The potential of Alternative Transport Services

An exploration of the potential and the factors influencing the potential of Alternative Transport Services in the province of Overijssel

Master thesis
Wietse te Morsche
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Preface

This report presents the results of my research on Alternative Transport Services in the province of Overijssel that has been done as the completion of the master program Civil Engineering & Management at the University of Twente. The research was carried out at the request of the province of Overijssel, because of the necessity to explore new forms of public transport and their potential.

Various persons have contributed to this master thesis and have helped me to finish the research. I would like to thank Lissy la Paix Puello and Karst Geurs from the university for their time, support and extensive feedback which helped me to conduct the research. Whenever I reached a dead end (especially during the model estimation process), their advice helped me to get back on track.

I would also like to thank Marco Berloth from the province of Overijssel for its help throughout the entire research process, but also for his valuable lessons on all kinds of different subjects and his understanding for my limited presence at the office. I truly have learned a lot from our meetings and his advice. I would like to thank Gerda Dekker, the others of the Ontwikkelteam Twente and I&O Research for making it possible for me to use the Overijssel panel of I&O and Syntus and MST Enschede for letting me recruit respondents in their buses in Twente and at the hospital. Furthermore, I would like to thank all colleagues at the province of Overijssel for making me feel welcome in both Zwolle and in Enschede.

Finally, I would like to thank my family and friends for being helpful and supportive during my time studying Civil Engineering & Management (and Environmental & Infrastructure Planning before). From my granddad collecting dozens of newspaper articles on small-scale public transport to Saidul and Twan helping me with the research itself, you all have helped me a lot. Special thanks go to Jana for everything she did for me and Oskar during the last year.

I hope that you will enjoy reading this report and end up with new insights on Alternative Transport Services and the need to explore new forms of public transport.

Wietse te Morsche

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Outline

The need for an appropriate public transport network is undisputable, but because of the continuous (financial) pressure on public transport, providing efficient and high-quality public transport alternatives at a fair price is often a major challenge for the responsible tiers of government and the transport companies. In general, regular public transport services are not suitable to deal with low and widely dispersed travel demand and are not always the most suitable solution. To, nevertheless, meet the challenge of providing appropriate public transport, new forms of public transport need to be explored. Such unconventional public transport services are known as Alternative Transport Services.

In its vision of public transport, the province of Overijssel acknowledges that regular public transport is not always the best option and endorses that new public transport forms should be explored. To achieve this, the province will offer help and financial contribution to municipalities and other initiators depending on the social added value of an initiative. However, it is often hard to know beforehand what is the social added value of a transport service, because the preferences of end-users vary from user to user. In addition, there are many different Alternative Transport Services types possible. Thus, the attractiveness and the potential of a transport service is difficult to predict and it is hard to know beforehand which kind of services should be considered for a region. The potential of transport service depends on the perceived attractiveness of the service for the potential end-users. The attractiveness of a service, in turn, depends on the operational design (level-of-service attributes) of the service, but also on variables or characteristics related to the traveller and/or its trip.

This research explores the concept of Alternative Transport Services and the variables influencing the attractiveness and potential of a service. Service types and their aspects are explored by an extensive literature review and the development of a comprehensive categorisation of service types, varying from more conventional services to recently upcoming services. In addition, based on the outcomes of a discrete choice experiment and choice model estimation process, it is determined which and how variables influence the attractiveness of an Alternative Transport Service type. Variables that are considered are level-of-service attributes, characteristics related to the traveller and/or its trip and the opinion of travellers on public transport in general and the attitude of travellers towards different types.

Based on the results of this research, recommendations are made to help the successful development of future Alternative Transport Service schemes.

Summary

Public transport plays an essential role in providing accessibility and countering problems related to social exclusion. The need for an appropriate public transport network is undisputable and suitable transport alternatives should be available for everyone at a fair price in order to be able to fulfil transport demand. However, regular public transport services, such as regular bus services, are not always the most desirable service for all situations. This is the case particularly in less densely populated areas where demand is low and widely dispersed. When demand is low, the service frequency is often low as well, making the public transport services unattractive to use. A survey conducted by the Government of Scotland showed that the most common reasons for not using public transport are the lack of services available at demanded time, inconvenience and the absence of direct routes and connections to other services. It is described in literature that it is not so much the travel speed that is considered important by travellers, but the flexibility of a service; in other words, whether the user can travel when, where and as often as desired.

Because of these problems related to regular public transport and the continuous financial pressure, it is often a major challenge for the responsible tiers of government to provide efficient and high-quality public transport services at a fair price. To meet the challenge of providing appropriate public transport alternatives, new forms of public transport need to be explored. For these new forms, it is desirable to achieve a certain level of flexibility or demand responsiveness. Although many different terms exist for these forms of transport, they all provide a transport service that is influenced by the demand and needs of the users. This is possible, for example, through flexible routing, demand responsive scheduling or by introducing possibilities to get in or out the service vehicle wherever the traveller wants. For this research, the term Alternative Transport Service is used to refer to this kind of service.

The need for this exploration is acknowledged by the province of Overijssel in its vision for public transport. In general, the province indicates that regular public transport is suitable when there are at least eight passengers per trip. When traveller flows fall short, the conclusion of the province is that regular public transport is not the most appropriate solution. When this is the case, the province will, together with municipalities and society, look for appropriate transport services that provide social added value. The social added value of a transport service is, however, hard to determine beforehand because the attractiveness of a service is perceived differently per user. A service's social added value depends to a great extent on the perceived attractiveness of the service and the willingness of potential users to use the service. In addition, service types can vary significantly based on their service attributes (i.e. its accessibility, schedule, travel costs, etc.).

The objective of this research is to obtain knowledge on how different variables, such as service attributes and traveller-related variables (i.e. age, gender, trip purpose, etc.) influence the potential of Alternative Transport Service types in the province of Overijssel.

To do this, firstly, service aspects are explored. Because the desired flexibility or demand responsiveness of a service depends largely on the design of the service, many choices have to be made on various service aspects. The aspects of ATSs can be seen as *building blocks*, because they can be combined to form a service. Well-motivated choices, based on the initiator's objective and the preferences and needs of potential end-users, have to be made for every aspect. Many service aspects are found, but not all of them are considered in this research. Because of the importance of flexibility for ATSs, the service aspects that are considered are the aspects that influence a service's operational flexibility the most. The service aspects (and the options for each aspect) that are considered are route type (A. fixed route, B. route deviation or C. flexible route) scheduling type (A. fixed schedule, B. demand-responsive schedule or C. unscheduled), booking needed (A. no or B. yes) and origin destination-service (A. fixed stops, B. stops flexible along the route, C. stops flexible in an area or D. door-to-door transport). These aspects are at the core of the operational design of a service.

Secondly, service types are explored. It is found that existing categorisations are not suitable to describe all kinds of service types. Therefore, it is chosen to develop a new categorisation based on the

Table 0.1: Categorisation matrix

		Service aspects and alternatives used as categorisation criteria													
		Route			Scheduling			OD-service				Booking		Approach	
Flexibility	Service types	A.	B.*	C.	A.	B.*	C.	A.	B.	C.	D.	A.	B.	A.	B.
	Regular bus	X			X			X				X		X	
Not flexible	Dial-a-ride	X			X			X					X	X	
	Stopflex	X			X			X	X			X		X	
	Routeflex		X			X		X		X	X	X		X	
	Stop hopper			X		X		X					X	X	
	Collective taxi			X		X	X				X		X	X	
	Ride-sharing			X		X			X	X	X		X		X
Flexible	Car-sharing			X			X				X		X		X
	Private car			X			X				X	X			X

***Semi-flexible routing and scheduling could also indicate that consultation or compromises are needed**
The meaning of A, B and C for each aspects is explained on the previous page

four mentioned service aspects. In addition, it is chosen to distinguish services based on the, so-called, service approach. Existing categorisations are found to merely focus on services that follow an approach similar to the approach of conventional public transport, with designated drivers and vehicles and clear roles between driver and passenger(s). However, recently emerging services, such as car-sharing and ride-sharing services, do not follow this approach. With these services, there are no clear roles between driver and passenger(s); a customer can be a passenger one moment and a driver or a service provider the next. Because such services are assumed to have great potential, these types of services are considered for the categorisation as well. In total, seven different Alternative Transport Service types are defined. These can be seen in Table 0.1. Regular bus services and the private car are shown as well to indicate that Alternative Transport Services are intermediate transportation options that fall between the private car and conventional public transport in terms of flexibility.

To determine the influence of various factors on the potential of these ATSs, a survey is conducted. A major part of this survey existed of a discrete choice experiment. In a discrete choice experiment, respondents are asked to choose one alternative out of two or more alternatives in multiple different hypothetical choice situations, with the service attributes (or service aspects) of the alternatives constantly changing for each choice situations. Because it is undesirable to include seven Alternative Transport Service types in the discrete choice experiment, it is chosen to include the four most *extreme* or most *diverse* alternatives from the categorisation shown in Table 0.1. These alternatives are briefly described here:

- **Stopflex:** More or less similar to regular public bus services, but stopflex services can have both fixed stops and stops flexible along the pre-defined route (instead of only fixed stops).
- **Collective taxi:** Services provide transport from door-to-door on request like regular taxis. Main difference is that the trips are shared with other users, possibly leading to a longer travel time and more inaccuracy regarding the departure/arrival time.
- **Ride-sharing:** Ride-sharing services make it possible for end-users to arrange the sharing of car trips, so that more people travel in a car. With ride-sharing services, customers can be a passenger one moment and a driver or a service provider the next.
- **Car-sharing:** Car-sharing services offer cars that can be rented for short periods of time.

Besides the discrete choice experiment to obtain information on choice behaviour of respondents, the survey consisted of additional questions to obtain information traveller- and trip-related variables. Based on an extensive literature review, it turned out that multiple factors influence travel mode choice and the use of ATSs. The factors that are considered in this research are:

- **Service attributes:** Accessibility, scheduling, departure and arrival time window, travel costs, travel time;

- **Travel-related variables:** Gender, age, number of cars in household, driving license, household structure, income, socio-economic participation and level of urbanisation of area wherein the trip is made;
- **Trip-related variables:** Trip purpose, travel distance, trip frequency, vehicle used; and
- **Additional variables:** Opinion about availability of public transport in general, attitude towards modern ATSs, attitude towards more conventional ATSs, perceived safety of services following sharing approach, perception on booking, perception on sharing, need for assistance from the driver.

Based on the choice behaviour of the respondents and that of the respondent groups in the different choice situations, several choice models are estimated. Based on the theory of utility maximisation, these choice models describe, among other things, the importance of service attributes and the importance of traveller- and trip-related variables on the attractiveness of the used Alternative Transport Service types.

With regard to the level-of-service attributes, it is found that several attributes have a significant influence on the attractiveness of the service types. The statement described in literature that it is not so much the travel speed that is considered important by travellers, but the flexibility of a service is found to be true. For example, the use of a wide time window (or a high inaccuracy) for the departure or arrival time is found to negatively influence the attractiveness of an ATS, while providing the transport service completely on demand – in other words an unscheduled service – has a positive influence. It should be noted that it is not found that providing a service with a pre-defined and fixed schedule has a negative influence. A small time window (approximately 5 minutes) is also not found to have an influence on the attractiveness of an Alternative Transport Service. Furthermore, it is found that the better accessible a transport service is (in terms of walking to and from the vehicle or transit stop), the more attractive a service is. For the attribute accessibility, three levels are defined; fixed stops, stops along the route and door-to-door. Compared to stops along the route, which allow travellers to get in and out the vehicle wherever they want along the route, merely using fixed stops has a considerable negative influence on the attractiveness of a service, while the provision of door-to-door transport has a positive influence on the attractiveness of a service. With regard to travel time and travel costs it is found that the slower and more expensive a transport service is, the less attractive it becomes. Based on the parameters for travel time and travel costs, a value of time of around €10.71/hour is found. The VOT of a traveller presents what the traveller would be willing to pay in order to save time (Litman, 2017). The found VOT corresponds to VOTs that are described in other researches (on public transport in general). By making a distinction between trips based on their trip purpose it is shown that for trips wherefore travel time is assumed to be important (i.e. trips with a work, study or medical purpose) the VOT is considerably higher than for trips wherefore travel time is assumed to be less important (i.e. trips with social or recreational purpose).

Regarding the other variables (the traveller- and trip related variables) it is found that not all of them have a significant influence on the attractiveness of a service. The variables that are found most influential are having a driving license and the level of urbanisation of the area wherein a trip takes place. In general, it is found that car-sharing is the most attractive transport service, but also that the preferences of travellers highly depend on traveller-related and trip-related variables and their opinion on and attitude towards service types. For example, car-sharing does not have the highest utility for people without a driving license. Based on the multiple simulations to obtain the predicted probability of travel mode choice, the statement about the importance of flexibility is proved. It is shown that making services more flexible in terms of when and where potential users can travel, increases the potential of services types considerable.

Based on the outcomes of the model results and the simulations, multiple recommendations are presented. The first recommendation is for the province of Overijssel to further look into Alternative Transport Services, because it is shown (both based on the literature review and the model results) that flexible transport options could have great potential. In addition, it is concluded that it is desirable to introduce interventions that make services more flexible, such as minimising the time window or providing the possibility for travellers to get in and out the vehicle wherever they want along the route.

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1. Introduction

In the Netherlands, the car is often the dominant transport mode, while public transport plays a small but important role for people who do not own or are not able to drive their own private vehicle (Dutch Ministry of Transport, 2010). Over the years, however, the public transport network (particularly in rural areas) has come under pressure. Because of changing demographics (i.e. ageing), higher fuel costs and the increasing use of cars and e-bikes, particularly in less densely populated areas, public transport becomes more expensive and increasingly unprofitable, leading to the need for high(er) subsidies (Dutch Ministry of Transport, 2010). For these reasons and because of budget savings, the public transport services in these areas have to be operated as efficiently as possible, possibly leading to a cutback of the amount of services offered (KpVV CROW, 2015). In addition, the quality and appeal of public transport services may be affected by the continuous pressure on operational costs, resulting in even less public transport users and even lower cost-revenues ratios. Therefore, public transport services, particularly in rural areas, are only future-proof when both the efficiency and quality are good (Dutch Ministry of Transport, 2010).

In addition, cutbacks of the amount of services in rural areas do not mean that there is no transport demand (KpVV CROW, 2015). Alternative forms of transport are still needed to be able to go the hospital, to reach the nearest train station or to visit family and friends. In fact, public transport plays an essential role in providing regional accessibility (Mulley, 2010) and appropriate transport alternatives should be available for everyone at a fair price to be able to fulfil the transport demand. Providing efficient and high-quality public transport alternatives at a fair price is, however, a major challenge for the responsible tiers of government. Brake and Nelson (2007) indicate that conventional public transport services are, by definition, inflexible. In an ideal world, however, public transport would be as convenient and flexible as private transport, suggesting that public transport services would be completely demand responsive and that the traveller could use the service whenever he or she wants. Such a level – or a level of convenience or flexibility close to that of private transport – can often not be achieved with conventional public transport services. This is especially the case in areas were travel demand is widely dispersed. When a certain level of convenience or flexibility cannot be offered by the public transport service, most travellers will use their personal car when both a conventional public transport service and a car are available for a journey (Velaga et al., 2012). The importance of flexibility for public transport was also found by the Government of Scotland. It was found that the most common reasons for not using public transport are the lack of services available at demanded time, inconvenience and the absence of direct routes and connections to other services (Scottish Executive, 2003). In addition, Cervero (1997) states that conventional public transport cannot compete with the private car, because it is, among other things, unable to serve spontaneous travel. What stands out is that it is not so much the travel speed that is considered important, but the ability to travel spontaneously; when, where and as often as desired (Daniels & Mulley, 2010).

To tackle the problem of the inflexibility of conventional public transport, new forms of public transport need to be explored (Jain et al., 2017). In the Netherlands (and in the rest of the world), the need to explore and provide future-proof and appropriate forms of public transport has resulted in a myriad of, so-called, Alternative Transport Services (ATSs). Often, the exploration was done independently by the responsible authorities, resulting in the development of more or less similar Alternative Transport Service types (Brake et al., 2006). What all the ATS types have in common is that the service provision is somehow influenced by the demand and needs of the users. This can be done, for example, through flexible routing or demand responsive scheduling (Mageean et al., 2013; Nelson & Phonphitakchai, 2012).

Many provinces in the Netherlands, including the province of Overijssel, intend to stimulate or facilitate such new transport services. In its vision for public transport, called Koersdocument OV (Provincie Overijssel, 2016), the province of Overijssel indicates that regular public transport services are often not appropriate or the most optimal solution. Together with the municipalities in the province, the province of Overijssel looks for appropriate solutions to be able to provide bespoke alternatives.

Examples of such alternatives are car-sharing services and, so-called, neighbourhood buses. As indicated in its vision, different solutions could be appropriate and suitable for different locations. In other words, tailored initiatives are desired. However, with regard to the development of these new initiatives and services, the province of Overijssel has chosen a facilitating role. Others, such as municipalities and the society, have the directing role and are responsible for setting up ATSs that are appropriate and suitable for different user groups. The province will offer help and financial contribution depending on an initiative's social added value and its explanation (Provincie Overijssel, 2016).

However, it is hard to know beforehand what is the social added value of a transport service. Different groups have different preferences and because the vast amount of today's Alternative Transport Services differ in many ways, determining which service is most appropriate or suitable for a given situation is very difficult (Ferreira et al., 2007). Moreover, whether a transport service is appropriate or suitable depends not only on the characteristics of the service, but also on the preferences of the end-user, since service characteristics can influence the fulfilment of certain user preferences. For example, the way a service is (or is not) scheduled (partly) determines the service's flexibility and whether a transport service operates with fixed stops or provides door-to-door transport (partly) determines the accessibility of the service. *Level-of-service attributes*, such as flexibility, accessibility and travel costs, may be highly appreciated by certain users or user groups but not at all by other users or user groups (Khan, 2007). As Finn (1996) states, "The success of a transport service will be related to its ability to meet the needs of at least some of the users in its area of coverage". Knowing how level-of-service attributes and user characteristics influence the attractiveness or potential of ATSs, is assumed to be critical for the successful development and operation of new initiatives.

Therefore, and because of the continuous pressure on conventional public transport services, this study explores which and how different factors (i.e. service attributes and user characteristics) influence the potential of various Alternative Transport Service types in the province of Overijssel. In order to explore the influence of different factors on the potential of ATS types, however, it is necessary to know which ATS types exist and which factors should be considered. Therefore, a major part of this research exists of an extensive literature study on service aspects, service categorisations and which factors (i.e. service attributes and user characteristics) are relevant. In addition, literature on travel mode choice is explored, since the choice for a travel mode – at least when there actually is a choice to make – says something about the preferences of end-users and whether the mode is considered to be attractive.

Based on the literature study, a survey, containing a stated choice experiment and additional questions, is developed to obtain information on which factors, including service attributes and user characteristics, influence the potential of Alternative Transport Service types. In general, stated choice experiments can be used to obtain information about preferences of respondents that cannot be obtained by looking at actual choice behaviour (Kjaer, 2005). Based on the outcomes of the research, recommendations are made to help future initiators of Alternative Transport Service schemes.

1.1. Problem definition and research purpose

The need for public transport services to tackle problems related to accessibility and mobility is undisputable (Currie, 2010). However, implementing and maintaining a viable public transport system is often hampered by financial pressure and the characteristics of conventional public transport services. Conventional public transport services are in general considered to be inflexible and sometimes not the most suitable solution. By being more demand responsive and flexible, the service level of ATSs can come closer to the level of flexibility and convenience of private transport modes. Because of the problems of conventional public transport, new forms of public transport need to be explored. The need for new forms of public transport (or Alternative Transport Services) is recognised by the province of Overijssel. Based on the social added value of a service, the province will offer help and financial contribution. However, it is often difficult to know the social added value of a service beforehand. This is nicely summarised by Pagano and McKnight (1983). They found – in the context of a dial-a-ride service – that providing a service is complex, because the performance of a service depends on many aspects, while different user groups do not attach the same relative importance to the different level-of-service attributes.

Thus, a regular public transport service is not always desirable and it could be that an Alternative Transport Service is desirable. However, whether such a service is desirable depends on its attractiveness or potential to possible end-users. It is not always easy to determine the potential of a transport service, because whether a service has potential, depends not only on the characteristics of the transport service, but also on the preferences of user groups, since service characteristics can influence the fulfilment of certain user preferences. Knowing the influence of various factors, such as level-of-service attributes and traveller-related variables, on the potential of Alternative Transport Services is assumed to be critical for the successful development and operation of new initiatives and services

Therefore, the aim of this research is:

- *To obtain knowledge on how various factors (including level-of-service attributes and traveller-related variables) influence the potential of Alternative Transport Service types in the province of Overijssel.*

In addition, as a secondary goal, the research report should be able to be used by future initiators of Alternative Transport Services as an inspiration and help for their own initiative.

1.2. Research questions

To achieve the research objectives, several research questions have been formulated. These are discussed here. The mean question of this research is:

- *Which factors (including level-of-service attributes and traveller-related variables) influence the potential of Alternative Transport Service types the most in the province of Overijssel and which recommendations can be made for future initiators?*

In addition to the main research question, eight sub-questions are formulated. The answers to these questions are used to answer the main research question. The first two sub-questions focus on service aspects of Alternative Transport Services and service types that are defined in state-of-the-art literature and used in previous studies.

Q1. *Which service aspects of Alternative Transport Services are defined in state-of-the-art literature?*

Q2. *Which Alternative Transport Service types are defined in literature and used in previous studies?*

To obtain knowledge on the potential of Alternative Transport Service types, a suitable categorisation of service types is required. As will be shown with the answer on Sub-question 2, however, there is a lack of a comprehensive categorisation of Alternative Transport Service types. Therefore, a new and comprehensive categorisation of ATSs is developed. Because of the importance of flexibility for ATSs – indicated by Brake and Nelson (2007), stating that in an ideal world public transport would be as convenient and flexible as private transport – the categorisation of the ATS types is based on service characteristics that have a profound influence on a service's operational flexibility. Operational flexibility refers to, as the term suggests, how a service operates in terms of, for example, routing and scheduling.

Q3. *How can Alternative Transport Services be categorised based on the service characteristics that profoundly influence a service's operational flexibility?*

As a result, seven service types are defined, varying from not flexible to completely demand responsive. This, in turn, ties in with the statement of Bakker (1999), indicating that Alternative Transport Services are transportation options that fall between conventional public transport services, which are considered to be inflexible, and the private car, which is considered to be a flexible transport mode.

Because the potential of ATSs depends not only on the service characteristics, but also on the preferences of end-users, it is needed to explore which factors determine the quality or the attractiveness of a service. In this exploration, a distinction is made between level-of-service attributes – the factors related to the service – and the factors related to the traveller (i.e. socio-economic characteristics, trip characteristics and attitude towards (public) transport services). The factors determining the attractiveness of a service are defined by answering Sub-question 4 and Sub-question 5.

Q4. *Which level-of-service attributes influence the potential of Alternative Transport Service types the most, according to literature?*

Q5. *What traveller- and trip-related characteristics (i.e. socio economic characteristics, trip characteristics and attitude towards public transport) influence the end-user preferences regarding Alternative Transport Service types the most, according to literature?*

The answers on these five sub-questions are used to develop a survey containing a stated choice experiment and additional questions. The aim of the survey is to obtain information about the level of influence certain factors have on the potential of ATS types and which factors influence the preferences of end-users regarding the use of Alternative Transport Services. In addition, with the outcomes of the survey, the potential of the different service types is determined. Therefore, the last three sub-questions are formulated.

Q6. *What influence have the found level-of-service attributes on the potential of Alternative Transport Service types?*

Q7. *Which traveller- and trip-related factors influence the end-user preferences regarding potential Alternative Transport Service types the most?*

Q8. *Which Alternative Transport Service type is most preferred by potential end-users in the province of Overijssel?*

The answers on these sub-questions are used to answer the main research question and to make recommendations regarding Alternative Transport Services types and the influence of various factors on the potential of such ATS types.

1.3. Research framework

To obtain knowledge on how various factors influence the potential of Alternative Transport Service types, several steps should be made. These steps are made in are explained in this section and are visually presented in Figure 1.1 on the next page. The figure summarises what is described in the previous sections (i.e. the research motivation, research problem, research purpose and the main research question) and shows the four parts of this research.

The next chapter (Chapter 2) presents the literature study and all theories that are needed to conduct the research. In addition, a new, comprehensive categorisation for Alternative Transport Service types is presented. The first five sub-questions are answered here.

Chapter 3 focuses on the concept of stated choice experiments and the development of the online survey. The data collection, the way the survey is distributed and part of the data preparation are discussed in Chapter 4. The composition of the survey sample is explored in Chapter 4 as well.

Chapter 5 presents the analytical framework, including theories on the subject of travel mode choice modelling. In addition, the chapter describes the model estimation process, the model results and the application of the estimated models. The remaining sub-questions are answered here.

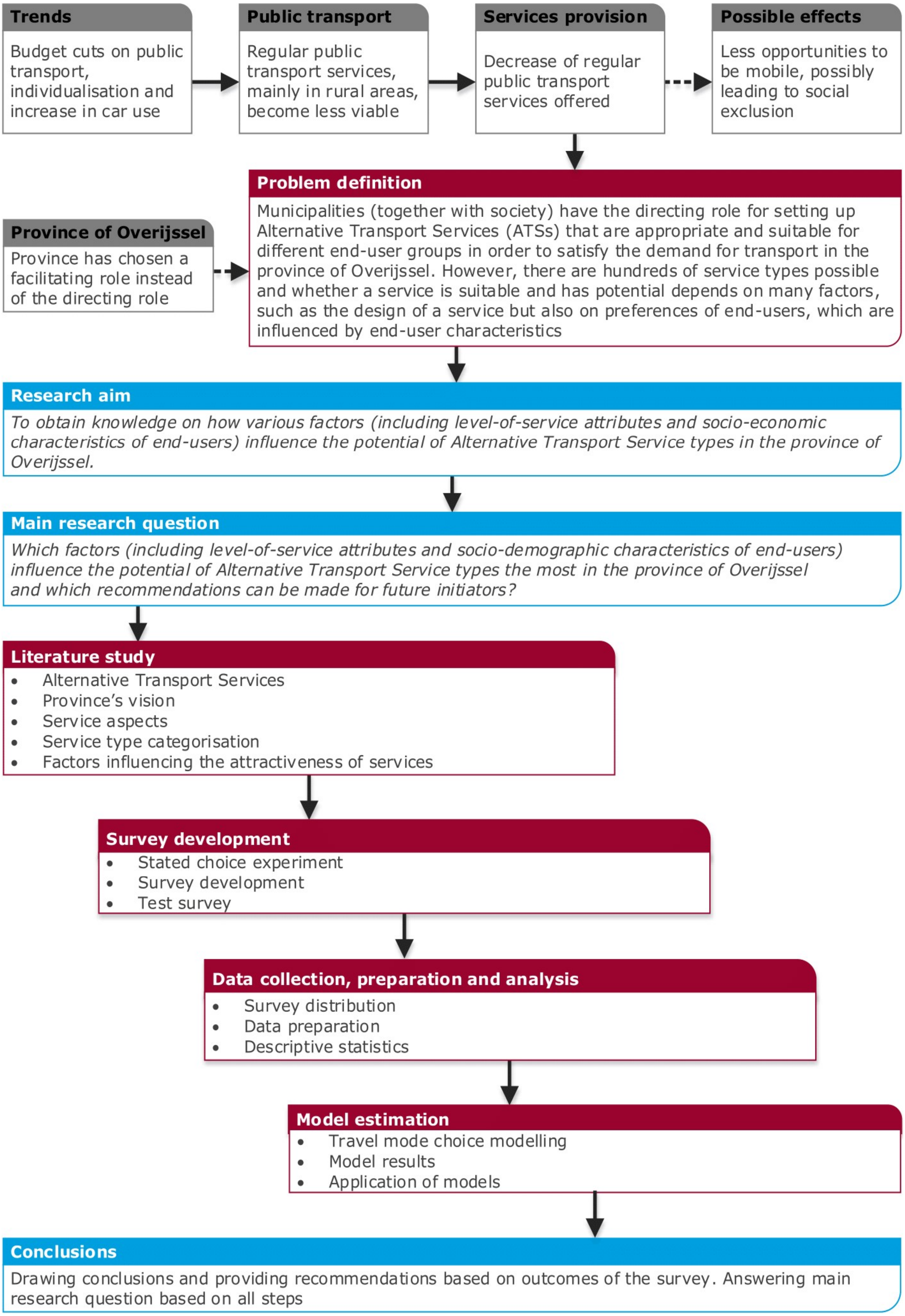

Figure 1.1: Research framework

Chapter 6 presents the conclusions of the research and shows recommendations for the province of Overijssel and future initiators of Alternative Transport Services. The research limitations and research evaluation are discussed in Chapter 7. In this chapter, recommendations for further research are discussed as well.

