the Dutch version of the survey.

Some remarks about the final survey are described here because these are not visible in the design of the final survey presented in this appendix. First, in the final survey respondents sometimes had the option for 'other, namely...' ('anders, namelijk' in Dutch). When respondents chose for this option, they were able to fill in their own answer. Second, above every choice situation the answers to the questions about the trip purpose, parking duration and reimbursable parking costs were made visible again so respondents could take them directly into account while making their preferred parking location choice in every choice situation.

Beste deelnemer,

Bedankt voor uw deelname aan dit onderzoek! Deze enquête gaat over de effecten van de **zelfrijdende auto** op de **parkeerlocatiekeuze** van reizigers. De enquête is onderdeel van het afstudeeronderzoek van Daphne van den Hurk aan de Technische Universiteit Delft en Goudappel Coffeng. De enquête duurt ongeveer 10 minuten en bestaat uit vijf vragen over uw laatste bezoek aan de binnenstad van Den Haag gevolgd door drie onderdelen:

- In deel 1 wordt een animatiefilmpje getoond met uitleg over de zelfrijdende auto en de opties voor de parkeerlocatiekeuze. Hierna worden twaalf scenario's geschetst waarin u uw voorkeur moet geven voor de **parkeerlocatiekeuze** met de **aanname** dat **uw eigen auto** een **zelfrijdende auto** is.
- In deel 2 wordt naar uw mening gevraagd over zes verschillende stellingen omtrent zelfrijdende auto's.
- In deel 3 worden een aantal vragen gesteld over uw persoonskenmerken.

Er wordt vertrouwelijk omgegaan met uw antwoorden en de informatie zal alleen gebruikt worden voor dit onderzoek. Verplichte vragen zijn gemarkeerd met een *.

UW LAATSTE BEZOEK AAN DE BINNENSTAD VAN DEN HAAG

*Deze vragen gaan over uw **laatste** (meest recente) bezoek aan de binnenstad van Den Haag met **uw eigen auto**.*

Wat was het doel van uw laatste bezoek aan de binnenstad van Den Haag met uw eigen auto? *

- ☐ Zakelijke afspraak
- ☐ Werkdag
- ☐ Recreatief (bijvoorbeeld winkelen, uitstapje, kennis bezoeken, etc..)
- ☐ Anders, namelijk….

Waar heeft u uw auto geparkeerd tijdens dit laatste bezoek? *

- ☐ Privé parkeerterrein
- ☐ Openbare parkeergarage
- ☐ Openbaar parkeerterrein
- ☐ P+R voorziening
- ☐ Anders, namelijk…

Hoe lang heeft u uw auto geparkeerd tijdens dit laatste bezoek? *

- ☐ Minder dan 1 uur
- ☐ 1 uur
- ☐ 2 uur
- ☐ 3 uur
- ☐ 4 uur
- ☐ 5 uur
- ☐ 6 uur
- ☐ 7 uur
- ☐ 8 uur
- ☐ Meer dan 8 uur

Dear participant,

Thank you for participating in this survey! This survey is about the effects of the **self-driving car** on passengers' **parking location choice**. The survey is part of the graduation study of Daphne van den Hurk and is conducted in cooperation with The Delft University of Technology and Goudappel Coffeng. The survey will take approximately 10 minutes and consists of five questions about your last trip to the inner city of The Hague, followed by three parts:

- In part 1, an animation movie is shown which contains an explanation of self-driving cars and the parking location options. Next, twelve scenarios will be shown in which you will give your preference for the **parking location** with the assumption that **your own car** is a **self-driving car**.
- In part 2, you will give your opinion on six different statements about self-driving cars.
- In part 3, questions are asked about your personal characteristics.

All answers will be treated confidentially and will only be used for this research. Compulsory questions are marked with a *.

YOUR LAST TRIP TO THE INNER CITY OF THE HAGUE

*These questions are about your **last** (most recent) trip to the inner city of The Hague with **your own car**.*

What was the purpose of your last trip to the inner city of The Hague with your own car? *

- ☐ Business appointment
- ☐ Working day
- ☐ Recreational (e.g. shopping, excursion, visit a friend, etc..)
- ☐ Different, namely…

Where did you park your car during this last trip? *

- ☐ Private parking lot
- ☐ Public parking garage
- ☐ Public parking lot
- ☐ Park-and-Ride facility
- ☐ Different, namely…

What was the vehicle parking time duration this last trip? *

- ☐ Less than 1 hour
- ☐ 1 hour
- ☐ 2 hours
- ☐ 3 hours
- ☐ 4 hours
- ☐ 5 hours
- ☐ 6 hours
- ☐ 7 hours
- ☐ 8 hours
- ☐ More than 8 hours

Wat waren uw totale parkeerkosten van dit laatste bezoek? *

☐ €0,00
☐ €0,01 - €5,00
☐ €5,00 - €10,00
☐ €10,00 - €15,00
☐ €15,00 - €20,00
☐ €20,00 - €25,00
☐ €25,00 - €30,00
☐ Meer dan €30,00

Werden u uw parkeerkosten vergoed tijdens dit laatste bezoek? (bijvoorbeeld door uw werkgever) *

☐ Ja
☐ Nee
☐ n.v.t.

DEEL 1: SCENARIO'S - PARKEERLOCATIEKEUZE MET DE ZELFRIJDENDE AUTO

In het volgende animatiefilmpje van ongeveer 2 minuten krijgt u uitleg over de reis met een zelfrijdende auto en de keuze voor de parkeerlocatie. Bekijk het animatiefilmpje aandachtig, de informatie is nodig voor de scenariovragen die volgen.

- U wordt met uw zelfrijdende auto afgezet op uw bestemming
- U stuurt uw zelfrijdende auto naar een openbare parkeervoorziening (bijvoorbeeld met uw smartphone)
- Op het moment dat u wenst te vertrekken, roept u uw zelfrijdende auto weer op (bijvoorbeeld met uw smartphone)
- Wanneer uw auto vanaf de stadsrand terug moet komen, kan het zijn dat de auto eerder of later terug is in verband met de onzekere reistijd onderweg. De auto is mogelijk ***later*** *of* ***eerder*** *bij uw ophaalpunt dan u. Wanneer de auto te laat is, moet u wachten. Wanneer de auto te vroeg is, moet deze tijdelijk wachten (parkeren) bij uw ophaalpunt. In sommige scenario's is het tijdelijk parkeren gratis. In sommige scenario's moet de auto tegen betaling tijdelijk parkeren.*

What were your total 'parking cost' during this last trip? *

☐ €0.00
☐ €0.01 - €5.00
☐ €5.00 - €10.00
☐ €10.00 - €15.00
☐ €15.00 - €20.00
☐ €20.00 - €25.00
☐ €25.00 - €30.00
☐ More than €30.00

Were your 'parking cost' reimbursable during this last trip? (e.g. by your employer) *

☐ Yes
☐ No
☐ Not applicable

PART 1: SCENARIOS – PARKING LOCATION CHOICE WITH THE SELF-DRIVING CAR

In the following animated movie of approximately 2 minutes, you will get an explanation about the trip with a self-driving car and the choice for a parking location. Please watch the animated movie attentively, the information is needed for the scenario questions.

- You will be dropped-off at your destination with your self-driving car
- You will send the self-driving car to a public parking facility (for example with your smartphone)
- When your activity has ended, you will call for your car to pick you up (for example with you smartphone)
- When the car needs to drive back from the edge of the city, the possibility arises that the car is returned later or earlier because of unreliable travel times. The possibility arises that the car is ***later*** *or* ***earlier*** *at the pick-up point than you are. When the car to too late, you need to wait. When the car is too early, it needs to wait (park) temporarily at your pick-up point. In some scenarios parking the car is free. In some scenarios, the car needs to be parked for a fee.*

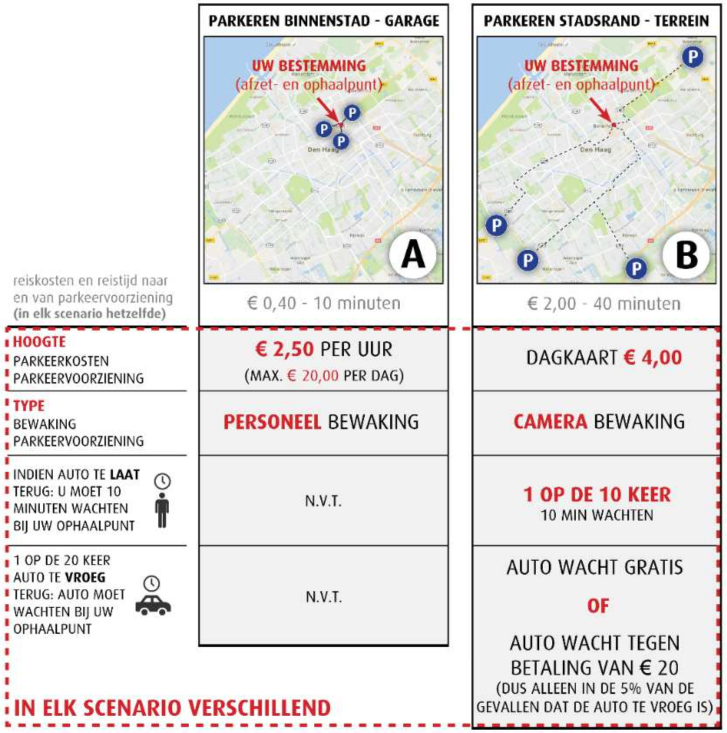
We hebben u eerder gevraagd naar het laatste bezoek aan de binnenstad van Den Haag met uw eigen auto. Stel dat u deze verplaatsing weer maakt, maar nu met de aanname dat uw eigen auto een zelfrijdende auto is. Stelt u zich voor dat de zelfrijdende auto u afzet bij uw eindbestemming. U stuurt dan uw zelfrijdende auto naar een openbare parkeervoorziening.

Bekijk de volgende twaalf scenario's die verschillen in kenmerken en kies elke keer voor de parkeervoorziening waar u uw zelfrijdende auto naar toe zou sturen:
- Optie A: Parkeren binnenstad
- Optie B: Parkeren stadsrand

VOORBEELD EN UITLEG SCENARIO'S

Deze parkeerkosten gelden ALTIJD (ook als u tijdens uw laatste rit gratis heeft geparkeerd)
Indien u tijdens uw laatste bezoek de parkeerkosten vergoed heeft gekregen, geldt dat voor nu ook.

Welke parkeervoorziening heeft uw voorkeur? *
(voor uw ingevulde reisdoel, parkeertijd en eventueel uw vergoede parkeerkosten)



A Parkeren binnenstad B Parkeren stadsrand ✓

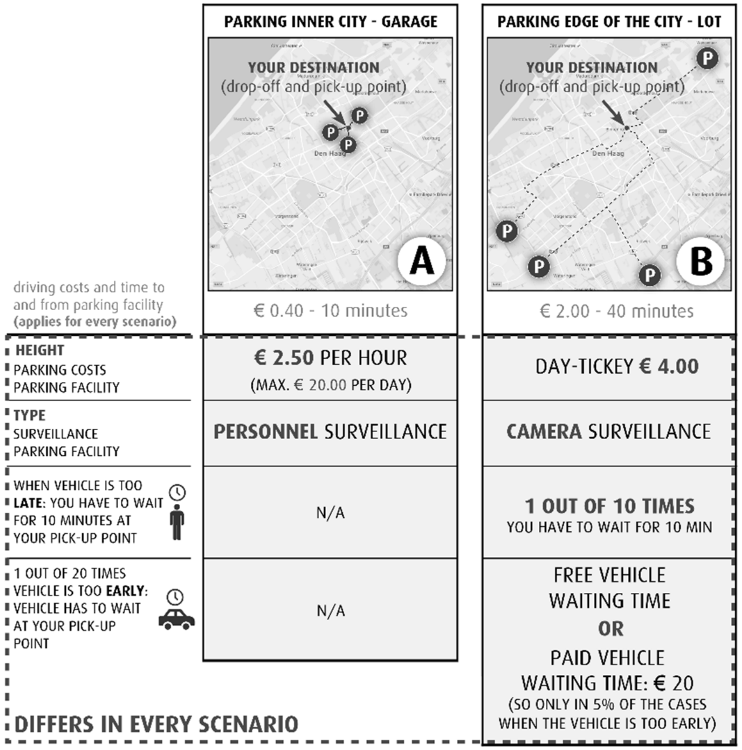
At the beginning of this survey, we asked you to fill in characteristics of your last trip to the inner city of The Hague you're your own vehicle. Imagine make this trip again and you are dropped-off at your final destination with your own car that is a self-driving car. You need to send your car to a public parking facility.

Please consider the following twelve scenarios with different characteristics and choose for every scenario the parking facility that you would send your self-driving car to park itself:
- Option A: Parking in the inner city
- Option B: Parking at the edge of the city

EXAMPLE QUESTION:

The parking cost in the following scenarios ALWAYS apply (even if you parked for free during your last trip)
When your 'parking cost' were reimbursable in the reference case, they are also reimbursable for this situation.

