Exploring alternative public transport in rural areas

What are the preferences of bus users in rural areas of the Netherlands for a demand responsive transport service and a multimodal alternative that combines express bus and bike-sharing?

K.A. Bronsvoort

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by

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What Are the Preferences of Bus Users in Rural Areas of the Netherlands for a Demand Responsive Transport Service and a Multimodal Alternative that Combines Express Bus and Bike-sharing?

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Abstract—**Public transport in rural areas is under pressure because flows are thin and it is cost-inefficient for public transport operators. Flexible and on-demand services are often proposed as alternatives for services with conventional buses and fixed schedules that are not suitable for rural areas. In this study, a stated-preference survey is designed and implemented in order to identify the preferences of rural bus users for alternative public transport such as demand responsive transport (DRT) and express bus services with bike-sharing systems for last mile transport. The results from the choice model indicate that cost has the largest influence on the preference for express bus services with bike-sharing systems for last mile transport, followed by shared bicycle egress time and in-vehicle travel time. Cost has the largest influence on the preference for DRT services followed by access and egress time and in-vehicle travel time.**

Index terms - Demand Responsive Transport, Bike-sharing, Rural public transport, Discrete choice modelling, Traveller preferences

I. Introduction

About 2.7 million individuals out of the 17.2 million inhabitants of the Netherlands live in rural regions. Another 3.7 million individuals live in low urbanised regions [1]. In these rural areas, public transport is under pressure. In thinly populated areas, public transport is often cost-inefficient and it is difficult to generate more income by attracting more passengers or to improve the quality of the service [2]. However, governments think that all inhabitants of the Netherlands should be able to use public transport [3].

New solutions that provide mobility to inhabitants of rural areas can be more suitable for public transport in regions where transport flows are thin, than traditional transport services with large busses and fixed schedules [2]. Flexible and on-demand services are often proposed as alternatives for failing classic forms of public transport [4]. In this research, the preferences of bus users in rural areas towards alternative public transport are explored.

The research question corresponding to the research problem stated above is formulated as follows:

"What are the preferences of bus users in rural areas of the Netherlands for a demand responsive transport service and a multimodal alternative that combines express bus and bike-sharing?"

In this study two alternatives for the rural bus are proposed: a demand responsive transport (DRT) system with a flexible route and schedule, and a multimodal alternative that combines an express bus service with shared bicycles for last mile transport.

II. Background

DRT is a form of public transport in which a group of passengers shares a vehicle that has flexible stops and flexible routes [5]. A trip with DRT is requested by the user. Users can book a trip via a smartphone application. The coverage and routing of DRT systems can differ in terms of route-flexibility and stopping locations. DRT systems can have fixed routes or no planned routes at all. Stopping locations can be existing public transport stops, recognised meeting places or non-predefined stops (the passenger's doorstep) [6].

Bike-sharing services enable users to temporarily use a bicycle from a shared fleet on a short term basis for a fixed price (per minute or kilometre) [7]. There are two forms of shared bicycles: station based and free floating. Station based bicycles have to be brought back to a fixed location and free floating bicycles can be parked anywhere and can be used for one way trips [8].

III. Research design

The objective of this research is to find the preferences of rural bus users for alternative public transport. To gain insight into the preferences of rural bus users a stated preference survey is developed and conducted.

The stated choice experiment designed in this study included three alternatives:

1) A multimodal alternative that combines an express bus service with shared bicycles for last mile transport called ”Combi”;
2) A demand responsive transport system with flexible routes and schedules called ”Flexi”;
3) Regular bus.

The regular bus is included as a status quo alternative. The bus alternative has fixed attribute values that are based on the characteristics of an average bus trip in rural areas.

Each alternative has attributes with different values, such as access time, travel time, costs, minimum booking time, headway, bicycle availability, departure delay and travel time deviation.

Because of the on-demand nature of DRT, other attributes than those that are used for fixed public transport services have to be taken into account. The new attributes are related to the reliability and flexibility of DRT, due to the lack of a fixed schedule and the booking interval. Another new aspect that has to be taken into account for both DRT and bike-sharing systems, is the availability attribute. There is no guarantee that the vehicle is available exactly at the desired place and time. More research in the area of flexibility and reliability is needed, and this study tries to gain a better understanding of these characteristics.

The following attributes are included in the experiment: access time, travel time, costs, minimum booking time (Flexi), headway (Combi and bus), bicycle availability (Combi), departure delay (Flexi) and travel time deviation (Flexi). Table I provides an overview of the attributes and attribute levels used per alternative.

The attributes related to the reliability and flexibility of Flexi and Combi are minimum booking time, bicycle availability, departure delay and travel time deviation. The attribute associated with the on-demand character of Flexi is the minimum booking time. The minimum booking time is the number of minutes in advance an individual has to book Flexi before the desired departure time.

An attribute that is included to represent the reliability of bike-sharing systems is bicycle availability. This attribute represents the number of bicycles available at the arrival bus stop at the starting time of the trip.

Other attributes related to reliability are departure delay and travel time deviation. The departure delay represents the maximum delay in the departure time of the trip with Flexi. This attribute can take on any value between zero and the maximum value of the departure delay. The travel time deviation is the maximum number of extra minutes of travel time, for example, caused by making a detour to pick up an additional passenger.

An orthogonal fractional factorial design is used to construct the stated choice experiment. For this particular experiment an orthogonal fractional factorial design results in 27 choice sets. This amount is too big for one respondent, therefore the experiment is divided into three blocks of 9 choice sets.

From the experimental design, the stated choice part of the questionnaire can be constructed. Each row in the experimental design contains the attribute levels for a choice situation. An example of a choice situation presented to the respondents is visible in Figure 1. In addition to the data related to the respondents' preferences, socio-demographic data and data pertaining attitudes towards flexibility and reliability are collected.

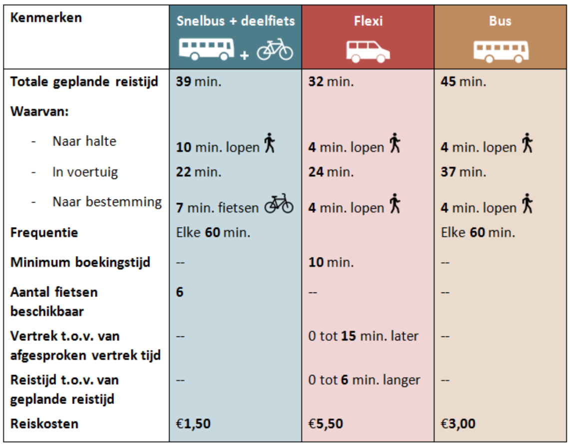
IV. Survey and sample

Flyers with a link to the survey were handed out on bus stations in the following Dutch cities and village: Enschede, Zwolle, Almelo and Haaksbergen. Additional respondents were found via public transport traveller organisations and a link on Facebook. In total 112 suitable entries were collected.

The sample is found to be representative for the bus user population in rural areas in the Netherlands. Half of the respondents are

TABLE I
ATTRIBUTE LEVELS USED IN THE CHOICE EXPERIMENT

Attribute	**Attribute levels**		
Access time Combi [min]	2	6	10
Access time Flexi [min]	2	4	6
Access time bus [min]		4	
Travel time express bus Combi [min]	22	27	32
Travel time shared bicycle Combi [min]	2	7	12
Travel time Flexi [min]	24	32	40
Travel time bus [min]		37	
Cost Combi [€]	1.50	3.50	5.50
Cost Flexi [€]	1.50	3.50	5.50
Cost bus [€]		3.00	
Headway Combi [min]	10	35	60
Headway bus [min]		60	
Minimum booking time Flexi [min]	10	35	60
Bicycle availability Combi [# shared bicycles]	1	6	11
Departure delay Flexi [min]	0-3	0-9	0-15
Travel time deviation Flexi [min]	0-2	0-6	0-10



Kenmerken	Snelbus + deelfiets	Flexi	Bus
Totale geplande reistijd	39 min.	32 min.	45 min.
Waarvan:			
- Naar halte	10 min. lopen	4 min. lopen	4 min. lopen
- In voertuig	22 min.	24 min.	37 min.
- Naar bestemming	7 min. fietsen	4 min. lopen	4 min. lopen
Frequentie	Elke 60 min.		Elke 60 min.
Minimum boekingstijd	--	10 min.	--
Aantal fietsen beschikbaar	6	--	--
Vertrek t.o.v. van afgesproken vertrek tijd	--	0 tot 15 min. later	--
Reistijd t.o.v. van geplande reistijd	--	0 tot 6 min. langer	--
Reiskosten	€1,50	€5,50	€3,00

Fig. 1. Example of a choice set presented to respondents

students and the most common travel motive is education. Furthermore, it was found that around 50% of the respondents live in areas classified as moderately urbanised or lower. Another finding is that few respondents have experience with shared bicycles or DRT, 27% and 4% respectively. 17% of the respondents never use the car as a mode of transport, implying that they are captives of public transport.

Of all respondents, 15% are characterised as non-traders and always choose the bus alternative in the choice experiment. Non-traders are in general older than traders, this corresponds with the fact that fewer students are among non-traders and education is not as often mentioned as the travel motive by non-traders.

All alternatives ever chosen in the choice experiment are considered as the modal portfolio of the respondent. The modal portfolios of all individuals are obtained and presented in Figure 2. A large group of respondents consider all three alternatives (46%). In the setting of the experiment, 68% of respondents are considering Flexi as a mode of transport. 71% of the respondents are considering Combi as a mode of transport. 15% of the bus users always choose bus and are not willing to shift to Flexi and Combi under the circumstances presented in the choice experiment.

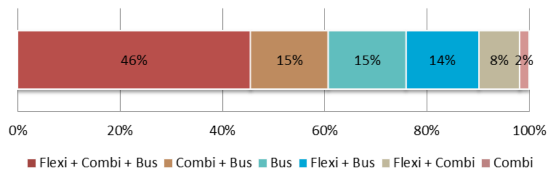


Fig. 2. Modal portfolio's

V. RESULTS

Data gathered from the survey is analysed using discrete choice modelling. The results are presented in this section.

A. *Discrete choice models*

Four models are estimated: a multinomial logit (MNL) model, a nested logit (NL) model, a mixed logit (ML) model with an error component and an extended ML model with an error component and socio-demographic variables. The error component represents the utility of the common unobserved factors of Flexi and Combi. The model outcomes are presented in Table II. The extended mixed logit model has the best model fit.

TABLE II
ESTIMATED MODELS WITH MODEL SCORES

Model	# of observations	# of parameters	ρ^2	$\bar{\rho}^2$	Null LL	Final LL	LRS
MNL Base	990	13	0.160	0.149	-1087.626	-913.086	349.08
NL	990	14	0.163	0.15	-1087.626	-910.281	354.691
ML EC	990	14	0.296	0.283	-1087.626	-765.805	643.643
ML EC extended	990	21	0.315	0.296	-1087.626	-744.925	685.402

B. *Parameter interpretation*

The extended ML model includes parameters for the attributes, socio-demographic variables, one of the attitudinal statements and an error-component that tests heterogeneity within the nest and corrects for panel effects. The parameter estimates are presented in Table III. Except for the parameters for headway, bicycle availability and departure delay, all parameters are significant at the 95% confidence interval.

The estimated parameter for in-vehicle travel time is slightly higher for time spent inside the Flexi vehicle than for time spent in the express bus of the Combi alternative, meaning that travel time of Flexi is perceived more negative than travel time of the bus part of Combi. The access time of Flexi is perceived as more negative than the access time of Combi. The estimated parameters for cost for the two alternatives are quite similar. An increase in cost is valued almost equally negative for Combi as for Flexi.

The socio-demographic parameters can be interpreted as follows. Men have a lower preference towards Flexi than women, and men have a higher preference for Combi and bus than for Flexi. Individuals that are under 30 have a higher preference for Combi and Flexi than for bus and have the highest preference for Combi. Individuals between 30 and 60 years old have a higher preference for Combi than individuals over 60. It can be concluded that individuals under 30 are more willing to use Combi and Flexi as an alternative for the bus than older individuals.

Individuals with a driving licence prefer Flexi and Combi over the bus. Individuals with a driving licence have a higher preference for Combi and Flexi than individuals without a driving licence. Having a driving licence probably makes them less dependent on the current bus service.

Having a high distrust in transport services without fixed schedules results in a lower preference for Flexi. Logically, individuals with a high distrust in transport services without fixed schedules have a lower preference for Flexi than for Combi and bus.

Finally, the sigma for new modes is significant. Meaning that a nest is present between the Flexi alternative and the Combi alternative. The nest captures what Flexi and Combi intuitively have in common, but is not captured in the deterministic part of the utility [9]. It is assumed that it captures the fact that both Combi and Flexi are (relatively) new forms of transport for respondents. The sigma captures the correlation between unobserved utilities of the two modes as well as the correlations between choices that are made over time by the same individual [9].

C. *Value of travel time savings*

The values of travel time savings (VoTTS) are calculated to get a better understanding of how respondents value the different trip parts, the VoTTS are presented in Table IV. Overall, respondents are willing to pay more for a decrease in access and egress time, than for a decrease in in-vehicle times. Respondents are willing to pay more for a decrease of in-vehicle time of Flexi than for a decrease in in-vehicle time of Combi.

VI. MODEL APPLICATION

The sensitivity of the estimated choice model for changes in the design attributes of the alternatives was tested through simulation. A reference scenario was used, the reference scenario is presented in Table V. In the situation of the reference scenario the modal shares are 31%, 16% and 53% for Combi, Flexi and bus, respectively.

From the simulation outcomes, it can be concluded that within the attribute ranges tested, changes in the travel time with shared bicycle and the cost of Combi have the largest influence on the modal share of Combi and also influence the shift away from the bus. See Figure 3 for the sensitivity of shared bicycle

TABLE III
PARAMETER ESTIMATES OF EXTENDED ML EC MODEL

Name	Value	Robust SE	Robust t-test	p-value	
ASC_{Combi}	2.170	1.050	2.070	0.040	
ASC_{Flexi}	4.710	0.948	4.970	0.000	
$\beta_{Cost\ Combi}$	-0.426	0.067	-6.330	0.000	
$\beta_{Cost\ Flexi}$	-0.416	0.081	-5.150	0.000	
$\beta_{Access\ and\ egress\ time\ Flexi}$	-0.174	0.064	-2.700	0.010	
$\beta_{Egress\ time\ shared\ bicycle}$	-0.148	0.021	-7.000	0.000	
$\beta_{Access\ time\ Combi}$	-0.117	0.028	-4.200	0.000	
$\beta_{Travel\ time\ Flexi}$	-0.106	0.018	-5.860	0.000	
$\beta_{Travel\ time\ express\ bus\ Combi}$	-0.086	0.022	-3.880	0.000	
$\beta_{Departure\ delay\ Flexi}$	-0.011	0.020	-0.550	0.580	*
$\beta_{Minimum\ booking\ time\ Flexi}$	-0.011	0.005	-2.140	0.030	
$\beta_{Headway\ Combi}$	-0.008	0.005	-1.560	0.120	*
$\beta_{Bicycle\ availability}$	0.053	0.027	1.950	0.050	*
$\beta_{Age1\ Combi}$	1.920	0.687	2.790	0.010	
$\beta_{Age\ 2\ Combi}$	1.350	0.586	2.300	0.020	
$\beta_{Driving\ licence\ Combi}$	1.320	0.491	2.690	0.010	
$\beta_{Driving\ licence\ Flexi}$	1.260	0.456	2.770	0.010	
$\beta_{Age1\ Flexi}$	1.130	0.524	2.160	0.030	
$\beta_{Gender\ Flexi}$	-0.846	0.295	-2.870	0.000	
$\beta_{ST4\ Flexi}$	-0.374	0.125	-3.000	0.000	
$\sigma_{New\ Mode}$	2.060	0.208	9.920	0.000	

* not significant at a 95% confidence interval

travel time and Figure 4 for the sensitivity of the cost of Combi.

From the operational characteristics tested, cost and in-vehicle time have the largest influence on the modal share of Flexi within the range tested. A two euro decrease in cost resulted in an increase in a modal share of 18%, an 8 minute decrease in travel time had the almost the same effect on the modal share of Flexi.