It should be noted that, although various people can be considered as users, in this research the terms users and end-users are used to refer to the direct customers of a transport service. In addition, Alternative Transport Services generally focus on road transport, because rail-guided transport services are, by definition, not very suitable to function as Alternative Transport Service. Therefore, sometimes the terms public transportation and public transport services are used to refer to public road transport (services).

2. Literature study

This chapter presents the outcomes of the literature study done on Alternative Transport Services, their service aspects, categorisations of service types, the factors influencing the potential of services and the vision of the province of Overijssel on ATSs.

2.1. Alternative Transport Services

This section firstly describes what ATSs are and why ATSs are relevant.

2.1.1. Definition

In many economically developed countries, public authorities are obligated to guarantee that all inhabitants are provided with appropriate and adequate transport options to reach their desired destinations. This worldwide obligation has resulted in a multitude of public transport services, not only including conventional bus, rail, ferry and air services, but also alternative services, such as individual and shared ride taxis, private hire, community transport group hire and community owned vehicles (Brake et al., 2004).

Various terms have been used as collective noun for the set of unconventional public transport services, such as Demand Responsive Transport (DRT) and Flexible Transport Services (FTSs) (Nelson et al., 2010). Although the history of DRT can be traced back over forty years (Nelson & Phonphitakchai, 2012), the term Demand Responsive Transport has been increasingly used in recent years to indicate a niche market that replaces conventional transport in areas with low and widely dispersed demand (Brake & Nelson, 2007). According to Bakker (1999), DRT is a "transportation option that falls between private car and conventional public bus services", while Ambrosino et al. (2004) describe DRT as "an intermediate form of transport, somewhere between bus and taxi, which covers a wide range of transport services ranging from less formal community transport through to area-wide service networks".

While Flexible Transport Services (FTSs) generally has been a term used to indicate services that are flexible in terms of route, vehicle allocation, vehicle typology, fleet operator, type of payment and passenger category, the term has been increasingly applied to services that feed or replace conventional transport services were demand is low and spread over a large area (Nelson et al., 2010). It turns out that – especially in the last few years – the terms DRT and FTSs have been used for the same kind of services.

Other terms used for ATSs are Dial-a-Ride (Cordeau & Laporte, 2007), ad-hoc ride-sharing (Braun & Winter, 2009), Special Transport Services (Nelson et al., 2010), Adaptive Transit (Enoch et al., 2006) and Paratransit (Kisla et al., 2016). Although these terms are more applicable to types of transport services, which can differ on aspects such as design and purpose, sometimes they are used to indicate unconventional transport services in general as well (Jain et al., 2017).

What all the terms have in common is that they apply to transport alternatives where service provision is influenced by the demand and needs of the users, for example through flexible routing or demand responsive scheduling (Mageean et al., 2013; Nelson & Phonphitakchai, 2012). For this research, it is chosen to use the term Alternative Transport Service (ATS) instead of Demand Responsive Transport (DRT) or Flexible Transport Service (FTS) in order to emphasise that not all services have to be purely demand responsive or flexible (as will be shown later on in this research report). Although conventional public transport services are also, in some extend, demand responsive (since routes are fixed based on historical knowledge of customer demand) such services are not considered to be flexible or demand responsive (Brake et al., 2004).

2.1.2. Relevance

When countries started to implement requirements for transport authorities to provide transport to mobility impaired and disabled persons in the 1970s and 1980s, it turned out that the conventional fixed route public transport services at that time were not suitable to transport passengers with disabilities. Therefore, unconventional public transport services or Alternative Transport Services (ATSs) were offered (Nelson et al., 2010). In 1999, Bakker (1999) described that ATSs are "usually considered to be an option only for less developed countries and for niches like elderly and disabled people". In recent years, however, unconventional public transport services have been found to be adequate measures to improve accessibility, complementary to the conventional public transport services, by serving areas where demand is low and widely dispersed (Brake et al., 2004; Nelson et al., 2010). Especially, but certainly not exclusively, in these areas where demand is low and widely dispersed, unconventional public transport services have shown major advantages compared to regular public transport services.

Besides the various barriers to develop public transport and maintain viable public transportation in rural areas, Brake and Nelson (2007) indicate that, traditionally, public transport is seen as an inflexible transport option by definition. However, in an ideal world, public transport would be as convenient as private transport, suggesting that public transport services would be completely demand responsive. Because this – or at least tending to be as convenient as private transport – is not possible with (conventional) public transport services for a reasonable price, most passengers will use a personal car when both a (conventional) public transport service and access to a car are available for a journey (Velaga et al., 2012). A survey conducted by the Government of Scotland showed that the most common reasons for not using public transport are the lack of services available at demanded time, inconvenience and the absence of direct routes and connections to other services (Scottish Executive, 2003). In addition, Cervero (1997) states that conventional public transport cannot compete with the private car, because it is, among other things, unable to serve spontaneous travel. What stands out is that it is not so much the travel speed that is considered important, but the ability to travel spontaneously; when, where and as often as desired (Daniels & Mulley, 2010).

According to a report of ActiveAge (2008) and Daniels and Mulley (2010), the main opportunities for greater use of ATSs therefore include:

- Obtaining wider network coverage with the same resources by providing feeder services from rural areas to major public transport corridors;
- Providing high-frequency, on-demand services in specific zones or areas where low and wide-spread demand means that conventional services are very low frequency;
- Providing services at times when conventional public transport services are not viable; and
- Obtaining flexibility by providing services that are quick and easy to change with adjustable operating times;

Thus, conventional public transport services are sometimes not the most suitable solution and the possibilities to travel spontaneously are often limited. By being more demand responsive and flexible, ATSs can tackle this problem (Wang & Winter, 2010). Not least because of technological developments, such as transport telematics, ATSs will become increasingly attractive, because transport telematics enable operators to schedule a greater number of journeys closer to the time of travel. In addition, booking will become more convenient with the rise of (smartphone) applications (Brake et al., 2004). Therefore, the service level of ATSs can come closer to the level of flexibility and convenience of private transport modes, whilst also having the potential to improve regional accessibility at a cheaper costs than private hire and taxis (Brake et al., 2004; Jain et al., 2017).

2.2. Province's vision on public transport

The budget savings mentioned in the introductory chapter of this research report have also had their effect on the province of Overijssel, resulting in a deficit of budget; the costs and expenses exceed the (financial) resources that are actually available for the provision of public transportation. In order to solve this problem, the province of Overijssel has started to transform the way its public transport system is set up. How this transformation process should take place and the roles of the province, municipalities and society in this process are presented in the province's vision for public transport, called the *Koersdocument OV* (Provincie Overijssel, 2016). This section presents the parts of this vision covering alternative forms of public transport.

It should be noted that, officially, the Koersdocument OV only applies to the western part of Overijssel. This is, because before 1 January 2015, a major part of eastern Overijssel was an independent (city)region with, among other things, its own budget for public transport. Therefore, the region, which was called Regio Twente, developed its own vision for public transport, called OV-Visie Twente 2010-2018 (Regio Twente, 2010). In the next years, Regio Twente will follow the ongoing public transport policy, but will also gradually adapt to the new, province-wide policy on public transport. It is indicated in the Koersdocument OV, namely, that the problems experienced in the western part of Overijssel are increasingly experienced in the eastern part of Overijssel as well. Therefore, a transportation process of the public transport might be needed in Twente as well. Because of the ongoing importance of the vision for public of Regio Twente, in this section and in the remaining part of this research, this vision is considered as well.

In the Koersdocument OV, societal trends influencing mobility patterns are described as the main challenges for (public) transport in the province. Trends, such as ageing and digitalisation are named as examples. Not only are there more elderly people, in general these elderly people have the ability to *be mobile* longer, resulting in more and different demand. Because the possible temporal nature of these trends and the vast demand for new solutions, it is stated that the public transport system in Overijssel should be both flexible and future-proof.

To achieve this, the province distinguished two parts of its public transport network: the *kernnet* or core network and the *mobiliteitsmix* or mobility mix. The core network should be attractive and future-proof to compete with private vehicles, such as the car, and will contain national and regional rail corridors and widely used bus services. By making the services attractive, for example by increasing their frequency and travel speed, the province will try to attract more public transport users.

This is certainly not the case for the mobility mix. There are many situations for which the province does not consider conventional public transport services the optimal solution. For example, for short distances, the province prefers travellers to use their bicycle. Because of the e-bike, the range of the bicycle increases. In the mobility mix, outside the core network, bus services can still have a major role in places with *sufficient* clustering of traveller flows. In its vision, the province defines sufficient as eight passengers per trip. When traveller flows fall short, the conclusion of the province is that regular public transport is not the most appropriate solution. Although the bicycle and car are considered to be appropriate for respectively short and longer distances, the province of Overijssel and municipalities will look for appropriate solutions for places where a sort of transport service is desired. The parties will, together with society, look for appropriate solutions to be able to provide bespoke alternatives. Possible alternatives differ from ride-sharing to dial-a-ride services and from collective taxis to car-sharing services.

Key for the possible alternatives is that they should be flexible and that the costs for providing these Alternative Transport Services should be lower than the costs for providing regular public transport services. In addition, with regard to the development of these ATSs, the province of Overijssel has chosen a facilitating role. Others, such as the municipalities and society, have the directing role and are responsible for setting up the services. Depending on whether an initiative is considered suitable and the initiative’s social added value, the province will offer help and financial contribution.

2.3. Service aspects

As indicated in Sub-section 2.1.2, services can be adapted in many ways to achieve a certain level of flexibility or demand responsiveness. To achieve this, many choices have to be made on various service aspects or attributes, because the flexibility or demand responsiveness of a service can vary significantly because of the design of the service, including the composition of service aspects (Ambrosino et al., 2004). Table 2.1 shows the most important service aspects, according to Round and Cervero (1996), Ambrosino et al. (2004) and Enoch et al. (2004). According to Ambrosino et al. (2004),

Table 2.1: The most important level-of-service aspects (characteristics) of Alternative Transport Services (Ambrosino et al., 2004; Enoch et al., 2004; Round & Cervero, 1996)

Aspect	Alternatives
Route type	Fixed-route, route-deviation, flexible route
Scheduling type	Fixed-schedule, demand-responsive, unscheduled
Booking type	On-board booking, direct booking, wide time windows – trip notification, collecting requests – defining service
Vehicle type	Minicab, taxi, minibus, seater car
Vehicle allocation	One vehicle available, extendable vehicle allocation, dynamic allocation of vehicles
Origin-destination relationship	One-to-one, one-to-many, many-to-one, many-to-many
Origin-destination service	Checkpoint/fixed stops, stops flexible along route, stops flexible in an area, door-to-door
Network concept	Stand-alone service, feeder service, service with multiple service roles

these aspects can be seen as the *building blocks* of an Alternative Transport Service, because the several alternatives can be combined to form a service. Well-motivated choices have to be made for every aspect, based on the initiator's objective and the preferences and needs of (potential) end-users. The different aspects and alternatives are individually described in the coming sections.

The various service aspects or service characteristics can, as Nelson et al. (2010) state, "vary along a continuum of demand responsiveness […] from services where all variables are fixed a considerable time before operation (e.g. a conventional public transport bus route) to services whose constituent variables are determined close to the time of operation". This is illustrated in Figure 2.1 on the next page. As can be seen, the *network concept* is not included in this figure. The reason for this is explained later on in this research in Sub-section 2.4.1.

2.3.1. Route type

The routing of a service is closely related to the alternative chosen for the origin-destination service aspect. Although Ambrosino et al. (2004) define the route of a service as "the list of stops that will be served in a specific order", often it is not as straightforward as this definition suggests, because other aspects, such as the service's schedule, play an important role as well.

Fixed-route services provide transportation with scheduled arrivals at given points along a pre-defined route (Enoch et al., 2004). Important for fixed-route services is that the stops are served in a pre-defined order. However, depending on the demand, it could be possible that not all stops are served and that some stops are skipped. With a fixed-route service, this does not influence the order in which the other stops are served or the trajectory of the service vehicles between the remaining stops.

With regard to the accessibility of a service (e.g. the walking distance to the access point), services offering *route-deviation* or *semi-flexible* routes are more flexible than pure *fixed-route* services. Services operating with semi-flexible routes also call at the pre-defined stops in a pre-defined order, but when a stop is skipped, service vehicles may deviate from their initial route between the remaining stops. Constraints, such as fixed stops, may still be applicable. Enoch et al. (2004) explain this by saying that, "For example, a vehicle may be required to deviate from its route and yet pass through all its checkpoints, making it *late* on the section of route beyond the deviation. Even more flexible are services with flexible routing. With such services, the vehicles go wherever they are requested, totally independent of a pre-defined route or stops.

2.3.2. Scheduling type

As stated in the introductory chapter of this report, for transport modes, a mode's ability to serve spontaneous travel is extremely important (Cervero, 1997; Daniels & Mulley, 2010). This makes that scheduling is an important aspect. Most conventional public transport services are *fixed-schedule* services, while the car is totally unscheduled. In addition, services may have a fixed time schedule, but require booking or operate with flexible pickup times. For the last option, often the pickup time has to

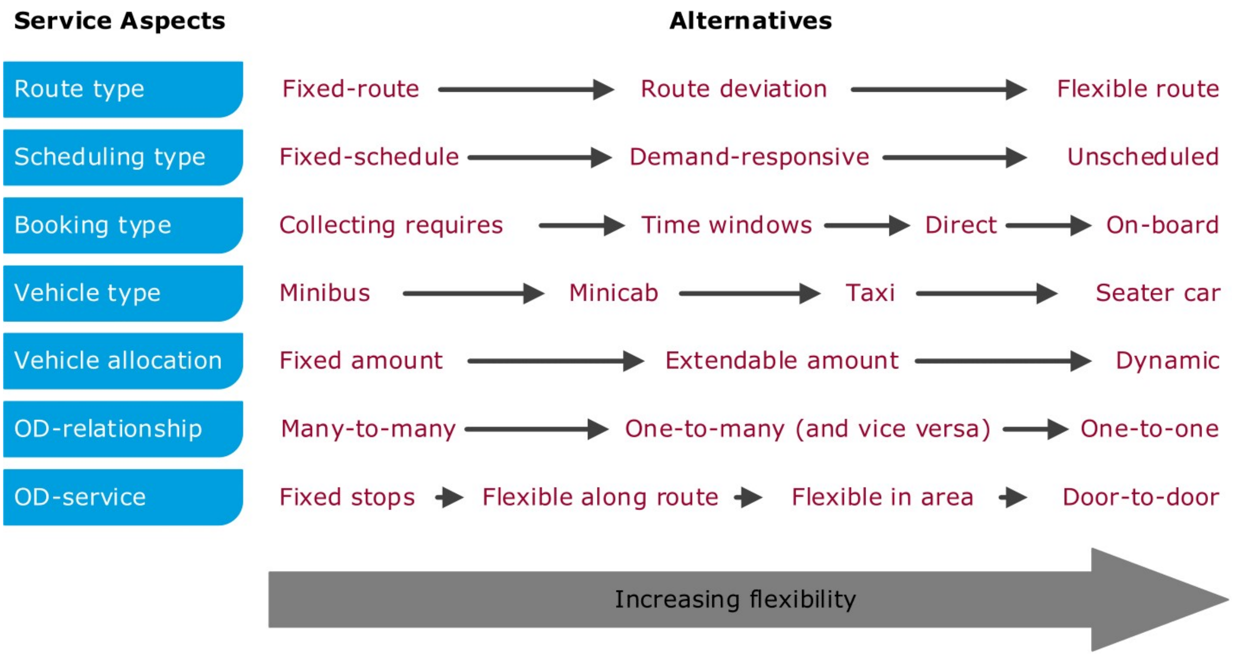

Figure 2.1: The demand responsiveness of transport alternatives (based on Brake and Nelson (2007))

be discussed and/or concessions have to be made. These alternatives are grouped as *demand-responsive* scheduled services.

2.3.3. Booking type

For booking a transport service there are multiple options. The most common option for conventional public transport is the *on-board booking* alternative. In this situation, customers *book* a trip by notifying the driver directly at the boarding stop and it is up to the driver to decide whether he will allow the passenger to board the vehicle.

With *direct booking*, the customer issues a request to the operator. As a response, the operator proposes one or more options from which the customer has to choose. In order to organise the service, the operator allows the booking to be done up on a certain time limit (e.g. one or two hours before the departure time). Because of transport telematics and convenient (smartphone) applications, operators are able to schedule a greater number of journeys closer to the time of travel. By reducing the time limit, services become more flexible and demand responsive.

Related to direct booking are the alternatives of *wide time window – trip notification* and *collecting requests – defining service*. As explained by Ambrosino et al. (2004), with the first alternative, customers receives proposals from the operator with relatively wide time margins on departure and arrival times. To allow the operator to optimise the organisation of the service, customers confirm the booking based on these time windows. A short time before departure, the customer will receive more information about the precise departure time.

With *collecting requests – defining service*, operators will first collect all requests and calculate their most optimal routes. Based on these routes, customers will be informed about the services they can use (Ambrosino et al., 2004).

2.3.4. Vehicle type

Regarding vehicle type there are many options. The size of vehicle is influenced by the expected levels of demand and the costs (Enoch et al., 2004). In addition, the chosen vehicle type should be suitable for the potential end-user group. For example, for services aimed at elderly it is wise to choose vehicles that are easy to get in and get out of, and specific facilities for wheelchairs may be needed.

2.3.5. Vehicle allocation

In addition to the choice of vehicle type, another choice is the vehicle allocation. With fixed vehicle allocation, passengers have to choose an earlier or later service or have to use a different transport service when the capacity of the allocated vehicles is reached. If the service operator does not want to refuse passengers, the operator can use vehicles (possibly from another operator or company) that are on standby. For this situation, which is named extendable vehicle allocation, a good statistical analysis is needed to determine the best balance between the basic service and the additional standby capacity. Dynamic allocation of vehicles applies to the situation where the operator has a pool of different types of vehicles (capacity, accessibility, special facilities) available to realise the service (Ambrosino et al., 2004).

2.3.6. Origin-destination relationship

By definition, a one-to-one service operates between two points, with the possibility of access and egress at intermediate points. A one-to-many service provides transport from multiple origins to a single destination or vice versa (Enoch et al., 2004). A many-to-many service transports passengers between locations in the area served by the service.

2.3.7. Origin-destination service

This service aspect describes the type of stops of a service. *Door-to-door service* are able to increase the accessibility of an area, but tend to be very expensive (Enoch et al., 2004). Services operating with between *fixed stops* or *checkpoints* tend to be less expensive, but also decrease the proportion of the area that is covered by the service. In between these two options are *stops flexible along route*, where passengers can get in or out along the route, or *stops flexible in an area*, where services deviate on request within the service area. An important difference between *door-to-door* and *stops flexible in an area* is that for the latter, the vehicles deviate from the route, while for the former there does not have to be a route to begin with.

2.3.8. Network concept

In addition to the above-mentioned service aspects, Ambrosino et al. (2004) considers the role of ATSs in the general public transport offer as the final service aspect. However, as explained in Sub-section 2.4.1, there are reasons to think that the network concept is not a service aspect. Nevertheless, the aspect and related alternatives are presented here.

When an ATS is operated without any time or spatial relation with other services, the service is considered a *Stand-alone service*. Another extreme possibility is that the ATS, for almost 100% of its customers, operates as a *feeder service* to a regular public transport service. Important for such services is that convenient and comfortable transfer possibilities are provided. The third alternative for the network concept is that services have multiple service roles (Ambrosino et al., 2004).

2.4. Service types

Because of the multitude of alternative for the service aspects, many different service types can be formed. In theory, it is possible to form any combination of the various alternatives described in the previous section (Enoch et al., 2004). In reality, some combinations are more plausible and desirable than others. Because of this, to determine the potential of Alternative Transport Services, it is desirable to categorise and define different service types. Several categorisations are described in previously done studies. Some of these are described here. As it turns out, none of the categorisations are considered to be suitable for this research. Therefore, a new comprehensive categorisation for ATSs is developed in Sub-section 2.4.3. To be better able to do this, the second part of this section presents an exploration of ATSs that are active in the Netherlands.

2.4.1. Categorisations found in literature

Enoch et al. (2004) distinguish four composite types, based on their functions and position in the total public transport network:

- **Interchange services:** Interchange services provide feeder links outside an existing conventional public transport corridor in order to extend the network and coverage for the conventional service. They should provide high-quality transport, comparable to taxi services, but with integrated timetabling and reliable connections.

- **Network services:** Network services are part of the overall public transport network in order to enhance the conventional public transport either by providing additional services, or by replacing uneconomic services in a particular place or at certain times. In this situation, ATSs are not primarily providing feeder links, but provide parts of the public transport services. As Enoch et al. (2004) state, "They may perform a feeder function, but this is just part of a more integrative public transport function".
- **Destination-specific service:** Destination-specific services serve particular destinations such as airports or employment locations.
- **Substitute service:** Substitute ATSs completely replace public transport services.

The disadvantages of this categorisation – which is similar to the service aspect network concept, as described by Ambrosino et al. (2004) – is that different services can consist of similar characteristics, whilst having a totally different function and position in the complete public transport network. For this research, this is the main reason why the role of ATSs in the total network of public transportation is not considered to be a service aspect. The fact that services with different network functions can consist of similar characteristics makes that this categorisation is unsuitable to explore the influence of various level-of-service attributes, which are (partly) influenced by the service characteristics, on the potential of different Alternative Transport Service types.

Another categorisation, described by the Scottish Executive (2006), defines four types of services based on their main types of service markets:

- **High care needs services**: These services are suitable for diverse markets, including services for people with disabilities and some non-emergency patient transport, social services transport and community transport.
- **Best value services**: These services are suitable for a market where demand is low and where flexible services (regarding route type, scheduling type, etc.) can provide better value services and wider network coverage than conventional public transport services. This is often the case in rural areas.
- **High value to agency services**: This are services that are tailored to needs of public agencies, such as school transport or shuttles for business parks.
- **Premium value services**: High value services that are defined by the need to reduce travel times and provide a high level of customer care. Airport transfer services or airport shuttles are examples of such services.

The problem with this categorisation is, however, that services do not have to serve one specific market and, as with the categorisation of Enoch et al. (2004), services can consist of similar aspects but serve different markets. To explore the influence of level-of-service attributes and service aspects on the potential of ATS types, a categorisation is required based on service aspects. However, a categorisation based on all aspects and alternatives presented in Table 2.1 (page 10) would, theoretically, result in (3*3*4*4*3*4*4=) 6.912 different service types. Such a large number of services types is undesirable. Although a categorisation based on service aspects is desirable, in order to be able to work with the categorisation and the amount of service types, not all aspects and the related alternatives should be considered.

An example of a categorisation that is based on a selection of service aspects is the one presented by the Dutch municipality Steenwijkerland (Gemeente Steenwijkerland, 2008). Based on route type, scheduling type and origin-destination service, eight forms of alternative (public) transport services are distinguished, differing from a regular bus service to an area-wide collective taxi. This categorisation can be seen in Appendix A. The problem with this categorisation, in turn, is that it focuses on services that follow an approach similar to that of conventional public transport, with designated drivers and vehicles and clear roles between driver and passenger(s). Recently emerging services that do not follow this approach, such as car-sharing and ride-sharing services, are not considered. Such services, however, are often considered to hold great promise, not least because research suggests that the proportion of young people in North-America and Europe who have a driving licence or own a private car has been on decline in recent decades (Schroders, 2015). In addition, technological developments such as (smartphone) applications have the potential to make these services more and more convenient.

For their categorisation, Kisla et al. (2016) did include services such as car-sharing and ride-sharing services. They distinguish four different service types, which are briefly explained below. Mageean and Nelson (2003) and Westerlund et al. (2000) present more or less similar categorisations.

- **Fixed corridor services**: Vehicles of these services halt at all stops between the starting point and the end point regardless of the demand at the stops, with routes and timing fixed in pre-specified time tables (Horn, 2002).
- **Semi-fixed corridor services**: Vehicles of these services do not halt at stops without demand. According to Häll (2006), the vehicles follow their pre-determined route through pre-destined stops unless the service is required at a non-pre-defined location. As a result, the route is adjusted to the demanded deviation.
- **Flexible area service**: Such services provide area-wide door-to-door services based on dynamic demand. Access and egress locations can be widely dispersed within an area and not just deviated along the route. Vehicles can receive dynamic information to handle requests. Door-to-door service can be provided.
- **Flexible corridor service**: The vehicles of these services follow a route in complete accordance with personal demands. Since there are no fixed routes or pre-defined stops, such services only provide door-to-door service. Taxis, car-sharing and ride-sharing are included in this concept.

Since this categorisation merely takes into account two service aspects – route type and origin-destination service – some widely applied service types cannot be distinguished. For example, the so-called Dutch neighbourhood buses operate via the stopflex principle as described in Appendix A. Such services cannot be distinguished with the categorisation of Kisla et al. (2016). Because of this all, a different and more comprehensive categorisation is desired. Therefore, based on a selection of the mentioned service aspects, a new categorisation is developed in Sub-section 2.4.3.

2.4.2. Alternative Transport Services in the Netherlands

It is assumed that, to be better able to develop a comprehensive categorisation, it is required to have knowledge on which kind of services actually exist. Therefore, an exploration was done on active ATSs in the Netherlands. A total of 189 existing services were identified using a wide range of sources, such as internet and existing (regional) overviews and with the help of Dutch municipalities and provinces. All municipalities and provinces were contacted by e-mail with the question whether they knew of the existence of active unconventional transport alternatives. As a response, more than 200 municipalities and provinces replied. More detailed information on the 189 services is available on request.

2.4.3. Categorisation of service types

As indicated, to explore the potential of ATS types, a comprehensive categorisation of ATS types is required first. For all categorisations described in Sub-section 2.4.1, problems or disadvantages are found.

Because of the importance of flexibility, the categorisation is based on the service aspects that influence a service's operational flexibility the most. These aspects are at the core of the operational design process. The categorisation of Kisla et al. (2016) is used as basis, combined with the aspects used in the categorisation of the municipality Steenwijkerland (2008). Service aspects that are considered to profoundly influence the flexibility of a service are *route type*, *scheduling type*, *booking type* and *origin-destination service*. This are also the service aspects that are taken into account by the municipality Steenwijkerland (2008) and (Kisla et al., 2016). The aspects and categorisation criteria that are considered for the categorisation can be seen in Table 2.2. For most aspects, a brief explanation is presented in the rightmost column of the table.

