Employees' and students' preferences towards a Supportive Car System and the influence on commuting mode choice

An approach to discourage car commuting traffic

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Employees' and students' preferences towards a Supportive Car System and the influence on commuting mode choice

An approach to discourage car commuting traffic

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Preface

Proudly I present you this report, which is the result of my graduation project. The report is established in collaboration with the Faculty of the Built Environment and the Internal Affairs Department of Eindhoven University of Technology. This official thesis fulfills the last requirements of the Masters' degree of Construction Management and Engineering at the Eindhoven University of Technology.

My educational process at the Eindhoven University of Technology within the Built Environment started with the bachelor program Architecture, Urbanism and Building Sciences with specialization towards Urban Systems and Real Estate. It continued with my Master in the field of Construction Management and Engineering, focused on the field of Urban Development. This final research of my educational career at the Eindhoven University of Technology was a long process due to several reasons, but was the most informative period at the Eindhoven University of Technology.

The purpose of this research is to give businesses, carsharing companies and organizations like the Eindhoven University of Technology more insights in the implementation of Supportive Car Systems. The potential of Supportive Car Systems stimulating Travel Demand Management as one of the measures can be estimated. This is all set up, to help the companies and organizations in their decision making process concerning congestion issues, the implementation of Mobility plans and the discouraging of car commuting traffic.

Worldwide, there are discussions about mobility, sustainability and human behavior. Due to increased urbanization and mobility, the level of urban congestion will continue to rise. To reduce congestion, two action plans exist: reducing the attractiveness and supply of cars or offering and improving alternatives for the car. These themes are also connected to the environmental problems that have become clear over the past decades, because more sustainable alternatives for the car could be offered. It is important to know what peoples' motivations and preferences are in transportation mode decision making. Changes in human behavior, connected to these transportation mode choices and mobility could help the world getting more sustainable. This report tries to help with new and better insights in Travel Demand Management and Supportive Car Systems as one of the measures. I believe that the present report contributes to the trend of compliance with sustainability. I hope you will get enthusiastic about carsharing and Supportive Car Systems. Please enjoy reading this report!

Dedicated to the memory of my grandfather, Henk, who was a beloved structural engineer. You always believed in my ability to be successful in the construction management and engineering discipline. You are no longer with us, but your belief in me has made this journey possible.

Acknowledgements

Before getting into the content of this report, I would first like to express my gratitude toward the people who have contributed to making this research possible. During the execution of the research I faced many different and hard challenges. Many people helped me in some, or many stages of this project and without their support, advice or help the completion of this research would not have been possible.

First, I would like to thank my direct supervisor Peter van der Waerden for his mentorship. He helped me from the very start of writing my research proposal and has been enthusiastically helping me ever since. Since the subject of was chosen, Peter has guided me from the set-up of the thesis, through the methodology to this final product. Thank you for the many fun project meetings, and for showing me how you do research and motivating me in difficult times. I learned a lot from you and I respect you for your broad knowledge in the field of research methodologies. Your help was essential for developing and structuring the research and report.

Second, I would like to thank the other member in my graduation committee. I would like to thank Simone Vonken from the department of Internal Affairs at the Eindhoven University of Technology, to make it possible to carry out the case study at the TU/e and offering me some insights and information/documents of the TU/e about their strategies and recent researches. I would like to thank the others who made this research possible: Aloys Borgers, for his support and time during the essential meetings and providing feedback at crucial moments in the process of developing this thesis. Also, I would like to thank Bauke de Vries for his time and effort to chair the graduation committee and criticize this work.

Last, I would like to thank my girlfriend, family, friends, and study mates for their support and fun times during my entire studies. I also would like to thank many others for assisting me in developing the survey and testing the questionnaire, with all your feedback, it was very helpful. Without all the respondents of the questionnaire, the study would also not be possible, so thanks to all the respondents.

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Summary

The use of private cars has grown rapidly during the last decades. Car usage is growing, because the car is an attractive mode of transportation. In comparison with other travel modes, the car is comfortable, fast, reliable, flexible and convenient. But the growth of car use causes serious problems. Because of all the negative impacts of car usage, the current transportation system is not sustainable. The negative impact of car traffic needs to be managed. To achieve a long-term sustainable transport system, households need to reduce their use of private cars, especially in peak hours. The car should be the focus, because this is the most used commuting transportation mode. All the proposed measures concerning the change or the reduction of the demand for car use, are part of Travel Demand Management (TDM). One of the newest trends in TDM is carsharing, a short term car rental service in which service members can rent a car and pay per hour or mile of use. Companies could introduce or implement such carsharing opportunities in their mobility plans to discourage car commuting under their employees, this is called a Supportive Car System (SCS). A SCS is a car system, available at the working location and shared by employees to support in particular goals as business trips and other work-related purposes.

The objectives of this research are finally to contribute to the improvement of this specific TDM measure. In the first place this was done by identifying the most important attributes of a SCS, supported by companies/organizations, to optimize the potential and acceptance of the system. With these attributes, the optimal setting for the adoption of the SCS could be reached. Secondly, it needs to be identified if the optimal system could influence the commuting mode choice of the employees to discourage the car as commuting traffic.

A literature review to SCS attributes resulted in the used attributes in this research. The most important attributes of a SCS are the location of the SCS (walking time to the car), the amount of advertisements on the car, the type of car, the tariff systems of the car (per reserved time and per driven kilometer), the type of fuel, the accessibility of the car (how to unlock the car), the availability of the car (in which time slots the car is available), reservation techniques of the car and for which type of trip purpose the car could be used.

To research the importance of the SCS attributes and if they are influencing the respondents' choice when selecting a SCS a stated choice (SC) method will be used. This approach allows this study to estimate the respondents' preferences and predict the respondents' choice probabilities for the alternatives. And it has the ability to use choice situations that do not yet exist.

Besides the respondents' preferences, a goal of the research is to check if a SCS influences the commuting mode choice of people. The transportation mode choice depends on different factors. It all starts with the sociodemographic aspects of a person. These are on influence on the transportation mode choice decision process. In this process, people have travel needs. There is a hierarchy in those needs. In order of importance: the feasibility and accessibility of a certain transportation mode, the basic safety and security, the convenience and costs of a certain transportation mode, enjoyment and pleasure and in the end also habit is a factors in the transportation mode choice decision process.

A web-based survey has been used for this research. The survey was spread amongst 8.800 employees and students as a case study at the Eindhoven University of Technology (TU/e). The main part of this survey is the SP experiment, where respondents needed to select one of the two offered Supportive Car Systems. According to the (with fractional factorial designed) choice tasks with above mentioned attributes, the respondents needed to select their favorable SCS. The car commuters also needed to answer the question if they are likely to change their car commuting mode if the selected SCS is available at their working location. After data preparation, the survey resulted in 383 respondents for further research. The importance and influence of the SCS attributes are analyzed with a multinomial logit (MNL) model. The willingness of the car commuters to change commuting mode is analyzed with a binary logit choice model.

The results of this research state that the availability of the SCS is a very important attribute when selecting a SCS for all the (sub)groups. Other very important attributes are the tariff systems and the type of fuel. Less important attributes are the location of the SCS, the presence of advertisements on the SCS and the reservation possibilities. The least important attributes for the SCS are the type of car, the accessibility of the SCS and the trip purposes. The optimal setting of a SCS, according to this research is an electric SCS that costs €0.30 per kilometer or €4 per hour. A system that is available for 24 hours a day, 7 days per week, to use for every possible trip purpose. The SCS is located at a walking duration of 1 minute from the user's location. There is a mobile application available to reserve and unlock the car. The optimal design of the SCS is a luxurious car with only the logo of the company on the exterior. The biggest part of the people who commute by car are not willing to change their commuting mode (41%) if the preferred SCS is available. 24% is willing to change their commuting mode the train, 21% to the bicycle and 14% to the bus. The most important settings to achieve this goal are a price of €0.30 per km or €4 per hour, the availability of the SCS of 24 hours per day, 7 days per week and it has to be an electric vehicle.

Samenvatting

Het gebruik van private auto's is laatste decennia gegroeid. Autogebruik groeit nog steeds, want de auto is een attractief vervoersmiddel. In vergelijking met andere middelen zorgt de auto voor comfort, snelheid, betrouwbaarheid, flexibiliteit en gebruiksgemak. De groei van het autogebruik zorgt voor serieuze problemen, zo negatief dat het huidige verkeerssysteem niet duurzaam is. Er moet grip gekregen worden op de groei en de negatieve invloeden van het autoverkeer. Het gebruik van private auto's in de spits moet verminderen voor een duurzaam verkeerssysteem. Hierin is de auto de focus, omdat de meeste forenzen met de auto plaatsvinden. Alle maatregelen om het autoverkeer te reduceren zijn onderdeel van 'Travel Demand Management' (TDM). Een recente ontwikkeling in TDM is autodelen. Bedrijven kunnen een bedrijfsdeelauto implementeren in hun mobiliteitsplan om auto forenzen te verminderen. Een bedrijfsdeelauto is een autosysteem, beschikbaar op de werklocatie, gedeeld door alle werknemers om te voorzien als vervoersmiddel voor werk-gerelateerde doelen zoals dienstreizen.

De doelen van dit onderzoek zijn uiteindelijk om bij te dragen aan de ontwikkeling van TDM maatregelen. In de eerste plaats, door het identificeren van de belangrijkste attributen van de bedrijfsdeelauto, om de potentie van het systeem te vergroten. Deze attributen zorgen voor betere adoptie van de bedrijfsdeelauto. Ten tweede wordt onderzocht of de optimale inrichting van de bedrijfsdeelauto invloed heeft in het ontmoedigen van de auto als woon-werkverkeer.

Een literatuuronderzoek naar verschillende attributen van deelautosystemen heeft geresulteerd in een lijst met gebruikte attributen in dit onderzoek. De belangrijkste en daarom meegenomen attributen in dit onderzoek zijn de locatie van de deelauto (looptijd naar de auto), de hoeveelheid advertenties op de auto, het type van de auto, het tarief (per gereserveerde tijd en per gereden kilometer), het type brandstof, de toegankelijkheid van de auto (hoe de auto te openen), de beschikbaarheid van de auto (in welk tijdslot de auto te gebruiken is), verschillende boekingsmogelijkheden en voor welke doelen de auto gebruikt mag worden.

Het eerste deel van het onderzoek is het onderzoeken van het belang van de verschillende deelauto-attributen voor het selecteren van een bedrijfsdeelauto. Dit deel is gedaan met behulp van de 'stated choice' (SC) methode. Een methode waarbij respondenten een keuze moeten maken tussen twee (hypothetische) verschillende keuzesets. Met deze methode is het mogelijk om de keuzes van de respondenten te analyseren en mogelijk om de kans dat een alternatief gekozen wordt te voorspellen. Ook kunnen hypothetische alternatieven worden onderzocht met deze methode.

Het tweede deel van het onderzoek is het onderzoeken van de invloed van een bedrijfsdeelauto op de vervoersmiddelkeuze tijdens woon-werkverkeer van mensen. De vervoersmiddelkeuze hangt af van meerdere factoren. Het begint met sociaal-demografische kenmerken, deze zijn van invloed op het proces en wat men wel of niet overweegt in de keuze. In het vervoersmiddelkeuze-proces hebben mensen/reizigers bepaalde reisbehoeften. Er zit een hiërarchie in deze reisbehoeften. Ten eerste de haalbaarheid en toegankelijkheid van verschillende vervoersmiddelen. Daarna de veiligheid en zekerheid, het gebruiksgemak en de kosten van een bepaald vervoersmiddel. Ook genot en genoegen zijn een factor in het vervoersmiddelkeuze-proces, hetzelfde geldt voor gewoonte.

Het onderzoek is uitgevoerd door middel van een online enquête. De enquête is verspreid onder ongeveer 8,800 werknemers en studenten als casus op de Technische Universiteit Eindhoven (TU/e). Het hoofddeel van de enquête is het SP experiment, waar respondenten een keuze moeten maken tussen twee aangeboden bedrijfsdeelauto's. De keuzetaken, met bovengenoemde attributen, dwingen de respondenten om een favoriete keuze aan te geven. De respondenten die de auto voor woon-werkverkeer gebruiken moeten ook aangeven of ze hun vervoersmiddelkeuze voor woon-werkverkeer aanpassen, als de gekozen bedrijfsdeelauto aanwezig is op de werklocatie. Na de data-voorbereiding bleven 383 respondenten over voor verder onderzoek. De belangrijkheid en invloed van de bedrijfsdeelauto-attributen zijn geanalyseerd door middel van een 'Multinomial Logit' (MNL) model. De bereidvaardigheid om het woon-werkverkeer aan te passen is geanalyseerd door middel van een 'binary logit' keuzemodel.

Een resultaat van het onderzoek is dat de beschikbaarheid van de bedrijfsdeelauto één van de belangrijkste attributen is. Andere zeer waardevolle attributen zijn de prijs-calculaties en het type brandstof. Minder waardevolle attributen zijn de locatie van de bedrijfsdeelauto, de aanwezigheid van advertenties en de boekingsmogelijkheden. Het minst belangrijk zijn het type van de auto, de toegankelijkheid van de auto en de doelen waarvoor het gebruikt mag worden. De optimale bedrijfsdeelauto ziet er als volgt uit: Een elektrische auto, die €0,30 per kilometer of €4 per uur kost. De auto moet 24 uur per dag, 7 dagen per week beschikbaar zijn, voor elk mogelijk reisdoel. De bedrijfsdeelauto is geplaatst op 1 minuut lopen vanaf de werkplek. Er is een mobiele applicatie aanwezig voor het reserveren en openen van de auto. Het uiterlijk van de auto is een luxueuze auto met enkel het bedrijfslogo op de buitenkant. Het grootste deel van de autogebruikers zegt niet te overwegen om van forensvervoersmiddel te willen overstappen (41%). 24% van de autogebruikers zou willen overstappen naar de trein, 21% naar de fiets en 14% naar de bus als de gewenste bedrijfsdeelauto beschikbaar is. Om dit doel te bereiken is er een elektrisch aangedreven bedrijfsdeelauto nodig met een prijs van €0.30 per km of €4 uur met 24/7 beschikbaarheid.

Abstract

Car usage has grown rapidly the last decades and is still growing. But this causes serious problems, so the negative impact of car traffic needs to be managed. Travel Demand Management (TDM) includes measures to discourage car usage. A Supportive Car System (SCS) is a car system, available at the working location and shared by employees to discourage car commuting and support in particular goals as business trips. This research tries to contribute to the improvement of this specific TDM measure, by identifying the most important attributes of a SCS when selecting a SCS. With these attributes, the optimal setting for the adoption of the SCS could be reached and it could be researched if it could influence the commuting mode choice of the employees to discourage the car as commuting traffic. To reach these goals, a survey was spread amongst 8,800 employees and students as a case study at the Eindhoven University of Technology (TU/e). The main part of this survey is a stated choice (SC) experiment, where respondents needed to select one of the two offered Supportive Car Systems. The systems were defined according to 10 SCS-attributes with different levels. The car commuters also answered the question if they are likely to change their car commuting mode if the selected SCS is available at their working location. After data preparation, 383 respondents remained for further research. The part-worth utilities of attribute levels and the probabilities of the attributes are investigated with the help of multinomial logit (MNL). The attributes that contribute the most when selecting a SCS are the availability, tariff systems and the type of fuel of the SCS. The optimal setting is an electric SCS that costs €0.30/km and €4/hour. The car is available 24/7 for every trip purpose. The car is located at 1 minute walking. There is a mobile application to reserve and unlock the car and it is a luxurious car with only the company-logo on the outside. The biggest part of the people who commute by car are not willing to change their commuting mode (41%) if the preferred SCS is available. 24% is willing to change their commuting mode the train, 21% to the bicycle and 14% to the bus.

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List of abbreviations

B2B	Business to business
B2C	Business to customer
DCM	Discrete choice model
MNL	Multinomial logit
MNP	Multinomial probit
ML	Mixed logit
PT	Public transportation
P2P	Peer to peer
RP	Revealed preference
SA	Stated adaptation
SC	Stated choice
SCS	Supportive Car System
SP	Stated preference
TDM	Travel demand management
TU/e	Eindhoven University of Technology

1. Introduction

1.1 Problem definition

The use of private cars has grown rapidly during the last decades. In 1950 there were approximately 75 million motorized vehicles in the world. The number of cars increased to 411 million in 1980 and further to 688 million in 1998 (Gärling & Schuitema, 2007). More than 70% of the travelled kilometers are travelled by car. Approximately 8,000 kilometers are travelled by car per person per year (CBS, 2016). The car is the most used mode of transport nowadays (Simon, 2014). The number of cars is still growing rapidly, according to Voelcker (2014) in the year 2014 there were 1.2 billion cars around the globe. The billion was reached around 2010 and the expectations are there are 2 billion cars in 2035. The calculations contain all passenger cars, trucks, busses, but not heavy construction vehicles. Not only car ownership, also the numbers of kilometers driven are expected to further increase in the future. Car usage is growing, because the car is an attractive mode of transportation. In comparison with other travel modes, the car is comfortable, fast, reliable, flexible and convenient. Cars also provide carrying capacity for other people/goods and privacy (Gärling & Schuitema, 2007). Besides this, people are sensitive for attractive designs, status and prestige. This could be obtained by the car. The car is a status symbol, because a car expresses the societal position of the user. With the ownership of a car, people could show their identity on the street. But this could also cause societal isolation or aversion (Frenken, 2013).

The growth of car use causes serious problems. The huge amount of car traffic uses a lot of energy and contributes to the global warming. In 2004 the transport sector consumed 28% of the world's total energy consumption (Gärling & Schuitema, 2007). This is because scarce raw materials and energy are needed for the production and usage of vehicles. Also the extension of necessary road infrastructure for the growing amount of cars, causes a lot of energy consumption, pollution and distortion and fragmentation of natural areas (Steg, 2003a).

According to European Environment Agency (2016) the air quality in the Netherlands is scoring badly in comparison with the air quality of other countries in Europa. The air pollution in the Netherlands scores nearly the worst of Europe; only in Germany the concentration of nitrogen dioxide (NO_2) is higher than in the Netherlands. The concentration of NO_2 in the air is mainly caused by traffic emissions. A bad air quality does not only have negative economic consequences for the country, but also health consequences and odor nuisance. The huge amount of car usage also decreases the quality of life in urban areas due to noise, traffic accident risks, and encroachment on the value of land besides highways or busy roads. Car traffic is identified as the main cause of environmental noise (16% of the population in OECD countries is exposed to high noise levels which disturb sleep and communication) and traffic accidents (Steg, 2003a). Because of all these negative impacts of car usage, the current transportation system is not sustainable. The negative impact of car traffic needs to be managed.

To achieve a long-term sustainable transport system, households need to reduce their use of private cars, or more in general: change the use of cars with respect to when and where to drive, especially in peak hours in dense urban centers. All the proposed measures concerning the change or the reduction of the demand for car use, are part of so called Travel Demand Management (TDM). Other terms with the same meaning are transport management or mobility management (Gärling et al., 2002). One of the newest trends in TDM is carsharing, a short term car rental service in which service members can rent a car and pay per hour or mile of use. It is promoted as a TDM policy based on three arguments:

- Carsharing is the missing link between public transportation and private vehicles,
- Carsharing is a way to change a good (the vehicle) into a service (mobility),
- Carsharing is a way to move from fixed costs to variable costs (Tal, 2009).

From collected data, a lot of early attempts to forecast the effects of TDM policies were generally too optimistic, and policies failed to deliver the promised behavioral changes (Tal, 2009). The issues with the effectiveness of TDM measures concern the effects it will have on other travel modes, for example improving bicycle facilities will not automatically reduce car use. From (Gärling & Schuitema, 2007) it may be concluded that TDM measures are acceptable if they do not limit individuals' freedom of driving and if they actually deliver the promised reduction of problems they aim to reduce (car use). This is quite contradictory, but this is also the challenge that has to be accomplished.

Commuting, the travel between one's home and workplace, accounts for 25% of the travel (OECD, 2002). The car is the most used commuting mode and also often used for business travel, because the car has the flexibility to be used anytime and provide carrying capacity (TU/e, 2016). So TDM measures could have a big impact at workplaces to affect car commuting. Experiences with expanding and sustaining TDM in workplaces resulted in some important implementation factors: the measures on its own is of high importance, but it does not only depends on the measures themselves, also on the integration of the TDM measures. The measures need to get into good business practice and building a supportive culture. This is an interplay between the company/organization and the employees/students (Wake, 2007). A lot of businesses and organizations are facing this obstacle to introduce TDM measures to their employees. Organizations implement mobility plans to solve mobility problems at their organization. But the desired effects of the mobility plans sometimes stay out. A lot of employees remain commuting by car. An example of a mobility plan adjustment is the implementation of a supportive car system at the working location, but the adoption of the Supportive Car System (SCS) at the TU/e is lacking and does not reach its planned goals:

'The usage of the available shared-use vehicles of Studentcar at the TU/e-Campus is disappointing, according to Angela Stevens-Van Gennip and Simone Vonken of the Internal Affairs Department of the Eindhoven University of Technology, a shared-use vehicle is only reserved once per week on average' (Gaal, 2016).

1.2 Research objective and questions

So the available Studentcar at the TU/e is not being used, but more in general a lot of companies and organizations are facing problems with the introduction of TDM measures, also Supportive Car Systems. The objectives of this research are eventually to contribute to the improvement of this specific TDM measure. In the first place, by identifying the most important factors of a SCS, supported by companies/organizations, the potential and acceptance of the system could be optimized. With these factors, the optimal setting for the adoption of the SCS could be reached. Secondly, it needs to be identified if the optimal system could influence the commuting modes of the employees to discourage the car as a commuting transportation mode.

To reach this objective, other objectives need to be researched first. It is important to make a clear overview of the attributes of transport mode and identify where peoples' commuting mode choice decisions depend on. Also all different supportive car systems (carsharing systems/shared-use vehicle systems) need to be reviewed. It is necessary to know all the characteristics of work related travel (commuting and during working hours), about the frequency of travel, the peak times of travel, transportation modes and activities or end destinations of the trips. In the end it is important to identify if and how a supportive car system could assist in the way people commute.

Based on the problem analysis, the following research questions are formulated:

- What factors are contributing to peoples' preferences towards a Supportive Car System, supported by companies/organizations, to get the optimal setting of a Supportive Car System?

- Could the optimal setting of the Supportive Car System help to discourage the car as commuting transportation mode, so employees and students will commute more by public transportation or bicycle?

1.3 Research design

This chapter introduces the research design of the graduation thesis. The research problem has already been identified and defined. After that some recent trends about the subject of the research are described. Following that, the focus of the research is already given and the research question is formulated. In this section, the total research design in illustrated (figure 1.1) and explained. At last, the societal and academic relevance of the research are explained.

After introducing the research, the beginning of the research includes the literature review. In the beginning of the literature review it is important to give a clear overview of related concepts and definitions of unclear notions. This will be followed by identifying all important factors that influence the transportation mode choice of travelers. Also the importance of attributes of the different commuting transportation modes is of interest. After identifying all these important elements, there is a foundation for the rest of the research.

The following goal is to identify the choice situation and motivations for making external trips during working/study hours at the TU/e campus and possibly using the SCS as transportation mode. The alternatives in the choice situation are the different setups of the Supportive Car Systems. The most important attributes of the Supportive Car Systems need to be identified and how they influence the transportation mode choice of the employees and students.

Afterwards it is required to find the most influencing factors of a SCS. So the optimal setting could be defined, which could possibly contribute to the reduction of the car as commuting travel mode. In a Stated Choice (SC) experiment respondents are presented with hypothetical choice situations between several SCS alternatives that differ on a number of attribute dimensions. The respondents are asked to specify their preferred alternative from the proposed set of alternatives.

The quantitative part of this research (stated choice) is carried out with a case study at the TU/e, the data collection is among TU/e employees and students. The TU/e campus offers ideal circumstances and boundaries for this research; a Mobility Plan, various TDM measures and the availability of a SCS. In figure 1.1 the research model and also the reading guide for the research to identify the optimal setting of a SCS is shown.

1.4 Societal and academic relevance

There are several expected results after constructing the research questions and the research approach of this research. The first and main goal of this research is to identify which attributes of a SCS are contributing to the preferences of people towards the SCS. Together with these practical goals of the research, there will also become data available about the demand for a SCS for companies and organizations, especially the TU/e. The TU/e society could benefit from this results.

The second goal of the research is focused at the settings of a SCS to discourage car commuting. In other words, encourage commuting by other, more sustainable transportation modes. In this case, the expected result is a list of attractive and unattractive attributes commuting transportation modes, based on the preferences of the travelers/commuters. This will also lead to new available data about commuting at the TU/e and the characteristics of the commuters.

The outcomes of the analysis could also provide new information of supportive car systems as a TDM measure, and the results will contribute to better adoption of TDM measures in general. In the end, the research contributes to the application of the SCS at the TU/e and hopefully other companies and organizations could benefit from this research. Besides the societal relevance, this was never researched before in the academic field, so this research could provide new academic insights.

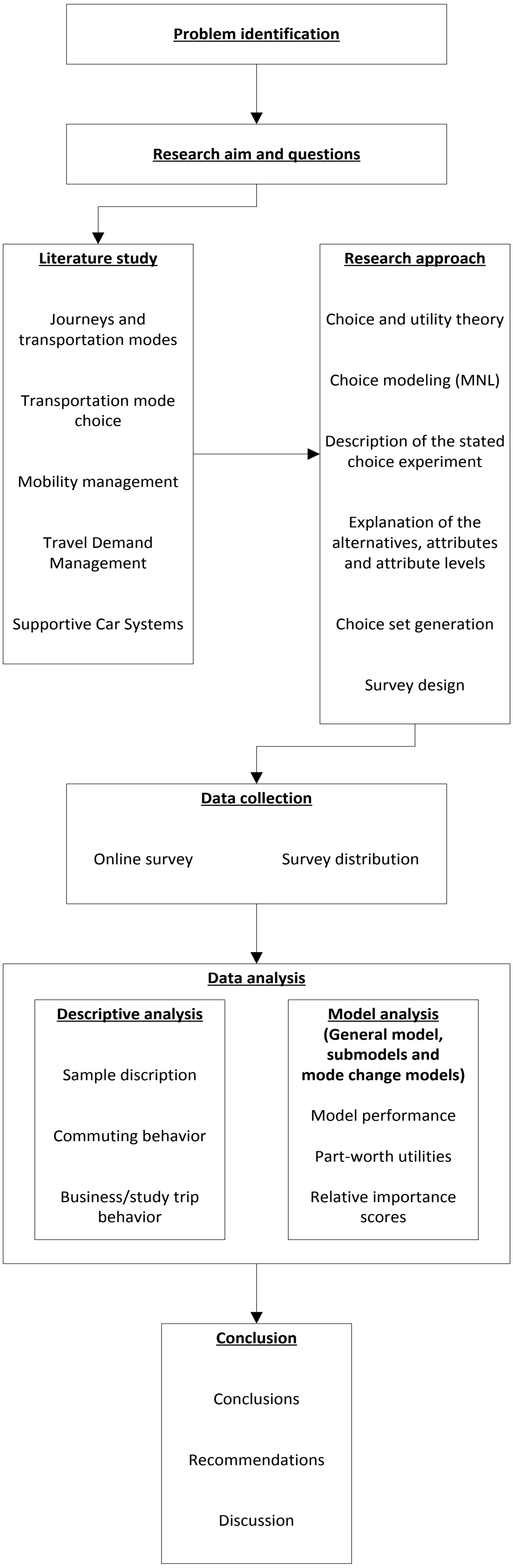


Figure 1.1: Research model/reading guide.

2. Literature review

2.1 Introduction

In this chapter of the thesis, all relevant subjects and methods for the thesis are presented. This theoretical framework will be the context for further research on the stated problem. It will also present the most important definitions, explanations and descriptions used in this research and related to the identified problem.

In the past, a lot of researches concerning transportation and travel behavior are executed and published. As described in the first chapter of the thesis, the sustainability of transportation and related solutions has received more attention in recent literature. As a strong knowledge basis for this research, this chapter provides a review of current literature in the field of journeys, especially focused on commuting, business travel and transportation mode choice behavior. Also the future developments and management to tackle the problems with the sustainability of the transportation will be reviewed.

First to avoid misunderstandings, the types of journeys that are applicable for this research are introduced. Transportation behavior exists of two sides; the supply side of existing infrastructure and travel facilities and the travel demand by travelers. First, the existing infrastructure and travel facilities will be illustrated. It starts with the history and recent developments of journeys. This part is followed by the current developments around the two different important journeys in this research; home-based journeys and work-based journeys.

Second, the demand side of travel mode choice will be described. All the aspects which influence the transportation mode choice behavior and different available theories will be introduced to explain the thoughts and behavior of travelers and to interrupt habits in people's travel behavior.

Third, the future developments to tackle issues with the current transportation system are explained. It is about what is already known in academic research concerning Travel Demand Management (TDM) measures and this will be further developed with car sharing possibilities and scoped to possible supportive car sharing options, available for campuses of companies and universities.

2.2 Infrastructure and travel facilities

2.2.1 Journeys

First, to describe the backgrounds of the transportation mode development, it has to be clear what is meant by journeys. Journeys are defined as acts of travelling from one place to another. A journey exists of at least two trips, because a journey is always based from one point. For example you have home-based journeys; journeys to an activity or destination reached from home. A trip is a component of the journey; a continues travel from door-to-door that consists out of one or more transportation modes from the start point to the end point of the trip, the place where the activity takes place (Givoni & Rietveld, 2007). This is illustrated in figure 2.1. In this research two different journeys are considered, because work-related travel could be divided into two categories; home-based journey, what is commonly known as commuting and work-based journeys, focused on business, work and study travel (Aguilera, 2014)

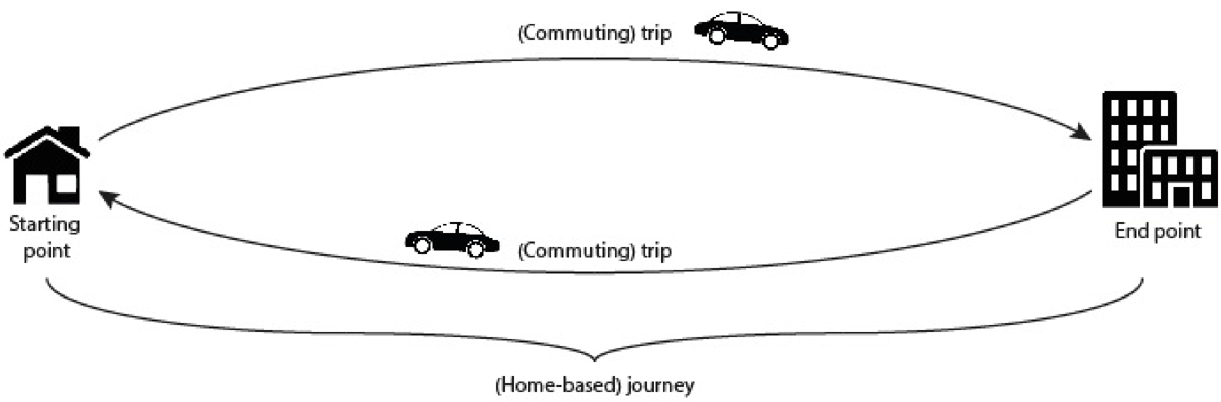


Figure 2.1: Schematic view of a (home-based) journey and (commuting) trips with start point and end point

2.2.2 Home-based journeys and commuting

The home-based journey is the journey which starts and ends at the residential place of a traveler. In this research the home-based journey is equivalent to the commuting trip of people, and the travelers are called commuters. To explain different aspects of commuting and the commuting market, it is necessary to make clear what is meant by commuting. Commuting is a (multimodal) trip between one's place of residence and the place of work or study. Most of the time people commute daily between their workplace and their home. This is called the home-based journey, the start point at the beginning of the day at the beginning of the journey is home and at the end of the day the commuter returns home. This all is illustrated in figure 2.1. Commuters have the choice between a lot of different commuting modes and commuting routes that differ per mode. According to OECD (2002), commuting accounts for an estimated 25% of the household travel.

History and recent developments

Through the time, the commuting journeys have developed a lot, so a little introduction as base for the actual commuting market is given. The history of the home-based journeys and transportation starts with spatial planning. Spatial planning and transportation have been regulated in the Netherlands since the beginning of the twentieth century (de Klerk & Kreukels, 2015). Long ago, people lived close to their places of work, as the farmers who lived on their working grounds. Later in history, factories were situated at locations where the resources for the production were found. This resulted in populated centers around the factories, where residential areas were built for the employees (e.g. Philipsdorp). Working and living was not separated as nowadays, it was all in the proximity of each other and the places became more and more overloaded (Schmal, 1992). The industrialization changed everything, the expansion of cities, municipalities and industrial areas had to be systematically planned. With the Housing Act (1901) the urban expansions needed to be organized and structured; a clustered land-use pattern to allocate all spatial functions. This had consequences for the employees. The distance between the working grounds and the residential areas increased (de Vos, 2015). Three historical impacts have changed the travelling patterns very much; the industrialization, the increasing prosperity and population, and the suburbanization (de Klerk & Kreukels, 2015).

A lot of technological innovations would not exist these days without the industrialization, one of the products of the industrialization is the car. Together with the trend of the increasing prosperity in the Netherlands, the car became affordable for a big part of the population. This increased the car usage enormously in a short period, so people were able to travel longer distances. Suburbanization was the result of the adaptation of the car and the increasing travel distances. The city was not attractive anymore as residential area in the seventies; only the proximity of cities was appreciated because of the employment. People were moving to suburbs with spacious, affordable housing in green areas (Krabbenborg & Daalhuizen, 2016). Solutions needed to be found for the regulation of the suburbanization and the increasing volume of commuting. This led to a shift in working areas, as places became more accessible due to the integration and growth of car-use. This shift in working places resulted in a shift of residential areas and commuting streams (Brunt, 1992).

With the fast population increase in the twentieth century, the pressure on the capacity of the inner-city transportation network increased. New policies were devised to locate new residential areas and locations of firms, to affect the commuting streams. Firms needed to be located so car commuting would be discouraged and commuting with other modes of transportation would be encouraged. So production firms need to be located close to regional transport nodes and highways, because of their logistics, while service firms need to be located in urban networks, close to railway stations (de Vos, 2015). This could also be described as the first forms of Mobility Management, what will be further described in section 2.4.

Because of these developments, the commuting patterns change. Commuting patterns are shaped by changes in jobs, homes and residential location over time. With the suburbanization, also the functional layout of cities changed from city centers to suburban development nodes. How people travel and commute is greatly affected by the motorization and suburbanization. This resulted into a decline of cycling, walking and the use of public transport and an increase in private car use for commuting and other travel purposes (Susilo & Maat, 2007; de Vos, 2015).

The most important mobility trends during the last few decades are caused by several socioeconomic changes. This resulted into an increase of car use in the last decades. The total distance travelled by car has almost doubled from 1980 till now (de Vos, 2015). From 1980, the amount of travel kilometers has increased with 40% to 130 billion kilometers in 2008 (Goudappel Coffeng, 2010). In the recent decades the commuting distances increased due to the bigger distance that easily could be travelled by car. The overall increase of commuting distance is from 12 to 18 km (KiM, 2013). The increase in distances is the biggest for car commuters; from 15 to 23 km. Also the average travel commuting time increased, because of the high occupancy of the roads. Another cause for the increase of commuting distances the last decades is the emancipation. Because of more female employees, households need to choose their residential location between two different working locations. This might be part of the explanation of the increasing commuting distances and times.

The current transportation supply

For each travel purpose, the importance of the facilities and attributes of the transportation modes differ. These are the facilities and attributes which best match the demands of the users. The demand of the commuter depends on the individual characteristics that influence the commuting trips and patterns. Olde Kalter et al. (2010) discovered some characteristics with a significant influence. Commuters with a higher income, full-time job (more than 30 hours per week), and higher educational level or with access to a car, are willing to commute longer distances.

But not only are the individual characteristics of influence, also the spatial and physical aspects influence commuting. And these aspects differ per transportation mode. One transportation mode fits better to one's demands than the demand of someone else. The Dutch Central Bureau of Statistics (CBS) yearly presents a report about the movements of travelers in the Netherlands: 'Onderzoek Verplaatsingen in Nederland (OViN)'. From this report of 2017 (CBS, 2018) it could be concluded that the three main travel modes in the Netherlands are the car, public transport (train, bus and metro) and the bicycle. In the research of Olde Kalter et al. (2015), the commuting travel and travel choice behavior of Dutch travelers was analyzed. In the research of Olde Kalter et al. (2015), the commuting travel and travel choice behavior of Dutch travelers was analyzed, see table 2.1.