The simulation model was also used to forecast the modal shares in five different scenarios. The scenario where the Combi network was designed as a high frequency network predicted the highest model share for Combi. In this scenario the share of Combi was 46%, Flexi had a share of 11% and bus a share of 44%.

The scenario where Flexi was designed as a node-to-node network, with short in-vehicle times, lower cost and normal access times, predicted the largest modal share of Flexi, 35%. In this scenario the share of Combi was 21% and the share of bus 44%.

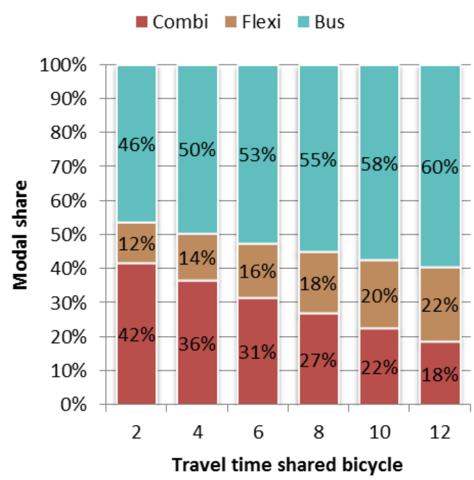


Fig. 3. Sensitivity shared bicycle travel time

TABLE IV
VALUES OF TRAVEL TIME SAVINGS FOR FLEXI AND COMBI

Value of Travel Time Savings	Value	Unit
In-vehicle travel time express bus Combi	12.08	€/hour
In-vehicle travel time Flexi	15.29	€/hour
Travel time shared bicycle	20.85	€/hour
Access time Flexi	25.10	€/hour
Access time Combi	16.48	€/hour

TABLE V
REFERENCE SCENARIO

Reference scenario	Combi	Flexi	Bus
Access time [min]	6	4	4
In-vehicle travel time [min]	26	32	37
Egress time [min]		4	4
Shared bicycle travel time [min]	6		
Minimum booking time [min]		30	
Headway [min]	30		60
Cost [€]	3.50	3.50	3.00
Bicycle availability [# shared bicycles]	6		
Departure delay [min]		0-10	

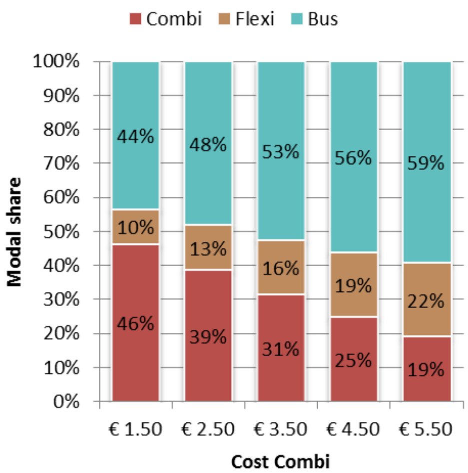


Fig. 4. Sensitivity cost Combi

VII. Conclusion and Recommendations

This study aimed to determine the preferences of rural bus users for DRT services and express bus services with bike-sharing systems for the egress part of the trip. From the research, it can be concluded that both mode characteristics as personal characteristics influence the preferences of bus users for Combi and Flexi.

Cost has the largest negative effect per unit (€) on the preference for Flexi and Combi, followed by access and egress times. Walking as an access mode has a larger negative effect on the preference for Flexi than for Combi. The in-vehicle travel time has the largest negative effect on the total utility of the alternatives for the ranges used in this study. The in-vehicle time of Flexi is perceived as more negative than the in-vehicle time of express bus.

Public transport operators that want to attract passengers to Combi should mainly focus on lowering cost and egress times of shared bicycles. Low cost, low in-vehicle travel times and low access times can attract passengers to Flexi.

The network design characteristic that has an influence on the access and egress times and on the in-vehicle times of Combi is the stop distance. The stop distance of the Combi network should be sufficiently large to be able to have a high operating speed, but not too large because large stop-density will result in longer access and egress times.

The in-vehicle time of Flexi is affected by the stop density and the number and size of the detours made to pick-up additional passengers. To keep in-vehicle times low a node-to-node Flexi service is advised. Furthermore, research should be done to find the optimal fleet size and dispatching scheme.

The networks of Combi and Flexi can be designed in such a way that the modes are more attractive for bus users. However, in all the scenarios tested bus still has a high modal share. Suggesting that although the design characteristics of Flexi and Combi networks are made more attractive, still a large number of individuals prefers the regular bus service over Combi and Flexi.

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Kristel Bronsvoort
Delft, Maart 2019

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Part I

Introduction and Approach

1 Introduction

In this chapter, the research problem is introduced and the corresponding research question is stated. Next, the objective, scope and contribution of the research are discussed. Lastly, the structure of this report is addressed.

1.1 Problem Statement

In areas where transport flows are thin, few travellers will use public transport. In rural areas there are a lot of thin transport flows. In these areas public transport is under pressure, because the costs per passenger kilometre are high, and it is difficult to generate more income by attracting more passengers or to improve the quality of the service (Zijlstra, Bakker, Durand, & Wüst, 2018). In thinly populated areas (no more than 200 inhabitants per km^2) public transport is usually cost-inefficient. However, the government of the Netherlands considers access to public transportation of high importance for all residents (de Jong, Vogels, van Wijk, & Cazemier, 2011). Providing sufficient public transport in rural areas is a challenge. Therefore, new solutions have to be investigated to meet the mobility needs of inhabitants of rural areas (Bouwknegt & de Winter, 2009). Traditional transport services with fixed schedules and large busses are suitable for large transport flows, but not for public transport in regions where flows are limited in size (Zijlstra et al., 2018).

In areas where classic forms of public transport are lacking or are too expensive, flexible and demand-driven transport can be the solution (Programma Toekomstbeeld OV, 2016). In their report, the partners of Programma Toekomstbeeld OV (2016) present a new vision for mobility in areas where the demand is low and classic forms of public transport are failing. In such areas, they want to offer flexible and demand driven systems. At the same time, they want to integrate cycling and bicycle infrastructure into the mobility chain (Programma Toekomstbeeld OV, 2016).

Different on-demand services are emerging. Individual and collective on-demand services exist. Examples of individual on-demand services are car-sharing, bike-sharing, car rental, taxis and companies that connect travellers to a driver via smartphone applications (such as Uber and Lyft). A collective form of flexible and on-demand transport is Demand Responsive Transport (DRT) (Alonso-González, van Oort, Cats, & Hoogendoorn, 2017b). DRT is a form of public transport that is demand oriented and where passengers share a vehicle that has flexible stops and/or a flexible timetable (Atasoy, Ikeda, Song, & Ben-Akiva, 2015). DRT is often used when it comes to providing public transport services in areas where the demand is low (Barrilero, Sauerländer-Biebl, Sohr, & Hesse, 2017).

In this research two of the above mentioned on-demand services are investigated as alternatives for existing rural bus lines: a DRT service and a multimodal alternative that combines an express bus service with bike-sharing services for last mile transport. Both alternatives have an on-demand character. DRT is a collective form and bike-sharing is an individual form of an on-demand service. DRT is chosen because, just like private cars, it can offer flexibility and convenience (Alonso-González, Liu, Cats, Van Oort, & Hoogendoorn, 2018). Also, this form of collective public transport is known for its ability to replace fixed public transport when demand is low or dispersed (Enoch, Potter, Parkhurst, & Smith, 2004).

The express bus service with bike-sharing services for last mile transport is chosen because the express bus service can decrease the number of bus lines and stops needed to make an area accessible while improving the in-vehicle time (van Nes, 2015). Shared bicycle systems are chosen for last mile transport because they can increase the egress distance of public transport stops (Krygsman, Dijst, & Arentze, 2004). Using a bicycle for the last mile increases flexibility and accessibility.

1.2 Stakeholders

Three parties are involved in public transport network design: the traveller, the operator and authorities. Whilst designing a transport network, several (opposing) objectives need to be balanced. The main controversy in public transport network design is the difference between the objectives of the traveller and the objectives of the operator.

Travellers judge transport services on the following three components: travel time, cost and comfort. Their main interest is the perceived door-to-door travel time, which consists of different weighted time elements: access time, waiting time, in-vehicle time, transfer time and egress time (van Nes, 2015).

The main interest of transport operators is profitability. Public transport operators have two types of clients: the traveller and the authorities. The revenues from the travellers are dependent on the fare they pay and the number of travellers. Travellers are sensitive to the quality of the services offered. The revenues from the authorities might be a fixed sum or a subsidy per traveller or kilometre travelled. Operators want to maximise the cost efficiency, maximise the profit and maximise the subsidies they receive from authorities (van Nes, 2015).

The authorities have different viewpoints than travellers and operators. They want to minimise the total cost and subsidies and maximise patronage and social welfare. Social welfare is the sum of consumer surplus and operator surplus. Surplus is the value gained by users and operators by offering a specific service. Authorities also have another role in public transport, they can set constraints, such as a maximum access distance or a minimum frequency (van Nes, 2015).

The objectives of the three involved parties are summarised in figure 1.1.

1.3 Research Questions

In this research the focus lies on the preferences of the traveller, the objective is finding the factors that influence the preferences of rural bus users for alternative modes. Two alternatives are proposed: a demand responsive transport system with flexible routes and schedules and a multimodal alternative that combines an express bus service with a bike-sharing service for last mile transport.

Based on the research problem presented in Section 1.1, the following research question is formulated:

"What are the preferences of bus users in rural areas of the Netherlands for a demand responsive transport service and a multimodal alternative that combines express bus and bike-sharing?"

The following sub-questions are introduced to help answer the main research question:

1. *Do attitudes towards flexibility and reliability influence the mode choice of bus travellers between rural bus, demand responsive transport services and a multimodal alternative that combines express bus and bike-sharing?*

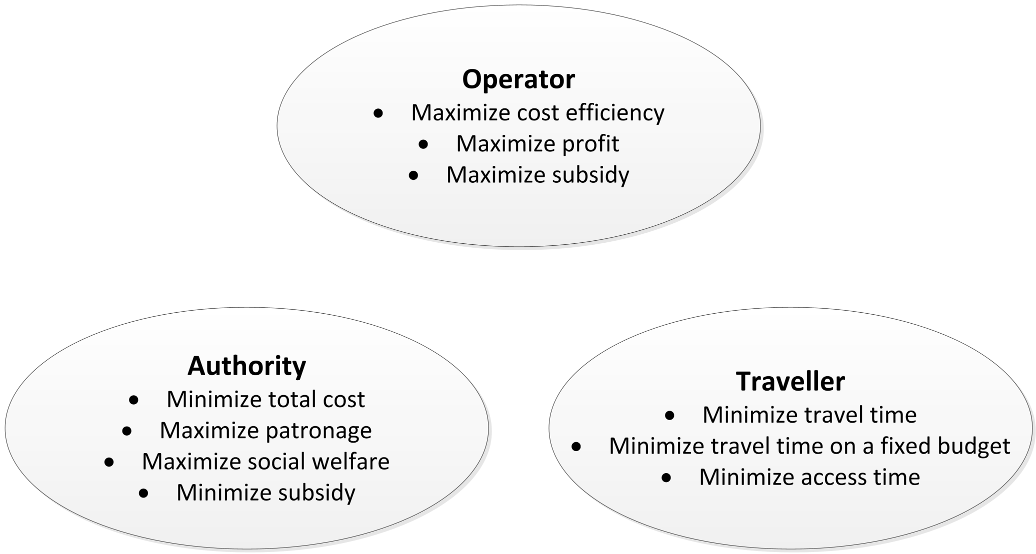


FIGURE 1.1: Objectives of stakeholders. Figure based on *Public Transport Network Design*, by R. van Nes, 2015.

2. *Do personal characteristics influence the mode choice of bus travellers between rural bus, demand responsive transport services and a multimodal alternative that combines express bus and bike-sharing?*
3. *Which mode attributes influence the mode choice of bus travellers between rural bus, demand responsive transport services and a multimodal alternative that combines express bus and bike-sharing?*
4. *What are the values of time for an express bus service with bike-sharing as last mile transport and a demand responsive transport services service?*
5. *Which changes in design characteristics can attract bus users towards demand responsive transport services and express bus services with bike-sharing as last mile transport?*

In Chapter 6 subquestion 1, 2, 3, and 4 are answered. Sub-question 5 is answered in Chapter 7.

1.4 Research Objective

The objective of this research is to find the preferences of rural bus users for a demand responsive transport service and a multimodal service that combines bus and bike-sharing as alternatives for regular bus services. This information is useful for transport operators and government agencies. When designing a public transport network in a rural area operators and authorities can take the preferences of rural bus users into account and decide if DRT services and/or bike-sharing services can be implemented.

1.5 Scientific and Practical Contribution

Studies exist that investigate DRT as a substitute for fixed lines, Barrilero et al. (2017) solve the Dial-a-Ride optimisation problem associated with DRT systems, others use stated choice experiments to make respondents choose between DRT and other modalities (e.g. Alonso-González, van Oort, Cats, & Hoogendoorn, 2017a; Frei, Hyland, & Mahmassani, 2017; Ryley, Stanley, Enoch, Zanni, & Quddus, 2014). However, to the author's knowledge, the preferences of travellers for DRT and/or bike-sharing services as replacements of fixed bus lines in rural areas have not been thoroughly researched. For scientific purposes, it is interesting to determine which attributes are important for rural passengers when choosing between DRT, express bus and shared bicycle and bus. For operators, it is useful to know where and how they can improve public transport by switching from fixed to flexible public transport systems and offering on-demand services such as bike-sharing and DRT.

1.6 Scope

In this thesis two modalities are considered as alternatives for fixed bus lines. Namely, DRT and express bus in combination with bike-sharing services. Public transport operators in the Netherlands are more and more implementing both modes. Several public transport operators have introduced bike-sharing systems (KeoBike, Arriva Nextbike) and/or demand responsive alternatives for bus lines (e.g. BrengFlex, BravoFlex, TwentsFlex). However, limited research has been conducted before implementing these systems.

The research focuses on rural areas in the Netherlands because in these regions public transport accessibility is poor and alternatives for the bus are needed.

1.7 Thesis Structure

This thesis can be divided into three parts: I Introduction and approach, II Data collection and analysis and III Results and conclusions. Part I consists of Chapters 1, 2 and 3. Chapter 1 introduces the research problem and research questions. Chapter 2 discusses the used research methodology. A literature study on the modes investigated and the current state of public transport in rural areas is presented in Chapter 3.

Part II includes Chapters 4, 5 and 6. In these chapters the survey is developed, data is gathered and analysed using discrete choice models.

The last part consists of Chapters 7, 8 and 9 where the developed choice model is applied to study modal splits, conclusions and recommendations are given and the presented work is discussed and reflected on.

The thesis structure is visualised in Figure 1.2.