Which parking facility do you prefer? *
(for your previously filled in trip purpose, parking duration and possible reimbursable parking costs)



A Parking inner city B Parking edge of the city ✓

DEEL 1: SCENARIO'S - PARKEERLOCATIEKEUZE MET DE ZELFRIJDENDE AUTO

Welke parkeervoorziening heeft uw voorkeur? [1/12] *

	PARKEREN BINNENSTAD - GARAGE	PARKEREN STADSRAND - TERREIN
		
reiskosten en reistijd naar en van parkeervoorziening (in elk scenario hetzelfde)	€ 0,40 - 10 minuten	€ 2,00 - 40 minuten
PARKEERKOSTEN PARKEERVOORZIENING	€ 3,50 PER UUR (MAX. € 30,00 PER DAG)	DAGKAART € 0,00
TYPE BEWAKING PARKEERVOORZIENING	PERSONEEL BEWAKING	CAMERA BEWAKING
INDIEN AUTO TE **LAAT** TERUG: U MOET 10 MINUTEN WACHTEN BIJ UW OPHAALPUNT	N.V.T.	3 OP DE 10 KEER MOET U 10 MIN WACHTEN
1 OP DE 20 KEER AUTO TE **VROEG** TERUG: AUTO MOET WACHTEN BIJ UW OPHAALPUNT	N.V.T.	AUTO WACHT GRATIS

Welke parkeervoorziening heeft uw voorkeur? [2/12] *

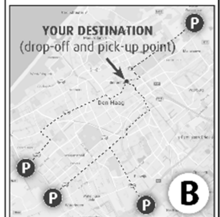
	PARKEREN BINNENSTAD - GARAGE	PARKEREN STADSRAND - TERREIN
		
reiskosten en reistijd naar en van parkeervoorziening (in elk scenario hetzelfde)	€ 0,40 - 10 minuten	€ 2,00 - 40 minuten
PARKEERKOSTEN PARKEERVOORZIENING	€ 3,50 PER UUR (MAX. € 30,00 PER DAG)	DAGKAART € 0,00
TYPE BEWAKING PARKEERVOORZIENING	CAMERA BEWAKING	GEEN BEWAKING
INDIEN AUTO TE **LAAT** TERUG: U MOET 10 MINUTEN WACHTEN BIJ UW OPHAALPUNT	N.V.T.	5 OP DE 10 KEER MOET U 10 MIN WACHTEN
1 OP DE 20 KEER AUTO TE **VROEG** TERUG: AUTO MOET WACHTEN BIJ UW OPHAALPUNT	N.V.T.	AUTO WACHT GRATIS

PART 1: SCENARIOS – PARKING LOCATION CHOICE WITH THE SELF-DRIVING CAR

Which parking facility do you prefer? [1/12] *

	PARKING INNER CITY - GARAGE	PARKING EDGE OF THE CITY - LOT
		
driving costs and time to and from parking facility (applies for every scenario)	€ 0.40 - 10 minutes	€ 2.00 - 40 minutes
PARKING COSTS PARKING FACILITY	€ 3.50 PER HOUR (MAX. € 30.00 PER DAY)	DAY-TICKET € 0.00
TYPE OF SURVEILLANCE PARKING FACILITY	PERSONNEL SURVEILLANCE	CAMERA SURVEILLANCE
WHEN VEHICLE IS TOO **LATE**: YOU HAVE TO WAIT FOR 10 MINUTES AT YOUR PICK UP POINT	N/A	3 OUT OF 10 TIMES YOU HAVE TO WAIT FOR 10 MIN
1 OUT OF 20 TIMES VEHICLE IS TOO **EARLY**: VEHICLE HAS TO WAIT AT YOUR PICK UP POINT	N/A	FREE VEHICLE WAITING TIME

Which parking facility do you prefer? [2/12] *

	PARKING INNER CITY - GARAGE	PARKING EDGE OF THE CITY - LOT
		
driving costs and time to and from parking facility (applies for every scenario)	€ 0.40 - 10 minutes	€ 2.00 - 40 minutes
PARKING COSTS PARKING FACILITY	€ 3.50 PER HOUR (MAX. € 30.00 PER DAY)	DAY-TICKET € 0.00
TYPE OF SURVEILLANCE PARKING FACILITY	CAMERA SURVEILLANCE	NO SURVEILLANCE
WHEN VEHICLE IS TOO **LATE**: YOU HAVE TO WAIT FOR 10 MINUTES AT YOUR PICK-UP POINT	N/A	5 OUT OF 10 TIMES YOU HAVE TO WAIT FOR 10 MIN
1 OUT OF 20 TIMES VEHICLE IS TOO **EARLY**: VEHICLE HAS TO WAIT AT YOUR PICK-UP POINT	N/A	FREE VEHICLE WAITING TIME

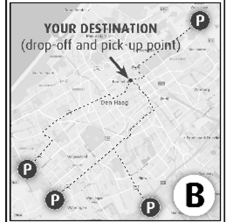
Welke parkeervoorziening heeft uw voorkeur? [3/12] *

	PARKEREN BINNENSTAD - GARAGE	PARKEREN STADSRAND - TERREIN
		
reiskosten en reistijd naar en van parkeervoorziening (in elk scenario hetzelfde)	€ 0,40 - 10 minuten	€ 2,00 - 40 minuten
PARKEERKOSTEN PARKEERVOORZIENING	€ 4,50 PER UUR (MAX. € 40,00 PER DAG)	DAGKAART € 4,00
TYPE BEWAKING PARKEERVOORZIENING	PERSONEEL BEWAKING	CAMERA BEWAKING
INDIEN AUTO TE **LAAT** TERUG: U MOET 10 MINUTEN WACHTEN BIJ UW OPHAALPUNT	N.V.T.	3 OP DE 10 KEER MOET U 10 MIN WACHTEN
1 OP DE 20 KEER AUTO TE **VROEG** TERUG: AUTO MOET WACHTEN BIJ UW OPHAALPUNT	N.V.T.	AUTO WACHT TEGEN BETALING VAN € 20 (DUS ALLEEN IN DE 5% VAN DE GEVALLEN DAT DEZE TE VROEG IS)

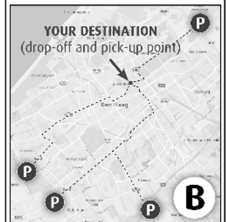
Welke parkeervoorziening heeft uw voorkeur? [4/12] *

	PARKEREN BINNENSTAD - GARAGE	PARKEREN STADSRAND - TERREIN
		
reiskosten en reistijd naar en van parkeervoorziening (in elk scenario hetzelfde)	€ 0,40 - 10 minuten	€ 2,00 - 40 minuten
PARKEERKOSTEN PARKEERVOORZIENING	€ 2,50 PER UUR (MAX. € 20,00 PER DAG)	DAGKAART € 8,00
TYPE BEWAKING PARKEERVOORZIENING	PERSONEEL BEWAKING	GEEN BEWAKING
INDIEN AUTO TE **LAAT** TERUG: U MOET 10 MINUTEN WACHTEN BIJ UW OPHAALPUNT	N.V.T.	5 OP DE 10 KEER MOET U 10 MIN WACHTEN
1 OP DE 20 KEER AUTO TE **VROEG** TERUG: AUTO MOET WACHTEN BIJ UW OPHAALPUNT	N.V.T.	AUTO WACHT GRATIS

Which parking facility do you prefer? [3/12] *

	PARKING INNER CITY - GARAGE	PARKING EDGE OF THE CITY - LOT
		
driving costs and time to and from parking facility (applies for every scenario)	€ 0.40 - 10 minutes	€ 2.00 - 40 minutes
PARKING COSTS PARKING FACILITY	€ 4.50 PER HOUR (MAX. € 40.00 PER DAY)	DAY-TICKET € 4.00
TYPE OF SURVEILLANCE PARKING FACILITY	PERSONNEL SURVEILLANCE	CAMERA SURVEILLANCE
WHEN VEHICLE IS TOO **LATE**: YOU HAVE TO WAIT FOR 10 MINUTES AT YOUR PICK UP POINT	N/A	3 OUT OF 10 TIMES YOU HAVE TO WAIT FOR 10 MIN
1 OUT OF 20 TIMES VEHICLE IS TOO **EARLY**: VEHICLE HAS TO WAIT AT YOUR PICK-UP POINT	N/A	PAID VEHICLE WAITING TIME: € 20 (SO ONLY IN 5% OF THE CASES WHEN THE VEHICLE IS TOO EARLY)

Which parking facility do you prefer? [4/12] *

	PARKING INNER CITY - GARAGE	PARKING EDGE OF THE CITY - LOT
		
driving costs and time to and from parking facility (applies for every scenario)	€ 0.40 - 10 minutes	€ 2.00 - 40 minutes
PARKING COSTS PARKING FACILITY	€ 2.50 PER HOUR (MAX. € 20.00 PER DAY)	DAY-TICKET € 8.00
TYPE OF SURVEILLANCE PARKING FACILITY	PERSONNEL SURVEILLANCE	NO SURVEILLANCE
WHEN VEHICLE IS TOO **LATE**: YOU HAVE TO WAIT FOR 10 MINUTES AT YOUR PICK-UP POINT	N/A	5 OUT OF 10 TIMES YOU HAVE TO WAIT FOR 10 MIN
1 OUT OF 20 TIMES VEHICLE IS TOO **EARLY**: VEHICLE HAS TO WAIT AT YOUR PICK-UP POINT	N/A	FREE VEHICLE WAITING TIME

Welke parkeervoorziening heeft uw voorkeur? [5/12] *

	PARKEREN BINNENSTAD - GARAGE	PARKEREN STADSRAND - TERREIN
		
reiskosten en reistijd naar en van parkeervoorziening (in elk scenario hetzelfde)	€ 0,40 - 10 minuten	€ 2,00 - 40 minuten
PARKEERKOSTEN PARKEERVOORZIENING	€ 2,50 PER UUR (MAX. € 20,00 PER DAG)	DAGKAART € 0,00
TYPE BEWAKING PARKEERVOORZIENING	CAMERA BEWAKING	GEEN BEWAKING
INDIEN AUTO TE **LAAT** TERUG: U MOET 10 MINUTEN WACHTEN BIJ UW OPHAALPUNT	N.V.T.	1 OP DE 10 KEER MOET U 10 MIN WACHTEN
1 OP DE 20 KEER AUTO TE **VROEG** TERUG: AUTO MOET WACHTEN BIJ UW OPHAALPUNT	N.V.T.	AUTO WACHT TEGEN BETALING VAN € 20 (DUS ALLEEN IN DE 5% VAN DE GEVALLEN DAT DEZE TE VROEG IS)

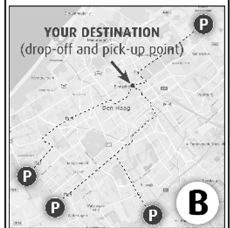
Welke parkeervoorziening heeft uw voorkeur? [6/12] *

	PARKEREN BINNENSTAD - GARAGE	PARKEREN STADSRAND - TERREIN
		
reiskosten en reistijd naar en van parkeervoorziening (in elk scenario hetzelfde)	€ 0,40 - 10 minuten	€ 2,00 - 40 minuten
PARKEERKOSTEN PARKEERVOORZIENING	€ 2,50 PER UUR (MAX. € 20,00 PER DAG)	DAGKAART € 4,00
TYPE BEWAKING PARKEERVOORZIENING	CAMERA BEWAKING	PERSONEEL BEWAKING
INDIEN AUTO TE **LAAT** TERUG: U MOET 10 MINUTEN WACHTEN BIJ UW OPHAALPUNT	N.V.T.	5 OP DE 10 KEER MOET U 10 MIN WACHTEN
1 OP DE 20 KEER AUTO TE **VROEG** TERUG: AUTO MOET WACHTEN BIJ UW OPHAALPUNT	N.V.T.	AUTO WACHT TEGEN BETALING VAN € 20 (DUS ALLEEN IN DE 5% VAN DE GEVALLEN DAT DEZE TE VROEG IS)

Which parking facility do you prefer? [5/12] *

	PARKING INNER CITY - GARAGE	PARKING EDGE OF THE CITY - LOT
		
driving costs and time to and from parking facility (applies for every scenario)	€ 0.40 - 10 minutes	€ 2.00 - 40 minutes
PARKING COSTS PARKING FACILITY	€ 2.50 PER HOUR (MAX. € 20.00 PER DAY)	DAY-TICKET € 0.00
TYPE OF SURVEILLANCE PARKING FACILITY	CAMERA SURVEILLANCE	NO SURVEILLANCE
WHEN VEHICLE IS TOO **LATE**: YOU HAVE TO WAIT FOR 10 MINUTES AT YOUR PICK UP POINT	N/A	1 OUT OF 10 TIMES YOU HAVE TO WAIT FOR 10 MIN
1 OUT OF 20 TIMES VEHICLE IS TOO **EARLY**: VEHICLE HAS TO WAIT AT YOUR PICK UP POINT	N/A	PAID VEHICLE WAITING TIME: € 20 (SO ONLY IN 5% OF THE CASES WHEN THE VEHICLE IS TOO EARLY)

Which parking facility do you prefer? [6/12] *

	PARKING INNER CITY - GARAGE	PARKING EDGE OF THE CITY - LOT
		
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PARKING COSTS PARKING FACILITY	€ 2.50 PER HOUR (MAX. € 20.00 PER DAY)	DAY-TICKET € 4.00
TYPE OF SURVEILLANCE PARKING FACILITY	CAMERA SURVEILLANCE	PERSONNEL SURVEILLANCE
WHEN VEHICLE IS TOO **LATE**: YOU HAVE TO WAIT FOR 10 MINUTES AT YOUR PICK-UP POINT	N/A	5 OUT OF 10 TIMES YOU HAVE TO WAIT FOR 10 MIN
1 OUT OF 20 TIMES VEHICLE IS TOO **EARLY**: VEHICLE HAS TO WAIT AT YOUR PICK-UP POINT	N/A	PAID VEHICLE WAITING TIME: € 20 (SO ONLY IN 5% OF THE CASES WHEN THE VEHICLE IS TOO EARLY)