Table 2.1: Translocation features of commuting (Olde Kalter et al., 2015)

Travel mode	Share (%)	Distance (km)	Travel time (min)
Car	63.9	24.8	29.4
Public transport	13.3	34.5	59.7
Bicycle	22.8	4.6	20.7

From this research, it could be concluded that these are the three main commuting travel mode choices and that the car and public transportation are used for longer distances of commuting, while the bicycles produce relatively the shortest travel time. Focused on commuting, Limtanakool et al. (2006) found that men depend much more on the use of private cars in commuting than women. And for business activities, more than 90.5 percent of the people use the car for such journeys. The preference for the car seems to be the result of the higher flexibility of cars than public transportation. This is because the different accessibility of the transportation modes (Goudappel Coffeng, 2008).

The situation at the TU/e differs from the national situation (TU/e, 2017a), probably because of the students which are a different population group than the general commuters. At the TU/e, the car is not the most used commuting mode. The employees commute mainly by bicycle (43%), especially for distances less than 8 km. The car is used by 37% of the TU/e commuters, especially for the medium distances. The public transport is usually used for distances more than 51 km (14% of all employees). Students use the bicycle even more than the employees as commuting mode (59%). Second the students commute the most with the public transport (33%) and last, they almost do not commute by car (only 5%).

Car commuting factors

But the question is why people choose the car for commuting instead of the other transportation mode alternatives. The car must have some extraordinary benefits above the other possible commuting modes. People have to make some considerations between travel modes to choose. This will be explained in section 2.3 'Transportation mode choice' that is about all influencing factors in mode choice behavior.

There are several reasons why the car is so popular. This is because the car is an attractive mode of transportation. In comparison with other travel modes, the car is comfortable, fast, reliable, flexible and convenient (Gärling & Schuitema, 2007). The participants of a survey amongst adults in the UK indicated the speed, cost savings, convenience and flexibility more important than the environmental disadvantages of car travel (Goodwin, 1995; Anable et al., 2006; Featherstone, 2004).

Flexibility and convenience are also mentioned the most as factors to choose for a certain commuting mode at the TU/e (55%) (TU/e, 2016). The car also has cultural and symbolic values (Forward, 1998). Olsson (2003) arrived at the conclusion that the car is not only convenient etc. but it also satisfies other needs of the traveler like the feeling to be in control of the journey. In the car, the driver and passengers feel undisturbed and secure; it is a moment for themselves. Steg (2003a) also named the independency of the car use and the pleasure people perceive from driving. Another important factor of the car is that it offers more status and the car could be acquired to indicate prestige and success. People weight these factors more than the safety, because travelling by car is less safe than travelling by public transport.

Olsson (2003), Gärling & Schuitema (2007) and Heinen et al. (2013) pointed out another need of some travelers to commute by car. Cars provide carrying capacity for other people/goods and privacy, it is easier for commuters to travel together or bring along goods with the car than other transportation modes. The employees and student at the TU/e also indicate that the commuting mode choice is selected by the need for carrying other people and goods (TU/e, 2016). Olsson (2003) also pointed out that the need to travel during work hours is important in someone's choice for commuting transportation mode. At the TU/e (TU/e, 2016), 11% of the students and 4% of the employees indicates that they choose the commuting transportation mode because of the possibility to travel during working time to other locations.

2.2.3 Work-based journeys and business trips

Travelling during working hours is a form of trip chaining. The definition of trip chaining is scheduling and linking activities in time and space. Srinivasan (1998) identified four specific types and travelling during working hours is identified as work-based trip chains. It differs from combining other activities with the commuting journey to or from work, because in fact these are home-based trips. In this research these trip chains are indicated with work-based journeys or business journeys

Primerano et al. (2008) showed that employer's business (75%) is the secondary activity within a trip chain to be undertaken. These work-based trip chains; trips for the employer's business, are most actively pursued during working times, from 9am to 5pm. Trip chaining is possible because of the flexibility of travel modes. 78% of business travelers choose for the car to make their business trips, because of the high flexibility of the car travel mode (Department for Transport, 2011).

As described, the home-based journey has a starting and ending point at the residential location of the traveler. So, the work-based journey has a starting and ending point at the work location of the traveler. The business journey is a (multimodal) trip between one's place of work and a visited location during working time. There are a lot of reasons for business travel: meetings with other companies, customers, training courses, corporate conventions or conferences and more as shown in figure 2.2 (Aguilèra, 2014).

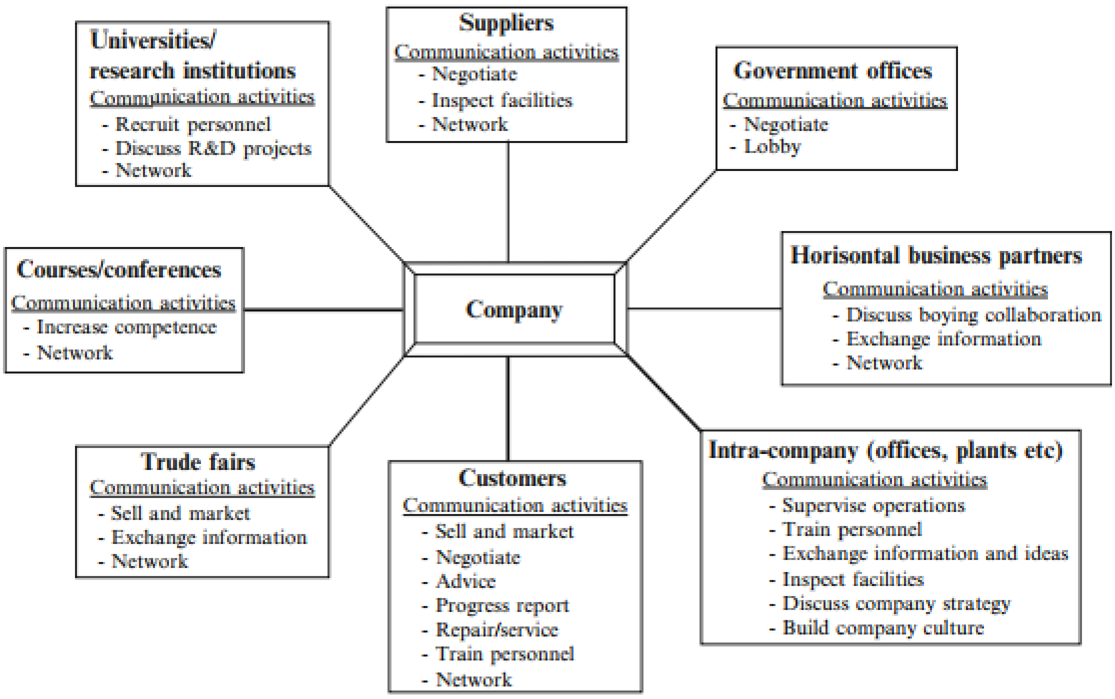


Figure 2.2: Major connections and communication activities within business travel (Adapted from Aguilèra, 2014).

The past few decades have witnessed a substantial increase in business travel, especially among managers and professionals (Doyle & Nathan, 2001; Swarbrooke & Horner, 2001). Important factors underlying this development are globalization and geographically expanded markets, growing numbers of multi-unit companies, new organizational trends such as networking, outsourcing and work in project teams, and improved infrastructures for mobility (Aguiléra, 2008). These different factors have created a growing demand for communication and interaction between persons who work at different locations. Businesspeople need to meet in order to buy, sell, and negotiate other agreements; cooperate, coordinate and exercise managerial control; create productive settings for teamwork, brainstorming and innovation; and develop professional networks and interpersonal trust (Faulconbridge et al., 2009). Arnfalk and Kogg (2003) stated that face-to-face meetings are the most effective way of doing business, seeking out new market, exchanging ideas and to communicate with colleagues and customers. Hugoson (2001) finds that the willingness to make a business trip increases with the size of the firm, and is greater in the manufacturing industry than in others.

There is more and more attention for business travel as a transportation activity generated by economic activity. But this is not the fact for short-term academic travel. This is particularly undertaken by tenured staff at universities who are locally situated at a specific institution, but also have connections with others and seek balance between all of them (also abroad), especially because of their high degree of freedom and low degree of control (Enders, 2001; Lassen, 2006). Better understanding of academic travel alternative strategies is needed.

The transportation modes, used for making business trips, are chosen due to the complexity of the trips. The complexity of trip chaining and thus business trips is increasing and this leads to higher car dependency (Ye et al., 2007; Strathman & Dueker 1995; Wallace et al., 2000). The flexibility and convenience of the car has additional benefits compared to other transportation modes (Ye, 2010). Goodwin (1995) even stated that at least 20% of the national business trips by car unavoidably need to be made by car in terms of the absence of viable alternatives. But there are also 20% of the trips which are very suitable for other alternatives.

Yun et al. (2011) stated that trip chaining has significant effects on the transportation mode choice. A higher complexity and thus more activities in a trip chain, lead to selection of flexible modes; car, motorcycle, bicycle and e-bike. Because there are other transportation mode possibilities to make business and study trips, companies seek to reduce travel costs, not by reducing the total number of trips, but the cost per trip.

The amount of business trips and the used transportation modes for these business trips at the TU/e (2016) are described in table 2.2.

Table 2.2: Business trips at the TU/e

Frequency		Transportation modes	
Daily	3 %	Car	25 %
Once per week	6 %	Bus	1 %
Once per month	18 %	Train	57 %
Once per quartile	10 %	Bicycle	3 %
Once per year	39 %	Rental/sharing	4 %
Less	25 %	Total	100 %
Total	100 %		

2.3 Transportation mode choice

As described, the last decades the mobility over the world has improved massively. And in the future, people will become more mobile, travel more often and travel longer distances. A lot of inventions and innovations caused a wide range of possible transportation modes for every journey. Each mode has its own characteristics and purposes and every day when people have the needs to travel, they have to make decisions regarding the travel mode to use. The determination how a certain trip is made and the selection for a specific transportation mode alternative is called the transportation mode choice decision process (Schneider, 2013).

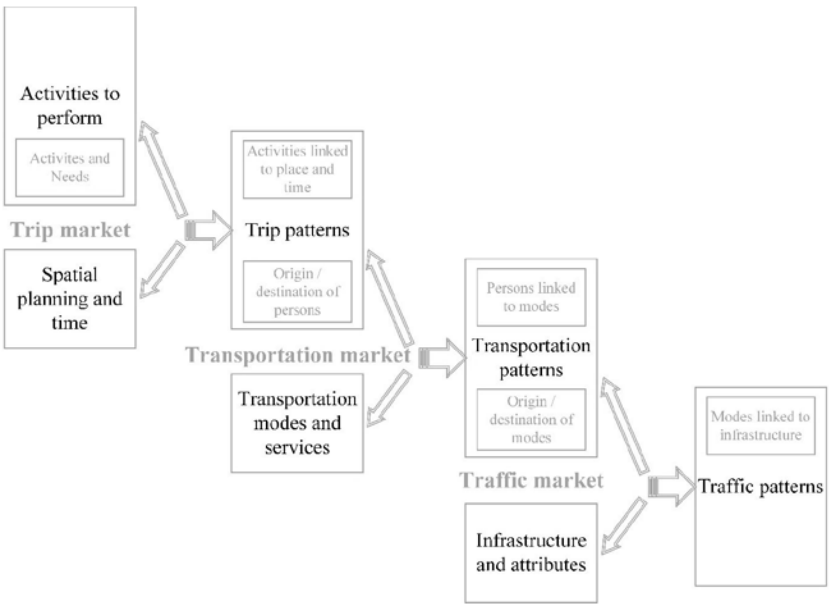


Figure 2.3: Traffic and transportation market diagram (Adapted from van de Riet & Egeter, 1998)

The selection of a commuting transportation mode is an activity related to the transportation market, see figure 2.3. At the transportation market it is about the demand and supply of transportation modes, services and perceptions. The individual selection of a travel mode is a trade-off between the supply and demand of travel modes. A lot of different aspects influence these trade-offs, for example the supply side is affected by costs, demographic factors and external changes such as land-use. These factors change over time. The supplies are the different alternative commuting modes, which could be selected. As described above, the three most used commuting transportation modes are the car, public transportation (train, bus and metro) and bicycle (Olde Kalter et al., 2015). The demand differs because of different individuals have different perceptions, needs and activities (Bates, 2008). The needs of all travelers could be classified according to their importance; this is described in the next section 'Hierarchy of travel needs'. These travel needs are the foundation of mode choice decisions, where also socioeconomic factors and habit are of importance.

2.3.1 Hierarchy of travel needs

The first stage in the transportation decision-making is a consideration of the hierarchy of travel needs. It categorizes and ranks the attributes which drive the evaluative process of transportation decisions (Singleton, 2013). The hierarchy defines the importance during travel decision-making processes. This hierarchical arrangement of needs is illustrated in figure 2.4 and is adapted from Alfonzo (2005). This hierarchy was created with the focus on walking needs, the hierarchy could differ in some extent depending on the person or transportation goal (e.g. commuting). The most important travel need starts at the bottom of the pyramid. All the travel needs are explained in the following sections.

Figure 2.4: The hierarchy of travel needs (Adapted from Alfonzo, 2005).

Feasibility

An important individual factor according to the travel needs is the feasibility. It refers to the use of a certain travel mode in practice. It is about the possibility of a transportation mode for a particular trip. Availability and awareness of the transportation modes are the most influencing factors. For example, some travel modes (walking and bicycling) could not be feasible for somebody with a physical disorder. Other major aspects of the feasibility of a transportation mode are time, frequency and schedule, because they could limit one's ability to use certain modes to travel to certain destinations (Singleton, 2013). It could be described very easily, because if a certain travel mode could not even be considered for a journey, than it will not be checked in the travel-mode decision. If a mode is not available or the traveler is not aware of this, the probability of choosing this mode is zero (Johansson et al., 2006). The subjective choice set of the traveler is different compared to the total set (Exel & Rietveld, 2009). In the objective choice set only the alternatives which the person is aware of and considers as acceptable are taken into account (Punj & Brookes, 2001). This is affected by the following factors: access to a car or motor vehicle, possession of a driver's license, access to a bicycle, but also trip costs could affect the feasibility of a transportation mode.

Accessibility

The accessibility of a travel option is the feasibility based on built- and natural environmental constraints. It includes the locations as factors; possible destinations, connectivity, barriers and other physical characteristics (Singleton, 2013). In contrast to the above described feasibility to an individual choice, the accessibility defines whether the environmental aspects will make certain travel modes more attractive. For example, a sloping landscape or night-time will not promote walking or cycling travel mode decisions, but also the season and weather conditions will influence this (Scheepers et al., 2013; St-Louis et al., 2014; Huisman & Hengeveld, 2014). So the accessibility could be defined as the feasibility of a travel mode in space and time. In the theory of travel decision-making, accessibility will be defined as a function of the following components (Tal & Handy, 2012): the proximity between destinations (residential, job, school and other locations) and the connectivity of these locations (or barriers).

Safety and security

The safety and security deals with the differences between the travel modes. So safety deals with the safety of the traveler towards traffic accidents or collisions and security deals with feeling secure from crime or violence. A journey without unsafe and unsecured feelings is rated as positive, but one traveler has other standards in safety and security than another. Gender has influence on the valuation of safety and security. Dill & Gliebe (2008) found that women are more concerned about safety and security while making travel mode-choice decisions. Safety and security does also differ a lot between transportation modes, so within bicycling it is mainly about safe travel routes and separated bicycle lanes (Winters et al., 2011). The same applies to car traffic, route safety to avoid collisions is most important. But for public transportation it is different; the security at transfer stations is mainly important, because of the density of travelers and place's suitability for crimes (Cozens et al., 2003).

Cost

The economic aspects of travel always bother people. Travelers seek transportation modes within an acceptable amount of time, effort and money. These factors could all be defined in costs; costs of travel time, monetary costs, physical effort, mental effort and possible inconvenience or unreliability (Singleton, 2013). Costs reflect the negative aspects of travel, which need to be minimized, that is what people do when they make a rational choice.

The costs of travel time describe the level-of-service of a certain transportation mode. Travel time will depend on characteristics of the travel option under consideration: route, destination, mode, time-of-day, valuation of time. The time of the journeys could be divided into different components; access, egress, in/on-vehicle, parking and waiting time (which also could include congestion). Every component is valued differently by travelers (Wee, et al., 2013). In/on-vehicle time is valued the highest and waiting time is valued the lowest (three times lower) (Wardman, 2004). Majumdar & Mitra (2013) found the travel time flexibility and the perception of travel times as psychological factors in travel mode behavior.

The money spent during a travel journey is obvious an important consideration: monetary costs. Travelers measure the costs in relation to the quality of the trip and the travel time. There are direct monetary costs and indirect monetary costs. The direct monetary costs are linked to the journey; the costs of fuel, tolls, parking, transit pass/fare, food (energy demand when using active travel modes). But there are also indirect costs, the purchase, insurance and maintenance of goods to guarantee the feasibility of the transportation modes. According to Frank et al. (2008), fuel and parking costs have much influence on the transportation mode choice behavior.

The experienced effort during a trip could be described as the physical effort of a transportation mode. One transportation mode takes more effort than another. The physical effort of a journey deals with barriers, environmental aspects and other physical attributes of a journey/route. People want as less physical effort involved as possible, but the boundaries differ for individuals. In fact, the physical effort is the personal valuation and acceptation of the above described feasibility and accessibility aspect. At the other side, some transportation mode alternatives have exercise benefits of physical activity, these are explained in the next section: pleasure. Also mental effort is involved in making considerations and completing travel behavior. Particularly when considering new transportation modes. If a traveler has experience with a certain travel mode, the mental effort will be low. Mental effort is a cognitive perception of the number and complexity of decision points, simplicity in the travel journey is of importance in travel decision-making (Lynch, 1960; Taylor, 2009).

The last factor affecting the costs are the travel convenience and reliability. These are the future potential costs of changing one's mind or encountering changing conditions. It is the effect of reliability in travel time; the variability needs to be low, so certainty is key and is more important than the reduction of the total travel time (Liu et al., 2004). Carrion & Levinson (2012) found that one minute of travel time reliability is weighted higher than one minute of total time savings. The total journey need to be predictable, controllable, feeling self-sufficient, flexible and with minimal preparation (Gardner & Abraham, 2007). If the travel is unreliable, pre-travel considerations and scheduling costs are higher (Brons & Rietveld, 2008).

Pleasure

Pleasure describes comfort, enjoyment and other personal, social or environmental benefits of a travel option. Personality traits and attitudes cause differences between people and so differences in needs of comfort, enjoyment and benefits, leading to different transportation mode choice decisions. One traveler is more satisfied with environmental benefits, while another is more satisfied with the benefits of physical activity. For example some benefits from car travel mode that people will satisfy vary from cultural values, to the car as a symbol of freedom and independence or status and aesthetics. Some people think that driving is pleasurable (Redman et al., 2013; Steg, 2003a). Every travel mode aspect, attribute or option that could possibly improve the pleasure to travel with the travel mode for an individual could be described as a benefit. If transportation mode satisfies the pleasures and needs of an individual, it is more obvious the transportation mode will be chosen. Schepers et al. (2014) mention that travel behavior is based on personal needs, opportunities and abilities that contribute to the pleasure.

2.3.2 Mode choice decisions

A lot of researches tried to describe how people choose a transportation mode for their trip purposes. But behavioral aspects are complex to study, because they are hard to understand. The hierarchy of travel needs differs per person and this needs to be included in the mode choice decision process. This resulted in a lot of different travel behavior theories. Theories describe a conceptual model of behavior, which explain conceptual factors which may influence the behavior and relationships between them (Handy, 2005). Theories about the travel behavior and the forecasting of travel demand at the transportation market could be divided into theories from the fields of geography, economics and psychology. Recently, the recognition that not only economic factors influence the travel decision-making process has increased. Perception, attitudes, beliefs and preferences may play key roles in the process, so psychological behavior theories are important in travel behavior. This resulted in the Theory of routine mode choice decisions of Schneider (2013), which is particularly useful as psychological theory to explain relationships and factors influencing transportation choices.

Schneider's theory combines aspects of different psychological theories about planned behavior, normative decision-making and habitual processes (Singleton, 2013). The theory (Schneider, 2013) proposes an operational theory to describe how people choose travel modes; the Theory of Routine Mode Choice Decisions. According to the theory, there are five steps in the mode choice decision process. First, a travel mode must be available, people need to be aware of this mode and it need to be considered as a possible choice of travel. The next three elements assess situational trade-offs between modes in the choice set: basic safety and security, people want a basic level of safety from traffic collisions and security from crime. The convenience and cost mean that the travel mode need to provide an acceptable amount of time, effort and money in the eyes of the traveler. And enjoyment, people seek a travel mode that provides personal (e.g. physical, mental, or emotional), social, or environmental benefits. These are all socioeconomic characteristics, and according to Ewing & Cervero (2010), travel mode choice depends largely on socioeconomic characteristics. The final step of the theory is habit, people reinforce previous choices, and they are more likely to consider a regularly chosen mode as an option in the future. The theory of Schneider is displayed in figure 2.5.

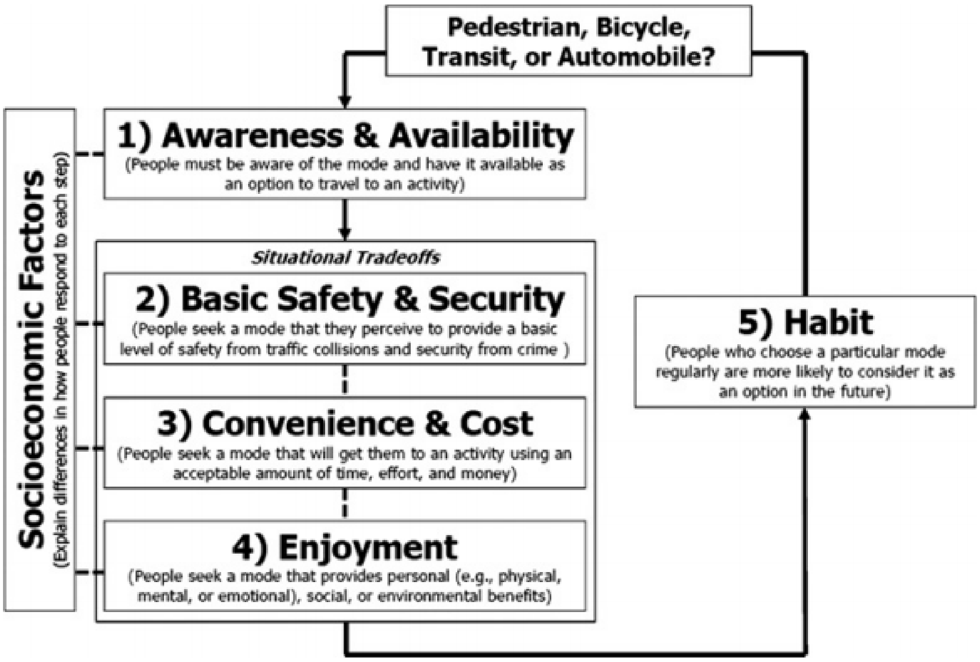


Figure 2.5: Schneider's theory of routine mode choice decisions (Schneider, 2013).

Schneider's theory contains similarities with Alfonzo's hierarchy of travel needs (Alfonzo, 2005): availability, safety, cost and enjoyment. In Alfonzo's theory, the travel needs are feasibility, accessibility, safety, comfort and pleasure. Schneider made some improvements on Alfonzo's hierarchy by the addition of a feedback mechanism and socioeconomic factors (Singleton, 2013).

Some components are not explicitly included in Schneider's theory. De Waard (2013) mentioned time, destination and frequency as important influencers on commuting. These are not included in this model, because these components are not directly linked to transportation modes. A couple of other influences on commuting are land-use diversity, population/job density and the Gross Domestic Product (de Waard, 2013). Other influences are represented by socioeconomic or demographic (sociodemographic) factors, these are variables like age, education, gender etc. These sociodemographic factors could explain differences in behavior, rather than directly affecting the choices. De Waard (2013) mentioned psychological variables (commuting experience) that could be classified as part of the habit section in the theory, same as the theory of Schneider (2013). The sociodemographic factors and the habit feedback loops in the theory will be explained in the next sections.

2.3.3 Sociodemographic factors

The term 'Sociodemographic factor' covers both the demographic characteristics and the socioeconomic characteristics in travel decision making. These characteristics are dependent on the decision maker and thus are outside of the decision-making process, because they could only explain differences in behavior and not directly affect them. Some demographic characteristics like age, gender and ethnicity are exogenous of the travel decision-making process, because they cannot be changed. And the socioeconomic characteristics like education level, income and household composition are long-term aspects and do rarely change.

Rather, the individual demographic and socioeconomic characteristics do have indirect influence on travel behavior. This is because the demand for activities and travel purposes is related to the descriptive characteristics of individuals. The following aspects affect travel decisions and outcomes according to previous researches. First, the basic demographic attributes; gender, age, education level, household composition (partner, children), housing type, income, lifestyle (de Waard, 2013). But also some long term household decisions have influence on transportation mode choice: home ownership (location), car ownership, bicycle ownership and the ownership of a transit pass. The location of the household also affects several attributes which could affect the mode choice behavior: population density, residential density, job density and land-use diversity (Frank et al., 2008; Pinjari et al., 2007). Carse et al. (2013) also include health factors; body mass index and physical as mental conditions, this gives insights in the background of the travelers and their decisions.

2.3.4 Habit feedback loops

Transportation and mode choice are deeply integrated into the daily life. It is a iterative type of behavior. Habitual behavior is an iteration of actions in a stable context; the environment where the behavior takes place (Verplanken et al., 2008). As above described, a lot of factors could change the stable context and change the habits in travel mode choice decisions. This is also the goal of travel demand management, to change the daily habits of travelers into the wanted behavior. The presence of a Supportive Car System (or other TDM measures) could be a long-term external factor that could break the habit feedback loop and thus influence the travel mode-choice behavior. Friedrichsmeier (2013) concluded that a combination of behavior frequency and context stability are the involving factors of habit, the more the stronger the habit.

2.3.5 Transportation modes and services

The transportation modes are the supply side of the transportation market. The three most used transportation modes (explained in section 2.2.2) all have their own important facilities and attributes to match the demands of the users. Some of the facilities and attributes are entitled as more important to the users of a particular transportation mode. First, car travelers like flexibility, accessibility and convenience of the car. The main advantage of the car is that it has no fixed routes, which creates more accessibility, flexibility and convenience for the user. The route of a car trip depends on the monetary costs and congestion, which could result in taking another route by the car user (flexibility) (Ye, et al., 2007). The parking places are also important factors of the accessibility, flexibility and convenience of a car journey. It depends on the length of the parking place search time, the proximity of the parking place and the costs of the parking place (Sanders, 2015).

Second, a trip by public transportation is very different compared to a car trip. A public transportation (PT) journey consists out of more elements with more impact on the journey and has fixed routes, what hinders the flexibility of the journey. A PT journey is a multimodal journey, with the train or bus as main transportation mode (Givoni & Rietveld, 2007). Before the PT trip, there is an access trip and at the end an egress trip to the end destination. The PT journey is as strong as the weakest element (Arntzen & Lindeman, 2013). So not only the train trip is important but railway stations and other aspects of the trip are important. For a PT journey, where the access and egress modes are of more importance than with other transportation modes, the most influencing factors are travel time, costs and effort (Wee, et al., 2013). The research of Litman (2008) shows that especially the attribute 'waiting time' is of high importance. Users see waiting time as lost time and the loss of time is irritating, while in-vehicle time is valued a lot higher.

The third mode; a bicycle journey is mainly dependent on the travel distance and infrastructure quality. Bicyclists want fast and safe cycle routes from one's home to the location of the activity. If this is the case, people commute by bicycle because of the direct benefits of the trip; costs, convenience and health benefits (Heinen et al., 2011). The main direct benefit of bicycle commuting is the fact that almost everyone in the Netherland owns a bicycle and there are no extra monetary costs such as ticket prizes or fuel. Because of this benefits, Gatersleben and Uzzell (2007) concluded that a bicycle trip is experienced the most relaxing and with less stress, but only on short commuting distances.

2.4 Mobility management

Because of the enormously increase of private car use, car use has reached its limits. As explained in chapter 1 'Introduction', the limits of the road capacity, resulting in more and more congestion problems and negative consequences for the environment. The transportation policies are turning to tackle the negative impacts of the private car use, thus to make car use relatively less attractive compared to other transportation modes (Krabbenborg & Daalhuizen, 2016).

2.4.1 Travel Demand Management measures

All measures concerning making car use relatively less attractive and change or reduce the demand for car use, are part of Travel Demand Management (TDM). This combination of policies tends to make car use less attractive, but this also includes policies to make alternative transportation modes faster and more convenient and promote those (Buehler, 2011).

The current transportation system, with an overload of car use is not sustainable. The negative impact of car traffic needs to be managed. There is need for other travel modes which can compete with the private cars on the fields of comfort and cost-effectiveness. Besides this, travelers need to be educated about the availability of travel alternatives. There is also a better balance of the supply and demand for travel services and infrastructure needed (Obermann, 2012). These three components are necessary for TDM to reach the goals for people to reduce their car use and change their travel behavior (especially at peak hours).

A classification of TDM measures is made with the help of Steg (2003b), Ludlow & Key (2009) and Ison & Rye (2008). In table 2.3 the classification of TDM measures is shown. Seven different main categories of TDM measures are distinguished in the left column. In the right column, several examples per measures are named.

The economic measures aim to make other travel modes relatively cheaper than car use, because people’s travel choice depends on cost-benefit analyses of alternatives. The physical changes aim to increase the relative attractiveness of alternative travel modes, so people will reduce their car use due to the measures. With the land use measures, the main goal is to reduce the distances that people have to travel, because short distances to the travel destinations reduce car use. The next component is to inform and educate people about travel mode alternatives and the issues of car use, with the hope to change people’s perceptions, attitudes, beliefs, values and norms about car use (Gärling & Schuitema, 2007). Organizations and businesses could also discourage all modes of travel with the introduction of telecommuting or e-shopping as substitutions of communications for travel. The legal measures enforce car use, these policies are hoping to result in changes in social norms in long-term. The last component of administrative measures are the introduction of alternative work patterns, to keep car traffic from the peak hours.

Table 2.3: Travel Demand Management measures.

TDM measure	Examples
Economic measures	- Taxations of cars and fuel - Road user charging - Congestion pricing - Parking charges (also at work sites) - Tradable permits (combined with regulation by quantity) - Public transport subsidiation
Physical change measures	- Improving public transport: Traditional transit service, express bus service, Intelligent Transportation Systems (ITS) - Improving infrastructure for walking and cycling - Technical changes to make cars more energy-efficient - Traffic calming (reduce vehicle travel speed and volume)
Land use measures	- Land use and transportation strategies such as: car free developments and location of new developments - Park and ride facilities - Land use planning to encourage shorter travel distances - Transit Oriented Development
Information and education for travellers	- Travel information before a trip is undertaken - Car sharing - Ride sharing (carpooling or vanpooling) - Marketing and information campaigns - Giving feedback about consequences of behavior
Substitution of communications for travel	- Telecommuting - E-shopping
Legal measures	- Parking controls - Prohibiting car traffic in city centers - Decreasing speed limits - Pedestrianised zones
Administrative measures	- Alternative working patterns : Flextime, alternate work schedule, compressed workweek.

2.4.2 Company mobility plans

A lot of companies/organizations have mobility plans to comply with the TDM goals. Mobility plans are introduced to support commuting travel by the alternative transfer modes than the car, so by public transport or bicycle. According to Wake (2007), typical TDM measures taken by companies/organizations, include:

- Improving the cycle facilities (e.g. secure bicycle parking);
- Providing information of alternative travel modes;
- Promotional activities as walking and cycling challenges;
- Carpool registers to link up employees to commute together ;
- Providing alternative/supportive transport modes to aid use of these modes for business trips where appropriate (public transport tickets, pool bicycles, shared-use vehicles).

Like a lot of businesses and organizations, also the Eindhoven University of Technology (TU/e) has introduced a Mobility Plan (Cursor, 2017). The main proposal of the mobility plan aims to reduce the number of employees commuting by car: from 31 percent to 24 percent of the employees. Together with the new plans for transforming the TU/e Science Park to a sustainable TU/e-Campus, they try to implement several TDM measures. The plans regarding the TU/e-Campus is to transform the campus into a ‘city park’, with a lot of green area and a traffic-free central zone to promote the slow travel modes and increase the quality of the outdoor environment. Together with the operations to eliminate a large number of parking places and the introduction of parking fees, the TU/e wants employees to reconsider the way they commute. Other measures to discourage car use are the introduction of a new bus line from the NS train station in Eindhoven to the TU/e-Campus, the possibility to participate in an e-bike program and better parking spots for bikes.

Another incentive to make the campus more sustainable, reduce the amount of employees commuting by car and use sustainable means of transport (public transport and bicycles) is the introduction of car rent possibilities at the TU/e-Campus. Besides the car rent possibilities of Europcar, TU/e employees and also students can use the available shared-use vehicles of Studentcar as supportive car system. The shared-use vehicles could be used if needed for any purpose, if employees and students (mostly requested by students) have the need of a car at the TU/e-Campus (TU/e, 2017b).

2.5 Supportive Car Systems

As described in section 2.4; all the proposed measures concerning the change or the reduction of demand for car use are described as TDM. Carsharing is mentioned in table 2.3 as TDM measure. It is ideal for companies to introduce alternative/supportive transportation modes, because they could be offered at the place of work. Chatterjee et al., 2013 gives ‘business travel’ and ‘use car share for work-related purposes’ as motivations for carsharing. A Supportive Car System (SCS) is what the name says; a car system, shared by employees to support in particular goals as business trips and other work-related purposes.

In this section, first it will be explained what carsharing is, and the goals, stated by the Dutch government, are explained. Then, the different approaches for carsharing will be described; the Supportive Car Systems for companies could obtain information of these approaches. At last, the important attributes for the SCS are explained.

2.5.1 Carsharing

In the recent years during the global economic and financial crisis, people started thinking about the existing economic system of capitalism and consumerism. The existing economic system has been very successful for a long period of time. But at this time considerable problems persist, the system is stuck. It is necessary to improve the existing system with the creation, development and rise of new innovations (Heinrichs, 2013).

Sharing, per se, is not a new innovation. It is an age-old form of human transactions involving bartering of goods and services without monetary exchange. But the shift from the Industrial Age to the Digital Age brought some technologies that took this concept forward and created opportunities to monetize their skills of underutilized resources (Ernst & Young LLP, 2015). The sharing economy is also known as peer-to-peer (P2P) or collaborative consumption. It challenges the concept of private ownership and is based on shared production and consumption of goods and services. It is the social media and mobile technologies that turns the sharing economy into big businesses, for example Airbnb (sharing of homes), Uber (sharing of private cars and driving skills as a taxi approach) and thus also carsharing (Penn & Wihbey, 2016). Botsman (2013) described the sharing economy as follows: “an economic model based on sharing underutilized assets from spaces to skills to stuff for monetary or non-monetary benefits”.

Carsharing has appeared in numerous different forms through the years. For example open-access shared vehicles, accessible for occasional trips when needed, but also station cars for the end trips of

commuters from transit stations to work. Different carsharing approaches are distinguished in business models, goals, target groups and technologies, but they all share some common features:
- An organized group of participants;
- One or more shared vehicles;
- A decentralized network of parking locations;
- Usage booked in advance;
- Rentals for short time periods ;
- Self-accessing vehicles (Millard-Ball et al., 2005).

Probably the best definition of carsharing according to Frenken (2013) is a system that enables people to hire locally available cars at any desired moment of the day for any desired amount of time. So carsharing differs certainly from the traditional car renting services, because with that approach people have to pick up the cars at the car renting company and usually it is only possible to rent a car per day. Carsharing is also different from company cars, because company cars are not shared for daily usage. At least carsharing differs from taxi services and also the sharing economy Uber approach because the shared car user drives the car by himself.