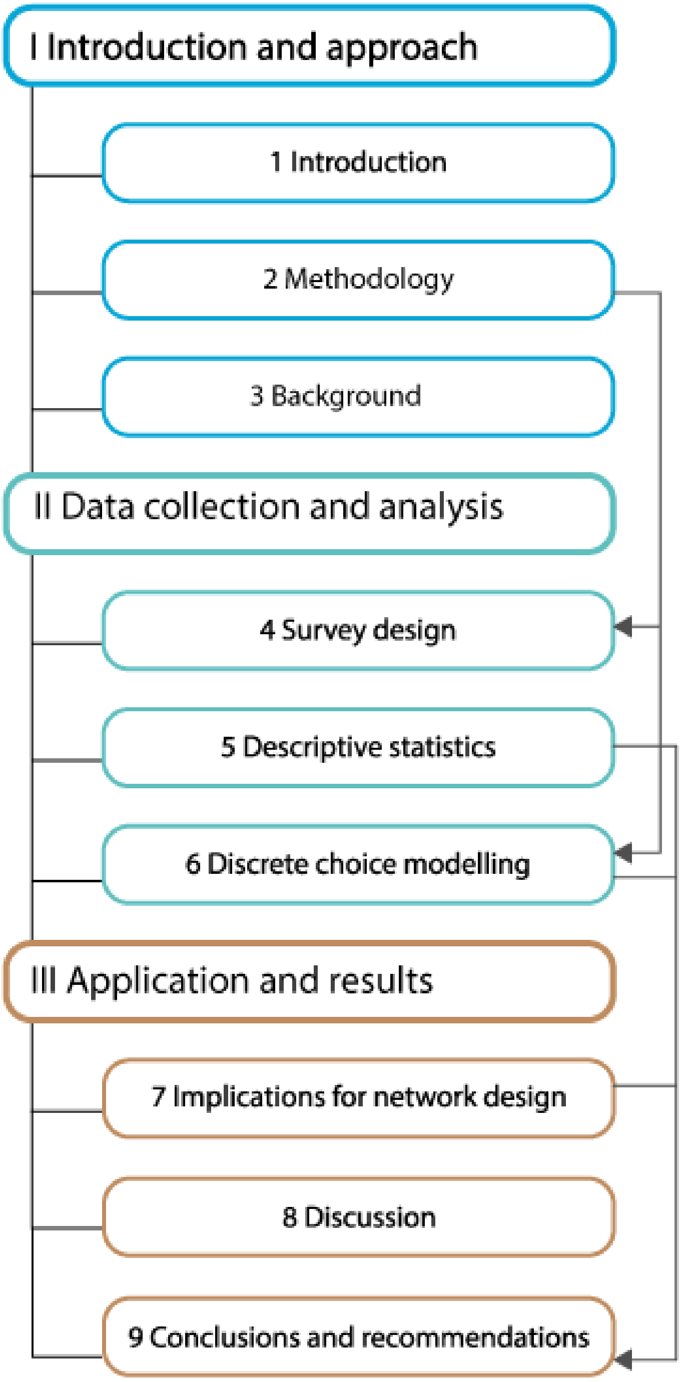


FIGURE 1.2: Thesis flowchart

2 Methodology

In this chapter, the methodology used to answer the research questions is proposed. First, the general approach of the research is given. Second, the data collection method is discussed. Third, the methods used to analyse the gathered data are explained.

2.1 Research Approach

As was stated in the previous chapter, the objective of this research is to find the preferences of rural bus users for alternative public transport. To gain insight into the preferences of rural bus users a survey is developed and conducted. Before developing the survey, information on the current state of public transport in rural areas, DRT and bike-sharing systems is gathered. The methods used to develop the survey and analyse the data gathered with the survey are explained in Section 2.2 and Section 2.3.

Instead of directly asking respondents if they are willing to use DRT or express bus with bike-sharing as last mile transport in case the bus service is cancelled, respondents are asked to choose between bus, DRT and express bus with bike-sharing as last mile transport. This approach prevents respondents from being afraid that their current bus service will be cancelled. Furthermore, this approach makes it possible to determine the preference for the alternatives relative to the preference for regular bus.

2.2 Stated Preference Surveys

Two types of data can be used in modelling travel demand: revealed preference and stated preference data. Traditionally, models to estimate travel demand were based on data obtained by travel behaviour observations or obtained from surveys on actual travel behaviour. So called revealed preference methods. Revealed Preference (RP) is suitable when forecasting demand in case market conditions do not change. However, a model based on RP data cannot predict market shares for new modes (Kroes & Sheldon, 1988).

Since this research is about introducing new modes to travellers in rural areas, RP data is not sufficient. Therefore, Stated Preference (SP) data is used in this research. Stated preference data is data that is collected on the preferences of respondents in hypothetical choice situations (Train, 2009). This gives the possibility to include hypothetical alternatives, including non-existing alternatives, new attributes and levels for attributes that are outside the current value range (Molin, 2017a).

A stated choice (SC) survey is a common used SP method and is also used in this research. In an SC survey, respondents must choose their favorite alternative from a group of alternatives. Each alternative has attributes with different values (de Dios Ortúzar & Willumsen, 2011). The design of the stated choice experiment will be discussed in Chapter 4.

The biggest drawback of stated choice experiments is that results can be affected by hypothetical bias (Molin, 2017a). This means that respondents might choose a different option in real life, than in the hypothetical setting of the experiment. Consequentiality can play a role if the respondent believes his answers will influence the decisions to be made as a result of the research (Herriges, Kling, Liu, & Tobias, 2010).

2.3 Discrete Choice Modelling

In this section, the concept of discrete choice modelling is explained. The general formulation is given and various model types are discussed.

2.3.1 General formulation

Discrete choice models are used to explain the choices of respondents between alternatives. Discrete choice models normally assume that the decision maker selects the alternative in a choice set that has the highest utility (Train, 2009). Utility captures the value that a decision maker attaches to an alternative (Ben-Akiva & Bierlaire, 1999). Models that are derived under this assumption are called Random Utility Models (RUM) (Train, 2009).

All alternatives, J, presented to the decision maker, n, have a certain level of utility. The utility that decision maker n obtains from alternative j is U_{nj}, $j = 1, ..., J$. The decision maker chooses the alternative with the highest total utility. Alternative i is only chosen if $U_{\mathrm{ni}} > U_{\mathrm{nj}}\ \forall j \neq i$ (Chorus, 2017; Train, 2009).

There are differences between the utility observed by the researcher and the utility obtained by the decision maker. The researcher observes the utility related to the observed factors, the so called systematic utility, V_{nj}. The systematic utility consists of everything that can be related to observed factors such as the attributes of the alternatives and characteristics of the decision maker (Chorus, 2017; Train, 2009).

Because the researcher does not observe all aspects of the decision maker's utility, $V_{\mathrm{nj}} \neq U_{\mathrm{nj}}$. The total utility is decomposed into the systematic utility and the error term, see Formula 2.1.

$$U_{\mathrm{nj}} = V_{\mathrm{nj}} + \epsilon_{\mathrm{nj}} \tag{2.1}$$

The error term, ϵ_{nj}, captures all unobserved factors and randomness in choices that are not included in V_{nj} (Chorus, 2017; Train, 2009).

The utility of an alternative can be expressed with Formula 2.2. The utility of an alternative is the weighted sum of the attributes:

$$V_{\mathrm{i}} = \sum_{m} \beta_{\mathrm{m}} \cdot x_{\mathrm{im}} \tag{2.2}$$

Where V_{i} is the systematic utility of an alternative i, β_{m} is the weight that needs to be estimated for attribute m and x_{im} the attribute value (Chorus, 2017).

2.3.2 Model types

Several models can be used to predict choices. The most frequently used models will be discussed in this subsection.

Multinomial logit model

The most used discrete choice model is the multinomial logit (MNL) model (Train, 2009). It is derived under the assumption that ϵ_{in} is independently and identically distributed (IID) for each alternative. Meaning that there are no correlations between error terms over alternatives and the error terms have the same variance for all alternatives. Assuming independence can be inappropriate in some situations (Train, 2009).

The MNL model also assumes that each choice is independent of the other choices. The MNL model holds the independence from irrelevant alternative (IIA) property (Train, 2009). This means that the preferences between any two alternatives are independent of the preference for another alternative in the choice set (Chorus, 2017).

The MNL model is expressed in Equation 2.3. The model parameters for all attributes of the alternatives are estimated with maximum likelihood estimation based on observed choices. Maximum likelihood estimation searches for parameter values in the population which have the greatest probability of having generated the observed sample (Ben-Akiva & Lerman, 1985).

$$P_n(i) = \frac{e^{V_{in}}}{\sum_{j \in C_n} e^{V_{jn}}} \tag{2.3}$$

Where $P_n(i)$ is the choice probability for individual n of alternative i, C_n is the choice set of j alternatives of individual n and e is the base number for a natural logarithm.

The simplicity of the MNL model may cause problems in any of the following cases (Chorus, 2017):

- When alternatives are not independent (nesting effects);
- When tastes differ between individuals or within groups of individuals (taste heterogeneity);
- When one individual answers multiple choice sets (panel effects).

Nested logit

A nested logit model is a good model to use if the some of alternatives shown to the respondent intuitively have something in common and can be grouped into so called nests. For the nested logit model the following properties hold as described by Train (2009):

1. The preferences between any two alternatives in the same nest are independent of preferences for all other alternatives. The IIA holds within each nest;
2. The preferences betwen two alternatives in different nests can depend on other alternatives in the two nests. The IIA does not hold for alternatives in different nests.

Nested logit can capture correlations between (unobserved) utilities of alternatives within the same nest. However, it cannot capture taste heterogeneity and panel effects (Chorus, 2017). The nested logit formula is presented in Equation 2.4 (Train, 2009).

$$P_n(i) = \frac{e^{\frac{V_{ni}}{\lambda_k}} (\sum_{j \in B_k} e^{\frac{V_{nj}}{\lambda_k}})^{\lambda_{k-1}}}{\sum_{l=1}^{K} (\sum_{j \in B_l} e^{\frac{V_{nj}}{\lambda_l}})^{\lambda_l}} \tag{2.4}$$

Where $P_n(i)$ is the choice probability for individual n of alternative i, which is in nest k. V_{ni} is the observed utility of alternative i. B_k is the set of alternatives in nest k. Parameter λ_k is a measure of the degree of independence in unobserved utility among the alternatives in nest k.

Mixed logit

The Mixed Logit (ML) model can overcome some of the limitations of the MNL model and NL model, by capturing taste heterogeneity and panel effects (Chorus, 2017; Train, 2009).

Taste variations between individuals can be captured by varying β across individuals for the attribute parameters or alternative specific constants (Chorus, 2017; Train, 2009).

Panel effects are described as the correlations between choices made by the same individual across time. Mixed logit can capture panel effects by taking the complete sequence of choices made by an individual as the unit of observation (Chorus, 2017).

The mixed logit model can account for correlations between error components by adding an additional error term that represents the utility of common unobserved factors (Chorus, 2017).

The probability of any mixed logit modal can be expressed with the function presented in Equation 2.5 adopted from Train (2009).

$$P_{ni} = \int L_{ni}(\beta) f(\beta) d\beta \tag{2.5}$$

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

$$L_{ni}(\beta) = \frac{e^{V_{ni}(\beta)}}{\sum_{j=1}^{J} e^{V_{nj}(\beta)}} \tag{2.6}$$

Where $f(\beta)$ is a density function. $V_{ni}(\beta)$ is the observed portion of utility. With a mixed logit model the logit function is evaluated at different β's with $f(\beta)$ as the mixing distribution (Train, 2009).

2.3.3 Goodness of fit

To measure how good a particular model fits the data, McFaddens' rho-square can be used. McFaddens' rho-square measures the performance of the model with the estimated parameters compared with a model with constants only (Chorus, 2017). McFaddens' rho-square can be calculated with Equation 2.7 (Hauser, 1978).

$$\rho^2 = 1 - \frac{LL(\beta)}{LL(0)} \tag{2.7}$$

Where:
ρ^2 = McFaddens' rho-square
$LL(\beta)$ = final log-likelihood
$LL(0)$ = null log-likelihood

When $\rho^2 = 0$, the model is not better than throwing a dice. If $\rho^2 = 1$ the model has a perfect fit (Chorus, 2017). To compare different models the adjusted rho-square ($\bar{\rho}^2$) can be used. The adjusted rho-square corrects for the number of parameters estimated (Bierlaire, 2016b; de Dios Ortúzar & Willumsen, 2011).

To compare the model fit across nested models the likelihood ratio test can be used. The likelihood ratio test is based on the likelihood ratio statistic (LRS). If the LRS is greater than the threshold associated with the significance level, the base model is rejected (Chorus, 2017).

$$LRS = -2 * (LL_A - LL_B) \tag{2.8}$$

2.4 Measuring Attitudes

Attitudes and perceptions cannot be observed directly, they are so called latent variables. However, they can be derived from other variables called indicators (Daly, Hess, Patruni, Potoglou, & Rohr, 2012). In this study, statements are used to measure respondents' attitudes towards reliability and flexibility. Exploratory factor analysis is used to see if a large number of indicators can be combined into a smaller group of uncorrelated latent variables.

Different approaches to include attitudes in discrete choice models are available. The most direct approach is using a choice model with indicators (see Figure 2.1a). In this approach, indicators, such as attitudinal statements, are directly included into the choice model. It is assumed that the indicators directly explain choice behaviour and are error-free, but this assumption is not correct. It is more correct to treat the indicators as functions of underlying attitudes. Disadvantages of directly including indicators are that strongly agreeing with with an attitudinal statement does not always has a causality with choice. Additionally, whith this approach the measurements errors of the latent variables are ignored. Furthermore, there are correlations between the error of the choice model and the indicators (Daly et al., 2012).

An improvement of the first method is to use exploratory factor analyses to combine the large number of indicators into a smaller group of latent variables (see Figure 2.1b) and then include the latent variable into the utility functions. The disadvantage of this approach is that the latent factors are derived from the attitudinal statements only and do not take the actual choices of the respondent into account (Daly et al., 2012).

The Integrated Choice and Latent Variable (ICLV) model (See Figure 2.1c) is a more realistic model because it describes how perceptions and attitudes affect choices, and also uses information on observed choices for the estimation of the latent attitudinal variables (Daly et al., 2012).

Because the ICLV model is very complex, this method is not used in this research. Instead, the latent variables that are derived with the factor analysis are included in the utility functions (See figure 2.1b).

The factor analysis is explained with more detail in Chapter 5.

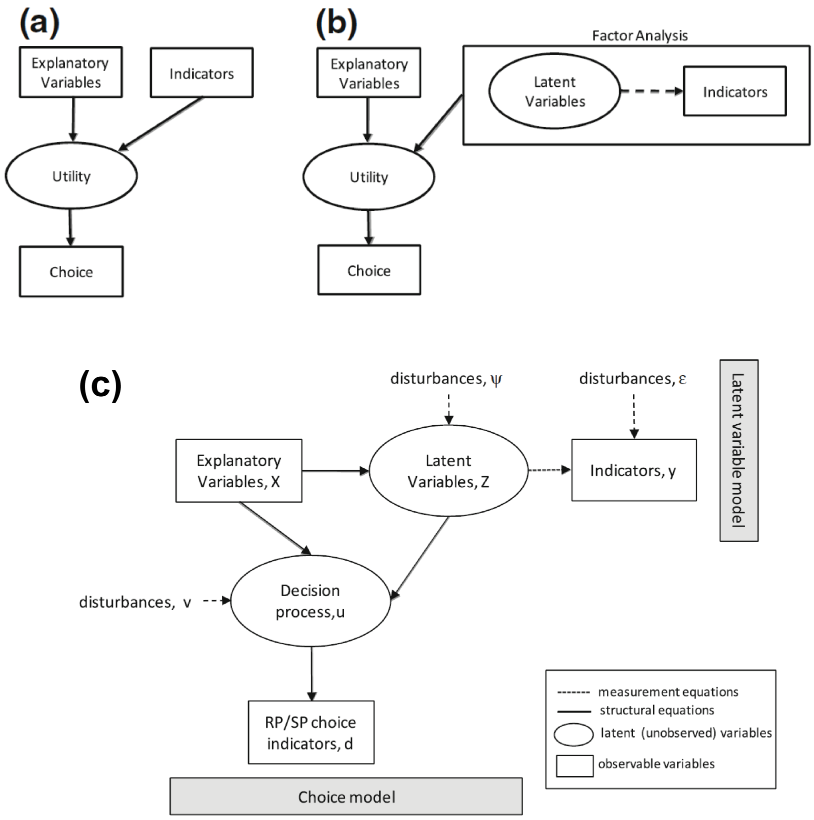


FIGURE 2.1: Incorporating latent variables in discrete choice models using: **a** direct indicators, **b** factor analysis, **c** the integrated latent variable and discrete choice-modelling framework (ICLV), adapted from "Using ordered attitudinal indicators in a latent variable choice model: a study of the impact of security on rail travel behaviour" by Daley et al., 2011, Transportation, 39(2), p. 269–270. Copyright 2011 by Springer Science+Business Media, LLC.

Conclusion

This chapter elaborates on the methodology used. It is decided to develop a survey that includes a choice experiment to gather data. Discrete choice modelling is used to analyse this data. Latent variables are included in the choice model to explore if attitudes towards reliability and flexibility influence choices made by respondents.