Welke parkeervoorziening heeft uw voorkeur? [7/12] *

	PARKEREN BINNENSTAD - GARAGE	PARKEREN STADSRAND - TERREIN
reiskosten en reistijd naar en van parkeervoorziening (in elk scenario hetzelfde)	€ 0,40 - 10 minuten	€ 2,00 - 40 minuten
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TYPE BEWAKING PARKEERVOORZIENING	GEEN BEWAKING	PERSONEEL BEWAKING
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Welke parkeervoorziening heeft uw voorkeur? [8/12] *

	PARKEREN BINNENSTAD - GARAGE	PARKEREN STADSRAND - TERREIN
reiskosten en reistijd naar en van parkeervoorziening (in elk scenario hetzelfde)	€ 0,40 - 10 minuten	€ 2,00 - 40 minuten
PARKEERKOSTEN PARKEERVOORZIENING	€ 4,50 PER UUR (MAX. € 40,00 PER DAG)	DAGKAART € 8,00
TYPE BEWAKING PARKEERVOORZIENING	GEEN BEWAKING	GEEN BEWAKING
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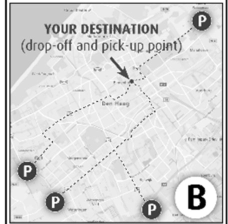
Which parking facility do you prefer? [7/12] *



	PARKING INNER CITY - GARAGE	PARKING EDGE OF THE CITY - LOT
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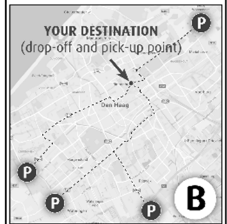
PARKING COSTS PARKING FACILITY	€ 3.50 PER HOUR (MAX. € 30.00 PER DAY)	DAY-TICKET € 8.00
TYPE OF SURVEILLANCE PARKING FACILITY	NO SURVEILLANCE	PERSONNEL SURVEILLANCE
WHEN VEHICLE IS TOO **LATE**: YOU HAVE TO WAIT FOR 10 MINUTES AT YOUR PICK-UP POINT	N/A	1 OUT OF 10 TIMES YOU HAVE TO WAIT FOR 10 MIN
1 OUT OF 20 TIMES VEHICLE IS TOO **EARLY**: VEHICLE HAS TO WAIT AT YOUR PICK-UP POINT	N/A	PAID VEHICLE WAITING TIME: € 20 (SO ONLY IN 5% OF THE CASES WHEN THE VEHICLE IS TOO EARLY)

Which parking facility do you prefer? [8/12] *



	PARKING INNER CITY - GARAGE	PARKING EDGE OF THE CITY - LOT
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PARKING COSTS PARKING FACILITY	€ 4.50 PER HOUR (MAX. € 40.00 PER DAY)	DAY-TICKET € 8.00
TYPE OF SURVEILLANCE PARKING FACILITY	NO SURVEILLANCE	NO SURVEILLANCE
WHEN VEHICLE IS TOO **LATE**: YOU HAVE TO WAIT FOR 10 MINUTES AT YOUR PICK-UP POINT	N/A	3 OUT OF 10 TIMES YOU HAVE TO WAIT FOR 10 MIN
1 OUT OF 20 TIMES VEHICLE IS TOO **EARLY**: VEHICLE HAS TO WAIT AT YOUR PICK UP POINT	N/A	PAID VEHICLE WAITING TIME: € 20 (SO ONLY IN 5% OF THE CASES WHEN THE VEHICLE IS TOO EARLY)

Welke parkeervoorziening heeft uw voorkeur? [9/12] *

	PARKEREN BINNENSTAD - GARAGE	PARKEREN STADSRAND - TERREIN
		
reiskosten en reistijd naar en van parkeervoorziening (in elk scenario hetzelfde)	€ 0,40 - 10 minuten	€ 2,00 - 40 minuten
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TYPE BEWAKING PARKEERVOORZIENING	GEEN BEWAKING	CAMERA BEWAKING
INDIEN AUTO TE **LAAT** TERUG: U MOET 10 MINUTEN WACHTEN BIJ UW OPHAALPUNT	N.V.T.	1 OP DE 10 KEER MOET U 10 MIN WACHTEN
1 OP DE 20 KEER AUTO TE **VROEG** TERUG: AUTO MOET WACHTEN BIJ UW OPHAALPUNT	N.V.T.	AUTO WACHT GRATIS

Welke parkeervoorziening heeft uw voorkeur? [10/12] *

	PARKEREN BINNENSTAD - GARAGE	PARKEREN STADSRAND - TERREIN
		
reiskosten en reistijd naar en van parkeervoorziening (in elk scenario hetzelfde)	€ 0,40 - 10 minuten	€ 2,00 - 40 minuten
PARKEERKOSTEN PARKEERVOORZIENING	€ 4,50 PER UUR (MAX. € 40,00 PER DAG)	DAGKAART € 0,00
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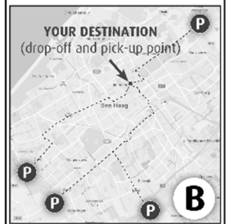
INDIEN AUTO TE **LAAT** TERUG: U MOET 10 MINUTEN WACHTEN BIJ UW OPHAALPUNT	N.V.T.	5 OP DE 10 KEER MOET U 10 MIN WACHTEN
1 OP DE 20 KEER AUTO TE **VROEG** TERUG: AUTO MOET WACHTEN BIJ UW OPHAALPUNT	N.V.T.	AUTO WACHT TEGEN BETALING VAN € 20 (DUS ALLEEN IN DE 5% VAN DE GEVALLEN DAT DEZE TE VROEG IS)

Which parking facility do you prefer? [9/12] *

	PARKING INNER CITY - GARAGE	PARKING EDGE OF THE CITY - LOT
		
driving costs and time to and from parking facility (applies for every scenario)	€ 0.40 - 10 minutes	€ 2.00 - 40 minutes
PARKING COSTS PARKING FACILITY	€ 2.50 PER HOUR (MAX. € 20.00 PER DAY)	DAY-TICKET € 4.00
TYPE OF SURVEILLANCE PARKING FACILITY	NO SURVEILLANCE	CAMERA SURVEILLANCE
WHEN VEHICLE IS TOO **LATE**: YOU HAVE TO WAIT FOR 10 MINUTES AT YOUR PICK-UP POINT	N/A	1 OUT OF 10 TIMES YOU HAVE TO WAIT FOR 10 MIN
1 OUT OF 20 TIMES VEHICLE IS TOO **EARLY**: VEHICLE HAS TO WAIT AT YOUR PICK-UP POINT	N/A	FREE VEHICLE WAITING TIME

Which parking facility do you prefer? [10/12] *

	PARKING INNER CITY - GARAGE	PARKING EDGE OF THE CITY - LOT
		
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PARKING COSTS PARKING FACILITY	€ 4.50 PER HOUR (MAX. € 40.00 PER DAY)	DAY-TICKET € 0.00
TYPE OF SURVEILLANCE PARKING FACILITY	NO SURVEILLANCE	PERSONNEL SURVEILLANCE
WHEN VEHICLE IS TOO **LATE**: YOU HAVE TO WAIT FOR 10 MINUTES AT YOUR PICK-UP POINT	N/A	5 OUT OF 10 TIMES YOU HAVE TO WAIT FOR 10 MIN
1 OUT OF 20 TIMES VEHICLE IS TOO **EARLY**: VEHICLE HAS TO WAIT AT YOUR PICK-UP POINT	N/A	PAID VEHICLE WAITING TIME: € 20 (SO ONLY IN 5% OF THE CASES WHEN THE VEHICLE IS TOO EARLY)

Welke parkeervoorziening heeft uw voorkeur? [11/12] *

	PARKEREN BINNENSTAD - GARAGE	PARKEREN STADSRAND - TERREIN
reiskosten en reistijd naar en van parkeervoorziening (in elk scenario hetzelfde)	€ 0,40 - 10 minuten	€ 2,00 - 40 minuten
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TYPE BEWAKING PARKEERVOORZIENING	CAMERA BEWAKING	CAMERA BEWAKING
INDIEN AUTO TE **LAAT** TERUG: U MOET 10 MINUTEN WACHTEN BIJ UW OPHAALPUNT	N.V.T.	1 OP DE 10 KEER MOET U 10 MIN WACHTEN
1 OP DE 20 KEER AUTO TE **VROEG** TERUG: AUTO MOET WACHTEN BIJ UW OPHAALPUNT	N.V.T.	AUTO WACHT GRATIS

Welke parkeervoorziening heeft uw voorkeur? [12/12] *

	PARKEREN BINNENSTAD - GARAGE	PARKEREN STADSRAND - TERREIN
reiskosten en reistijd naar en van parkeervoorziening (in elk scenario hetzelfde)	€ 0,40 - 10 minuten	€ 2,00 - 40 minuten
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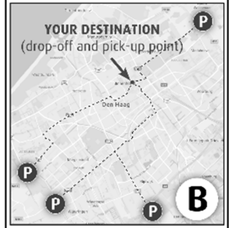
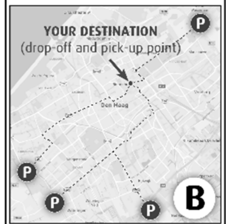
TYPE BEWAKING PARKEERVOORZIENING	PERSONEEL BEWAKING	PERSONEEL BEWAKING
INDIEN AUTO TE **LAAT** TERUG: U MOET 10 MINUTEN WACHTEN BIJ UW OPHAALPUNT	N.V.T.	3 OP DE 10 KEER MOET U 10 MIN WACHTEN
1 OP DE 20 KEER AUTO TE **VROEG** TERUG: AUTO MOET WACHTEN BIJ UW OPHAALPUNT	N.V.T.	AUTO WACHT GRATIS

Which parking facility do you prefer? [11/12] *



	PARKING INNER CITY - GARAGE	PARKING EDGE OF THE CITY - LOT
driving costs and time to and from parking facility (applies for every scenario)	€ 0.40 - 10 minutes	€ 2.00 - 40 minutes
PARKING COSTS PARKING FACILITY	€ 4.50 PER HOUR (MAX. € 40.00 PER DAY)	DAY-TICKET € 8.00
TYPE OF SURVEILLANCE PARKING FACILITY	CAMERA SURVEILLANCE	CAMERA SURVEILLANCE
WHEN VEHICLE IS TOO **LATE**: YOU HAVE TO WAIT FOR 10 MINUTES AT YOUR PICK-UP POINT	N/A	1 OUT OF 10 TIMES YOU HAVE TO WAIT FOR 10 MIN
1 OUT OF 20 TIMES VEHICLE IS TOO **EARLY**: VEHICLE HAS TO WAIT AT YOUR PICK-UP POINT	N/A	FREE VEHICLE WAITING TIME

Which parking facility do you prefer? [12/12] *



	PARKING INNER CITY - GARAGE	PARKING EDGE OF THE CITY - LOT
driving costs and time to and from parking facility (applies for every scenario)	€ 0.40 - 10 minutes	€ 2.00 - 40 minutes
PARKING COSTS PARKING FACILITY	€ 3.50 PER HOUR (MAX. € 30.00 PER DAY)	DAY-TICKET € 4.00
TYPE OF SURVEILLANCE PARKING FACILITY	PERSONNEL SURVEILLANCE	PERSONNEL SURVEILLANCE
WHEN VEHICLE IS TOO **LATE**: YOU HAVE TO WAIT FOR 10 MINUTES AT YOUR PICK-UP POINT	N/A	3 OUT OF 10 TIMES YOU HAVE TO WAIT FOR 10 MIN
1 OUT OF 20 TIMES VEHICLE IS TOO **EARLY**: VEHICLE HAS TO WAIT AT YOUR PICK UP POINT	N/A	FREE VEHICLE WAITING TIME

DEEL 2: STELLINGEN OVER ZELFRIJDENDE AUTO'S

In dit onderdeel worden zes verschillende stellingen over zelfrijdende auto's (een auto zonder bestuurder) getoond. Bij elke stelling geeft u op een 5-puntsschaal aan in hoeverre u het oneens of eens bent met de stelling.

Ik maak me zorgen dat er gevaarlijke situaties zouden kunnen ontstaan tijdens de lege voertuig rit wanneer mijn zelfrijdende auto tussen het andere verkeer rijdt, zoals auto's met bestuurders, fietsers en voetgangers *

1	2	3	4	5
Helemaal mee oneens		Niet oneens / niet eens		Helemaal mee eens

Ik denk dat ik het moeilijk vind om te begrijpen hoe ik met mijn smartphone of laptop mijn zelfrijdende auto kan laten parkeren en ook weer kan oproepen *

1	2	3	4	5
Helemaal mee oneens		Niet oneens / niet eens		Helemaal mee eens

Ik heb vertrouwen in de technologie van de zelfrijdende auto tijdens de lege voertuig rit *

1	2	3	4	5
Helemaal mee oneens		Niet oneens / niet eens		Helemaal mee eens

Ik denk dat ik het eenvoudig vind om te begrijpen hoe een zelfrijdende auto gebruikt moet worden *

1	2	3	4	5
Helemaal mee oneens		Niet oneens / niet eens		Helemaal mee eens

Ik denk dat tijdens de lege voertuig rit de zelfrijdende auto niet zo goed zou rijden als een auto met bestuurder *

1	2	3	4	5
Helemaal mee oneens		Niet oneens / niet eens		Helemaal mee eens

Ik vind het leuk om gebruik te maken van de nieuwste technologie *

1	2	3	4	5
Helemaal mee oneens		Niet oneens / niet eens		Helemaal mee eens

PART 2: STATEMENTS ABOUT SELF-DRIVING CARS

In this part, six different statements about self-driving cars (a car without a human driver) are presented. Indicate for every statement, on a 5-point scale, whether you agree or disagree.