In the Netherlands the government started the ‘Green Deal-approach’ in 2011. With the Green Deals the government tries to facilitate sustainable initiatives from the society. This approach allows to eliminate/adapt the legislation, create new markets and create optimal collaborations between the government and involved businesses (Green Deal Board, 2017). The ultimate goal of the Green Deals is to give the opportunities to contribute to sustainable growth of the Dutch society. One of the Green deal initiatives is the ‘Green Deal Carsharing (GD183)’ (Green Deal Board, 2015). This Green Deal tries to create an accelerated completion of the ‘SER-Energieakkoord voor duurzame groei’ of 100,000 available shared-use vehicles in the Netherlands in 2020. In 2014, there were approximately 15,000 shared-use vehicles available but it was growing intensively (Ministerie van Infrastructuur en Milieu, 2015). The goal to reach the 100,000 shared-use vehicles in 2020 will be difficult to reach in time, because the amount of shared-use vehicles in 2016 was still 25,128. This meant a growth of 55 percent in the first 2 years. If this proportional growth will continue over time the amount of 100,000 shared-use vehicles will be reached in 2023 (Verkeersnet, 2016).

When people are sharing a car together, it is not axiomatic that the users will automatically drive less kilometers with their shared car. But when not having the exclusive rights for the use of a car and the fact that most of the people travel at the same time slots (rush hour), it is proven that shared cars will not only cost less per person but users also travel less frequently by car. A research of TNS-NIPO (2014) proved that users of different carsharing-approaches reduce their driven kilometers by car by

15-20 percent compared with the time when still owning a car by them. Also the 'Planbureau voor de Leefomgeving' published a research about the effect of carsharing to the mobility and environment: 'Effecten van autodelen op mobiliteit en CO_2-uitstoot' (Nijland et al., 2015). People who use carsharing through a platform or organization, reduced their amount of travelled car kilometers by 1,600 kilometers per year. This leads to a reduction of 175 to 265 kilos of carbon dioxide (CO_2) emissions, only within the Netherlands. A reduction of approximately 8 till 12 percent.

2.5.2 Different approaches

There are different approaches to share a car or to share the costs of the ownership of a car. A study of Barth & Shaheen (2002) tried to classify the different carsharing approaches at that moment of time: neighborhood carsharing, station cars, and multimodal shared-use vehicles. This classification is a little outdated, because the carsharing approaches evolved and for example a 'station car' nowadays is equal to a car rental company close to a railway station. So, a new classification of the different carsharing approaches in 2018 is needed. The first division results in one side with the private vehicles by individuals or households and another side with a fleet of vehicles offered by carsharing companies. In figure 2.6, a final hierarchical graphic of all the different carsharing approaches is given. All these approaches will further discussed.

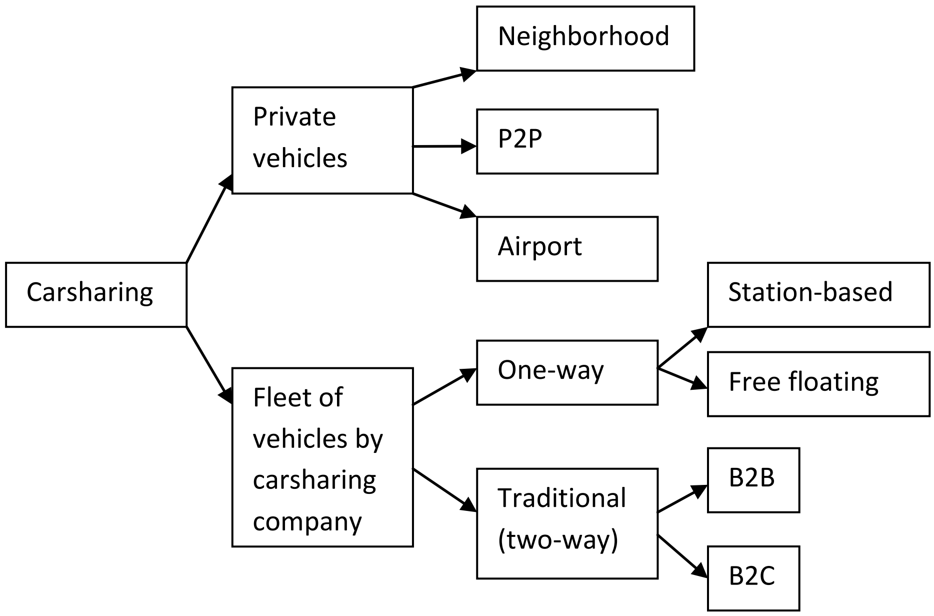


Figure 2.6: Hierarchal graphic of the different carsharing approaches.

The private vehicles offered through carsharing platforms are first classified. There are three different forms of private car sharing. Private carsharing could also be identified as a customer to customer (C2C) approach, with or without a company as mediator. All the approaches of private vehicle sharing are two-way trips, because the car needs to be returned to the owner(s).

The first approach is called neighborhood carsharing. Neighborhood carsharing is to share your car with neighbors, households and other closely related people to the owner of the car. It is also possible to purchase a car together with more people/households to share the costs of owning a car. All the arrangements about the costs, usage, ownership are by the group of carsharing people on themselves (Autodelen.net, 2016).

The second approach of sharing private cars has risen together with the sharing economy, mobile phones and other applications. The so-called Peer-to-Peer (P2P) carsharing is offering your private car through an online platform (website or mobile application) for all the users of that platform. Different to neighborhood carsharing is that there is a bigger platform to share your car, so more chances to make profit from the shared-use of your vehicle. Especially when the owner of the car does no use the car often, the expensive costs of car ownership could be reduced by sharing the car (CROW-KpVV, 2016). Competition on the platform between different private car suppliers determine the price of the usage of a shared car (Autodelen.net, 2016). This private carsharing approach is used the most of the different carsharing approaches.

The third option of sharing private cars is a more recent option, called airport carsharing. When the owner of a car goes on a holiday it is possible to share the car while it is parked at the airport. This different option of carsharing gives the opportunity to the car owner to make money instead of paying for the expensive parking spaces at airports (Ritjeweg, 2017).

Also the carsharing opportunities, offered by carsharing companies have different approaches. All the carsharing suppliers have a own fleet of vehicles, and consumers have the possibility to rent a car. The cars are easily approachable and could be reserved just before usage. But there are differences in the way of parking the cars. There are three different options of carsharing by suppliers: One-way station-based, one-way free floating and two-way station-based carsharing.

First, the two one-way approaches are discussed. With one-way carsharing, it is possible to make single trips, so without returning the car to the place/node where the car was picked up at the beginning of the rental period. The one-way carsharing approach was introduced by the automotive industry because less and less cars were sold. They introduced the one-way approach with the possibility to leave the rented car anywhere the driver wants (CROW-KpVV, 2016). A one-way station-based approach is when a carsharing supplier has more sites with reserved parking places where the car could be parked.

Second, the free floating approach allows to pick up and leave a car anywhere at a parking place in a certain zone close to the final destination of the trip (Autodelen.net, 2016). Advanced technologies with mobile applications to search the availability of one-way shared-use vehicles and advanced accessibility techniques to the car have made the one-way systems much easier to manage and cost-effective as well (Barth & Shaheen, 2002).

Third, instead of the one-way station-based carsharing approach is there also the more traditional two-way station-based approach. Users of a shared-use vehicle from the fleet of vehicles of a carsharing supplier need to bring the used car back to the place where they took it at the beginning of their trip (Ritjeweg, 2017). Two different approaches of two-way station-based carsharing could be distinguished: Business to business (B2B) and business to consumer (B2C). With the B2B approach the shared-use vehicles are made available to companies by the carsharing supplier. The companies make the cars available to their employees as company cars. The B2C is the classical approach where carsharing suppliers make the shared-use vehicles from their fleet of vehicles directly available to the customers, mostly public transport commuters who want to use a car sometimes (Fleet&Mobility, 2015). This approach is also called the traditional carsharing approach.

In figure 2.7 the differences between the two biggest carsharing approaches are shown, the traditional (two-way) carsharing approach and the P2P (private and two-way) carsharing approach.

2.5.3 Attributes

The literature review and the results of the focus group sessions conducted by KiM (Jorritsma et al., 2015) resulted in at least seven features of carsharing. These features of carsharing are identified as important for people to adopt carsharing: costs, distance to a shared-use vehicle, reservation, fixed post, reserved parking, personal contact and fuel type. In figure 2.7, also some attributes of the traditional carsharing and peer to peer carsharing are shown.

To research the preferences towards carsharing, KiM worked together with the Eindhoven University of Technology. Together with Dieten (2015) they identified the preferences with a 'stated preference research', what resulted in the master thesis of Dieten (2015); '*Identifying preferences regarding car sharing systems: Using a stated choice experiment among car users to identify factors of influence*'.

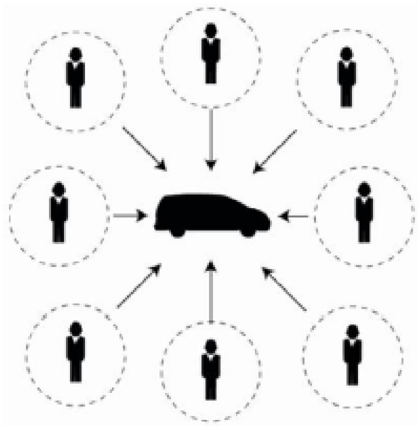
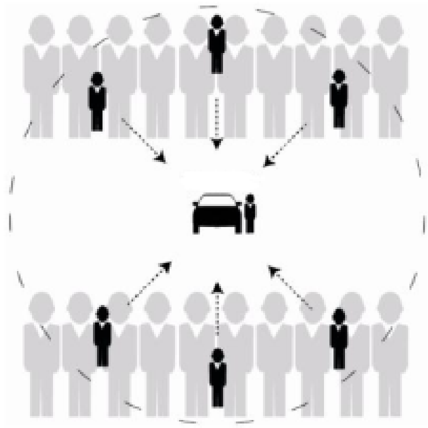
	Traditional carsharing	Peer-to-peer
		
- **Reservations**	- Up to a minute before use	- Reserving in consensus with car owner
- **Contact**	- Formal	- Informal
- **Location of car**	- Predetermined spot in neighbourhood	- Random spot in neighbourhood
- **Price**	- Predetermined price by organization	- Variable price (usually lower)
- **Availability**	- 24/7	- Dependent on car owners' availability
- **Type of cars**	- New, light and sustainable cars. Limited types	- Any car
- **Monthly cost**	- Usually a monthly fee	- No monthly fee
- **Service**	- Full-service	- Only assurance is arranged by organization
- **Organization type**	- Usually top-down	- Usually bottom-up
- **Rental orientation**	- Individual	- Collective
- **Market orientation**	- Urban areas	- Any area
- **Parking**	- Reserved parking on pickup location	- No
- **Visibility**	- Advertisements, stickers on cars etc.	- Advertisement

Figure 2.7: Differences between traditional carsharing and Peer to peer carharing (Hogerheide, 2014)

In the research of Dieten (2015) a table with all attributes and motives for carsharing is presented. This overview is shown in Appendix 1. The results of the research are as follows. First, a lot of people are familiar with the sharing economy principle, but less familiar with carsharing. The people who were unknown with carsharing have increased affinity with carsharing after the explanation. So this means that informing people about carsharing helps to increase the popularity of carsharing. Second, Dieten (2015) has researched the focus groups with most affinity/adoption rate of carsharing. The people who are early adopters of the shared-use vehicles are higher educated, younger people who live in urban areas. This could mean that a university population, and thus the TU/e campus is well suited for a carsharing system.

Third, in the research of Dieten (2015), the preferences regarding carsharing systems are reviewed. The tested attributes are reservation of the car, personal contact, price per hour and price per km, reserved parking, mandatory returning the car to the pickup point, type of fuel and walking time to the car. The main outcome is people want a cheap and flexible free-floating, electrical carsharing service, with the possibility to reserve a parking. This means that three of the, above described, seven features of carsharing are of importance: affordability (cost), flexibility (high coverage & free-floating fleet) and an all-inclusive service (reserved parking). For working trips, Dieten (2015) stated

that a low price per hour and km, walking time to the car, reserved parking, no mandatory return to pickup point and electric car are the attributes with the highest estimates.
Cost saving, affordability and the cost of owning an (additional) car often play a large role in joining a carsharing program. With carsharing the ownership is cheap and the driving is expensive (Mont, 2004). Environmental reasons can also be triggers for joining. As earlier indicated to be of importance for the shared economy (Glind, 2013), it can also be important for carsharing.

According to Herrmann et al. (2014), users of carsharing approaches only accepts a maximum of availability and reliability of the system. This includes a maximum distance to the car, maximum waiting time and maximum price. An option to reduce the prices is to attract external investors, so the car would be accommodated with advertisements. Altogether, price is an important aspect; carsharing is usually cheaper than traditionally renting or owning a car (Dill et al., 2015).

Paundra et al. (2017) investigated the influence of price, parking convenience and car type of the carsharing service. All three attributes were statistically significant. Abraham (2000) found peoples' preferences for the parking location of the carsharing service in the walking distance. Other important influences are the type of reservation system, the fee (hourly and per kilometer), and the age and type of the car.

In Appendix 2, a selection of all the carsharing companies in the Netherlands are classified according to the founded attributes in this research. Only the attributes where information is available of, are taken into account.

2.6 Conclusions

The transportation mode choice depends on different factors. It all starts with the sociodemographic aspects of a person. These are on influence on the transportation mode choice decision process. In this process, people have travel needs. There is a hierarchy in those needs. First, the feasibility and accessibility of a certain transportation mode, also the awareness of the possibility of a transportation mode plays a role in this. Second, the basic safety and security always plays a role in the decision process. Third, the convenience and costs of a certain transportation mode are of importance. And fourth, the transportation mode choice must also bring some enjoyment and pleasure to a person. At last, also habit is a factor in the transportation mode choice decision process.

Every transportation mode has its own characteristics. A big difference between the car and other modes is that the car has no fixed routes, which is the basis for these characteristics. These characteristics are also influenced by the monetary costs, congestion and availability, proximity and safety of parking places. A public transportation (PT) trip differs from a car trip. The PT trip exists of more parts and the PT trip has a fixed route what hinders the flexibility. The access and egress trip within the PT journey are of high importance, the most influencing factors are travel time, costs and effort. Especially waiting time is rated of high (negative) importance. The benefits of a public transportation trip is there is no driving skill needed and the traveler does not have to drive, so the traveler has time to do other things. The PT mode also differ in monetary costs and environmental impact. The bicycle transportation mode is mainly dependent on the travel distance and infrastructure quality; the safety and speed of the cycle routes. The benefits of a bicycle journey are the costs, convenience and health benefits what results in that a bicycle trip is experienced as most relaxing and with less stress. The environmental impact for bicycles is extremely low.

Because of the increasing amount of car traffic, policy makers take measures to control this. All measures concerning making car use relatively less attractive and reduce the demand for car use, are described as Travel Demand Management (TDM). This combination of policies tend to make car use less attractive, but it also includes policies to make alternative transportation modes faster and more convenient and promote those. These TDM measures are integrated in mobility plans by companies and organizations. The most applied TDM measures by companies are improvements of the cycle facilities, providing information and promotions about alternatives, carpooling and providing alternative/supporting transportation modes. This last TDM measure also includes shared-use vehicles. A Supportive Car System (SCS) is an example of a shared-use vehicle with specific attributes, it differs from carsharing. Carsharing is explained as a system that enables people to hire locally available cars at any desired moment of the day for any desired amount of time. The cars could be reserved in advance, are self-accessing vehicles and are used by an organized group of participants. The benefits of carsharing are that people drive less and it costs less than owning a private car. A SCS is a car system, available at the working location and shared by employees to support in particular goals as business trips and other work-related purposes.

There are several different approaches of carsharing. The most important approaches are one-way carsharing, traditional two-way carsharing and P2P carsharing. With the one-way approach it is possible to pick and leave a car anywhere at a parking place in a certain zone close to the final destination of the trip. With the traditional two-way approach, users of a shared-use vehicle from the fleet of vehicles of a carsharing supplier need to bring the used car back to the place where they took it at the beginning of their trip. And the P2P approach is offering a private car through an online platform for all the users of that platform. When not using your own private car, you could rent it to others.

The most important attributes, also used in this research are the location of the SCS (walking time to the car), the amount of advertisements on the car, the type of car, the tariff systems of the car (per reserved time and per driven kilometer), the type of fuel, the accessibility of the car, the availability of the car, reservation techniques of the car and for which type of trip purpose the car could be used.

3. Methodology/Approach

3.1 Introduction

In chapter 2, a literature study has been carried out to define the relevant concepts related to transportation market developments, mode choice decisions making and the Travel Demand Management (TDM) measures. These measures also include the introduction of a Supportive Car System (SCS). The adoption of such system is about the demand and supply of the transportation market, explained in section 2.3. Compared with other fields, as the field of marketing research, it is necessary to predict how consumers will react on the availability of a new system (Carson et al., 1994). Decision makers are looking for well substantiated assessments of new products by identifying significant attributes and be aware of the advantages and benefits, before making investments. With the selected attributes from the literature study a conceptual model could be designed (figure 3.1). Discrete choice modelling is a research technique to identify significant attributes, also in transportation management. Stated choice and stated preference techniques were therefore introduced in the field of transportation research (Ortúzar & Willumsen, 2011).

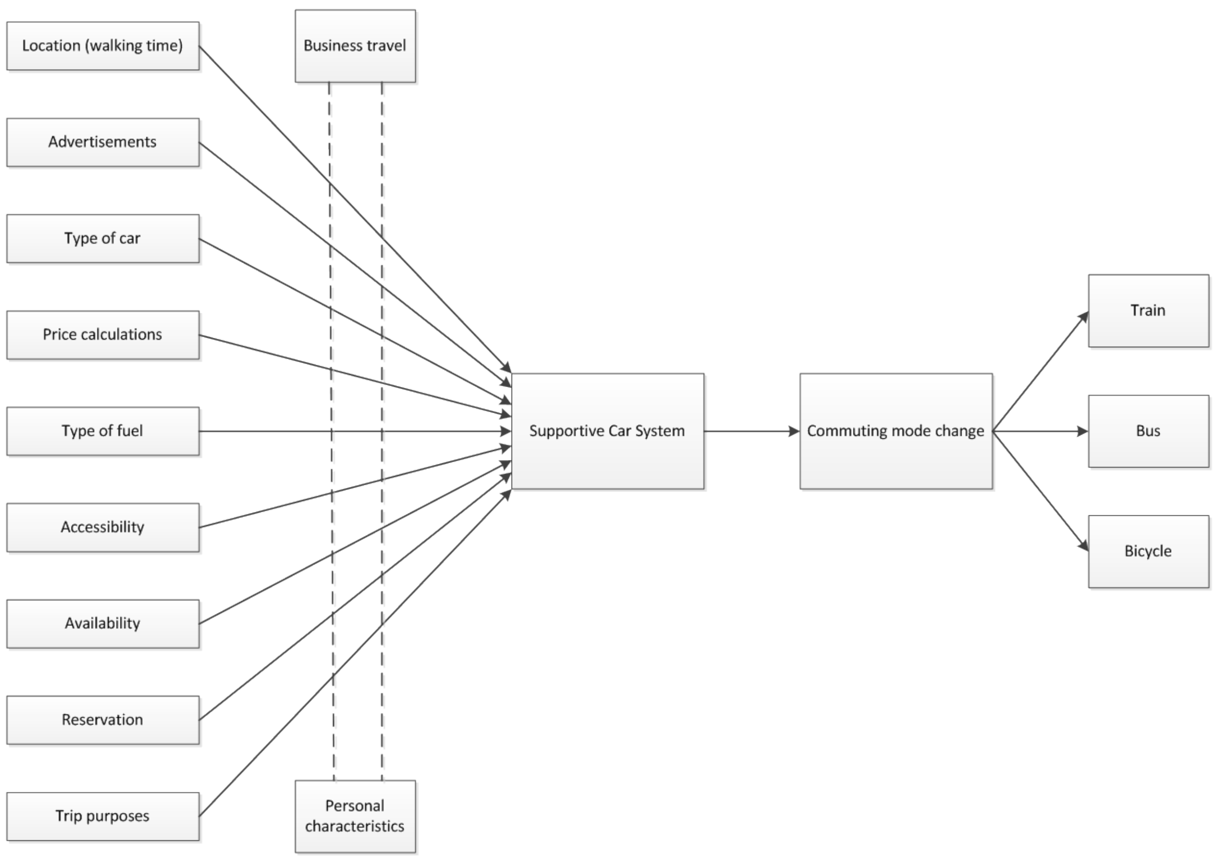


Figure 3.1: Conceptual model

In this chapter, first the choice and utility theory will be explained. This includes the different stated preference techniques and the selection of the technique. Also the proposed steps to collect the data with the selected technique (adapted from Hensher et al., 2005) and design the model will be explained. Second, the theory behind the used models will be explained. The collected data of the stated choice experiment will be analyzed by the discrete choice model Multinomial logit (MNL). Third, when the methodology is explained, the experimental design will follow. All the alternatives, attributes and attribute levels are discussed. Afterwards, with these attributes and levels, the set of alternatives are generated and randomized. Fourth and last, the survey construction and design will be explained, as the survey distribution.

3.2 Method

3.2.1 Choice and utility theory

When people are exposed to situations in which a choice or decision has to be made, it is called the decision making process. A choice is the results of the decision making process. A choice has always to be made between multiple alternatives with different attributes. To some degree, all decisions in a life, involve a choice. Observing the choices of individuals is interesting, but a really achievement is observing the choices of a larger group or population, resulting in some substantiated statements or conclusions. The choices of a population form the market demand for a service or commodity.

Ben-Akiva and Lerman (1985) stated that a choice can be viewed as an outcome of a sequential decision-making process that includes the following steps:

1. Definition of the choice problem;
2. Generation of alternatives;
3. Evaluation of attributes of the alternatives;
4. Choice;
5. Implementation.

The definition of the choice problem is set by the decision maker. This could be an individual, but also a group, organization, household or family. They make choices from a set of alternatives. Luce (1959) defined possibilities for different choices in a situation as alternative choices; alternatives. The environment of the decision maker determines these alternatives. Not the universal set of alternatives will be considered, but only a subset of alternatives that are feasible and known by the decision maker. At last, before making a choice and implementing it, decision makers evaluate the attributes of the alternatives. Choices are not based on the alternatives, but on the attributes of the alternatives. Ben-Akiva and Lerman (1985) stated that 'the attractiveness of an alternative is evaluated in terms of a vector of attribute values'.

To make a unique choice, the decision maker uses an internal process with the available information. This is called the decision rule. Theoretically, there are four categories in rules how a choice could be made (Slovic, 1977; Svenon, 1979):

1. Rule of dominance; one alternative in the choice set is better than the others, because one attribute of this alternative is better and all the other attributes are no worse. It is often used to exclude the worse alternatives in the choice set.
2. Rule of satisfaction level; this means that every attribute of one alternative assume a level of satisfaction. This level of satisfaction is set by the decision maker, and according to the level of satisfaction one of the alternatives is chosen. But there is no scale in the level of satisfaction, there is only a minimum value to be reached to satisfy the decision maker.
3. Lexicographical rules; all the attributes are ranked by importance by the decision maker. The decision is based on the most important attribute, if this is not possible, the decision maker will try to make a decision on the second most important attribute and further on.
4. The utility rule; the utility is the attractiveness of attributes of the alternatives. There is an objective function which expresses the attractiveness of the attributes of the alternatives; the utility function. The decision maker tries to maximize the utility function to choose an alternative.

The utility theory, based on the utility rule, has been used most in recent models. Anand (1993) stated that the utility theory is the best rule to achieve a choice with best fit to the person's beliefs and desires. The essential assumptions are that the decision variable of the consumer is in proportion to the target population and the choice is the result of utility maximization.

3.2.2 Stated choice

In this research, the choices of the population, based on the utility theory, need to be researched. So the behavior of the population could be identified. Carrying out effective behavioral research on the potential effects of the respondents' choices, the data could be gathered with stated preference (SP) and revealed preference (RP). Both approaches to measure preference and choice are subdivided in several methods, as shown in figure 3.2.

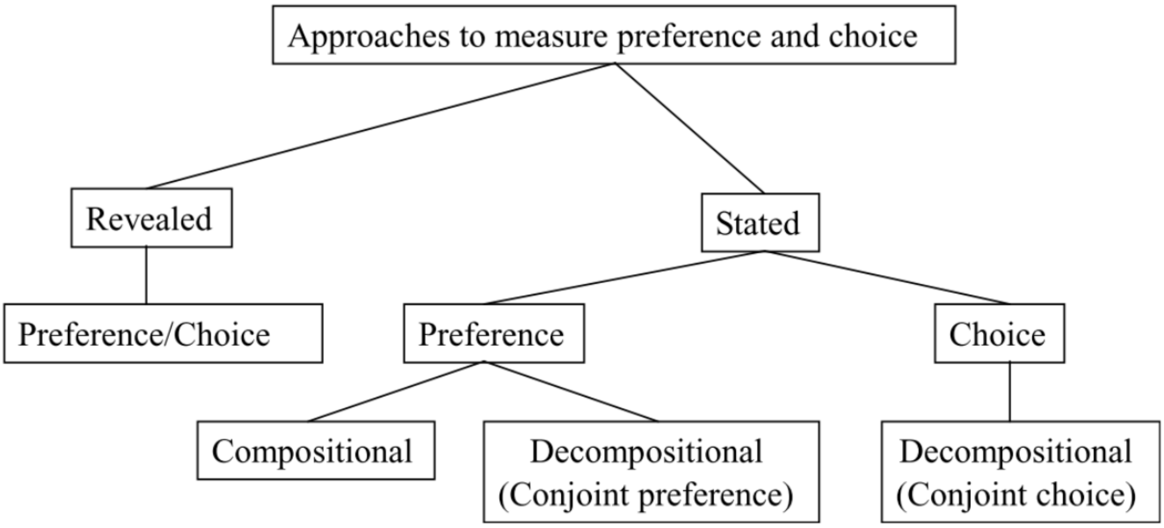


Figure 3.2: Preference and choice measure approaches (Kemperman, 2000)

First, the differences between revealed and stated need to be explained. Revealed preference is based on decisions in an existing situation, for example using GPS data for route-choice decisions when travelling (Broach et al., 2012). It is called RP, because decision makers express their preferences in their real world behavior. With this type of data, the current market could be investigated. Revealed preference approaches use past behavior as basis for modelling choice behavior in the future. In research, factual information or actual behavior is observed on real made actions. RP looks at the current market equilibrium, only existing alternatives are observed (Sanko, 2001). In the RP approach actual behavior is observed, so the utility function is defined by observing behavior, this could not allow to confront the respondent with hypothetical situations.
In a SP survey it is not about the actual behavior, respondents are asked what he or she would do in specific designed situations. These could also include hypothetical situations. According to Kroes and Sheldon (1988) SP methods are 'a family of techniques which use statements of individual respondents about their preferences'. It is possible to find preference weights for separate influential attributes and non-existing attributes. But to gather reliable data, the alternatives and attributes need to be realistic (Hensher et al., 2005).

The SP data is collected with experimental surveys, where respondents are faced with hypothetical (choice) situations. Though, these situations should be imaginable and rational (Hensher, 1994; Louviere et al., 2000). Stated preference has major benefits in comparison to revealed preference in this research. SP has better ability in predicting the future situations that does not exist yet. Therefore, SP could give more insight in the effectiveness of hypothetical Supportive Car Systems, although there is one available at the moment. With SP the impacts on transportation mode choices could be forecasted when alternatives are suggested (Fujii & Gärling, 2003). So SP could also capture hypothetical behavior and non-existing SCS alternatives. To make the applicable for different companies or organizations, SP allows that the range of attribute levels could be easily extended, reliant on the context. Another advantage is that with SP more responses can be gathered per respondent (Sanko, 2001).

The family of SP methods, available to carry out a study to measure preferences and choices of potential users about hypothetical alternatives are a family of techniques which contain stated preference (SP) and stated choice (SC). These are similar techniques, but there is an important difference between the two approaches. With the stated preference approach, respondents need to rank a certain set of alternatives from first till last or to rate them on a scale. Rating has an advantage over ranking, because it also includes a measured scale of the attractiveness of all different options. But with ranking all the different alternatives it could be possible that none of the given alternatives is preferred (Kemperman, 2000).

With the stated choice approach, the respondents have to make a choice between the given alternatives, also hypothetical (non-existing) alternatives. The choice the respondents make is the alternative that best fits their preferences. The advantage of the stated choice approach over the stated preference approach is that making choices is more like natural behavior for people above ranking/rating alternatives. It is what people do throughout every day with all choices they have to make. The disadvantage of the stated choice approach is the lack of knowledge about how much one alternative is chosen above the other alternative(s). But it is possible to extract the part worth utilities of the attributes of for example TDM measures and also of the SCS, because the alternatives are generated with experimental design on attribute level under 'controlled experimental conditions' (Kemperman, 2000).

Concluding, for this research the stated choice method will be used. This approach allows this study to estimate the respondents' preferences and predict the respondent choice probabilities for the alternatives. A modification and extension of the stated choice approach is the stated adaptation approach (SA). SA experiments deal with individual's adaptation behavior under policies that are exogenous (Nijland et al., 2006; Van Bladel et al., 2008). Respondents are asked to indicate changes in their behavior and so the attributes which trigger a change in behavior could be identified.

3.2.3 Choice modeling

The stated choice method differs from general market surveys, it is a choice model. The difference between choice models and a general market survey is the use of experimental designs. These designs are calculated in advance and the data will be analyzed with a statistic model, so it is possible to predict the demand of hypothetical or virtual alternatives before reaching to the actual market.

With choice modeling decision maker's choice of one alternative from a finite set of mutually exclusive and collectively exhaustive alternatives could be analyzed and even predicted (Koppelman & Bhat, 2006). The ultimate goal is to predict decision making behavior of a group of individuals. It could be used to determine the relative influence of different attributes of alternatives when people make choice decisions. All possible alternatives should be included in the choice set. The finite set of mutually exclusive and collectively exhaustive alternatives is called a choice set. The development of the choice set is a complex and time consuming task. With choice modelling, the decision maker is placed in the position in which he or she is obligated to make decisions. And when the choice set is well developed, it allows researchers to investigate interrelations between made choices (Hensher et al., 2005).

With choice modeling, the behavior of individuals could be examined. According to Ben-Akiva and Lerman (1985), the theoretical behavior needs to be abstract, descriptive and operational. The abstractness is important because the behavior needs to be independent of specific circumstances, so general behavior could be formalized. Descriptive, because it makes it possible to conclude how individuals behave and also to formalize general behavior. At last, the behavior needs to be operational, meaning that it results in an actual model in which parameters and variables could be estimated and measured. But there is no choice model that could satisfy all these requirements. This is because the models differ in how they interpret and detail the different steps in the choice making process. But all models share some common assumptions. One of them is that a choice is not a single choice at a specific time, but it is a process.

Discrete choice models have been most used in recent researches to examine choice behavior. Discrete choice models are usually derived from utility maximizing. The respondent will choose the alternative where he or she derives the most utility from. In discrete choice theory, types of alternatives are described as discrete bundles of attributes. The alternatives have multiple attributes, which are defined by a series of levels. The respondent tries to maximize his or her own utility, and this will indicate their preferences (Wang et al., 2000; Hurtado & Manuel, 2010). The advantages of discrete choice models are (Train, 2009):

1. The respondents are forced to trade-off attributes;
2. The attributes will be estimated with implicit coefficients;
3. The level of customer demand for an alternative in non-monetary terms could be estimated;
4. The possibility of strategical behavior of a respondent is reduced.

Besides these benefits of discrete choice modelling, there are some beneficial outcomes as a model equation, a set of utilities for each of the attributes and variance statistics for the utilities (Train, 2009). To come to this outcome of the discrete choice model, the utility is the numerical measure as explained before. Utility does not have a natural unit, level or scale (Train, 2002). If the levels of the included attributes vary enough when repeating the steps, the utility of the alternatives of individuals can be estimated.

As described, an utility function is needed for utility-maximization. If it is assumed that human behavior has a probabilistic nature, a decision maker chooses the alternative if the highest utility is derived from that alternative. Another assumption is that people use the utility maximization to choose from a choice set, based on modelled and observed factors, the utility function could be defined as the vector of weighted attribute values for every alternative by every decision maker. But every decision maker has different characteristics as age, income, education and other sociodemographic characteristics. This results in a different utility function for every person, unknown for the researcher. Because of this, McFadden (1974) introduced the representative or systematic utility. This is the mean utility or expected value perceived by all the decision makers (in the same decision context). The perceived utility or the attractiveness of an alternative could be expressed as the sum of two terms: the systematic utility together with the random residual. The random residual is the unknown deviation of the utility perceived by a certain decision maker from the mean value. This could be affected by different factors, as the sociodemographic characteristics of the decision maker, which are the hidden, unobserved factors.

$$U_{iq} = V_{iq} + \varepsilon_{iq} \tag{1}$$

Where: U_{iq} = unobserved utility value of alternative *i* by decision maker *q*;
V_{iq} = systematic utility/observed utility of alternative *i* by decision maker *q*;
ε_{iq} = random residual of alternative *i* by decision maker *q*.

Because the unobserved utility value depends on different factors the researcher cannot know, it makes sense that $U_{iq} \neq V_{iq}$. The unobserved utility factor is unknown to the researcher and is treated as a random factor. The observed or systematic utility value could be defined as the mean perceived utility among all individuals who have the same attributes. This could be expressed as a function of the vector of the included k variables χ_{iqk} with parameter estimates β (Hensher et al., 2005). According to Hensher et al. (2005) this could be translated to a linear function for analytical and statistical convenience.

$$V_{iq} = \sum_{k} \beta_k \chi_{iqk} \tag{2}$$

Where: V_{iq} = systematic utility/observed utility of alternative *i* by decision maker *q*;

B_k = parameter estimate of variable *k*;

χ_{iqk} = attribute value of variable *k* for alternative *i* by decision maker *q*.

It could be assumed that there is a linear relation between the attributes and the structural utility of an alternative. The parameter estimates are estimated utility weights of the attributes, multiplying by the attribute value, these results in the observed utility of an alternative. The next step is the model specification, estimation and evaluation to analyze the results.

3.2.4 Multinomial logit model

Model specification

The model specification and development is not straightforward. The model can be seen as a combination of behavioral theories, statistical methods and subjective judgments of the researcher (Hoyos, 2010). The data that is collected with a stated choice experiment can be analyzed with a discrete choice model and utility theory. The random utility theory and model are already introduced in section 3.2.3. The outcomes from the developed survey instrument reveal the individual's preferences in a discrete categorical manner, over a discrete set of alternatives. A set of utilities for all attributes as outcome expresses the intensity of the respondents' preferences. Common regression methods are not applicable in this case and more advanced econometric models are required.

There are three common models in choice theory: the binary model, the probit model and the logit model (Wittink, 2011). If there are more alternatives in the choice set than two, a binary choice model is not applicable. Although the binary model is applicable where respondents need to decide between two choices, for example a dichotomous scale. If the decision process includes more than two alternatives in the choice set, the type of model needed is called multinomial choice model. There are different types of multinomial choice models. Hensher et al. (2005) described two of these econometric models: the Multinomial Probit (MNP) model and the Multinomial Logit (MNL) model. The MNL model is preferable to the MNP model, because its integral for the choice probabilities takes a closed form and therefore is readily interpretable and analytically convenient. The MNP model is far more complex and could give estimation problems because of the open integral (Train, 2009). The most important characteristics of the applicability of the logit models are:

- Logit models represent systematic taste variations that relate to observed characteristics that the decision maker determined on forehand. To observe specific, determined characteristics. But it cannot represent random taste variations that cannot be linked to observed characteristics.
- The logit model implies proportional substitution of the alternatives, these are determined from the researcher's specification of representative utility. Therefore it can only capture forms of substitution to a certain flexibility, for more flexible forms other models are needed.
- If factors that are unobserved prove to be independent over time in repeated choice situations, logit can capture the dynamics of this repeated choice, including state-dependence (Train, 2009).

For the ease of use, the MNL model is preferred over the MNP model. The MNL model is the most widely used discrete choice model, it is readily interpretability and it has closed form of integral (Ortúzar & Willumsen, 2011). In transportation research the MNL model is used for among others: mode choice, road pricing, and the evaluation of environmental impacts of transportation studies (Louviere et al., 2000; Hensher 1994). Because of these reasons, the MNL model is chosen to be used in this research. The binary logit model will be used if a dichotomous scale is applicable in the research.

Model estimation

With the MNL model, knowing the utilities of the attributes and the utilities of the alternatives, it is possible to calculate the probability for choosing an alternative. Manski (1977) formalized the random utility approach, because as stated in section 3.2.1 the researcher still does not know the utility of a decision maker with full certainty. So the utilities are treated as random variables. Ben-Akiva and Lerman (1985) defined the choice for a specific alternative in a choice set if the probability for the chosen alternative is higher than the probability of another alternative. The alternatives have to be different and be present in the same choice set. One alternative is never similar to another ($i \neq j$). The probability can be calculated using the following behavioral model (Train, 2002):

$$P_{iq} = Pr(U_{iq} \geq U_{jq} \ \forall j \in C_q, j \neq i) \tag{3}$$

Where: P_{iq} = probability of choosing alternative *i* by decision maker *q*;

U_{iq} = unobserved utility value for alternative *i* by decision maker *q*;

C_q= choice set for decision maker *q*.