3 Background

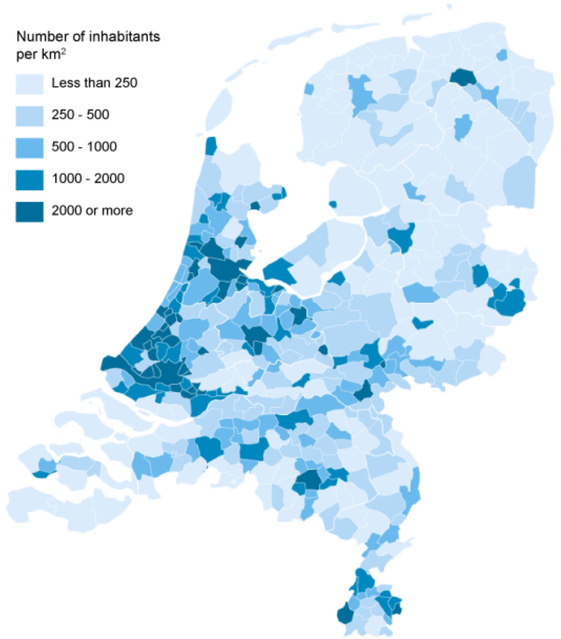
This chapter will provide background information. In section 3.1 public transport in low demand areas will be discussed. Next, in Section 3.2 the characteristics of bus users in the Netherlands are presented. Section 3.3 will discuss DRT in general and DRT in the Netherlands. The bicycle and public transport combination is discussed in Section 3.4. Section 3.5 provides information on bike-sharing systems.

3.1 Public Transport in Low Demand Areas

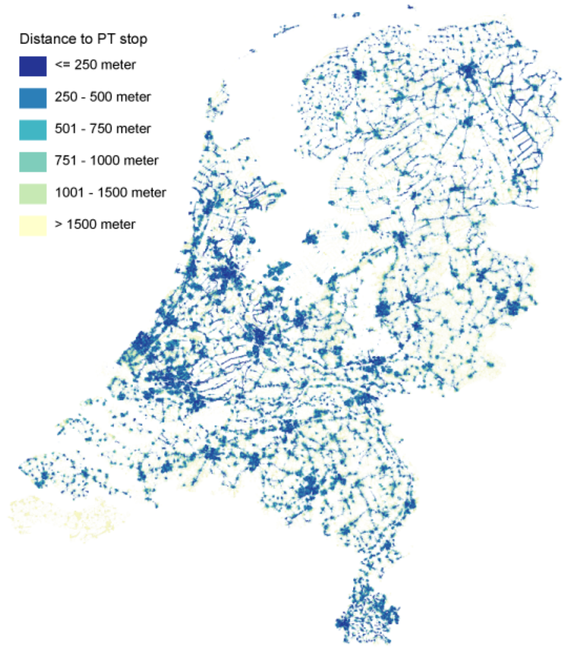
All over the world public transport systems in rural areas are having difficulties (Wang, Quddus, Enoch, Ryley, & Davison, 2015). In rural areas, the risk of low public transport access is greater than in urban areas. For operators, it is difficult to operate a transport service that is profitable, because of the dispersed and thin population and strong competition from the car in rural areas. People living in rural areas have travel demands that are time sensitive (access to jobs, access to healthcare), but not all travellers want to travel at the same time (Commission for Integrated Transport, 2008).

Also, different groups, such as the elderly, youngsters, families, working people and disabled people all have different needs. In these areas where total demand is low, resulting in a low service frequency, it is difficult to meet different accessibility needs of rural residents (Commission for Integrated Transport, 2008).

As can be seen in Figure 3.1a and Figure 3.1b, in regions in the Netherlands that have a low population density the distance to public transport stops is larger. This corresponds with the earlier statement that public transport availability is poorer in low density areas.



(A) Population density per municipality. Adapted from *Compendium for Leefomgeving* website, by CBS, 2016, retrieved from http://www.clo.nl/indicatoren/nl2102-bevolkingsgroei-nederland- Copyright 2016 by CBS



(B) Distance to nearest public transport stop. Adapted from *EduGIS* website, by EduGis, n.d., retrieved from http://kaart.edugis.nl Copyright by Edugis

FIGURE 3.1: Visualisation of population density and distance to public transport stop in the Netherlands

The CBS has a classification for the level of urbanity of an area. Five categories are distinguished: extremely urbanised: an average of 2500 or more addresses per km^2; strongly urbanised: an average of 1500 to 2500 addresses per km^2; moderately urbanised: an average of 1000 to 1500 addresses per km^2; hardly urbanised: an average of 500 to 1000 addresses per km^2; not urbanised: an average of fewer than 500 addresses per km^2 (Centraal Bureau voor de Statistiek, n.d.). This classification is used in the remainder of this report.

About 2.7 million individuals out of the 17.2 inhabitants of the Netherlands live in regions classified as not urbanised. Another 3.7 million individuals live in hardly urbanised regions (Centraal Bureau voor de Statistiek, 2018a).

3.2 Characteristics of Bus Users in the Netherlands

There are roughly 1 million unique (return trips and trips with multiple modes excluded) bus passengers per day in the Netherlands (Zijlstra et al., 2018). Bus *passengers* are described by Zijlstra et al. (2018) as a representative snapshot of the people who are in busses in the Netherlands. The average age of bus passengers is relatively low, less than 30 years (Zijlstra et al., 2018). Bus *users* are characterised as individuals that used the bus at least once in the past six months. The average age of bus users is 45 years. More women than men travel by bus, 57% of bus passengers are female (Zijlstra et al., 2018).

Most bus passengers travel in areas with a high population density. However, the length of bus trips is longer in rural than in urbanised areas (CROW, 2017).

The most common travel motives for bus trips in the Netherlands are education and commuting. Education is the travel motive for 33% of the bus trips and 24% of bus trips has the travel motive commuting (Zijlstra et al., 2018).

There are differences between bus users on the very thin lines of the network, the so called capillaries of the transport system, and bus users outside. Users on the very thin lines have a lower level of education and income. The share of users with a low education level is 17% outside of the capillaries and 24% within the very thin lines. Also, the employment rate of bus users in the very thin lines is lower (Zijlstra et al., 2018).

In this research alternatives for bus are investigated. Common alternatives for bus users are bicycle and car. Without the bus, 11% of the people would not be able to make the trip. This share is larger with bus users on very thin lines, within this group 21% would not be able to make the trip. Other forms of public transport are not often an alternative for bus users on the very thin lines of the network. This is probably because in rural areas, not many public transport options are available (Zijlstra et al., 2018).

3.3 DRT

Demand Responsive Transport (DRT) is a form of public transport in which a group of passengers share a vehicle that has flexible stops and flexible routes, the route and schedule of DRT is dependent on the demand of passengers (Barrilero et al., 2017). The first subsection provides more information on DRT services. The following subsection gives examples of DRT services in the Netherlands.

3.3.1 DRT in general

DRT is described by Wang et al. (2015) as follows: DRT is a service that is available for everyone and uses low capacity road vehicles which responds to variation in demand by changing its route and/or its timetable and that collects fares on a per passenger basis. DRT systems are a well known solution when it comes to providing public transport in areas where demand is low and traditional fixed services are not viable (Barrilero et al., 2017; Davison, Enoch, Ryley, Quddus, & Wang, 2014).

In the past, DRT services were characterised as dial-a-ride door-to-door services that could only be used by a restricted group, mainly individuals with disabilities and elderly. Users had to book their trip by telephone and the operator would plan the service manually. This form of DRT was often criticised because of the high costs and inflexibility in route planning (Nelson, Wright, Masson, Ambrosino, & Naniopoulos, 2010). The development of ICT has enabled more innovative solutions, for example how and when a trip is booked and which route the vehicle takes (Brake, Mulley, Nelson, & Wright, 2007).

Different forms of DRT exist, in their paper Alonso-González et al. (2018) mention five aspects of DRT systems: coverage and routing, operating hours, vehicle characteristics, booking system and request acceptance criteria.

The coverage and routing of a DRT system can differ in terms of route-flexibility and stopping points. Stopping points can be fixed intermediate stopping points (existing public transport stops), end stopping points (terminals), predefined stopping points (recognised meeting places) and non-predefined stops (passengers doorstep) (Mageean & Nelson, 2003).

DRT systems can have fixed routes, semi-fixed routes, flexible and virtual flexible routes. When fixed routes are applied, the vehicle does not deviate from the predefined route. With semi-fixed routes, the vehicle can both stop at predefined and non-predefined stopping points. In a flexible route, there is a begin and end point and all stops in between are non-predefined. In case the DRT service operates based on virtual flexible routes, there is a depot from where the vehicle departs, it has no end stop points or fixed stop point but operates as a door-to-door service (Mageean & Nelson, 2003).

Other terms related to DRT are flexible transport services (FTS), para-transit and microtransit. FTS is an umbrella term for all services that transport people without a fixed route and/or schedule to accommodate door-to-door service (Mulley & Nelson, 2009). Microtransit is a form of DRT that is privately operated (Shaheen & Cohen, 2018). Paratransit is a form of DRT, but available to pre-qualified user bases, such as people with disabilities and the elderly (Federal Transport Administration, 2017).

DRT services have clear social benefits, they can offer mobility in areas where public transport accessibility is low. However, the disadvantage of DRT systems is that it is difficult to make them economically viable (Ryley et al., 2014).

3.3.2 DRT in the Netherlands

In the Netherlands there are multiple forms of DRT run by public transport operators. In this subsection the following forms will be explained: RegioTaxi, Belbus, Breng flex, Bravoflex, AML flex, Twentsflex and Buurtbus. These examples all have different levels of flexibility and different target groups.

RegioTaxi

RegioTaxi is a form of public transport where a taxi collects passengers at their front door and takes them to their final destination. Sometimes rides are shared with other passengers. The RegioTaxi is accessible for everyone, but its focus is on passengers with decreased mobility. Reservations can be made at least 1 hour in advance (RegioTaxi Haaglanden, 2017).

Belbus

This type of bus operates according to a fixed schedule and a fixed route. The belbus only runs when a reservation is made at least an hour in advance. Reservations can only be made by phone (Arriva, n.d.-a). The belbus operates on lines with low ridership (at certain times of the day). By obligating passengers to make a reservation it prevents the operation of empty buses. Usually, the service is operated with small taxibuses (Bouwknegt & de Winter, 2009). An example of the belbus is the service "Kolibrie" that is offered by public transport operator Keolis (Keolis Nederland, n.d.).

Breng flex

Breng flex is demand driven public transport that operates in the Arnhem-Nijmegen region and is operated by public transport operator Breng (a brand name of Connexxion). Breng flex does not have a fixed schedule and route. It uses cars and buses to transport passengers between any combination of public transport stops in the region. Reservations can be made by using an application for mobile phones or via the phone (Breng, 2017).

The Breng flex service has been monitored and evaluated. The results from the evaluation show that travellers are very satisfied with the service. The short waiting times and the fact that no transfers are needed are highly valued. 15 % of the passengers stated that they are willing to replace car with the Breng flex service. Another advantage of the service is that compared with traditional bus services in the region Arnhem-Nijmegen, Breng flex has less emissions per passenger kilometre (Haansta, van der Pool, & van Weert, 2017).

Bravoflex

Bravoflex offers the same service as Breng flex. Bravoflex operates in the city of Helmond, Noord-Brabant and is operated by public transport operator Hermes (a brand name of Connexxion) (Bravo, n.d.).

AML flex

AML flex offers the same service as Breng flex. It is a service of public transport operator connexxion. AML flex operates in the concession area Amstelland Meerlanden (Connexxion, 2018).

TwentsFlex

Twentsflex offers the same service as Breng flex. It is operated in the municipality Rijssen-Holten by Twents, a brandname of public transport operator Keolis Nederland (Keolis Nederland, 2017).

Mokumflex

Mokumflex is similar to Breng flex and is offered by transport operator GVB for trips going to and from Driemond and in the region Landelijk Noord. To use the service a reservation needs to be made at least an hour in advance. when making the reservation the desired pick up time, departure bus stop and arrival bus stop needs to be specified. Reservations can be made via the website, mobile phone application or by phone. Mokumflex does not have a fixed schedule and route (RMC B.V., 2018).

Buurtbus

The buurtbus can replace a fixed bus line in areas with a low population density. It has fixed schedules and stops. It is an initiative supported by volunteers and a volunteer also drives the buurtbus. The buurtbus connects to traditional public transport such as regional buses and train stations in at least one location (Bouwknegt & de Winter, 2009). This is not a form of demand responsive transit, but it is a replacement for regular public transport.

3.4 Bicycle and Public Transport

In recent years, research has been conducted on the combination of bicycle and public transport. Because bicycle offers accessibility and public transport offers speed, together they can compete with automobiles (Shelat, Huisman, & van Oort, 2018).

Mobility related problems that occur in cities all over the world are traffic congestion and air pollution. Governments want to increase the modal share of active modes, such as walking and cycling, and of public transport to combat these mobility related problems. However, individually these modes are unable to compete with cars due to the low spatial reach and high effort of active modes and the fact that transit modes do not provide door-to-door accessibility (Shelat et al., 2018). The bicycle can overcome the first and last mile problem that transit alone faces because bicycle as an access or egress mode increases the catchment area of transit stations. On the other hand, longer distances can be covered by transit than by bicycle alone. It is proven that the combination of bicycle and transit is powerful (Brand, Hoogendoorn, van Oort, & Schalkwijk, 2017).

On the access side of public transport, bicycle is an important modality, whereas on the egress side bicycle is used less frequently. The fact that on the egress side bicycles are often not available can explain this. To increase the share of the bicycle on the egress side, bicycle-sharing and bicycle-renting systems can be provided (Brand et al., 2017).

Krygsman et al. (2004) found that the median access distance of cycling is 1.8 km while the median access distance of walking is 550 m and the median egress distances are 2.4 kilometres and 600 meters (respectively). Shelat et al. (2018) stated that transit users are willing to travel further towards train station than towards bus, tram and metro stations: 3.8 versus 1.5 kilometres, respectively. The same applies to egress distances: 2.7 versus 0.7 kilometres, respectively. Brand et al. (2017) concluded that the access and egress distances to high quality transit stops are twice as large as those to regular transit. To increase the share of the bicycle on the access side to bus networks parking facilities at bus stops can be provided (Brand et al., 2017).

Van Mil, Leferink, Annema, and van Oort (2018) performed a literature review on the bicycle-transit combination. They found nearly forty factors that influence bicycle-transit demand and divided them into three groups: transit related, first/last-mile and context. Six transit related factors that were found to have a positive influence on the demand for bicycle-transit (Van Mil et al., 2018) are listed in Table 3.1.

TABLE 3.1: Transit related factors influencing bicycle-transit demand

Transit related factors **Positive influence**
Significant total trip length (min. 10-15km)
Station at small or medium-sized city centre, out of town or urban areas with parking
Urbanised areas
Direct routes
High transit service levels

Twelve first/last-mile factors that influence bicycle demand positively were found and eight first/last-mile factors that influence bicycle demand negatively were found. They are listed in Table 3.2 (Van Mil et al., 2018).

TABLE 3.2: First/last-mile factors influencing bicycle-transit demand

First/last-mile factors	
Positive influence	**Negative influence**
Many hours of daylight	Hilly
Good quality of cycling lanes	Low temperature
High quantity of cycling lanes	Rainy weather
Often right of way	Lack of safety
Large number of other cyclists	Good bus, tram and metro network
Directness of cycling route	Available and affordable car parking (at station)
High bicycle ownership	High car ownership
Good bicycle storage facilities	Inexpensive bus, tram and metro

The last category described by (Van Mil et al., 2018) are the context factors. An overview of the context factors is given in Table 3.3.

TABLE 3.3: Context factors influencing bicycle-transit demand

Transit related factors	
Positive influence	**Negative influence**
Positive attitude towards cycling	Car as a status symbol
Positive attitude towards rail	Travel with heavy luggage
Low perception of barriers	Wearing smart clothes
High number of commuters	
High number of students	
Full-time employment	
Share of mid/higher income	
Economic growth	
High number of frequent rail travellers	
High share of males	
Higher level of education	

Most of the factors described by Van Mil et al. (2018) are related to bicycle-rail transport and less relevant for the bicycle-bus combination in rural areas.

The bicycle has many benefits: physical activity helps prevent health problems, cycling does not produce emissions and not dependent on finite natural resources, and it provides mobility at a low cost. However, the bicycle is not capable of fulfilling all travel activities of travellers.

The combination of public transport and bicycle can overcome the disadvantages of the individual modes. The bicycle can overcome the last mile problem of transit and longer distances can be covered by public transport than by bike.