I am afraid that dangerous situations may arise when my self-driving car drives between other traffic on the road, such as human-operated cars, bicycles and pedestrians *

1	2	3	4	5
Strongly disagree		Neither agree nor disagree		Strongly agree

I think it would be difficult to understand how to use my smartphone or laptop to park my self-driving car and plan for the car to arrive *

1	2	3	4	5
Strongly disagree		Neither agree nor disagree		Strongly agree

I trust the technology of the self-driving car during the empty vehicle trip *

1	2	3	4	5
Strongly disagree		Neither agree nor disagree		Strongly agree

I think it would be easy to understand how to use a self-driving car *

1	2	3	4	5
Strongly disagree		Neither agree nor disagree		Strongly agree

I think a self-driving vehicle may not drive as well as a car with a human driver during the empty vehicle trip *

1	2	3	4	5
Strongly disagree		Neither agree nor disagree		Strongly agree

I like to make use of the latest technology systems *

1	2	3	4	5
Strongly disagree		Neither agree nor disagree		Strongly agree

DEEL 3: PERSOONSKENMERKEN

In dit onderdeel wordt gevraagd om antwoord te geven op vragen over uw persoonskenmerken. De gegevens worden anoniem verwerkt.

Wat is uw geslacht? *
- Man
- Vrouw

Wat is uw geboortejaar? *
''Uw antwoord''

Wat is het totale bruto jaarinkomen van uw gehele huishouden? (alle inkomsten, van alle leden van uw huishouden voordat u belasting betaalt) *
- Minder dan €10.000
- €10.000 - €20.000
- €20.000 - €30.000
- €30.000 - €40.000
- €40.000 - €50.000
- €50.000 - €60.000
- €60.000 - €70.000
- €70.000 - €80.000
- Meer dan €80.000
- Weet ik niet / wil ik niet zeggen

Wat is uw woonplaats?
''Uw antwoord''

Wat is uw hoogst afgeronde opleidingsniveau? *
- Basisonderwijs
- Middelbaar onderwijs
- MBO
- HBO
- Bachelor WO
- Master WO
- PhD
- Anders, namelijk...

Wat was de aankoopprijs van uw auto? *
- Minder dan €5.000
- €5.000 - €10.000
- €10.000 - €15.000
- €15.000 - €20.000
- Meer dan €20.000
- Weet ik niet: ik heb een leaseauto
- Weet ik niet / wil ik niet zeggen

PART 3: PERSONAL CHARACTERISTICS

In this part, you will give answer to questions about your personal characteristics. Your answers will be processed anonymously.

What is your gender? *
- Male
- Female

What is your year of birth? *
''Your answer''

What is the total gross annual income of your entire household (all income of all household members before you pay the tax)? *
- Less than €10,000
- €10,000 - €20,000
- €20,000 - €30,000
- €30,000 - €40,000
- €40,000 - €50,000
- €50,000 - €60,000
- €60,000 - €70,000
- €70,000 - €80,000
- More than €80,000
- I don't know / I don't want to tell

What is your place of residence?
''Your answer''

What is your highest educated degree? *
- Primary school
- Secondary education
- MBO
- HBO
- Bachelor WO
- Master WO
- PhD
- Other, namely...

What was the purchase price of your car? *
- Less than €5,000
- €5,000 - €10,000
- €10,000 - €15,000
- €15,000 - €20,000
- More than €20,000
- I don't know: I have a lease car
- I don't know / I don't want to tell

Hoeveel ritten maakt u gemiddeld met uw eigen auto naar de binnenstad van Den Haag? *
- □ Één of een aantal ritten per dag
- □ Één of een aantal ritten per week
- □ Één of een aantal ritten per maand
- □ Één of een aantal ritten per jaar
- □ Minder dan één rit per jaar

In hoeverre maakt u (wel eens) gebruik van geautomatiseerde systemen tijdens het rijden? *
- □ Ik maak geen gebruik van geautomatiseerde systemen
- □ Zeer beperkte geautomatiseerde systemen (bijv. cruise control)
- □ Beperkte geautomatiseerde systemen (antiblokkeersysteem of sensoren die afstanden tot objecten meten)
- □ Gevorderde geautomatiseerde systemen (rijbaanassistentie of automatisch inparkeren)
- □ Weet ik niet

Voordat u begon met deze enquête, was u bekend met zelfrijdende voertuigen en heeft u wel eens in een zelfrijdend voertuig gereden? *
- □ Ik wist niet wat zelfrijdende voertuigen waren, ik heb nog nooit in een zelfrijdend voertuig gezeten
- □ Ik wist wel wat zelfrijdende voertuigen waren, ik heb nog nooit in een zelfrijdend voertuig gezeten
- □ Ik wist wat zelfrijdende voertuigen waren, ik heb weleens in een zelfrijdend voertuig gezeten

Wat is uw relatie met zelfrijdende voertuigen? *
- □ Ik ben professioneel werkzaam op het gebied van zelfrijdende voertuigen: werk gerelateerd of student
- □ Ik ben geïnteresseerd in het concept van zelfrijdende voertuigen, maar ik ben niet professioneel actief op dit gebied
- □ Ik ben niet geïnteresseerd in zelfrijdende voertuigen
- □ Anders, namelijk…

Zou u uw auto over het algemeen liever laten parkeren in een garage of op een terrein? *
- □ Parkeergarage
- □ Parkeerterrein
- □ Geen voorkeur

Zou u een zelfrijdend voertuig overwegen vanwege parkeergemak? *
- □ Ja
- □ Nee
- □ Weet ik niet

Heeft u nog vragen of opmerkingen over deze enquête of zijn er nog andere dingen die u graag wilt zeggen?
''Uw antwoord''

Bedankt voor uw deelname aan dit onderzoek!

What is your average number of trips to city centre of The Hague with your own car? *
- □ One or several trips per day
- □ One or several trips per week
- □ One or several trips per month
- □ One or several trip per year
- □ Less than one trip per year

To what extent do you use automated features while driving? *
- □ I do not use any automated features
- □ Very limited automated features (e.g. cruise control)
- □ Limited automated features (e.g. anti-lock braking system and sensors measuring distances to objects)
- □ Advanced automated features (assisting in regular driving tasks such as lane assistance or automated parking)
- □ I don't know

Before participating in this survey, did you know about self-driving cars and have you ever been in a self-driving car? *
- □ I did not know what self-driving vehicles are, I have never been in one
- □ I knew what self-driving vehicles are, I have never been in one
- □ I knew what self-driving vehicles are, I have been in one

What is your relationship with self-driving cars? *
- □ I am professionally active in the field of self-driving cars: work related or student
- □ I am interested in the concept of self-driving cars but I am not professionally active in this field
- □ I am not interested in self-driving cars
- □ Different, namely…

In general, do you prefer your car being parked in a parking garage or at a parking lot? *
- □ Parking garage
- □ Parking lot
- □ No preference

Would you consider to use a self-driving car because of parking convenience? *
- □ Yes
- □ No
- □ I don't know

Do you have comments on the questionnaire or other things you would like to say?
''Your answer''

Thank you for participating in this survey!

Table F.1 lists the questions from the online survey and their relationship with the conceptual framework of this research.

Table F.1 Questions in the online survey and their relationship with the conceptual framework

		Survey Question	Related to conceptual model	Extra information
Introduction Questions on most recent trip to the inner city of The Hague	1	Trip purpose of most recent trip	Context factor: trip purpose	
	2	Parking location of most recent trip		Extra question
	3	Parking duration of most recent trip	Context factor: parking duration	
	4	'parking cost' of most recent trip		Extra question
	5	'parking cost' reimbursement of most recent trip	Context factor: trip reimbursement	
Part 1 Hypothetical choice situations	6 - 17	Which parking facility do you prefer?	Attributes: 'parking cost' Surveillance parking facility 'risk of extra waiting time' 'risk of parking fee' ('empty vehicle driving costs' and time are fixed)	-
-	18	Comments	-	For filtering process / further research recommendations
Part 2 Perceptions on automated driving	19, 21, 23	Statements on trust in technology/AVs	Perception: risk of damage caused by other road user or by AV itself	-
	20, 22, 24	Statements use of system		Perception: use of the system
Part 3 Personal characteristics / preferences	25	Gender	Gender	-
	26	Age	Age	-
	27	Income	Income	-
	28	Place of residence	-	Exclude respondents from database who live in The Hague
	29	Level of education	-	Extra question
	30	Value car	Value of the car	-
	31	# trips to inner city of The Hague	# trips to inner city of The Hague	-
	32	Use automated systems	Familiarity with AVs	-
	32	Knowledge / experience		
	34	Interest		
	35	Parking preference parking garage or parking lot	-	For fixed preference PIC and PEC
	36	Parking convenience	-	How many people would make use of the system for parking convenience
-	37	Comments	-	For filtering process / further research recommendations

G

STATED PREFERENCE FINAL SURVEY RESULTS

This appendix first lists the frequency distribution of respondents' answers to 1) personal characteristics, 2) context factors, 3) choice situations and 4) statements (G.1). Next, the results of the MNL model estimations are presented (G.2). Last, the Biogeme model files for the MNL model estimation and MNL model estimation with interaction variables are presented (G.3).

G.1 DESCRIPTIVE STATISTICS

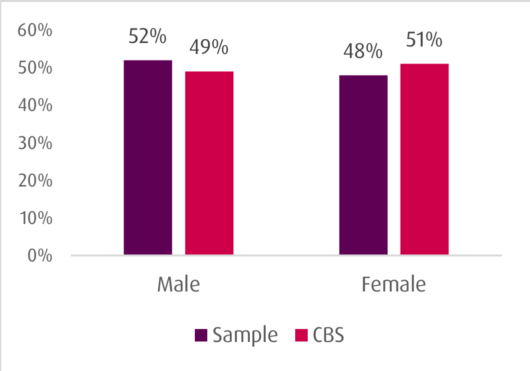
The frequency distribution of respondents' personal characteristics are shown in Table G.1 until G.3.

Table G.1 Frequency distribution of respondents' socio-demographic characteristics (part 3)

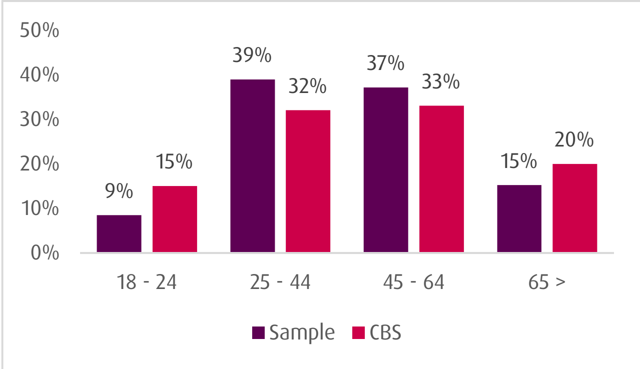
	Number of respondents	Percentage of sample
Gender		
Male	202	52
Female	186	48
Age		
18 - 24 (1992 ≥)	33	9
25 - 44 (1991 – 1972)	151	39
45 - 64 (1971 – 1952)	144	37
65 ≥ (≤ 1951)	59	15
Unknown	1	0
Income		
< €10,000	8	2
€10,000 - €20,000	39	10
€20,000 - €30,000	50	13
€30,000 - €40,000	69	18
€40,000 - €50,000	61	16
€50,000 - €60,000	34	9
€60,000 - €70,000	43	11
€70,000 - €80,000	17	4
€80,000 >	13	3
Unknown	54	14
Education		
Primary school	7	2
Secondary education	76	20
MBO	125	32
HBO	129	33
Bachelor WO	23	6
Master WO	28	7

The frequency distribution of the sample regarding gender, age and education are compared to the average distribution of inhabitants of the province of South Holland. The comparison is visualised in Figure G.1.

Gender (CBS, 2015a)



Age (CBS, 2015b)



Level of education (CBS, 2015c)

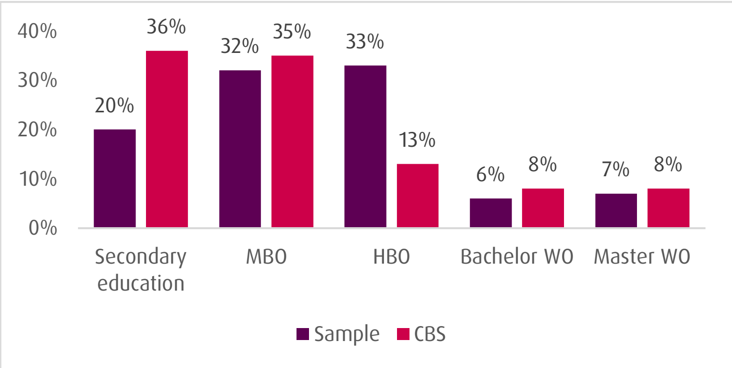


Figure G.1 Frequency distribution of the sample compared to CBS statistics

In Figure G.1, it can be seen that the sample is fairly representative for *gender*. There are slightly more men in the sample compared to the average of the population of South Holland. Regarding *age* it can be seen that the sample contains less individuals who are young (18-24) and old (65 ≥). It might be the case that younger people do not know about the existence of an online panel and that older people do not own a computer or do not use the internet. Regarding *education* it can be seen that the sample has a substantial higher amount of HBO educated people and contains less secondary educated people. Overall, it can be concluded that the sample is fairly representative for the population of South Holland.