With the assumption that the distributed error components are Gumbel distributed, the random residual is independently and identically distributed. The integral for the choice probability has a closed form, resulting in an analytically more convenient type of model. This brings the following choice probability equation for the MNL model (Louviere et al., 2000; Hensher et al., 2005):

$$P_{iq} = \frac{e^{V_{iq}}}{\sum_{j=1}^{J} e^{V_{jq}}} \tag{4}$$

Where: P_{iq} = probability of choosing alternative *i* by decision maker *q*;

e^{Viq} = mathematical constant to the power of the structural utility value for alternative *i* by decision maker *q*;

j = 1, J with J is the number of alternatives in C_q.

This formula states the probability for choosing the alternative *i* is the exponential of the systematic utility of alternative i out of j alternatives in the enumerator: divided by the sum of exponentials of all systematic utilities for the alternatives. This results in the probability of choosing alternative i.

The binary logit model does not differ much from the MNL model. It is even a simpler version of the MNL model. Because there are less alternatives in the choice set. Equation 3 of the random choice utility is applicable, only the choice set (C_q) exists of only 2 alternatives, i and j. In this case the probability that the decision maker will choose alternative i or j is:

$$P_{iq} = Pr(U_{iq} > U_{jq}) \tag{5}$$

$$P_{jq} = 1 - P_{iq} \tag{6}$$

The combination of the equations 4, 5 and 6 results in the choice probability equation for the binary choice model, with the assumption that the random residual is Gumbel distributed:

$$P_{iq} = \frac{e^{V_{iq}}}{e^{V_{iq}} + 1} \tag{7}$$

Model evaluation

Before evaluating the data in the research, first it is important to evaluate the model. The performance of the model needs to be tested. This could be done by the Rho-squared test and the Likelihood Ratio test. The tests measure how well the model performs compared with a model that has all parameters set to zero; a null-model, what is the same as having no model at all. The Maximum Likelihood Estimation (MLE) is needed to find the optimal parameters such that Rho-squared has to highest possible value. The MLE procedure can be applied in this case, because the model is of closed form. In this case for the model with parameters β:

$$L\,(\beta) = \Pi_q \Pi_i (P_{iq})^{Yiq} \tag{8}$$

Where: $L(\beta)$ = likelihood of the model;

P_{iq} = probability that individual q will choose alternative i;

y_{iq} = factor that indicates if alternative i is chosen by decision maker q.

The fact that an alternative is chosen or not could obtain 2 values: 1 if the alternative is chosen, 0 otherwise. Equation 8 could be translated into the log-likelihood function using a natural logarithm (equation 9) and the log-likelihood for the null model (equation 10). In these equations, the nonchosen alternatives are not included since the likelihood is then multiplied by zero, which results in no outcome. β is a vector containing the parameters of the model.

$$LL\,(\beta) = \sum_q \sum_i y_{iq} \, ln(P_{iq}) \tag{9}$$

$$LL\,(0) = \sum_q \sum_i y_{iq} \, ln(S_i) \tag{10}$$

Where: $LL(\beta)$ = is the log-likelihood function for all estimated parameters;

$LL(0)$ = the log-likelihood function for the null-model with all parameters set to zero;

y_{iq} = factor that indicates if alternative i is chosen by decision maker q;

ln = natural logarithm;

P_{iq} = probability that individual q will choose alternative i;

S_i = equally distributed shares for alternative i.

The formula shows that the log-likelihood is the summation over the chosen alternatives of the natural logarithm of the probability of choosing the alternative for each respondent. The model significance could be further investigated by comparing the fitted model with the null model. A statistic to compare the performance of different subsets of variables, as the null-model with the optimal model is the likelihood ratio test, also named as the Likelihood Ratio Statistic (LRS) (Hensher et al., 2015). The log-likelihood ratio test checks if the model has better performance than having no model at all.

$$LRS = -2[LL(0) - LL(\beta)] \tag{11}$$

Where: *LL(0)* = the log-likelihood function for the null-model with all parameters set to zero.
LL(β) = is the log-likelihood function for all estimated parameters;

If the value of the calculated statistic exceeds the Chi-square value according to Chi-square tables with the appropriate degrees of freedom, the optimal model is a significant improvement of the null-model and it can be concluded that the model can be used for analysis (Hensher et al., 2005).

Another common used statistic to measure how well the model fits the data is the Mc Fadden's Rho-squared test or the 'likelihood ratio index'. This is formulated as:

$$R^2 = 1 - [LL(\beta) / LL(0)] \tag{12}$$

Where: *LL(β)* = is the log-likelihood function for all estimated parameters;
LL(0) = the log-likelihood function for the null-model with all parameters set to zero.

The Rho-squared compares the observations and the predictions, how well the predictions perform in comparison with the observations of the model. The Rho-squared assumes that every single variable explains the variation in the dependent variable. The Rho-squared could be misleading because the more predictors in the model, the higher the Rho-squared. The adjusted Rho-squared (McFadden, 1984) penalizes for adding independent variables to the model. The adjusted Rho-squared tells the percentage of variation explained by only the independent variables that actually affect the dependent variable.

$$R_{adj}^{2} = 1 - \left[\frac{(1 - R^{2})(n - 1)}{n - k - 1}\right] \tag{13}$$

Where: R^2 = Rho-squared;

N = number of respondents in de sample;

k = number of independent variables, i.e. degrees of freedom.

The results of the Rho-squared test have a range from 0 (no fit) to 1 (perfect fit). There are different interpretations about when a model fits. Ortúzar & Willemsen (2011) consider an excellent fit with a likelihood ratio index value of 0.4 and Hensher et al. (2015) talk about a good model fit for a value of 0.3. Train (2009) states that a value of 0.2 or higher is preferred, a value below 0.05 is significant but weak, and a value between 0.05 and 0.2 is moderate. The value of the adjusted Rho-squared could also be negative, meaning that the model is insignificant. The adjusted Rho-squared is used to compare different sub models with a different amount of predictors. The next step is considering the data involved in the choice modeling.

3.3 Experimental design

This section describes the theory of the experimental design as the foundation for any stated choice experiment. To collect the correct data, it is important to use the experimental design as a guideline. The design process is implemented in the research, following the 8 stages of the process. The steps of the experimental design process (Hensher et al., 2005, p. 102) are displayed in figure 3.3.

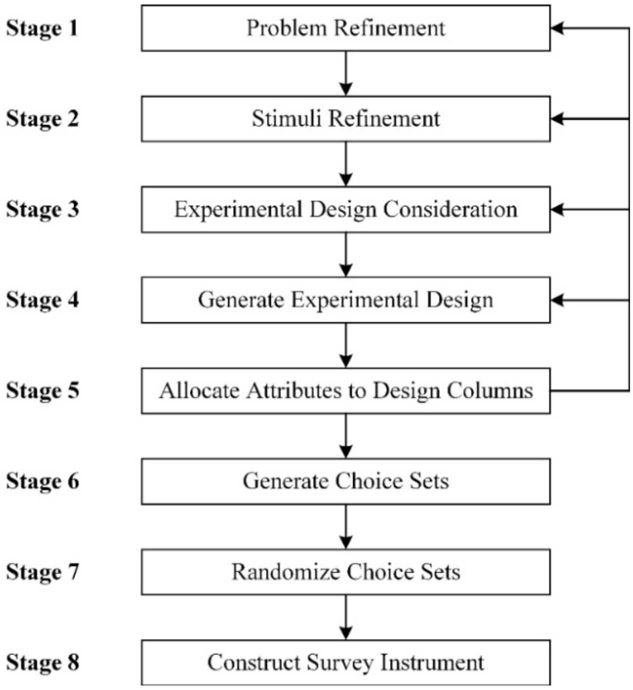


Figure 3.3: The experimental design process (Hensher er al., 2005)

As could be stated, the generation of such experiment does not take place in a random way, but it requires a strategic setup process. Efficient data is gathered with efficient designs. The design as mentioned by Hensher et al. (2005) contains eight steps. First, the problem is defined. This is the basis for the research. After the problem refinement, the stimuli are identified. The stimuli in this experimental design are the alternatives, attributes and attribute levels. Identifying these is an important and iterative part of the design. In the further process of the research development, it could be that some identified stimuli are changed or left out of the research. The next step is to select the most suitable experimental design for this research. In this the type of the design and model specification are considered. Afterwards, the experimental design is generated. The selection of the coding scheme, determination of the choice situations and the required sample size are part of this step. The attributes will be allocated to design columns. With this experimental design with allocated attributes the choice sets are generated. When the choice sets are generated the iterative process in experiment design is over and the alternatives, attributes, attribute levels and type of design are fixed and cannot be changed without redoing all the stages. To create a useful random research these generated choice sets are randomized. When randomized they are ready to be used in the survey instrument and presented to the respondents. In the survey construction, the respondents need to be selected; the coding of levels needs to be replaced with actual values and the choice situations need to be randomized.

3.3.1 Problem refinement

The problem definition in section 1.1 and the stated research questions in section 1.2 are the basis for the problem refinement. Having a clear understanding of the research problem is the first part of the experimental design process. This gives insights into the questions which have to be answered (Hensher et al., 2005). In chapter 2, a theoretical framework about all relevant concepts and travelers mode choice behavior is presented, also displayed in the conceptual model in figure 3.1. The sub-research questions from section 1.2 could be answered with this information. But the information is also the basis for the important content of the experiment. With help of the literature review (chapter 2) the scope of the experiment could be refined. The experiment is a general experiment, presented as a case study for every employee and student at the TU/e. The research consists of a mode-choice experiment of hypothetical offered supportive car systems at the TU/e campus, with some comprehensive questions for a selection of the sample size. This selection of the sample size concerns car-commuters. This will be further explained in the following sections. With the help of the SC experiment, the main research questions about the optimal setting for the SCS could be answered. With the mode-choice experiment, the second main research question about commuting traffic could be answered. This question only applies to a selection of the sample size. The questions, attributes and attribute levels in the experiment are adjusted to the TU/e circumstances.

3.3.2 Stimuli refinement

The stimuli refinement is the second stage of the experimental design process (Hensher et al., 2005). Once the problem is well understood, it is required to identify and refine the stimuli to be used in the experiment. Decisions have to be made about the statistical properties for the final design of the experiment. This stage in the process has three stages; the identification of alternatives, the identification of attributes and the identification of the levels of the attributes. The first step is to refine the alternatives. In the end, the respondents should be able to choose from a finite set of alternatives who represent the real-life situation. Therefore, first every possibility need to be defined. In the experiment, the respondents have to choose between two Supportive Car Systems. The definition of a SCS (which could be offered in different settings) is an offered facility by the TU/e to rent and use if needed, also the (financial) regulations and accommodations of the SCS are part of the system. In the experiment, the SCS is described as:

> *'A Supportive Car System consists of available cars stationed at or near the TU/e campus. These cars can be used for business trips and/or personal journeys by both employees and students. Examples of Supportive Car Systems are car rental and car sharing: members of a shared car (other employees and students of the TU/e) could use the offered car if necessary.'*

The requirements of the alternatives are: the set of alternatives must be exhaustive, the alternatives must be mutually exclusive and the set must exist of a finite number of alternatives (Train, 2009). Hensher et al. (2005) describe several ways to reduce the number of alternatives, for example the insignificant alternatives could be excluded or 'unlabeled' alternatives could be used. In this mode-choice experiment, the alternatives are unlabeled because the alternatives themselves do not have a value to the respondent. The unlabeled alternatives are Supportive Car System 1 and Supportive Car System 2. These names do not have any intrinsic value to the respondent. The descriptions of the two different supportive car systems define the characteristics and differences of the two systems.

After defining the relevant alternatives, the attributes need to be identified. This is a more complex step, because the attributes are the characteristics of the alternatives. Each attribute is again described by a number of levels, which represent actual values. In this unlabeled experiment, each alternative is described by the same attributes, but the attribute levels differ. Hensher et al. (2005) mention that it is important to be attentive of ambiguity and correlations between attributes. The attributes are identified attributes of Supportive Car Systems, as researched in section 2.5.3.

After the attributes of the Supportive Car Systems are selected, the next step is to choose the levels of the attributes. This requires attention. The more levels per attribute, the more accurate the finding of the experiment, but also the higher the complexity. Sanko (2001) and Rose (2011) consider some points when defining the levels of attributes: a wide range of levels is preferred, levels should be realistic, levels need to relate to respondents' experience and levels should ensure competitive trade-offs. In this research, all attributes have two or three levels. They are shown in table 3.1. For example, the range of the attribute levels of Location (walking time) is calculated with the help of Google Maps; walking time from the border of the campus to the center of the campus. A comprehensive explanation about the prices in the experiment is necessary. The tariff system of the SCS could be calculated by price per driven km or price per reserved hour (or with a combination). To capture the preferences towards the tariff systems, two versions of the experiment design are distributed among the respondents. The experiment designs are the same, only the pricing methods differs. Each respondent receives one of the two versions to avoid misunderstandings. The tariffs (per km and per hour) are calculated with the help of the prices of Studentcar, see Appendix 3.

Table 3.1: The attributes and attribute levels

Attribute	**Attribute levels**	**Explanation to respondent**
Location (walking time) (A)	- 1 minute (1) - 5 minutes (2) - 9 minutes (3)	The time you need to walk from the building/faculty at the TU/e campus in which you work/study to the parking spot of the Supportive Car System at the TU/e campus.
Advertisements (B)	- Plain car (1) - Only TU/e logo (2) - Full with advertisements (3)	
Car type (C)	- Standard car (1) - Luxurious car (2) - Multi-Purpose vehicle (MPV) (3)	
Price * (D)	- €4 per hour / €0.30 per km (1) - €5 per hour / €0.40 per km (2) - €6 per hour / €0.50 per km (3)	The price of the usage of the Supportive Car System could be calculated in different ways: Price per driven km or Price per reserved hour.
Fuel type (E)	- Petrol (1) - Hybrid (2) - Electric (3)	The car could be supplied with three types of fuel: Fossil fuels (petrol, diesel), a Hybrid system or an Electric car.
Accessibility (F)	- Key exchange is necessary (1) - Access with mobile application (2)	The car could be accessed in two ways: with a key, so key exchange is necessary or unlocking the car with a mobile application and unlock code.
Availability (G)	- 24 hours – 7 days a week available (1) - Only available during working hours (9am - 5pm) (2)	The car could be available for 24 hours every day, 7 days a week. Or the car is only available during working hours, because personal contact is necessary.
Reservation (H)	- By telephone contact (1) - By e-mail (2) - With mobile application (online) (3)	There are different ways to reserve a Supportive Car System, with telephone contact, with the mobile application (online), or by e-mail.
Trip purposes (I)	- Only for business/study trips (1) - For business/study and private trips (2)	The car could be applied for two different kinds of trips; business/study trips for the TU/e or also for private trips.

* = The respondents are randomly selected to get Price per driven km or Price per reserved hour.

According to travel mode choice fundamentals, there are five (I to V) mode choice attributes for car users (Prettenthaler & Steiniger, 1999). The nine different attributes in this experiment fit to these as follows:

I. Cost (Price, Advertisements);

II. Time demand (Location (walking time), Availability);

III. Convenience (Reservation, Accessibility, Car type);

IV. Flexibility (Trip purposes);

V. Environmental soundness (Fuel type).

3.3.3 Experimental design consideration

The next step in the process after refinement of the stimuli is to consider the experimental design. The most general class is the ‘full factorial design’. In this design all possible treatment combinations of the attributes are enumerated (Hensher et al., 2005). A treatment combination or profile represents a possible setting of attributes for an alternative. In this choice experiment, there are 6 attributes with 3 levels and 3 attributes with 2 levels. So a ‘full factorial design’ in this choice experiment results in (3^6 x 2^3 =) 5,832 treatment combinations. This many treatment combinations makes investigating the ‘full factorial design’ no option. So the number of treatment combinations need to be reduced. According to Hensher et al., 2015 there are four strategies to reduce the number: reduce the number of attribute levels, use ‘fractional factorial design’, block the design or use a combination of ‘fractional factorial design’ and blocking strategy.

Because of the complexity, the experimental design is limited to 3 attribute levels; the minimum, maximum and a center value. In this choice experiment design, a ‘fractional factorial design’ strategy will be used to reduce the number of treatment combinations. When using a ‘fractional factorial design’ the full design is reduce to a fraction of the total combinations. It is important to achieve orthogonality (no correlations between the attributes). This means that each possible pair of attribute levels appears an equal number of times over the design. In addition, the possible main effects and interaction effects have to be considered. An ‘orthogonal main effects only design’, allows that the main effects (direct independent effect of each attribute upon the research variable) could be estimated independently, though leaves interactions (combined effect of two attributes is different from the sum of their two main effect utilities) cofounded with one another (Hensher et al., 2005).

With the 'fractional factorial design', a coding scheme is required to calculate the utilities of the attributes. As described, the utility is the attractiveness of the attributes which could be used to calculate how attractive an alternative is. The attractiveness at attribute level is called the part-worth utility. It could also have a negative value if an attribute level is disliked. For example, if the respondents prefer accessibility of the car with the mobile application, than they dislike the accessibility by key exchange as the exact opposite. So if the level utility of 'access by mobile application' will be (for example) 0.3, the part-worth utility (dislike of 'key exchange is necessary') will be -0.3. These utilities are calculated using effect coding. With the help of the utility function, described in section 3.2.2, the utilities can be calculated. In the following table 3.2, the effect-coded attributes in order to calculate the derived part-worth utilities are shown.

Table 3.2: Effect coding

Number of levels	Attribute level	Design code	Effect coding		Derived part-worth utility
2	1	0	-1		$\beta_1 * -1$
	2	1	1		$\beta_1 * 1$
3	1	0	1	0	$\beta_1 * 1 + \beta_2 * 0$
	2	1	0	1	$\beta_1 * 0 + \beta_2 * 1$
	3	2	-1	-1	$\beta_1 * -1 + \beta_2 * -1$

The applied blocking strategy will be described in the section of 'Choice task generation'.

3.3.4. Experimental design generation

As mentioned in the previous section, an 'orthogonal main effect only design' will be used in this choice experiment design. This design is generated with the help of the software package IBM SPSS Statistics 23. The orthogonal design is shown in table 3.3 and contains 27 treatment combinations. In Appendix 4, the profiles of orthogonal design for the stated choice experiment are shown with the labels of the attribute levels.

Table 3.3: The orthogonal design.

Profiles	Attributes								
	A	B	C	D	E	F	G	H	I
1	1	1	3	2	2	1	2	1	1
2	3	2	3	1	1	2	2	1	1
3	2	2	3	2	1	1	1	2	2
4	2	2	2	3	2	1	1	2	1
5	3	1	2	1	3	1	1	2	1
6	2	3	2	1	1	1	1	1	1
7	1	3	2	2	1	2	1	2	2
8	2	1	2	2	3	2	2	3	1
9	3	2	2	2	2	2	1	1	1
10	3	3	3	2	3	1	1	3	1
11	2	1	1	3	1	2	1	3	1
12	1	2	1	2	3	1	1	3	1
13	1	3	1	3	2	2	2	2	1
14	3	3	1	1	2	1	1	3	2
15	1	1	2	3	3	1	1	1	2
16	2	1	3	1	2	2	1	3	2
17	1	2	3	3	1	1	1	3	1
18	1	1	1	1	1	1	1	1	1
19	3	1	1	2	1	1	2	2	2
20	1	3	3	1	3	2	1	2	1
21	3	2	1	3	3	2	1	1	2
22	2	3	1	2	2	1	1	1	1
23	1	2	2	1	2	1	2	3	2
24	3	3	2	3	1	1	2	3	1
25	2	3	3	3	3	1	2	1	2
26	3	1	3	3	2	1	1	2	1
27	2	2	1	1	3	1	2	2	1

3.3.5 Choice set generation

With the generated design of treatment combinations, the next step is to allocate the treatment combinations into choice sets that will be presented to the respondents. The next step is to attach the attributes and levels to the design. Every treatment combination forms an alternative to be evaluated in the stated choice experiment. The codes in the design above are translated into interpretable alternatives and combined so the respondent can choose one out of 2 alternatives in a hypothetical scenario. The allocation and translation of the treatment combinations into alternatives for the experiment is followed by the randomization of the alternatives.

The alternatives need to be randomized to combine them into combinations in the choice set, to present to the respondents. To be sure that every alternative is combined with several other alternatives in the experiment, the alternatives are first duplicated, and afterwards randomized again. This will result in outcomes with better reliability. Presenting the choice sets in the same order every time might lead to biased results. Now, one alternative is not only compared with one another alternative, but with a wider variety of alternatives. The randomization of the treatment combinations is displayed in figure 3.4.

Treatment combinations (SCS 1)	**Randomized treatment combinations (SCS 2)**
1	18
.	.
.	Randomization
. Duplication	.
27	4
1	12
.	.
.	. Randomization
.	.
27	3

Figure 3.4: Randomization of the treatment combinations.

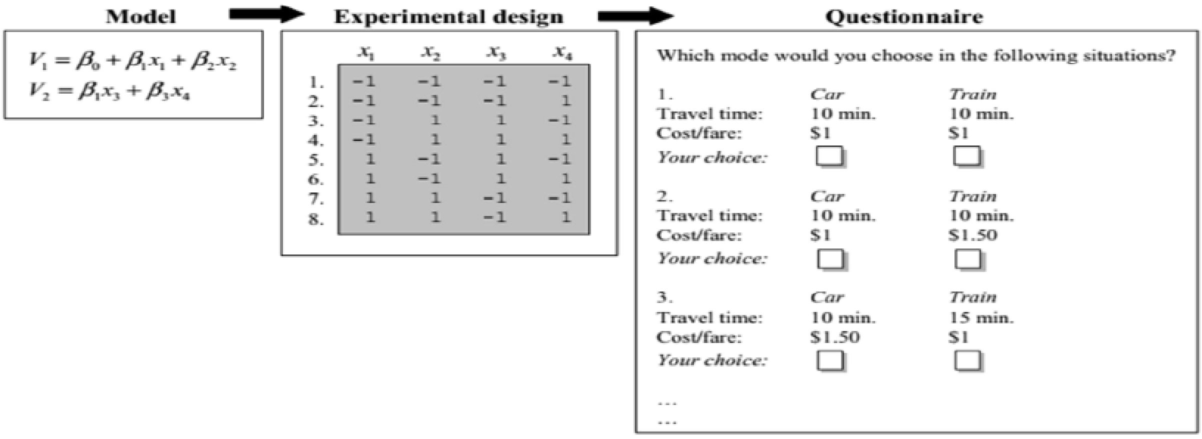
First, for the second SCS alternative in the choice set, the treatment combinations are randomized. Then they are duplicated and randomized again. So in the final choice set design, contains 54 alternative combinations (see table 3.4). All alternatives are represented four times, two times as SCS 1 and two times as SCS 2. The alternative combinations are checked on double combinations and afterwards the set is duplicated again. One choice set is with only 'price per driven kilometer' attribute levels and the other choice set is with 'price per reserved hour' levels, so respondents only could receive one of the two versions. This makes a final choice set design of 108 choice tasks.

Table 3.4: The 54 alternative combinations.

	SCS 1	SCS 2		SCS 1	SCS 2
1	1	18	28	1	12
2	2	25	29	2	15
3	3	6	30	3	24
4	4	16	31	4	23
5	5	12	32	5	14
6	6	19	33	6	2
7	7	11	34	7	4
8	8	27	35	8	17
9	9	2	36	9	25
10	10	20	37	10	6
11	11	1	38	11	5
12	12	3	39	12	26
13	13	14	40	13	18
14	14	26	41	14	20
15	15	5	42	15	1
16	16	13	43	16	9
17	17	15	44	17	7
18	18	7	45	18	10
19	19	8	46	19	16
20	20	9	47	20	13
21	21	24	48	21	11
22	22	21	49	22	19
23	23	17	50	23	27
24	24	10	51	24	22
25	25	22	52	25	21
26	26	23	53	26	8
27	27	4	54	27	3

3.3.6 Choice task generation

The last step of the stated choice experiment design is to transfer the generated choice set into choice tasks for the respondent, applicable in the survey. This was also described by Rose & Bliemer (2008) in figure 3.5.



	x_1	x_2	x_3	x_4
1.	−1	−1	−1	−1
2.	−1	−1	−1	1
3.	−1	1	1	−1
4.	−1	1	1	1
5.	1	−1	1	−1
6.	1	−1	1	1
7.	1	1	−1	−1
8.	1	1	−1	1

Figure 3.5: Stated choice survey design (Rose & Bliemer, 2008).

The choice tasks are designed to capture the respondents' preferences as best as possible. Because respondents have a certain learning curve, respondent need an example first to get used to the choice tasks. This learning curve will also lead to other reasoning behind made choices for the first choice sets against later made choices (Hensher et al., 2005). So every respondent has to receive more choice tasks, but not too many to make the stated choice experiment too complex. Sanko (2001) suggested a maximum of 9-16 games (choice tasks) per respondent, but this is for alternatives with a maximum of 6-7 attributes. Because the high amount of attributes in this experiment (9), the decision is made to lower the choice tasks per respondent to six.

When entering the stated choice experiment, each respondent was randomly assigned to group one or group two. The first group got the choice set with the price attribute levels 'price per driven km' and the second group got the attributes 'price per reserved hour'. This was done in an organized way, so the alternatives in both groups were answered the same number of times.

The design of both groups is blocked, so every respondent did not have to answer all 54 different choice set combinations. The choice set design is divided into 9 different blocks and giving each one to a different respondent. This includes that 9 respondents are required to complete the full design. Each respondent receives a fixed set of 6 of the treatment combinations. This is done in an organized way which ensures that all alternatives are answered the similar number of times. The first respondent receives the choice task combinations 1 to 6 from group 1, the second respondent receives the choice task combinations 1 to 6 from group 2, the third respondent receives the choice task combinations 7 to 12 from group 1 and so on.

3.4 Survey construction

The final step mentioned by Hensher et al. (2015) is the construction of the survey instrument. The survey instrument is created in order to collect the data from this stated choice experiment. The instrument should be appropriate for the objective of the research and unimportant questions need to be excluded.

The survey is constructed with the help of an online survey tool. This tool was developed by the Eindhoven University of Technology called 'Berg Enquête System'. An advantage is that a stated choice research could fit in perfectly. Important is that it is possible to randomize the choice sets of the stated choice experiment and provide to each of the respondents 6 different alternatives, keeping track of how many times each one has been replied in order to collect a similar amount of answers from all 27 alternatives.

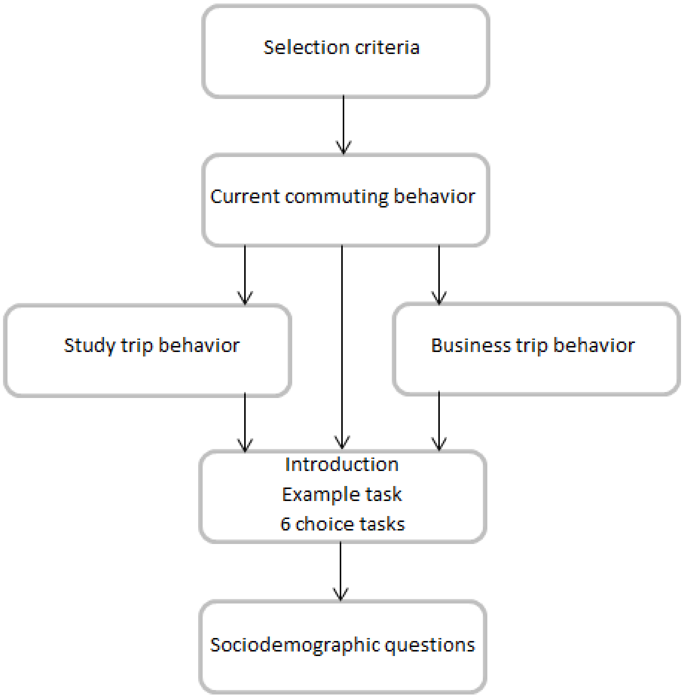


Figure 3.6: Survey structure.

The survey contains 5 main blocks; these can be found in figure 3.6. The first main block is a preliminary block containing some general questions about the relationship of the respondent with the TU/e. These questions are used as selection criteria for the rest of the survey. The second block and the third block contain questions about the current travel behavior; about commuting and about business and study trips. The fourth block is the main part of the research. In this part, the stated choice approach will be used. Each respondent receives an information page, an example page and finally 6 choice tasks. In the last block, the sociodemographic characteristics of the respondent have been questioned. The full survey was in English and is shown in Appendix 5.

3.4.1 Preliminary questions

There is only one selection question which is about the respondent's driver's license, because without a driver's license the respondent does not belong to the target population of the SCS and thus this research. This selection criterion has a dichotomous scale, only 'yes' or 'no'. People who answer that they have no driver's license are automatically linked to the page as shown in figure 3.7 and redirected to the last page of the survey.

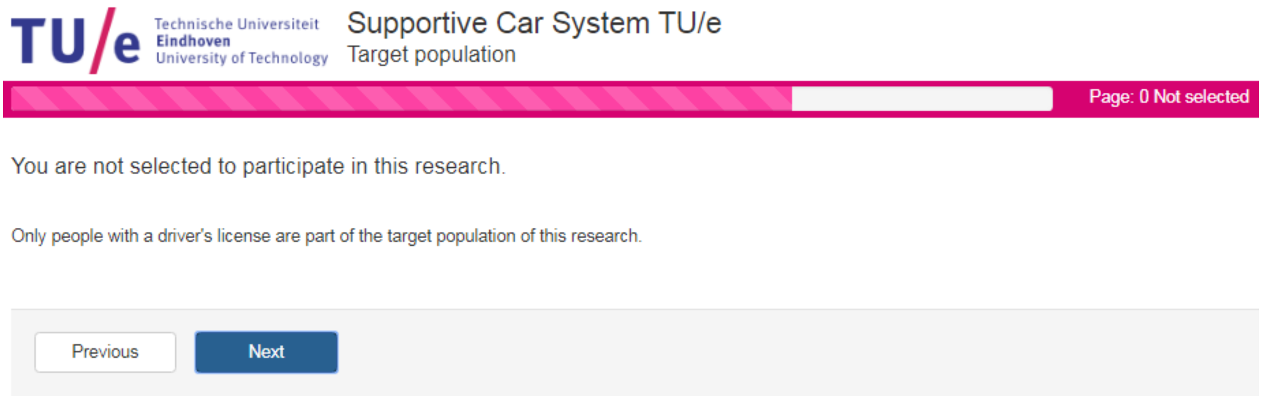


Figure 3.7: Page of the survey for people without driver's license.

Beside the driver's license questions, some other introduction questions are asked to the respondent. These sociodemographic questions give a first insight in the respondent and the respondent will not know which questions leads to exclusion of the survey. These questions are about the current commuting frequency on a weekly scale, the relation with the TU/e (employee, student or other) and if they make business or study trips; business trips for employees, study trips for students (dichotomous scale).

3.4.2 Commuting habits behavior

The second block of the survey contains questions about the current commuting behavior of the respondent from home to the TU/e campus. It is explained what a commuting trip is, and that the questions are a about a one-way commuting trip. The first question is about the commuting travel mode. A 5-point Likert scale is used to rank how often a certain travel mode (car, bus, train, bicycle, walking, other) is used to commute; Never, rarely, occasionally, often, always. The main focus in this question is on the car commuting mode, but now it gives also some information about the other modes. The second question about commuting distances has an ordinal scale with the fixed ranges of 10 km, only the last step is 'More than 50 km'. This scale differs from the 'Mobiliteitsenquête TU/e 2016' (TU/e, 2016), because they kept different ranges in the steps of the scale.

3.4.3 Business/study behavior

The third block of the survey contains questions about the behavior of respondents related to business or study trips. Also an explanation of business trips and study trips is given. With the preliminary questions, it was asked if the respondents make business or study trips. If they do, this section of the survey will appear. First, it is asked if the respondents make national and/or international trips (dichotomous scale). Secondly, how often the respondents make national and international trips if they have answered the first question with 'yes'. The used interval scales are adopted from the 'Mobiliteitsenquête TU/e 2016' (TU/e, 2016).

At the following page, questions are asked about the travel modes for the trips and the travelled distances when making a trip. A 5-point Likert scale is used to rank how often a certain travel mode is used is used; Never, rarely, occasionally, often, always. The second question about the distances of the trips has an ordinal scale with the different ranges of 50 km for national trips and 250 km for international trips. With the last steps 'More than 50 km' and 'More than 1000 km'.

Because the supportive car system is the main focus of this research, some additional questions are asked if the respondent stated that they use a sharing or rental car of business/study trips. An interval scale is used for the frequency of the usage of a rental or sharing car and in addition the respondents are asked what their motivations are for the usage of certain rental and sharing companies. In this question, some examples are given, but there is also a possibility to give additional reasons.

3.4.4 Stated choice experiment

The fourth part of the survey is the stated choice experiment. Before the questions about the mode choice are asked, there is a comprehensive explanation of the Supportive Car System and what the purpose is of the stated choice experiment. The explanation is as follows:

> *'With the following choice experiment, we want to identify your preferences regarding the characteristics of a possible Supportive Car System. A Supportive Car System consists of available cars stationed at or near the TU/e campus. These cars can be used for business trips and/or personal journeys by both employees and students. Examples of Supportive Car Systems are car rental and car sharing: members of a shared car (other employees and*

students of the TU/e) could use the offered car if necessary.

On the following page, an example of the choice experiment is given. You will receive two different settings of a possible Supportive Car System. There are two alternative possibilities to set up the Supportive Car System, but you have to choose the most preferable system. Please review the descriptions of the two systems carefully before you make a choice.'

An example question will follow, to introduce the respondent with the choice tasks and the setup of the choice experiment. With the example question it is intended to help understanding the experiment for the respondent. People normally experience startup problems with complicated questions/choice tasks. The example question also need to be answered, so before the real choice experiment starts, the respondent is required to read the table and the explanations of the attributes. The explanations of the attributes are included in pop-ups in the table. Therefore, mouse-over effects are included. It is also mentioned, that the description of the attributes are included as mouse-over effects.

After the example questions, the real choice experiment starts. Still, in every choice task the mouse-over effects are present, so the respondent does not have to go back to check the descriptions of the attributes.

Figure 3.8 shows an example of a choice task in the survey. The respondent need to select the Supportive Car System that is preferred the most. In every of the 6 presented choice tasks, it is shown to the respodent which of the choice tasks it is. So the respondent could see his/her progress.

Characteristics	Supportive Car System 1	Supportive Car System 2
Location (walking time)	1 minute	9 minutes
Advertisements	Full with advertisements	Plain car
Car type	Luxurious car	Multi-Purpose Vehicle (MPV)
Price	€6 per hour	€4 per hour
Fuel type	Fossil	Electric
Accessibility	Key exchange is necessary	Access with mobile application
Availability	Only available during work hours	24 hours - 7 days a week available
Reservation	With the mobile application (online)	By e-mail
Trip purposes	Only for business/study trips	For business/study and private trips
Which Supportive Car System do you prefer most?	○	○

Figure 3.8: A choice task in the survey.

If the respondent is a car commuter, there are additional questions in every choice task. The respodent has to choose if he/she would change the car commuting to bus, train or bicycle or not, if the chosen Supportive Car System would be available at the TU/e campus. The questions are shown in figure 3.9.

You have indicated that you commute by car, we would want to know if you might change your commuting travel mode in case you have to make a business or study trip, given that the chosen Supportive Car System will be available at the TU/e campus.

I would change my car commuting mode to ...

	Yes	No
Bus	○	○
Train	○	○
Bicycle	○	○

Figure 3.9: The additional stated choice questions for car users.

3.4.5 Personal characteristics

In the fifth and final part of the survey, some questions regarding sociodemographic, personal characteristics of the respondents are asked. This is to check if the sample population is representable for the target population, and subgroups could be determined. The personal questions are asked at the end because the focus of the respondents could be less at the end and these questions are easy to fill in. Firstly, the questions in this final part are the same for all respondents. Afterwards some questions differ for the employees and students.