3.5 Bike-sharing Systems

Bike-sharing is becoming more popular, several bike-sharing programs operate in the Netherlands. A bike-sharing program gives the user the opportunity to use a bike from a shared fleet on a short term basis for a price or for free (Shaheen, Guzman, & Zhang, 2010).

Five generations of bike-sharing systems can be distinguished: (1) free bicycle systems (or white bicycles), (2) coin-deposit systems, (3) systems with smart stations and real time information, (4) smart bicycles and (5) flexible systems (Cannegieter, Huysmans, & van Boggelen, 2018; Shaheen et al., 2010).

First generation bike-sharing systems have only one component: bicycles. The bicycles have a distinct colour and are left unlocked somewhere in the city (Shaheen et al., 2010). One of the initiatives with free bicycles was the "white bicycle plan" in Amsterdam in the ’60s, a number of white bicycles was scattered throughout the city for free use for everyone (Cannegieter et al., 2018).

In the ’70s bike-sharing systems were introduced that could be used by means of coin access (Cannegieter et al., 2018). Second generation systems have three components: distinguishable bicycles, docking stations and small deposits to unlock the bicycles. To operate a bicycle, users make a small deposit to unlock the bicycle. Both first and second generation systems had problems with bicycle theft because of anonymity.

Around the year 2000 systems with smart stations were introduced (Cannegieter et al., 2018). Third generation systems use smart technology for bicycle check-in and check-out. Also, theft deterrents are used. Users pay for a membership of a bike-sharing service, members have to provide ID, bankcard, or mobile phone number to identify themselves (Shaheen et al., 2010).

The fourth generation bike-sharing systems were introduced around 2010. Here a transition from smart station to smart bicycle is visible. Smart technologies are integrated into the bicycles and no longer in the stations. This ensures that the bike-sharing system can be developed much more flexible. The registration and access to bicycles is also shifting from terminal to smartphones (Cannegieter et al., 2018).

The present generation bike-sharing systems is characterised by free-floating systems with electronic locks that can be opened via a smartphone application. Changes with previous generations are: (1) added flexibility through electronic locks, (2) disappearance of shared-bike stations, (3) new forms such as free-floating bicycles, (4) more focus on extra income from data gathered with the bicycles and (5) links with other providers, other cities and Mobility as a Service-solutions.

One of the first bike-sharing systems in the Netherlands was the "OV-fiets". In 2003 OV-fiets was established in the Netherlands as an independent foundation. Since 2009 the Nederlandse Spoorwegen is the owner of OV-fiets (Redactie kennisplatform CROW, 2016).

In recent years, more and more bike-sharing systems have been introduced in the Netherlands. There are two forms of bike-sharing systems: station based and free floating. Station based bicycles have to be brought back to a fixed location and free floating bicycles can be parked anywhere (Duursma, 2017).

There are a lot of bike-sharing systems that operate in the Netherlands, for example: BimBimBikes, Cykl, Mobike, Gobike (electric bicycle with navigation), Donkey Republic, Hello-bike, Nextbike and KeoBike (Duursma, 2017; Slütter, 2018b). Nextbike is an initiative of public transport operator Arriva and KeoBike is owned by public transport operator Keolis (Arriva, n.d.-b; Keolis Nederland, 2016).

The high bicycle ownership in the Netherlands is often mentioned as a problem for implementing bike-sharing systems in the Netherlands. However, in places where an own bicycle is not available, shared-bicycles can offer a solution (Broer, 2016). A problem with shared-bicycle systems, in general, is the redistribution of the bicycles. Bicycles that are parked at unpopular locations need to be relocated to locations where they will be used, this requires a lot of time, money and resources (Broer, 2016; Slütter, 2018a).

Summary

This chapter provided some additional information on public transport in rural areas and the characteristics of Dutch bus users. The modes that are proposed as alternatives for bus in this thesis are also discussed. The main advantage of DRT services is that they can offer accessibility in low demand areas, a disadvantage of DRT services is that it is difficult to make these services cost efficient. The advantage of bike-sharing systems is that they can offer a solution to the last mile problem of public transport. A disadvantage is that the is difficult for providers to cover the operational costs of bike-sharing systems, especially the redistribution of bicycles requires a lot of time, money and resources.

Part II

Data Collection and Analysis

4 Survey Design

Whilst creating the stated choice experiment the following steps, based on ChoiceMetrics (2018), are taken: (1) model specification, (2) generation of the experimental design, and (3) construction of the questionnaire. First, the complete model has to be specified with all parameters to be estimated. Based on the model specification an experimental design type has to be chosen and then the experimental design can be generated. The last step is to use the experimental design to create the choice sets in the questionnaire.

4.1 Experimental Conditions

Before the model specification, the context of the experiment and the choice situation have to be specified. The goal of the experiment is to get insight into the preferences of rural bus users for alternatives for bus. Two alternatives are presented: a form of demand responsive transport and a multimodal mode that combines an express bus service with a shared bicycle trip for the last part of the trip. The respondents targeted for this survey are bus users in rural areas where options for public transportation are limited. The following context was presented to the respondents:

"Assume you are making a trip. You are making a trip with the travel motive <here the most common travel motive of the respondent is inserted>. The temperature is around 16 degrees Celsius and there is no rainfall. You are not carrying luggage. The starting point of the trip is your home and the endpoint your destination."

4.2 Model Specification

In this section, the complete model is specified with all corresponding alternatives, attributes and attribute levels.

4.2.1 Alternatives

A choice situation in an SP survey presents the respondents with a fixed number of alternatives to choose from, each being described by a number of attributes having a certain value (attribute level) (Hess & Rose, 2009).

The choice experiment developed in this study has three alternatives: (1) a demand responsive transport service, (2) a multimodal alternative that combines an express bus service with shared bicycles and, (3) regular bus. The multimodal alternative is called "Combi" and the DRT alternative is called "Flexi".

The alternatives are explained to the respondents as follows:

- Combi: The Combi trip consists of three parts: walking to the bus stop, travelling with an express bus and using a shared bicycle for the egress part of the trip. The express bus has a higher speed than the regular bus and stops less frequent. Shared bicycles can be used by everyone, reservation is not possible and the possibility exists that no bicycle is available at the desired place and time. Shared bicycles are available at bus stops and can be parked at any destination. A bicycle can be rented via a smartphone application;

- Flexi: The Flexi trip consists of three parts: walking to the bus stop, in-vehicle travel time and walking to the final destination. Flexi is an on demand transport service that operates with small buses between any combination of bus stops. A seat in a Flexi vehicle can be reserved via a smartphone application. During the trip the vehicle can stop or make a detour to pick-up or drop-off passengers. Flexi has no fixed schedule and actual travel times and departure times can differ from the scheduled times;

- Bus: this alternative is similar to existing bus services in rural areas.

The experiment is labelled if the name of the alternative represents a characteristics that is not included in the experiment (Molin, 2017b). This has an impact on the number of parameters that have to be estimated (Rose & Bliemer, 2009). Generally, for unlabelled experiments (the names of the alternatives have no meaning (Molin, 2017b)) only generic parameters are estimated, whereas for labelled experiments also alternative specific parameters can be estimated (Rose & Bliemer, 2009).

The goal of this thesis is to find the preferences for the alternatives Combi and Flexi relative to the preference for bus. Bus is included as one of the options to choose from. It represents the current state of bus services in rural areas and is used as a status quo alternative. The bus alternative has fixed attribute values that are based on the characteristics of an average bus trip in a rural area.

Using a reference alternative or status quo alternative can make the choice set more realistic for the respondent (ChoiceMetrics, 2018). Nevertheless, in many experiments that involve status quo alternatives problems with inertia or non-trading between alternatives occur (Hess & Rose, 2009). This non-trading could lead to less accurate model parameters, because the parameters are estimated on choice data that included a great amount of non-trading behaviour (Chintakayala, Hess, & Rose, 2009).

More information can be obtained if respondents are asked to rank the alternatives. In other words, fewer respondents are needed to obtain more information. However, in practice choices of a lower rank are less reliable than first choices (Fok, Paap, & Van Dijk, 2012). In the survey respondents are asked to state their first choice, next they are asked to state their second choice out of the two remaining alternatives. This way, ranking data can be gathered without using a ranking type response mechanism.

The ranking data will be used if the analysis shows that: (1) inertia takes place in the choice selection and (2) the analysis suggests that the second choices are reliable. Otherwise, only the first choices are used for model estimation.

4.2.2 Attributes and attribute levels

Previous stated preference experiments used DRT as one of the alternatives for respondents to choose from. Attributes often used are walking time to stop, in-vehicle travel time, cost and waiting time (specified as the difference between the scheduled and actual starting time) (Alonso-González et al., 2017a; Frei et al., 2017; Ryley et al., 2014).

Because of the on-demand nature of DRT, other attributes than those that are used for fixed public transport services have to be taken into account. New attributes are related to the reliability and flexibility of DRT, due to their lack of fixed schedules and the booking interval (Alonso-González et al., 2017a). All of the above mentioned studies include the deviation from the expected waiting time as an attribute. Alonso-González et al. (2017a) also include the minimum booking time and the probability of the ride being offered at the requested time as attributes of DRT.

Another new aspect that has to be taken into account for both DRT and bike-sharing systems is the availability attribute, there is no guarantee that the vehicle is available at the desired place and time. More research in the area of flexibility and reliability is needed, and this study tries to gain a better understanding of these characteristics.

The following attributes are included in the experiment: access time, travel time, cost, minimum booking time (Flexi), headway (bus), bicycle availability (Combi), departure delay (Flexi) and travel time deviation (Flexi). Table 4.1 provides an overview of the attributes used per alternative. Most of the attribute levels are based on literature or existing services.

The alternatives Flexi and Combi come with a certain amount of uncertainty. For example, Flexi has no fixed timetable and there is no guarantee that a passenger can make a trip at the preferred departure time and place. Also, when using a shared bicycle for the last part of the trip, the traveller does not know if there is a bicycle available in advance. Flexibility and reliability are incorporated into the experiment by adding the attributes minimum booking time for Flexi, bicycle availability for Combi, departure delay for Flexi and travel time deviation for Flexi. The minimum booking time is the minutes in advance an individual has to book Flexi before the desired departure time. The bicycle availability represents the number of bicycles available at the arrival bus stop at the starting time of the trip. The departure delay represents the maximum delay in the departure time of the trip with Flexi, the departure delay can be any value between 0 and the maximum minutes of departure delay. The travel time deviation is the maximum number of extra travel time minutes caused by for example making a detour to pick up an additional passenger.

TABLE 4.1: Attributes used in the choice experiment

Attribute	Combi	Flexi	Bus
Access time	X	X	X
Travel time bus	X		X
Travel time DRT		X	
Travel time shared bicycle	X		
Cost	X	X	X
Minimum booking time		X	
Headway	X		X
Bicycle availability	X		
Departure delay		X	
Travel time deviation		X	

The proposed experiment has alternative specific attributes, with three levels for all attributes. Having three levels instead of two makes it possible to test for linearity. An experimental design is used to determine which attribute levels are combined in the choice tasks (Molin, 2017a). The attribute levels used are visible in Table 4.2.

TABLE 4.2: Attribute levels used in the choice experiment

Attribute	Attribute levels		
Access time Combi	2	6	10
Access time Flexi	2	4	6
Access time bus		4	
Travel time express bus Combi	22	27	32
Travel time shared bicycle Combi	2	7	12
Travel time Flexi	24	32	40
Travel time bus		37	
Cost Combi	€1.50	€3.50	€5.50
Cost Flexi	€1.50	€3.50	€5.50
Cost bus		€3.00	
Headway Combi	10	35	60
Headway bus		60	
Minimum booking time Flexi	10	35	60
Bicycle availability Combi	1	6	11
Departure delay Flexi	3	9	15
Travel time deviation Flexi	2	6	10

Levels for access times are varied around access times of existing DRT, express bus and bus services. The existing DRT service TwentsFlex has a stop every 400 meter (Keolis Nederland, 2017). A quick calculation is made assuming a walking speed of 5 km/h and an average distance to the nearest stop of 200 meters to find the average access time of approximately 2,5 minutes. It is assumed that travellers in rural areas are used to longer access time, so the attribute levels of access time for Flexi are set to 2, 4 and 6 minutes. The catchment area for bus for pedestrians is approximately 500 meters, for the express bus this is 800 meters (van der Blij, Veger, Amsterdam, & Slebos, 2010). The corresponding access times are 6 and 10 minutes, these are the maximum access times tolerated by travellers. The attributes levels for access time of express bus are set to 2, 6 and 10 minutes. And the access time of bus is fixed to 4 minutes.

Travel times are based on the average speeds of the modes. The average speeds are 25, 20 and 35 for DRT, bus and express bus services (Ryley et al., 2014; van Nes, 2015). The trip length was fixed on 13 kilometres, corresponding with the average bus trip length in the Netherlands (Centraal Bureau voor de Statistiek, 2018b). The travel time for cycling is based on a cycling distance of 1 to 3 kilometres with an average speed of 14 km/hour, roughly based on Dutch cycling statistics (Harms & Kansen, 2018). The attribute levels for travel time with the express bus are 22, 27 and 32 minutes. For the shared bicycle travel time the values 2, 7 and 12 minutes are chosen. Flexi travel time is set to 24, 32 and 40 minutes. The bus travel time is fixed to 37 minutes.

The cost of Flexi varies around the cost of existing DRT services (Bravo, n.d.; Breng, 2017; Keolis Nederland, 2017) and set at €1.50, €3.50 and €5.50. The cost of Combi are equal to the cost of Flexi. The cost of bus is based on the public transport rate of Syntus Overijssel of €0.90 + €0.164 $*$ km $\approx$ €3.00 (Keolis Nederland, 2018).

The minimum booking time of Flexi is based on the minimum booking time of Breng flex, TwentsFlex en Bravoflex (Bravo, n.d.; Breng, 2017; Keolis Nederland, 2017). To keep an equidistance between the attribute levels they are set on 10, 35 and 60 minutes.

The attribute levels for headway of express bus are equal to the minimum booking time of Flexi. The headway of bus is set to 60 minutes, representing the low frequency of rural bus services.

The bicycle availability is based on the number of shared bicycles available at small train stations. The levels are 1, 6 and 12 available bicycles.

The attribute values for departure delay and ride time deviation are determined by the researcher. The values chosen for departure delay are 3, 9 and 15 minutes. The values chosen for ride time deviation are 2, 6 and 10 minutes.

The value of travel time savings (VoTTS) for all combinations of travel time and cost is calculated. The calculated VoTTS need to be realistic, therefore they vary around the VoTTS for public transport in the Netherlands (€7.42 per person per hour on average) (Kennisinstituut voor Mobiliteitsbeleid, 2017). The ranges of VoTTS used in the experiment are presented in Table 4.3.

TABLE 4.3: Values of time in the choice experiment

	Combi	**Flexi**
Min. VoT	€2.05	€2.25
Max. VoT	€13.75	€13.75
Avg. VoT	€6.85	€6.37

4.3 Generation of Experimental Design

As stated earlier the second step in the design of a choice experiment is the generation of the experimental design. Many experimental designs could be used (Rose & Bliemer, 2009). How to select the best experimental design depends upon different considerations, the following decisions have to be made:

- Should the design be labelled or unlabelled?;
- Should the design be attribute level balanced?;
- How many attribute levels are used?;
- What are the attribute level ranges?;
- What type of design to be used?;
- How many choice situations to use? (ChoiceMetrics, 2018).

As stated before, the alternatives are labelled and have alternative-specific parameters. The experimental design will be attribute level balanced, this ensures that each attribute level occurs just as often and the parameters can be estimated correctly for all levels (ChoiceMetrics, 2018). If non-linear effects are expected, more than two attribute levels are needed to test for non-linearity (Rose & Bliemer, 2009).

Using more levels or more attributes will result in a higher number of choice tasks. Also, using different levels in the same experiment results in a higher number of choice situations (Rose & Bliemer, 2009).

It is decided to include three levels because with three levels it is possible to test for non-linearity and more than three levels will result in a higher number of choice tasks.

The attribute ranges are set relatively wide because in theory wider ranges will lead to parameter estimates with smaller standard errors. While keeping attribute ranges wide enough to estimate good parameters, it is even more important to choose the attribute values in such a way that they are credible for the respondents (Rose & Bliemer, 2009).