As can be seen, the services are also distinguished based on the service approach. As indicated in Sub-section 2.4.1, the categorisation of the municipality Steenwijkerland merely focuses on services that follow an approach similar to the approach of conventional public transport, with designated drivers

Table 2.2: Service aspects and alternatives used for the categorisation of Alternative Transport Services

Aspect	Alternatives (used)	Explanation
Route	A. Fixed-route	Stops are served in pre-defined order. Stops could be skipped, but order and trajectory is fixed
	B. Semi-flexible	Stops are serviced in pre-defined order, but vehicle could deviate from route when a stop is skipped
	C. Flexible route	Vehicles of service can go wherever they are requested, regardless of pre-defined stops
Scheduling	A. Fixed-schedule	Service has scheduled arrivals at given locations
	B. Semi-flexible	Service need to be booked in advance. Both fixed and flexible time schedule possible
	C. Unscheduled	Service does not operate with any scheduled arrival times
Booking	A. Reservation not required	*On-board booking* is sufficient
	B. Reservation required	Service has to be booked in advance
Origin-destination service	A. Fixed stops	Fixed locations where travellers get in and out the vehicle
	B. Stops flexible along route	Travellers can get in and out along the route, as well as at fixed stops
	C. Stops flexible in an area	Service vehicle deviates from its route to desired location
	D. Door-to-door	Service vehicle goes wherever they are requested. There is no route to deviate from.
Approach	A. Conventional	
	B. Sharing	

and vehicles and clear roles between driver and passenger(s). Recently emerging services that do not follow this approach, such as car-sharing and ride-sharing services, are not considered. With these services, there are no clear roles between driver and passenger(s); a customer can be a passenger one moment and a driver or a service provider the next. For this research it is chosen to include a distinction between services based on the approach that they follow, either the *conventional approach* or the *sharing approach*.

The service aspects vehicle type and vehicle allocation are not considered, because it is assumed that a service, regardless of whether it is desirable or not, can be operated with different vehicle types without influencing the flexibility of a service. *Origin-destination relationship* and *network concept* are also not considered. The main reason why the role of ATSs in the total public transportation network is not considered to be a service aspect, is that different services can consist of similar characteristics, whilst having a totally different function and position in the complete public transport network.

A *code*, in the form of a letter, is assigned to every alternative. In this way, the categorisation matrix, shown in Table 2.3*,* becomes clearer and more convenient to read. As can be seen, seven service types are defined. Regular bus services and private car are also shown in the matrix. This is done to emphasise that ATSs fall between private car and conventional public bus services (Bakker, 1999). The flexibility related to a transport mode increases the further the transport mode is down in the table, as is shown with the arrow on the left side of the table. It should be noted that for car-sharing it is assumed that there is a sufficient number of cars available in the car-sharing scheme and that there are plenty of pick-up points and places to leave the cars. The defined service types, and the choices made for the categorisation, are individually discussed in the coming sections. In addition, for each service type, one or more examples are presented in Appendix C. The examples can be used as inspiration or trigger for further reading.

Dial-a-ride

The design of a dial-a-ride service is more or less similar to the design of a regular bus service. As can be seen in the categorisation of the municipality of Steenwijkerland as well (Appendix A), dial-a-ride services operate with fixed routes and time schedules. The main difference with a regular bus service, besides that the service often uses smaller vehicles, is that a dial-a-ride service only calls at the fixed

Table 2.3: Categorisation matrix

		Service aspects and alternatives used as categorisation criteria													
		Route			Scheduling			OD-service				Booking		Approach	
Flexibility	**Service types**	A.	B.*	C.	A.	B.*	C.	A.	B.	C.	D.	A.	B.	A.	B.
Not flexible	Regular bus	X			X			X				X		X	
	Dial-a-ride	X			X			X					X	X	
	Stopflex	X			X			X	X			X		X	
	Routeflex		X			X		X		X	X	X		X	
	Stop hopper			X		X		X					X	X	
	Collective taxi			X		X	X				X		X	X	
	Ride-sharing			X		X			X	X	X		X		X
Flexible	Car-sharing			X			X				X		X		X
	Private car			X			X				X	X			X

***Semi-flexible routing and scheduling could also indicate that consultation or compromises are needed**

checkpoints when the service is requested beforehand. An example of a well-known dial-a-ride service in the Netherlands is the LijnBelBus, as presented in Appendix C.

Stopflex

Stopflex services are also more or less similar to regular public bus services. The main difference, as can be seen in Table 2.3, is that a stopflex service may have both fixed stops and stops flexible along the route. The passengers of a stopflex service can, as long as it is safe, stop the service vehicles along the entire route to (de)board. Because it is not required to book the service, service vehicles will not deviate from the pre-defined route. Well-known stopflex services are the neighbourhood buses in the Netherlands.

Routeflex

In principle, routeflex services depart at fixed departure times and then serve pre-defined stops in a pre-defined order. The vehicles follow their pre-determined route, unless the service is required at another location within the service area. Thus, depending on the demand, the route is adjusted to the demanded deviation. This also means that routeflex services may operate with fixed stops and stops flexible in the service areas (including door-to-door). Although the services operate with fixed departure times, the routeflex services are assumed to have semi-flexible time schedules, because the potential deviations make that the schedule is only more or less known for stops further on the route. In addition, the departure times at non-pre-defined locations have to be discussed and (possibly) concessions have to be made.

Stop hopper

Stop hopper services, in Dutch known as haltehoppers, transport passengers between fixed stops or checkpoints. There are no pre-defined routes and services only operate when they are requested. Based on the total demand and the requested departure and arrival times of all passengers, routes are determined and driven. With regard to departure and arrival times, passengers may have to make concessions.

Collective taxi

Collective taxi services provide transport from door-to-door. There are no fixed routes and time schedules and the taxis only operate on request. Often *wide time window – trip notification* is used as booking type (for this categorisation not used as a categorisation criterion), because the service is shared with other users. In the Netherlands, because they offer transport from door-to-door, and because of the (possible) presence of a qualified and skilled driver, collective taxis are often used to provide WMO-transport. The Wet Maatschappelijke Ondersteuning (WMO), or the Dutch Social Support Act, ensures that everyone is able to participate in society and can live independently as long as possible (Ministry of Health, 2016). WMO-transport provides convenient transport services at cheaper costs for people with mobility issues, because of physical or social disabilities. The presence of a qualified and skilled driver and the door-to-door service makes that collective taxi services are suitable to provide WMO-transport. As indicated by Enoch et al. (2004), door-to-door services tend to be very expensive. Appendix C presents both a public and private example of a collective taxi service.

Ride-sharing
Ride-sharing services make it possible for end-users to arrange the sharing of car trips, so that more people travel in a car (Amey et al., 2010). Services can be simple and straightforward, by for example using a fixed carpool pick-up place, but can also use recent technological advances. More modern ride-sharing services often offer an application that allows travellers to submit a trip request. Based on their location, drivers receive an overview of all requests, which they then can accept or reject. When a driver accepts a requests, often, the application determines a driver's route to arrange the shared ride. In addition, the application can instantaneously handle the payment. In a similar way, it is possible that drivers can indicate that they drive a particular route and are willing to take travellers. It is important for any ride-sharing service that the revenue for the driver is not more than a compensation for his or her costs. Otherwise, when the driver makes a profit, it is illegal under the Dutch Taxi Act (Samobiel, 2017).

Depending on the driver and traveller(s), the interpretation of a service can be different. For example, it is up to the driver how far he/she deviates from his/her route and how flexible he/she wants to be with regard to departure time and pick-up location. It is likely that concessions have to be made on both sides. With ride-sharing services, customers can be a passenger one moment and a driver or a service provider the next. Two different ride-sharing services are presented in Appendix C.

Car-sharing
Car-sharing services offer cars that can be rented for short periods of time. Such services are attractive to people who do not need (or want) to own a car, but occasionally have to use a car. As with ride-sharing, the technology of car-sharing services can vary enormously, from simple manual systems using key boxes and log books to increasingly complex computer systems (Shaheen et al., 2006). Recently emerging car-sharing services allow travellers to find a nearby car via a (smartphone) application and allow travellers to pick up and drop off the cars at any available public parking space within the service area.

Although car-sharing is often assumed to be successful merely at densely populated areas, car-sharing can also be used in rural areas. In the latter case, often, one or more cars are placed at a central location (for example the central market square). The Dutch technology platform for transport, infrastructure and public space, called KpVV CROW, distinguishes five different forms of car-sharing (KpVV CROW, 2016a). These forms are presented in Appendix C. In the remainder of this research, in particular in the discrete choice experiment, the one-way car-sharing service is kept in mind when talking about car-sharing alternatives.

2.5. Factors influencing the potential of ATS types

As said, the potential or utility of a transport mode depends on many factors. This section explores which factors are described in literature to influence the potential of Alternative Transport Service types. The factors that are found are used later on in this research in Chapter 3 to develop the survey. The first part of this section focuses on the factors related to the service (the level-of-service attributes) and the second part on the factors related to the traveller (i.e. socio-economic characteristics, trip characteristics and attitude towards (public) transport services).

2.5.1. Service-related factors

As stated by Gauthier and Mitchelson (1981), "It is not the travel mode that is evaluated by a traveller in a choice situation, but it is the attributal composition of the mode which serves as the evaluative criterion". Thus, the attractiveness of a service depends on its service attributes and the perceived importance of these attributes. Various researchers, therefore, have attempted to define level-of-service attributes and quality criteria that influence the attractiveness, perceived performance and quality of Alternative Transport Services (Paquette et al., 2007). As stated by Paquette et al. (2007), because many academics and scholars feel that several attributes and criteria that apply to conventional public transport services also apply to Alternative Transport Services, many so-called quality indices for ATSs are based on lists of attributes and criteria that were originally used to determine the attractiveness and quality of conventional public transport services. Four of such quality indices are shown in Appendix B and highlighted below.

Based on a list of attributes developed for conventional public transportation and their own observations, Pagano and McKnight (1983) defined 64 level-of-service attributes. To test the importance of the individual attributes and to make sure that no important attributes were left out, the list of 64 attributes was sent to a panel of experts. Based on the expertise of the panel, the number of attributes was narrowed to 41, distributed under eight dimensions. This list can be seen in Appendix B1. Influenced by Pagano and McKnight (1983), Knutsson (1999) developed a list of level-of-service attributes to estimate the demand for a dial-a-ride service in Sweden. He distinguished five dimensions, under which 40 attributes were distributed. This list can be seen in Appendix B2.

Table 2.4: Selection of level-of-service attributes influencing the quality and potential of Alternative Transport Service types

Level-of-service attribute	**Based on (factors shown in Appendix B) ***		**Description**
1. Accessibility	PM27	Distance destination-vehicle	Related to the route type and OD-service of a service. Is it convenient to reach the service vehicle or transit stop? Is the distance from one's house to the service stop walkable or does the service provide door-to-door transport?
	K28	Distance to vehicle	
	T2	Spatial availability	
	OV6	Access and egress	
2. Schedule	PM13	Being picked up at desirable time	Related to the scheduling type of a service. Is the departure or arrival time fixed or based on the preferences of the end-user? In other words, is there a fixed schedule or is the service demand responsive?
	K31	Possibility to choose departure time	
	T1	Temporal availability	
3. Departure and arrival time window	PM2	Wait time at home	Related to the booking type of a service. Is the departure or arrival time in accordance with the desired or expected departure/arrival time? In other words, are there wide time windows for the departure/arrival times or fixed times with limited margins?
	PM3	Wait time away from home	
	PM4	Arriving on time	
	K16	Punctuality, departure	
	K17	Punctuality, arrival	
	K33	Waiting time	
	K38	Punctuality, pickup time	
	T1	Temporal availability	
	T5	Waiting at stop	
	OV7	Punctuality	
4. Travel costs	K39	Worth its price compared to public transport	Is the service worth its fare/prices compared to other modes, such as the car? In addition, is the fare reasonable and are customers willing to pay extra for extra service, such as door-to-door transport?
	K40	Fare	
	T23	Fare	
	T24	Value of using mode, relative to other modes	
	OV13	Fare	
5. Travel time	K32	Reasonable in-vehicle time	Is the travel time reasonable for the distance to be travelled or does the service have to make many detours and how does the travel time compare to the travel time of other modes?
	K35	Total trip time	
	T7	Travel time (relative to other modes)	
	T24	Value of using public transport, compared to using other modes	
	OV9	In-vehicle time	

**PM = Pagano and McKnight (1983), K = Knutsson (1999), T = Transportation Research Board (2013), OV = KPVV CROW (2016b)*

In its manual regarding the quality of transport services, the Transportation Research Board (2013) presents a, so-called, Quality of Service Framework for regular public transport services as well as for Alternative Transport Services. The Transportation Research Board (2013) distinguishes various factors (dimensions) and components (attributes) that affect the quality of services, which are extensively discussed. The dimensions and attributes are shown in Appendix B3. In the Netherlands, with the nationwide public transport customer satisfaction survey, called the OV-klantenbarometer, every year all public transport services and their operators are evaluated. This is done by conducting a survey among the end-users (KPVV CROW, 2016b). In 2015, approximately 90.000 completed surveys were collected. In this satisfaction survey, respondents are asked to assess various aspects of their current trip. Aspects that are tested in the customer satisfaction survey are shown in Appendix B4.

A total of five level-of-service attributes are identified for the remainder of this research (i.e. in the stated choice experiment). These can be seen in Table 2.4 (on the previous page). The attributes are composed based on a selection of attributes that are described in these quality indices. For every level-of-service attribute it is indicated how it is composed from the attributes used in the mentioned studies and researches. Because of the importance of the operational flexibility of a service, it is chosen to select level-of-service attributes that are typical for the operational design of the service. This means that, for example, criteria such as *noise in the vehicle* or *heating and ventilation* are not discussed, because it is assumed that these criteria are not dependent on the type of service. Therefore, although the perceived quality of a transport service can be influenced by such criteria, they do not influence the potential of an Alternative Transport Service type. Because of this, most of the level-of-service attributes are closely related to the service aspects that are described previously.

2.5.2. Traveller- and trip-related factors

Litman (2013) mentions that various demographic variables can affect travel demand – which is defined as "the amount and type of travel which people would choose in particular situations" – in an area and, in addition, Kattiyapornpong and Miller (2006) point out that demographic variables, such as age, income and life cycle, have significant effects on someone's travel behaviour. In addition, multiple studies show that other factors, such as trip characteristics and the attitude towards certain travel modes effect travel behaviour (Best & Lanzendorf, 2005; Mageean & Nelson, 2003). As indicated by Piatkowski and Marshall (2015) and Jain et al. (2017), various socio-economic characteristics of end-users and trip characteristics affect travel decisions and end-user preferences, and therefore the potential of ATSs.

Related specifically to ATSs, Jain et al. (2017) reviewed a large number of papers and studies to identify the impact of socio-economic variables and trip characteristics on travel behaviour and end-user preferences influencing the use of Alternative Transport Services. Table 2.5, which is shown on the next page, presents the most important findings of this review. Based on the most important findings, characteristics are identified that possibly influence end-user preferences regarding the use of ATSs. These are shown in the rightmost column of Table 2.5.

In addition to the characteristics presented in Table 2.5, socio-economic characteristics of travellers that specifically influence travel behaviour with regard to the use of public transportation in the Netherlands are studied as well. In its report regarding the importance and social added value of public transport, the Netherlands Bureau for Economic Policy Analysis (2009) explored by whom and why public transport services are used. The outcomes of this exploration are summarised in Table 2.6 (page 21). Based on the most important findings of the Netherlands Bureau for Economic Policy Analysis (2009), socio-economic and trip characteristics are identified that influence the use of public transport and the end-user preferences regarding the use of public transport in the Netherlands.

As can be seen, there is considerable overlap between the characteristics that are presented in Table 2.5 and Table 2.6. In total, by combining the tables, seven traveller- related and three trip-related variables that influence the use of ATSs can be defined. Trip frequency and the level of urbanisation of the area in which the trip takes place are added because of findings of Statistics Netherlands (2017) in their annual research on travel behaviour and factors influencing travel behaviour in the Netherlands.

Table 2.5: Important findings of literature and studies on the use of ATSs, and socio-economic characteristics and trip characteristics affecting end-user preferences influencing the use of Alternative Transport Services (Based on Jain et al. (2017))

Study	Findings	Characteristics
ActiveAge (2008)	Healthcare access, shopping and social visits were the main reasons for customers to use the 49Link Alternative Transport Service	• Trip purpose
Anspacher et al. (2004)	An important factor to predict the willingness to use a shuttle service is the distance to the nearest transit station. In addition, willingness is influenced by the number of vehicles per household	• Car ownership • Accessibility of service in terms of walking distance/time
Bearse et al. (2004)	Women make 30% more trips with Alternative Transport Services than men	• Gender
Enoch et al. (2006)	Target markets for ATSs are: people who cannot access public transport because public transport is not available in their living area, people without their own transport, unemployed people, single pensioner households, and youngsters	• Age group • Car ownership • Income • Socio-economic participation • Household structure
Häme (2013)	In order to compete with private cars, public transport should offer direct and fast connections, with minimal walking distances and waiting times	• Accessibility of service in terms of walking distance/time • Waiting time
Koffman (2004)	In Winnipeg, Manitoba, 53% of the users of the dial-a-ride scheme are female and 29% are aged under 18	• Gender • Age group
Laws (2009)	The users of the Wiltshire Wigglybus are mainly school children and retired people. In addition, 33% of the trips are for shopping purposes	• Age group • Socio-economic participation • Trip purpose
Lerman et al. (1980)	The greater the number of cars per household, the smaller the number of ATS trips	• Car ownership
Maddern and Jenner (2007)	With regard to the Telebus Melbourne, Australia), 74% of the users are in the age groups of 15-24 years and over 55 years, 78% of the users do not hold a driving license and 74% of the users are female. 31% of the trips are used for shopping	• Age group • Gender • Driving license • Trip purpose
Mageean and Nelson (2003)	Females are the dominant users of Alternative Transport Services. Most users are pensioners, house persons and students. Trip purpose reflects the type of users	• Gender • Age group • Socio-economic participation • Trip purpose
Nelson and Phonphitakchai (2012)	In Tyne and Wear (United Kingdom), more than 50% of the users of ATSs are female and retired. In addition, car access is very low among ATS users	• Age group • Gender • Socio-economic participation • Car ownership
Rosenbloom and Fielding (1998)	For the OmniLink ATS (Prince William Country, Virginia, USA) 61% of the users are female and 64% earn less than $25,000 per annum	• Gender • Income
Ryley et al. (2013)	Trips to healthcare, shopping and social visits have the highest possibility to be done with ATSs	• Trip purpose
Scott (2010)	ATSs are suitable for transport disadvantaged people, including elderly, youngsters, children, people without own motorised vehicle, people with low income and people living in areas without public transportation	• Age group • Car ownership • Income • Accessibility of service in terms of walking
Spielberg and Pratt (2004)	Typical ATS users are likely to be pensioners with relatively low incomes	• Age group • Income
TCRP (1995)	Potential target groups for ATSs are elderly, mobility limited and people with relatively low incomes	• Age group • Income
Takeuchi et al. (2003)	End-users prefer shorter waiting times and shorter in-vehicle times	• In-vehicle time • Waiting time
Wang et al. (2013)	ATS use is inversely associated with the number of cars per household. Income is also important	• Car ownership • Income

Table 2.6: Important findings on the use of public transportation in the Netherlands and socio-economic and trip characteristics influencing end-user preferences regarding the use of public transport (Based on Netherlands Bureau for Economic Policy Analysis (2009))

Findings	**Characteristics**
More than half of the public transport trips are made in order to reach places of work and/or education. Commuter trips (home-work and home-school) make up for 63% of the total amount of kilometres travelled with public transport services	• Trip purpose • Socio-economic participation
Public transport is used mainly by adults without driving licence. Public transport services are used for 35% of their total amount of kilometres travelled, while this is only 9% for adults with a driving license. Adults without driving license are more often female than male	• Driving licence • Gender
People who (generally) do not have access to a car, use public transport for 23% of their total amount of kilometres travelled, while this is only 5% for people with frequent access to a car	• Car ownership • Vehicle-used
Students and schoolchildren use public transport more often than other groups. Pensioners and unemployed people do not use public transport more often than people with permanent jobs	• Socio-economic participation • Age group
People with relatively low income use public transport more often than people with relatively high income	• Income
Public transport services are relatively more attractive on longer distances than on short distances, because the, so-called, *first* and *last mile* become less important. In addition, in the Netherlands the bicycle is widely used for short distance trips.	• Distance

Besides these twelve factors there are some more factors influencing the potential of a service type. In fact, Lee et al. (2015) – in the context of carpooling – found that perceptions may even play a larger role than criteria such as costs or convenience. For example, the way some Alternative Transport Service types operate might be perceived to put constraints on their independence, but it is also possible that travellers do not assume that some service types can fulfil their transport demand.

A factor that is assumed to be important is the perceived safety of customers, which is described by Pagano and McKnight (1983), Knutsson (1999) and KPVV CROW (2016b). For example, with a ride-sharing service, (almost) anyone can offer trips. However, some travellers might perceive this as unsafe and will be more cautious to use the service. This has resulted in safety worries of ride-sharing services and as a result, for example, several all-female ride-sharing services have been developed (Feeney, 2015; Manning, 2016). Therefore, it is interesting to test the attitude of potential end-users regarding the safety of services that follow the *sharing approach*. The attitude regarding safety partly determines the willingness of travellers to both use (and offer) services that follow a *sharing approach*. Because these services depend entirely on whether customers are willing to share their trip or car.

The final factor that is considered is related to a traveller's ability to use public transport services, both independently or with assistance from the driver. In their quality indices, Knutsson (1999) and Pagano and McKnight (1983) indicate that the quality of a service is affected by the ability of the driver to assist a customer when needed. For example, a driver can help the customer to get from the vehicle to its destination. However, this is only possible when it is possible within the margin of the time schedule. For the driver of a regular bus services, it is not possible to assist every customer to reach their destination, because it would result in significant delays further down the route. It is assumed that whether travellers appreciate and need assistance from the driver greatly influences which service type is most preferred.

2.6. Concluding

This chapter presents most information that is needed to conduct the survey, containing the stated choice experiment. A service's flexibility depends to a great extent on the choices that are made for the design of the service. To explore the influence of level-of-service attributes and service aspects on the potential of ATS types, a categorisation is required based on service aspects. Therefore, a comprehensive categorisation of Alternative Transport Service types is developed, based on the service aspects that influence a service's operational flexibility the most.

The categorisation and the information obtained on travel mode choice and the factors influencing travel mode choice are used in the next chapter to develop the survey in Chapter 3.

3. Survey development

To obtain knowledge about the potential and factors influencing the potential of Alternative Transport Service types, a survey is developed and conducted. The survey consists of a stated choice experiment to obtain information on mode choice behaviour and general questions to obtain information on traveller and trip characteristics. Stated choice experiments are used to obtain information about preferences of respondents that cannot be obtained by looking at actual choice behaviour (Kjaer, 2005). This could be the case, for example, when preferences regarding new transport alternatives are tested. This chapter introduces stated choice experiment and describes the survey development process. The data obtained with the survey is presented and analysed in Chapter 4 and used in Chapter 5 to estimate various choice models and to determine the potential of the service types.

3.1. Stated choice experiment

Traditionally, when conducting an experiment regarding travel behaviour, individuals were asked or observed to learn what the individuals actually did (Sanko, 2001). Such experiments are known as revealed preference methods. According to the Competition Commission (2010), revealed preference methods refer to "the observation of preferences revealed by actual market behaviour and represents real-world evidence on the choices that individuals exercise'. However, it might be possible that the behaviour is not yet observable or currently available. To, nevertheless, obtain information about the behaviour of interest, the preference method that is used should be capable to observe behaviour of the respondents in hypothetical situations. Stated preference methods are able to explore such hypothetical situations. Over the years, stated preference methods have been widely applied for modelling travel demand and behaviour and have become one of the key tools of transportation planners and researchers (Khan, 2007; Yang et al., 2009). A stated preference method, as Kjaer (2005) states, "provides preferences and information that are otherwise impossible to reveal when actual choice behaviour is restricted in some way".

In the case of this research, because of the use of relative new or unknown transport services, there is no revealed preference data available. Moreover, although some revealed preference data could be obtained via a questionnaire among the end-users of existing/active Alternative Transport Services, it is likely that not *enough* data would (and could) be obtained in order to make significant judgements. By conducting a stated choice experiment, and thus by using hypothetical choice alternatives, respondents do not have to be actual end-users of existing ATSs. In this way, obtaining data is assumed to be more convenient and obtaining enough data would be more likely.

Within the family of stated preference methods, there are several different techniques. In general, all these techniques assume that transport services can be described in terms of their aspects and related alternatives (Competition Commission, 2010). For this research, the discrete choice or stated choice experiment technique is chosen, since this technique provides respondents with tasks that are similar to those that people face in real life (Competition Commission, 2010; Hensher et al., 2005; Louviere et al., 2000). With a discrete choice experiment, respondents choose one alternative out of two or more alternatives. Respondents might be asked to repeat the choice experiment with the levels of the attributes changing. An example of a stated choice experiment question – in the context of travel behaviour of air, rail and car users in the UK – can be seen in Figure 3.1 on the next page;

Within a stated choice experiment, several research terms are used. These are listed below. The example presented in Figure 3.1 is used to clarify the terms.

- **Choice set:** Set of alternatives from which respondents have to choose the alternative that they prefer. Figure 3.1 shows a complete choice set. A choice set is also known as a choice situation.
- **Alternative:** Transport alternative, defined by its attributes. In Figure 3.1, coach, rail and air are the presented alternatives.

Question: If the following transport options were available, which would you choose for your journey between Cambridge and Manchester?

	Coach	**Rail**	**Air**
Expected travel time	7 hrs 55 mins	3 hrs 50 mins	2 hrs
Waiting time	10 mins	5 mins	1.5 hrs
Ticket price (one-way trip)	£40.20	£81.60	£70.00
Service frequency	Once a day	Every 30 mins	Twice a day
Interchanges	0	2	0
I would prefer (choose one)	O	O	O

Figure 3.1: Example of a stated choice experiment question (Competition Commission, 2010)

- **Brand:** Name of an alternative (e.g. Coach, Rail or Air). When brand names are shown to the respondents, such as in Figure 3.1, it is called a *with brand name experiment*. It is also possible that brand names are not shown. Then, the experiment is a *without brand name experiment* (Sanko, 2001).
- **Attribute:** Attributes define the alternatives. Examples from Figure 3.1 are travel time, waiting time and frequency.
- **Attribute level:** Value of the attributes. For example, 10 minutes, £81.60 or 2 hours. These can be changed for different choice sets

Not least because of the hypothetical situations, to obtain the data that is wanted, it is vital that a stated choice experiment is well-designed and that the alternatives used are relevant, plausible and understandable (Khan, 2007; Yang et al., 2009). In order to set up a well-designed stated choice experiment, according to the Competition Commission (2010), several steps have to be made. These steps are explained in the next sections.

3.1.1. Step 1: Problem definition

The first step defined by the Competition Commission (2010) deals with the problem definition. Several questions - for example regarding the study context and possible transport alternatives – have to be asked to achieve better understanding of the problem.

The information needed for this step is already extensively described in the introductory chapter of this research. To summarise, regular public transportation is not always desirable. In the province of Overijssel, in such situations, municipalities and society are responsible to provide suitable Alternative Transport Services (ATSs). For the successful development and operation of new initiatives and services, it is assumed to be critical to know the influence of both service-related factors and traveller-related factors.

3.1.2. Step 2: Qualitative study

The objective of the second step is to define potential alternatives, the related attributes and their attributes levels. Seven different ATS types are defined in Sub-section 2.4.3. However, as is explained in the coming steps, it is not desirable to include all seven service types as alternatives. The five level-of-service attributes that are included are already described in the previous chapter (Sub-section 2.5.1). The attributes and their attribute levels are further elaborated here and can also be seen in Table 3.1.

Accessibility

This attribute refers to the distance that has to be walked to reach the access point of a service. The accessibility of a service is highly influenced by a service's route type and its OD-service. The attribute levels considered are fixed stops (with an estimated 10 minutes walking time), stops along the route (with approximately 5 minutes walking time) and door-to-door transport (0 minutes walking time). It is chosen to indicate a walking time in order to make the attribute levels easier to imagine for respondents.