The questions about the personal characteristics are about the age of the respondents, starting at an age of 17 (because it is the lowest age to drive a car in the Netherlands) and with steps of 10 years, because most students are finished with studying when 26 years old and the retirement age in the Netherlands is 67 years. Other sociodemographic questions are about the gender, educational level, the ratio between driver's licenses and cars in the household, the department/support service where the respondent is active, study year and if the respondent is active full time or part time at the TU/e.

3.5 Data collection

The data for the SC experiment is not randomly collected. Because of the design of the research, the data will be collected from a specific target group. The target group of the experiment includes only students and employees of the TU/e. Everyone who would not be able to drive the potential SCS is rejected for the SC experiment. Only students and employees studying/working at the TU/e campus with a driver's license are in the target population. The target group is chosen because of the following reasons. First, the selected people have to be able to use the proposed potential SCS.

Second, the proposed potential SCS possibly could be used by everyone, but it is financed and initiated by the TU/e. So the first desire is to satisfy the needs and preferences of the students and employees at the TU/e.

The respondents for the survey are selected from the mailing list (address book) of the TU/e. In this address book, all e-mail addresses of students and employees are available. To create an appropriate and reliable group of respondents for the research, a diverse range of all TU/e-students and employees need to be reached. So, respondents are selected randomly from the address book of the TU/e. Only e-mail addresses ending with @student.tue.nl (students) or @tue.nl (employees) are selected for this research.

As described, a web-based survey has been used for this research. The online survey tool was the 'Berg Enquête System'. This software has been developed by the DDSS research group (Design and Decision Support Systems) at the Built Environment faculty at the University of Technology Eindhoven. Besides the survey construction with this tool, it is also well suited to distribute a stated choice survey. So the data is collected with the help of this tool and information remains private from external organizations providing similar survey systems.

In total the TU/e counts about 14,000 employees and students (TU/e, 2017a), the survey is send to around 8.800 randomly selected employees and students at the TU/e. This is more than half of the target population, so the selected target group could be a representation of all people studying and working for the TU/e at the TU/e campus.

The random selection of the employees and students was executed by selecting the first 100 people with the surname starting with an A, then 100 people with the surname starting with a B and so on. Till all the characters of the alphabet were selected, then number 101-200 from people with the surname starting with an A were selected and so on. When all people with certain starting letter were reached, the random selection continued with the following letter in the alphabet. This was done till the required sample size was reached. The required sample size is important in a stated choice experiment. A good sample could guarantee the consistency of the experiment. There are different rules of thumb used for calculating the sample size requirements in SC studies (Rose & Bliemer, 2013). McFadden (1984) stated that at least thirty responses per alternative are required. Orme (2010) suggests a minimum sample size of 200 respondents. The most commonly cited determination of the size of the sample was proposed by Orme (1998) as in equation 14. But the cited rules of thumb could be problematic from theoretical perspective, because the sample size rules of thumb are not related to the experimental design (Rose & Bliemer, 2013). For example, from theoretical view a randomly generated design requires more respondents than an orthogonal design. The rules of thumb do not deal with this.

$$N \geq \frac{500 \cdot L_{max}}{t \cdot a} \tag{14}$$

Where
L_{max} = largest number of levels of any of the attributes
t = number of alternatives per choice set
a = number of choice sets

In this experiment, the largest number of levels on any of the attributes is three, the number of alternatives per choice set is 2 and the total of choice sets is 54. There are 54 choice set combinations and there are 9 people needed to examine every choice set in the design, because of the blocking strategy. This will result in a required sample size of (13.89 * 9 =) 125 respondents. But because there are two groups for the pricing attribute, there are 125 respondents needed for every group. So the total required sample size of the experiment will be 250 respondents. According to McFadden (1984) and Orme (2010) respectively 270 and 200 respondents are required.

3.6 Conclusions

In this chapter the relevant theories, concepts and techniques are described to assess the attribributes of Supportive Car Systems and evaluate their influence on commuting mode choice. The stated choice (SC) technique is selected to carry out effective behavioral research on the potential effects on the respondent's choices. This approach allows this study to estimate the respondents' preferences and predict the respondents' choice probabilities for the alternatives. And it has the ability to use choice situations that do not yet exist.

In this chapter all the proposed steps to collect the data with this technique (adapted from Hensher, 2005) are described and applied, resulting in the experimental design for the survey. The used alternatives, attributes, attribute levels, effect coding, orthogonal design, treatment combinations, choice sets and choice tasks are all described. This resulted in the construction of the survey instrument, the design of the survey intrument and the data collection approach.

After the data collection, the data of the experiment will be analyzed by the discrete choice model Multinomial Logit (MNL). In this chapter, the model specification, estimation and evaluation will be described. In the next chapter, the results will be described.

4. Descriptive analysis

4.1 Introduction

The first step in the data processing process was to filter out the incomplete surveys. In total, around 8.800 students and employees were reached by e-mail. From these e-mails, 830 hits were received. Hits are the times that a respondent opened the link of the survey. There was no option to save the started survey. The number of respondents who did not only open the survey but also started was 659. From this dataset 57 surveys were removed due to the selection criterion for the respondents, since users of the Supportive Car System (SCS) need to have a driver's license. After removing the surveys with incomplete data, a dataset of 440 filled-in, finished and completed surveys was obtained. Hence 383 usable surveys remained in the dataset. Since hardly any questions were asked using an open answer field, no extreme values or out of range answers could be given by the respondents. The desired number of filled in surveys for the research was around 250 to 270 as explained before, the total prepared surveys of 383 is sufficient to get reliable results. An overview is given in figure 4.1.

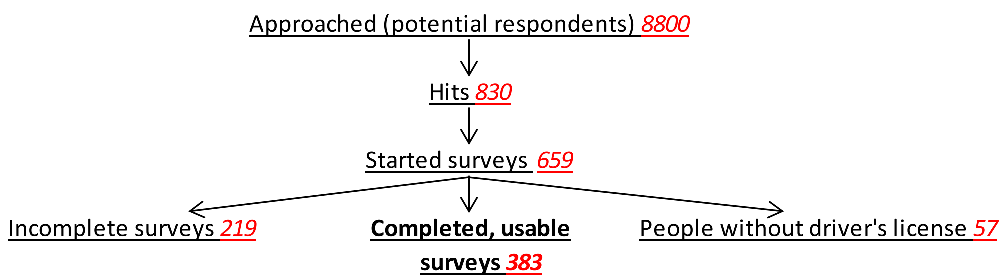


Figure 4.1: An overview of the data processing process.

The survey was built up in five parts. The last part of the survey contained questions about the personal characteristics of the respondents and the first and second part of the survey were used to gather more information on the preferences and behavior of the respondents towards commuting and business/study trips. To get an overview of the respondents' characteristics, the descriptive statistics will be presented in the following sections. The results are achieved with the help of IBM SPSS Statistics 23 software. If possible the sample population's characteristics will be compared with the population of employees and students at the University of Technology Eindhoven, as described in the 'Jaarverslag 2016' (TU/e, 2017a) and the 'Mobiliteitsenquête TU/e 2016' (TU/e, 2016).

4.2 Respondents' characteristics

The last part of the survey contained questions about the respondents' personal characteristics. With the results of this personal information, the characteristics of the group of respondents are determined. In this chapter the results of the personal information of the respondents will be verified to show what people represent the research results. Table 4.1 shows the respondents' personal information. The ratio between the driver's licenses and available cars in the household, is not shown because it has some invalid results. All the frequencies from the survey results are shown in Appendix 6.

Table 4.1: Respondent's personal information

	Characteristics	Sample frequency	Sample percentage	Reference percentage
Gender	Male	268	70	73.1
	Female	115	30	26.9
Age	Under the age of 17	0	0	
	17 - 26 years old	252	65.8	
	27 - 36 years old	61	15.9	
	37 - 46 years old	24	6.3	
	47 - 56 years old	30	7.8	
	57 - 66 years old	15	3.9	
	67 years or older	1	0.3	
Educational level	Vocational education (MBO)	15	3.9	
	Higher education (HBO)	52	13.6	
	Academic education (WO)	316	82.5	
Function	Employee	122	31.9	23.1
	Student	251	65.5	76.9
	Other	10	2.6	
	Total	383	100	

The personal characteristics of the respondents will be compared with the TU/e population, because of two reasons. The first reason is to check if the sample of the research has some parallels with the TU/e population, so the research is reliable. The second is to check if there are interesting subgroups in the research, which are equally represented to analyze further in the next chapter. The gender distribution at the TU/e, according to the 'Jaarverslag TU/e 2016' is 73 percent males and 27 percent females. In this research, the ratio between males and females is 70 – 30, what is compliant with the actual gender distribution at the TU/e.

The age distribution at a campus of a school or university could be expected to be different from the general population in a country. Young people, as the students, are mainly overcrowded at a TU/e campus. Checking at the age distribution in this research, almost two-thirds of the people are under the age of 27. There seems to be a resemblance with the ratio of students and employees at the TU/e, this could be because the most students are graduated before their 27th birthday.

The distribution of the highest reached educational level at the TU/e could also be expected as different as the educational level distribution in a country. At the TU/e, it could be assumed that there are more highly educated people than in than the national distribution.

The respondents could also be divided towards the function they fill in at the TU Eindhoven. At the University of Technology Eindhoven, approximately 14,000 people have a relation with the University of Technology Eindhoven and the TU/e campus. This is divided in approximately 3,200 employees and approximately 10,800 students, the amount of students is slightly growing the last years. The questionnaire was filled in by 122 employees, 251 students and 10 people with another function, as shown in table 4.1. The respondents with another function had to clarify which other function they fill in at the TU/e (campus). From these results, all the other function could be described as employee (PhD or external employee), but because they have not received additional questions, they will be excluded for the further research.

Employees and students specific questions

Now, the total population of the research is described. In the last part of the questionnaire also some specific questions for employees or students were asked. Questions were about at which Department they work or study and if they work or study full-time or part-time. In Appendix 7 the results of these questions are given. At least, all the Departments at the Eindhoven University of Technology are represented in the research, for as well the students as the employees. So the dataset will represent the target population of the TU/e. The ratio between department personnel and support service personnel is 76 – 24. According to 'Jaarverslag TU/e 2016' (TU/e, 2017a), the ratio between academic personnel (2,068) and other personnel (1,171) is 64 – 36. There could be assumed that these two groups have a different opinion on the Supportive Car Systems, because academic personnel have more freedom in their working schedule. Most other personnel have more strict working schedules and locations, which could affect their vision on the SCS.

Amongst the respondents which are students, the sample description could also be compared with the student population at the TU/e. Almost all students are fulltime present at the TU/e campus. In the 'Jaarverslag TU/e 2016' (TU/e, 2017a), the students are classified as bachelor vs master student and they are subdivided per department. In Appendix 8, the similarities with the research sample are clear. All the departments are represented and the biggest departments (Built environment, Industrial Engineering & Innovation Sciences, Mechanical Engineering and Mathematics & Computer

Sciences) are also more represented in the research sample. Looking at the distribution of bachelor and master students in the research, there are more bachelor student respondents than master student respondents, what also represents the TU/e population (65% bachelor versus 35% master) (TU/e, 2017a).

Overall, it can be stated that the dataset shows similarities compared to the population of people (employees and students) at the Eindhoven University of Technology. More research should be conducted to investigate whether this is a proper reference. Some subgroups are equally represented in the sample population. For example the two function-subgroups (employee or student), this subgroup classification will also subdivide the age automatically to under 27 years and above 27 years. These subgroups are similar represented in the database according to the population at the TU/e.

4.3 Respondents' commuting behavior

The current travel behavior of the respondents is presented in this section by means of the results of the survey. First, the frequency of commuting trips made to the TU/e campus is shown (figure 4.2). Second, the transportation modes used to make the commuting trips to the TU/e campus will be explained. And all these results are compared with the results of the 'Mobiliteitsenquête TU/e 2016' (TU/e, 2016), which show the commuting habits of the TU/e population.

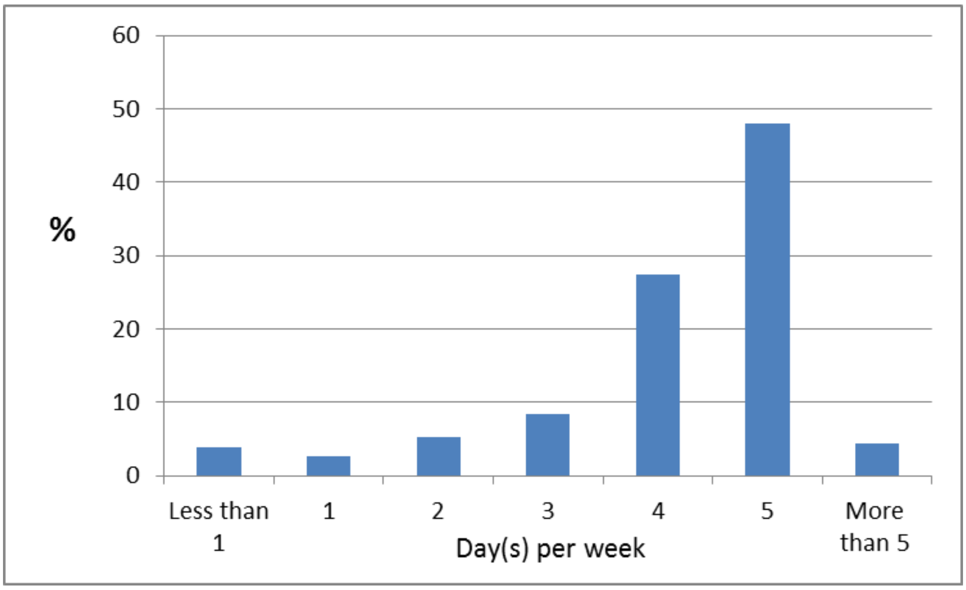


Figure 4.2: Commuting transportation frequency

The commuting frequency in figure 4.2 shows that 52% of the respondents commute 5 days per week or more to the TU/e campus. The 'Mobiliteitsenquête TU/e 2016' stated that 54 % of the employees work 5 days or more per week at the TU/e campus. 46% of the students commute to the

TU/e campus at least 5 days per week. With a simple calculation, this means that 48% of the target population at the TU/e commutes 5 days per week or more to the TU/e campus.

In the 'Mobiliteitsenquête TU/e 2016' different scales are used to measure the commuting distances of the employees and students from their residential locations to the TU/e campus. To simplify these results, it could be concluded that the biggest part of the TU/e population lives close to the TU/e campus (56% of the employees commute less than 7 km and 64% of the students commute less than 8 km to the TU/e campus). In figure 4.3, the results of the research sample is given.

The research sample shows that 51% of the respondents travels 10 km or less to the TU/e campus. And a remarkable detail is that the second most commuting distance is more than 50 km (22%), this could be the fact because a large number of students receive a free public transportation pass while studying. This could also be concluded from the results of the commuting transport modes, the second most used transport mode is the train, as shown in figure 4.4.

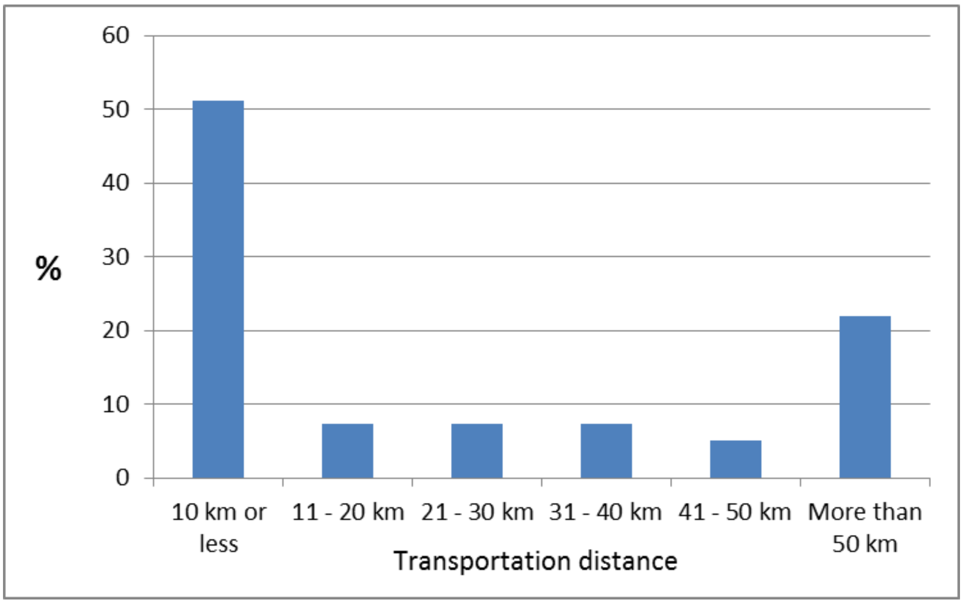


Figure 4.3: Commuting transportation distance

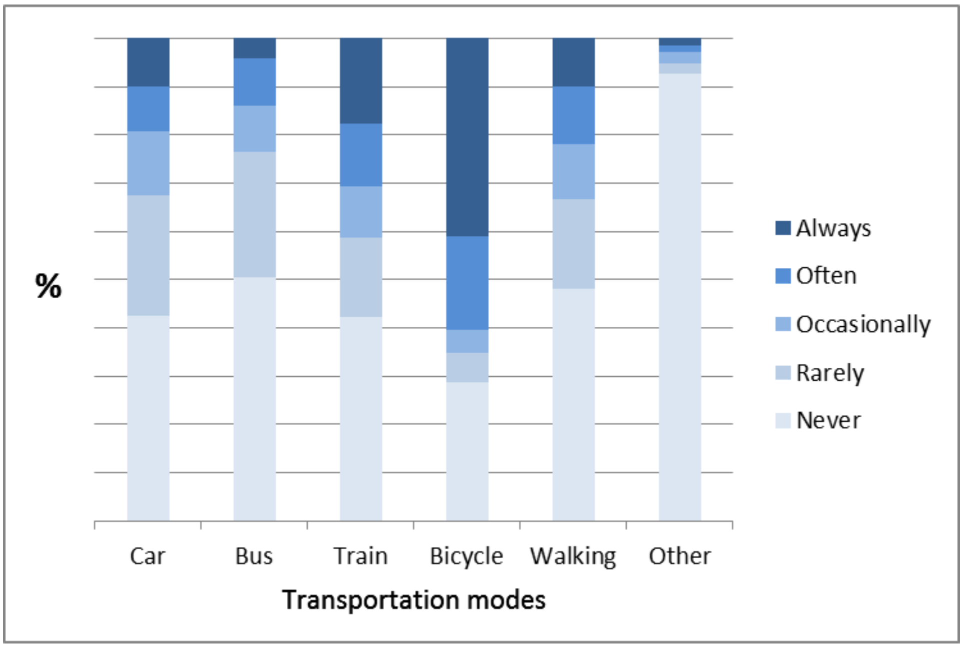


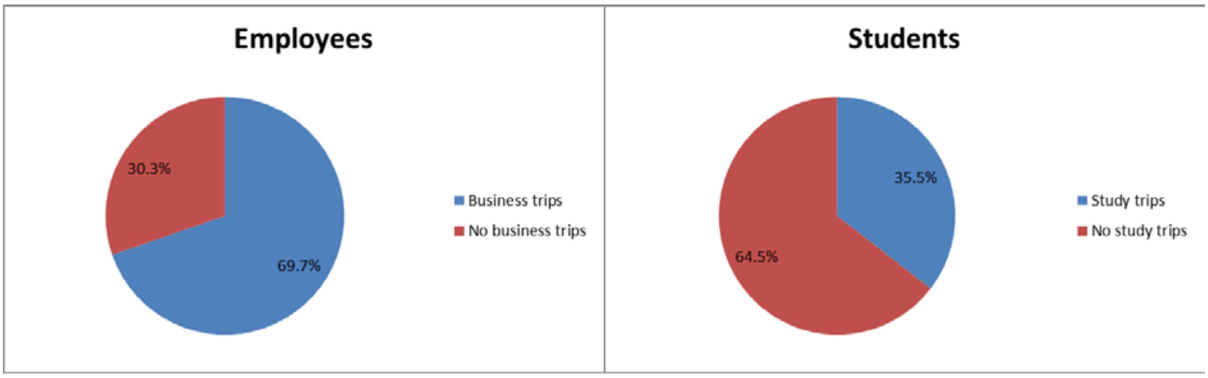
Figure 4.4: Commuting transportation modes

The most used commuting transportation mode is the bicycle, this transportation mode is appropriate for the short commuting distances. 42% of the respondents stated that they always use the bicycle as commuting transport mode.

About car commuting, 'Mobiliteitsenquête TU/e 2016' stated that 35% of the employees always use the car and 62% sometimes use the car as commuting travel mode. For the students, 5% use the car always and 25% sometimes as commuting travel mode. A simple calculation results in the insight that 34% of the TU/e population sometimes use the car as commuting travel mode. In this research, the results show that 57% of the respondents use the car at least rarely for commuting.

4.4 Respondents' behavior towards business and study trips

The third part of the descriptive analysis is about the behavior of the respondents towards business and study trips. To clarify, the employees have the possibility to make business trips and the students have the possibility to make study trips. These are trips with business or study purposes, mostly starting from the TU/e campus to another destination. As shown in Appendix 6, 47% of the respondents make such trips, mostly national trips. Figures 4.5 and 4.6 show that employees have a more active behavior towards business trips than students towards study trips.



Figures 4.5 and 4.6: the behavior towards trips for employees and students.

The research of TU/e (2016) 'Mobiliteitsenquête TU/e 2016' only explored the behavior of the employees towards business trips. A quarter of the employees never make business trips and 39% of the employees make business trips several times per year. 18% of the employees makes a business trip once per quartile and the most used transport modes are the train (57%) and the car (25%). The results of this research state that 30% of the employees never make business trips.

To get more insights in the frequency, distance and used transportation modes of the trips in this research, they are subdivided in national and international trips.

National trips

From all the respondents who make business or study trips, 84% make business or study trips within the national border. Most respondents make a national business or study trip once per quartile, as shown in Appendix 6. This is most frequently done within a range of 100 km from the starting destination (TU/e campus). Figure 4.7 indicates that the most used transportation mode for the national business and study trips is the train, followed by the car. A rental/sharing car is not frequently used what shows that there is some potential for the rental/sharing car to overtake from the frequently used car.

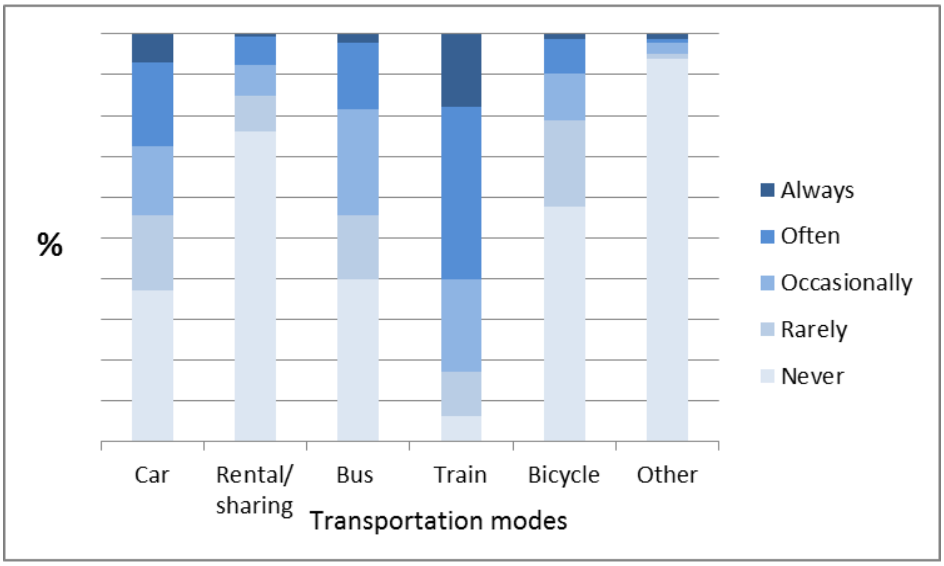


Figure 4.7: The used transportation modes for national trips

International trips

From all the respondents who make business or study trips, 47% make business or study trips abroad. International trips are made less frequently than national trips, only 16% make international trips once per quartile or more frequently, while 22% does make an international trip less than one time a year. The distances of international trips have a wide range, almost every distance above the 250 km is distributed equally. Together with the used transportation modes for international trips, this could be clarified. The most used mode is evidently the airplane (figure 4.8), this transportation has a wide range of approachable distances. So a lot of possible distances could be travelled. The difference between car usage and rental/sharing car usage, shows again some potential for the rental/sharing car for international business and study trips.

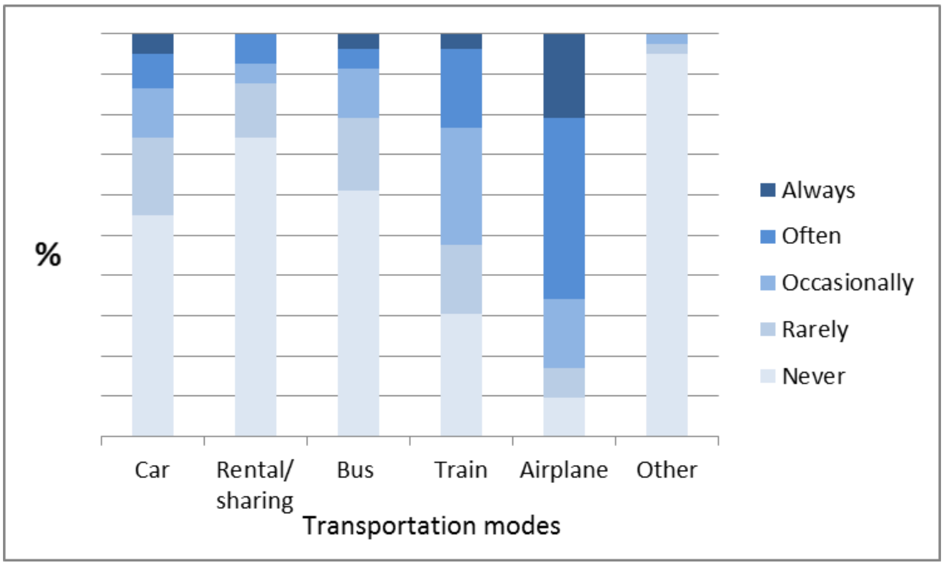


Figure 4.8: The used transportation modes for international trips

Rental/sharing car

From figures 4.7 and 4.8 could be concluded that there is some potential market for the supportive car system, because there are people making trips with their cars, but also with rental and sharing cars. In fact, 56 respondents stated that they use rental/sharing cars for business and study trips. As shown in Appendix 6, most respondents use rental/sharing cars 3 times or less per year and the most important reasons to choose a certain rental/sharing company are the prices and the location of the sharing car/car rental.

4.5 Conclusions

From the descriptive analysis, it could be concluded that the research sample shows some resemblance to the TU/e population. This population is not equal with the general population in the Netherlands, because younger ages and higher educated people are over-represented. The behavior of the respondents according commuting and business/study trips is very resemble with the recent research 'Mobiliteitsenquête TU/e 2016' of the TU/e (2016). The numbers of transportation frequency, distances and used modes are in compliance with each other. Some subgroups are (almost) equally distributed in the dataset and would be worth it to analyze and compare them, to get insights in the optimal setting for the Supportive Car System in the next chapter. The following subgroups divisions are distinguished:

I. The function or relation with TU/e (employee/ student). People with paid employment versus student are interesting, because they have a different amount of money to spend on the SCS.

II. The frequency of commuting days of the people with a connection to the TU/e and the campus (4 days or less per week/ 5 days or more per week). This distribution goes with the classical distribution of part-time and full-time work weeks. It is interesting to see if people who are more frequently present at the TU/e campus show more interest in the SCS and if they prefer other settings or not, so the SCS could be adapted to these preferences.

III. The commuting distance of the respondents, from home to the TU/e campus (10 km or less / 11 km or more). Different transportation modes have different accessibility (Goudappel Coffeng, 2008), maybe this will affect the preferences of the respondents towards the SCS.

IV. The commuting transportation modes of the respondents, if they commute by car or commute with another transportation mode, as public transportation or bicycle (car commuters/ non-car commuters). The subgroup of car commuters is interesting, because the second research questions is to find if the SCS could discourage car commuting. Differences in preferences for these subgroups could be interesting to find the best SCS setup as TDM measure.

V. If the respondents make business/study trips or not (trips/ non-trips). According to Olsson (2003), the need of travel during work hours is important in someone's choice for commuting transportation mode. According to the TU/e (2017) there is a market potential for the SCS for business/study trips. The subgroups (trips versus non-trips) maybe have different preferences towards the SCS focused on the flexibility and convenience (Ye, 2010).

VI. The age of the potential adopters of the Supportive Car System could give interesting insights. For example that younger people show more affection with innovations (as the SCS). As Dieten (2015) described that younger people are the early adopters of the shared-used vehicles. There are more younger people (students) than older people at the TU/e.

VII. Gender is a demographic characteristic of the respondent that cannot be changed. There are a lot more males than females at the TU/e, it is interesting what the differences towards a SCS are of the two different genders.

5. Model analysis

5.1 Introduction

The main goal of the research is to identify in what extent individuals prefer certain setups and attributes of a Supportive Car System (SCS). The results of the stated choice experiment are investigated with the help of a multinomial logit model. With the help of the fifth version of the NLOGIT® Software (Econometric Software, Inc., 2012), the results are generated. In this chapter, the results are shown. First, the model performance of the general model is analyzed, with the help of the Likelihood Ratio Statistic (LRS) and the Rho-squared. This is to test the model with the null-model and the likelihood ratio index, to test how well the model fits the data. Second, the preferences of the respondents for the attribute levels are shown. A value higher than 0 means a high affection towards an attribute level. A negative number means aversion. The higher or the lower, the more affection or aversion towards an attribute level. Not all parameters are significant at a 90% level according to the Multinomial Logit (MNL) model. So with the significant parameters, the part-worth utilities and the relative importance of the attributes could be calculated. This is done with the help of effect coding (table 3.2). Third, the steps above are executed for several more specific sub models. Fourth, the mode change probability of car commuters is calculated.

5.2 General model

5.2.1 Model performance

The model goodness of fit is measured by checking the Ratio Statistic and the Rho-squared. This is done with the help of the log-likelihood of the optimal model (LL(ß)), calculated as presented in equation 9 and obtained from the output of the NLOGIT® model (shown in Appendix 9). Another parameter is the log-likelihood of the null-model (LL(0)), calculated with the natural logarithm of 0.5 (equation 10). Because the probability of choosing an alternative when two alternatives are presented is fifty percent. The log-likelihood of the null-model, means that all parameters are set to zero. This results into an equal probability for each alternative presented to the respondents.

Likelihood Ratio Statistic

The Likelihood Ratio Statistic (LRS) is used to test whether the approximations of the model are accurate enough. The LRS is described in equation 11 and is used to compare the performance of different subsets of variables. With this test the null-model and the optimal model will be compared to check whether the attributes and attribute levels contribute to the model or not. The log-likelihood of the null-model is -1592.85 and the log-likelihood of the optimal model is -1256.40, the optimal model is better since this value is closer to zero. These log-likelihoods result in a LRS of 672.91, this statistic is Chi-square distributed. The critical Chi-square with the degrees of freedom and a chance on error of 0.05 are compared with the LRS to test the performance of the model. The degrees of freedom are obtained from the Nlogit output and is 17 (Appendix 9). The critical Chi-square belonging to 17 degrees of freedom and chance error of 0.05 is 27.59. Because the LRS of the optimal model is higher than the critical Chi-square, the optimal model perform significantly better than the null-model. As the Chi-square statistic of 672.91 exceeds this critical value (27.59), the null hypothesis is rejected and it could be concluded that the results of the research (output of the model) are performing significantly better than having no model at all.

Rho-squared

The Likelihood Ratio Index or the Rho-squared is often used with discrete choice models to predict observed behavior. With the help of the McFadden's Rho-squared (equation 12) it is measured how well a model fits the data. It measures how well the model with estimated parameters performs compared with the null-model in which all parameters are zero, the null model. This comparison is made on the basis of the log-likelihood function of the optimal model and the null-model. With the Rho-squared it could be stated how well the model predicts. The value of the Likelihood Ratio Index could range from zero to one, a value of 0.2 or higher is preferred (Train, 2009) and values between 0.2 and 0.4 are normally seen as excellent fits (Ortúzar & Willumsen, 2011). The Rho-squared is 0.21. The value above 0.2 states that the model fits the observed behavior excellent and it proves that the model performs better than the null-model.

5.2.2 Attribute performance

After checking the model performance of the general model, the choices and preferences of the respondents could be analyzed. The results of the MNL model are shown in table 5.1. The parameters of the attribute levels with their level of significance are shown, together with the overall range (highest minus lowest parameter). The estimates (β) are the parameters, which show the preferences for the attribute levels. The strength of preference is indicated by the β-estimate, a higher β-estimate indicates a stronger preference. If the estimate is negative, it shows aversion caused by the attribute level.

By attributes with three levels, the values of every third attribute level of the attributes (indicated with an asterisk) were calculated by summing the estimates of the first two estimates multiplied by -1 so that all the estimates of an attribute together are 0. By attributes with two levels, the first attribute level is the negative of the estimate (multiplied with -1), while the second attribute level (indicated with an asterisk) is the estimate. The used effect coding is explained in section 3.3.3 (and table 3.2).

All the attributes included in the model gave significant attribute levels, indicating that all attribute levels contributed to the choice to a statistical significant extent. The level of significance used in this research is 0.10, this means a confidence level of 90 percent is used. The bold parameters in table 5.1 are significant. The fact that attributes showed little significance for some of the attribute levels indicates that those levels were not different from zero and thus have equal influence on the overall utility. The insignificant attribute levels were set to zero. In Appendix 10, the estimates of all attribute levels (also insignificant) of all attributes of all models (also sub models) are given.

Looking at the significant attribute levels in table 5.1, the first noticeable thing is that 4 attributes have attribute levels with higher estimates than the rest. The attribute levels of €0.30 per km, availability of 24/7, €4 per hour and an electrical vehicle have by far the highest estimates. The probabilities that these attribute levels contribute in selecting a SCS are the highest.

From the literature review about the SCS attributes in section 2.5.3 was concluded that that a low price per hour and km, walking time to the car and an electric car have significant influence on selecting a shared-use vehicle (Dieten, 2015). This research shows that there are more attribute levels that are of significant importance to selecting a SCS. First, the exterior of the car influences the choice for a SCS. A car with only a company logo on the outside is more likely when selecting a SCS. Second, the type of car contributes in selecting a SCS, a luxurious car has the highest probability to be chosen. Third, how to gain access to the car and the reservation possibilities are of influence, a SCS with a mobile application to access the car and to reserve the car are more likely. Fourth, a car available 24 hours a day, 7 days a week, for all possible trip purposes contributes to the probability that a SCS is chosen.

A visualization of the probability that an attribute level contributes to that an offered SCS is chosen, is shown in figure 5.1. The gradient of the graphs indicate the importance of the attribute. From the results can be easily noticed how big the effects of the attribute levels are on choosing for a SCS.