Table G.2 Frequency distribution of respondents' extra personal characteristics (part 3)

	Number of respondents	Percentage of sample
Purchase value of the car		
< €5,000	56	14
€5,000 - €10,000	87	22
€10,000 - €15,000	83	21
€15,000 - €20,000	57	15
€20,000 >	71	18
Unknown: I have a lease car	10	3
Unknown	24	6
Average number of trips to inner city with car		
One or several trips per day	19	5
One or several trips per week	47	12
One or several trips per month	95	24
One or several trips per year	186	48
Less than one trip per year	41	11

Table G.3 Frequency distribution of respondents' characteristics related to familiarities with AVs (part 3)

	Number of respondents	Percentage of sample
Use of automated features while driving		
I do not use automated features	195	50
Very limited automated features	112	29
Limited automated features	57	15
Advanced automated features	8	2
I don't know	16	4
Knowledge / Experience		
No knowledge / No experience	56	14
Knowledge / No experience	321	83
Knowledge / Experience	11	3
Interest		
Professionally active	5	1
Interested	221	57
Not interested	158	41
Different	4	1
Consider AV for parking convenience		
Yes	130	34
No	133	34
I don't know	125	32

Table G.4 Frequency distribution of answers to context factors (introduction questions)

	Number of respondents	Percentage of sample
Trip purpose		
Business appointment	50	13
Working day	25	6
Recreational	307	79
Different	6	2
Parking location		
Private parking lot	36	9
Public parking garage	219	56
Public parking lot	84	22
Park-and-Ride facility	34	9
Different	15	4
Parking duration		
< 1 hour	16	4
1 hour	21	5
2 hours	75	19
3 hours	128	33
4 hours	87	22
5 hours	31	8
6 hours	12	3
7 hours	4	1
8 hours	8	2
8 hours >	6	2
Parking cost		
€ 0.00	71	18
€0.01 - €5.00	51	13
€5.00 - €10.00	132	34
€10.00 - €15.00	76	20
€15.00 - €20.00	45	12
€20.00 - €25.00	4	1
€25.00 - €30.00	6	2
€30.00 >	3	1
Trip reimbursement		
Yes	44	11
No	286	74
Not applicable	58	15

The frequency distribution of respondents' answers to the context factors, choice situations and statements are shown in Table G.4, Table G.5 and Table G.6 respectively.

Table G.5 Frequency distribution of answers to choice situations (part 1)

Choice situation	PIC Number of respondents	Percentage of sample	PEC	Percentage of sample
1	145	37%	243	63%
2	152	39%	236	61%
3	189	49%	199	51%
4	274	71%	114	29%
5	228	59%	160	41%
6	251	65%	137	35%
7	235	61%	153	39%
8	202	52%	186	48%
9	148	38%	240	62%
10	155	40%	233	60%
11	130	34%	258	66%
12	125	32%	263	68%

Table G.6 Frequency distribution of answers to statements (part 2)

Statement number	Statement	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1	I am afraid that dangerous situations may arise when my self-driving car drives between other traffic on the road, such as human-operated cars, bicycles and pedestrians	14	43	100	146	85
2	I think it would be difficult to understand how to use my smartphone or laptop to park my self-driving car and plan for the car to arrive	77	100	96	77	38
3	I trust the technology of the self-driving car during the empty vehicle trip	30	86	157	80	35
4	I think it would be easy to understand how to use a self-driving car	9	54	142	134	49
5	I think a self-driving vehicle may not drive as well as a car with a human driver during the empty vehicle trip	29	71	160	91	37
6	I like to make use of the latest technology systems	15	53	136	126	58

G.2 RESULTS MNL MODEL ESTIMATIONS

Nine MNL models are estimated using the program *Biogeme*. The final log-likelihood, rho-square, adjusted rho-square and the % of significant parameters for every model are shown in Table G.7. The results of the MNL models estimations are shown in Table G.8.

Table G.7 Outcomes model estimations

MNL	Final LL	Rho-square	Adjusted rho-square	% of parameters significant
1	-3085.349	0.044	0.041	77.8%
2	-3087.282	0.043	0.041	85.7%
3	-3089.033	0.043	0.041	100%
4	-3085.536	0.044	0.041	87.5%
5	-3073.939	0.048	0.044	33.3%
6	-3075.943	0.047	0.044	70%
7	-3077.152	0.047	0.044	100%
8	-3077.066	0.047	0.044	77.8%
9	-3077.282	0.046	0.044	75%

Table G.8 Parameter estimates of different MNL models (estimated with Biogeme)

		PIC					PEC						
		asc	Parking cost	Parking cost²	Personnel surveillance	Camera surveillance	Parking cost	Parking cost²	Personnel surveillance	Camera surveillance	Risk of extra waiting time	Risk of extra waiting time²	Risk of parking fee
1	parameter estimate	**0.436**	**-0.408**		**0.216**	0.0789	**-0.0792**		**0.304**	0.158	**-0.0885**		**-0.760**
	t-value	2.54	-9.59		2.49	0.95	-7.74		3.91	1.67	-3.69		-10.36
	p-value	0.01*	0.00*		0.01*	0.34	0.00*		0.00*	0.10	0.00*		0.00*
2	parameter estimate	**0.456**	**-0.442**		0.133		**-0.0806**		**0.273**		**-0.112**		**-0.788**
	t-value	3.12	-11.38		1.87		-8.32		3.90		-5.53		-11.20
	p-value	0.00*	0.00*		0.06		0.00*		0.00*		0.00*		0.00*
3	parameter estimate	**0.471**	**-0.436**				**-0.0817**		**0.281**		**-0.122**		**-0.747**
	t-value	3.23	-11.31				-8.48		4.00		-6.21		-11.19
	p-value	0.00*	0.00*				0.00*		0.00*		0.00*		0.00*
4	parameter estimate	**0.386**	**-0.411**		**0.224**	0.113	**-0.0811**		**0.284**	0.113	**-0.0932**		**-0.773**
	t-value	2.55	-9.80		2.63	1.88	-8.33		4.05	1.88	-4.09		-10.96
	p-value	0.01*	0.00*		0.01*	0.06	0.00*		0.00*	0.06	0.00*		0.00*
5	parameter estimate	-0.953	0.570	0.142	**0.401**	0.0599	0.0363	**-0.0153**	**0.272**	-0.0555	0.287	-0.0654	**-0.933**
	t-value	-0.79	0.77	1.37	3.46	0.70	0.67	-2.27	2.28	-0.44	1.34	-1.90	-9.66
	p-value	0.43	0.44	0.17	0.00*	0.49	0.50	0.02*	0.02*	0.66	0.18	0.06	0.00*
6	parameter estimate	**0.560**	**-0.498**		**0.297**	0.105	**0.101**	**-0.0234**	0.117	-0.114	**-0.109**		**-0.843**
	t-value	3.19	-10.47		3.30	1.26	2.37	-4.35	1.31	-1.00	-4.42		-11.01
	p-value	0.00*	0.00*		0.00*	0.21	0.02*	0.00*	0.19	0.32	0.00*		0.00*
7	parameter estimate	**0.672**	**-0.484**		**0.248**		**0.0808**	**-0.0202**	**0.184**		**-0.100**		**-0.806**
	t-value	4.32	-12.07		3.29		2.18	-4.50	2.50		-4.84		-11.39
	p-value	0.00*	0.00*		0.00*		0.03*	0.00*	0.01*		0.00*		0.00*
8	parameter estimate	**0.648**	**-0.475**		**0.266**	0.0267	0.0757	**-0.0196**	**0.189**	0.0267	**-0.0960**		**-0.802**
	t-value	3.92	-10.53		3.06	0.41	1.93	-4.13	2.54	0.41	-4.18		-11.23
	p-value	0.00*	0.00*		0.00*	0.68	0.05	0.00*	0.01*	0.68	0.00*		0.00*
9	parameter estimate	**0.653**	**-0.477**		**0.222**	0.0153	0.0682	**-0.0187**	**0.222**	0.0153	**-0.102**		**-0.803**
	t-value	3.95	-10.58		3.99	0.25	1.82	-4.10	3.99	0.25	-4.91		-11.24
	p-value	0.00*	0.00*		0.00*	0.81	0.07	0.00*	0.00*	0.81	0.00*		0.00*

Significant values are marked in **pink bold** and with a * ($p < 0.05$)

Where:

[1] = MNL model with all parameters, no quadratic parameter components

[2] = MNL model with only significant parameters, no quadratic parameter components ('personnel surveillance' is not significant anymore)

[3] = MNL model with only significant parameters, no quadratic parameter components

[4] = MNL model with all parameters, no quadratic parameter components, generic parameter for 'camera surveillance' (when estimating a generic parameter, the parameter is based on more observations which enlarges the chance of finding a significant parameter)

[5] = MNL model with all parameters, quadratic parameter components for 'parking cost' (PIC and PEC) and 'risk of extra waiting time'

[6] = MNL model with all parameters, quadratic parameter component for 'parking cost' PEC

[7] = MNL model with all parameters except 'camera surveillance', quadratic parameter component for 'parking cost' PEC

[8] = MNL model with all parameters, quadratic parameter component for 'parking cost' PEC, generic parameter for 'camera surveillance'

[9] = MNL model with all parameters, quadratic parameter component for 'parking cost' PEC, generic parameter for 'camera surveillance' and 'personnel surveillance'

G.3 BIOGEME MODEL FILES

The **model file (.mod)** for the SP final survey is constructed as follows:

BIOGEME MODEL FILE (.MOD)

```
// File PARKING.mod

[Choice]
CHOICE

[Beta]
// Name    Value   LowerBound   UpperBound   status (0=variable, 1=fixed)
asc1       0       -10000       10000        0
asc2       0       -10000       10000        1
costi      0       -10000       10000        0
survip     0       -10000       10000        0
survic     0       -10000       10000        0
costel     0       -10000       10000        0
costeq     0       -10000       10000        0
survep     0       -10000       10000        0
survec     0       -10000       10000        0
wait       0       -10000       10000        0
fee        0       -10000       10000        0

[Utilities]
// Id  Name  Avail  linear-in-parameter expression (beta1*x1 + beta2*x2 + ...)
 1     PIC   AV1    asc1 * CONST + costi * COSTI + survip * SURVIP + survic * SURVIC
 2     PEC   AV2    asc2 * CONST + costel * COSTE + survep * SURVEP + survec * SURVEC + wait * WAIT + fee * FEE

[GeneralizedUtilities]
2 costeq * COSTE * COSTE

[Model]
$MNL
```

The **model file (.mod)** for the SP final survey with the implementation of gender as an interaction effect is constructed as follows:

BIOGEME MODEL FILE – INTERACTION GENDER (.MOD)

```
// File PARKING.mod

[Choice]
CHOICE

[Beta]
// Name          Value   LowerBound   UpperBound   status (0=variable, 1=fixed)
asc1             0       -10000       10000        0
asc2             0       -10000       10000        1
gender           0       -10000       10000        0
costi            0       -10000       10000        0
survip           0       -10000       10000        0
survic           0       -10000       10000        0
coste            0       -10000       10000        0
survep           0       -10000       10000        0
survec           0       -10000       10000        0
wait             0       -10000       10000        0
fee              0       -10000       10000        0
costigender      0       -10000       10000        0
survigenderp     0       -10000       10000        0
survigenderc     0       -10000       10000        0
costegender      0       -10000       10000        0
survegenderp     0       -10000       10000        0
survegenderc     0       -10000       10000        0
waitgender       0       -10000       10000        0
feegender        0       -10000       10000        0
costeq           0       -10000       10000        0
```

```
costeqgender            0       -10000          10000           0

[Utilities]
// Id  Name    Avail    linear-in-parameter expression (beta1*x1 + beta2*x2 + ...)
 1     PIC     AV1      asc1 * CONST + gender * GENDER + costi * COSTI + survip * SURVIP + survic * SURVIC
 2     PEC     AV2      asc2 * CONST + coste * COSTE + survep * SURVEP + survec * SURVEC + wait * WAIT + fee * FEE

[GeneralizedUtilities]
1 costigender * COSTI * GENDER
+ survigenderp * SURVIP * GENDER
+ survigenderc * SURVIC * GENDER

2 costeq * COSTE * COSTE
+ costegender * COSTE * GENDER
+ costeqgender * COSTE * COSTE * GENDER
+ survegenderp * SURVEP * GENDER
+ survegenderc * SURVEC * GENDER
+ waitgender * WAIT * GENDER
+ feegender * FEE * GENDER

[Model]
$MNL
```

The **model file (.mod)** for the SP final survey with the implementation of trip purpose as an interaction effect is constructed as follows:

BIOGEME MODEL FILE – INTERACTION TRIP PURPOSE (.MOD)

```
// File PARKING.mod

[Choice]
CHOICE

[Beta]
// Name                 Value   LowerBound      UpperBound      status (0=variable, 1=fixed)
asc1                    0       -10000          10000           0
asc2                    0       -10000          10000           1
business                0       -10000          10000           0
work                    0       -10000          10000           0
recreational            0       -10000          10000           0
costi                   0       -10000          10000           0
survip                  0       -10000          10000           0
survic                  0       -10000          10000           0
costel                  0       -10000          10000           0
costeq                  0       -10000          10000           0
survep                  0       -10000          10000           0
survec                  0       -10000          10000           0
wait                    0       -10000          10000           0
fee                     0       -10000          10000           0
costibusiness           0       -10000          10000           0
costiwork               0       -10000          10000           0
costirecreational       0       -10000          10000           0
survibusinessp          0       -10000          10000           0
surviworkp              0       -10000          10000           0
survirecreationalp      0       -10000          10000           0
survibusinessc          0       -10000          10000           0
surviworkc              0       -10000          10000           0
survirecreationalc      0       -10000          10000           0
costelbusiness          0       -10000          10000           0
costelwork              0       -10000          10000           0
costelrecreational      0       -10000          10000           0
costeqbusiness          0       -10000          10000           0
costeqwork              0       -10000          10000           0
costeqrecreational      0       -10000          10000           0
survebusinessp          0       -10000          10000           0
surveworkp              0       -10000          10000           0
surverecreationalp      0       -10000          10000           0
```

```
survebusinessc          0    -10000    10000    0
surveworkc              0    -10000    10000    0
surverecreationalc      0    -10000    10000    0
waitbusiness            0    -10000    10000    0
waitwork                0    -10000    10000    0
waitrecreational        0    -10000    10000    0
feebusiness             0    -10000    10000    0
feework                 0    -10000    10000    0
feerecreational         0    -10000    10000    0

[Utilities]
// Id  Name  Avail  linear-in-parameter expression (beta1*x1 + beta2*x2 + ...)
 1     PIC   AV1    asc1 * CONST + business * TRIPPB + work * TRIPPW + recreational * TRIPPR + costi * COSTI
                    + survip * SURVIP + survic * SURVIC
 2     PEC   AV2    asc2 * CONST + costel * COSTE + survep * SURVEP + survec * SURVEC + wait * WAIT + fee * FEE

[GeneralizedUtilities]
1 costibusiness * COSTI * TRIPPB + costiwork * COSTI * TRIPPW + costirecreational * COSTI * TRIPPR
+ survibusinessp * SURVIP * TRIPPB + surviworkp * SURVIP * TRIPPW + survirecreationalp * SURVIP * TRIPPR
+ survibusinessc * SURVIC * TRIPPB + surviworkc * SURVIC * TRIPPW + survirecreationalc * SURVIC * TRIPPR

2 costeq * COSTE * COSTE
+ costelbusiness * COSTE * TRIPPB + costelwork * COSTE * TRIPPW + costelrecreational * COSTE * TRIPPR
+ costeqbusiness * COSTE * COSTE * TRIPPB + costeqwork * COSTE * COSTE * TRIPPW + costeqrecreational * COSTE * COSTE * TRIPPR
+ survebusinessp * SURVEP * TRIPPB + surveworkp * SURVEP * TRIPPW + surverecreationalp * SURVEP * TRIPPR
+ survebusinessc * SURVEC * TRIPPB + surveworkc * SURVEC * TRIPPW + surverecreationalc * SURVEC * TRIPPR
+ waitbusiness * WAIT * TRIPPB + waitwork * WAIT * TRIPPW + waitrecreational * WAIT * TRIPPR
+ feebusiness * FEE * TRIPPB + feework * FEE * TRIPPW + feerecreational * FEE * TRIPPR

[Model]
$MNL
```

The **model file (.mod)** for the SP final survey with the implementation of the perception on risk of damage as an interaction effect is constructed as follows:

BIOGEME MODEL FILE – INTERACTION PERCEPTION RISK OF DAMAGE (.MOD)

```
// File PARKING.mod

[Choice]
CHOICE

[Beta]
// Name                 Value  LowerBound  UpperBound  status (0=variable, 1=fixed)
asc1                    0    -10000    10000    0
asc2                    0    -10000    10000    1
riskdamage              0    -10000    10000    0
costi                   0    -10000    10000    0
survip                  0    -10000    10000    0
survic                  0    -10000    10000    0
coste                   0    -10000    10000    0
costeq                  0    -10000    10000    0
survep                  0    -10000    10000    0
survec                  0    -10000    10000    0
wait                    0    -10000    10000    0
fee                     0    -10000    10000    0
costiriskdamage         0    -10000    10000    0
surviriskdamagep        0    -10000    10000    0
surviriskdamagec        0    -10000    10000    0
costeriskdamage         0    -10000    10000    0
costeqriskdamage        0    -10000    10000    0
surveriskdamagep        0    -10000    10000    0
surveriskdamagec        0    -10000    10000    0
waitriskdamage          0    -10000    10000    0
feeriskdamage           0    -10000    10000    0

[Utilities]
// Id  Name  Avail  linear-in-parameter expression (beta1*x1 + beta2*x2 + ...)
```

```
1    PIC    AV1    asc1 * CONST + riskdamage * RDAMC + costi * COSTI + survip * SURVIP + survic * SURVIC
2    PEC    AV2    asc2 * CONST + coste * COSTE + survep * SURVEP + survec * SURVEC + wait * WAIT + fee * FEE

[GeneralizedUtilities]

1 costiriskdamage * COSTI * RDAMC
+ surviriskdamagep * SURVIP * RDAMC
+ surviriskdamagec * SURVIC * RDAMC

2 costeq * COSTE * COSTE
+ costeriskdamage * COSTE * RDAMC
+ costeqriskdamage * COSTE * COSTE * RDAMC
+ surveriskdamagep * SURVEP * RDAMC
+ surveriskdamagec * SURVEC * RDAMC
+ waitriskdamage * WAIT * RDAMC
+ feeriskdamage * FEE * RDAMC

[Model]
$MNL
```

G.4 INTERACTION EFFECTS

The values, standard errors, t-test values and p-values of the interaction models with the personal characteristics are listed in Tables G.9 until G.13.

Table G.9 Values, standard errors, t-test values and p-values of the interaction models personal characteristics – asc and parking cost (PIC)

PIC	asc				Parking cost			
	Value	St error	t-test	p-value	Value	St error	t-test	p-value
Gender								
Main parameter	**0.548**	0.179	3.06	0.00*	**-0.499**	0.0476	-10.46	0.00*
Female	-0.255	0.179	-1.42	0.15	0.0119	0.0476	0.25	0.80
Male	0.255	-	-	-	-0.0119	-	-	-
Age								
Main parameter	**0.449**	0.221	2.26	0.02*	**-0.505**	0.0590	-8.56	0.00*
18 – 24 (1992 ≥)	-0.17157	-	-	-	-0.0578	-	-	-
25 – 44 (1991 – 1972)	-0.00423	0.298	-0.01	0.99	0.0760	0.0795	0.96	0.34
45 – 64 (1971 – 1952)	0.245	0.302	0.81	0.42	-0.0707	0.0808	-0.87	0.38
65 ≥ (≤ 1951)	-0.0692	0.404	-0.17	0.86	0.0525	0.107	0.49	0.62
Income								
Main parameter	**0.592**	0.205	2.89	0.00*	**-0.509**	0.0547	-9.30	0.00*
≤ €20,000	-0.1986	-	-	-	0.0258	-	-	-
€20,000 – €40,000	0.0886	0.307	0.29	0.77	0.0137	0.0815	0.17	0.87
€40,000 - €60,000	0.309	0.329	0.94	0.35	-0.0283	0.0879	-0.32	0.75
€60,000 ≥	-0.199	0.355	-0.56	0.57	-0.0112	0.0960	-0.12	0.91
Education								
Main parameter	**0.554**	0.192	2.88	0.00*	**-0.483**	0.0514	-9.40	0.00*
Primary / secondary school	0.0456	-	-	-	0.0284	-	-	-
MBO	-0.0736	0.295	-0.25	0.80	-0.0456	0.0787	-0.58	0.56
HBO	0.142	0.293	0.48	0.63	0.0763	0.0786	-0.97	0.33
Bachelor / Master WO	-0.114	0.399	-0.28	0.78	0.0935	0.108	0.87	0.38
Purchase value of the car								
Main parameter	**0.608**	0.191	3.18	0.00*	**-0.504**	0.0512	-9.84	0.00*
≤€5,000	-0.2845	-	-	-	0.0322	-	-	-
€5,000 - €10,000	0.00340	0.352	0.01	0.99	-0.211	0.152	-1.39	0.16
€10,000 - €15,000	0.0205	0.356	0.06	0.95	-0.177	0.153	-1.16	0.25
€15,000 - €20,000	0.293	0.414	0.71	0.48	0.0121	0.109	0.11	0.91
€20,000 ≥	-0.0324	0.374	-0.09	0.93	0.0570	0.100	0.57	0.57
Average number of trips to inner city with car								
Main parameter	**0.527**	0.240	2.20	0.03*	**-0.462**	0.0634	-7.28	0.00*
Less than one trip per year	-0.745	-	-	-	-0.0247	-	-	-
One or several trips per year	0.154	0.314	0.49	0.62	-0.109	0.0832	-1.31	0.19
One or several trips per month	0.127	0.368	0.34	0.73	-0.0197	0.0985	-0.20	0.84
One or several trips per week	-0.241	0.462	-0.52	0.60	0.0905	0.123	0.74	0.46
One or several trips per day[a]	0.705	0.663	1.06	0.29	0.0629	0.174	0.36	0.72
Use automated features while driving								
Main parameter	**0.733**	0.359	2.04	0.04*	**-0.521**	0.103	-5.07	0.00*
No use of automated features	-0.1449	-	-	-	-0.0175	-	-	-
Use of very limited automated features	-0.0661	0.431	-0.15	0.88	0.00240	0.121	0.02	0.98
Use of limited automated features	0.106	0.492	0.22	0.83	-0.0341	0.137	-0.25	0.80
Use of advanced automated features[a]	0.105	0.978	0.11	0.91	0.0492	0.284	0.17	0.86
Knowledge / Experience								
Main parameter	0.425	0.429	0.99	0.32	-0.315	**0.111**	-2.85	0.00*
No knowledge / no experience	0.268	-	-	-	-0.203	-	-	-
Knowledge / no experience	0.140	0.444	0.31	0.75	-0.203	0.115	-1.78	0.08
Knowledge / experience[a]	-0.408	0.806	-0.51	0.61	0.406	**0.207**	1.96	0.05*
Interest								
Main parameter	1.01	0.563	1.79	0.07	**-0.496**	0.145	-3.42	0.00*
Not interested	-0.626	-	-	-	0.0624	-	-	-
Interested	-0.328	0.579	-0.57	0.57	-0.0475	0.149	-0.32	0.75
Professionally active[a]	0.954	1.11	0.86	0.39	-0.0149	0.284	-0.05	0.96

Significant values are marked in **pink bold** and with a * ($p < 0.05$)

Table G.10 Values, standard errors, t-test values and p-values of the interaction models personal characteristics – personnel and camera surveillance (PIC)

PIC	Personnel surveillance				Camera surveillance			
	Value	St error	t-test	p-value	Value	St error	t-test	p-value
Gender								
Main parameter	**0.301**	0.0904	3.33	0.00*	0.110	0.0832	1.32	0.19
Female	0.0683	0.0904	0.76	0.45	0.0904	0.0832	1.09	0.28
Male	-0.0683	-	-	-	-0.0904	-	-	-
Age								
Main parameter	**0.348**	0.112	3.12	0.00*	0.151	0.103	1.46	0.14
18 – 24 (1992 ≥)	0.004	-	-	-	0.2132	-	-	-
25 – 44 (1991 – 1972)	-0.110	0.150	-0.73	0.47	-0.0893	0.139	-0.64	0.52
45 – 64 (1971 – 1952)	-0.118	0.153	-0.77	0.44	-0.0418	0.141	-0.30	0.77
65 ≥ (≤ 1951)	0.224	0.205	1.09	0.27	-0.0821	0.189	-0.43	0.66
Income								
Main parameter	**0.304**	0.103	2.94	0.00*	0.0949	0.0948	1.00	0.32
≤ €20,000	0.3057	-	-	-	0.1359	-	-	-
€20,000 – €40,000	0.0281	0.0877	0.32	0.75	-0.0103	0.142	-0.07	0.94
€40,000 - €60,000	-0.0483	0.165	-0.29	0.77	-0.0488	0.151	-0.32	0.75
€60,000 ≥	-0.175	0.179	-0.98	0.33	-0.0768	0.166	-0.46	0.64
Education								
Main parameter	**0.283**	0.0965	2.93	0.00*	0.116	0.0887	1.30	0.19
Primary / secondary school	0.0635	-	-	-	0.12763	-	-	-
MBO	0.0168	0.149	0.11	0.91	0.0769	0.137	0.56	0.58
HBO	0.0447	0.147	0.30	0.76	-0.203	0.136	-1.50	0.13
Bachelor / Master WO	-0.125	0.200	-0.62	0.53	-0.00153	0.183	-0.01	0.99
Purchase value of the car								
Main parameter	**0.286**	0.0966	2.96	0.00*	0.0998	0.0886	1.13	0.26
≤€5,000	0.2092	-	-	-	0.3869	-	-	-
€5,000 - €10,000	0.0622	0.178	0.35	0.73	-0.0660	0.164	-0.40	0.69
€10,000 - €15,000	-0.124	0.179	-0.69	0.49	-0.104	0.165	-0.63	0.53
€15,000 - €20,000	-0.174	0.210	-0.83	0.41	-0.186	0.190	-0.98	0.33
€20,000 ≥	0.0266	0.188	0.14	0.89	-0.0309	0.174	-0.18	0.86
Average number of trips to inner city with car								
Main parameter	**0.302**	0.121	2.49	0.01*	0.122	0.110	1.11	0.27
Less than one trip per year	0.02083	-	-	-	0.2583	-	-	-
One or several trips per year	0.00377	0.159	0.02	0.98	-0.0371	0.145	-0.26	0.80
One or several trips per month	-0.0678	0.185	-0.37	0.71	-0.0344	0.170	-0.20	0.84
One or several trips per week	0.138	0.232	0.59	0.55	-0.0588	0.212	-0.28	0.78
One or several trips per day[a]	-0.0948	0.333	-0.28	0.78	-0.128	0.302	-0.42	0.67
Use automated features while driving								
Main parameter	**0.443**	0.177	2.50	0.01*	0.306	0.174	1.76	0.08
No use of automated features	-0.159	-	-	-	-0.172	-	-	-
Use of very limited automated features	-0.270	0.214	-1.26	0.21	-0.315	0.206	-1.53	0.13
Use of limited automated features	0.171	0.244	0.70	0.48	-0.234	0.233	-1.00	0.32
Use of advanced automated features[a]	0.258	0.483	0.53	0.59	0.721	0.478	1.51	0.13
Knowledge / Experience								
Main parameter	0.359	0.205	1.75	0.08	0.317	0.195	1.63	0.10
No knowledge / no experience	-0.2391	-	-	-	-0.384	-	-	-
Knowledge / no experience	-0.0409	0.212	-0.19	0.85	-0.209	0.202	-1.04	0.30
Knowledge / experience[a]	0.280	0.381	0.74	0.46	0.593	0.364	1.63	0.10
Interest								
Main parameter	0.269	0.282	0.95	0.34	0.0818	0.255	0.32	0.75
Not interested	0.114	-	-	-	0.04827	-	-	-
Interested	-0.0348	0.290	-0.12	0.90	0.00873	0.263	0.03	0.97
Professionally active[a]	-0.0792	0.553	-0.14	0.89	-0.0570	0.500	-0.11	0.91