Table 3.1: Overview of attributes and attribute levels used in the stated choice experiment

Attribute		Attribute levels	Explanation	Comment
1.	Accessibility	Fixed stops on fixed route	Walking time to access point is 10 minutes	
		Stops along semi-flexible route	Walking time to access point is 5 minutes	
		Door-to-door	Walking time to access point of 0 minutes	
2.	Schedule	Fixed schedule	No input	
		Demand responsive	In consultation with customers	
		Unscheduled	Whenever customer wants	
3.	Departure and arrival time window	Wide time window	Departure and arrival time +/- 15 minutes	
		Small time window	Departure and arrival time +/- 5 minutes	
		No time window	Departure and arrival time +/- 0 minutes	
4.	Travel time	Very high	R + 30%	Based on the earlier revealed current travel time.
		Higher	R + 15%	
		Medium	R +/- 0%	
		Lower	R - 15%	
		Very low	R - 30%	
5.	Travel costs	Very high	Basic fare + 40%	The used basic fare is in between the regular bus and train fare and based on travel distance. A fare of €0.20 per kilometre and a fixed flag-down rate of €1,- are used.
		Higher	Basic fare + 20%	
		Medium	Basic fare +/- 0%	
		Lower	Basic fare - 20%	
		Very low	Basic fare - 40%	

Schedule
Whether a service is available at desired times for customers, depends on the service's scheduling. As attribute levels it is chosen to use fixed schedule (the customer has no say in the departure and arrival times), demand responsive, (the departure and arrival times are determined in consultation with the customer and (when applicable) all other customers) and unscheduled (the service is available whenever the customer wants).

Departure and arrival time window
Related to the availability and time schedule of a service are the time windows in which departure or arrival can take place. The attribute levels that are considered are +/- 15 minutes (wide time window), +/- 5 minutes (small time window) and +/- 0 minutes (no time window). The wide time window of 15 minutes is chosen because this is the time window used for the Regiotaxi in the province of Overijssel (Regiotaxi Overijssel, 2016; Regiotaxi Twente, 2016).

Travel time
Important for all public transportation services is the total travel time and how the travel time compares to the travel time of other modes (Exel & Van Hagen, 2011). For the potential of any *new* Alternative Transport Service type, the travel time needed for a trip when using the ATS compared to the travel time when using another mode is assumed to be very important. For example, few travellers will use a transport service when it is much slower than their current transport mode. Therefore, it is chosen to make the attribute levels for travel time adaptive to the current travel time of respondents. This is done by including two higher levels (current travel time +15% and +30%), two lower levels (current travel time -15% and -30%) and a base level that equals the current travel time of respondents.

The major advantage of use these percentages is that the travel times of the alternatives in a choice set become somewhat realistic because they are based on the current travel time of respondents. A major disadvantages, however, is that for shorter trips the differences in travel time are small. At first it was chosen to use pivots +/-10% and +/- 20%. However, it is possible that for small trips the travel time differences caused by these pivots are not big enough to make a difference in the choice behaviour of respondents. Therefore, it was chosen to raise the pivots to +/-15% and +/-30%.

Travel costs
It is undesirable to use the same approach for travel costs, because it is considered unlikely that people currently travelling by car would choose a service following a public transport approach, which might be far more expensive than their current car trip. Therefore, it is not appropriate to use pivots and then base the travel costs of the alternatives in the choice sets purely on the current travel costs. Because of this, the base travel costs for the transport alternatives is based on travel distance and an assumed public transport fare. This public transport fare is between the general bus fare and train fare used in the Netherlands. Because the public transport fare provides a lower price per kilometre than the operating costs per kilometre of the car, the travel costs of the alternatives in the choice sets are attractive for respondents currently travelling by car. In addition, because the used public transport fare is more or less equal to the fare of the bus and train, the travel costs of the alternatives in the choice sets are considered to be realistic and attractive for respondents currently travelling by bus or train. By using the pivots +/-20% and +/-40% (instead of +/- 15% and +/- 30%) it is tried to include *significant* travel cost differences between the alternatives within a choice set.

3.1.3. Step 3: Experimental design

This step describes the development of the experimental design of the stated choice experiment. As mentioned earlier, a stated choice experiment consists of several choice sets and for each set the respondents have to indicate which alternative they would choose. This step describes the development of the experimental design, that is, how to combine attributes and attribute levels in order to create alternatives and choice games (Sanko, 2001). According to Ortuzar and Willumsen (2011), the number of possible choice sets to be evaluated increases exponentially with the number of alternatives, attributes and attribute levels. The design of the stated choice experiment is the core part of all stated preference methods (Sanko, 2001). For this research, it is chosen to conduct a, so-called, *without brand name experiment*. This is chosen, because all the defined alternatives consist of the same attributes and it is assumed that showing names of Alternative Transport Service types, such as *routeflex*, *stop hopper* or *collective taxi*, could possibly have a confusing effect, because respondent do not recognise the names. In addition, in the case that respondents do recognise a name (for example with collective taxi), it is possible that their choice behaviour is biased.

As described in the previous step, a total of five attributes are included for this research. When all possible combinations of attribute levels are considered, this would lead to (3*3*3*5*5=) 675 different alternatives. With 3 alternatives per choice set, this would result in 225 choice sets. A design containing all possible combinations of attribute levels is called a full factorial design (Sanko, 2001). Since it is not possible to include such a large number of choice sets into a stated choice experiment, it is desirable to reduce the amount of combinations and choice sets (Pearmain et al., 1991; Sanko, 2001; Schakenbos, 2014). This can be done by using a fractional factorial design instead of a full factorial design.

However, excluding choice sets results in a loss of information. The objective of the experimental design is to create a stated choice experiment with a minimum number of choice sets without losing the ability to say something about the influence or *effects* of all attributes (Louviere et al., 2000). According to Kocur et al. (1981) and Louviere et al. (2000), three different types of effects can be distinguished:

- **Main effects:** The effect of a single attribute on the choice;
- **Two-way interaction effects:** The effect of a combination of two attributes on the choice; and
- **Higher order interaction effects:** The effect of a combination of more than two attributes on the choice.

Because it is not possible to use a full factorial design, a fractional factorial design is used instead. In a fractional factorial design, not all possible choice sets are included and the number of choice situations is limited (Pearmain et al., 1991). Although the exclusion of choice sets generally results in a loss of information, it is still possible to estimate the main effects when the fractional factorial design is well-designed. Other effects cannot be estimated. This is assumed to be acceptable, because main effects often explain more than 80% of the amount of variance in the response data (Louviere, 1988, as cited in Sanko, 2001). A *perfect* fractional factorial design is both balanced and orthogonal. Balanced means that each attribute level occurs equally often within each attribute and orthogonal means that the attributes of the design are statistically independent of each other (Mangham et al., 2009; Sanko, 2001). However, as stated by, among others, Kuhfeld (2005), fractional factorial designs that are both balanced and orthogonal only exist in a limited number of choice situations for certain combinations of attributes and attribute levels. For the combination of attributes and attribute levels that is used for this research, such a *perfect* fractional factorial design does not exist. According to Mangham et al. (2009), when using combinations for which a *perfect* fractional factorial design does not exist, researches should make a trade-off between the degrees of orthogonality and balance and select the most efficient design, using a measure known as D-efficiency. The (D-)efficiency of the design is further explained in the next step.

For the design of the experiment, it is chosen to use the software application JMP13® of SAS. JMP13® is a data analysis tool that can be used to design discrete choice experiments in a customer friendly way (JMP Statistical Discovery, 2017). One of the reasons to use this software application is the possibility to include constraints between certain attribute levels. For example, although it is possible in theory, in practice it is highly unlikely that a transport service operates with a fixed time schedule, while offering door-to-door transport. To ensure realistic alternatives, combinations like these should be avoided. With JMP13® constraints between attribute levels can be easily included. In addition, the software application provides the possibility to create multiple designs at once. This makes that it is possible to compare the designs and choose the best one. The next step explains the generation of the design and its choice sets in more detail.

3.1.4. Step 4: Choice sets

Like with most discrete choice experiments, respondents are presented various choice sets. In this way the amount of respondents needed is reduced. However, as stated by, the amount of choice sets that can be presented to respondents is limited. Mangham et al. (2009) suggest a limit of 18 choice sets. The limit of choice sets depends on the amount of alternatives within a choice set, the number of attributes and attribute levels and the familiarity of the attributes. For this research, it is assumed that most respondents are familiar with the attributes, but that they are not used to carefully evaluate multiple transport alternatives at the same time, simply because often there are not more than one or two transport alternatives available or because they generally use the same alternative out of habit. For this reason, it is chosen not to include all seven Alternative Transport Service types that are defined earlier, but to include four alternatives; three service types that are defined earlier and one service type that is composed of the remaining service types. The alternatives can be seen in Table 3.2 on the next page. The service type stopflex represents the service types dial-a-ride, stopflex, routeflex and stop hopper. The name stopflex is chosen instead of the initial name busflex because the acronym BF is already used to refer to the basic fare. As can be seen, unrealistic combinations, such as an alternative offering door-to-door transport with a fixed schedule, are not possible. In addition, it is chosen to limit the amount of choice sets per respondent to eight. As stated by Louviere et al. (2000), this is the average amount of choice sets used. For all choice situations, respondents could choose to *use another alternative.* This is the, so-called*, no-option*.

These four alternatives, their attribute levels and the constraints are put into the tool of JMP13® to design a discrete choice experiment. In the tool, it is possible to choose several aspects of the design, such as the number of alternatives in each choice set, the amount of choice sets (per survey) and the amount of surveys. In order to keep the choice sets relatively easy, it is chosen to present three alternatives per choice set. To ensure an appropriate efficient design, the design gives a warning when a combination of design aspects is undesirable. By trial and error, it is found that a design with sixteen choice sets, containing three alternatives per choice set, is appropriate for the used combination of attributes and attribute levels. Because sixteen is not a preferable amount to present to respondents, it is chosen to divide this amount by two. In this way, the design contains two blocks of eight choice sets. All respondents are presented one block of eight choice sets. Using two blocks of eight choice sets instead of one block with sixteen choice sets, requires the inclusion of more respondents. With JMP13®

Table 3.2: Alternative Transport Service types and their attribute levels used in the discrete choice experiment

	Stopflex (SF)	Collective taxi (CT)	Ride-sharing (RS)	Car-sharing (CS)
Accessibility	Fixed stops Along the route	Door-to-door	Along the route Door-to-door	Door-to-door
Schedule	Fixed schedule Demand responsive	Demand responsive Unscheduled	Demand responsive Unscheduled	Unscheduled
Departure and arrival time window	Wide time window Small time window No time window	Wide time window Small time window No time window	Wide time window Small time window No time window	No time window
Travel time	R + 30% R + 15% R +/- 0% R - 15% R - 30%	R + 30% R + 15% R +/- 0% R - 15% R - 30%	R + 30% R + 15% R +/- 0% R - 15% R - 30%	R + 30% R + 15% R +/- 0% R - 15% R - 30%
Travel costs	BF + 40% BF + 20% BF + /- 0% BF - 20% BF - 40%	BF + 40% BF + 20% BF +/- 0% BF - 20% BF - 40%	BF + 40% BF + 20% BF +/- 0% BF - 20% BF - 40%	BF + 40% BF + 20% BF +/- 0% BF - 20% BF - 40%

R = Revealed travel time, BF = Basic fare

it is tested whether the expected number of respondents is sufficient to use two blocks instead of one. The design of the choice experiment is shown (both in English and in Dutch) in Appendix D.

Design efficiency
As said in the previous step, fractional factorial designs that are both perfectly balanced and orthogonal only exist for certain combinations of attributes and attribute levels. When this is not the case, a trade-off has to be made between the degrees of orthogonality and balance. A trade-off can be made and justified by choosing the most efficient design, using a measure known as D-efficiency. Kuhfeld (2005) states that the D-efficiency measures "the goodness of the design relative to hypothetical orthogonal designs that may be far from possible". A D-efficiency of 100% indicates a *perfect* fractional factorial design. For the design used for this research – containing two blocks of eight choice sets with three alternatives per choice set – the D-efficiency is 91.2%. This is considered to be appropriate, because an efficiency of 90% is acceptable (La Paix, 2015). Other designs containing more or less blocks and/or choice sets were analysed as well, but no major differences with regard to the D-efficiency are found when more choice sets are included. Therefore, it is chosen to maintain the amount of eight choice sets per respondent.

3.1.5. Step 5: Construct survey instrument

With the design of the stated choice experiment completed, the fifth step deals with the development of the survey instrument. However, because the survey is also used to obtain traveller-related information, questions regarding this information should be stated as well before the survey instrument can be developed. Therefore, the development of the survey instrument is described in the next section.

3.2. Survey instrument

The questions on the traveller- and trip-related factors are based on the factors that are described in Sub-section 2.5.2. It is chosen to include questions regarding the most frequent trips and the most recent trip of respondents.

In general, it is chosen to use multiple-choice questions in order to ease the analysis of the data. For factors used as input for other questions or choice situations, however, open questions are used. In addition, to obtain information about various additional factors, such as a respondent's willingness to share a service, respondents are asked whether they agree or disagree with several statements about transport services and their characteristics. For example, respondents are asked about their willingness to share their own car. The statements are presented with a five-level Likert scale (Dawes, 2008). Table 3.3 shows an overview of the survey, including the sequence in which questions and statements about

Table 3.3: Overview of the survey subjects and question types

Subject/Variable	Type	Information	Options based on
Vehicle used (most frequent trip)	MC	Variable used for analysis	
Travel purpose (most frequent trip)	MC	Variable used for analysis	Sociaal Planbureau Groningen (2014)
Frequency (most frequent trip)	MC	Variable used for analysis	Statistics Netherlands (2015)
Vehicle used (most recent trip)	MC	Variable used for analysis	
Travel purpose (most recent trip)	MC	Variable used for analysis	Sociaal Planbureau Groningen (2014)
Frequency (most recent trip)	MC	Variable used for analysis	Statistics Netherlands (2015)
Origin – destination (most recent trip)	O	Used to check/indicate travel distance Variable used for analysis	Statistics Netherlands (2017)
Travel distance (most recent trip)	O	Variable used for analysis Used to determine travel costs in choice experiment	
Travel costs (most recent trip)	O	Used as indication in choice experiment	
Travel time (most recent trip)	O	Used as indication in choice experiment Used to determine travel time in choice experiment	
Calculation of attributes (travel time and travel costs) used in choice experiment			
Choice experiments (8 per respondent)			
Opinion on availability of PT	S	Variable used for analysis	
Perception on booking	S	Variable used for analysis	
Perception on sharing (statement on travel time)	S	Variable used for analysis	
Perception on sharing (statement on privacy)	S	Variable used for analysis	
Need for assistance from the driver	S	Variable used for analysis	
Attitude towards car-sharing	S	Variable used for analysis	
Attitude towards ride-sharing	S	Variable used for analysis	
Attitude towards safety of ride-sharing	S	Variable used for analysis	
Attitude towards sharing own ride	S	Variable used for analysis	
Gender	MC	Variable used for analysis	
Age group	MC	Variable used for analysis	Sociaal Planbureau Groningen (2014)
Number of cars in household	MC	Variable used for analysis	
Driving license	MC	Variable used for analysis	
Household structure	MC	Variable used for analysis	(Statistics Netherlands, 2007)
Socio-economic participation	MC	Variable used for analysis	(Netherlands Bureau for Economic Policy Analysis, 2009)
Income (gross, monthly)	MC	Variable used for analysis	(Statistics Netherlands, 2016)
Use of tools/aids	MC	Additional factor used for analysis	
General remarks/comments	**O**		

MC = Multiple-choice; O = Open question; S = Statement with Likert scale

the factors are presented to the respondents, which question types are used and what is done with the obtained information. As can be seen, the survey starts with question about trip-related factors. This is done, because answers on these questions are used as input for other questions and the choice situations. An overview of the complete survey is not included in this report, but is available on request. This overview contains the questions, equations used to determine attribute levels, routing and logic, answer options for the multiple-choice questions and some argumentation.

For this research, it is chosen to set up the survey online (via Limesurvey.com), because executing the survey offline (on paper) is considered impractical and very time-consuming, not least because of the high amount of choice sets and the fact that some answers are used as input for questions further in the survey. When the survey would be distributed offline, these values have to be calculated by hand, while respondents fill in the survey. Moreover, for researches like these, a vast amount of response is needed and it is assumed that this response can be reached more easily by using an online survey. In addition, online surveys allow respondents to complete the survey whenever they want, possibly leading to a higher response rate.

A drawback of conducting the survey online is that it possibly excludes some potential respondents. For example, it is assumed that fewer people of 70+ years old participate in online surveys, compared to people of other (younger) age groups. This is accepted, however, since it is assumed that people who are able to use (public) transportation services are able to participate in an online survey as well. This assumption is strengthened by findings of Worrell et al. (2015). They found that of all people of 65+ years old in the Netherlands, 42% are online on their tablet and 96% on their laptop or desktop pc.

Which channels are used to reach the respondents and the way the survey is distributed is discussed in the next chapter.

3.3. Testing

In addition to the five steps described by the Competition Commission (2010), a sixth step should be made in order to set up a well-designed stated choice experiment. This step is testing (Khan, 2007). The aim of conducting a test or pilot survey is to identify potential flaws and technical errors and to find if and where additional information or answer options are needed. Conducting a pilot survey follows the popular plan-do-check-act control approach, as described by Dr W.E. Deming (Aguayo, 1991).

The test phases for this research consisted of two pilot surveys among a group of approximately 30 respondents, consisting of friends, family and colleagues. In the first test survey, five alternatives were used in each choice set. It was indicated by the respondents that this made the choice situations very difficult. Therefore, it was chosen to redesign the experiment and use only three alternatives per choice set. In addition, it was pointed out that the first test survey contained several *unrealistic* combinations of attribute levels and that respondents found it difficult to deal with this. To tackle this problem, several more constraints between attribute levels were added.

The most important findings of the second test survey were that three alternatives per choice set made the survey easier to complete. However, because of the time respondents needed to complete the survey and the number of *dropouts* it could be concluded that more than eight choice sets per respondents is not desirable. In addition, because respondents indicated that they found it difficult to estimate their travel distance and travel costs, some *tools* were incorporated in the survey to indicate travel distance and travel costs. An example of such a tool was a hyperlink to Google Maps that automatically changed based on the revealed origin and destination. With this link, respondents could check their travel distance.

The layout of the survey – particularly of the choice situations – was tested by asking several colleagues which layout they preferred. Several layouts were made and colleagues were asked to indicate which one they preferred. An outcome of this process was, for example, not to include indicators for walking time and time windows on the choice card, but to *hide* these indicators behind a pop-up message. It was indicated that by presenting these indicators on the choice cards respondents would get to see

Choice set X (of 8)

You have indicated that your most recent trip takes … minutes and costs … euro. To make this trip, three alternatives are available. Which alternative do you prefer?

	1	2	3
			
	Passenger	Passenger	Driver
Accessibility [?]	Fixed stops	Stops along the route	Door-to-door
Schedule [?]	Fixed schedule	Demand responsive	Unscheduled
Time window [?]	Small time window	No time window	No time window
Travel time [?]	… minutes	… minutes	… minutes
Travel costs [?]	… euro	… euro	… euro

- I would not make this trip or would use a different transport mode
- Alternative 1
- Alternative 2
- Alternative 3

[?] Information about the attributes and attribute levels can be obtained by clicking on the question marks. A pop-up message will then appear.

Figure 3.2: Example of a choice card of a choice situation. In the survey, respondents can get additional information about the attributes and attribute levels by clicking on the question marks. The travel time and travel costs are based on a respondent's current travel time and travel distance. Translated from Dutch.

even more information at once. In addition, it was found that respondents preferred to see pictures of the service vehicle and whether they would be the driver or a passenger. Figure 3.2 shows a (translated) example of a choice card presented to the respondents. Because several major changes were made to the test surveys, the response obtained during the test phases is not included in the final dataset.

3.4. Concluding

This chapter focuses on the development of the survey instrument and the design of the stated choice experiment. Six steps are made to develop a stated choice experiment that should be able to obtain the information that is required to identify the potential of ATSs and the level of influence of various factors in the potential. The distribution of the survey and the data obtained with the survey is extensively explored in the next chapter.

4. Data collection, preparation and analysis

This chapter focuses on the data obtained with the survey. The first section describes how the survey is distributed, the second section describes the exclusion of respondents and the third section presents statistics on the respondents, their characteristics and the choices the respondents made.

4.1. Survey distribution

As said in the previous chapter, it is chosen to conduct the survey online. To obtain enough respondents, the survey is distributed province-wide. The target sample size is at least 500 respondents. This is chosen because, according to the rule of thumb of Ortuzar and Willumsen (2011), 75-100 respondents are needed per group segment to say something about a group (Schakenbos, 2014). Since the maximum number of answer options for a question is five, the total number should equal at least 375–500 respondents. It is chosen to aim at 500 respondents, because the actual distribution of respondents in the used segments is not known in advance. To get at least 500 respondents, several methods to distribute the survey were used during the period from the 8th of February 2017 to the 26th of February 2017.

To obtain information about public transport users it was agreed with Syntus (the public transport company providing public transport in region Twente) to display a message or a call-to-action on the monitors in their buses in Twente. In the buses without monitors, posters were put up. In addition, on several days, travellers were actively stimulated to fill in the survey by asking them.

At the MST hospital in Enschede flyers were handed out to focus on potential respondents of which it was known that their travel purpose was not related to work or school. In addition, it was assumed that at the MST it was easier to reach *older* respondents. Handing out the flyers took place on three different days and on two different locations at the MST.

A major part of the respondents was reached with the help of the Overijssel panel of I&O Research. This panel of I&O Research exists of approximately 1,900 members who all live in the province of Overijssel. For this panel a separate survey was created, because information on several socio-economic characteristics was already available to I&O Research. It was agreed with I&O Research that asking respondents about these characteristics would be undesirable. For the panel of I&O Research the survey was online from the 21th of February to the 26th of February. In total, 443 members of the Overijssel panel completed the survey.

In addition, the survey was distributed through personal channels. In total, 567 respondents completed the survey.

4.2. Exclusion of respondents

To conduct the survey analysis, it is desired to focus only on useful surveys. Therefore, several of the completed surveys are excluded for a variety of reasons. The first selection is based on based on the comments made during and/or at the end of the survey. Some respondents indicated that they did not (fully) understand the survey. These respondents are excluded from the sample.

The second selection is based on the revealed data of the respondents. Firstly, respondents that revealed unrealistic values for travel time, travel costs and travel distance are excluded. Because it is arbitrary which values are unrealistic, the exclusion of respondents is done with caution. For example, a travel distance smaller than 300 metres is considered unrealistic, because respondents were asked about a trip they currently made with by car, bus, train or Regiotaxi. A similar assumption is made for the travel costs. For example, a trip costing only a few cents is not assumed to be realistic. Secondly, it is looked at unrealistic combinations of travel time, costs and distance. For example, one respondent described a car trip of 250 kilometres with travel costs of €1000. Another respondent described a trip of 82 kilometres with a travel time of only 1 minutes. Respondents revealing trips containing such unrealistic combinations are excluded as well.

As a third selection step, it is checked whether there are respondents that chose the same alternative (alternative 1, alternative 2 or alternative 3) for all the eight choice sets, but this is not the case.

The final selection step is based on the choices the respondents made. For this research it is chosen to exclude respondents when the no-choice option was chosen for all the eight choice sets. This is chosen because for these respondents the choice alternatives, apparently, were not realistic for the respondents. It is assumed that the choices made by respondents who do not consider Alternative Transport Services to be realistic alternatives do not provide useful results, because they could disturb the outcomes of the models. For example, when someone constantly chose the no-option (i.e. its own transport alternative), regardless of the costs of other alternatives, the level of importance of travel costs that can be measured during the model estimation could be disturbed. Costs savings up to 40%, for example, are not important for respondents who do not consider Alternative Transport Services at all, making it more difficult to measure the level of importance of travel costs for travellers that do consider to use Alternative Transport Services. The exclusion of respondents who chose the no-option in all the eight choice sets tackles this problem and provides more realistic results. The exclusion of 93 respondents based on their choices made is considered to be legitimate, because these respondents do not provide useful information on how factors, such as level-of-service attributes and traveller-related variables, influence the potential of Alternative Transport Services, because these respondents are assumed not to take the level-of-service attributes of ATSs into account.

As a result of this exclusion process, a total of 113 respondents is excluded. As said, 93 respondents are excluded because they chose the no-option in all eight choice situations. An additional number of 20 respondents is excluded based on the other exclusion criteria. This leads to a sample size of 454 respondents. Although the exclusion of 113 respondents means that the initial aim of 500 respondents is no longer met, the number of respondents still exceeds the minimum indicated by Ortuzar and Willumsen (2011). How the respondents are divided among different characteristic groups is explored in the next section.

4.3. Descriptive statistics

The sample composition and the choices the respondents made in the survey provide some interesting results that can be used to guide the model estimation process of Chapter 5, because the so-called, descriptive statistics provide information on what can be expected. The first thing to look at is the choice behaviour of the respondents when certain attribute levels were available in the choice sets. Thereafter, the sample composition and the choices made by the different respondent groups are explored. Finally, the outcomes of the statements in the survey are described.

Table 4.1 (on the next page) shows the number of times an alternative with a certain attribute level was chosen when it was available. It can be seen that respondents seem to have some clear preferences. For example, a service offering door-to-door transport is preferred over a service using fixed stops only. Although these percentages do not necessarily say something about the relative importance of the attributes (because of other attribute levels in the alternatives), the percentages can be used as an indication for what can be expected in the models. For example, based on Table 4.1 it can be expected that – when stops along the route is used as reference level – the parameters for door-to-door and fixed stops are respectively positive and negative. When looking at the schedule, it seems that flexibility is perceived positively. In the same way, a service without a time window for the departure time seems to be perceived positively, while there is no clear difference between the perception of small and wide time window. With regard to travel time, the differences in the percentages in Table 4.1 are not that clear. For travel costs, the differences are clear; alternatives containing the lower cost pivots were chosen more often than the alternatives containing the higher cost pivots. Table 4.1*Table 4.1* clearly indicates that flexible alternatives were preferred by the respondents.

Table 4.2 on page 35 presents the segments that can be distinguished based on the traveller- and trip-related variables and the distribution of the respondents in these segments made. The trip-related variables are based on the most recent trip of the respondents. It can be seen that the sample contains a relatively large number of older respondents and a large group of unemployed/retired respondents. Interestingly, only ten respondents indicated that they need assistance from the driver or use aids. Because of this, it is chosen not to take this variable into account in the remainder of this research. Therefore, it is not shown in Table 4.2. The relatively large number of respondents for which the income is unknown is caused by the fact that respondents were given the option not to indicate their income.

Table 4.1: Number of times an alternative with a certain attribute level was chosen when it was available

Attribute	**Level**	**Chosen**
Accessibility	Fixed stops	10.3%
	Stops along the route	26.0%
	Door-to-door	35.6%
Schedule	Fixed schedule	19.5%
	Demand responsive	21.7%
	Unscheduled	37.9%
Time window	No time window	32.2%
	Small time window	24.7%
	Wide time window	23.1%
Travel time	R + 30%	26.7%
	R+ 15	25.4%
	R +/- 0%	24.2%
	R - 15%	26.1%
	R - 30%	32.0%
Travel costs	BF + 40%	24.4%
	BF + 20%	22.4%
	BF +/-0%	25.6%
	BF - 20%	29.4%
	BF - 40%	33.4%

Because this research focuses on the province of Overijssel, it is desirable that the sample composition corresponds to the population of the province of Overijssel and the travel behaviour of the population of the province of Overijssel. To explore whether this is the case and thus whether the sample composition is representative for the travel behaviour in the province of Overijssel, the sample is compared with extensive data on mobility in the province of Overijssel. The data is obtained from the Onderzoek Verplaatsingen in Nederland (OViN) from Statistics Netherlands (2017). OViN is a nationwide research on travel behaviour of the Dutch population and on the variables influencing the travel behaviour of inhabitants. Data from the years 2012, 2013 and 2014 is used. The distribution of the travellers in the province of Overijssel among the different characteristic groups can be seen in Table 4.2 as well. Not for all variables data is available in the OViN data. For example, the income classes used in the OViN data are very different than the income classes used in this research and are therefore not usable. For most variables, the differences between the sample and the OViN data are indicated with a ratio. As can be seen, for several traveller-related variables the composition of the sample corresponds to the composition of the OViN data of the province of Overijssel. However, for other variables some considerable differences can be seen. As indicated earlier, for example, the group of elderly and unemployed or retired respondents is quite large and the group of students is underrepresented. To tackle the problems of the representativeness of the sample, weighting factors are assigned to the respondents. How this is done is further explained in Chapter 5.