A number of different design types are considered. The full factorial design is not used because it includes all different choice situations possible and thus results in very large designs. Instead, a selection of the full factorial design is used, the so called fractional factorial designs. Within the fractional factorial designs, many different types of design exist (Rose & Bliemer, 2009).

Orthogonal fractional factorial designs are often used in practice because they are easy to generate and because they have been used often in the recent past (Rose & Bliemer, 2009). A design is orthogonal if all attribute levels occur an equal number of times and there are no correlations between the attributes in the design (ChoiceMetrics, 2018; Molin, 2017a).

A more recent approach is the use of efficient designs. Efficient designs aim to minimise the standard error of the parameter estimates (Rose & Bliemer, 2009) and are able to outperform orthogonal designs (ChoiceMetrics, 2018). However, efficient designs rely on the use of accurate priors (ChoiceMetrics, 2018). If priors are uncertain using an efficient design can give problems (Walker, Wang, Thorhauge, & Ben-Akiva, 2017). Because no priors are available for this study, an orthogonal fractional factorial design is used.

The number of choice sets depends on the chosen design, in general orthogonal designs result in a larger number of choice sets than efficient designs (Rose & Bliemer, 2009). For this particular experiment, an orthogonal fractional factorial design results in 27 choice sets. This amount is too big for one respondent, therefore blocking is be used. This means that the design is blocked into smaller parts, that each have attribute level balance (ChoiceMetrics, 2018). The experimental design is divided into three blocks, every respondent is presented with 9 choice sets.

The software package Ngene is used to construct the experimental design. The Ngene syntax and the experimental design can be found in Appendix A.

4.4 Construction of the Questionnaire

From the experimental design, the stated choice part of the questionnaire can be constructed. Every row in the experimental design is converted into a choice situation. An example of a choice situation is given in Figure 4.1. First, respondents are asked to select their first choice. Next, they are asked to select their second choice from the remaining alternatives. In addition to the data related to the respondents' preferences, socio-demographic and attitudinal data is collected.

Kenmerken	Snelbus + deelfiets	Flexi	Bus
Totale geplande reistijd	39 min.	32 min.	45 min.
Waarvan:			
- Naar halte	10 min. lopen	4 min. lopen	4 min. lopen
- In voertuig	22 min.	24 min.	37 min.
- Naar bestemming	7 min. fietsen	4 min. lopen	4 min. lopen
Frequentie	Elke 60 min.		Elke 60 min.
Minimum boekingstijd	--	10 min.	--
Aantal fietsen beschikbaar	6	--	--
Vertrek t.o.v. van afgesproken vertrek tijd	--	0 tot 15 min. later	--
Reistijd t.o.v. van geplande reistijd	--	0 tot 6 min. langer	--
Reiskosten	€1,50	€5,50	€3,00

FIGURE 4.1: Example of a choice set presented to respondents

4.4.1 Socio-demographic data

Socio-demographic data provides information about the respondent. Respondents were asked about driving licence possession, smartphone possession, vehicle ownership, travel behaviour, gender, age, occupation, education, residence and income. Some of these questions are personal, therefore this data is collected after the stated choice experiment to prevent respondents leaving the survey before finishing the choice experiment. Appendix B contains the whole survey.

4.4.2 Statements

Reliability is an important aspect of DRT and bike-sharing systems. Although DRT and shared bicycles offer flexibility, these on-demand modes are accompanied by uncertainty. The traveller does not know in advance if a vehicle is available at the desired place and time.

Statements are used to measure the attitudes of respondents towards reliability. Respondents rated 6 attitudinal statements on a 5-point Likert scale (1=strongly disagree, 2=mildly disagree, 3=neutral, 4= mildly agree, 5=strongly agree). An odd number of options is used to give respondents the possibility to select a neutral answer (Wakita, Ueshima, & Noguchi, 2012). Exploratory factor analysis is used to see if the indicator variables can be transformed into a smaller group of uncorrelated latent variables. Latent variables can be inserted in the utility functions.

The list below shows all the statements used in the survey. In the survey the statements are in Dutch, they can be found in Appendix B.

1. I easily change my plans last minute if circumstances change
2. I like it when a transport service has a fixed schedule
3. I find it important that a transport service can be used spontaneously without planning

4. I do not trust a transport service without a fixed schedule
5. I find it important that a transport service always has the same trip duration for the same trip
6. I find that reliability is more important than speed

Summary

This chapter contained four parts: experimental conditions, model specification, generation of experimental design and construction of the questionnaire. Bus users in rural areas are the target group of the experiment. In the choice experiment respondents have to choose between three alternatives: Flexi (a DRT service), Combi (a multimodal alternative that combines an express bus service with shared bicycles) and bus. The attributes included in the choice experiments are access time, travel time, cost, minimum booking time, headway, bicycle availability, departure delay and travel time deviation. An orthogonal fractional factorial design is used to create the choice sets. Apart from the choice experiment the survey also includes socio-demographic questions and statements.

5 Descriptive statistics

After the creation of the survey, as described in the previous chapter, the survey was distributed and some of the descriptive statistics are presented in this chapter. The characteristics of the sample, the answers of the choice sets, the non-trader analysis and the exploratory factor analysis are covered in this chapter.

5.1 Sample characteristics

This section elaborates on the characteristics of the sample. First, the data gathering method is explained. Next, the sample is compared with the population of bus users in the Netherlands. Then, the level of urbanisation of the respondents is discussed. Lastly, the travel characteristics of the sample are presented.

5.1.1 Data gathering method

In this study, the preferences of bus users in rural areas and on thin lines are studied. It is difficult to target this specific group of users because where flows are thin, few users can be found. Therefore the decision was made to hand out flyers at bus stations where multiple regional lines come together to reach more respondents. An example of the flyer handed out can be found in Figure B.1 in Appendix B. The assumption was made that the bus users that travel to or from these stations are familiar with the rural character of the region and the poor quality of public transport in the rural regions. To attract more respondents, the public transport traveller organisations Rover and ROCOV were contacted to distribute the survey among their members, and a link to the survey was shared on the social media platform Facebook.

From the 5th to the 10th of November flyers were handed out on bus stations in the province Overijssel. Roughly 600 flyers were distributed on bus stations in Enschede, Zwolle, Almelo and Haaksbergen. Most of the data was gathered this way (71%). A link to the survey was sent to the members of public transport traveller organisations ROVER (15% of respondents) and ROCOV (5% of respondents). A small part of the respondents was reached via a link on Facebook (9%). The link to the survey was open from the 2nd of November till the 28th of November. A total of 119 respondents filled in the complete survey.

A rule of thumb to find the minimum number of respondents needed for discrete choice modelling is presented in Equation 5.1 (Johnson & Orme, 2003; Orme, 2010).

$$N = 500 \times \frac{C}{T \times A} = 500 \times \frac{3}{27 \times 2} = 27.8 = 28 \tag{5.1}$$

Where N is the minimum number of respondents required, C equals the largest number of levels for any attribute, T the number of choice sets and A the number of alternatives.

Because the choice tasks are divided into three blocks, three times as many respondents are needed: $3 \times 28 = 84$. Data was filtered based on time spent on the survey. Respondents that spent less than 6 minutes on the survey were eliminated from the data (5% of the sample) because it is believed that this time is too low for its results to be trusted. The 112 remaining entries were used for choice modelling.

5.1.2 Representativeness of the sample

The sample is compared with the population of bus users in the Netherlands in Table 5.1. Bus users are described as people who have used the bus at least once in the past half year (Zijlstra et al., 2018). A distinction is made between bus users and bus passengers. Bus passengers are the people you would find in a random bus on an average day, bus passengers are mainly students (Zijlstra et al., 2018). In this research the preferences of bus users were important, therefore the sample is compared with the population of bus users in the Netherlands.

Respondents with a moderate level of education are underrepresented in the sample. In the bus sample of Zijlstra et al. (2018) share respondents with a HAVO or VWO diploma are categorised as having a moderate level of education. The survey used in this research made no difference between a VMBO, HAVO or VWO diploma, all respondents with a high school diploma were categorised as having a low level of education. This may have caused the difference in education level between sample and the bus user share in the Netherlands.

The comparison in employment status shows large differences between population and sample. Students are overrepresented in the sample. A note should be made that the majority of people at the bus stations visited, were indeed students. This corresponds with the fact that most of the bus passengers are students (Zijlstra et al., 2018). This probably caused the high share of students in the sample.

The sample is representative for bus users in terms of travel motive. The travel motive education is slightly overrepresented in the sample (+7%), again this can be the result of having a large number of students in the sample. In the survey, all leisure purposes were combined into one travel motive, while in Zijlstra et al. (2018) a distinction is made between shopping and visiting. The share of respondents travelling for leisure corresponds with the combined shares of shopping and visiting.

In the sample males are overrepresented (+11%). The number of respondents with a driving licence is lower (-7%) in the sample than within the population of bus users.

The age distribution of the sample reasonably corresponds with the bus user population. The age groups 20-29 and >70 are overrepresented and the age group 12-19 is underrepresented. The large share of students in the sample might have influenced the age distribution of the sample.

There are significant differences between the sample and the population of bus users in the Netherlands. However, large differences also exist between bus users on thin lines and bus users on the thick and frequent lines (Zijlstra et al., 2018). For this survey, a specific group of bus users was targeted. Almost 50% of the respondents live in the province Overijssel and 25% of the respondents live in the province Gelderland, these provinces differ from other provinces in terms of population density (see Figure 3.1a). It is assumed that the bus users travelling in provinces with a low degree of urbanisation differ from the bus users in the extremely urbanised regions.

In conclusion, although there are significant differences between the sample and population, the sample is found to be representative for bus users in the targeted area because for most of the socio-demographic variables, the shares of the sample are in line with those of the bus user population.

TABLE 5.1: Sample characteristics compared with bus user characteristics

Socio-demographic variable	Category	Sample share	Bus user share*
Gender	Male	54%	43%
	Female	46%	57%
	Total number	*110*	
Driving licence	Yes	68%	75%
	No	32%	25%
	Total number	*112*	
Age	12-19	25.5%	30.6%
	20-29	40.0%	35.5%
	30-39	9.1%	8.9%
	40-49	5.5%	8.0%
	50-59	7.3%	8.0%
	60-69	6.4%	6.1%
	>70	6.4%	2.9%
	Total number	*110*	
Education level	High level of education	44%	49%
	Moderate level of education	19%	34%
	Low level of education	37%	17%
	Total number	*108*	
Employment status	Other / don't want to say	3%	22%
	Retired	9%	18%
	Employed, from which:	34%	47%
	Full time employed	*20%*	-
	Part time employed	*14%*	-
	Student	54%	13%
	Total number	*110*	
Travel motives	Education	40%	33%
	Commuting	23%	24%
	Leisure	23%***	
	Shopping		12%
	Visiting		12%
	Other	14%	19%
	Total number	*112*	

* (Zijlstra et al., 2018)
*** Combined value for all leisure motives (shopping, visiting, sports etc.)

5.1.3 Level of urbanisation

The target group of the survey are bus users in rural areas. This section discusses whether the sample meets these requirements.

Respondents answered questions about the departure and arrival place of their latest bus trip as well as their residence. With this information the level of urbanisation of these places is determined. Figure 5.1 displays the level of urbanisation of the arrival or departure place of the latest bus trip, the level of urbanisation of the residence of the sample and the level of urbanisation of the residence of the Dutch population. See Section 3.1 for the definition of the degree of urbanisation.

As can be seen in Figure 5.1, a small share of the respondents started or ended (4%) their latest bus trip in a not urbanised area. 26% of the respondents started or ended their latest bus trip in a hardly urbanised area. Taking into account that flyers were handed out at bus stations in areas that are categorised as strongly urbanised (Almelo, Enschede and Zwolle) it is logical that the share of trips starting or ending in strongly urbanised areas is high.

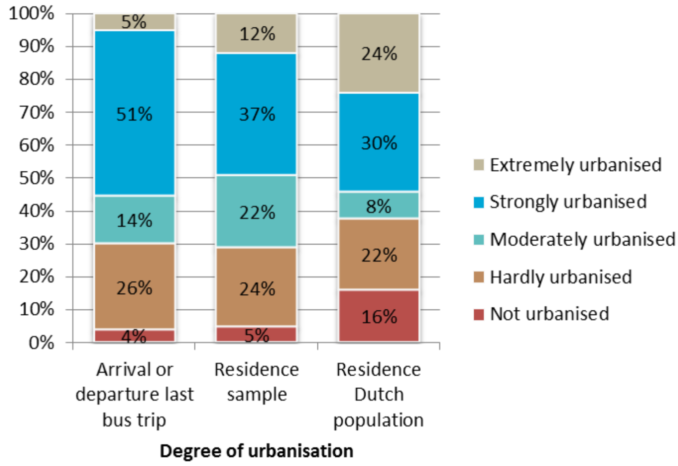


FIGURE 5.1: Degrees of urbanisation

As shown in Figure 5.1 only 5% of the respondents live in an area categorised as not urban. The largest group (37%) lives in strongly urbanised areas, 22% lives in moderately urbanised areas and 24% lives in hardly urbanised areas. The distribution of the level of urbanisation from the sample differs from the distribution of the level of urbanisation of the Dutch population.

Half of the respondents live in the province Overijssel, a quarter of the sample have their residence in the province Gelderland and 7% live in the province Utrecht. The provinces Overijssel and Gelderland are known for their rural character.

This study attempted finding respondents that live in rural areas, despite the measures taken with approaching respondents, only 51% of the respondents live in moderately or lower urbanised regions. The largest share of the respondents lives in provinces with a rural character, and therefore it is assumed that they are familiar with the quality of public transport in rural areas.

Furthermore, care has to be taken with the interpretation of the degree of urbanisation. The classification of extremely urbanised is 2,500 or more addresses per square kilometre. Relatively small cities, such as Beverwijk and Rijswijk that have a population of approximately 50000 inhabitants, are already categorised as extremely urbanised. Also, compared with international standards, the degree of urbanisation is still low.

Given these points, the fact that not all respondents are from areas categorised as hardly urbanised or not urbanised is not seen as a problem.

5.1.4 Travel characteristics

Figure 5.2, 5.3 and 5.4 display some travel characteristics of the respondents.

First, the familiarity with the alternative modes, shared bicycle and demand responsive transport, is analysed. As can be seen in Figure 5.2, respondents are more familiar with shared bicycles than with demand responsive services. 16% of the sample is not familiar with shared bicycles compared to 58% of the respondents that is not familiar with DRT. Only 4% of the respondents occasionally used a demand responsive service, respondents are more likely to have used a shared bicycle. 27% of the respondents have used a shared bicycle. Around 15% of the respondents do not know what DRT services are and also do not know what bike-sharing services are. 24% are familiar with both of the concepts but never used any of the concepts.

Almost every train station in the Netherlands is equipped with shared bicycles. DRT systems, on the other hand, are not that common. That a large share of the respondents is not familiar with DRT is logical.

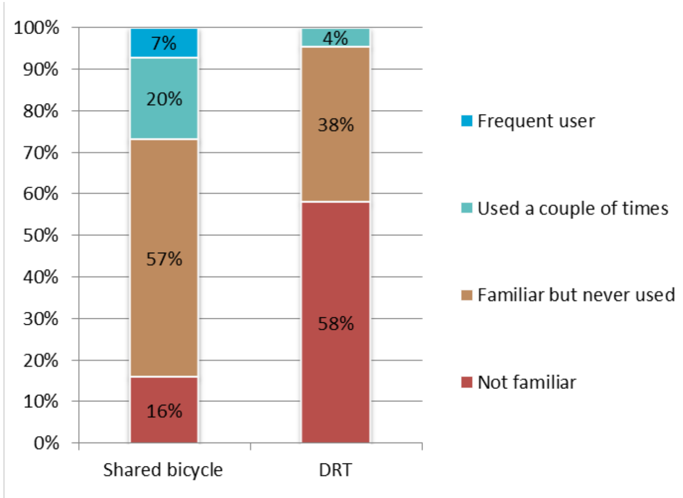


FIGURE 5.2: Familiarity with shared bicycle systems and demand responsive transport

Respondents were asked to indicate how often they use the modes car, bicycle train and bus. The bicycle is the mode most often used, 64% uses the bike more than 4 days a week. From all respondents, 43% use the bus at least 4 days a week. The mode least often used is the car, 17% indicated that they never use the car as a mode of transportation. Note that 30% of the respondents also do not have a driving licence (Table 5.1), the low usage of the car can be explained by this fact. Furthermore, the respondents that never make a trip by car are more likely to be captives of public transport.