Table 5.1: The results from the MNL model for the general model

Attribute	Level	β	Sign.	Range
Location (walking time)	1 minute	**0.2920**	0.0000	0.5841
	5 minutes	0.0000	0.6940	
	9 minutes*	-0.2920		
Advertisements	No ads	0.0000	0.7306	0.2114
	TU/e logo	**0.1057**	0.0885	
	Full*	-0.1057		
Cartype	Standard	0.0000	0.5318	0.2237
	Luxurious	**0.1119**	0.0192	
	MPV*	-0.1119		
Price/hour	€ 4	**0.4711**	0.0000	0.7944
	€ 5	**-0.1478**	0.0306	
	€ 6*	-0.3233		
Price/km	€ 0.30	**0.5357**	0.0000	1.0714
	€ 0.40	0.0000	0.7131	
	€ 0.50*	-0.5357		
Fuel type	Petrol	**-0.4037**	0.0000	0.8075
	Hybrid	0.0000	0.8073	
	Electric*	0.4037		
Accessibility	Key exchange	**-0.2821**	0.0000	0.5643
	Mobile access*	0.2821		
Availability	24 hours 7 days	**0.4775**	0.0000	0.9550
	Working hours*	-0.4775		
Reservation	Telephone	**-0.2207**	0.0020	0.4415
	E-mail	0.0000	0.5381	
	Application*	0.2207		
Trip purposes	Business/study	**-0.2623**	0.0000	0.5245
	All trips*	0.2623		

Degrees of freedom	17	*= the β-values of these levels are
LL(β)	-1256.3976	calculations, based on the other
LL(0)	-1592.8522	significant parameter(s).
Rho-squared	0.2112	Calculated by the effect coding
Adjusted rho-squared	0.1745	from table 3.2.
LRS	672.9092	

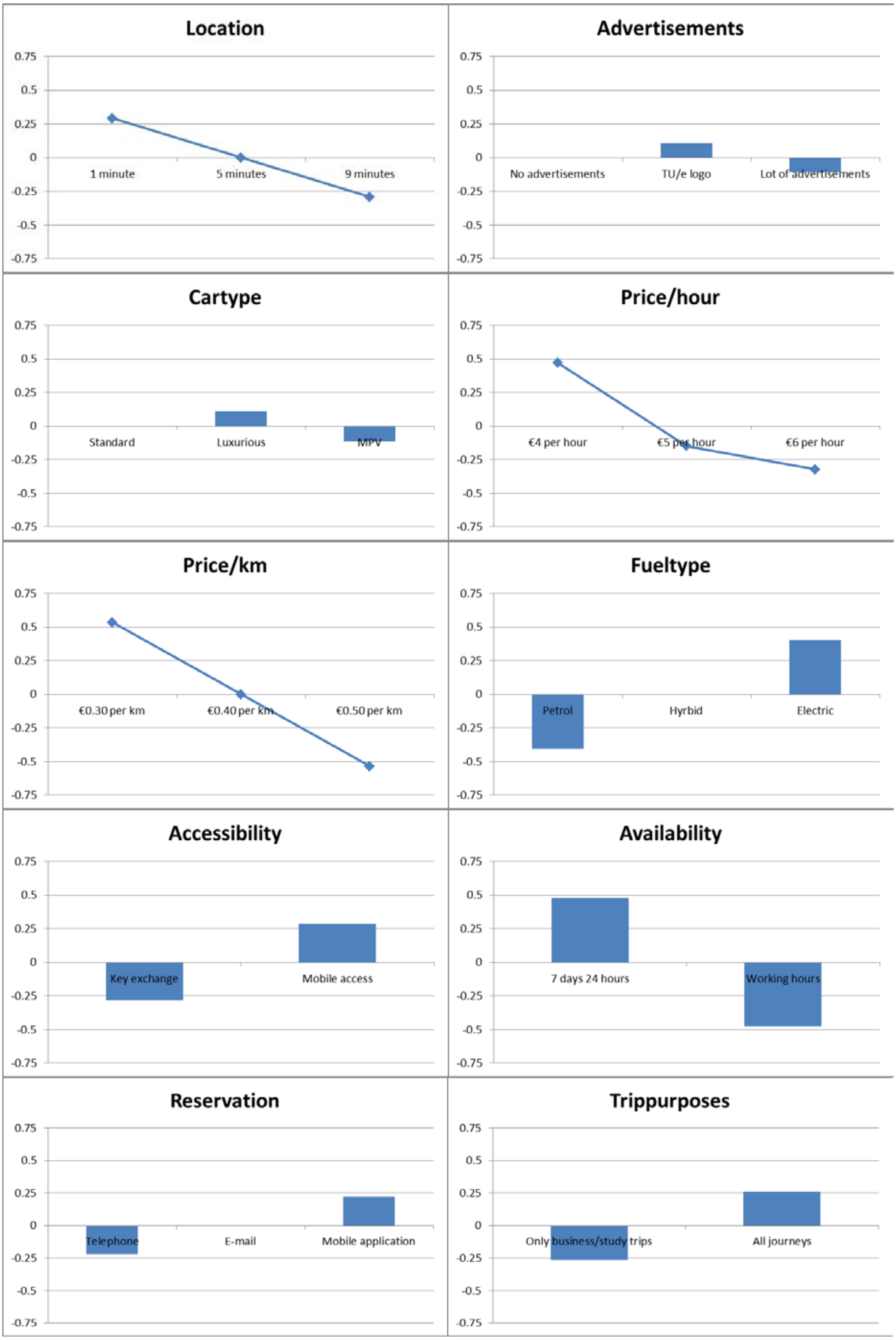


Figure 5.1: Graphical visualization of the part-worth utilities of the attribute levels

Figure 5.1 shows some expected results. The respondents prefer cheaper options of the SCS, a system that is close to their working place and is easily accessible and anytime available. It is also remarkable that the step of Price/hour from €4 to €5 is much bigger than the step from €5 to €6. The respondents would like to have access to the SCS for all the journeys and they choose for electric fueled cars. The respondents' preferences towards advertisements on the car and type of car are a TU/e-logo on a luxurious car, according to the found part-worth utilities.

Now that all attributes and attribute levels that influence SCS choice are discussed, the impact that the attributes have on the choice will be explained. The impact that attributes have indicate the weight of the contribution to the SCS choice. Figure 5.2 shows the importance of each significant attribute of the research. The impact of the attributes on the SCS choice was indicated by calculating the range between the highest and lowest estimated utility of the attribute. The bigger the range, the bigger are the differences in influence (impact) of the attribute when selecting a SCS. The 4 attributes have the most impact when selecting a SCS are; Price/km-tariff, Availability, Price/hour-tariff and Fuel type. So it is likely that if the Price/km-tariff is low, the offered SCS is chosen. From the results can be easily noticed how big the effects of the attributes are on choosing for a SCS. People weight less value on the type of car and advertisements on the car. It is possible that respondents choose a SCS that is a MPV with a lot of advertisements, if other attributes are satisfying the preferences of the respondent.

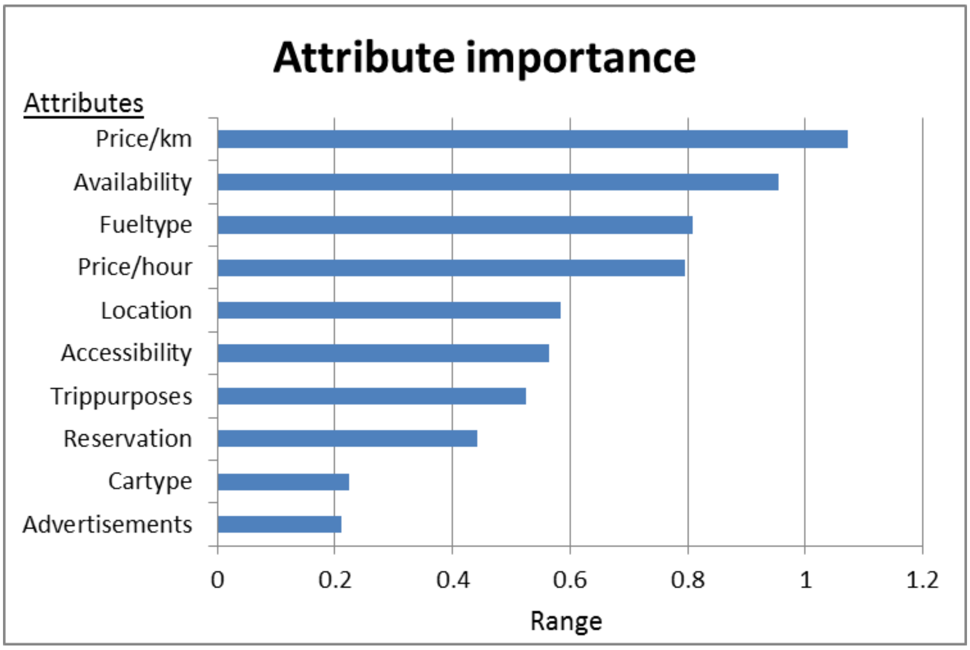


Figure 5.2: Importance of the attributes

5.3 Specific models

Now that the main effects of the Supportive Car System (SCS) attributes are estimated, it is of interest to find significant differences between several subgroups within the sample. First the model performance of all models of the subgroups will be discussed and afterwards the attribute performances will be described, analyzed, interpreted and compared.

The subgroups are explained in the conclusions of chapter 4:
- relation with the TU/e (employees versus students);
- commuting frequency of the respondents (4 days or less per week versus 5 days or more per week);
- commuting distance of the respondents (10 km or less versus 11 km or more);
- commuting mode of the respondents (car commuters versus non-car commuters);
- behavior towards business/study trips of respondents (trip-makers versus no trip-makers);
- age of the respondents (26 years or younger versus 27 years or older);
- gender of the respondents (male versus female).

5.3.1 Model performance

The model goodness of fit is measured by checking the Ratio Statistic and the Rho-squared. The Likelihood Ratio Statistic (LRS) (equation 11), the Rho-squared (equation 12) and the McFadden's adjusted Rho-squared (equation 13) are taken when the sub models are compared. The Rho-squared could be misleading, because the more predictors in the model the higher the Rho-squared, so a better fit. The model could be overfitting, so the adjusted Rho-squared penalizes you for adding independent variables, by taking the number of degrees of freedom into account. The Rho-squared, adjusted Rho-squared and the LRS values of all sub models are shown in table 5.2. The degrees of freedom, LL(ß), LL(0) per sub model can be found in Appendix 11.

Table 5.2: Comparison of the (adjusted) Rho-squared and Likelihood Ratio Statistic.

Model	Rho-squared	Adjusted rho-squared	LRS
General	0.2112	0.1745	672.9092
Employee	0.1713	0.1327	188.1165
Student	0.2490	0.2140	519.8093
0-4 days	0.1992	0.1619	301.6161
5 days +	0.2270	0.1910	379.5619
0-10 km	0.2199	0.1835	358.4207
11 km +	0.2107	0.1739	327.7174
Car	0.2336	0.1979	427.3871
No car	0.2328	0.1971	315.6630
Trips	0.1963	0.1589	284.1561
No trips	0.2373	0.2018	392.7949
0 - 26 year	0.2141	0.1775	448.8219
27 year +	0.2174	0.1810	236.9276
Male	0.2137	0.1771	476.4052
Female	0.2342	0.1985	223.9832

The critical Chi-square for all the sub models is 27.59. Because the LRS of all the models is higher than the critical Chi-square, the models perform significantly better than the null-model. The null hypothesis is rejected and it could be concluded that the results of all sub models (output of the models) are performing significantly better than having no model at all.

The value of the Rho-squared could range from zero to one, a value of 0.2 or higher is preferred (Train, 2009) and values between 0.2 and 0.4 are normally seen as excellent fits (Ortúzar & Willumsen, 2011). Almost all Rho-squared values are above 0.2, this states that the model fits the observed behavior excellent and it proves that the model performs better than the null-model. Some Rho-squared values are close to 0.2, so the models are predicting weaker, but they are still performing well. Train (2009) stated that a value between 0.05 and 0.2 is moderate in predicting observed behavior.

Comparing the adjusted Rho-squared of the sub models with each other, it is noticeable that the sub models with more respondents score better than the sub models with less respondents. For example the amount of student (251) is higher than the amount of employees (121), so this model is better in predicting observed behavior.

5.3.2 Attribute performance

After checking the model performance of the sub models, the choices and preferences of the respondents can be analyzed. The focus is on differences between sub models and extraordinary differences between a sub model and the general model.

In the sub models, not all attributes gave significant attribute levels, indicating that not all attribute levels contributed to the choice to a statistical significant extent. The level of significance used in this research is 0.10, this means a confidence level of 90 percent is used. In Appendix 10, the estimates of all attribute levels (also insignificant) of all attributes of all models (also the general model) are given.

The results of all significant parameters of the sub models are shown in Appendix 11. The parameters of the attribute levels with their level of significance are shown, together with the overall range (highest minus lowest parameter). The insignificant attributes show that those levels were not different from zero and thus have equal influence on the overall utility. The insignificant attribute levels were set to zero.

In all sub models, when an attribute is significant, it shows attribute levels with estimates in the same direction (positive or negative) as the general model. Therefore, only big differences between the sub models or with the general model are discussed in this section.

Relation with TU/e

In the research, 122 employees and 251 students responded to the survey. A visualization of the contribution of an attribute level to the probability than a SCS will be chosen, is shown in figure 5.3. This figure shows the significant part-worth utilities per subgroup. The length of the bars in the figure indicates the importance of the attribute level. From the results it can be easily noticed how big the effect of the attribute levels are on the probabilities of choosing a certain SCS.

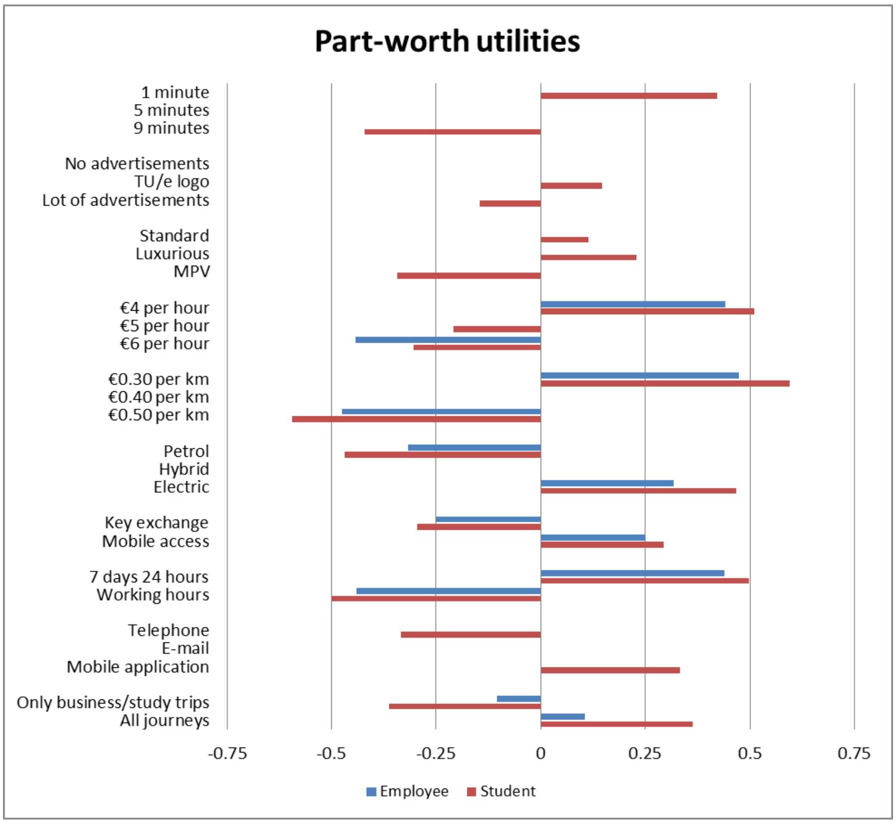


Figure 5.3: Part-worth utilities of the attribute levels for the relation subgroups

Figure 5.3 shows significant differences between students and employees. The subgroup of employees show some insignificant attributes, in contrast with the students. The attributes of car location, advertisements, car type and reservation tool have no significance for the preferences of the employees. The part-worth utilities show that the students are more decided than the employees, because the values are more extreme according to the employees. The students prefer a lower price more than employees, but they have less aversion against higher prices than employees. The noticable difference between the students and employees is related to trip purposes, maybe because students make less trips. The students prefer the reservation possibility with a mobile application. This could be clarified by their younger age and more affection with new technology than the employees. It is remarkable that students find that the location of the car is of relative high importance. Students are far more decisive in their opinion than employees.

Commuting frequency

From all respondents, 201 commute at least 5 days per week to the TU/e campus, 182 commute less than 5 days. A visualization of the contribution of an attribute level to the probability that a SCS will be chosen, is shown in figure 5.4.

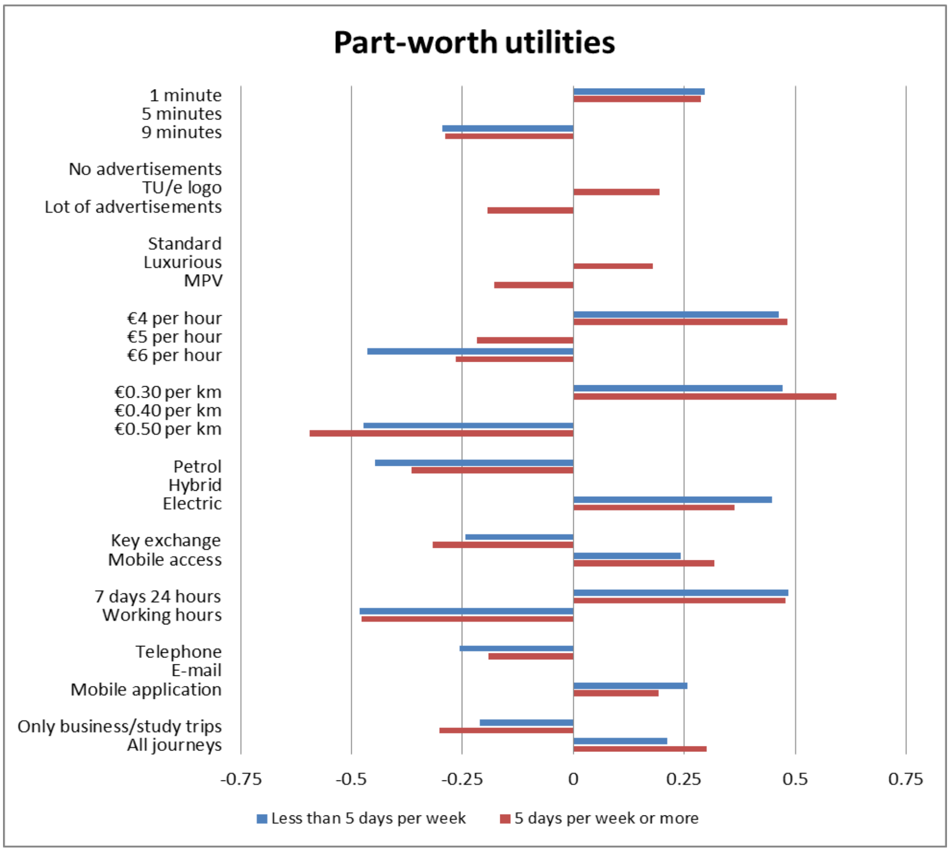


Figure 5.4: Part-worth utilities of the attribute levels for the frequency subgroups

The part-worth utilities show quite the same importance of the attribute levels for both subgroups. Some attributes are insignificant for the subgroup of less than 5 days commuters, while all the attributes are significant for the subgroup that frequently commute to the TU/e campus. The attributes of advertisements and car type have no significance for the preferences of the less than 5 days commuters. The big differences are in these two attributes, where the more frequently commuters are more decisive. It is also interesting that with a tariff systems per hour, the more frequently commuters have lower aversion against higher prices, while with the price per km they show more affection with lower prices. For the more frequently commuters, the lower tariffs result in a higher probability that a SCS will be chosen.

Commuting distance

196 of the respondents live closer than 10 from the TU/e campus, 187 of the respondents commute more than 10 km. A visualization of the contribution of an attribute level to the probability that a SCS will be chosen, is shown in figure 5.5.

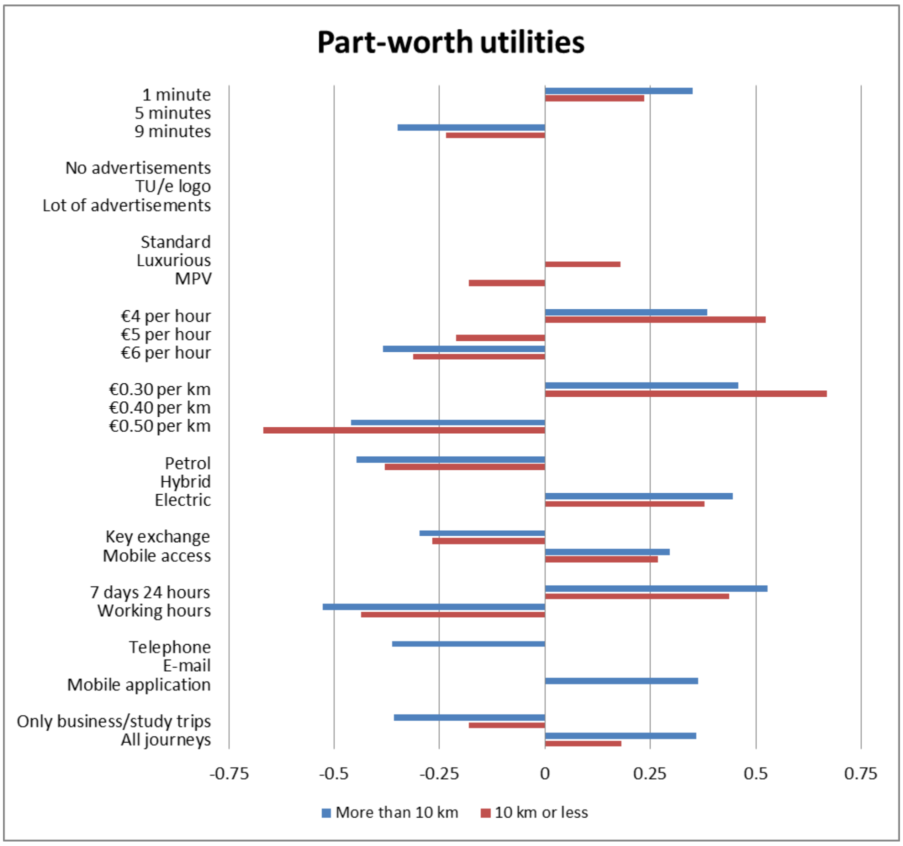


Figure 5.5: Part-worth utilities of the attribute levels for the distance subgroups

Both outputs of the models show some insignificant attributes. For the long distance commuters, the attributes of advertisements and car type are not significant. For the short distance commuters, also the attribute of the advertisements and the attribute of reservation mode are not significant. There are significant differences between the two subgroups. The part-worth utilities of the respondents who live close to the TU/e campus show that they prefer low prices of the SCS. The contribution of a €0.30 per km tariff is extraordinary high for short distance commuters, when selecting a SCS. For the respondents who live further from the TU/e campus a SCS, close to the working location and usable for every trip purpose, show higher utilities than for the respondents who commute shorter distances. Compared with the short distance commuters, the long distance commuters are more interested in the attributes of reservation possibilities and usability of the SCS for trip purposes.

Car commuting

From all respondents, 220 of the respondents stated they use (at least sometimes) the car to commute to the TU/e campus and 163 never use the car as commuting mode. A visualization of the contribution of an attribute level to the probability that a SCS will be chosen, is shown in figure 5.6.

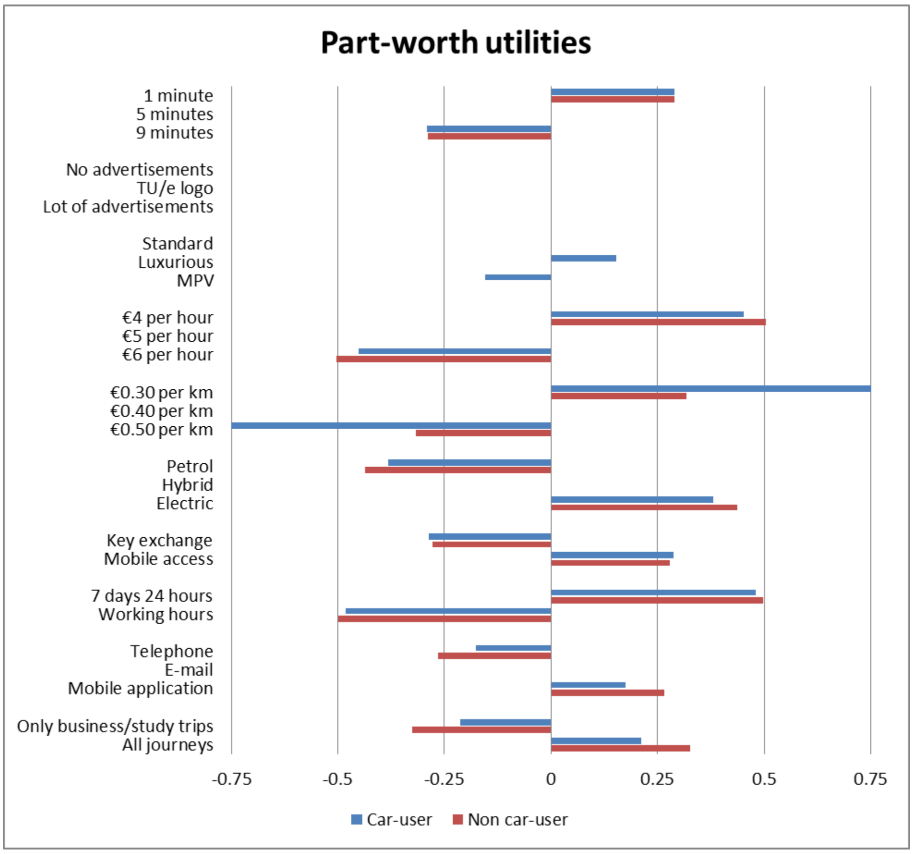


Figure 5.6: Part-worth utilities of the attribute levels for the car- user subgroups

The output of both models show some insignificant attributes. For the car commuters, the attributes of advertisements are insignificant. This attribute is also insignificant for the non-car commuters, while the car type attribute has also no significance. The rest of figure 5.6 states there a no significant differences between car and non-car commuters, except for one: Car users think that the price per kilometer tariff is of very high importance. They show the most affection of all models with the €0.30 per km tariff and the most aversion with the €0.50 per km tariff. This could be probably because they have reference values with their personal car.

Business/study trips

The behavior of the employees and students towards business and study trip behavior stated that 174 respondents make business/study trips and 199 never make such trips. A visualization of the contribution of an attribute level to the probability that a SCS will be chosen, is shown in figure 5.7.

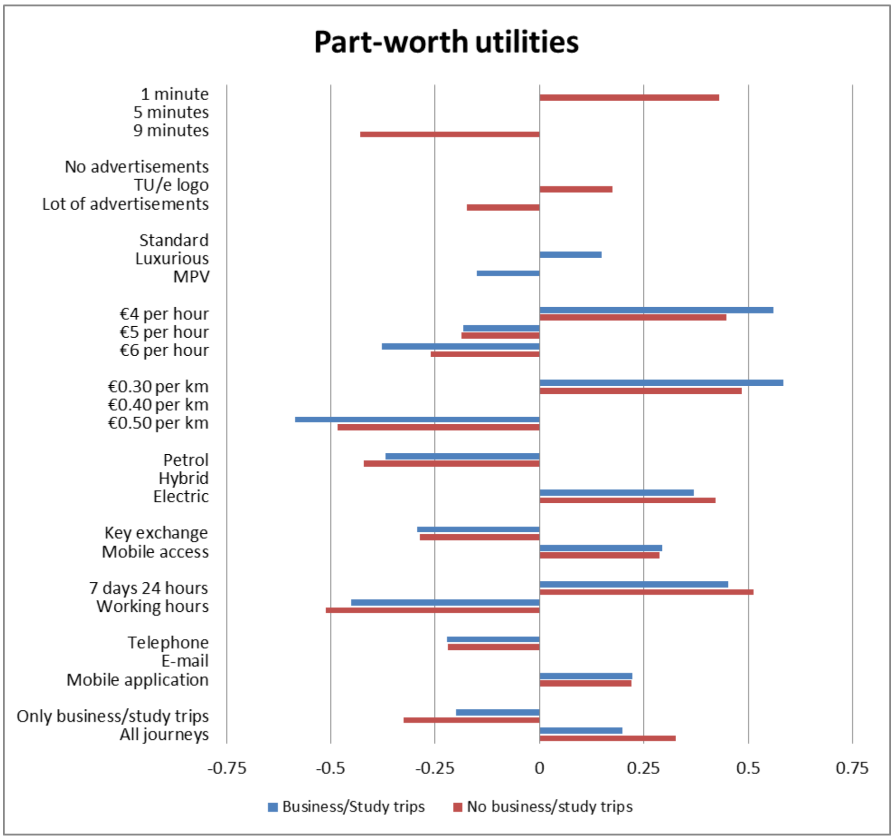


Figure 5.7: Part-worth utilities of the attribute levels for the trip subgroups

The output of both models show some insignificant attributes. For the business/study trip makers, the attributes of car location, advertisements and type of car are insignificant. The respondents who does not make business/study trips only have insignificant values for the attribute of car type. It seems to make sense that the respondents who do not make business or study trips prefer that the SCS that is also available for other trip purposes has higher utilities than a SCS which only could be used for business and study trips. However, the utilities for the prices of the SCS are higher for business and study trips makers, because they have reference material of other transportation modes to make those trips with.

Age

In the research, 252 respondents have an age of 26 years or younger, 131 respondents have an age of 27 years or older. A visualization of the contribution of an attribute level to the probability than a SCS will be chosen, is shown in figure 5.8.

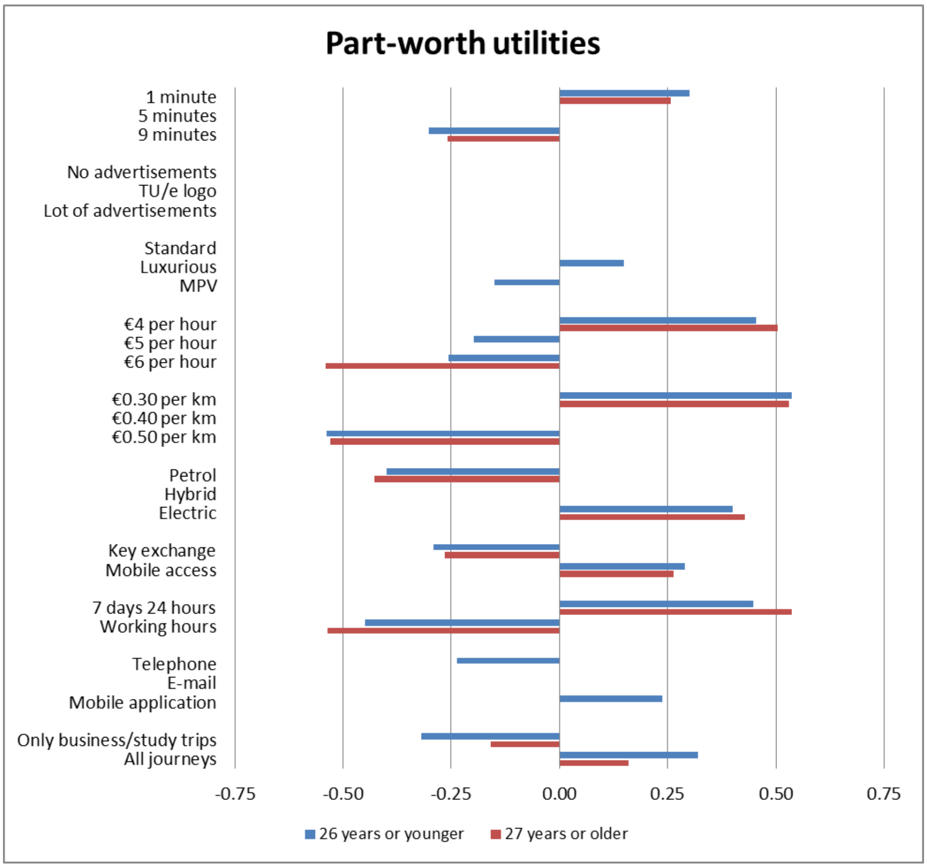


Figure 5.8: Part-worth utilities of the attribute levels for the age subgroups

The output of both models show some insignificant attributes. For both subgroups the advertisements are insignificant, the older respondents also show insignificance for the type of car and the reservation system. A lot of attribute levels show similarities, but there are also some important differences between the younger and older people. The affection and aversion towards the price tariffs are similar for both subgroups, there is only an exeptional case for the aversion of older people againt expensive hour-tariffs. The part-worth utilities for the two mobile related attribute levels (mobile access and mobile application for reservation) show higher utilities for the younger people. This could maybe be clarified by their younger age and more affection with new technology than the older people. For younger people, the possibility to make all journeys contributes more in selecting a SCS, maybe because younger people make less trips than the older respondents.

Gender

From all respondents, 268 of the respondents are male and 115 are female. A visualization of the contribution of an attribute level to the probability that a SCS will be chosen, is shown in figure 5.9.

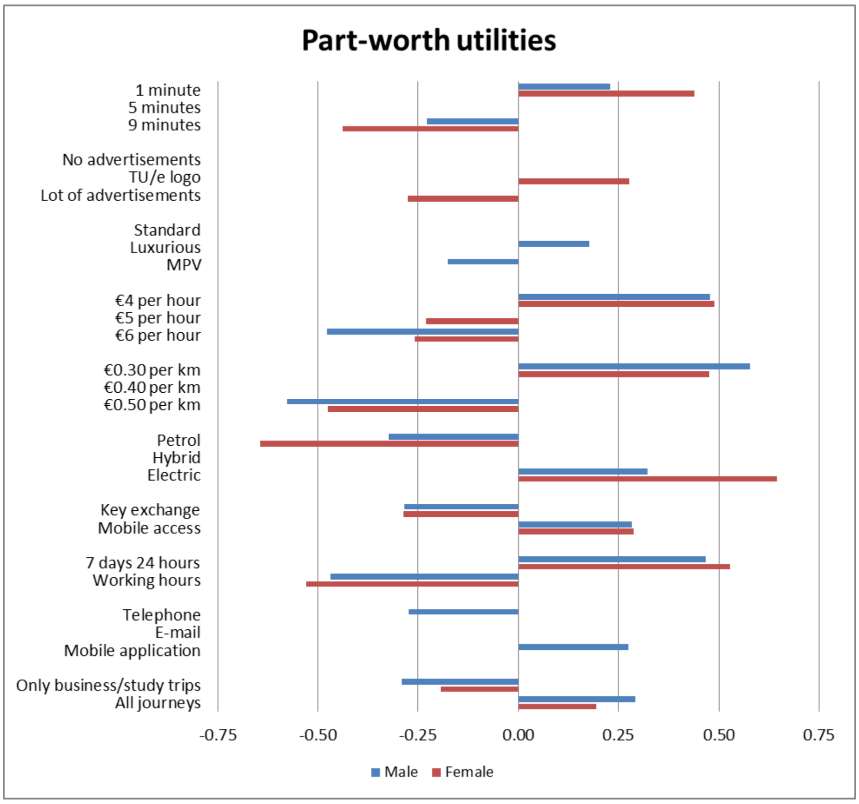


Figure 5.9: Part-worth utilities of the attribute levels for the gender subgroups

Figure 5.9 shows significant differences between males and females. The output of both models show some insignificant attributes. For the male respondents the amount of advertisements on the car is only insignificant attribute. For the females, the type of car and the type of reservation system have insignificant values. Looking at the differences, the females are far more decisive than the male respondents about the walking distance and the type of fuel. The female respondents state that a walking distance of 1 minute and an electric vehicle are contributing more when selecting a SCS. The male respondents, in comparison to the females, show more aversion to the more expensive tariffs and they show more affection to a luxurious car that could be reserved with the mobile application. It is noticeable that females value an electric SCS as the most important characteristic in selecting a SCS.

5.4 Mode change models

As stated in section 5.3.4, there are 220 respondents who commute with their car to the TU/e campus. Because the SCS could be an option to leave the car at home, the car commuters were asked if they would like to commute with an alternative commuting mode to the TU/e campus (bus, train or bicycle) if the preferred SCS is available at the TU/e campus. This questions was asked for all of the six choice sets in the stated choice experiment. So in total, this question was answered 1,320 times. In table 5.3, the frequency of answers and percentage of respondents who would change their commuting is shown (towards which alternative commuting mode).

Table 5.3: Frequency and percentage of mode changers when the preferred SCS is available.

	N	%
No change	545	41.29
Bus	64	4.85
Train	179	13.56
Bicycle	154	11.67
Bus/Train	95	7.20
Bus/Bicycle	58	4.39
Train/Bicycle	103	7.80
Bus/Train/Bicycle	122	9.24
Total	1320	100

The preferences of the car commuters to change to an alternative commuting mode were analyzed with the help of binary logit choice models. Though, the models did show a very low performance. The Rho-squared values were little above zero (<0.1), so the models were unable to predict the observed behavior sufficient. The results of the binary choice models showed contrary results with each other and with the general model (section 5.2). Therefore, it was decided to take the preferred SCS system of all the car-commuters (section 5.2.4) and calculate what the probabilities of the car-commuters are to change to one of the other commuting transportation modes (bus, train, bicycle). The probabilities are shown in table 5.4 and calculated by the following formula (the bus is taken as example): $P_{bus} = 1*\%_{bus} + 0.5*\%_{bus/train} + 0.5*\%_{bus/bicycle} + 0.33*\%_{bus/train/bicycle}$

Table 5.4: Probability of mode change per commuting mode.

	Probability
Bus	0.1372
Train	0.2414
Bicycle	0.2085
No change	0.4129

The car-commuters show the highest probability to change to another commuting mode if the preferred SCS is offered. If a car-commuter want to change to another commuting mode, the train shows the highest probability to change to, followed by the bicycle and at last the bus. More than 40% state that a SCS has no influence on their mode choice and they remain to commute by car.