Although the distribution of the respondents over the different segments provides some interesting results, it is even more interesting to look at the choices the respondents and the different groups of respondents made. As said, an exploration of the choices made by the respondents helps to understand what can be expected in the models and can be used to guide the model estimation process. Already it is concluded that flexible alternatives seem to be preferred by the respondents. Based on the alternatives that were chosen in the choice sets, more or less the same conclusion can be drawn. The alternatives following an approach similar to that of conventional public transport (i.e. stopflex and collective taxi) were chosen respectively 19.0% and 26.1% of the times that they were available, while the alternatives following the sharing approach, ride-sharing and car-sharing, were chosen respectively 30.0% and 56.6% of the times that they were available. Flexibility, privacy and the ability to travel spontaneously seem to be important for the respondents.

When looking at the choice behaviour of the different segments (as presented in Table 4.2), interesting differences can be observed. The most striking differences are highlighted in Figure 4.1. It can be seen

Table 4.2: Choices made by survey segments. Total number of respondents is 454

		Sample composition		OViN		Choices				
Variables	**Segments**	**Freq.**	**%**	**%**	**Ratio**	**SF**	**CT**	**RS**	**CS**	**NO**
Gender	Male	256	56%	53%	0.94	18%	23%	30%	55%	23%
	Female	198	44%	47%	1.08	21%	30%	30%	59%	15%
Age	Younger than 25	52	11%	11%	0.96	26%	27%	27%	46%	15%
	25-44	73	16%	32%	1.99	20%	24%	26%	62%	22%
	45-64	170	37%	39%	1.04	19%	26%	29%	57%	21%
	65 and older	159	35%	19%	0.54	16%	26%	34%	57%	18%
Cars is household	0 cars	55	12%	7%	0.58	25%	36%	29%	43%	11%
	1 car	288	63%	52%	0.82	18%	24%	31%	58%	19%
	2 cars or more	111	24%	41%	1.68	18%	27%	27%	59%	23%
Driving license	Yes	414	91%	90%	0.99	18%	25%	30%	59%	20%
	No	40	9%	10%	1.14	27%	35%	29%	36%	11%
Household structure	One-person household	89	20%	11%	0.56	20%	26%	29%	57%	18%
	Multiple-person, no children	234	52%	25%	0.49	17%	27%	32%	56%	19%
	Multiple-person, children	119	26%	58%	2.21	21%	23%	26%	60%	21%
	Other	12	3%	6%	2.27	28%	30%	35%	33%	6%
Economic participation	Working full-time	139	31%	28%	0.91	19%	25%	27%	62%	21%
	Working part-time	80	18%	16%	0.91	21%	27%	28%	57%	18%
	Student / schoolchild	44	10%	19%	1.96	27%	28%	26%	42%	16%
	Unemployed / Retired	173	38%	19%	0.50	16%	26%	34%	56%	19%
	Other	18	4%	14%	3.53	18%	19%	33%	56%	21%
Income	Unknown	102	22%			20%	27%	29%	60%	17%
	Less than €1900	81	18%			19%	26%	30%	49%	22%
	€1900 - €2700	119	26%			19%	26%	27%	55%	23%
	€2700 - €5400	86	19%			18%	27%	32%	59%	18%
	€5400 or more	66	15%			20%	23%	34%	58%	15%
Urbanisation	Unknown	17	4%			19%	21%	39%	50%	13%
	Very strongly urban	5	1%			29%	27%	17%	60%	18%
	Strongly urban	187	41%	38%	0.92	19%	27%	30%	54%	19%
	Moderate urban	90	20%	16%	0.81	19%	23%	30%	58%	20%
	Little urban	99	22%	34%	1.56	18%	25%	28%	62%	21%
	Not urban	56	12%	11%	0.89	21%	29%	30%	55%	16%
Vehicle used	Car	306	67%			16%	25%	31%	60%	21%
	Public Transport	142	31%			24%	27%	28%	50%	16%
	Other	6	1%			24%	50%	28%	50%	6%
Trip purpose	Work/business	149	33%	19%	0.58	20%	26%	26%	61%	20%
	Education	198	44%	52%	1.19	18%	27%	31%	55%	18%
	Social/recreational	31	7%	12%	1.76	26%	24%	24%	44%	21%
	Doctor's appointment	32	7%	3%	0.43	16%	21%	35%	64%	19%
	Other	44	10%	14%	1.44	14%	25%	36%	53%	20%
Trip frequency	4 or more days a week	106	23%			20%	25%	26%	61%	21%
	1 to 3 days a week	145	32%			19%	26%	31%	58%	19%
	1 to 3 days a month	91	20%			19%	25%	29%	53%	22%
	6 to 11 days a year	55	12%			20%	24%	36%	54%	14%
	5 or less days a year	57	13%			16%	31%	31%	54%	20%

SF = Stopflex; CT = Collective taxi; RS = Ride-sharing; CS = Car-sharing; NO = No-option
Percentages for choices indicate how often alternative was chosen when the alternative was available

that respondents without a driving license choose differently than respondents with a driving license. For the respondents without a driving license, car-sharing and the no-option were far less attractive. This makes sense, because to use car-sharing (or their own private car), travellers would need a driving license. Therefore, it is assumed that having no driving license (compared to having a driving license) has a negative influence on the utility of a car-sharing alternative. It is remarkable, however, that the

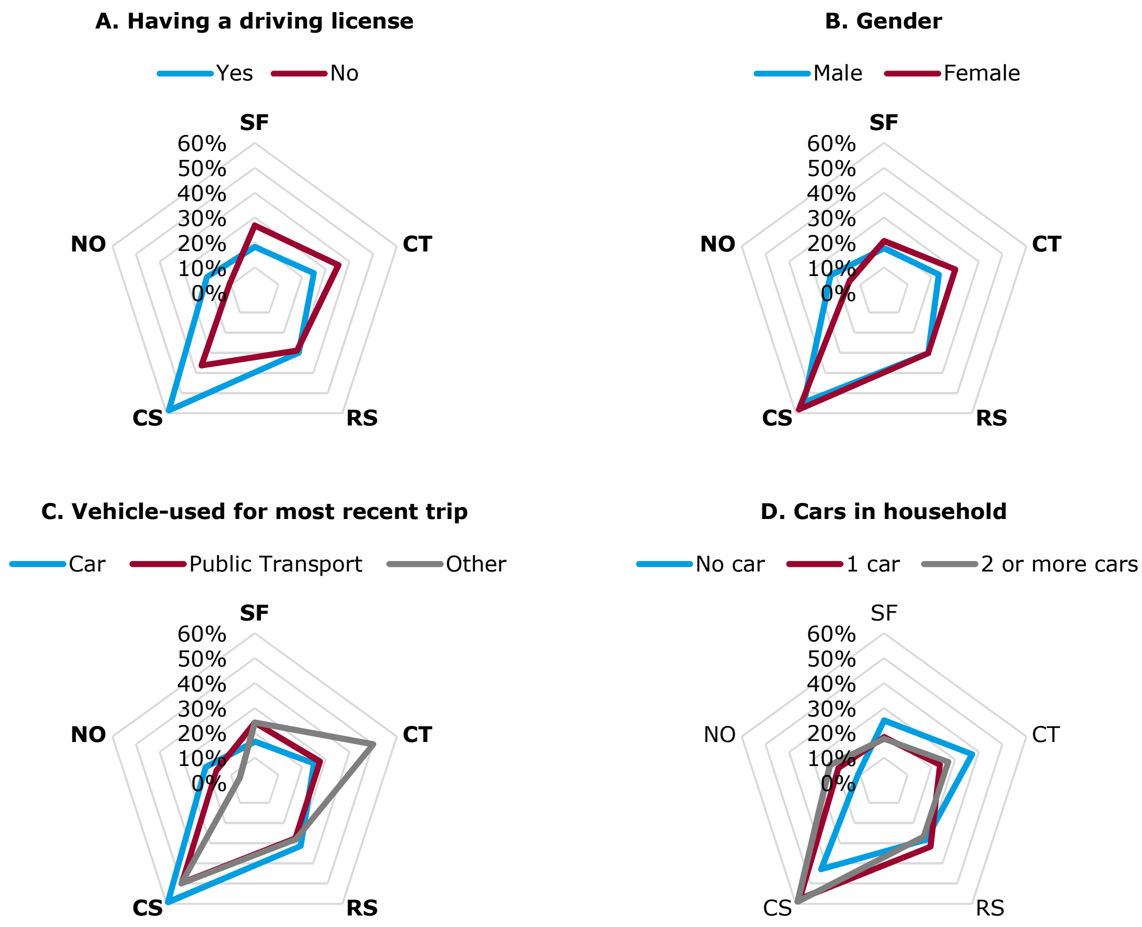

Figure 4.1: Number of times respondent groups chose each alternative when it was available. More results are shown in Appendix E.

respondents without a driving license chose car-sharing in 35% of the times that the alternative was available.

With regard to gender it can be seen that male respondents chose to use another transport mode (probably their own private car) more often than female respondents. Female respondents chose stopflex or collective taxi more often. Looking at Figure 4.1C, it can be seen that people currently using a car for their trip chose ride-sharing, car-sharing and the no-option more often than people currently travelling with public transport. It is assumed that currently using public transport has a negative influence on the utility of car-sharing and/or ride-sharing. In addition, respondent who indicated that they do not have a car in their household chose for the alternatives following the conventional public transport approach more often than respondents that have one or more cars in their household. Not having a car in your household is assumed to have a negative influence on the utility of a car-sharing alternative (and the no-option).

The variable trip distance is not included in Table 4.2. It is chosen not to include the variable in the tables because it is thought to be more interesting to visually present the choice behaviour of the respondents per travel distance. This can be seen in Figure 4.2 on the next page. It seems that collective taxi is chosen more often when travel distance is longer. For other alternatives, no clear differences are observed.

The statement outcomes do also provide various interesting results. Table 4.3 presents the answers given on the statements in the survey and the choices made by the sample segments that can be distinguished based on their answers. For many statements the options *strongly disagree* and *strongly agree* were not chosen often. Therefore, these answers are added to (respectively) *disagree* and *agree*.

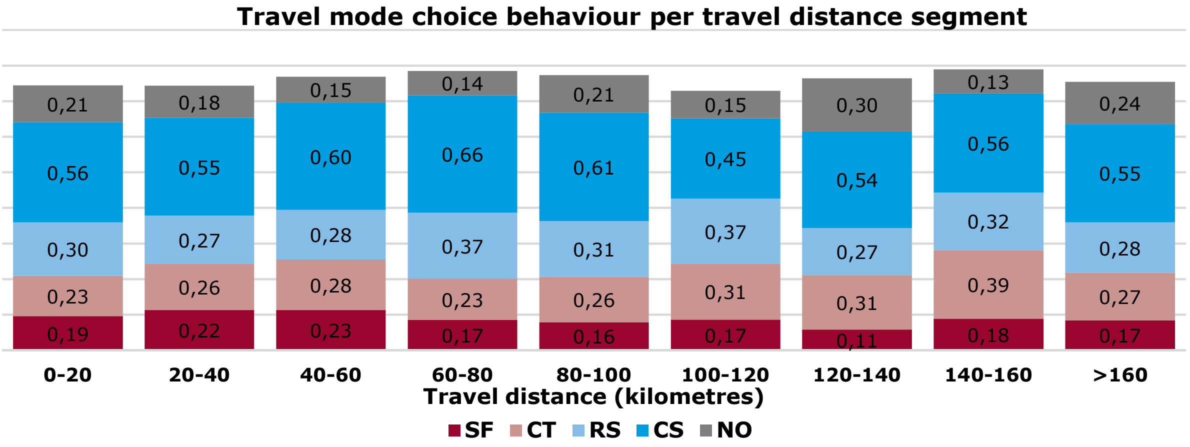

Figure 4.2: Relative number of times alternatives where chosen (when available) per travel distance segment

The table shows some interesting outcomes. A very large majority of the respondents, for example, thinks that the availability of public transport is important, no matter what the costs are for the service provider or the responsible government. Looking at Statement 6, it turns out that car-sharing is not perceived as an attractive alternative for many respondents. However, as can be seen in Table 4.2, car-sharing was often chosen more than half of time when the alternative was available. Moreover, people who disagreed that car-sharing is attractive, chose car-sharing more often when it was available than people who agreed with the statement.

Table 4.3: Survey segments (based on answers given on the statements) and choices made by survey segments. Total number of respondents is 454

		Composition		**Choices**				
Statement	**Answer**	**Frequency**	**%**	**SF**	**CT**	**RS**	**CS**	**NO**
1 Availability of public transport is important, regardless of the costs for transport company or government	Disagree	73	16%	16%	27%	26%	58%	27%
	Neutral	77	17%	18%	20%	33%	53%	22%
	Agree	304	67%	20%	27%	30%	57%	17%
2 Having to book a transport service is negative, because it comes at the expense of the possibility to travel spontaneous	Disagree	81	18%	22%	26%	28%	57%	18%
	Neutral	83	18%	18%	30%	29%	61%	18%
	Agree	290	64%	18%	25%	31%	55%	20%
3 I perceive sharing a service as negative, because it comes at the expense of the travel time	Disagree	98	22%	21%	29%	31%	51%	16%
	Neutral	104	23%	20%	23%	29%	52%	21%
	Agree	252	56%	18%	26%	30%	61%	20%
4 I perceive sharing a service as negative because it comes at the expense of my privacy	Disagree	242	53%	22%	29%	29%	55%	16%
	Neutral	109	24%	18%	25%	28%	56%	23%
	Agree	103	23%	14%	20%	35%	61%	23%
5 I like to use public transport services because the driver can offer me assistance when I need it	Disagree	184	41%	17%	24%	29%	58%	23%
	Neutral	160	35%	19%	26%	31%	59%	18%
	Agree	110	24%	23%	28%	30%	51%	14%
6 A shared car or car-sharing service would be an attractive alternative to make the trip I described	Disagree	235	52%	18%	26%	30%	58%	21%
	Neutral	106	23%	19%	23%	32%	56%	19%
	Agree	113	25%	22%	29%	29%	54%	15%
7 A ride-sharing service would be an attractive alternative to make the trip I described	Disagree	261	57%	17%	26%	29%	56%	23%
	Neutral	168	37%	18%	25%	31%	57%	20%
	Agree	95	21%	24%	28%	30%	56%	11%
8 I think that sharing a ride, as is the case with ride-sharing services, is safe	Disagree	129	28%	19%	22%	29%	59%	22%
	Neutral	192	42%	20%	26%	30%	53%	19%
	Agree	133	29%	18%	29%	31%	61%	17%
9 I like to share my own trips and would therefore like to share my own ride with a ride-sharing service	Disagree	287	63%	18%	27%	29%	56%	20%
	Neutral	108	24%	19%	21%	32%	59%	18%
	Agree	59	13%	21%	29%	30%	56%	15%

SF = Stopflex; CT = Collective taxi; RS = Ride-sharing; CS = Car-sharing; NO = No-option
Percentages for choices indicate how often alternative was chosen when the alternative was available

With regard to the statement outcomes, it is likely that the respondents responded more or less similarly to the different statements. For example, it is plausible that someone who does not think that ride-sharing is safe, also does not want to share its own trip. It could be the case that respondents gave similar answers to questions about the same topic, because the answers are associated with the respondent's opinion on the general topic. For example, it is plausible that someone who thinks that the availability of public transport is important also likes to use public transport, because he/she likes public transport in general. To obtain information about the opinion of the respondents on the general topic or the, so-called, covering component, a factor analysis is conducted. As stated by Rahn (2017), "The key concept of factor analysis is that multiple observed variables have similar patterns of responses because they are all associated with a latent (i.e. not directly measured) variable". In the case of this research, the variable that is not directly measured could be the general opinion on a topic. Moreover, as is further explained in Chapter 5, it is undesirable to include all outcomes of the nine statements in the choice model. When statements turn out not to have significant effects, these statements will be left out of the model, resulting in a loss of information of the statements that are not included. As is illustrated in Chapter 5, this loss of information could be prevented by including the covering components into the choice models.

Table 4.4: Rotated component matrix with principal components and correlation for every statement (S)

	Component		
	Opinion on public transport in general	**Opinion on conventional transport services**	**Opinion on more modern transport services**
S1	0.779		
S2		0.680	
S3		0.802	
S4		0.759	
S5	0.743		
S6			0.582
S7			0.833
S8			0.772
S9			0.793

Rotation method: Varimax

The factor analysis is conducted with the software programme SPSS and the result can be seen in Table 4.4. It can be seen that there are three covering components:

1. Someone's opinion of public transport in general;
2. Someone's opinion on conventional public transport services; and
3. Someone's opinion on te more modern services (car-sharing and ride-sharing)

The three components explain approximately 60% of the variance. The correlation between each statement and the factor is called the *loading*. Based on the loadings, scores can be calculated for each respondent for each component. These scores indicate the opinion of a respondent on one of the components and are used in Chapter 5 in the model estimation process. It is tested how someone's opinion influences the attractiveness of the four alternatives used in the discrete choice experiment. It is likely, for example, that someone's positive opinion on modern services, influences the attractiveness of car-sharing and ride-sharing.

4.4. Concluding

This chapter focuses on the data obtained with the survey and the preparation of the data. The data is obtained by distributing the survey through various channels. After the data preparation process, 454 completed surveys are found to be useful. Section 4.3 presents the composition of the sample and explores the choices made by the different *segments* of the sample population. In the next chapter, various choice models are estimated to the potential of ATS types and the level of influence of various factors on the potential of ATS types. The descriptive statistics described in Section 4.3 are used to *guide* the estimation process. That is to say, the statistics can be used as indicators for what can be expected and the statistics can also be used to determine what is desirable to test first.

5. Model estimation

This chapter presents the data analysis, including the estimation of various choice models, the results of these models and the application of the models. But firstly, the analytical framework is presented. It is explained how the influence of attributes and other variables can be determined. In addition, it is described what is done with the data before the models are estimated.

5.1. Analytical framework

To determine the level of influence the various factors described in Chapter 2 have on the preferences of travellers and their use of Alternative Transport Services, it is necessary to explore how travellers choose their travel mode. The choice for a particular travel mode – at least when there actually is a choice to be made – says something about whether the mode is considered to be suitable and the preferences of end-users. According to Khan (2007), when confronted with alternative travel modes, consumers will make decisions "on the basis of the terms upon which the different travel modes are offered, i.e. the travel times, costs and other level-of-service attributes of the competing alternative traveling modes" and an individual will select the mode which maximises his or her *utility*. The utility of a certain transport mode for an individual is a measure for the attractiveness or potential of the mode for a specific trip, due to several attributes such as in-vehicle travel time, access time and waiting time (Ben-Akiva & Lerman, 1985). This hypothesis is named *utility maximisation* and all travel demand models are based on this hypothesis.

For each mode or alternative, the utility can be formed from the weighted sum of the level-of-service attributes of the alternative (Davidson & Davidson, 2016). This is shown in Formula 5.1 (Hensher et al., 2005; Khan, 2007). As can be seen, the utility of a certain transport *m* by individual *i* consists of two components: a systematic component and a random component. The systematic component describes the importance of the attributes that are included in the utility function, while the random component describes the importance of factors that are not included or cannot be observed.

$$U_{mi} = \beta_1 x_{mi1} + \beta_1 x_{mi2} + \ldots + \beta_k x_{mik} + \varepsilon_{mi}$$ *Formula 5.1*

where,

U_{mi}	is the net utility function for mode *m* for individual *i*;
$X_{mi1}, \ldots, x_{mik}$	are *k* numbers of level-of-service attributes for mode *m* for individual *i*; and
$\beta_1, \ldots, \beta_k$	are *k* numbers of coefficients (or relative importance of each level-of-service attribute). The sign (+ or -) indicates whether the attribute contributes positive or negative to the mode's alternative.
ε_{mi}	is a random, unobservable component for mode *m* for individual *i*.

Based on the utility maximisation, if there are *M* number of total travelling modes available, an individual will select mode *m* – where $m \in M$ – based on its utility function U_m, such that (Khan, 2007),

$$U_m > U_n$$ *Formula 5.2*

where,

U_m	represents the utility of alternative travel mode *m*; and
U_n	represents the utility of any other alternative in the set of available travel modes.

The probability that an individual chooses a certain alternative *m* can be calculated by comparing the utility of alternative *i* with the total utility of all available alternatives. This is shown in Formula 5.3.

$$P_{mi} = \frac{e^{U_{mi}}}{\sum e^{U_{Ni}}}$$ *Formula 5.3*

where,

P_{mi}	is the probability that individual *i* chooses transport mode *m;*

U_{mi} represents the utility of alternative travelling mode *m* for individual *i*; and
U_{Ni} represents the utilities of all available alternatives (including mode *m*) in the set of available travelling modes for individual *i*.

Because the random component cannot be observed, the remainder of this research looks mainly at the systematic component. The systematic component can be determined based on the outcomes of the conducted choice experiment. To obtain information about the unknown values in the utility functions, multinomial logit (MNL) models are the most commonly used models to estimate the unknown values of the systematic component, but in recent years mixed logit (ML) models have become increasingly popular to do this (Cirillo, 2016; Train, 2002).

To be clear, because this research aims to obtain knowledge on the level of influence of various factors on the potential of Alternative Transport Service types, in Chapter 5 the MNL and ML models are used to estimate the values of the betas of the various variables that are described in Section 2.5. The types of models are introduced in the next two sub-sections. Sub-section 5.1.3 describes how it can be determined how well a model fits with the data.

5.1.1. Multinomial logit model

Based on the outcomes of the choice sets in the stated choice experiment, a MNL model estimates combinations of values for the betas that predict the chance of having obtained the outcomes of the choice sets. In other words, a MNL model estimates the likelihood of observing the choices made by respondents and a higher value for the likelihood indicates a better estimate for the model (Louviere et al., 2000; Train, 2002). Often the log-likelihood function is used for this (Train, 2002).

Assuming a set of choice situations (x_1, x_2, …, x_n), the log-likelihood function is:

$$LL(\beta) = \sum_{i=1}^{I} \sum x \; y_{ix} \; \ln(P_{ix}) \qquad \textit{Formula 5.4}$$

where,

$LL(\beta)$ is the log-likelihood function on the estimated attributes;
I is the total number of respondents;
y_{ix} is the choice of respondent *i* for choice situation *x*; and
P_{ix} is the choice probability of respondent *i* for choice situation *x*.

As said, a higher value for the log-likelihood function indicates a better estimate for the model. Therefore, the combination of values for the betas that provides the highest likelihood is the best estimate for the model (Schakenbos, 2014). This is called the *maximum likelihood estimation* (Louviere et al., 2000). As is further explained in Section 5.2, for this research it is chosen to conduct the maximum likelihood estimation with the software program Biogeme.

5.1.2. Mixed logit model

Although the MNL model is often used to model travel behaviour, it certainly has some limitations. One of the main disadvantages is that the MNL model assumes that all observations are independent. However, this is often not the case. It is likely that the choices made in successive choice situations by one person are not independent. In statistics, the data obtained from multiple observations for the same individual is referred to as panel data (Diggle et al., 2002). With Mixed Logit (ML) models it is possible to consider, so-called, panel effects. Because of this, ML models have become increasingly popular in recent years (Cirillo, 2016).

According to Train (2002), ML models are the integrals of standard logit probabilities over a density of parameters:

$$P_{mi} = \int L_{mi}(\beta) f(\beta) d\beta \qquad \textit{Formula 5.5}$$

where,

$f(\beta)$ is a density function; and

$L_{mi}(\beta)$ is the logit probability evaluated at parameters β:

$$L_{mi}(\beta) = \frac{e^{V_{mi}(\beta)}}{\sum e^{V_{Ni}(\beta)}} \quad \textit{Formula 5.6}$$

where,

$V_{mi}(\beta)$ is a portion of the utility that depends on parameter β.

When the utility is linear with β, $V_{mi}(\beta) = \beta' x_{mi}$. In this case the mixed logit probability is:

$$P_{mi} = \int \frac{e^{\beta' x_{mi}}}{\sum e^{\beta' x_{Ni}}} f(\beta) d\beta \quad \textit{Formula 5.7}$$

In the model estimation (with Biogeme), to account for panel effects, error components can be added to the utility functions in Biogeme. The error components vary from respondent to respondent, but not from observation to observation for one respondent. The error components for each alternative indicate the 'loyalty' of respondents to a certain alternative. A positive (and significant) value for the error component of an alternative indicates that respondents chose the same alternatives in multiple choice situations, while a negative and significant value indicates the opposite.

Because there is no closed form for the integral in Formula 5.7, simulation is needed to estimate the parameters. According to Train (2002), at least 125 draws is desirable. As is explained later in this chapter, 250 draws are used to estimate the models in this research.

5.1.3. Goodness of fit

How well a model fits with the data can be checked with the likelihood ratio index. The likelihood ratio index measures how the model with the estimated values for the betas performs compared to the model where all betas are equal to zero. The likelihood ratio index can be seen in Formula 5.8.

$$\rho^2 = 1 - \frac{LL(\beta)}{LL(0)} \quad \textit{Formula 5.8}$$

where,

$LL(0)$ is the log-likelihood function of the model when all betas are zero (zero model)

Although a value of 1 for ρ^2 indicates a perfect fit, Louviere et al. (2000) states that values of ρ^2 between 0.2 and 0.4 are considered to indicate extremely good model fits.

The likelihood ratio index can be improved by keeping in mind the degrees of freedom (Louviere et al. (2000). This measure is called the adjusted rho-squared (Formula 5.9).

$$\text{Adjusted } \rho^2 = 1 - \frac{LL(\beta) - K}{LL(0)} \quad \textit{Formula 5.9}$$

where,

K is the number of estimated parameters.

In the remainder of this research, the adjusted rho-squared is used to determine the model fit.

5.1.4. Comparing models

To compare whether a model with more parameters (or betas) fits with the data better, two models can be compared by using the likelihood ratio test (Louviere et al., 2000). With this test, the log-likelihood of the first model (O) is compared with the log-likelihood of the model with more parameters (β). The formula to be used for the likelihood ratio test is shown below.

$$LR = -2*(LL(\beta) - LL(O)) \quad \textit{Formula 5.10}$$

Assuming an amount of *r* extra parameters, the model with more parameters is assumed to be significantly better than the original model when the value of LR is higher than the value of the Chi-squared distribution for *r* degrees of freedom.

5.1.5. Coding

Before the model estimation can be started, some data has to be further prepared. This has to do with the fact that most of the used attributes are categorical rather than continuous. For example, the attribute level *fixed schedule* is not linear with the levels *demand responsive* and *unscheduled*. Therefore, it is needed to code several attributes. By coding attributes and attribute levels, the software program used for the model estimation – called Biogeme - can read the various attributes and attribute levels that are used in the research.

The attributes and attribute levels are coded by the so-called 'dummy coding' method. By using this method, each attribute level is seen as an individual variable with its own parameter in the utility function of an alternative.

Therefore, multiple parameters are estimated for each attribute. In fact, the number of estimated parameters is equal to the amount of attribute levels minus one. The attribute level for which no parameter is estimated is used as the reference level. In the dataset, when the variable corresponds with the attribute level of that variable it is indicated with 1. When the variable does not correspond with the attribute level of that variable it is indicated with 0 (Kugler et al., 2016). An example for the level-of-service attribute *schedule* is shown in Table 5.1 at the bottom of this page.