Significant values are marked in **pink bold** and with a * ($p < 0.05$)

Table G.11 Values, standard errors, t-test values and p-values of the interaction models personal characteristics - parking cost and parking cost² (PEC)

PEC	Parking cost				Parking cost²			
	Value	St error	t-test	p-value	Value	St error	t-test	p-value
Gender								
Main parameter	**0.102**	0.0428	2.38	0.02*	**-0.0235**	0.00539	-4.36	0.00*
Female	-0.0257	0.0428	-0.60	0.55	0.00289	0.00539	0.54	0.59
Male	0.0257	-	-	-	-0.00289	-	-	-
Age								
Main parameter	0.0845	0.0532	1.59	0.11	**-0.0214**	0.00669	-3.19	0.00*
18 – 24 (1992 ≥)	-0.1231	-	-	-	0.01242	-	-	-
25 – 44 (1991 – 1972)	-0.0158	0.0716	-0.22	0.83	0.00200	0.00901	0.22	0.82
45 – 64 (1971 – 1952)	0.0605	0.0727	0.83	0.41	-0.00802	0.00917	-0.87	0.38
65 ≥ (≤ 1951)	0.0784	0.0966	0.81	0.42	-0.00640	0.0122	-0.52	0.60
Income								
Main parameter	**0.0987**	0.0489	2.02	0.04*	**-0.0245**	0.00618	-3.96	0.00*
≤ €20,000	0.0316	-	-	-	-0.00601	-	-	-
€20,000 – €40,000	-0.0249	0.0736	-0.34	0.73	0.00671	0.00928	0.72	0.47
€40,000 - €60,000	0.0707	0.0783	0.90	0.37	-0.0108	0.00991	-1.09	0.28
€60,000 ≥	-0.0774	0.0852	-0.91	0.36	0.0101	0.0108	0.94	0.35
Education								
Main parameter	**0.0960**	0.0459	2.09	0.04*	-0.0231	**0.00580**	-3.98	0.00*
Primary / secondary school	0.0176	-	-	-	0.00222	-	-	-
MBO	0.0110	0.0710	0.16	0.88	0.000350	0.00895	0.04	0.97
HBO	0.0224	0.0699	0.32	0.75	-0.00535	0.00885	-0.60	0.55
Bachelor / Master WO	-0.0510	0.0953	-0.54	0.59	0.00278	0.0120	0.23	0.82
Purchase value of the car								
Main parameter	**0.109**	0.0459	2.37	0.02*	**-0.0248**	0.00579	-4.29	0.00*
≤€5,000	-0.14143	-	-	-	0.01256	-	-	-
€5,000 - €10,000	0.0268	0.0846	0.32	0.75	-0.00526	0.0107	-0.49	0.62
€10,000 - €15,000	0.0291	0.0854	0.34	0.73	-0.00239	0.0108	-0.22	0.82
€15,000 - €20,000	0.0935	0.0997	0.94	0.35	-0.0100	0.0125	-0.80	0.42
€20,000 ≥	-0.00797	0.0889	-0.09	0.93	0.00509	0.0112	0.45	0.65
Average number of trips to inner city with car								
Main parameter	0.102	0.0580	1.75	0.08	**-0.0231**	0.00728	-3.18	0.00*
Less than one trip per year	-0.16209	-	-	-	0.01535	-	-	-
One or several trips per year	0.0430	0.0756	0.57	0.57	-0.00561	0.00951	-0.59	0.56
One or several trips per month	-0.0644	0.0882	-0.73	0.47	0.00697	0.0111	0.63	0.53
One or several trips per week	0.00649	0.110	0.06	0.95	-0.00191	0.0139	-0.14	0.89
One or several trips per day[a]	0.177	0.157	1.12	0.26	-0.0148	0.0198	-0.75	0.45
Use automated features while driving								
Main parameter	0.135	0.0859	1.57	0.12	**-0.0271**	0.0108	-2.50	0.01*
No use of automated features	-0.0438	-	-	-	0.00256	-	-	-
Use of very limited automated features	-0.0309	0.103	-0.30	0.76	0.00587	0.0130	0.45	0.65
Use of limited automated features	0.0467	0.117	0.40	0.69	-0.00350	0.0148	-0.24	0.81
Use of advanced automated features[a]	0.0280	0.235	0.12	0.91	-0.00493	0.0296	-0.17	0.87
Knowledge / Experience								
Main parameter	0.0162	0.0980	0.16	0.87	-0.0117	0.0123	-0.95	0.34
No knowledge / no experience	0.1503	-	-	-	-0.0174	-	-	-
Knowledge / no experience	0.0877	0.102	0.86	0.39	-0.0125	0.0128	-0.97	0.33
Knowledge / experience[a]	-0.238	0.183	-1.30	0.19	0.0299	0.0230	1.30	0.19
Interest								
Main parameter	0.209	0.130	1.61	0.11	-0.0307	0.0162	-1.89	0.06
Not interested	-0.100	-	-	-	0.00844	-	-	-
Interested	-0.119	0.134	-0.89	0.37	0.00676	0.0167	0.40	0.69
Professionally active[a]	0.219	0.255	0.86	0.39	-0.0152	0.0317	-0.48	0.63

Significant values are marked in **pink bold** and with a * ($p < 0.05$)

Table G.12 Values, standard errors, t-test values and p-values of the interaction models personal characteristics – personnel and camera surveillance (PEC)

PEC	Personnel surveillance				Camera surveillance			
	Value	St error	t-test	p-value	Value	St error	t-test	p-value
Gender								
Main parameter	**0.117**	0.0511	2.29	0.02*	-0.116	0.0654	-1.77	0.08
Female	0.0537	0.0511	1.05	0.29	0.0111	0.0654	0.17	0.86
Male	-0.0537	-	-	-	-0.0111	-	-	-
Age								
Main parameter	**0.133**	0.0629	2.12	0.03*	-0.0998	0.0809	-1.23	0.22
18 – 24 (1992 ≥)	-0.0317	-	-	-	0.0754	-	-	-
25 – 44 (1991 – 1972)	-0.0662	0.0850	-0.78	0.44	0.0136	0.109	0.12	0.90
45 – 64 (1971 – 1952)	-0.0121	0.0866	-0.14	0.89	-0.0638	0.111	-0.57	0.57
65 ≥ (≤ 1951)	0.110	0.115	0.96	0.34	-0.0252	0.148	-0.17	0.86
Income								
Main parameter	0.0943	0.0585	1.61	0.11	-0.128	0.0743	-1.72	0.09
≤ €20,000	-0.0078	-	-	-	-0.0061	-	-	-
€20,000 – €40,000	0.0281	0.0877	0.32	0.75	0.0644	0.112	0.57	0.57
€40,000 - €60,000	-0.101	0.0942	-1.07	0.28	0.0292	0.119	0.25	0.81
€60,000 ≥	0.0807	0.102	0.79	0.43	-0.0875	0.130	-0.67	0.50
Education								
Main parameter	**0.118**	0.0549	2.16	0.03*	-0.105	0.0697	-1.51	0.13
Primary / secondary school	0.0269	-	-	-	-0.0819	-	-	-
MBO	0.0157	0.0849	0.19	0.85	-0.0657	0.109	-0.60	0.55
HBO	-0.0297	0.0836	-0.36	0.72	0.0326	0.106	0.31	0.76
Bachelor / Master WO	-0.0129	0.114	-0.11	0.91	0.115	0.143	0.81	0.42
Purchase value of the car								
Main parameter	0.103	0.0548	1.88	0.06	-0.103	0.0700	-1.47	0.14
≤€5,000	0.0556	-	-	-	0.05958	-	-	-
€5,000 - €10,000	0.0474	0.101	0.47	0.64	-0.0701	0.130	-0.54	0.59
€10,000 - €15,000	0.0297	0.102	0.29	0.77	-0.0489	0.131	-0.37	0.71
€15,000 - €20,000	-0.149	0.120	-1.25	0.21	0.0666	0.153	0.43	0.66
€20,000 ≥	0.0163	0.106	0.15	0.88	-0.00718	0.135	-0.05	0.96
Average number of trips to inner city with car								
Main parameter	**0.139**	0.0688	2.01	0.04*	-0.131	0.0884	-1.48	0.14
Less than one trip per year	0.07997	-	-	-	-0.0295	-	-	-
One or several trips per year	-0.0429	0.0899	-0.48	0.63	0.0235	0.116	0.20	0.84
One or several trips per month	-0.00647	0.105	-0.06	0.95	0.0328	0.134	0.25	0.81
One or several trips per week	-0.0417	0.132	-0.32	0.75	-0.102	0.167	-0.61	0.54
One or several trips per day[a]	0.0111	0.189	0.06	0.95	-0.0166	0.240	-0.07	0.94
Use automated features while driving								
Main parameter	0.0768	0.101	0.76	0.45	-0.158	0.130	-1.21	0.23
No use of automated features	-0.004	-	-	-	0.0183	-	-	-
Use of very limited automated features	0.122	0.122	1.00	0.31	0.120	0.157	0.76	0.45
Use of limited automated features	0.121	0.139	0.88	0.38	-0.0538	0.177	-0.30	0.76
Use of advanced automated features[a]	-0.239	0.275	-0.87	0.38	-0.0845	0.355	-0.24	0.81
Knowledge / Experience								
Main parameter	0.0725	0.121	0.60	0.55	0.0478	0.152	0.31	0.75
No knowledge / no experience	0.1355	-	-	-	-0.285	-	-	-
Knowledge / no experience	0.0355	0.125	0.28	0.78	-0.166	0.158	-1.05	0.29
Knowledge / experience[a]	-0.171	0.226	-0.76	0.45	0.451	0.284	1.59	0.11
Interest								
Main parameter	0.220	0.166	1.32	0.19	-0.122	0.216	-0.56	0.57
Not interested	-0.1984	-	-	-	0.0515	-	-	-
Interested	-0.0995	0.171	-0.58	0.56	-0.0276	0.222	-0.12	0.90
Professionally active[a]	0.226	0.327	0.69	0.49	-0.0239	0.426	-0.06	0.96

Significant values are marked in **pink bold** and with a * ($p < 0.05$)

Table G.13 Values, standard errors, t-test values and p-values of the interaction models personal characteristics – risk of extra waiting time and risk of parking fee (PEC)

PEC	Risk of extra waiting time				Risk of parking fee			
	Value	St error	t-test	p-value	Value	St error	t-test	p-value
Gender								
Main parameter	**-0.110**	0.0248	-4.46	0.00*	**-0.849**	0.0768	-11.06	0.00*
Female	-0.0135	0.0248	-0.54	0.59	-0.0791	0.0768	-1.03	0.30
Male	0.0135	-	-	-	0.0791	-	-	-
Age								
Main parameter	**-0.111**	0.0307	-3.60	0.00*	**-0.847**	0.0944	-8.97	0.00*
18 – 24 (1992 ≥)	-0.0297	-	-	-	-0.1148	-	-	-
25 – 44 (1991 – 1972)	0.0130	0.0414	0.31	0.75	0.0625	0.127	0.49	0.62
45 – 64 (1971 – 1952)	-0.0176	0.0421	-0.42	0.68	-0.0787	0.130	-0.61	0.54
65 ≥ (≤ 1951)	0.0343	0.0555	0.62	0.54	0.131	0.172	0.76	0.45
Income								
Main parameter	**-0.113**	0.0284	-3.99	0.00*	-0.822	**0.0874**	-9.41	0.00*
≤ €20,000	0.0335	-	-	-	0.0922	-	-	-
€20,000 – €40,000	0.0456	0.0423	1.08	0.28	0.111	0.131	0.84	0.40
€40,000 - €60,000	0.0219	0.0459	0.48	0.63	-0.0972	0.140	-0.70	0.49
€60,000 ≥	**-0.101**	0.0499	-2.03	0.04*	-0.106	0.153	-0.70	0.49
Education								
Main parameter	**-0.109**	0.0267	-4.09	0.00*	**-0.817**	0.0817	-10.00	0.00*
Primary / secondary school	0.0282	-	-	-	0.0361	-	-	-
MBO	0.00172	0.0409	0.04	0.97	-0.0661	0.127	-0.52	0.60
HBO	-0.0237	0.0407	-0.58	0.56	-0.117	0.125	-0.94	0.35
Bachelor / Master WO	-0.00622	0.0558	-0.11	0.91	0.147	0.168	0.87	0.38
Purchase value of the car								
Main parameter	**-0.109**	0.0266	-4.08	0.00*	**-0.798**	0.0822	-9.71	0.00*
≤€5,000	0.009	-	-	-	0.035	-	-	-
€5,000 - €10,000	-0.0275	0.0489	-0.56	0.57	-0.211	0.152	-1.39	0.16
€10,000 - €15,000	-0.0344	0.0496	-0.69	0.49	-0.177	0.153	-1.16	0.25
€15,000 - €20,000	**0.114**	0.0562	2.03	0.04*	0.201	0.180	1.11	0.26
€20,000 ≥	-0.0611	0.0521	-1.17	0.24	0.152	0.159	0.96	0.34
Average number of trips to inner city with car								
Main parameter	**-0.0863**	0.0331	-2.61	0.01*	**-0.789**	0.103	-7.68	0.00*
Less than one trip per year	0.0726	-	-	-	-0.274833	-	-	-
One or several trips per year	-0.0412	0.0432	-0.95	0.34	-0.110	0.134	-0.82	0.41
One or several trips per month	-0.0474	0.0515	-0.92	0.36	-0.0352	0.157	-0.22	0.82
One or several trips per week	-0.0283	0.0638	-0.44	0.66	-0.000967	0.197	-0.00	1.00
One or several trips per day[a]	0.0443	0.0915	0.48	0.63	0.421	0.281	1.50	0.13
Use automated features while driving								
Main parameter	**-0.132**	0.0550	-2.41	0.02*	**-0.819**	0.158	-5.18	0.00*
No use of automated features	0.03908	-	-	-	-0.166	-	-	-
Use of very limited automated features	0.00909	0.0639	0.14	0.89	0.241	0.188	1.28	0.20
Use of limited automated features	0.00603	0.0727	0.08	0.93	**-0.438**	0.213	-2.05	0.04*
Use of advanced automated features[a]	-0.0542	0.153	-0.35	0.72	0.363	0.434	0.84	0.40
Knowledge / Experience								
Main parameter	-0.00265	0.0614	-0.04	0.97	**-0.744**	0.183	-4.08	0.00*
No knowledge / no experience	-0.129	-	-	-	-0.114	-	-	-
Knowledge / no experience	-0.115	0.0634	-1.81	0.07	-0.117	0.189	-0.62	0.53
Knowledge / experience[a]	0.244	0.116	2.11	0.03	0.231	0.342	0.67	0.50
Interest								
Main parameter	-0.0288	0.0820	-0.35	0.73	**-0.877**	0.250	-3.51	0.00*
Not interested	-0.0607	-	-	-	-0.0035	-	-	-
Interested	-0.0993	0.0842	-1.18	0.24	0.0515	0.257	0.20	0.84
Professionally active[a]	0.160	0.161	0.99	0.32	-0.0480	0.492	-0.10	0.92