5.5 Conclusions

The output of all the models (general model and sub models) showed a good performance. The LRS of all models was higher than the critical Chi-square, so all models perform significantly better than the null-model, they perform significantly better than having no model at all. The Rho-squared of all models show that the observed behavior can be predicted good to excellent and it proves that the models perform better than the null-model. The mode change models had very low Rho-squared values, so the mode change models were unable to predict the observed behavior sufficient.

All the researched attributes in the general model were significant. The most influencing SCS attributes and attribute levels are: both the lowest tariff systems, but the price of €0.30 per kilometer has a higher influence than the price of €4 per hour. The availability of the SCS is of very high importance and the type of fuel is also important. The results of the research show that people are obliging to obtain electric cars, a high affection to electric cars is shown and a high aversion to petrol fueled cars. Stated that the availability of the SCS is an attribute with high importance, there is affection with a car that is always available (24 hours per day and 7 days per week).

For the conclusions, an overview table is given with the most important attribute levels of all the models. Only the top 5 of attribute levels with the highest part-worth utilities are taken into the overview in table 5.5. The attribute level with the highest part-worth utility per sub model is the darkest green, descending to the lightest green.

From the table, it is clear that the most popular SCS is an electric vehicle with a mobile application to reserve the car and to get access to the car. The SCS is situated at 1 minute walking distance and costs €4 per hour or € 0.30 per km. The SCS is available for all trip purposes, 24 hours a day, 7 days per week.

On the other hand, the least popular SCS is the opposite of the most popular SCS. This SCS is a petrol fueled car that has to be accessed with a key. The SCS needs to be reserved with telephone contact and is situated at the maximum of 9 minutes walking distance. The SCS has the most expensive tariff systems of €6 per hour or €0.50 per km and is not always available. The SCS is only available during working hours and only it the user want to make business or study trips.

Table 5.5: Overview table of the attribute levels with the highest part-worth utilities

Model	1 minute	€4/hour	€0.30/km	Electric vehicle	Mobile access	24 hours 7 days	Mobile application	All trips
General	**0.2920**	**0.4711**	**0.5357**	**0.4037**	**0.2821**	**0.4775**	**0.2207**	**0.2623**
Employee	0.0000	**0.4419**	**0.4746**	**0.3177**	**0.2500**	**0.4399**	0.0000	**0.1044**
Student	**0.4208**	**0.5118**	**0.5951**	**0.4680**	**0.2950**	**0.4982**	**0.3337**	**0.3631**
0-4 days	**0.2958**	**0.4638**	**0.4727**	**0.4469**	**0.2426**	**0.4853**	**0.2569**	**0.2119**
5 days +	**0.2879**	**0.4835**	**0.5939**	**0.3638**	**0.3179**	**0.4780**	**0.1912**	**0.3016**
0-10 km	**0.3501**	**0.3852**	**0.4593**	**0.4463**	**0.2972**	**0.5277**	**0.3629**	**0.3590**
11 km +	**0.2350**	**0.5234**	**0.6690**	**0.3793**	**0.2675**	**0.4371**	0.0000	**0.1817**
Car	**0.2902**	**0.4515**	**0.7515**	**0.3817**	**0.2872**	**0.4809**	**0.1752**	**0.2123**
No car	**0.2899**	**0.5032**	**0.3175**	**0.4363**	**0.2779**	**0.4981**	**0.2648**	**0.3256**
Trips	0.0000	**0.5605**	**0.5850**	**0.3692**	**0.2943**	**0.4513**	**0.2216**	**0.1990**
No trips	**0.4305**	**0.4475**	**0.4840**	**0.4210**	**0.2878**	**0.5119**	**0.2206**	**0.3261**
0 - 26 year	**0.3009**	**0.4547**	**0.5374**	**0.3998**	**0.2903**	**0.4487**	**0.2371**	**0.3190**
27 year +	**0.2582**	**0.5045**	**0.5298**	**0.4275**	**0.2643**	**0.5361**	0.0000	**0.1586**
Male	**0.2287**	**0.4784**	**0.5774**	**0.3228**	**0.2836**	**0.4678**	**0.2746**	**0.2918**
Female	**0.4387**	**0.4897**	**0.4762**	**0.6449**	**0.2878**	**0.5290**	0.0000	**0.1936**

The results gave some extraordinary findings about some subgroups. So are the students far more decisive in their preferences for a SCS than employees. Short distance commuters and people who make business and study trips add a lot of value on the cheapest tariff systems (€0.30 per km or €4 per hour). While car commuters add extraordinary much value on only the Price per km-tariff system. People who do not make trips for business or study value a SCS that is available for all possible trip journeys higher. The last notable result is that females value an electric SCS as the most important characteristic in selecting a SCS.

People who commute by car were asked if the presence of the preferred SCS contributes that a respondent would commute by another commuting transportation mode (bus, train, bicycle) in the future. The probability to not change the (car) commuting mode is 41%. If a car-commuter is willing to change the commuting mode, the train shows the highest probability (24%), followed by the bicycle (21%), followed by the bus (14%). The most preferred SCS for all the car-commuters is as follows: By far the most important attribute level contributing to selecting a SCS is the €0.30 per km tariff. The SCS needs to be available 24 hours, 7 days a week. Also the € 4 per hour tariff is of high importance, even as that the SCS has to be an electric vehicle. The SCS needs to be accessed with a mobile application, which could also be used to reserve the system. It has to be a luxurious car at 1 minute walking distance and the SCS need to be available for all journeys (see Table 5.5).

6. Conclusions and Discussion

This chapter presents interesting findings and discusses possible answers to the questions. This research has a different approach than asking Supportive Car System (SCS) users about their experiences and characteristics. In this chapter the experiences and characteristics of the respondents are presented and the research questions could be answered. Afterwards the answers are discussed according to their scientific and societal relevance. At the end, the practical and scientific recommendations are given. These recommendations are for the TU/e, other similar companies, carsharing organizations and recommendations for further research.

6.1 Conclusions

All the researched attributes in the general model were significant. This results into an optimal setting for the SCS at the TU/e. It is of high importance that this SCS is set up as follows, ranked from most important attribute level to less important attribute level:

- A low as possible tariff system of the SCS, preferably based on a price per kilometer-tariff (€0.30 per km) than a price per hour-tariff (€4 per hour).
- A SCS that is always available (24 hours per day and 7 days per week).
- An electrical vehicle.
- The SCS needs to be located as close as possible.
- People like a SCS that could be opened with a mobile application, so key exchange is not necessary.
- The SCS needs to be usable for every possible trip purpose.
- The preferred way for people to reserve the SCS is with a mobile application.
- The type of car and advertisements are the least important characteristics of the SCS, but people would like a luxurious car with only a logo of the company on the exterior.

It is also researched if the presence of the optimal setting at the TU/e campus will affect the way of commuting of the students and employees. This was focused on the car commuters and if the presence of a SCS could help to reduce the amount of car commuters. To obtain this result three additional subgroups were selected, people who are willing to change their commuting mode to train, bus and bicycle. The biggest part of the people who commute by car are not willing to change their commuting mode (41%) if the preferred SCS is available. 24% is willing to change their commuting mode the train, 21% to the bicycle and 14% to the bus. The preferred SCS for car commuters is an electric vehicle, available 24 hours, 7 days a week, with the lowest price tariffs (€0.30 per km or €4 per hour). The SCS has a mobile application to reserve and access the car. The SCS is a luxurious car at a short walking distance (1 minute), available for all possible journeys.

With the data, the main research questions as stated in chapter 1 could be answered.

What factors are contributing to peoples' preferences towards a Supportive Car System, supported by companies/organizations, to get the optimal setting of the Supportive Car System?

The optimal setting of a SCS, according to this research is an electric SCS that costs €0.30 per kilometer or €4 per hour. Which is available 24 hours a day, 7 days per week, to be used for every possible trip purpose. The SCS is located at a walking duration of 1 minute from the user's location. The SCS has a mobile application, to reserve the car and unlock the car with. Last, the optimal type of the SCS is a luxurious car with only the logo of the company (TU/e) on the exterior.

But by far the most important factors, also including all sub models are the tariff systems per hour and per kilometer, the type of fuel and the availability of the SCS.

Could the optimal setting of the Supportive Car System help to discourage the car as commuting transportation mode, so employees and students will commute by public transportation or bicycle?

The optimal setting of the SCS could help discouraging the car as commuting traffic. 41% of the car commuters say that they are not willing to change to another commuting mode. 24% of the car commuters say that they would change their commuting mode to the train, 14% say that they would change their commuting mode to the bus and 21% say that they would change their commuting mode to the bicycle. The most important settings to achieve this goal are a price of €0.30 per km or €4 per hour, the availability of the SCS of 24 hours per day, 7 days per week and it has to be an electric vehicle.

6.2 Discussion

In this section, the results will be discussed. Firstly, the scientific relevancy will be paid attention to: how does this research contribute to the existing researches. Secondly, possible reasons on most noticeable or unexpected results are interpreted and what their relevance is for the society. This also includes possible applications of the study.

6.2.1 Scientific relevance

Several researches about carsharing and transportation mode choice have been conducted over the last decades. Most researches explored the optimal settings and distribution of carsharing approaches, but no research was focused on the influence of a carsharing approach on the commuting. This research focuses on the influences of different factors of a carsharing approach as

travel demand measurement (TDM). A carsharing approach at the workplace; a SCS, and what is the optimal setting and could this affect peoples' car commuting behavior.
Another important scientific relevant difference between existing researches and this research, is the focus group. The focus group does not only exist of existing carsharing users, but exists of a wide range of different people with different commuting modes. This gives new insights in the subject, because now a new potential group of SCS users is included in the research.

This was achieved with the help of an alternative research approach, so the most important part of the survey was the Stated Choice (SC) approach. For this approach several of the considered most important attributes for supportive car systems were applied in SC tasks: the location of the car, the presence of advertisements on the car, the type of car, the tariff systems (per hour and per km), the type of fuel, the accessibility of the car, the availability of the car, the reservation possibilities and the trip purposes wherefore the car could be used. New insights were found on the importance of these characteristics at an university campus location, with especially younger people and highly educated people. The research gave some new insights about some subgroups. So are the students far more decisive in their preferences for a SCS than employees. Short distance commuters and people who make business and study trips add a lot of value on the cheapest tariff systems. While car commuters add extraordinary much value on only the Price per km-tariff system. People who do not make trips for business or study value a SCS that is available for all possible trip journeys higher. The last notable result is that females value an electric SCS as the most important characteristic in selecting a SCS.

6.2.2 Societal relevance

The research contributes to a better understanding of Supportive Car Systems, transportation mode choice, TDM measures and mode changes of car commuters. The research contributes to the insights of the importance of SCS characteristics, especially at an university campus. These characteristics were tested as a case study among student and employees at the TU/e campus. This resulted in preferred attribute levels for the whole TU/e population, but also for some subgroups. The selected subgroups in this research are: employees, students, low commuting frequency, high commuting frequency, short commuting distance, long commuting distance, commuting by car, or not, making business/study trips, or not, younger people, older people, males and females.

Some of the SCS characteristics could be verified and quantified, that they are of importance for a population at an university campus. All the SCS characteristics in this research show significant results in contributing when choosing a SCS. The verified and quantified characteristics of a SCS result in the optimal setting of a SCS at the TU/e university campus (as described in section 6.1).

An important part of the research focuses on the relevance of the presence of a SCS in the commuting mode choice behavior, with in particular the specific characteristics of this SCS. There is stated that the rise of private car use is a problem. This problem is still expanding and it is important that environmental friendly alternatives need to be developed and promoted. This research contributes to a SCS at the working location and if it could help to change the trend of an increase of private car use in the Netherlands. Congestion during rush hour is a growing problem, it costs a lot of money and creates irritation and pollution. It is also stated that a car is parked most of the time, what costs a lot of expensive land, especially in urbanized areas. This growing problem need to be dealt with. Therefore TDM measures are introduced. One of those measures is to provide alternative/supporting transportation modes as supportive car systems. People share cars, so there will be less cars, and also less cars on the road leading to less congestion. This research quantified the impact of offering such system on the commuting behavior. To discourage car commuting and offering other alternative transportation modes at the working location, people are willing to commute with other modes as the train, bus and bicycle. Such alternative transportation mode at the working location could be a SCS. The most important aspects of this system to discourage car commuting are a price of €0.30 per km or €4 per hour, the availability of the SCS of 24 hours per day, 7 days per week and it has to be an electric vehicle.

6.3 Recommendations

This section discusses practical recommendations for the TU/e and other similar companies, who want to apply TDM measurements as a SCS. There are also some practical recommendations for carsharing organizations, which characteristics of their systems are interesting and what they need to focus on. Further the possible weaknesses and shortcomings of this research are presented, followed by scientific recommendations for follow-up research.

6.3.1 Practical recommendations

If the TU/e wants an existing company to fulfill the carsharing approach, available at the TU/e campus, they have to compare the research results with the existing carsharing companies. Existing carsharing companies in the Netherlands are compared on the available information for the used attributes in this research. In Appendix 2, an overview of the existing carsharing companies and their approaches is given. If the results from this research are compared with existing carsharing organizations and the alternatives they are offering, the approaches of ‘Amber Mobility’ and ‘We Drive Solar’ fits the best within the TU/e population at the campus. The only consideration to be made is the importance of which tariff system approach versus the type of car (small versus luxurious).

Similar companies who want their employees to reduce car commuting by offering a SCS, could best focusing on the following aspects: an electric vehicle, available 24 hours, 7 days a week, with the lowest price tariffs (€0.30 per km or €4 per hour). The SCS has a mobile application to reserve and access the car. The SCS is a luxurious car at a short walking distance (1 minute), available for all possible journeys.

From the general model and all sub models in this model, some recommendations could be drawn for carsharing organizations. People think that some characteristics of shared-use vehicles are more important than other. The most important characteristics are the tariff systems per reserved hour and the tariff systems per driven kilometer, and they show more affection for lower prices than higher prices. The type of fuel is also of high importance, people like electric vehicles more than petrol fueled vehicles. The most important characteristics of the shared-use vehicle is the availability, people always want a vehicle available when they want to use one, preferably 24 hours a day, 7 days per week. The least important attributes for the shared-use vehicles are the presence of advertisements on the car and the size and type of car, so people are less interested in the car design.

6.3.2 Scientific recommendations

A weakness of this research could be the reliability of the results. This could be because of the small amount of respondents per sub group, or the choice tasks and the presentation were too complex for the respondents. This could be helped with expanding the sample population of the research or changing the choice tasks and the layout. Or the amount of the choice tasks was too many for the respondents, especially for the car-commuters who received extra questions. Maybe the survey effects led to insignificant results, so to help this the survey could be distributed differently, focusing on only car-commuters.

In this research, a multinomial logit (MNL) model was used to analyze the results of the SC experiment. The MNL model is a relatively simple model, which affects the results of the model. A mixed logit (ML) model or Latent Class model does not have some of the MNL model limitations and could fit better (Train, 2009).

To expand the research and make the analysis more complete, there are several ways to expand or change the research. The target population of this research could be changed or expanded. Because a TU/e population differs a lot from the population of other companies. Each company has a different group of employees. Also different respondent groups could be researched or different sub models could be created. Maybe this will lead to interesting findings. Also different models could be researched, where some of the attribute are taken out, especially the costs attribute. It is of general knowledge that people prefer the cheapest option, so this will maybe result in different important attributes.

There are always options to remove or add different attribute levels into the research and maybe it is interesting to investigate other attribute levels and level ranges. And the differences between station-based and free-floating supportive car systems could be investigated. It would also be interesting to execute the research at other companies, organizations or campuses to investigate the commuting mode choice in other areas and situations.

The low performance of the binary logit choice models of the mode change could only be clarified by misunderstanding of the question in the survey by the respondents. For further research a solution to this problem needs to be found, probably with a better understandable question. It is a possibility to identify the attributes of carsharing for the willingness to change car commuting.

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Appendices

Appendix 1: Overview of attributes and motives for carsharing (adopted from Dieten, 2015)

Cost (TNS-Nipo 2014)	As replacement for second car (Chatterjee et al. 2013)
Availability for the car (TNS-Nipo 2014)	To give up car due to low usage and expense (Chatterjee et al. 2013)
In case of a job elsewhere (TNS-Nipo 2014)	For business travel (Chatterjee et al. 2013)
Quality of the car (TNS-Nipo 2014)	Access to car for occasional travel (Chatterjee et al. 2013)
When car breaks down (TNS-Nipo 2014)	Use car share van for work-related purposes (Chatterjee et al. 2013)
Choice for different cars (TNS-Nipo 2014)	Low mileage, but still occasionally need car (Chatterjee et al. 2013)
Location of the car (TNS-Nipo 2014)	As replacement for infrequently used owned car (Chatterjee et al. 2013)
Possibility to contact service desk of the company (TNS-Nipo 2014)	Low usage (Chatterjee et al. 2013)
Customer service friendliness (TNS-Nipo 2014)	Save money (Chatterjee et al. 2013)
A friend recommended the service (TNS-Nipo 2014)	Occasional access to a car (Chatterjee et al. 2013)
Privacy (other people in my car) (TNS-Nipo 2014)	To maintain driving skills (Chatterjee et al. 2013)
Reliability of the service, e.g. the reservation is often cancelled (TNS-Nipo 2014)	More convenient than hire cars (Chatterjee et al. 2013)
Booking way (Efthymiou et al. 2013)	More convenient than public transport (Chatterjee et al. 2013)
Return vehicle in another station (Efthymiou et al., 2013)	Alternative for taxi (Chatterjee et al. 2013)
Return vehicle without informing in advance when and where (Efthymiou et al., 2013)	Lost job, and therefore gave up car (Chatterjee et al. 2013)
Type of vehicle (Efthymiou et al., 2013)	Trust issues (Ballús-Armet et al. 2014)
Symbol of social status (Efthymiou et al., 2013)	Convenience and availability (Ballus-Armet, et al., 2014)
Time of day (Efthymiou et al., 2013)	Environmental (Ballus-Armet, et al., 2014)
Travel convenience (Efthymiou et al., 2013)	Expand mobility options (Ballus-Armet, et al., 2014)
Comfort of travel (Efthymiou et al., 2013)	Resource sharing (Ballus-Armet, et al., 2014)
Distance of station from house or job (Efthymiou, Antoniou, & Waddell, 2013)	Prefere P2P over big company (Ballus-Armet, et al., 2014)
small size	Prefere a big company over P2P (Ballus-Armet, et al., 2014)
fleet size	Monetary (Ballus-Armet, et al., 2014)
Distinct design	Liability (Ballus-Armet, et al., 2014)
Time of day	No need to own a car (Ballus-Armet, et al., 2014)
Social aspects, personal contact when handing over keys etc.	Personal interaction (Ballus-Armet, et al., 2014)
Time of usage	Vehicle reliability (Ballus-Armet, et al., 2014)
Place of residence	Cleanliness (Ballus-Armet, et al., 2014)
Curiousness (Glind 2013)	Damages (Self)
Practical motives (Glind, 2013)	Insurance (Self)
Social motives (Glind, 2013)	Occasionally need other car, e.g. for moving (Self)
Environmental motives (Glind, 2013)	Status (Self)
Financial motives (Glind, 2013)	Pricing (Self)
Contributing to a healthy natural environment (Glind, 2013)	Practicalities (Self)
Saving money (Glind, 2013)	Flexibility (Self)
Meeting people (Glind 2013)	Personal contact (Self)
Save time (Schaefers 2013)	Travel patterns (Martin et al., 2011)
Reasonable prices (Schaefers, 2013)	Vehicle purchase plans (Martin et al., 2011)
Everything included (Schaefers, 2013)	Commuting time duration (Martin et al., 2011)
Pay per use (Schaefers, 2013)	Commute distance (Martin et al., 2011)
Belonging (Schaefers, 2013)	Major shopping mode (Taxi, Car, Bus, Metro, Bike, Walk) (Martin et al., 2011)
Free parking (Schaefers, 2013)	Convenience (Prettenthaler & Steininger 1999)
Save money (Schaefers, 2013)	Cost (Prettenthaler & Steininger, 1999)
Designated parking (Schaefers, 2013)	Good value for money (Prettenthaler & Steininger, 1999)
Gas efficiency (Schaefers, 2013)	Time demand (Prettenthaler & Steininger, 1999)
Visible labelling (Schaefers, 2013)	Traffic mitigation/reduction (Prettenthaler & Steininger, 1999)
No worries (Schaefers, 2013)	Transparency of cost (Prettenthaler & Steininger, 1999)
No responsibilities (Schaefers, 2013)	Flexibility (Prettenthaler & Steininger, 1999)
Sense of community (Schaefers, 2013)	Cost saving (Dill, 2014)
Thriftiness (Schaefers, 2013)	Convenience of not owning a car (Dill, 2014)
Comfort (Schaefers, 2013)	Affordability (Dill, 2014)
Free parking (Schaefers, 2013)	Personal freedom (Dill, 2014)
Flee-floating (Schaefers, 2013)	All-included insurance and environmentally sound image (Schrader, 1999)
Ad-hoc usage (Schaefers, 2013)	Weather influences (Schmöller & Bogenberger 2014)
Cost savings (Mont 2004)	P2P matching rejected? Volkskrant, 2014 (Velden & Lier 2014)
Lack of initial investment (Mont, 2004)	Provision of free parking spaces, (Mont, 2004)
Maintenance responsibilities (Mont, 2004)	

Appendix 2: Carsharing approaches in the Netherlands

The results are obtained from the website of the concerned carsharing company.

		Price	Ads	Fuel	Access	Availability	Reserv.	Type
Greenwheels	Twoway	€/hour	Logo	Petrol	Card	24/7	App	All
Mywheels	C2C							
Snappcar	C2C							
Car2Go	Oneway	€/min	Logo	Electric	Mobile	24/7	App	Small
WeGo	C2C							
Connectcar (Studentcar)	Twoway	Combi	Logo	Petrol	Mobile	24/7	App	Small
Drive carsharing	Twoway	Combi	Logo	Petrol	Card	24/7	Site	Small
Mobility---s (Free to go)	Twoway	€/hour	Logo	All	Card	24/7	Site	All
Drivemoby	C2C*							
Buurtauto	Twoway	€/maand	Logo	Electric	Mobile	24/7	App	Small
Carecar	Twoway	Combi	Logo	Electric	Card	24/7	Site	Small
Stapp.in	Twoway	€/hour	Logo	Petrol	Mobile	24/7	App	All
Witkar	Oneway	Combi		Petrol	Mobile	24/7	App	Small
Oproepauto (Europcar)	Twoway	€/maand	No ads	Petrol	Key	Workhours	Site	Small
(Vincent) Deelt auto's	C2C							
ParkFlyRent	C2C*							
Amber mobility	Twoway	€/hour	Logo	Electric	Mobile	24/7	App	Luxe
Hyundai IONIQ Car Sharing	Oneway	€/min	Logo	Electric	Mobile	24/7	App	Luxe
Drive now	Oneway	€/min	Logo	All	Mobile	24/7	App	All
We Drive Solar	Twoway	€/km	Logo	Electric	Mobile	24/7	App	Small

C2C = Customer to customer

All = All possible options, as asked in the stated choice experiment, are available at this company.

*Drivemoby = A subscription for an own car, that could be rented to other customers.

*ParkFlyRent = While on holidays with the airplane, renting your own car.

Appendix 3: Tariff calculations (price/hour and price/km)

Studentcar

Fixed start costs: €3,05

Price/hour: €2,54

Price<100km: €0,22

Price>100km: €0,11

Reservation time	Driven km	Price (Studentcar)	Price/km	Price/hour
4 hours	25	18.71	0.75	4.68
	50	24.21	0.47	6.05
	75	29.71	0.40	7.43
9 hours	100	36.91	0.37	4.10
	150	42.41	0.28	4.71
	200	47.91	0.24	5.32
		Average	**0.42**	**5.38**

The averages of the tariff systems are approximately €0.40 and €5.00, this is taken as middle values. The low values are €0.30 and €4.00 and the high values are €0.50 and €6.00.

Appendix 4: Stated choice profiles

	A	B	C	D	E	F	G	H	I
1	1 minute	Plain car	Multi-Purpose Vehicle (MPV)	€5 per hour / €0.40 per km	Hybrid	Key exchange is necessary	Only during work hours (9am - 5pm)	By telephone contact	Only for business/study trips
2	9 minutes	Only TU/e logo	Multi-Purpose Vehicle (MPV)	€4 per hour / €0.30 per km	Petrol	Access with mobile application	Only during work hours (9am - 5pm)	By telephone contact	Only for business/study trips
3	5 minutes	Only TU/e logo	Multi-Purpose Vehicle (MPV)	€5 per hour / €0.40 per km	Petrol	Key exchange is necessary	24 hours - 7 days a week	By e-mail	For business/study and private trips
4	5 minutes	Only TU/e logo	Luxurious car	€6 per hour / €0.50 per km	Hybrid	Key exchange is necessary	24 hours - 7 days a week	By e-mail	Only for business/study trips
5	9 minutes	Plain car	Luxurious car	€4 per hour / €0.30 per km	Electric	Key exchange is necessary	24 hours - 7 days a week	By e-mail	Only for business/study trips
6	5 minutes	Full with advertisements	Luxurious car	€4 per hour / €0.30 per km	Petrol	Key exchange is necessary	24 hours - 7 days a week	By telephone contact	Only for business/study trips
7	1 minute	Full with advertisements	Luxurious car	€5 per hour / €0.40 per km	Petrol	Access with mobile application	24 hours - 7 days a week	By e-mail	For business/study and private trips
8	5 minutes	Plain car	Luxurious car	€5 per hour / €0.40 per km	Electric	Access with mobile application	Only during work hours (9am - 5pm)	With mobile application	Only for business/study trips
9	9 minutes	Only TU/e logo	Luxurious car	€5 per hour / €0.40 per km	Hybrid	Access with mobile application	24 hours - 7 days a week	By telephone contact	Only for business/study trips
10	9 minutes	Full with advertisements	Multi-Purpose Vehicle (MPV)	€5 per hour / €0.40 per km	Electric	Key exchange is necessary	24 hours - 7 days a week	With mobile application	Only for business/study trips
11	5 minutes	Plain car	Standard (small) car	€6 per hour / €0.50 per km	Petrol	Access with mobile application	24 hours - 7 days a week	With mobile application	Only for business/study trips
12	1 minute	Only TU/e logo	Standard (small) car	€5 per hour / €0.40 per km	Electric	Key exchange is necessary	24 hours - 7 days a week	With mobile application	Only for business/study trips
13	1 minute	Full with advertisements	Standard (small) car	€6 per hour / €0.50 per km	Hybrid	Access with mobile application	Only during work hours (9am - 5pm)	By e-mail	Only for business/study trips
14	9 minutes	Full with advertisements	Standard (small) car	€4 per hour / €0.30 per km	Hybrid	Key exchange is necessary	24 hours - 7 days a week	With mobile application	For business/study and private trips
15	1 minute	Plain car	Luxurious car	€6 per hour / €0.50 per km	Electric	Key exchange is necessary	24 hours - 7 days a week	By telephone contact	For business/study and private trips
16	5 minutes	Plain car	Multi-Purpose Vehicle (MPV)	€4 per hour / €0.30 per km	Hybrid	Access with mobile application	24 hours - 7 days a week	With mobile application	For business/study and private trips
17	1 minute	Only TU/e logo	Multi-Purpose Vehicle (MPV)	€6 per hour / €0.50 per km	Petrol	Key exchange is necessary	24 hours - 7 days a week	With mobile application	Only for business/study trips
18	1 minute	Plain car	Standard (small) car	€4 per hour / €0.30 per km	Petrol	Key exchange is necessary	24 hours - 7 days a week	By telephone contact	Only for business/study trips
19	9 minutes	Plain car	Standard (small) car	€5 per hour / €0.40 per km	Petrol	Key exchange is necessary	Only during work hours (9am - 5pm)	By e-mail	For business/study and private trips
20	1 minute	Full with advertisements	Multi-Purpose Vehicle (MPV)	€4 per hour / €0.30 per km	Electric	Access with mobile application	24 hours - 7 days a week	By e-mail	Only for business/study trips
21	9 minutes	Only TU/e logo	Standard (small) car	€6 per hour / €0.50 per km	Electric	Access with mobile application	24 hours - 7 days a week	By telephone contact	For business/study and private trips
22	5 minutes	Full with advertisements	Standard (small) car	€5 per hour / €0.40 per km	Hybrid	Key exchange is necessary	24 hours - 7 days a week	By telephone contact	Only for business/study trips
23	1 minute	Only TU/e logo	Luxurious car	€4 per hour / €0.30 per km	Hybrid	Key exchange is necessary	Only during work hours (9am - 5pm)	With mobile application	For business/study and private trips
24	9 minutes	Full with advertisements	Luxurious car	€6 per hour / €0.50 per km	Petrol	Key exchange is necessary	Only during work hours (9am - 5pm)	With mobile application	Only for business/study trips
25	5 minutes	Full with advertisements	Multi-Purpose Vehicle (MPV)	€6 per hour / €0.50 per km	Electric	Key exchange is necessary	Only during work hours (9am - 5pm)	By telephone contact	For business/study and private trips
26	9 minutes	Plain car	Multi-Purpose Vehicle (MPV)	€6 per hour / €0.50 per km	Hybrid	Key exchange is necessary	24 hours - 7 days a week	By e-mail	Only for business/study trips
27	5 minutes	Only TU/e logo	Standard (small) car	€4 per hour / €0.30 per km	Electric	Key exchange is necessary	Only during work hours (9am - 5pm)	By e-mail	Only for business/study trips

Appendix 5: Example online questionnaire

TU/e Technische Universiteit Eindhoven University of Technology

Supportive Car System TU/e

Page: 0 Welcome

Welcome to this questionnaire.

This questionnaire is about commuting and the potential of a **Supportive Car System** at the TU/e campus. It is part of my masterthesis for Construction Management and Urban Development at the TU/e.

The questionnaire consists of 4 parts:

- Part 1: Your commuting trip
- Part 2: Possible business/study trips
- Part 3: Preferences for a Supportive Car System
- Part 4: Personal information

The completion of the questionnaire will take approximately **15** minutes. The data will be processed in full anonymity.

If you have any questions, please contact: **r.folmer@student.tue.nl**

Thank you in advance for your participation in this research,

Randy Folmer

Next

TU/e Technische Universiteit Eindhoven University of Technology

Supportive Car System TU/e

Preliminary questions

Page: 1 Selection criteria

The goal of this research is to get insight in the possibilities and the setup of a Supportive Car System for the TU/e. To reach this goal, we need some pre-information to guide you correctly through the questionnaire.

On average, how many days per week do you commute to the TU/e campus?

5 days per week

Do you have a driver's license?

- (•) Yes
- ( ) No

What is your main function/relation with the TU/e?

- (•) Employee
- ( ) Student
- ( ) Other

If other, please specify:

Do you ever make business trips during working hours as TU/e employee?

- (•) Yes
- ( ) No

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Technische Universiteit Eindhoven University of Technology

Supportive Car System TU/e

Commuting behaviour

Page: 2 Commuting behaviour

This part contains questions about your actual commuting behaviour. A commuting trip is a trip from home to the TU/e campus. If travel distances are asked, keep in mind that this concerns a one-way commuting trip.

On average, how often do yo use the following travel modes as main commuting mode?

	Never	Rarely	Occasionally	Often	Always
Car	○	●	○	○	○
Bus	●	○	○	○	○
Train	○	○	●	○	○
Bicycle	○	○	○	●	○
Walking	●	○	○	○	○
Other	●	○	○	○	○

If other, please specify:

What is the average commuting distance from your home to the TU/e campus?

10 km or less

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Supportive Car System TU/e

Business trips

Page: 3 Business trips

You have indicated that you make work related trips as TU/e employee. This part of the questionnaire is about these business trips.

A business trip is a trip to destinations outside the TU/e campus, related to work activities. If travel distances are asked, keep in mind that this concerns a one-way business trip.

Do you make national business trips as TU/e employee?

● Yes
○ No

Do you make international (within Europe) business trips as TU/e employee?

● Yes
○ No

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TU/e Technische Universiteit Eindhoven University of Technology

Supportive Car System TU/e

National business trips

Page: 3.1 National business

How often do you make national business trips as TU/e employee?

Once a quartile

Which main travel mode do you use if you make national business trips as TU/e employee?

	Never	Rarely	Occasionally	Often	Always
Car	○	●	○	○	○
Rental/sharing car	○	●	○	○	○
Bus	●	○	○	○	○
Train	○	○	○	●	○
Bicycle	●	○	○	○	○
Other	●	○	○	○	○

If other, please specify:

What is the average distance of a national business trip as TU/e employee?

51 - 100 km

How often do you use a rental car or sharing car for national business trips?

1 time a year

What are the reasons for choosing a certain rental/sharing company?

- [x] Prices of car rental/sharing
- [x] Service of the personnel
- [ ] Location of the company
- [ ] Reputation of the company
- [ ] Other

If other, please specify:

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Supportive Car System TU/e

International business trips

Page: 3.2 International business

How often do you make international (within Europe) business trips as TU/e employee?

1 time a year

Which main travel mode do you use if you make international (within Europe) business trips as TU/e employee?

	Never	Rarely	Occasionally	Often	Always
Car	◉	○	○	○	○
Rental/sharing car	◉	○	○	○	○
Bus	◉	○	○	○	○
Train	◉	○	○	○	○
Airplane	○	○	○	○	◉
Other	◉	○	○	○	○

If other, please specify:

What is the average distance of an international (within Europe) business trip as TU/e employee?

501 - 750 km

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Supportive Car System TU/e

Choice experiment

Page: 5 Stated choice experiment

With the following choice experiment, we want to identify your preferences regarding the characteristics of a possible Supportive Car System.

A Supportive Car System consists of available cars stationed at or near the TU/e campus. These cars can be used for business trips and/or personal journeys by both employees and students. Examples of Supportive Car Systems are car rental and car sharing: members of a shared car (other employees and students of the TU/e) could use the offered car if necessary.

On the following page, an example of the choice experiment is given. You will receive two different settings of a possible Supportive Car System. There are two alternative possibilites to set up the Supportive Car System, **but you have to choose the most preferable system.** Please review the descriptions of the two systems carefully before you make a choice.

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Supportive Car System TU/e
Example

Page: 6 Examplecar

If you move your mouse over one of the 'Characteristics', you will see a pop-up with explanation of each characteristic.

Characteristics	Supportive Car System 1	Supportive Car System 2
Location (walking time)	1 minute	9 minutes
Advertisements	Full with advertisements	Plain car
Car type	Luxurious car	Multi-Purpose Vehicle (MPV)
Price	€6 per hour	€4 per hour
Fuel type	Fossil	Electric
Accessibility	Key exchange is necessary	Access with mobile application
Availability	Only available during work hours	24 hours - 7 days a week available
Reservation	With the mobile application (online)	By e-mail
Trip purposes	Only for business/study trips	For business/study and private trips
Which Supportive Car System do you prefer most?	◉	○

You have indicated that you commute by car, we would want to know if you might change your commuting travel mode in case you have to make a business or study trip, given that the chosen Supportive Car System will be available at the TU/e campus.

I would change my car commuting mode to ...

	Yes	No
Bus	◉	○
Train	○	◉
Bicycle	○	◉

Now 6 different choice tasks will be given.

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Choice experiment

Page: Choice_experiment

This is choice set 1 of the total 6 choice sets.

Characteristics	Supportive Car System 1	Supportive Car System 2
Location (walking time)	1 minute	9 minutes
Advertisements	Full with advertisements	Full with advertisements
Car type	Standard (small) car	Standard (small) car
Price	€6 per hour	€4 per hour
Fuel type	Hybrid	Hybrid
Accessibility	Access with mobile application	Key exchange is necessary
Availability	Only during work hours (9am - 5pm)	24 hours - 7 days a week
Reservation	By e-mail	With mobile application
Trip purposes	Only for business/study trips	For business/study and private trips
Which Supportive Car System do you prefer most?	◉	○

You have indicated that you commute by car, we would want to know if you might change your commuting travel mode in case you have to make a business or study trip, given that the chosen Supportive Car System will be available at the TU/e campus.

I would change my car commuting mode to ...

	Yes	No
Bus	○	◉
Train	◉	○
Bicycle	○	◉

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Supportive Car System TU/e

Sociodemographic questions

Page: 7 Sociodemographic

What is your age?

17 - 26 years old

What is your gender?

- ◉ Male
- ○ Female

What is the highest level of education you have reached?