As a result of dummy coding, in the utility function of an alternative, for example the attribute *schedule* is covered by two parameters (amount of attribute levels minus one). No parameter is estimated for *demand responsive service*. The importance of the other two attribute levels is then relative to this attribute level (Formula 5.11).

$$U_{Schedule} = \beta_{DR} x_{FS} + \beta_{UN} x_{UN} \qquad \textit{Formula 5.11}$$

where,

$U_{Schedule}$ is the utility of the attribute schedule for a certain alternative;

x_{FS}, x_{UN} indicate whether the attribute levels *fixed schedule* and *unscheduled* are available; and

β_{FS}, β_{UN}, are the values of the importance of *fixed schedule* and *unscheduled*, relative to the reference level *demand responsive*.

Dummy coding is used for the attributes *accessibility* and *departure and arrival time window* and all the traveller-related variables as well. Because the values for travel time and travel costs are continuous, dummy coding is not needed for these attributes.

5.1.6. Weighting respondents

As shown in Section 4.3 on page 35, the sample is not completely representative for the population of the province of Overijssel and the trips made in the province (according to the OViN data). Therefore, it is chosen to assign weighting factor to the respondents. In this way, it is possible, for example, to tackle the problem of the underrepresented group of students. Three variables with the relatively high ratios in Table 4.2 are chosen to determine the weighting factors. The first variable that is chosen is the age of the respondents. Age is chosen because of the assumed importance on travel behaviour and the considerable overrepresentation of elderly respondents. As a second variable, the household structure is chosen, because of the huge differences between the OViN data and the composition of the sample. The final variable is trip purpose. This variable is also assumed to be important for travel

Table 5.1: Example of dummy coding for level-of-service attribute 'schedule'.

	Variables		
Initial attribute levels	**Fixed schedule**	**Demand responsive**	**Unscheduled**
Fixed schedule	1	0	0
Demand responsive service	0	1	0
Unscheduled	0	0	1

behaviour and in Table 4.2 it can be seen that there are considerable differences between the OViN data and the composition of the sample. For each respondent a weighting factor is calculated, based on the product of the ratios in Table 4.2 for the age category, household structure and the trip purpose of the respondent. The weighting factor is used by Biogeme to compensate for the (under)representation of the sample segments.

5.2. Model results

By using all information obtained so far, several models can be estimated. As indicated earlier, this is done by using Biogeme. As described on the website of the developer, "Biogeme is an open source freeware designed for the maximum likelihood estimation of parametric models in general, with a special emphasis on discrete choice models" (Bierlaire, 2017). In Biogeme, utility functions are described for each alternative, consisting of parameters and the corresponding attributes values. As said in Sub-section 5.1.5, because of dummy coding, not all attribute levels are included in the utility function of an alternative with their own parameter. As already said in this sub-section, for the attribute schedule, two parameters are included (one for *fixed schedule* and one for *unscheduled*) and the importance of these two attribute levels are relative to the importance of attribute level *demand responsive*. For the attributes *accessibility* and *time window*, the attribute levels *stops along the route* and *no time window* are used as the reference levels. These reference levels are chosen, because the other attribute levels that are available for stopflex, collective taxi and ride-sharing can all be compared to these levels. For example, the importance of fixed stops of stopflex can be compared to the importance of stops along the route, while the importance of door-to-door transport of ride-sharing can also be compared to the importance of stops along the route. Because the attributes travel time and travel costs are continuous variables, they are modelled as a linear function.

For each alternative, an alternative-specific constant (ASC) is included as well. These constants indicate preferences of respondents that cannot be observed with the included parameters and attributes. The meaning of ASCs is further explained in the coming sections.

Because it turned out that the ML models provide significantly better model fits than the MNL models, it is chosen to estimate both MNL and ML models; MNL models during the estimation process and ML models as final models. This is chosen because the need for simulation with ML models results in considerable longer estimation time. For the estimation of MNL models, the importance of the attributes and attribute levels is systematically tested. This means that it is started with a model consisting of ASCs only and that the attributes and attribute levels are then added step-by-step. When a parameter for an attribute (level) turns out to be significant (on a 90% significance level), it is kept in the utility function. When this is not the case, the parameter is removed. This is repeatedly done until all parameters of the variables are tested. It is important to note that on beforehand it was chosen to keep the ASCs and parameters for travel time and travel costs in the model, regardless of their significance or insignificance. This was chosen because of the assumed importance of the constants and the parameters. The final MNL models are converted into ML models. Parameters that are not significant in the ML models are removed step by step, starting with the less significant parameter. For the estimation of the ML models, 250 draws are used. To be sure, some models are tested with 500 draws as well, but this did not result in better model fits.

Several different models are estimated step-by-step. The different models and steps are stated below. Each new model is based upon the previous model. Thus, to test the influence of the different variables, the parameters for these variables are added to the model that turned out to have the best model fit.

1. Estimate basic (generic) MNL and ML models;
2. Estimate MNL and ML models with alternative-specific parameters
3. Estimate MNL and ML models with vehicle-specific parameters
4. Choose model with best model fit;
5. Estimate MNL and ML models with traveller- and trip-related variables;
6. Estimate MNL and ML models with traveller- and trip-related variables and opinions of respondents.

The next sections individually describe the model estimation process and the results of each model. Table 5.2 on page 46 presents the outcomes of the generic ML model, the ML model with alternative-specific parameters and the ML model with traveller- and trip-related variables. By presenting all models in one table, the variables can be easily compared.

5.2.1. Generic model

The first model (or the basic model) is a generic model to test the influence of the level-of-service attributes and attributes levels included in the stated choice experiment. In this model, the same betas are used to describe the utilities of the different Alternative Transport Services. In other words, only one beta for each attribute level is estimated. For example, the beta that describes the importance of travel time is the same for the collective taxi and the car-sharing alternative. Thus, in this research phase it is assumed that travel time in a collective taxi is valued equally as travel time in a shared car.

In the generic ML model, all ASCs are found to be significant. The ASC of car-sharing indicates a positive base preference for car-sharing compared to the stopflex alternative that cannot be observed with the model. It is likely that the relatively large ASC of car-sharing (compared to the other ASCs) is caused by the fact that car-sharing has fixed attribute levels for *accessibility, schedule* and *time window*. Because these attribute levels are fixed, these attributes are not included in the alternative's utility function. This leaves only the parameters for travel time and travel costs to *explain* why respondents chose for car-sharing. The preferences of respondents regarding car-sharing that cannot be observed when merely looking at travel time and travel costs are therefore included in the ASC. The ASCs of the other alternatives indicate that these alternatives are disfavoured compared to the stopflex alternative. For the no-option, the relatively large value is probably caused by the fact that there are no other parameters in the utility function of the alternative.

It is interesting to compare the descriptive statistics of Section 4.3 with the results of the generic model. The amount of times car-sharing was chosen corresponds to its relatively high ASC, but for the other alternatives this is not the case. Since ride-sharing was chosen in approximately 30% of the choice situations that it was available, while stopflex was chosen in only 19% of the choice situations that it was available, it would be plausible to see a positive base preference for ride-sharing. However, this is not the case. Thus, there are other variables that explain the utility of ride-sharing alternatives. The same applies to collective taxi.

Most parameters in the generic ML model do correspond to what could be expected from the descriptive statistics (and logical assumptions). As can be seen, the parameters for travel time and travel costs are negative. Thus, the longer the travel time or the more expensive a trip, the less attractive it becomes. Although the absolute values of the parameters are quite small, it should be noted that the parameters are presented *per euro* and *per minute*. To obtain the actual (dis)utility of an alternative caused by the travel time, the parameter for travel time should be multiplied by the actual travel time. The same should be done to obtain the (dis)utility caused by travel costs, but then with the actual travel costs and the parameter for travel costs. Furthermore, it can be concluded that a wide time window or large inaccuracy for the departure time has a negative effect on the attractiveness of a services. The parameter for wide time window is found to be negative and significant. However, the parameter for small time window is not found to be significant. Thus, it cannot be concluded that a small time window negatively influences the utility of an alternative, compared to having no time window. Apparently, a time window of five minutes is considered acceptable, while a time window of fifteen minutes is not.

In addition, it is found that the shorter the walking time to the departure location of a service, the more attractive a service becomes. Door-to-door transport has a positive influence on the attractiveness of a service, while fixed stops have a negative influence (relative to the attribute level *stops along the route*). A fixed schedule does not have an influence on the attractiveness of a service, while an unscheduled service is more attractive than a demand responsive service.

The adjusted rho-squared of 0.187 indicates a modest fit on the data, meaning that the model fits with the data only quite well. Based on the sigmas of the alternatives it can be concluded that respondents choosing car-sharing and stopflex in one choice set, are likely to choose the same alternatives in other choice sets when they are available.

5.2.2. Model with alternative-specific parameters

As said, in the generic model, the same parameters are used to determine the relative importance of a certain attribute or attribute level. This is not the case for the model with alternative-specific parameters. In this model, several alternative-specific parameters are included to test whether the importance of an attribute depends on the alternative. For example, it is plausible to think that the valuation of travel time is different for a collective taxi than the valuation of travel time in a shared car. The parameters for accessibility are not converted into alternative-specific parameters, since these parameters are already alternative-specific. As can be seen in Table 3.2 (on page 28) the alternatives collective taxi and car-sharing always provide door-to-door transport, meaning that for these alternatives it is not possible to estimate the importance of door-to-door. Fixed stops are only possible at a stopflex alternative and door-to-door can only be provided by the ride-sharing alternative. The remaining attributes (schedule, time window, travel time and travel costs) are included as alternative-specific parameters. However, the alternative-specific parameters for the attribute levels of time window and schedule are not found to be significant. Therefore, these parameters are kept in the model as generic parameters.

As can be seen in Table 5.2, the outcomes of the model with alternative-specific parameters are almost the same as the outcomes of the generic model. With the exception of the travel time parameter for collective taxi, the signs of the parameters are all as expected. Because the parameter values are more or less equal to the values in the generic model and assumed to be logical as well, they are not discussed in detail here.

Despite the more or less similar results, the adjusted rho-squared of the model (0.188) indicates that the model with alternative-specific parameters provides a better fit. In addition, based on the outcomes of the likelihood ratio test (Sub-section 5.1.4), it can be concluded that the model with alternative-specific parameters indeed fits with the data better than the generic model.

5.2.3. Model with vehicle-specific parameters

An additional ML model is estimated with vehicle-specific parameters. This is done to explore whether a better model can be estimated with vehicle-specific parameters instead of alternative-specific parameters. Because the names of the alternatives were not shown in the stated choice experiment, it is plausible to think that the valuation of travel time is influenced by the vehicle instead of the alternative. After the model estimation, however, it turned out that the adjusted rho-squared of the model with vehicle-specific parameters is lower than that of the model with alternative-specific parameters and that the vehicle-specific model contained more insignificant parameters. Therefore, the model with vehicle-specific parameters is not further used in the remainder of this research.

5.2.4. Influence of traveller- and trip-related variables and the attitude of respondents

Because the utility of an alternative varies from user to user, it is interesting to look at how the variables related to the traveller (i.e. age, household structure, having a driving license, etc.) and its trip (i.e. trip purpose), influence the parameter values. The model with alternative-specific parameters is used a basis. Since the aim of this part of the research is to obtain knowledge about how variables influence the preferences of respondents with regard to Alternative Transport Service types, just looking at the generic model would provide far less interesting results. Therefore, alternative-specific parameters are used for the traveller- and trip-related variables.

Different models are estimated in this section; MNL and ML models with traveller- and trip-related variables and MNL and ML models with parameters for the three components obtained from the factor analysis included as well. The results of the models are also shown in Table 5.2. Different models are estimated because it is assumed that the opinion of potential travellers is not always known. Information on traveller- and trip-related variables can often be obtained via Statistics Netherlands (or another institution).

Similar to the other models, the parameters are added step-by-step. When a parameter turns out to be significant (on a 90% significance level) it is kept in the model, otherwise it is removed. Different from the other models is that it is even more important to choose the reference level. This is because it is possible, for example, to include three different parameters for age (and compare the influence of

Table 5.2: Model results (Table continues on next page)

Variable	Generic ML model		ML model with alternative-specific parameters		ML Model with traveller-related variables		Final ML model (including respondents' attitude)	
	Value	T-test	Value	T-test	Value	T-test	Value	T-test
ASC SF	0	Fixed**	0	Fixed**	0	Fixed**	0	Fixed**
ASC CT	-0.474	-5.26	-0.605	-4.77	-0.547	-2.28	-0.379	-1.76*
ASC RS	-0.53	-5.43	-0.537	-4.56	0.0521	0.25†	-0.0799	-0.42†
ASC CS	1.22	9.69	1.49	7.94	0.888	2.95	0.931	3.33
ASC NO	-2.68	-11.2	-2.59	-10.56	-3.28	-8.15	-3.06	-8.05
Fixed stops	-1.23	-15.5	-1.23	-15.46	-1.22	-15.42	-1.21	-15.37
Stops along the route	0	Fixed**	0	Fixed**	0	Fixed**	0	Fixed**
Door-to-door	0.408	5.16	0.469	5.79	0.457	5.64	0.454	5.62
Fixed schedule/Demand responsive	0	Fixed**	0	Fixed**	0	Fixed**	0	Fixed**
Unscheduled	0.2	3.35	0.232	3.81	0.227	3.72	0.221	3.63
No time window/Small time window	0	Fixed**	0	Fixed**	0	Fixed*	0	Fixed*
Wide-time window	-0.112	-2.32	-0.0879	-1.81†	-0.0958	-1.96	-0.0982	-2.02
Travel time generic	-0.00742	-4.54						
Travel time SF (/minute)			-0.00368	-1.80*	-0.00448	-2.14	-0.00555	-2.7
Travel time CT (/minute)			0.000668	0.21†	0.00182	0.56†	0.000784	0.24†
Travel time RS (/minute)			-0.0119	-5.72	-0.0112	-5.36	-0.0109	-5.28
Travel time CS (/minute)			-0.00901	-2.11	-0.00773	-1.85*	-0.00745	-1.84*
Travel costs generic	-0.0242	-5.13						
Travel costs SF (/euro)			-0.0381	-5.41	-0.0308	-4.31	-0.0311	-4.4
Travel costs CT (/euro)			-0.0452	-4.16	-0.0475	-4.41	-0.0454	-4.22
Travel costs RS (/euro)			-0.00747	-1.22†	-0.0111	-1.8*	-0.0114	-1.88*
Travel costs CS (/euro)			-0.0357	-1.92*	-0.0341	-1.89*	-0.0277	-1.57†
Being 25-44 years old (CS)					0.756	3.02	0.655	2.71
No cars in household (CT)					0.439	1.83*		
No driving license (SF)					0.416	2.26		
No driving license (CT)					0.484	2.42	0.353	1.78*
No driving license (CS)					-0.818	-2.39	-0.884	-2.66
No driving license (NO)					-0.912	-1.83*	-1.17	-2.4
Being student (SF)					0.453	2.52		
Being unemployed/retired (RS)					-0.315	-1.91*		
Being male (RS)					0.224	2.17	1.34	4.03
Being male (NO)					1.45	4.33		
Multiple-person household without children (SF)					-0.543	-2.31		
Multiple-person household without children (RS)					-0.383	-1.83*		
Multiple-person household with children (SF)					-0.813	-3.57	-0.798	-3.47
Multiple-person household with children (CT)					-1.11	-4.74	-0.949	-4.18
Multiple-person household with children (RS)					-0.90	-3.64	-0.952	-4.72
Location little urban (CS)					0.619	2.33	0.556	2.16
Location not urban (SF)					1.46	2.96	1.44	2.91
Location not urban (CT)					1.70	3.40	1.70	3.35
Location not urban (RS)					1.36	2.79	1.40	2.85
Location not urban (CS)					1.96	3.21	1.98	3.31
Work/business trip (SF)					0.672	4.62	0.517	3.83
Work/business trip (CT)					0.495	3.26	0.398	2.68
Public transport used (SF)					0.256	1.73*	0.335	2.3
Opinion on PT in general (/score on components) (SF)							0.450	4.52

Opinion on PT in general (/score on components) (CT)							0.444	4.17
Opinion on PT in general (/score on components) (RS)							0.407	4.26
Opinion on conventional services (/score on components) (SF)							0.274	4.6
Opinion on conventional services (/score on components) (CT)							0.197	2.95
Opinion on conventional services (/score on components) (CS)							-0.245	-2.22
Opinion on modern services (/score on components) (RS)							0.233	4.96
Sigma SF	0.743	8.31	0.666	7.73	0.623	7.18	0.536	6.27
Sigma CT	0.307	1.43†	0.333	1.91*	0.226	1.15†	0.259	1.43†
Sigma RS	-0.219	-0.91†	-0.28	-1.82*	-0.245	-1.52†	-0.00355	-0.01†
Sigma CS	1.58	7.82	-1.66	-8.02	-1.48	-7.81	-1.35	-7.07
Sigma NO	-3.11	-14.97	-3.05	-14.87	-2.97	-15.98	-2.92	-15.76
Statistics	**Values**		**Values**				**Values**	
Adjusted ρ2	0.187		0.188		0.197		0.203	
LL (0)	-5358.882		-5358.882		-5358.882		-5358.882	
LL (β)	-4343.518		-4330.995		-4258.111		-4222.394	
Individuals	454		454		454		454	
Value-of-time (based on significant (90% level) parameters only)	€18.40		€5.80 - €15.14		€8.72 - €60.54		€10.71 - €57.37	
Value-of-time (based on significant (95% level) parameters only)	€18.40				€8.72		€10.71	

Parameters without asterisk (*) or dagger (†) are significant on 95% level
*** Significant at 90% level; †Not significant, but included in the model; ** Attribute used as reference level**
SF = Stopflex; CT = Collective taxi; RS = Ridesharing; CS = Car-sharing; NO = No-option

each age category to the fourth group) or to include less parameters and to compare the included age category (or categories) to the remaining categories. To be sure, again taking age as an example, parameters are included step-by-step for the age categories with one category serving as the reference category. This is repeated until all age categories are tried as reference category and the best model is then chosen. The same is done for all other traveller- and trip related factors and their categories. In addition, it is necessary to choose which alternative is (or alternatives are) used as reference level(s), because the influence of a variable on an alternative is always in respect to the alternative or alternatives that is or are left out. For example, when the influence of not having a driving license is tested, it is desirable to at least include parameters for car-sharing and the no-option. The influence of not having a driving license on these alternatives is then in respect to the remaining alternatives. Testing the influence of not having a driving license on car-sharing in respect to the no-option could give a totally different result, because both the car-sharing alternative and the no-option are assumed to be influenced by the lack of a driving license. The assumption on which alternative or alternatives should be used as reference level is based on Table 4.2, but to be sure several different estimations are conducted with different reference levels as well.

As can be seen in Table 5.2, various traveller- and trip related variables are found to have a significant influence on the attractiveness of Alternative Transport Service types. Although there are some slight differences in the significant parameters in the final ML model compared to the third model (the ML model with traveller- and trip-related variables), the final ML model is discussed here extensively. In addition, a few comments are made about the third model and the differences between the model. The outcomes of the final ML model are visually presented in Appendix E. The figure in Appendix E shows an overview of the effects of all ASCs and parameters that are included in the final ML model.

As indicated earlier, to test the influence of the opinions of respondents it is not desirable to include all nine statements. Therefore, the factor analysis was conducted in Section 4.3. Three covering components were found and for each respondent scores were calculated for the three components. Because these scores are continuous variables, it is not necessary to use dummy variables. It should be noted that the way the statements are formulated influence the score of the respondents for each component, because respondents get a high score when they agree with the statements. For example, someone who agrees with the statements regarding the availability of public transport and whether he/she likes to use public transport, gets a high score on the component on public transport in general. This makes sense, because the respondent clearly has a positive attitude towards public transport in general. However, because of the way the statements are formulated, a respondent which agrees with the statements on more conventional public transport would get a high score on this component, but does not necessarily have a positive attitude towards the more conventional public transport services. In fact, the higher the score on the component regarding the more conventional public transport, the more negative the respondent thinks of these transport services and, for example, their need to be booked. To make the results easier to interpret, the scores of the respondents on the component regarding more conventional public transport is multiplied by -1. As shown in Table 5.2, the parameters for the components are more or less as could be expected. A positive opinion on more conventional services positively influences the utility of these services and negatively influences the utility of car-sharing. A positive opinion on more modern services positively influences the utility of a more modern service such as ride-sharing. Having a positive opinion on public transport in general has – as could be expected based on logical thinking – a positive influence on the attractiveness of stopflex, collective taxi. More or less unexpectedly, a positive opinion on public transport in general also has a positive effect on the attractiveness of ride-sharing. This was not expected because ride-sharing is a modern transport service. What stopflex, collective and ride-sharing have in common, however, is that all three alternatives were presented in the discrete choice experiment with a driver. Although not expected to influence travel mode choice behaviour much (because car-sharing was chosen very often in the discrete choice experiment), it could be the case that using a designated driver is important for the people who like public transport in general.

When looking at the other constants and parameters in the model, the first thing that stands out is that the absolute values of three ASCs are lower than they are in previous models. This means that because of the inclusion of traveller-related variables and the opinion of respondents, more preferences of respondents can be observed with the additional parameters. Most signs and values of the parameters for attributes and attributes levels are similar to the values found in the previous models.

Another thing that stands out is the considerable importance of the location of the trip. For all alternatives (expect of course the no-choice option that is used as reference), a rural location has a positive influence on the attractiveness of all the services. The four parameters are in the top five of most important variables. A location that is little urban only has a positive effect for the utility of car-sharing.

As could be expected based on Figure 4.1 (on page 36), the gender of a traveller and being in the possession of a driving license also influence the attractiveness of service types. As can be seen in Table 5.2, not having a driving license has a negative influence on the attractiveness of car-sharing and the no-option, while it has a positive influence on choosing collective taxi. When the parameters for the opinion of respondents are not included, not having a driving license also has a positive influence on choosing stopflex. In correspondence with what was expected, being male has a makes it more likely to choose the no-option. The utilities of the remaining alternatives (i.e. car-sharing) are not found to be influenced by gender. In addition, partly as was expected, travellers currently using public transport are more likely to choose stopflex. In the third model, it is found that travellers without a car in their household are more likely to choose collective taxi, but this effect cannot be found in the final model.

Another variable that has a positive influence on the attractiveness of stopflex and collective taxi is the trip purpose work/business. When looking at the model without the covering components of the factor analysis, it can be seen that being a student also positively influences the stopflex alternative. It is plausible to think that students thought that their student travel product (with which Dutch students can travel for free or with a discount on public transport in the Netherlands), could only be used in the stopflex alternative. This could have been thought because the normal bus service and the stopflex service look similar to each other. Another reason could be that students are less likely to have driving licenses. Variables that have a negative influence on one or more alternatives are living in a multiple-person household (either with or without children).

Although the significant parameters provide some interesting results, the insignificant parameters might provide even more interesting results. Based on the literature review in Section 2.5, many variables could be expected to influence the utility of alternatives. Only a small section of parameters of the expected variables was, however, found to be significant. An example of a parameters that unexpectedly not found to be significant is the parameter for travel distance for the collective taxi alternative. Based on Figure 4.2 (on page 37) it was expected that travel distance would have a positive effect on the utility of collective taxi, but this cannot be proved with the choice models. However, the parameter for travel time for collective taxi is found to be positive. Because travel time and travel distance are related to each other, the positive parameter for travel time for collective taxi could be explained by this. Another variable that was expected to have a more significant influence is the age of the respondents, not least because in real-life various transport companies and governments use price differentiations based on the age of travellers. Only the age category 25-44 is found to have a significant influence on the potential of car-sharing.

Looking at the adjusted rho-squared for each model it can be concluded that the models become better when more traveller- and trip-related variables are added. The values for the adjusted rho-squared indicate respectively an acceptable and a good model fit, according to Louviere et al. (2000).

5.2.5. Additional model outcomes

Based on the (significant) parameters for travel time and travel costs it is possible to calculate the value of time (VOT) of the respondents. parameters for travel time and travel costs it is possible to calculate the value of time (VOT) of the respondents. The VOT is equal to the parameter for travel time divided by the parameter for travel costs and presents what a traveller would be willing to pay in order to save time (Litman, 2017). When this is calculated based on the significant parameter (on the 95% level) from the final model, a VOT of €10.71/hour can be found. This value is approximately equal to the values that are found in studies by for example Schakenbos (2014) and Significance et al. (2012). The studies found that for social/recreational trips the VOT is around €7/hour and for work/business trips the VOT is approximately €13/hour. The mentioned studies focused on travel behaviour of users of regular public transport services. To test whether a difference in VOT can also be distinguished for this research, additional models are estimated with different parameters for travel costs and travel time based on the trip purpose. It is chosen to distinguish trip purpose based on the assumed importance of travel time. For trips with a work, business, study or medical purpose, time is assumed to be more important than for social/recreational trips. Both a generic model and a model with alternative-specific parameters are estimated, but the parameters were not found to be alternative-specific. For the generic model a VOT of €26.58/hour is found for work trips and a VOT of €10.40/hour is found for social/recreational trips. Because no traveller-related variables are included in the model, based on the VOT of the generic model in Table 5.2 it is assumed that the VOT for the model including traveller-related variables would be closer to the values found by Schakenbos (2014) and Significance et al. (2012).

5.3. Application of the results

In this section, several examples are explored based on the final ML model (the model including parameters for traveller- and trip-related variables and parameters for the opinion of respondents as well). The examples are used to present the potential of the alternatives and to show the influence of the attributes, attribute levels and the traveller- and trip-related variables. The probabilities for each example are determined by using Biosim. Biosim is an extension of Biogeme and can be used to compute market shares of alternatives and to evaluate policy effects (Bierlaire, 2009). The program uses the outcomes of the ML models (as presented in Table 5.2*Table 5.2*) and an additional data file to calculate the probabilities for the alternatives. Because the total output of ML models are used, the insignificant parameters for travel time and travel costs are used as well. The data file, provides the input for the utility functions of the alternatives (i.e. the travel costs or whether an alternative uses a

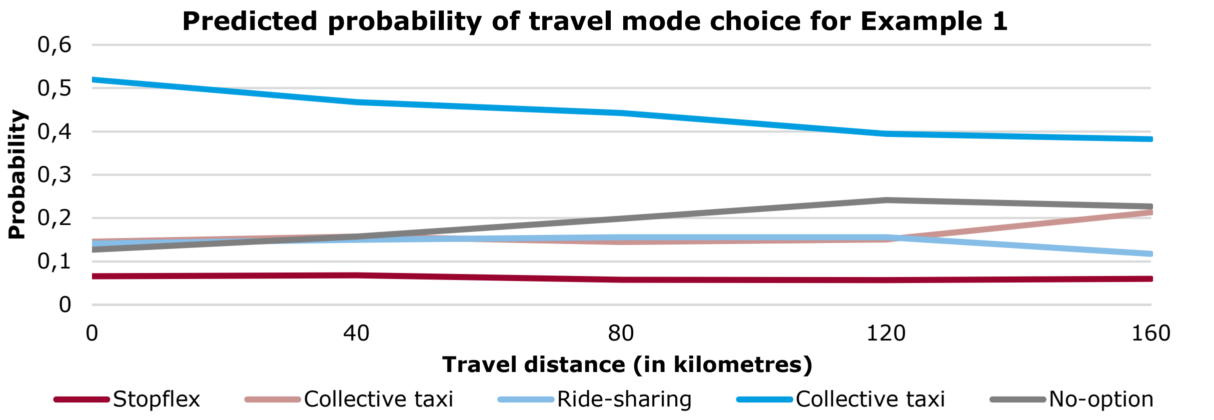

Figure 5.1: Outcomes of the simulation of Example 1

time window or not) for each example. In all examples, it is assumed that all four alternatives and the *no-option* are available for every respondent. It should be noted that the probabilities are calculated based on the respondents that are assumed to consider the possibility to use of ATSs.