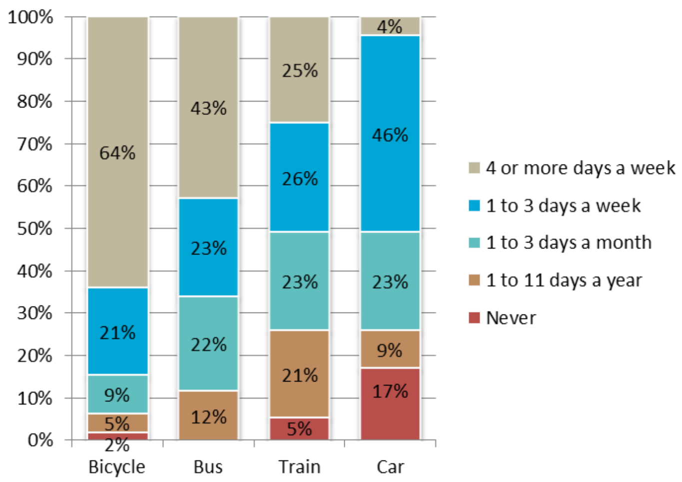


FIGURE 5.3: Usage per mode

The most used travel motive when travelling by bus is education (40%), followed by commuting and leisure (both 23%). 69% of the respondents makes more use of regional services than of city services.

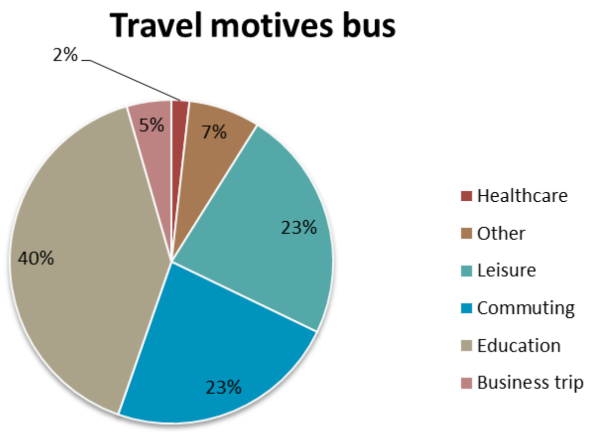


FIGURE 5.4: Travel motives bus

5.2 Choice sets

The most important part of the survey is the choice experiment. In this subsection some descriptive statistics of the choice experiment are presented. In Figure 5.5 the choices per respondent are shown. From all respondents, 17 individuals always chose bus and 2 individuals always chose Combi. Overall, the bus was the mode most chosen, followed by Combi.

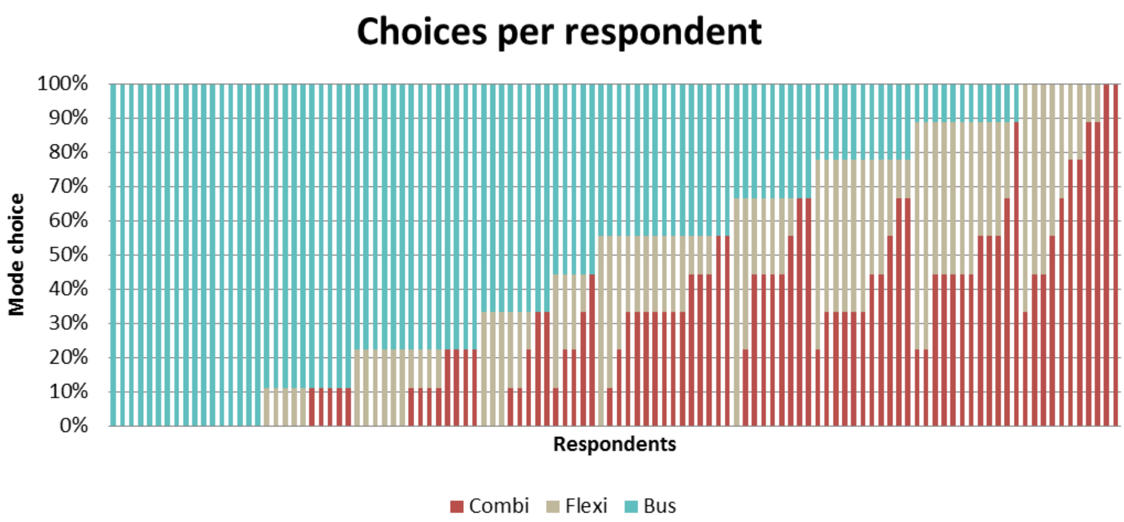


FIGURE 5.5: Choices per respondent

As was done in (Alonso-González et al., 2017b), all alternatives ever chosen in the choice experiment are considered as the modal portfolio of the respondent. The modal portfolios of all individuals are obtained and presented in Figure 5.6. A large group of respondents, 46%, is considering all three alternatives presented to them in the choice experiment in their portfolio. 37% have two alternatives in their portfolio. Only 15% of the respondents always choose traditional bus in all the choice sets. The number of respondents that include Flexi in their portfolio (68%) is approximately equal to the number of respondents that include Combi in their portfolio (71%).

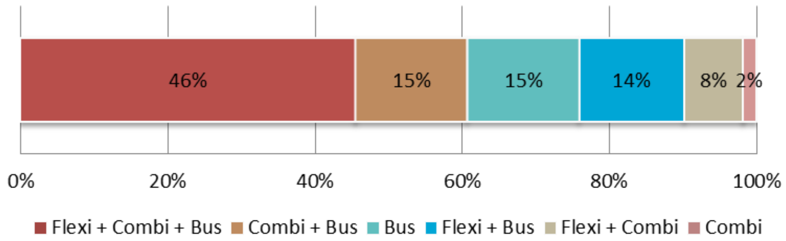


FIGURE 5.6: Modal portfolio's

5.3 Non-traders

In this section, the profiles of the respondents that never traded are analysed.

In total there are 19 non-traders (15% of the sample), 17 respondents always chose the bus alternative and 2 individuals always chose Combi. Hess, Rose, and Polak (2010) give three explanations for non-trading. The first explanation is that a respondent tries to maximise his utility but has a very strong preference for a particular alternative, in this situation the preference for one mode may be so strong that the other alternatives do not compete with the preferred mode of the respondent. Second, non-trading can occur when the respondent does not try to maximise his utility, because of boredom or fatigue during the experiment. Thirdly, non-trading behaviour can occur when a respondent chooses strategically Hess et al. (2010).

In general, it is impossible to distinguish between the above mentioned reasons for non-trading. Non-trading will mainly impact the alternative specific constants. However, when the model cannot explain everything in the constants, non-trading also influences the estimated parameters (Hess et al., 2010).

In this section, the non-traders are compared with the traders, see Table 5.2. Only two respondents always chose Combi, this number is too small to draw conclusions from and therefore left out of the comparison. A few differences between the traders and non-traders stand out.

The average age of the non-traders is higher than the average age of traders. Especially the share of respondents older than 35 is higher. This suggests that younger people are more willing to try out new modes. Moreover, the share of students is lower among non-traders than among traders and education is less frequently the travelling motive. The larger share of respondents over 35 is presumably linked to the lower share of students and also to the lower share of respondents travelling with educational purposes.

Furthermore, non-traders use the bus more often for leisure trips than traders. The share of users that use the bus more than four days a week is almost equal between traders and non-traders, however the share of people that travel less than 1 day a week is higher for non-traders. The share of respondents that have trouble with walking and cycling is slightly higher among non-traders, again it is assumed that this is correlated with age. In general, with increasing age physical hindrances increase.

TABLE 5.2: Comparison traders and non traders

Age	**Traders**	**Always bus**	**Always &Combi**	**Total sample**
15-24	56.5% (52)	25.0% (4)	50.0% (1)	51.8% (57)
25-34	19.6% (18)	12.5% (2)		18.2% (20)
35-44	6.5% (6)	18.8% (3)		8.2% (9)
45-54	5.4% (5)	12.5% (2)	50.0% (1)	7.3% (8)
55-64	4.3% (4)	12.5% (2)		5.5% (6)
65-74	4.3% (4)	18.8% (3)		6.4% (7)
75-84	3.3% (3)			2.7% (3)
Travel motive	**Traders**	**Always bus**	**Always &Combi**	**Total sample**
Commuting	22.6% (21)	29.4% (5)		23.2% (26)
Business visit	4.3% (4)	5.9% (1)		4.5% (5)
Education	45.2% (42)	11.8% (2)	50.0% (1)	40.2% (45)
Healthcare	1.1% (1)	5.9% (1)		1.8% (2)
Leisure	21.5% (20)	35.3% (6)		23.2% (26)
Other	5.4% (5)	11.8% (2)	50.0% (1)	7.1% (8)
Bus usage	**Traders**	**Always bus**	**Always &Combi**	**Total sample**
>4 days a week	43.0% (40)	41.2% (7)	50.0% (1)	42.9% (48)
1-3 days a week	26.9% (25)	5.9% (1)		23.2% (26)
1-3 days a month	20.4% (19)	35.3% (6)		22.3% (25)
1 to 11 days a year	9.7% (9)	17.6% (3)	50.0% (1)	11.6% (13)
Hindrance walking	**Traders**	**Always bus**	**Always &Combi**	**Total sample**
Very much	1.1% (1)	5.9% (1)		1.8% (2)
Slightly	3.2% (3)	5.9% (1)		3.6% (4)
Hardly	12.9% (12)	11.8% (2)		12.5% (14)
Not at all	82.8% (77)	76.5% (13)	100.0% (2)	82.1% (92)
Hindrance cycling	**Traders**	**Always bus**	**Always &Combi**	**Total sample**
Slightly	3.2% (3)	17.7% (3)		5.4% (6)
Hardly	7.5% (7)	5.9% (1)		7.1% (8)
Not at all	89.3% (83)	76.5% (13)	100.0% (2)	87.5% (98)
Employment status	**Traders**	**Always bus**	**Always &Combi**	**Total sample**
Student	62.2% (56)	20.0% (3)	50.0% (1)	56.1% (60)
Employed full time	17.8% (16)	33.3% (5)	50.0% (1)	20.6% (22)
Part time employment	12.2% (11)	26.7% (4)		14.0% (15)
Retired	7.8% (7)	20.0% (3)		9.3% (10)
Gender	**Traders**	**Always bus**	**Always &Combi**	**Total sample**
Male	52.2% (48)	56.3% (9)	100.0% (2)	53.6% (59)
Female	47.8% (44)	43.8% (7)		46.4% (51)

Chi-square tests are performed to check if personal and trip related characteristics have an influence on the fixed preference for bus. If more than 20% of the cells have less than 5 expected counts the chi-square assumption is violated. An overview of the characteristics that have significant results and do not violate the chi-square assumption are given in 5.3. The characteristics number of leisure trips, travel motives for bus use, number of car trips and occupation have an significant influence on the fixed preference for bus and their comprehensive results are reported in Table 5.4 to 5.7.

TABLE 5.3: Results Chi-Square test for personal and trip characteristics

Personal or trip characteristic	**Pearson X^2**	**p-value**
Number of leisure trips	8.291	0.016
Travel motives bus use	7.188	0.027
Number of car trips	8.235	0.016
Occupation	9.471	0.009

The observed count is the actual number of respondents with that specific characteristic. The expected count is the expected number of respondents when their are no correlations between the characteristic and the preference.

The results of the Chi-square test for occupation are presented in Table 5.4. Students less often have an observed preference for the bus than employed individuals.

TABLE 5.4: Chi-square test for occupation

Fixed preference	**Count**	**Occupation**		
		Student	Employed	Unemployed
Bus	Observed	3	9	3
	Expected	8.4	5.1	1.4
No fixed preference	Observed	56	27	7
	Expected	50.6	30.9	8.6
Total	Count	59	36	10
	% of total	56%	34%	10%

The results of the Chi-square test for travel motive are presented in Table 5.5, individuals that travel to work by bus more often have a fixed preference for bus.

TABLE 5.5: Chi-square test for travel motive bus trip

Fixed preference	**Count**	**Travel motive bus**		
		Work	Education	Other
Bus	Observed	6	1	10
	Expected	4.7	2.3	10.0
No fixed preference	Observed	24	14	54
	Expected	25.3	12.7	54.0
Total	Count	30	15	64
	% of total	27.5%	13.8%	58.7%

The number of leisure trips made by an individual also affect the fixed preference, see the result of the Chi-square test in Table 5.6. Individuals that make more leisure trips less often have a fixed preference for the bus.

TABLE 5.6: Chi-square test for the number of leisure trips

Fixed preference	Count	Number of leisure trips		
		More than once a week	Less than once a week	Never
Bus	Observed	3	10	4
	Expected	7.4	8.0	1.5
No fixed preference	Observed	45	42	6
	Expected	40.6	44.0	8.5
Total	Count	48	52	10
	% of total	43.6%	47.3%	9.1%

People that never make a trip by car, more often have a fixed preference for the bus, see Table 5.7. Maybe, respondents that never make a trip by car are captives of public transport and hesitant to use alternatives. Another explanation can be that they always choose the bus because of strategic reasons to prevent that their mode will disappear.

TABLE 5.7: Chi-square test for the number of car trips

Fixed preference	Count	Number of car trips		
		More than once a week	Less than once a week	Never
Bus	Observed	7	3	7
	Expected	8,8	5,3	2,9
No fixed preference	Observed	50	31	12
	Expected	48,2	28,7	16,1
Total	Count	57	34	19
	% of total	51,8%	30,9%	17,3%

In further analyses the non-traders are not excluded from the sample.

5.4 Attitudes towards reliability

Statements are developed to measure the attitudes of respondents towards reliability and flexibility. Respondents rated six attitudinal statements on a 5-point Likert scale (1=strongly disagree, 2=mildly disagree, 3=neutral, 4= mildly agree, 5=strongly agree). An Exploratory Factor Analysis (EFA) is performed on these statements.

5.4.1 Statements

Six statements regarding reliability and flexibility were developed. Respondents rated the following six statements:

1. I easily change my plans last minute if circumstances change (ST1)
2. I like it when a transport service has a fixed schedule (ST2)
3. I find it important that a transport service can be used spontaneously without planning (ST3)

4. I do not trust a transport service without a fixed schedule (ST4)

5. I find it important that a transport service always has the same trip duration for the same trip (ST5)

6. I find that reliability is more important than speed (ST6)

The distributions of answers can be seen in Figure 5.7. Descriptive statistics can be found in Table 5.8. Overall, the average answer to the statements is higher than 3. Especially statement two scores very high, with an average score of 4.53. Fixed schedules are appreciated highly by a very large share of the respondents. The average score of statement 6 is also relatively high with a score of 4.09, overall respondents agree with the statement that reliability is more important than speed. The answers to the other statements are more evenly distributed.

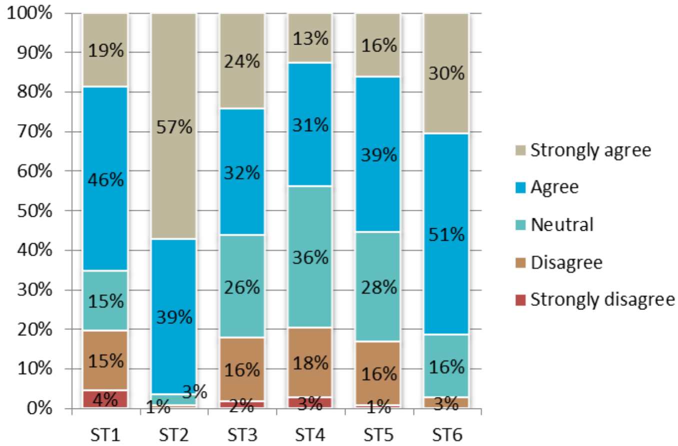


FIGURE 5.7: Distribution of answers on attitudinal statements on a scale from 1 (strongly disagree) to 5 (strongly agree)

TABLE 5.8: Descriptive statistics of the attitudinal statements

Statement	**N**	**Mean**	**Std. Dev.**
ST1	112	3.60	1.09
ST2	112	4.53	0.60
ST3	112	3.61	1.08
ST4	112	3.33	1.00
ST5	112	3.54	0.98
ST6	112	4.09	0.75

5.4.2 Exploratory Factor Analysis

Several steps are taken to see if the data gathered from the statements is suitable for an exploratory factor analysis. First, the suitability is assessed with the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity, see Table 5.9. The KMO index should be at least 0.50 and the Bartlett's test of sphericity should be significant ($p<0.05$) (Williams, Onsman, & Brown, 2010). The KMO index is slightly above 0.50 and is considered suitable for factor analysis. Bartlett's Test of Sphericity is smaller than 0.05 and therefore significant.