Significant values are marked in **pink bold** and with a * ($p < 0.05$)

The values, standard errors, t-test values and p-values of the interaction models with the trip characteristics are listed in Tables G.14 until G.18.

Table G.14 Values, standard errors, t-test values and p-values of the interaction models trip characteristics – asc and parking cost (PIC)

PIC	asc				Parking cost			
	Value	St error	t-test	p-value	Value	St error	t-test	p-value
Trip purpose								
Main parameter	**0.985**	0.504	1.96	0.05*	**-0.416**	0.132	-3.15	0.00*
Business	0.970	0.621	1.56	0.12	-0.201	0.165	-1.22	0.22
Work[a]	-1.01	0.709	-1.42	0.16	-0.00290	0.187	-0.02	0.99
Recreation	-0.603	0.524	-1.15	0.25	-0.0930	0.137	-0.68	0.50
Different[a]	0.643	-	-	-	0.2969	-	-	-
Trip duration								
Main parameter	0.887	0.512	1.73	0.08	**-0.344**	0.136	-2.53	0.01*
Trip duration	-0.0751	0.114	-0.66	0.51	-0.0381	0.0300	-1.27	0.20
Trip reimbursement								
Main parameter	**0.537**	0.249	2.16	0.03*	**-0.432**	0.0664	-6.51	0.00*
Yes	0.322	0.401	0.80	0.42	0.156	0.107	1.45	0.15
No	0.0668	0.277	0.24	0.81	-0.115	0.0738	-1.55	0.12
Not applicable	-0.3888	-	-	-	-0.041	-	-	-

Significant values are marked in **pink bold** and with a * ($p < 0.05$)

Table G.15 Values, standard errors, t-test values and p-values of the interaction models trip characteristics – personnel and camera surveillance (PIC)

PIC	Personnel surveillance				Camera surveillance			
	Value	St error	t-test	p-value	Value	St error	t-test	p-value
Trip purpose								
Main parameter	0.341	0.253	1.35	0.18	0.0810	0.227	0.36	0.72
Business	-0.187	0.310	-0.60	0.55	-0.254	0.280	-0.90	0.37
Work[a]	0.642	0.361	1.78	0.08	**0.709**	0.327	2.17	0.03*
Recreation	-0.0591	0.263	-0.22	0.82	0.0213	0.237	0.09	0.93
Different[a]	-0.3959	-	-	-	-0.4763	-	-	-
Trip duration								
Main parameter	0.0526	0.259	0.20	0.84	-0.0639	0.239	-0.27	0.79
Trip duration	0.0589	0.0580	1.02	0.31	0.0380	0.0538	0.71	0.48
Trip reimbursement								
Main parameter	**0.306**	0.125	2.45	0.01*	0.0957	0.114	0.84	0.40
Yes	0.0625	0.200	0.31	0.75	-0.0639	0.182	-0.35	0.73
No	-0.00651	0.139	-0.05	0.96	0.00768	0.127	0.06	0.95
Not applicable	-0.05599	-	-	-	0.05622	-	-	-

Significant values are marked in **pink bold** and with a * ($p < 0.05$)

Table G.16 Values, standard errors, t-test values and p-values of the interaction models trip characteristics - parking cost and parking cost^2 (PEC)

PEC	Parking cost				Parking cost^2			
	Value	St error	t-test	p-value	Value	St error	t-test	p-value
Trip purpose								
Main parameter	0.00279	0.118	0.02	0.98	-0.00967	0.0149	-0.65	0.52
Business	0.200	0.146	1.37	0.17	-0.0281	0.0185	-1.52	0.13
Work[a]	-0.0835	0.169	-0.49	0.62	0.00871	0.0212	0.41	0.68
Recreation	0.108	0.123	0.88	0.38	-0.0151	0.0155	-0.98	0.33
Different[a]	-0.2245	-	-	-	0.03449	-	-	-
Trip duration								
Main parameter	0.0341	0.122	0.28	0.78	-0.0177	0.0155	-1.14	0.25
Trip duration	0.0166	0.0272	0.61	0.54	-0.00149	0.00344	-0.43	0.67
Trip reimbursement								
Main parameter	0.0734	0.0596	1.23	0.22	**-0.0186**	0.00752	-2.47	0.01*
Yes	-0.0173	0.0953	-0.18	0.86	0.00534	0.0120	0.44	0.66
No	0.0514	0.0663	0.77	0.44	-0.00870	0.00837	-1.04	0.30
Not applicable	-0.0341	-	-	-	0.00336	-	-	-

Significant values are marked in **pink bold** and with a * ($p < 0.05$)

Table G.17 Values, standard errors, t-test values and p-values of the interaction models trip characteristics – personnel and camera surveillance (PEC)

PEC	Personnel surveillance				Camera surveillance			
	Value	St error	t-test	p-value	Value	St error	t-test	p-value
Trip purpose								
Main parameter	0.0851	0.148	0.57	0.57	-0.0472	0.179	-0.26	0.79
Business	-0.119	0.180	-0.66	0.51	-0.0842	0.219	-0.38	0.70
Work[a]	0.207	0.207	1.00	0.32	-0.112	0.252	-0.44	0.66
Recreation	0.0490	0.154	0.32	0.75	-0.0752	0.187	-0.40	0.69
Different[a]	-0.137	-	-	-	0.2714	-	-	-
Trip duration								
Main parameter	0.170	0.146	1.16	0.24	-0.136	0.188	-0.73	0.47
Trip duration	0.0123	0.0325	-0.38	0.71	0.00440	0.0423	0.10	0.92
Trip reimbursement								
Main parameter	**0.142**	0.0709	2.01	0.04*	-0.123	0.0905	-1.36	0.17
Yes	0.00818	0.113	0.07	0.94	-0.0375	0.0790	-0.48	0.63
No	0.0437	0.143	0.31	0.76	0.00603	0.101	0.06	0.95
Not applicable	0.02932	-	-	-	-0.04973	-	-	-

Significant values are marked in **pink bold** and with a * ($p < 0.05$)

Table G.18 Values, standard errors, t-test values and p-values of the interaction models trip characteristics – risk of extra waiting time and risk of parking fee (PEC)

PEC	Risk of extra waiting time				Risk of parking fee			
	Value	St error	t-test	p-value	Value	St error	t-test	p-value
Trip purpose								
Main parameter	-0.0527	0.0700	-0.75	0.45	**-0.590**	0.212	-2.79	0.01*
Business	-0.0610	0.0871	-0.70	0.48	0.146	0.259	0.56	0.57
Work[a]	0.0441	0.0986	0.45	0.65	0.0476	0.298	0.16	0.87
Recreation	-0.0705	0.0727	-0.97	0.33	-0.375	0.221	-1.70	0.09
Different[a]	0.0874	-	-	-	0.1814	-	-	-
Trip duration								
Main parameter	-0.115	0.0697	-1.65	0.10	-0.386	0.218	-1.77	0.08
Trip duration	0.000649	0.0153	0.04	0.97	**-0.111**	0.0488	-2.27	0.02*
Trip reimbursement								
Main parameter	**-0.101**	0.0345	-2.92	0.00*	**-0.752**	0.106	-7.09	0.00*
Yes	0.0278	0.0557	0.50	0.62	0.315	0.169	1.86	0.06
No	-0.0171	0.0383	-0.44	0.66	-0.160	0.118	-1.35	0.18
Not applicable	-0.0107	-	-	-	-0.155	-	-	-

Significant values are marked in **pink bold** and with a * ($p < 0.05$)

The values, standard errors, t-test values and p-values of the interaction models with the perceptions are listed in Tables G.19 until G.23. The null LL, final LL, rho-square and adjusted rho-square of the interaction models are listed in Table G.24.

Table G.19 Values, standard errors, t-test values and p-values of the interaction models perceptions – asc and parking cost (PIC)

PIC	asc				Parking cost			
	Value	St error	t-test	p-value	Value	St error	t-test	p-value
Perception								
Main parameter	**0.569**	0.179	3.17	0.00*	**-0.497**	0.0477	-10.42	0.00*
Perception risk of damage	0.00102	0.00241	0.43	0.67	0.00125	0.000646	1.93	0.05

Significant values are marked in **pink bold** and with a * ($p < 0.05$)

Table G.20 Values, standard errors, t-test values and p-values of the interaction models perceptions – personnel and camera surveillance (PIC)

PIC	Personnel surveillance				Camera surveillance			
	Value	St error	t-test	p-value	Value	St error	t-test	p-value
Perception								
Main parameter	**0.298**	0.0904	3.30	0.00*	0.106	0.0831	1.28	0.20
Perception risk of damage	0.000467	0.00122	0.38	0.70	0.000448	0.00112	0.40	0.69

Significant values are marked in **pink bold** and with a * ($p < 0.05$)

Table G.21 Values, standard errors, t-test values and p-values of the interaction models perceptions – parking cost and parking cost^2 (PEC)

PEC	Parking cost				Parking cost^2			
	Value	St error	t-test	p-value	Value	St error	t-test	p-value
Perception								
Main parameter	**0.103**	0.0430	2.41	0.02*	**-0.0235**	0.00542	-4.34	0.00*
Perception risk of damage	-0.000140	0.000583	-0.24	0.81	6.14e-005	7.37e-005	0.83	0.40

Significant values are marked in **pink bold** and with a * ($p < 0.05$)

Table G.22 Values, standard errors, t-test values and p-values of the interaction models perceptions – personnel and camera surveillance (PEC)

PEC	Personnel surveillance				Camera surveillance			
	Value	St error	t-test	p-value	Value	St error	t-test	p-value
Perception								
Main parameter	**0.116**	0.0513	2.26	0.02*	-0.117	0.0658	-1.77	0.08
Perception risk of damage	-0.000533	0.000695	-0.77	0.44	0.000929	0.000906	1.03	0.31

Significant values are marked in **pink bold** and with a * ($p < 0.05$)

Table G.23 Values, standard errors, t-test values and p-values of the interaction models perceptions – risk of extra waiting time and risk of parking fee (PEC)

PEC	Risk of extra waiting time				Risk of parking fee			
	Value	St error	t-test	p-value	Value	St error	t-test	p-value
Perception								
Main parameter	**-0.108**	0.0249	-4.34	0.00*	**-0.843**	0.0768	-10.97	0.00*
Perception risk of damage	**0.000748**	0.000335	2.23	0.03*	**0.00209**	0.00104	2.00	0.05*

Significant values are marked in **pink bold** and with a * ($p < 0.05$)

Table G.24 Null LL, Final LL, Rho-square and Adjusted rho-square interaction models

MNL	Null LL	Final LL	Rho-square	Adjusted rho-square
No interaction effects	-3227.293	-3077.152	0.047	0.044
Personal characteristics				
Gender	-3227.293	-3071.525	0.048	0.042
Age	-3218.976	-3056.632	0.050	0.038
Income	-2778.134	-2632.456	0.052	0.038
Education	-3227.293	-3054.292	0.054	0.041
Purchase value of the car	-2944.489	-2777.443	0.057	0.040
Average number of trips to inner city with own car	-3227.293	-3033.424	0.060	0.045
Use of automated features	-3094.209	-2902.887	0.062	0.049
Knowledge / experience	-3227.293	-3058.548	0.052	0.043
Interest	-3194.022	-3041.091	0.048	0.038
Trip characteristics				
Trip purpose	-3227.293	-3012.273	0.067	0.054
Trip duration	-3227.293	-3040.178	0.058	0.052
Trip reimbursement	-3227.293	-3034.779	0.060	0.050
Perception				
Risk of damage during empty vehicle driving trip	-3227.293	-3063.597	0.051	0.045