In the first example, the values used as input for travel time and travel costs are based on the revealed travel time and travel costs of the respondents. This means that the values are equal for all alternatives. With regard the design of the alternatives some assumptions are made. Stopflex does not use a time window, collective taxi uses a wide time window and ride-sharing uses a small time window (note that the parameter for this attribute level is not found to be significant and therefore is not included in the model). In addition, stopflex only provides transport to and from fixed stops and ride-sharing has stops along the route, while the collective taxi is unscheduled and the ride-sharing service is demand-responsive. The predicted probability of travel mode choice for Example 1 can be seen in Figure 5.1. The probabilities are presented with travel distance as independent variable. This is done because both travel time and travel costs are related to travel distance. It can be seen that, in general, car-sharing is the most preferred alternative. Although a significant effect was not found earlier, collective taxi seems to get more attractive when the travel distance increases. The attractiveness of the no-option also seems to increase when the travel distance (and thus the travel time and travel costs) increases. This is caused by the fact that there are no parameters for travel time and travel costs included in the utility function of the no-option. Thus, in contrast to the other alternatives, the utility of the no-option is not affected by travel time and travel costs. The attractiveness of the alternatives stopflex and ride-sharing are more or less constant over the travel distance.

To explore the influence of attribute levels, various additional simulations (/examples) are conducted with Biosim. For the first simulation (Example 2), the stopflex service also provides the possibility to get in or out the vehicle along the route. Although car-sharing remains the most preferred alternative, the average probability for stopflex increases to 0.166 (was 0.06 in Example 1). The probabilities for the other alternatives can be seen in Table 5.3. The table also shows the outcomes of other examples. For the examples, constantly only one attribute level is changed for an alternative. The alternatives as used in Example 2 are used as a basis for the other examples. It can be seen in Table 5.3 that the more flexible a service type becomes, the higher the predicted probability becomes. Based on the changes between the probabilities for the alternatives, it can be concluded that introducing stops along the route for stopflex seems to be the most influential change.

Table 5.3: Outcomes of simulation examples (values indicate average predicted probabilities of travel mode choice)

Ex.	Change made	SF	CT	RS	CS	NO
1.	[Alternatives described above]	0.064	0.154	0.144	0.479	0.160
2.	Stops along the route for SF	0.166	0.140	0.167	0.408	0.119
3.	No time window for CT	0.163	0.151	0.164	0.403	0.118
4.	RS provides door-to-door transport	0.149	0.126	0.233	0.380	0.113

SF = Stopflex; CT = Collective taxi; RS = Ride-sharing; CS = Car-sharing; NO = No-option

Table 5.4: Average predicted probability of travel mode choice for sample segments

		Predicted probability of travel mode choice				
Variables	**Segments**	**SF**	**CT**	**RS**	**CS**	**NO**
Gender	Female	0.189	0.135	0.127	0.448	0.100
	Male	0.152	0.120	0.116	0.425	0.187
Age	Younger than 25	0.233	0.168	0.113	0.376	0.110
	25-44	0.150	0.104	0.087	0.526	0.133
	45-64	0.168	0.122	0.118	0.444	0.148
	65 and older	0.156	0.128	0.142	0.404	0.170
Driving license	No	0.239	0.242	0.142	0.295	0.082
	Yes	0.161	0.115	0.119	0.449	0.155
Household structure	One-person household	0.192	0.154	0.132	0.399	0.123
	Multiple-person, without children	0.167	0.132	0.135	0.410	0.157
	Multiple-person, with children	0.144	0.089	0.084	0.523	0.159
Location	Very strongly urban	0.168	0.118	0.089	0.476	0.149
	Strongly urban	0.178	0.128	0.132	0.390	0.172
	Moderate urban	0.176	0.128	0.126	0.417	0.153
	Little urban	0.141	0.103	0.100	0.514	0.142
	Not urban	0.168	0.158	0.107	0.488	0.080
Vehicle used	Car	0.144	0.108	0.126	0.461	0.162
	Public Transport	0.219	0.163	0.109	0.385	0.124
Trip purpose	Work/business	0.192	0.128	0.098	0.452	0.131
	Social/recreational	0.153	0.126	0.133	0.420	0.167
	Education	0.209	0.146	0.106	0.414	0.126
	Doctor's appointment	0.149	0.111	0.133	0.463	0.142

SF = Stopflex; CT = Collective taxi; RS = Ride-sharing; CS = Car-sharing; NO = No-option

Finally, traveller- and trip-related variables are considered for the simulation in Biosim. Table 5.4 presents the average predicted probability of respondent groups choosing for the alternatives for. The alternatives consist of the attribute levels as used in Example 2. Thus, stopflex provides the possibility to get in or out along the route. The probabilities are not calculated for all segments. Only the variables that have at least one significant parameter for a segment are included in the table. Segments such as *other* and *unknown* are not included. The influence of traveller-related variables can be clearly observed in Table 5.4. For example, for people without a driving license the predicted probability of travel mode choice is considerably different than for people with a driving license. It can be seen that stopflex, collective taxi and ride-sharing services are more attractive for people without a driving license than that they are for people with driving license. The most important conclusion that can and should be drawn from Table 5.4 is that when a new service is implemented, it is highly desirable to precisely know the target group.

5.4. Concluding

In this chapter, several choice models are estimated. Appendix E presents an overview of the effects of all ASCs and parameters that are found to significantly influence the potential or utility of the ATS types. It is found that, in general, the most preferred Alternative Transport Service type is car-sharing. This is not considered to be surprising, because in the discrete choice experiment the one-way car-sharing service provided a high level of flexibility for the same price as the other alternatives.

In the final section of this chapter it is shown that the potential of the ATS types highly depends on traveller- and trip-related variables and the way a service is designed. As shown in the different simulations, the more flexible a service is, the higher the predicted probability that a traveller will choose the service. This corresponds to what was expected based on the findings in Chapter 2 of this research. As indicated by the statement of Daniels and Mulley (2010), the potential of an Alternative Transport Service highly depends on the possibility for the traveller to travel when and to where is desired.

The influence of the travel time and travel costs of alternatives is not tested in the previous simulations. It is chosen not to do this, because it would be most interesting to use realistic and situation-specific assumptions for the fare and travel speed of alternatives. For future initiators, it is recommended to explore which transport services could have high potential for its target group based on the outcomes of the choice models and to consider situation-specific fares and travel times for the alternatives.

6. *Conclusions and recommendations*

This chapter describes the conclusions of the research and provides recommendations for the province of Overijssel and future initiators of Alternative Transport Services.

6.1. Conclusions

The objective of this research was to:

- *To obtain knowledge on how various factors (including level-of-service attributes and socio-economic characteristics of end-users) influence the potential of Alternative Transport Service types in the province of Overijssel.*

To achieve this objective, eight sub-questions and the main research questions are stated in Chapter 1. The sub-questions are answered here first, after which the main research question is answered.

Q1. *Which service aspects of Alternative Transport Services are defined in state-of-the-art literature?*

Chapter 2 presents seven different service aspect for Alternative Transport Services. These are *route type, scheduling type, booking type, vehicle type, vehicle allocation, origin destination relationship* and *origin destination service*. For every aspect, three or four alternatives (or levels) are found. Based on combinations of the aspect alternatives, services can be designed and service types can be distinguished. It is worth noting that some combinations are more likely than others and that a service's flexibility depends to a great extent on the choices that are made for the design of the service.

Q2. *Which Alternative Transport Service types are defined in literature and used in previous studies?*

Alternative Transport Services can be designed in many ways and many different service types – varying from inflexible to flexible – and categorisations of service types are described in literature. An example of a categorisation found in the literature is the categorisation of Gemeente Steenwijkerland (2008). This categorisation distinguishes eight different service types, such as stopflex, routeflex, dial-a-ride, shuttle bus, dolmus bus, stop hopper and collective taxi. Other categorisations distinguish totally different service types, but it is undesirable to mention all service types here. Although many different categorisations and service types are found, none of the categorisations was found to be suitable for the remainder of this research, because the categorisation either used to many or not enough service aspects. Equally or even more importantly, none of the found categorisations considers the, so-called, approach. Recently emerging services, such as ride-sharing and car-sharing alternatives, do not follow the same approach as conventional public transport designated drivers and vehicles and clear roles between driver and passenger(s). Therefore, to answer Sub-question 3, a new categorisation is developed.

Q3. *How can Alternative Transport Services be categorised based on the service characteristics that profoundly influence a service's operational flexibility?*

In Section 2.4, seven different service types are defined: stopflex, dial-a-ride, routeflex, stop hopper, collective taxi, ride-sharing and car-sharing. The categorisation is based on both existing categorisations (in particularly the categorisations of Gemeente Steenwijkerland (2008) and Kisla et al. (2016)) and services found to be active in the Netherlands. Because it is found in literature that it is important that an ATS provides a high level of flexibility to the user, the categorisation is done based on the service aspects that profoundly influence a service's operational flexibility. These service aspects are routing, scheduling, booking type and OD-service. The approach of a service, as explained in the answer on Sub-question 2, is used as a categorisation criteria as well.

The seven services can be described as follows:

- **Dial-a-ride:** Service that is similar to a regular bus service but has to be booked in advance. The service only calls at the fixed checkpoints when the service is requested beforehand.
- **Stopflex:** More or less similar to regular public bus services, but stopflex services can have both fixed stops and stops flexible along the pre-defined route (instead of only fixed stops).
- **Routeflex:** The route of a routeflex service depends on the demand. There are a pre-defined route and a pre-defined schedule, but vehicles can deviate from the route and schedule based on the demand.
- **Stop hopper:** Stop hopper services provide transport from fixed checkpoints but without a schedule. The service is only available when requested beforehand. The route is determined based on the demand.
- **Collective taxi:** Services provide transport from door-to-door on request like regular taxis. Main difference is that the trips are shared with other users, possibly leading to a longer travel time and more inaccuracy regarding the departure/arrival time.
- **Ride-sharing:** Ride-sharing services make it possible for end-users to arrange the sharing of car trips, so that more people travel in a car. With ride-sharing services, customers can be a passenger one moment and a driver or a service provider the next.
- **Car-sharing:** Car-sharing services offer cars that can be rented for short periods of time.

Stopflex, collective taxi, ride-sharing and car-sharing are used in the discrete choice experiment to test the level of importance of several attributes and variables.

Q4. *Which level-of-service attributes influence the potential of Alternative Transport Service types the most, according to literature?*

Based on various previously done studies, multiple level-of-service attributes are found to influence the utility of an Alternative Transport Service type. Because of the assumed importance of operational flexibility, the research mainly considers the level-of-service attributes that are typical for the operational design and actual service operation. Therefore, a criterion such as *noise in the vehicle* is not considered, because the level of noise does not influence the operational flexibility of a service. Therefore, in this research the potential of an Alternative Transport Service type is not considered to be influenced by criteria such as noise, while it could influence the actual quality of a transport service. The level-of-service attributes that are found to influence the potential of ATSs types the most are:

- **Accessibility:** How convenient is it to reach the service vehicle or its transit stop?
- **Schedule:** Is the departure or arrival time fixed or based on the preferences of end-users?
- **Departure and arrival time window:** Is the departure or arrival time in accordance with the desired or expected departure/arrival time?
- **Travel costs:** Is the service worth its fare/prices compared to other modes?
- **Travel time:** Is the travel time reasonable for the distance to be travelled?

Q5. *What traveller- and trip-related characteristics (i.e. socio economic characteristics, trip characteristics and attitude towards public transport) influence the end-user preferences regarding Alternative Transport Service types the most, according to literature?*

A total of twelve different traveller- and trip- related variables are found in literature that are assumed to influence the travel behaviour of potential travellers of Alternative Transport Services. The variables

Table 6.1: Overview of traveller- and trip-related variables that influence the end-user preferences regarding Alternative Transport Service types the most, according to literature?

Type	Variable
Traveller-related	Age, gender, household structure, number of cars in household, driving license, socio-economic participation, income, need for assistance, level of urbanisation of trip
Trip-related	Trip purpose, trip frequency, vehicle currently used for trip
Attitude/opinion on	Opinion about availability of public transport in general, attitude towards modern ATSs, attitude towards conventional ATS, perceived safety of services following sharing approach, perception on booking, perception on sharing, need for assistance from the driver

vary from age and gender to income and household structure. In addition, the attitude towards public transport and the opinion of respondents on Alternative Transport Services are found to be important. All variables can be seen in Table 6.1 on the previous page. The importance of these variables on the attractiveness of Alternative Transport Service types is tested through the estimation of various choice models, based on the outcomes of the discrete choice experiment.

Q6. *What influence have the found level-of-service attributes on the potential of Alternative Transport Service types?*

In Chapter 5, multiple choice models are estimated to determine the importance of the level-of-service attributes on the potential of ATS types. It is found that not all levels of the service attributes have a significant influence. The potential of services is not influenced by using a small time window instead of no time window or by being demand responsive instead of using a fixed schedule. The level-of-service attributes that have a significant influence on the potential of Alternative Transport Service types are visually presented in Appendix E. In general, the effects of the significant attributes and attribute levels on the potential of ATSs can be summarised as follows:

- **Fixed stops:** Negative influence compared to *stops along the route;*
- **Door-to-door transport:** Positive influence compared to *stops along the route;*
- **Unscheduled transport:** Positive influence compared to *fixed schedule* and *demand-responsive transport*;
- **Wide time window:** Negative influence compared to *no time window* and *small time window;*
- **Travel time:** Negative influence. The longer the travel time, the less attractive the service;
- **Travel costs:** Negative influence. The more expensive a service, the less attractive the service.

Based on the outcomes of the simulations for the predicted probability for travel mode choice, it is shown that the potential of the ATS types highly depends on traveller- and trip-related variables and the way a service is designed. As shown in the different simulations, the more flexible a service is, the higher the predicted probability that a traveller will choose the service. For example, introducing the possibility to get in and out the vehicle wherever the traveller wants, increases the potential of the stopflex service considerably.

Q7. *Which socio-economic characteristics, trip characteristics and/or additional factors influence the end-user preferences regarding potential Alternative Transport Service types the most?*

By extending the choice models, it is found that various traveller- and trip-related variables significantly influence the end-user preferences on Alternative Transport Service types. Not all parameters for the variables that are described in the literature review of Section 2.5 are, however, found to be significant. Through the estimation of two different models containing traveller-related and trip-related variables it is found that variables such as *having a driving license* and the *level of urbanisation of the location of the trip* are the most important variables. The other variables that have a significant effect can be seen in Appendix E. Interesting conclusions can be drawn based on the insignificance of parameters as well. For example, the age of a traveller was expected to be more influential. In addition, the opinion of a traveller on public transport in general and its attitude towards more conventional service types and modern service types are found to have an important influence as well.

Q8. *Which Alternative Transport Service type is most preferred by potential end-users in the province of Overijssel?*

Based on the outcomes of the simulations presented in Section 5.3, it can be concluded that car-sharing has the highest overall potential. However, when looking at traveller-related variables, it is found that car-sharing is not for everybody. For example, for people without driving license, car-sharing is not suitable and/or attractive. Therefore, for future initiators, it is strongly recommended to determine the precise transport service demand and target group, before Alternative Transport Service types are even considered.

With the answers on the eight sub-questions present, the main research question can be answered.

- *Which factors, including level-of-service attributes and characteristics related to end-users, influence the potential of Alternative Transport Service types the most in the province of Overijssel and which recommendations can be made for future initiators?*

As said, Appendix E presents an overview of the effects of all ASCs and parameters that are found to influence the potential or utility of the ATS types that are used in the discrete choice experiment. Because a complete overview is presented in the figure in Appendix E, it is thought to be undesirable to present a similar list here as well. The factor that influences the utility of alternatives the most is the location of the traveller. Travellers in a rural area are more likely to choose Alternative Transport Services than travellers in more urban locations. Another important variable is not having a driving license.

6.2. Recommendations

Based on the research, both on the literature review as well as on the outcomes of the discrete choice experiment and the model estimation process, several recommendations can be made. The first recommendation is for the province of Overijssel to further look into Alternative Transport Services. As shown in the first two chapters of this research report, public transport is not always desirable, for example because the demand is too low. Not least because of technological developments, ATSs can tackle several problems of regular transport by being more convenient and flexible.

When implementing a service, various service types should be considered. In the literature review on existing categorisations of service types, it is found that most categorisations merely take into account service types that use a conventional service approach. However, recently emerging service types, such as modern variants of carpooling/ride-sharing and car-sharing do not follow this approach but area assumed to have great potential. Therefore, the new categorisation presented in Sub-section 2.4.3, does consider both approaches. The categorisation is assumed to be a useful tool to determine possible alternatives.

As said, recently emerging service types that follow the sharing approach are assumed to have great potential. In the discrete choice experiment, car-sharing is found to be the most preferred alternative overall. Various municipalities in the Netherlands are already experimenting with car-sharing or town cars. It is recommended for the province of Overijssel to explore locations where the unfulfilled transport demand could be fulfilled by implementing a car-sharing service.

Based on the outcomes of the research, the statement of Daniels and Mulley (2010) that is presented in Section 2.1 about the importance of flexibility can be proved. It is shown that making services more flexible in terms of when and where potential users can travel, increases the potential of services types considerable. Based on the simulations done in Section 5.3, it can be concluded that it could be desirable to convert regular, inflexible bus services into more flexible services by allowing travellers to get in and out the bus wherever they want along the route. It is shown that introducing stops along the route could increase the attractiveness of such a service considerably. Other interventions that make services more flexible, such as minimising the time window for the departure or arrival time, have similar effects.

For situations where it is not possible or undesirable to implement stops along the route at bus services or to implement a car-sharing service, the results of this research can be used to explore the potential of transport services. Based on the characteristics of potential end-users it can be explored which transport services could have high potential for the target group or on which similar services the initiator should focus. However, it is important to use the exploration just as an exploration and not as a tool to determine the absolute *best* alternative. Firstly, because the models are based on just four service types, while the categorisation in Sub-section 2.4.3 already contains seven alternatives. And secondly, because the potential of alternatives varies from end-user to end-user and because there are always situation-specific factors that should be taken into account, the most suitable services should be discussed with the potential users to determine which of the services they are most willing to use and which of the services they think are most attractive.

7. *Limitations, evaluation and further research*

This chapter discusses firstly discusses the limitations of the research. Three points of discussion are distinguished in the first three sections: discrete choice experiment, respondents and results. The fourth section presents recommendations for further research.

7.1. Discrete choice experiment

The main part of the research existed of a survey including a discrete choice experiment. The outcomes of every research containing a discrete choice experiment are to a great extent determined by the development of the experimental design. For this research, the experimental design could have been done differently to (possibly) obtain more information.

One of the main weaknesses of the used experimental design is the way car-sharing is included. As indicated in Chapter 5, car-sharing has fixed attribute levels for accessibility, schedule and time window. Therefore, there are no parameters included in the utility function of car-sharing for these three attributes and this leaves only two (travel time and travel costs) parameters (together with the alternative-specific constant) to describe why respondents choose for car-sharing. It is likely that the high value for the ASC of car-sharing is caused by the limited number of parameters that is included in the utility function of car-sharing. In addition, valuable information regarding the importance of door-to-door could be neglected because of this. The same applies, although in less extent, to door-to-door transport for collective taxi.

To tackle the *problem* of fixed attribute levels, another design approach could have been used. With the used approach, it was chosen to include the four most *extreme* or most *diverse* alternatives from the categorisation matrix that was developed in Sub-section 2.4.3. This was chosen because it was assumed that the inclusion of realistic alternatives would make the choice situations easier and more recognisable for the respondents. However, another design approach could have been to include hypothetical combinations of attribute levels and not to include pre-defined alternatives. This approach could have led to more information about the relative importance of the attribute levels that were fixed in the current design. However, it would not have been possible to calculate alternative-specific constants or alternative-specific parameters for travel time and travel costs. For these parameters, vehicle-specific parameters could have been more suitable. Furthermore, the hypothetical combinations of attribute levels could have resulted into *unrealistic* alternatives in the choice sets, possibly confusing the respondents and leading to unreliable results.

Another point of discussion regarding the fixed attribute levels, is that the car-sharing alternative always provided unscheduled transport from door-to-door without a time window. Although this is realistic for a one-way car-sharing service, it would have been interesting to explore the attractiveness of car-sharing when the service is less accessible.

Regarding the current design, it should be said that more useful information could have been obtained when more realistic values for the travel time and travel costs would have been included. In the current design, the same time pivots and the same basic fare are used for every alternative. For further research, it is desirable to base the travel time of the alternatives in the choice sets based on more realistic assumptions. For example, the vehicles of a car-sharing service probably have a higher average speed than a collective taxi. This could be taken into account for the determination of the travel times shown in the choice sets. The same applies for the values of the travel costs. In this way, the choice situations could become more realistic.

7.2. Respondents

According to the rule of thumb of Ortuzar and Willumsen (2011), 75-100 respondents are needed per group segment to say something about a group (Schakenbos, 2014). For some groups, the minimum of 75 respondents is not reached. In addition, compared to the OViN data for the province of Overijssel, particularly the group of students and respondents younger than 25 years old are underrepresented. To correct for this, a weighting factor is assigned to each respondent. For each respondent, a weighting factor is calculated based on the product of the weighting factors for the variables age, household structure and travel purpose. It is chosen to use these variables because they are assumed to be important and because for these variables the ratios between the sample composition and the OViN data are relatively large. It could also have been chosen, however, to use other variables. It could be the case that the results would have been slightly different. Because of the weighting, the sample is assumed to be representative for the population of the province of Overijssel and the trips made by the population.

Another point of discussion is the recruitment of the respondents. At first it was chosen to focus on two or three specific locations where regular public transport has come under pressure and/or where public transport services are listed to be terminated. It was assumed that approaching respondents at such specific locations would provide relevant response. In an ideal situation, respondents would have been current public transport users of services that are only limitedly used. However, since the (possible) termination of a service is for a reason, it turned out to be impossible to recruit a sufficient number of respondents from the small group of users of services that are (possibly) terminated. Because of this, it was chosen to distribute the survey province-wide.

Finally, approximately a hundred respondents were excluded, mainly because the respondents chose the no-option (probably their own car) in all eight choice sets. It was concluded that these respondents did not consider the use of ATSs at all and would therefore not provide relevant response. In fact, it was assumed that these respondents could disturb the model results. For example, when someone constantly chooses the no-option (i.e. its own transport alternative), regardless of the costs of other alternatives, the level of importance of travel costs that can be measured during the model estimation could be disturbed. Costs savings up to 40%, for example, are not important for respondents who do not consider Alternative Transport Services at all, making it more difficult to measure the level of importance of travel costs for travellers that do consider to use Alternative Transport Services. The exclusion of such a large number of respondents could have possibly been prevented by adding a question on whether respondents would actually consider using another transport mode. Respondents who do not consider other transport modes could be removed from the sample easily and an additional question could be asked why they do not consider other transport modes.

7.3. Results

The results of the model estimation process are possibly influenced by the limitations of the design of the discrete choice experiment. As said, because of the fixed attribute levels, the car-sharing alternative always provided unscheduled door-to-door transport without a time window. This makes that the car-sharing alternative in the choice sets in general was often more attractive than the other alternatives. Although this is realistic for a big one-way car-sharing service, this could be a reason why car-sharing is found to be the most preferred alternative.

Nevertheless, because the signs of (most of) the parameters are considered to be logical, because the parameters correspond to what was expected based on the descriptive statistics, because the found values of time correspond to values found in previously done studies on regular public transport and because weighting factors are applied to the respondents based on the population of the province of Overijssel, it is assumed that the models provide results that are close to reality. However, unfortunately, because of the lack of other studies done on the importance of service attributes and traveller-related variables for the preferences regarding the use of ATSs, it is not possible to validate the outcomes of this research.

7.4. Further research

For further research with a similar research question and research aim, it is highly recommended to take into account the points of discussion pointed out in the previous section. Probably the most interesting recommendation to extent this research would be to conduct a more or less similar research at locations where regular public transport has come under pressure and/or where public transport services are listed to be terminated and take into account location-specific variables.

Furthermore, caused by the need to keep the choice experiment relatively easy to complete, the alternatives consisted of only five attributes. The selection of these attribute came from an extensive literature review and the choice to categorise the alternatives based on aspects that profoundly influence a service's flexibility. Therefore, other level-of-service attributes are neglected. It would be interesting to explore what end-users think of service aspects such as noise, the possibility of having a place to sit or the waiting facilities.

Also, this research focuses merely on the perception of end-users. The needs, wishes and capabilities of the public transport companies are not considered. Moreover, the transport demand in a region and the capacity of alternatives are also not considered. Exploring the potential of Alternative Transport Services more locally, keeping in mind the transport company, responsible government, potential end-users and the actual transport demand would be interesting as well.

An actual topic regarding the potential and use of Alternative Transport Services is *Mobility-as-a-Service* (MaaS). MaaS describes, among other things, the improvement of the integration of the use of multiple transport service for one trip. To achieve this, the transport network should consist of a network of various transport services, including regular public transport services and Alternative Transport Services, and the transport services should complement and connect with each other. For further research, it is interesting to explore the potential of the Alternative Transport Services in combination with other transport services. For example, it could be tested what travellers think are the most attractive combinations of service types and what they are willing to pay to be allowed to use different combinations of service types. In addition, particularly in combinations with other transport services, it would be possible to include (e-)bike-sharing in the research as well. This was not included in this research because it is considered unlikely that a bike-sharing service can replace, for example, a regular bus service, but as a part of a complete network of transport services bike-sharing is considered to hold great promise.