Academic education (WO)

What about the number of driver's licenses and available cars in your household?

Less cars than people with driver's license

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Supportive Car System TU/e

Sociodemographic questions

Page: 7.1 Sociodemo work

Do you work at a department or support service at the TU/e?

- (x) Department
- ( ) Support Service

At which Department of the TU/e are you working?

Built Environment ▾

Do you work fulltime or parttime at the TU/e?

- (x) Fulltime
- ( ) Parttime

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TU/e Technische Universiteit Eindhoven University of Technology

Supportive Car System TU/e

Page: 8 End

Thank you for participating.

This is the end of the questionnaire. If you have any additional remarks, please leave them below.

To finish the questionnaire, press 'Send'.

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Appendix 6: Frequency results survey

On average, how many days per week do you commute to the TU/e campus?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 1 day per week	15	3,9	3,9	3,9
	1 day per week	10	2,6	2,6	6,5
	2 days per week	20	5,2	5,2	11,7
	3 days per week	32	8,4	8,4	20,1
	4 days per week	105	27,4	27,4	47,5
	5 days per week	184	48,0	48,0	95,6
	More than 5 days per week	17	4,4	4,4	100,0
	Total	383	100,0	100,0	

What is your main function/relation with the TU/e?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Employee	122	31,9	31,9	31,9
	Student	251	65,5	65,5	97,4
	Other	10	2,6	2,6	100,0
	Total	383	100,0	100,0	

Do you ever make business trips during working hours as TU/e employee?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	85	22,2	69,7	69,7
	No	37	9,7	30,3	100,0
	Total	122	31,9	100,0	
Missing	System	261	68,1		
Total		383	100,0		

Do you ever make study trips during study hours as TU/e student?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	89	23,2	35,3	35,3
	No	163	42,6	64,7	100,0
	Total	252	65,8	100,0	
Missing	System	131	34,2		
Total		383	100,0		

On average, how often do you use the following travel modes as main commuting mode?

	Never	Rarely	Occasionally	Often	Always	Total
Car	163	95	51	36	38	383
Bus	193	100	36	38	16	383
Train	162	63	40	50	68	383
Bicycle	109	23	19	73	156	383
Walking	184	71	44	46	38	383
Other	355	8	9	5	6	383

What is the average commuting distance from your home to the TU/e campus?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	10 km or less	196	51,2	51,2	51,2
	11 - 20 km	28	7,3	7,3	58,5
	21 - 30 km	28	7,3	7,3	65,8
	31 - 40 km	28	7,3	7,3	73,1
	41 - 50 km	19	5,0	5,0	78,1
	More than 50 km	84	21,9	21,9	100,0
	Total	383	100,0	100,0	

Do you make national/international (within Europe) business/study trips?

		Frequency		Percent
Employees	**Business trips**	85		69.7
	National trips		*81*	
	International trips		*58*	
	No business trips	37		30.3
	Total	122		100
Students	**Study trips**	89		35.5
	National trips		*65*	
	International trips		*24*	
	No study trips	162		64.5
	Total	251		100
All respondents	**Total trips**	174		46.6
	National trips		*146*	
	International trips		*82*	
	No trips	199		53.4
	Total	373		100

How often do you make national trips?

National	Frequency	Percent
More than once a week	7	4.8
Once a week	10	6.8
Once a month	28	19.2
Once a quartile	43	29.5
Once a semester	28	19.2
Once a year	23	15.8
Less than once a year	7	4.8
Total	146	100

What is the average distance of a national trip?

50 km or less	31	21.2
51 - 100 km	63	43.2
101 - 150 km	43	29.5
151 - 200 km	5	3.4
201 - 250 km	1	0.7
More than 250 km	3	2.1
Total	146	100

Which main travel mode do you use if you make national trips?

	Never	Rarely	Occasionally	Often	Always	Total
Car	54	27	25	30	10	146
Rental/ sharing	111	13	11	10	1	146
Bus	58	23	38	24	3	146
Train	9	16	33	62	26	146
Bicycle	84	31	17	12	2	146
Other	137	2	4	1	2	146

How often do you make international trips (within Europe)?

International	Frequency	Percent
More than 5 times a year	7	8.5
4 - 5 times a year	6	7.3
2 - 3 times a year	28	34.1
1 time a year	23	26.8
Less than 1 time a year	18	22.0
Total	82	100

What is the average distance of an international trip?

250 km or less	2	2.4
251 - 500 km	17	20.7
501 - 750 km	29	35.4
751 - 1000 km	20	24.4
More than 1000 km	14	17.1
Total	82	100

Which main travel mode do you use if you make international trips (within Europe)?

	Never	Rarely	Occasionally	Often	Always	Total
Car	45	16	10	7	4	82
Rental/ sharing	61	11	4	6	0	82
Bus	50	15	10	4	3	82
Train	25	14	24	16	3	82
Airplane	8	6	14	37	17	82
Other	78	2	2	0	0	82

How often do you use a rental or sharing car for trips?

	Frequency	Percent
More than 5 times a year	1	1.8
4 – 5 times a year	2	3.6
2 -3 times a year	17	30.4
1 time a year	15	26.8
Less than 1 time a year	21	37.5
Total	56	100

What are the reasons for choosing a certain rental/sharing company?

	Frequency	Percent
Prices of car rental/sharing	33	39.8
Service of the personnel	1	1.2
Location of the company	27	32.5
Reputation of the company	9	10.8
Other	13	15.7
Total	83	100

What is your age?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	17 - 26 years old	252	65,8	65,8	65,8
	27 - 36 years old	61	15,9	15,9	81,7
	37 - 46 years old	24	6,3	6,3	88,0
	47 - 56 years old	30	7,8	7,8	95,8
	57 - 66 years old	15	3,9	3,9	99,7
	67 years or older	1	,3	,3	100,0
	Total	383	100,0	100,0	

What is your gender?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	268	70,0	70,0	70,0
	Female	115	30,0	30,0	100,0
	Total	383	100,0	100,0	

What is the highest level of education you have reached?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Vocational education (MBO)	15	3,9	3,9	3,9
	Higher education (HBO)	52	13,6	13,6	17,5
	Academic education (WO)	316	82,5	82,5	100,0
	Total	383	100,0	100,0	

What about the number of driver's licenses and available cars in your household?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		26	6,8	6,8	6,8
	More cars than people	15	3,9	3,9	10,7
	Less cars than people	248	64,8	64,8	75,5
	As many cars as people	94	24,5	24,5	100,0
	Total	383	100,0	100,0	

Appendix 7: Sociodemographics employees

	Sample frequency	Sample percentage	Reference percentage*
Department	93	76.2	63.8
Support Service	29	23.8	36.2
Biomedical Engineering	2	2.2	
Built Environment	10	11	
Electrical Engineering	16	17.6	
Industrial Design	7	7.7	
Industrial Engineering & Innovation Sciences	15	16.5	
Chemical Engineering & Chemistry	9	9.9	
Applied Physics	10	11	
Mechanical Engineering	10	11	
Mathematics & Computer Sciences	12	13.2	
Information Expertise Center	6	20.7	
General Affairs Department	4	13.8	
Financial and Economic Affairs Department	2	6.9	
Real Estate Management	0	0	
ICT Services	0	0	
Internal Affairs	4	13.8	
Personnel and Organization	2	6.9	
Equipment & Prototype Center	2	6.9	
Education and Student Affairs	5	17.2	
TU/e Innovation Lab	4	13.8	
Fulltime	94	77	
Parttime	28	23	
Total	122	100	

* = obtained from Jaarverslag 2016 (TU/e, 2017)

Appendix 8: Sociodemographics student

	Sample frequency	Sample percentage	Reference percentage*
First year bachelor student	67	26.7	
Second year bachelor student	39	15.5	65.4
Third year bachelor student	41	16.3	
First year master student	38	15.1	34.6
Second year master student	66	26.3	
Biomedical Engineering	14	5.6	9.8
Built Environment	27	10.8	12.7
Electrical Engineering	30	12	7.3
Industrial Design	8	3.2	6.2
Industrial Engineering & Innovation Sciences	56	22.3	21.8
Chemical Engineering & Chemistry	10	4	5.9
Applied Physics	15	6	6.9
Mechanical Engineering	56	22.3	16
Mathematics & Computer Sciences	35	13.9	13.6
Fulltime	242	96.4	
Partime	9	3.6	
Total	251	100	

* = obtained from Jaarverslag 2016 (TU/e, 2017)

Appendix 9: Nlogit output general model

```
-----------------------------------------------------------------------------
Discrete choice (multinomial logit) model
Dependent variable                 Choice
Log likelihood function     -1256.39673
Estimation based on N =    2298, K =  17
Inf.Cr.AIC  =    2546.8 AIC/N =    1.108
Model estimated: Nov 13, 2017, 20:20:40
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only  -1592.8487  .2112 .2053
Response data are given as ind. choices
Number of obs.=  2298, skipped    0 obs
--------+--------------------------------------------------------------------
        |                Standard            Prob.       95% Confidence
    IKEU|  Coefficient     Error       z    |z|>Z*          Interval
--------+--------------------------------------------------------------------
   ILOC1|      .29204***     .06175     4.73  .0000      .17101     .41308
   ILOC2|     -.02227        .05661     -.39  .6940     -.13323     .08868
   IADV1|      .01977        .05742      .34  .7306     -.09277     .13231
   IADV2|      .10569*       .06205     1.70  .0885     -.01593     .22731
  ICTYP1|     -.03140        .05021     -.63  .5318     -.12982     .06702
  ICTYP2|      .11186**      .04779     2.34  .0192      .01819     .20553
    IPH1|      .47106***     .06612     7.12  .0000      .34148     .60065
    IPH2|     -.14775**      .06835    -2.16  .0306     -.28171    -.01379
    IPK1|      .53569***     .06739     7.95  .0000      .40361     .66778
    IPK2|      .02572        .06995      .37  .7131     -.11138     .16283
  IFTYP1|     -.40374***     .05577    -7.24  .0000     -.51305    -.29444
  IFTYP2|     -.01409        .05776     -.24  .8073     -.12729     .09912
    IACC|      .28213***     .04874     5.79  .0000      .18660     .37766
  IAVAIL|     -.47749***     .03881   -12.30  .0000     -.55355    -.40143
   IRES1|     -.22074***     .07139    -3.09  .0020     -.36066    -.08082
   IRES2|     -.03341        .05426     -.62  .5381     -.13976     .07295
    IPUR|      .26225***     .03621     7.24  .0000      .19127     .33322
--------+--------------------------------------------------------------------
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
-----------------------------------------------------------------------------
```

Appendix 10: Estimates of all models

	General	Employee	Student	0-4 days	5 days +	0-10 km	11 km +
Location 1	**0.2920**	0.1128	**0.4208**	**0.2958**	**0.2879**	**0.3501**	**0.2350**
Location 2	-0.0223	0.0413	-0.0684	-0.0472	0.0063	0.0578	-0.0913
Advertisements 1	0.0198	-0.0373	0.0596	0.0647	-0.0238	0.1020	-0.0574
Advertisements 2	**0.1057**	0.0578	**0.1464**	0.0126	0.1940	0.1465	0.0881
Cartype 1	-0.0314	0.0806	**0.1136**	0.0272	-0.0888	0.0023	-0.0632
Cartype 2	**0.1119**	-0.0506	**0.2298**	0.0527	**0.1783**	0.0379	**0.1796**
Price/hour 1	**0.4711**	**0.4419**	**0.5118**	**0.4638**	**0.4835**	**0.3852**	**0.5234**
Price/hour 2	**-0.1478**	-0.0635	**-0.2079**	-0.0813	**-0.2178**	-0.0400	**-0.2117**
Price/km 1	**0.5357**	**0.4746**	**0.5951**	**0.4727**	**0.5939**	**0.4593**	**0.6690**
Price/km 2	0.0257	0.0433	-0.0101	0.0777	-0.0233	-0.0482	0.1240
Fuel type 1	**-0.4037**	**-0.3177**	**-0.4680**	**-0.4469**	**-0.3638**	**-0.4463**	**-0.3793**
Fuel type 2	-0.0141	-0.1223	0.0750	0.0397	-0.0658	-0.0127	-0.0343
Accessibility 1	**0.2821**	**0.2500**	**0.2950**	**0.2426**	**0.3179**	**0.2972**	**0.2675**
Availability 1	**-0.4775**	**-0.4399**	**-0.4982**	**-0.4853**	**-0.4780**	**-0.5277**	**-0.4371**
Reservation 1	**-0.2207**	-0.0866	**-0.3337**	**-0.2569**	**-0.1912**	**-0.3629**	-0.0894
Reservation 2	-0.0334	-0.0922	0.0054	-0.0165	-0.0507	0.0000	-0.1111
Trip purposes 1	**0.2623**	**0.1044**	**0.3631**	**0.2119**	**0.3016**	**0.3590**	**0.1817**

	Car	No car	Trips	No trips	0 - 26 year	27 year +	Male	Female
Location 1	**0.2902**	**0.2899**	0.1299	**0.4305**	**0.3009**	**0.2582**	**0.2287**	**0.4387**
Location 2	-0.1246	0.1002	-0.0259	-0.0091	-0.0224	-0.0222	-0.0207	-0.0219
Advertisements 1	0.0559	-0.0027	-0.0114	0.0410	0.0774	-0.1177	0.0333	-0.0617
Advertisements 2	0.0775	0.1237	0.0274	**0.1751**	0.1053	0.1267	0.0413	**0.2757**
Cartype 1	-0.0760	0.0160	-0.0640	-0.0024	-0.0291	-0.0638	-0.0483	0.0377
Cartype 2	**0.1537**	0.0582	**0.1497**	0.1032	**0.1498**	0.0661	**0.1765**	-0.0688
Price/hour 1	**0.4515**	**0.5032**	**0.5605**	**0.4475**	**0.4547**	**0.5045**	**0.4784**	**0.4897**
Price/hour 2	-0.1380	-0.1657	**-0.1824**	**-0.1870**	**-0.1977**	-0.0629	-0.1164	**-0.2307**
Price/km 1	**0.7515**	**0.3175**	**0.5850**	**0.4840**	**0.5374**	**0.5298**	**0.5774**	**0.4762**
Price/km 2	0.0437	0.0095	-0.0743	0.1059	0.0033	0.0760	0.0253	-0.0289
Fuel type 1	**-0.3817**	**-0.4363**	**-0.3692**	**-0.4210**	**-0.3998**	**-0.4275**	**-0.3228**	**-0.6449**
Fuel type 2	-0.0800	0.0786	-0.0323	-0.0090	-0.0019	-0.0392	-0.0745	0.1482
Accessibility 1	**0.2872**	**0.2779**	**0.2943**	**0.2878**	**0.2903**	**0.2643**	**0.2836**	**0.2878**
Availability 1	**-0.4809**	**-0.4981**	**-0.4513**	**-0.5119**	**-0.4487**	**-0.5361**	**-0.4678**	**-0.5290**
Reservation 1	**-0.1752**	**-0.2648**	**-0.2216**	**-0.2206**	**-0.2371**	-0.1997	**-0.2746**	-0.0543
Reservation 2	-0.1179	0.0543	-0.0796	-0.0045	-0.0348	-0.0368	-0.0072	-0.1245
Trip purposes 1	**0.2123**	**0.3256**	**0.1990**	**0.3261**	**0.3190**	**0.1586**	**0.2918**	**0.1936**

= significant estimate

Appendix 11: Sub models tables

Function

	Employee				**Student**			
Attribute	**Level**	**β**	**Sign.**	**Range**	**Level**	**β**	**Sign.**	**Range**
Location (walking time)	1 minute	0.0000	0.2680	0.0000	1 minute	**0.4208**	0.0000	0.8417
	5 minutes	0.0000	0.6549		5 minutes	0.0000	0.3481	
	9 minutes*	0.0000			9 minutes*	-0.4208		
Advertisements	No ads	0.0000	0.6975	0.0000	No ads	0.0000	0.4150	0.2928
	TU/e logo	0.0000	0.5667		TU/e logo	**0.1464**	0.0673	
	Full*	0.0000			Full*	-0.1464		
Cartype	Standard	0.0000	0.3333	0.0000	Standard	**0.1136**	0.0766	0.5732
	Luxurious	0.0000	0.5113		Luxurious	**0.2298**	0.0002	
	MPV*	0.0000			MPV*	-0.3434		
Price/hour	€ 4	**0.4419**	0.0000	0.8838	€ 4	**0.5118**	0.0000	0.8157
	€ 5	0.0000	0.5527		€ 5	**-0.2079**	0.0208	
	€ 6*	-0.4419			€ 6*	-0.3039		
Price/km	€ 0.30	**0.4746**	0.0000	0.9491	€ 0.30	**0.5951**	0.0000	1.1901
	€ 0.40	0.0000	0.7187		€ 0.40	0.0000	0.9078	
	€ 0.50*	-0.4746			€ 0.50*	-0.5951		
Fuel type	Petrol	**-0.3177**	0.0004	0.6353	Petrol	**-0.4680**	0.0000	0.9360
	Hybrid	0.0000	0.1872		Hybrid	0.0000	0.3214	
	Electric*	0.3177			Electric*	0.4680		
Accessibility	Key exchange	**-0.2500**	0.0016	0.5000	Key exchange	**-0.2950**	0.0000	0.5899
	Mobile access*	0.2500			Mobile access*	0.2950		
Availability	24 hours 7 days	**0.4399**	0.0000	0.8798	24 hours 7 days	**0.4982**	0.0000	0.9965
	Working hours*	-0.4399			Working hours*	-0.4982		
Reservation	Telephone	0.0000	0.4717	0.0000	Telephone	**-0.3337**	0.0002	0.6674
	E-mail	0.0000	0.3138		E-mail	0.0000	0.9372	
	Application*	0.0000			Application*	0.3337		
Trip purposes	Business/study	**-0.1044**	0.0811	0.2089	Business/study	**-0.3631**	0.0000	0.7262
	All trips*	0.1044			All trips*	0.3631		
	Degrees of freedom	17			**Degrees of freedom**	17	*= the β-values of these	
	LL(β)	-454.9143			**LL(β)**	-783.9750	levels are calculations,	
	LL(0)	-548.9726			**LL(0)**	-1043.8797	based on the significant	
	Rho-squared	0.1713			**Rho-squared**	0.2490	parameter(s).	
	Adjusted rho-squared	0.1327			**Adjusted rho-squared**	0.2140	Calculated by the effect	
	LRS	188.1165			**LRS**	519.8093	coding from table 3.2.	

Frequency

Attribute	0-4 days Level	β	Sign.	Range	5 days or more Level	β	Sign.	Range
Location (walking time)	1 minute	**0.2958**	0.0012	0.5915	1 minute	**0.2879**	0.0007	0.5758
	5 minutes	0.0000	0.5659		5 minutes	0.0000	0.9364	
	9 minutes*	-0.2958			9 minutes*	-0.2879		
Advertisements	No ads	0.0000	0.4430	0.0000	No ads	0.0000	0.7640	0.3879
	TU/e logo	0.0000	0.8864		TU/e logo	**0.1940**	0.0283	
	Full*	0.0000			Full*	-0.1940		
Cartype	Standard	0.0000	0.7072	0.0000	Standard	0.0000	0.2094	0.3566
	Luxurious	0.0000	0.4406		Luxurious	**0.1783**	0.0084	
	MPV*	0.0000			MPV*	-0.1783		
Price/hour	€ 4	**0.4638**	0.0000	0.9276	€ 4	**0.4835**	0.0000	0.7492
	€ 5	0.0000	0.4002		€ 5	**-0.2178**	0.0255	
	€ 6*	-0.4638			€ 6*	-0.2657		
Price/km	€ 0.30	**0.4727**	0.0000	0.9454	€ 0.30	**0.5939**	0.0000	1.1879
	€ 0.40	0.0000	0.4483		€ 0.40	0.0000	0.8098	
	€ 0.50*	-0.4727			€ 0.50*	-0.5939		
Fuel type	Petrol	**-0.4469**	0.0000	0.8938	Petrol	**-0.3638**	0.0000	0.7276
	Hybrid	0.0000	0.6297		Hybrid	0.0000	0.4212	
	Electric*	0.4469			Electric*	0.3638		
Accessibility	Key exchange	**-0.2426**	0.0004	0.4852	Key exchange	**-0.3179**	0.0000	0.6357
	Mobile access*	0.2426			Mobile access*	0.3179		
Availability	24 hours 7 days	**0.4853**	0.0000	0.9678	24 hours 7 days	**0.4780**	0.0000	0.9560
	Working hours*	-0.4825			Working hours*	-0.4780		
Reservation	Telephone	**-0.2569**	0.0141	0.5139	Telephone	**-0.1912**	0.0529	0.3824
	E-mail	0.0000	0.8325		E-mail	0.0000	0.5061	
	Application*	0.2569			Application*	0.1912		
Trip purposes	Business/study	**-0.2119**	0.0000	0.4237	Business/study	**-0.3016**	0.0000	0.6031
	All trips*	0.2119			All trips*	0.3016		
	Degrees of freedom	17			**Degrees of freedom**	17	*= the β-values of these	
	LL(β)	-606.1087			**LL(β)**	-646.1546	levels are calculations,	
	LL(0)	-756.9167			**LL(0)**	-835.9355	based on the significant	
	Rho-squared	0.1992			**Rho-squared**	0.2270	parameter(s).	
	Adjusted rho-squared	0.1619			**Adjusted rho-squared**	0.1910	Calculated by the effect	
	LRS	301.6161			**LRS**	379.5619	coding from table 3.2.	

Distance

Attribute	0-10 km Level	β	Sign.	Range	11 km or more Level	β	Sign.	Range
Location (walking time)	1 minute	**0.3501**	0.0001	0.7002	1 minute	**0.2350**	0.0076	0.4699
	5 minutes	0.0000	0.4794		5 minutes	0.0000	0.2558	
	9 minutes*	-0.3501			9 minutes*	-0.2350		
Advertisements	No ads	0.0000	0.2108	0.0000	No ads	0.0000	0.4882	0.0000
	TU/e logo	0.0000	0.1037		TU/e logo	0.0000	0.3192	
	Full*	0.0000			Full*	0.0000		
Cartype	Standard	0.0000	0.9742	0.0000	Standard	0.0000	0.3832	0.3592
	Luxurious	0.0000	0.5798		Luxurious	**0.1796**	0.0083	
	MPV*	0.0000			MPV*	-0.1796		
Price/hour	€ 4	**0.3852**	0.0002	0.7703	€ 4	**0.5234**	0.0000	0.8352
	€ 5	0.0000	0.7046		€ 5	**-0.2117**	0.0202	
	€ 6*	-0.3852			€ 6*	-0.3118		
Price/km	€ 0.30	**0.4593**	0.0000	0.9185	€ 0.30	**0.6690**	0.0000	1.3380
	€ 0.40	0.0000	0.6158		€ 0.40	0.0000	0.2429	
	€ 0.50*	-0.4593			€ 0.50*	-0.6690		
Fuel type	Petrol	**-0.4463**	0.0000	0.8925	Petrol	**-0.3793**	0.0000	0.7585
	Hybrid	0.0000	0.8764		Hybrid	0.0000	0.6782	
	Electric*	0.4463			Electric*	0.3793		
Accessibility	Key exchange	**-0.2972**	0.0000	0.5944	Key exchange	**-0.2675**	0.0001	0.5350
	Mobile access*	0.2972			Mobile access*	0.2675		
Availability	24 hours 7 days	**0.5277**	0.0000	1.0554	24 hours 7 days	**0.4371**	0.0000	0.8741
	Working hours*	-0.5277			Working hours*	-0.4371		
Reservation	Telephone	**-0.3629**	0.0004	0.7258	Telephone	0.0000	0.3867	0.0000
	E-mail	0.0000	0.5066		E-mail	0.0000	0.1510	
	Application*	0.3629			Application*	0.0000		
Trip purposes	Business/study	**-0.3590**	0.0000	0.7180	Business/study	**-0.1817**	0.0005	0.3633
	All trips*	0.3590			All trips*	0.1817		
	Degrees of freedom	17			**Degrees of freedom**	17	*= the β-values of these	
	LL(β)	-635.9308			**LL(β)**	-613.8525	levels are calculations,	
	LL(0)	-815.1411			**LL(0)**	-777.7111	based on the significant	
	Rho-squared	0.2199			**Rho-squared**	0.2107	parameter(s).	
	Adjusted rho-squared	0.1835			**Adjusted rho-squared**	0.1739	Calculated by the effect	
	LRS	358.4207			**LRS**	327.7174	coding from table 3.2.	

Car commuting

Attribute	Car: Level	β	Sign.	Range	No car: Level	β	Sign.	Range
Location (walking time)	1 minute	**0.2902**	0.0004	0.5803	1 minute	**0.2899**	0.0023	0.5797
	5 minutes	0.0000	0.1019		5 minutes	0.0000	0.2497	
	9 minutes*	-0.2902			9 minutes*	-0.2899		
Advertisements	No ads	0.0000	0.4677	0.0000	No ads	0.0000	0.9753	0.0000
	TU/e logo	0.0000	0.3608		TU/e logo	0.0000	0.1825	
	Full*	0.0000			Full*	0.0000		
Cartype	Standard	0.0000	0.2647	0.3075	Standard	0.0000	0.8340	0.0000
	Luxurious	**0.1537**	0.0166		Luxurious	0.0000	0.4295	
	MPV*	-0.1537			MPV*	0.0000		
Price/hour	€ 4	**0.4515**	0.0000	0.9029	€ 4	**0.5032**	0.0000	1.0064
	€ 5	0.0000	0.1204		€ 5	0.0000	0.1131	
	€ 6*	-0.4515			€ 6*	-0.5032		
Price/km	€ 0.30	**0.7515**	0.0000	1.5030	€ 0.30	**0.3175**	0.0019	0.6350
	€ 0.40	0.0000	0.6318		€ 0.40	0.0000	0.9322	
	€ 0.50*	-0.7515			€ 0.50*	-0.3175		
Fuel type	Petrol	**-0.3817**	0.0000	0.7635	Petrol	**-0.4363**	0.0000	0.8726
	Hybrid	0.0000	0.3021		Hybrid	0.0000	0.3774	
	Electric*	0.3817			Electric*	0.4363		
Accessibility	Key exchange	**-0.2872**	0.0000	0.5745	Key exchange	**-0.2779**	0.0002	0.5557
	Mobile access*	0.2872			Mobile access*	0.2779		
Availability	24 hours 7 days	**0.4809**	0.0000	0.9618	24 hours 7 days	**0.4981**	0.0000	0.9962
	Working hours*	-0.4809			Working hours*	-0.4981		
Reservation	Telephone	**-0.1752**	0.0655	0.3504	Telephone	**-0.2648**	0.0169	0.5297
	E-mail	0.0000	0.1099		E-mail	0.0000	0.5124	
	Application*	0.1752			Application*	0.2648		
Trip purposes	Business/study	**-0.2123**	0.0000	0.4246	Business/study	**-0.3256**	0.0000	0.6512
	All trips*	0.2123			All trips*	0.3256		
	Degrees of freedom	17			**Degrees of freedom**	17	*= the β-values of these	
	LL(β)	-701.2607			**LL(β)**	-520.0664	levels are calculations,	
	LL(0)	-914.9543			**LL(0)**	-677.8979	based on the significant	
	Rho-squared	0.2336			**Rho-squared**	0.2328	parameter(s).	
	Adjusted rho-squared	0.1979			**Adjusted rho-squared**	0.1971	Calculated by the effect	
	LRS	427.3871			**LRS**	315.6630	coding from table 3.2.	

Business/study trips

Attribute	Trips Level	β	Sign.	Range	No trips Level	β	Sign.	Range
Location (walking time)	1 minute	0.0000	0.1437	0.0000	1 minute	**0.4305**	0.0000	0.8611
	5 minutes	0.0000	0.7528		5 minutes	0.0000	0.9107	
	9 minutes*	0.0000			9 minutes*	-0.4305		
Advertisements	No ads	0.0000	0.8913	0.0000	No ads	0.0000	0.6222	0.3501
	TU/e logo	0.0000	0.7620		TU/e logo	**0.1751**	0.0480	
	Full*	0.0000			Full*	-0.1751		
Cartype	Standard	0.0000	0.3934	0.2994	Standard	0.0000	0.9728	0.0000
	Luxurious	**0.1497**	0.0326		Luxurious	0.0000	0.1288	
	MPV*	-0.1497			MPV*	0.0000		
Price/hour	€ 4	**0.5605**	0.0000	0.9386	€ 4	**0.4475**	0.0000	0.7080
	€ 5	**-0.1824**	0.0628		€ 5	**-0.1870**	0.0620	
	€ 6*	-0.3781			€ 6*	-0.2605		
Price/km	€ 0.30	**0.5850**	0.0000	1.1700	€ 0.30	**0.4840**	0.0000	0.9679
	€ 0.40	0.0000	0.4708		€ 0.40	0.1059	0.2903	
	€ 0.50*	-0.5850			€ 0.50*	-0.4840		
Fuel type	Petrol	**-0.3692**	0.0000	0.7383	Petrol	**-0.4210**	0.0000	0.8420
	Hybrid	0.0000	0.7012		Hybrid	-0.0090	0.9140	
	Electric*	0.3692			Electric*	0.4210		
Accessibility	Key exchange	**-0.2943**	0.0000	0.5886	Key exchange	**-0.2878**	0.0000	0.5756
	Mobile access*	0.2943			Mobile access*	0.2878		
Availability	24 hours 7 days	**0.4513**	0.0000	0.9026	24 hours 7 days	**0.5119**	0.0000	1.0239
	Working hours*	-0.4513			Working hours*	-0.5119		
Reservation	Telephone	**-0.2216**	0.0322	0.4431	Telephone	**-0.2206**	0.0316	0.4412
	E-mail	0.0000	0.3213		E-mail	0.0000	0.9537	
	Application*	0.2216			Application*	0.2206		
Trip purposes	Business/study	**-0.1990**	0.0002	0.3981	Business/study	**-0.3261**	0.0000	0.6523
	All trips*	0.1990			All trips*	0.3261		
	Degrees of freedom	17			**Degrees of freedom**	17	*= the β-values of these	
	LL(β)	-581.5676			**LL(β)**	-631.2203	levels are calculations,	
	LL(0)	-723.6457			**LL(0)**	-827.6177	based on the significant	
	Rho-squared	0.1963			**Rho-squared**	0.2373	parameter(s).	
	Adjusted rho-squared	0.1589			**Adjusted rho-squared**	0.2018	Calculated by the effect	
	LRS	284.1561			**LRS**	392.7949	coding from table 3.2.	

Age

Attribute	0-26 year				27 year +			
	Level	β	Sign.	Range	Level	β	Sign.	Range
Location (walking time)	1 minute	**0.3009**	0.0002	0.6018	1 minute	**0.2582**	0.0159	0.5164
	5 minutes	0.0000	0.7500		5 minutes	-0.0222	0.8196	
	9 minutes*	-0.3009			9 minutes*	-0.2582		
Advertisements	No ads	0.0000	0.2689	0.0000	No ads	0.0000	0.2576	0.0000
	TU/e logo	0.0000	0.1714		TU/e logo	0.0000	0.2353	
	Full*	0.0000			Full*	0.0000		
Cartype	Standard	0.0000	0.6367	0.2996	Standard	0.0000	0.4711	0.0000
	Luxurious	**0.1498**	0.0126		Luxurious	0.0000	0.4114	
	MPV*	-0.1498			MPV*	0.0000		
Price/hour	€ 4	**0.4547**	0.0000	0.7118	€ 4	**0.5045**	0.0000	1.0450
	€ 5	**-0.1977**	0.0201		€ 5	0.0000	0.5897	
	€ 6*	-0.2571			€ 6*	-0.5405		
Price/km	€ 0.30	**0.5374**	0.0000	1.0748	€ 0.30	**0.5298**	0.0000	1.0596
	€ 0.40	0.0000	0.9695		€ 0.40	0.0000	0.5406	
	€ 0.50*	-0.5374			€ 0.50*	-0.5298		
Fuel type	Petrol	**-0.3998**	0.0000	0.7996	Petrol	**-0.4275**	0.0000	0.8550
	Hybrid	0.0000	0.9787		Hybrid	0.0000	0.6901	
	Electric*	0.3998			Electric*	0.4275		
Accessibility	Key exchange	**-0.2903**	0.0000	0.5806	Key exchange	**-0.2643**	0.0019	0.5285
	Mobile access*	0.2903			Mobile access*	0.2643		
Availability	24 hours 7 days	**0.4487**	0.0000	0.8973	24 hours 7 days	**0.5361**	0.0000	1.0722
	Working hours*	-0.4487			Working hours*	-0.5361		
Reservation	Telephone	**-0.2371**	0.0063	0.4742	Telephone	0.0000	0.1236	0.0000
	E-mail	0.0000	0.6035		E-mail	0.0000	0.6973	
	Application*	0.2371			Application*	0.0000		
Trip purposes	Business/study	**-0.3190**	0.0000	0.6381	Business/study	**-0.1586**	0.0121	0.3171
	All trips*	0.3190			All trips*	0.1586		
	Degrees of freedom	17			**Degrees of freedom**	17	*= the β-values of these	
	LL(β)	-823.6276			**LL(β)**	-426.3499	levels are calculations,	
	LL(0)	-1048.0385			**LL(0)**	-544.8137	based on the significant	
	Rho-squared	0.2141			**Rho-squared**	0.2174	parameter(s).	
	Adjusted rho-squared	0.1775			**Adjusted rho-squared**	0.1810	Calculated by the effect	
	LRS	448.8219			**LRS**	236.9276	coding from table 3.2.	

Gender

Attribute	Male Level	β	Sign.	Range	Female Level	β	Sign.	Range
Location (walking time)	1 minute	**0.2287**	0.0020	0.4573	1 minute	**0.4387**	0.0002	0.8774
	5 minutes	0.0000	0.7588		5 minutes	0.0000	0.8423	
	9 minutes*	-0.2287			9 minutes*	-0.4387		
Advertisements	No ads	0.0000	0.6231	0.0000	No ads	0.0000	0.5895	0.5515
	TU/e logo	0.0000	0.5796		TU/e logo	**0.2757**	0.0190	
	Full*	0.0000			Full*	-0.2757		
Cartype	Standard	0.0000	0.4161	0.3529	Standard	0.0000	0.7009	0.0000
	Luxurious	**0.1765**	-0.0022		Luxurious	0.0000	0.4527	
	MPV*	-0.1765			MPV*	0.0000		
Price/hour	€ 4	**0.4784**	0.0000	0.9568	€ 4	**0.4897**	0.0000	0.7486
	€ 5	0.0000	0.1502		€ 5	**-0.2307**	0.0831	
	€ 6*	-0.4784			€ 6*	-0.2590		
Price/km	€ 0.30	**0.5774**	0.0000	1.1548	€ 0.30	**0.4762**	0.0002	0.9524
	€ 0.40	0.0000	0.7571		€ 0.40	0.0000	0.8354	
	€ 0.50*	-0.5774			€ 0.50*	-0.4762		
Fuel type	Petrol	**-0.3228**	0.0000	0.6455	Petrol	**-0.6449**	0.0000	1.2898
	Hybrid	0.0000	0.2806		Hybrid	0.0000	0.1778	
	Electric*	0.3228			Electric*	0.6449		
Accessibility	Key exchange	**-0.2836**	0.0000	0.5671	Key exchange	**-0.2878**	0.0022	0.5756
	Mobile access*	0.2836			Mobile access*	0.2878		
Availability	24 hours 7 days	**0.4678**	0.0000	0.9356	24 hours 7 days	**0.5290**	0.0000	1.0580
	Working hours*	-0.4678			Working hours*	-0.5290		
Reservation	Telephone	**-0.2746**	0.0012	0.5492	Telephone	0.0000	0.6981	0.0000
	E-mail	0.0000	0.9123		E-mail	0.0000	0.2284	
	Application*	0.2746			Application*	0.0000		
Trip purposes	Business/study	**-0.2918**	0.0000	0.5837	Business/study	**-0.1936**	0.0053	0.3871
	All trips*	0.2918			All trips*	0.1936		
	Degrees of freedom	17			**Degrees of freedom**	17	*= the β-values of these	
	LL(β)	-876.3781			**LL(β)**	-366.2800	levels are calculations,	
	LL(0)	-1114.5807			**LL(0)**	-478.2716	based on the significant	
	Rho-squared	0.2137			**Rho-squared**	0.2342	parameter(s).	
	Adjusted rho-squared	0.1771			**Adjusted rho-squared**	0.1985	Calculated by the effect	
	LRS	476.4052			**LRS**	223.9832	coding from table 3.2.	