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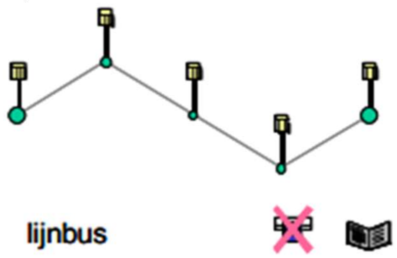
Appendix A: Forms of public road transport

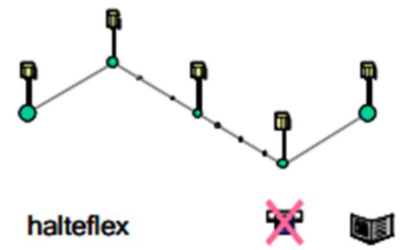
Legend

	Fixed route		Booking not required
	Flexible route		Booking required
	Dwelling		Fixed stop
	Access or egress stop		Fixed schedule

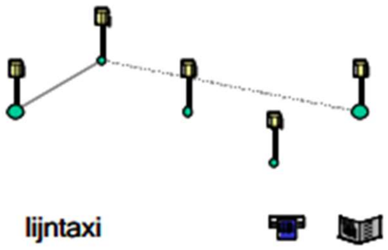
Lijnbus (Regular bus service): Bus for high travel demands. Fixed route, fixed schedule and fixed stops



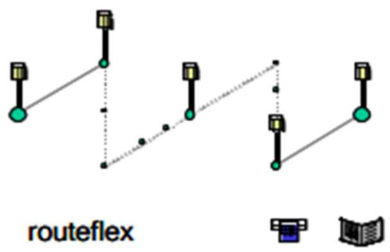
Halteflex (Stopflex): A bus with a fixed route and time schedule but passengers can get in or out along the route



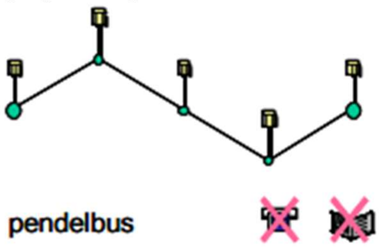
Lijntaxi (Dial-a-ride): A bus with semi-flexible routes and time schedules. Only operates when booked beforehand



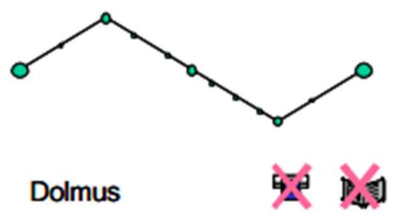
Routeflex: Bus with fixed departure time but with semi-flexible route and stops



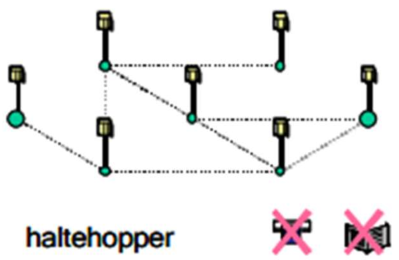
Pendelbus (Shuttle bus): Bus with fixed route and fixed stops. Only operates when there are *enough* passengers



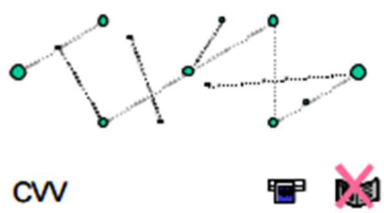
Dolmus: Bus with fixed route. Passengers can get in or out along the route. Only operates when there are *enough* passengers



Haltehopper (Stop hopper): Demand responsive without fixed routes. Access and egress only at fixed stops



Collectieve taxi (Collective taxi): Demand responsive without fixed route and time schedule. Provide transport service from door-to-door



Obtained and translated from Gemeente Steenwijkerland (2008)
Translations of names, when applicable, between brackets

Appendix B1: Quality index of Pagano and McKnight (1983)

Dimensions and Attributes used by Pagano and McKnight (1983)

Dimensions	Attributes*
Reliability	1. Notification of delays or cancellation of service
	2. Wait time for pickup at home
	3. Wait time for pickup away from home
	4. Arriving at destination on time
	5. Few delays while on the vehicle
Comfort	6. Guaranteed seat or location for wheelchair
	7. Condition and cleanliness of the vehicle
	8. Smoothness of the ride
	9. Air conditioning and good ventilation
	10. Sheltered waiting areas for pickups away from home
	11. Seats at waiting areas for pickups away from home
Convenience of making reservations	12. Accommodation to changes in reservations
	13. Being picked up at time selected by traveller
	14. Shortness of reservation time
	15. Convenience of return reservation procedure
Extent of service	16. Total number of hours of service
	17. No or few restrictions on where vehicle will go
	18. Service on evenings
	19. Service on weekends
	20. Low rate of turning down reservations
Vehicle access	21. Width of aisle
	22. Height of first step
	23. Number of steps
	24. Presence of wheelchair lift or ramp
	25. Assistance in getting from vehicle to destination
	26. Assistance in carrying packages
	27. Short distance from house or destination to vehicle
Safety	28. Low probability of personal assault
	29. Low probability of falling
	30. Type of tie down
	31. Position of the wheelchair in the vehicle
	32. Low probability of a traffic accident
Driver characteristics	33. Ability to handle medical emergencies
	34. Courtesy and friendliness
	35. Knowledge of general needs
	36. Familiarity with habits and needs of individual user
	37. Neatness and professionalism
Responsiveness	38. Courtesy and friendliness of telephone operators
	39. Ease of getting clear information on service
	40. Receptiveness to complaints and user suggestions
	41. Procedure for follow-up on complaints

Attributes in bold are used to form level-of-service attribute that are used in the survey

Appendix B2: Quality index of Knutsson (1999)

Dimensions and attributes used by Knutsson (1999)

Dimensions	**Attributes***
Information	1. Information access
	2. Understandable information
	3. Faultless and complete information
	4. Unambiguous information
Dignity	5. Being taken seriously as a traveller
	6. Confidence with respect to what to do and where to go
	7. Personal privacy
	8. Reliability of service
	9. Safety day and night time
	10. Medical emergency capability
	11. Suitable and motivated driver
	12. Courtesy and friendliness
	13. Familiarity with personal needs
Comfort	14. Service on weekdays
	15. Service on weekend
	16. Punctuality, departure
	17. Punctuality, arrival
	18. Freedom of crowding
	19. Booking
	20. Follow-up to complaints
	21. Few restrictions
	22. Pre-booking of return
	23. Smoothness of ride
	24. Vehicle inside design
	25. Number of steps
	26. Space and seating
	27. Lift (or ramp)
	28. Distance to vehicle
	29. Driver assistance
	30. Ease of complaining
	31. Possibility to choose departure time
Travel time	**32. Reasonable in-vehicle time**
	33. Waiting time away from home
	34. Waiting time in the telephone switchboard
	35. Total trip time
	36. Delays on vehicle
	37. Pre-booking time
	38. Punctuality, pickup time
Fare	**39. Worth its price compared to public transport**
	40. Fare

******Attributes*** **in bold are used to form level-of-service attribute that are used in the survey**

Appendix B3: Quality index of TRB (2013)

Quality of service framework for Alternative Transport Services of the Transportation Research Board (2013)

Dimensions	Attributes*
Availability	**1. Temporal availability (frequency, in accordance with demanded departure time)**
	2. Spatial availability (presence near one's origin and destination, accessibility of transit stops)
	3. Information availability (provision of correct information and real-time travel information)
	4. Capacity availability (on service vehicles and supporting facilities)
Travel time	**5. Waiting time at stop**
	6. Required transfer
	7. Travel time (relative to travel time of other modes)
Comfort	8. Climate control (heating and air conditioning)
	9. Seat comfort
	10. Ride comfort
Appearance and amenities	11. Benches
	12. Shelters
	13. Lighting
	14. Informational signing
	15. Trash receptacles
	16. Telephones
	17. Vending facilities
	18. Air conditioning
Safety	19. Potential for being injured
Security	20. Potential for becoming the victim of a crime (including irritants)
Convenience	**21. Reliability**
	22. No-shows
Costs	**23. Fare**
	24. Value of using public transport compared to using other modes

Attributes in bold are used to form level-of-service attribute that are used in the survey

Appendix B4: OV-klantenbarometer

Questions and attributes used in the Dutch public transport customer satisfaction survey, OV-klantenbarometer. Originally in Dutch, translated in English (KPVV CROW, 2016b)

Attributes*		Questions
1.	Noise	Wat vindt u van het geluid in het voertuig *What is your opinion on the noise of the vehicle?*
2.	Place to sit	Kon u moeilijk of makkelijk een zitplaats vinden toen u instapte? *Was it hard or easy to find a place to sit?*
3.	**Customer service / friendliness**	Wat vindt u van de klantvriendelijkheid van het personeel? *What is your opinion on the friendliness of the staff?*
4.	Condition and cleanliness of the vehicle	Wat vindt u van de netheid van het voertuig? *What is your opinion on the condition and cleanliness of the vehicle?*
5.	Smoothness of the ride	Wat vindt u van de rijstijl van de bestuurder? (optrekken, remmen, etc.) *What is your opinion on the driving style of the driver?*
6.	**Access and egress**	Kon u moeilijk of makkelijk instappen? (instaphoogte, afstand tot perron) *Was is hard or easy to get in the vehicle?*
7.	**Punctuality**	Wat vond u van de stiptheid (op tijd rijden) van het voertuig bij de vertrekhalte? *What is your opinion on the punctuality of the service vehicle?*
8.	Information at stop/station	Hoe vond u de informatie op uw instaphalte? (o.a. vertrektijden, prijs, route) *What is your opinion on the provision of information at the stop (or station)?*
9.	**In-vehicle time**	Wat vindt u van de reissnelheid van deze rit? (omrijden, directheid) *What is your opinion on the travel speed of the service?*
10.	Information on delays	Hoe wordt u geïnformeerd bij vertragingen of andere problemen? *What is your opinion on the provision of information regarding delays and other problems?*
11.	Frequency	Wat vindt u van het aantal vertrekmogelijkheden vanaf uw instaphalte? *What is your opinion on the departure possibilities at your departure stop?*
12.	Convenience of purchasing tickets	Vond u het moeilijk of makkelijk om uw vervoerbewijs te kopen/ uw reissaldo te laden? *What is your opinion on the convenience of the purchase of tickets?*
13.	**Fare**	Wat vindt u van de prijs van deze rit? *What do you think of the fare of this trip?*
14.	Perceived safety at stop	Hoe veilig voelt u zich (meestal) op de halte waar u bent ingestapt? *How safe do you feel at the departure stop?*
15.	Perceived safety during transport	Hoe veilig voelt u zich (meestal) tijdens deze rit? *How safe do you feel during the trip?*
16.	Transfer	Als u straks overstapt of bent overgestapt op ander openbaar vervoer, hoe beoordeelt u de overstaptijd? *How do you assess your (possible) transfer?*

Attributes in bold are used to form level-of-service attribute that are used in the survey

Appendix C: Examples of service types

Based on the exploration done on active Alternative Transport Services in the Netherlands, several examples of service types are presented here. This is done based on the categorisation developed in Section 2.3.

Dial-a-ride: Lijnbelbus
The LijnBelBus service in the provinces Groningen and Drenthe provides public transport at moments when the demand is limited, for example in the evening or in the weekends. The buses follow the same route and use the same stops as the buses that regularly provide public transport. The LijnBelBuses also use fixed schedules, but merely drive when the service is booked in advance. The LijnBelBus then drives the complete fixed route. The service is provided by local transport companies (Qbuzz, 2017).

Stopflex: Neighbourhood buses
In the Netherlands, the Buurtbus (neighbourhood bus) was introduced in 1977 to provide public transport in areas where demand is low and widely dispersed. To reduce operating costs the service is carried out by volunteers and with a minibus. Because this minibus can be driven by someone who has a driving license for a normal passenger car, volunteers do not need training. There are almost 200 Buurtbus services in the Netherlands. The buses for these services are often provided by the transport company. Because a Buurtbus often operates in areas where demand is widely dispersed, the fixed stops used by the buses are often widely dispersed in an area as well. Therefore, passengers can (as long as it is safe) board or disembark the buses along the fixed route (SRE, 2013).

Neighbourhood bus in the colours of the province of Overijssel (Hansen, 2010)

Routeflex: Casters Vervoer
Casteren, a small town in the province of North Brabant has its own public transport service, called Casters Vervoer and it is completely run and set up by volunteers. The service generally drives the same route with a fixed departure time and has some predefined stops. However, travellers that are not able to walk to these stops can ask to be picked up at their houses. The same applies for people with groceries; they can ask to be dropped off at home. Thus, although there is a pre-defined route with pre-defined stops and a pre-determined schedule, the service can deviate from the route and schedule to provide flexibility and convenience for its users. Of course, deviating from the route might cause delays further up the route, but this is taken into account for in the schedule (van de Weijer, 2014).

Stop hopper: Texelhopper and Dial-a-bus
To complement the public transport service on the Dutch island Texel (consisting of two regular bus lines), the Texelhopper provides transport between pre-defined stops, but without pre-defined routes. Travellers can book the Texelhoppers for transport from and to one of the 130 stops across the island. The booking has to be done at least an hour before the trip. Based on all the request, the operator determines the most optimal route and informs the travellers about the departure time at their stop (Texelhopper, 2017).

Like the Texelhopper, the Dial-a-bus service of public transport company De Lijn in Belgium complements the regular public transport system. In thinly populated areas, some of the buses of De Lijn only run on request. The Dial-a-bus services do not use pre-defined routes or timetables and only stop at stops that are requested in advance (De Lijn, 2017).

Collective taxi: RegioTaxi and Witte Raaf
The Regiotaxi is the best-known collective taxi in the Netherlands. As said above, in many regions the Regiotaxi is used to provide WMO-transport. Therefore, people with mobility issues can use the service at cheaper costs, but the service can be used for regular transport as well

The transport service association Witte Raaf in Eindhoven (North Brabant) provides a collective taxi service for elderly. The service is fully set up and operated by volunteers and provides demand responsive transport to prevent social exclusion.

Ride-sharing: Liftpaal and Samobiel
To test whether carpooling can be used to replace an underused bus service, in the town Lemelerveld (province of Overijssel) a pilot was done on carpooling. At the so-called carpool pole along the route of the bus service people could notify passing car drivers that they wanted to drive along with them to the near town Dalfsen. The pilot was not considered a success, mainly because the carpool pole was demolished after one day, probably because people disagreed with the possible replacement of the bus service. However, with support of society, carpooling could work as a transport service (RTV Oost, 2016)

Samobiel provides a more modern take on ride-sharing. Developed in a small village in Sweden in 2009, as of 2017 Samobiel is active in multiple towns in various countries. Samobiel provides an online platform and application for inhabitants of small villages to submit and accept trip requests. The application also determines the costs of a trip and handles the payments. Because of the concerns of social safety of ride-sharing, the services of Samobiel can only be used by small(er) communities. For each community, there are local contact persons. These persons determine the geographic boundaries in which Samobiel can be used and check whether new users live in the community. It is assumed that within the community, the contact persons know everybody. Because of this screening, users can feel safe about with whom they are sharing their ride, but it also means that Samobiel cannot be used by communities larger than 1,500 people. The costs of implementing Samobiel can often be paid by a municipality or province from a financial budget meant to improve the liveability of rural areas (Samobiel, 2017).

Car-sharing: Five forms of car-sharing
KpVV CROW (2016a) distinguishes five forms of car-sharing. An important criterion for their categorisation is *ownership*. It is possible that there is company providing the cars, but it is also possible that the users own the car and share the vehicle together. The forms of car-sharing are:

- **Traditional car-sharing**; Cars can be rented from fixed locations. They have to be returned to these locations as well.
- **One-way car-sharing**; Cars can be used for one-way trips as well. They can be picked up at several locations. An example of a one-way car-sharing service is Car2Go. With Car2Go you can park the car (and end your trip) at any parking space (legally) possible. By using GPS, customers get to know where there is a car nearby (Car2Go, 2017).
- **Business car-sharing**; The cars are used by companies and their staff.
- **Peer-2-peer car-sharing**; Individuals offer their private car for hire via an online community.
- **Individual car-sharing**; Friends, family members or neighbours share their car between themselves.

Appendix D1: Experiment design for choice experiment (English)

Survey/Block 1

Set	#	Accessibility	Schedule	Time window	Time	Costs
1	1	Fixed stops	Fixed schedule	No time window	R - 15%	BF +/- 0%
1	2	Along the route	Demand responsive	Wide time window	R + 30%	BF + 40%
1	3	Along the route	Unscheduled	Small time window	R - 30%	BF - 40%
2	1	Along the route	Demand responsive	No time window	R - 15%	BF - 20%
2	2	Door-to-door	Unscheduled	Small time window	R - 30%	BF + 20%
2	3	Fixed stops	Fixed schedule	Wide time window	R + 30%	BF - 40%
3	1	Door-to-door	Demand responsive	No time window	R +/- 0%	BF + 20%
3	2	Door-to-door	Unscheduled	No time window	R + 15%	BF - 40%
3	3	Fixed stops	Demand responsive	Wide time window	R - 30%	BF - 20%
4	1	Door-to-door	Unscheduled	No time window	R + 15%	BF + 40%
4	2	Fixed stops	Fixed schedule	Wide time window	R - 30%	BF + 20%
4	3	Door-to-door	Demand responsive	Small time window	R +/- 0%	BF - 40%
5	1	Along the route	Demand responsive	Small time window	R - 30%	BF + 40%
5	2	Door-to-door	Unscheduled	No time window	R + 30%	BF + 20%
5	3	Along the route	Demand responsive	Small time window	R +/- 0%	BF +/- 0%
6	1	Along the route	Demand responsive	Wide time window	R + 15%	BF + 20%
6	2	Door-to-door	Unscheduled	Wide time window	R - 15%	BF - 20%
6	3	Fixed stops	Fixed schedule	No time window	R + 30%	BF + 40%
7	1	Fixed stops	Demand responsive	No time window	R + 30%	BF + 20%
7	2	Along the route	Fixed schedule	Small time window	R +/- 0%	BF + 40%
7	3	Door-to-door	Unscheduled	Wide time window	R + 15%	BF - 40%
8	1	Door-to-door	Demand responsive	Small time window	R + 30%	BF +/- 0%
8	2	Along the route	Unscheduled	Wide time window	R - 15%	BF - 20%
8	3	Fixed stops	Demand responsive	No time window	R + 15%	BF + 40%

Survey/Block 2

Set	#	Accessibility	Schedule	Time window	Time	Costs
9	1	Along the route	Demand responsive	Wide time window	R + 15%	BF +/- 0%
9	2	Door-to-door	Unscheduled	No time window	R - 30%	BF - 20%
9	3	Door-to-door	Unscheduled	Small time window	R - 15%	BF + 20%
10	1	Door-to-door	Unscheduled	Wide time window	R +/- 0%	BF - 40%
10	2	Door-to-door	Demand responsive	Small time window	R - 15%	BF + 40%
10	3	Along the route	Fixed schedule	No time window	R + 15%	BF +/- 0%
11	1	Fixed stops	Demand responsive	Small time window	R - 15%	BF - 40%
11	2	Along the route	Fixed schedule	Wide time window	R - 30%	BF + 40%
11	3	Door-to-door	Demand responsive	No time window	R + 30%	BF + 40%
12	1	Along the route	Unscheduled	Small time window	R - 30%	BF - 40%
12	2	Door-to-door	Demand responsive	No time window	R + 30%	BF +/- 0%
12	3	Door-to-door	Unscheduled	Wide time window	R +/- 0%	BF + 20%
13	1	Door-to-door	Demand responsive	Wide time window	R - 15%	BF + 40%
13	2	Along the route	Fixed schedule	Small time window	R +/- 0%	BF - 20%
13	3	Door-to-door	Unscheduled	No time window	R - 30%	BF +/- 0%
14	1	Fixed stops	Fixed schedule	Small time window	R + 15%	BF - 20%
14	2	Along the route	Demand responsive	No time window	R + 30%	BF - 40%
14	3	Door-to-door	Unscheduled	No time window	R - 15%	BF +/- 0%
15	1	Along the route	Fixed schedule	No time window	R - 15%	BF - 40%
15	2	Door-to-door	Unscheduled	Small time window	R + 30%	BF - 20%
15	3	Fixed stops	Demand responsive	Wide time window	R +/- 0%	BF +/- 0%
16	1	Along the route	Demand responsive	Small time window	R + 15%	BF + 20%
16	2	Door-to-door	Demand responsive	Wide time window	R - 30%	BF +/- 0%
16	3	Along the route	Unscheduled	No time window	R +/- 0%	BF + 40%

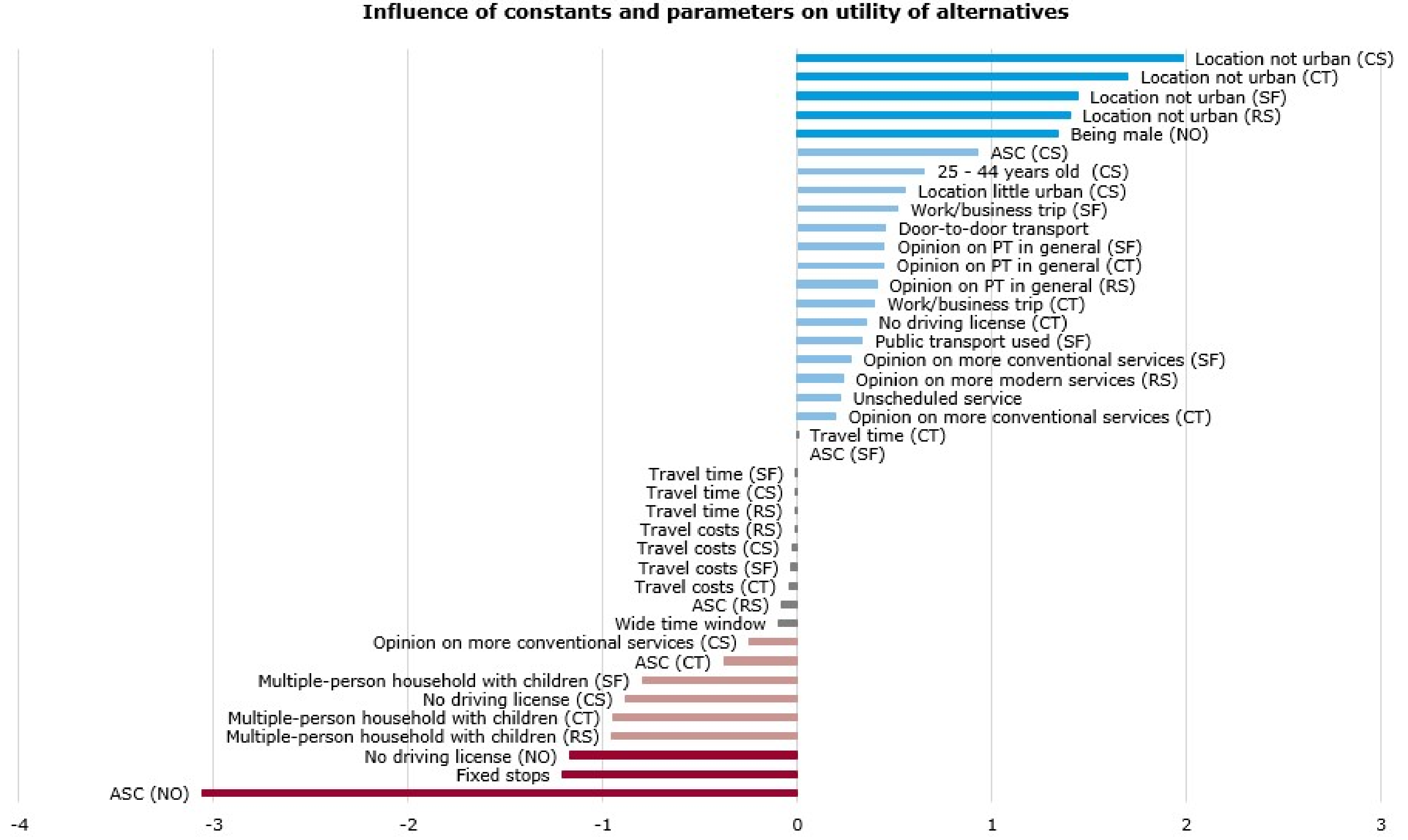
R = Revealed current travel time, BF = Basic fare

Appendix D2: Experiment design for choice experiment (Dutch)

Enquête/blok 1							**Enquête/blok 2**						
Situatie	**#**	**In- en uitstappen**	**Dienstregeling**	**Nauwkeurigheid**	**Reistijd**	**Reiskosten**	**Situatie**	**#**	**In- en uitstappen**	**Dienstregeling**	**Nauwkeurigheid**	**Reistijd**	**Reiskosten**
1	1	Vaste haltes	Vaste dienstregeling	Nauwkeurig	R - 15%	BF +/- 0%	9	1	Langs de route	Deels vraagafhankelijk	Onnauwkeurig	R + 15%	BF +/- 0%
1	2	Langs de route	Deels vraagafhankelijk	Onnauwkeurig	R + 30%	BF + 40%	9	2	Deur tot deur	Volledig vraagafhankelijk	Nauwkeurig	R - 30%	BF - 20%
1	3	Langs de route	Volledig vraagafhankelijk	Beperkt nauwkeurig	R - 30%	BF - 40%	9	3	Deur tot deur	Volledig vraagafhankelijk	Beperkt nauwkeurig	R - 15%	BF + 20%
2	1	Langs de route	Deels vraagafhankelijk	Nauwkeurig	R - 15%	BF - 20%	10	1	Deur tot deur	Volledig vraagafhankelijk	Onnauwkeurig	R +/- 0%	BF - 40%
2	2	Deur tot deur	Volledig vraagafhankelijk	Beperkt nauwkeurig	R - 30%	BF + 20%	10	2	Deur tot deur	Deels vraagafhankelijk	Beperkt nauwkeurig	R - 15%	BF + 40%
2	3	Vaste haltes	Vaste dienstregeling	Onnauwkeurig	R + 30%	BF - 40%	10	3	Langs de route	Vaste dienstregeling	Nauwkeurig	R + 15%	BF +/- 0%
3	1	Deur tot deur	Deels vraagafhankelijk	Nauwkeurig	R +/- 0%	BF + 20%	11	1	Vaste haltes	Deels vraagafhankelijk	Beperkt nauwkeurig	R - 15%	BF - 40%
3	2	Deur tot deur	Volledig vraagafhankelijk	Nauwkeurig	R + 15%	BF - 40%	11	2	Langs de route	Vaste dienstregeling	Onnauwkeurig	R - 30%	BF + 40%
3	3	Vaste haltes	Deels vraagafhankelijk	Onnauwkeurig	R - 30%	BF - 20%	11	3	Deur tot deur	Deels vraagafhankelijk	Nauwkeurig	R + 30%	BF + 40%
4	1	Deur tot deur	Volledig vraagafhankelijk	Nauwkeurig	R + 15%	BF + 40%	12	1	Langs de route	Volledig vraagafhankelijk	Beperkt nauwkeurig	R - 30%	BF - 40%
4	2	Vaste haltes	Vaste dienstregeling	Onnauwkeurig	R - 30%	BF + 20%	12	2	Deur tot deur	Deels vraagafhankelijk	Nauwkeurig	R + 30%	BF +/- 0%
4	3	Deur tot deur	Deels vraagafhankelijk	Beperkt nauwkeurig	R +/- 0%	BF - 40%	12	3	Deur tot deur	Volledig vraagafhankelijk	Onnauwkeurig	R +/- 0%	BF + 20%
5	1	Langs de route	Deels vraagafhankelijk	Beperkt nauwkeurig	R - 30%	BF + 40%	13	1	Deur tot deur	Deels vraagafhankelijk	Onnauwkeurig	R - 15%	BF + 40%
5	2	Deur tot deur	Volledig vraagafhankelijk	Nauwkeurig	R + 30%	BF + 20%	13	2	Langs de route	Vaste dienstregeling	Beperkt nauwkeurig	R +/- 0%	BF - 20%
5	3	Langs de route	Deels vraagafhankelijk	Beperkt nauwkeurig	R +/- 0%	BF +/- 0%	13	3	Deur tot deur	Volledig vraagafhankelijk	Nauwkeurig	R - 30%	BF +/- 0%
6	1	Langs de route	Deels vraagafhankelijk	Onnauwkeurig	R + 15%	BF + 20%	14	1	Vaste haltes	Vaste dienstregeling	Beperkt nauwkeurig	R + 15%	BF - 20%
6	2	Deur tot deur	Volledig vraagafhankelijk	Onnauwkeurig	R - 15%	BF - 20%	14	2	Langs de route	Deels vraagafhankelijk	Nauwkeurig	R + 30%	BF - 40%
6	3	Vaste haltes	Vaste dienstregeling	Nauwkeurig	R + 30%	BF + 40%	14	3	Deur tot deur	Volledig vraagafhankelijk	Nauwkeurig	R - 15%	BF +/- 0%
7	1	Vaste haltes	Deels vraagafhankelijk	Nauwkeurig	R + 30%	BF + 20%	15	1	Langs de route	Vaste dienstregeling	Nauwkeurig	R - 15%	BF - 40%
7	2	Langs de route	Vaste dienstregeling	Beperkt nauwkeurig	R +/- 0%	BF + 40%	15	2	Deur tot deur	Volledig vraagafhankelijk	Beperkt nauwkeurig	R + 30%	BF - 20%
7	3	Deur tot deur	Volledig vraagafhankelijk	Onnauwkeurig	R + 15%	BF - 40%	15	3	Vaste haltes	Deels vraagafhankelijk	Onnauwkeurig	R +/- 0%	BF +/- 0%
8	1	Deur tot deur	Deels vraagafhankelijk	Beperkt nauwkeurig	R + 30%	BF +/- 0%	16	1	Langs de route	Deels vraagafhankelijk	Beperkt nauwkeurig	R + 15%	BF + 20%
8	2	Langs de route	Volledig vraagafhankelijk	Onnauwkeurig	R - 15%	BF - 20%	16	2	Deur tot deur	Deels vraagafhankelijk	Onnauwkeurig	R - 30%	BF +/- 0%
8	3	Vaste haltes	Deels vraagafhankelijk	Nauwkeurig	R + 15%	BF + 40%	16	3	Langs de route	Volledig vraagafhankelijk	Nauwkeurig	R +/- 0%	BF + 40%

R = Huidige reistijd, BF = Basistarief

Appendix E: Constants and parameters with a significant influence



The abbreviations between brackets indicate on which alternative the constants and parameters have influence