TABLE 5.9: KMO and Bartlett's test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.503
Bartlett's Test of Sphericity	Approx. Chi-Square	31.697
	df	15
	Sig.	0.007

Table 5.10 displays the correlation matrix. The correlation matrix is inspected for correlations over 0.30. When the correlations are smaller than 0.30 using EFA is doubtful (Williams et al., 2010). The correlation matrix shows that only one correlation is above 0.3 and no correlation is higher than 0.4. EFA might not be the appropriate statistical method to use, because of the low correlations (Williams et al., 2010).

TABLE 5.10: Correlation matrix

Correlation Matrix [a]

Correlation	ST1	ST2	ST3	ST4	ST5	ST6
ST1	1.000	-0.073	0.102	-0.116	0.068	0.131
ST2	-0.073	1.000	-0.039	0.218	0.314	0.074
ST3	0.102	-0.039	1.000	0.080	-0.132	-0.101
ST4	-0.116	0.218	0.080	1.000	0.214	0.032
ST5	0.068	0.314	-0.132	0.214	1.000	0.057
ST6	0.131	0.074	-0.101	0.032	0.057	1.000

a. Determinant = 0.746

Principal axis factoring with varimax rotation is used. The communalities are inspected, they should have a value of at least 0.25 (Molin, 2018). Only ST2 and ST5 have a communality higher than 0.25 (see Table 5.11), the other indicators have a very low communality.

TABLE 5.11: Communalities

Communalities

	Initial	Extraction
ST2	0.098	0.313
ST5	0.098	0.313

Extraction Method: Principal Axis Factoring.

The indicators with a communality below 0.25 and a factor loading below 0.5 are removed from the model. ST5 and ST2 loaded on a common factor, see Table 5.12. If less than three or two indicators load on a factor it is difficult to describe the meaning of the factor (Williams et al., 2010). Because only two indicators had a sufficient loading on the factor and the correlation between the indicators was minimal, it is decided to not incorporate the extracted factor into the discrete choice models. Instead, the individual statements are directly incorporated into the choice model.

TABLE 5.12: Factor matrix

Factor Matrix[a]	
	Factor
	1
ST5	0.559
ST2	0.559

Extraction Method: Principal Axis Factoring.
[a] 1 factors extracted. 8 iterations required

Conclusion

This chapter provided findings of the survey. To start, the sample is found to be representative for the bus user population in the rural areas of the Netherlands. Half of the respondents are students and the most common travel motive is education. Furthermore, it was found that around 50% of the respondents live in areas classified as moderately urbanised or lower. Another finding is that few respondents have experience with shared bicycles or DRT, 27% and 4%, respectively. 17% of the respondents never use the car as a mode of transport, they are probably captives of public transport.

Of all respondents, 15% is characterised as a non-trader and always chooses bus in the choice experiment. Non-traders in general are older than traders, this corresponds with the facts that less students are among non-traders and education is not as often mentioned as the travel motive.

Factor analysis is applied to the statements, but the correlations between the statements are low and no common factor is extracted. Therefore, the statements are directly incorporated into the choice model. From the statements, it is concluded that respondents highly value fixed schedules.

6 Discrete Choice Modelling

This chapter discusses the data analysis using discrete choice modelling. Section 6.1 explains how the data is prepared for modelling. In Section 6.2 the estimated models are presented and the estimation results are discussed. The model with the best model fit is chosen in Section 6.3 and interpreted in Section 6.4. In the last section, 6.5, the value of travel time savings are calculated.

6.1 Data preparation

In order to use the data for model estimation in PythonBiogeme (Bierlaire, 2016b) the data must be in the correct format. The data from the attributes can directly be used in Biogeme. The socio-demographic variables need to be re-coded for use in Biogeme. The variables age, gender and driving licence are dummy coded, see Table 6.1. With dummy coding, a categorical variable with L levels is re-coded into L-1 indicator variables (IV) in which each IV is set to one when the level is present and set equal to zero if it is not. The L^{th} level is set to zero (Bech & Gyrd-Hansen, 2005; Daly, Dekker, & Hess, 2016). With the estimated parameters the utility contribution of the levels relative to the reference level can be calculated.

Socio-demographic variable	Category	IV 1	IV 2
Age	15-29	1	0
	30-59	0	1
	>59	0	0
Gender	Male	1	
	Female	0	
driving licence	Yes	1	
	No	0	

TABLE 6.1: Dummy coding used for socio-demographic variables

Respondents could choose between three alternatives, an alternative that combines an express bus service with shared bicycles for last mile transport called "Combi", a demand responsive service called "Flexi" and the regular bus. The bus alternative represents the current mode used by respondents, this is the base alternative. The bus alternative has fixed attribute levels that are equal in every choice set. No parameters are estimated for the bus alternative. The alternative specific constant of the bus is fixed to zero. The alternative specific constants (ASC) of Combi and Flexi and the parameter values for each attribute are estimated.

6.2 Estimated models

Four models are estimated: a multinomial logit (MNL) model, a nested logit (NL) model, a mixed logit (ML) model with an error component and an extended ML model with an error component. The MNL model is estimated to function as a reference for the more advanced models. To test whether nests are present an NL model is estimated. The ML model includes an error component that captures heterogeneity within the nest and also accounts for panel effects. The ML model is extended with socio-demographic variables. Table 6.2 gives an overview of the parameters included in the variations of choice models.

TABLE 6.2: Parameters used in different variations of choice models

Parameters included in different variations of choice models	**MNL base**	**NL**	**ML EC**	**ML EC extended**
Alternative specific constant Combi	X	X	X	X
Alternative specific constant Flexi	X	X	X	X
β access time Combi	X	X	X	X
β access time Flexi	X	X	X	X
β travel time bike Combi	X	X	X	X
β travel time bus Combi	X	X	X	X
β travel time Flexi	X	X	X	X
β cost Combi	X	X	X	X
β cost Flexi	X	X	X	X
β headway Combi	X*	X*	X*	X*
β minimum booking time Flexi	X	X*	X	X
β availability bicycle Combi	X	X*	X*	X*
β departure delay Flexi	X*	X*	X*	X*
β travel time deviation Flexi	-*	-	-	-
β age 1 Combi	-	-	-	X
β age 2 Combi	-	-	-	X
β age 1 Flexi	-	-	-	X
β gender Flexi	-	-	-	X
β driving licence Combi	-	-	-	X
β driving licence Flexi	-	-	-	X
β statement 4	-	-	-	X
β nest new mode	-	X	-	-
σ new mode	-	-	X	X

* not significant at a 95% confidence interval

6.2.1 Multinomial logit model

The base MNL model only includes the attributes from the choice experiment. The parameter for travel time deviation of Flexi was removed from the model because it had a positive value whereas a negative value was expected. Probably, the attribute travel time deviation was not understood by the respondents and therefore not taken into account during the decision making. The utility functions used in the base model are displayed in Equation 6.1 to 6.3. The parameter abbreviations used are displayed in Table 6.6.

All variables from the choice experiment were tested for non-linearity by adding quadratic components. The parameters estimated for quadratic components were found to be not statistically significant at the 95% confidence interval and are therefore not used in the model.

$$V_{\text{Combi}} = ASC_{\text{Combi}} + \beta_{\text{AT\_Combi}} * AT_{\text{Combi}} + \beta_{\text{TTBus\_Combi}} * TTBus_{\text{Combi}} + \beta_{\text{TTBike\_Combi}} * TTBike_{\text{Combi}} + \beta_{\text{H\_Combi}} * H_{\text{Combi}} + \beta_{\text{BA\_Combi}} * BA_{\text{Combi}} + \beta_{\text{C\_Combi}} * C_{\text{Combi}} \quad (6.1)$$

$$V_{\text{Flexi}} = ASC_{\text{Flexi}} + \beta_{\text{AT\_Flexi}} * AT_{\text{Flexi}} + \beta_{\text{TT\_Flexi}} * TT_{\text{Flexi}} + \beta_{\text{MBT\_Flexi}} * MBT_{\text{Flexi}} + \beta_{\text{DD\_Flexi}} * DD_{\text{Flexi}} + \beta_{\text{C\_Flexi}} * C_{\text{Flexi}} \quad (6.2)$$

$$V_{\text{bus}} = ASC_{\text{bus}} \quad (6.3)$$

6.2.2 Nested logit and mixed logit models

The nested model tests if nests are present. Different nests are tested and the nest between the two new modes is found to be significant at the 95% confidence interval. The mixed logit model includes an error-component for heterogeneity within the nest and also corrects for panel effects. The extended ML model includes socio-demographic variables as well as a variable for statement 4. Various socio-demographics were tested, age and driving licence proved to have a significant influence on the utility for Combi and Flexi. Gender proved to have a significant influence on the utility of Flexi. From all tested statements, only statement 4 (trust in transport services without a fixed schedule) proved to have a significant influence on the utility of DRT.

6.2.3 Models with second choices

Additionally, an MNL model with only the second choices is estimated, see Table 6.3 for the estimation statistics. This model performs poorly, the adjusted ρ-square is very low (0.069) as well as the LRS (120.065). Only the parameters cost Combi, cost Flexi, travel time bus Combi and travel time Flexi proved to be significant. This corresponds with existing literature on ranking data, which already states that data from lower rank choices is less reliable. Respondents may pay less attention when choosing their second best alternative. Additionally, it is also possible that individuals use different decision protocols according to the level of the rank (Ben-Akiva, Morikawa, & Shiroishi, 1991).

Because the model with only the second choices performed badly and the first choices did not have a high degree of inertia, no model with both first and second choices was estimated.

TABLE 6.3: Model estimation of the MNL model with second choices only

Model	**# of observations**	**# of parameters**	ρ^2	$\bar{\rho}^2$	**Null LL**	**Final LL**	**LRS**
MNL second choices	990	13	0.087	0.069	-686.216	-626.183	120.065

6.3 Model fit

The model outcomes are displayed in Table 6.4. To test whether an extended model fits the data better, the likelihood ratio test is used, see Formula 2.8. For each model the LRS is calculated to determine whether the model outperforms the previous model. The Chi-square distribution table is used to determine the critical X^2.

TABLE 6.4: Estimated models with model scores

Model	# of observations	# of parameters	ρ^2	$\bar{\rho}^2$	Null LL	Final LL	LRS
MNL Base	990	13	0.160	0.149	-1087.626	-913.086	349.08
NL	990	14	0.163	0.15	-1087.626	-910.281	354.691
ML EC	990	14	0.296	0.283	-1087.626	-765.805	643.643
ML EC extended	990	21	0.315	0.296	-1087.626	-744.925	685.402

$$LRS = -2 * (LL_{\text{MNL base}} - LL_{\text{NL}}) = -2 * (-913.086 - -910.281) = 5.610 \quad (6.4)$$

The nested logit model has one parameter more than the base model. The critical X^2 for 1 degree of freedom for a 5% significance level is 3.841. According to the likelihood ratio test the NL model has a better model fit.

The ML error-component model has the same number of parameters as the NL model, but is not nested in the NL model, therefore the LRS cannot be used. Instead, the Ben-Akiva & Swait test is used (Chorus, 2017), see Equation 6.5.

$$p = NormSDist(-\sqrt{2 * N * ln(J) * (LL(B) - LL(A))/LL(0)}) \quad (6.5)$$

Where:
NormSDist(X) = probability that a draw from the standard normal distribution is smaller than X
J = number of alternatives in the choice set
N = number of observations

$$p = NormSDist(-\sqrt{2 * 990 * ln(3) * (-910.281 - -765.805)/ - 1087.626}) = 7.174E^{-64} \quad (6.6)$$

The ML error-component has a higher loglikelihood than the nested logit model. The Ben-Akiva and Swait test gives a conservative estimate for the probability that although model A has a better model fit than model B, B is the better model in the population. The outcome of the test (Equation 6.6) is that p is very small, so the probability that the ML model is the incorrect model is very small.

$$LRS = -2 * (LL_{\text{ML error component}} - LL_{\text{ML extended}}) = -2 * (-765.805 - -744.925) = 41.76 \quad (6.7)$$

Last, the ML model is compared with the extended ML model. In the extended model 7 parameters are added. The critical X^2 for 7 degrees of freedom for a 5% significance level is 14.067. The LRS is higher than 14.067, thus it can be concluded that the extended ML modal has a better model fit than the normal ML model and therefore is the best model.

6.4 Parameter interpretation

The ML model with error components and socio-demographic variables is chosen as the best model. It has 21 estimated parameters and an adjusted ρ^2 of 0.296. Table 6.5 displays the estimated parameter values. The abbreviations used are displayed in Table 6.6.

All parameters from the experiment have the expected sign. Higher access times, cost, minimum booking time, departure delays and travel time result in lower utilities. On the other hand, a higher number of bicycles available leads to a higher utility for Combi. These parameters are measured on different ranges, therefore the values cannot be compared directly. First, the relative importance has to be calculated. All parameters, except headway, bicycle availability and departure delay, are highly significant.

TABLE 6.5: Parameter estimates of extended ML EC model

Name	Value	Robust SE	Robust t-test	p-value	Name	Value	Robust SE	Robust t-test	p-value
Combi					*Flexi*				
ASC	2.17	1.05	2.07	0.04	ASC	4.71	0.948	4.97	0
β_{TTBus}	-0.0858	0.0221	-3.88	0	β_{TT}	-0.106	0.018	-5.86	0
β_{TTBike}	-0.148	0.0211	-7	0					
β_{AT}	-0.117	0.0278	-4.2	0	β_{AT}	-0.174	0.0643	-2.7	0.01
β_{C}	-0.426	0.0673	-6.33	0	β_{C}	-0.416	0.0809	-5.15	0
β_{BA}	0.0532	0.0273	1.95	0.05*					
β_{H}	-0.00814	0.00523	-1.56	0.12*					
					β_{MBT}	-0.0105	0.00492	-2.14	0.03
					β_{DD}	-0.011	0.02	-0.55	0.58*
$\beta_{Licence}$	1.32	0.491	2.69	0.01	$\beta_{Licence}$	1.26	0.456	2.77	0.01
β_{Age1}	1.92	0.687	2.79	0.01	β_{Age1}	1.13	0.524	2.16	0.03
β_{Age2}	1.35	0.586	2.3	0.02					
					β_{ST4}	-0.374	0.125	-3	0
					β_{Gender}	-0.846	0.295	-2.87	0
Other									
$\sigma_{NewMode}$	2.06	0.208	9.92	0					

* not significant at a 95% confidence interval

Two alternative specific constants (ASC) are included in the model. The ASCs represent the total utility that is associated with factors other than observed attributes, they also give the utility of the alternative when all other atribute values are equal to zero. The ASC of Combi has a value of 2.17 and the ASC of Flexi has a value of 4.71. Meaning that there are bigger unobserved factors with a positive influence for Flexi than for Combi and bus. The utility function of bus only included an alternative specific constant. This constant was normalised, because only differences in utility matter. Because in the choice experiment the bus alternative had fixed values for travel time, access time, headway and cost, these values are represented in the ASC of bus.

TABLE 6.6: Parameter abbreviations

Abbreviation	
ASC	Alternative specific constant
TT	Travel time
AT	Access time
C	Cost
BA	Bicycle availability
H	Headway
MBT	Minimum booking time
DD	Departure delay
ST4	Statement 4: trust in transport services without fixed schedules

Although the parameters for headway, bicycle availability and departure delay are insignificant, they are kept in the model. In this research it is assumed that the true values of the parameters for headway, departure delay and bicycle availability are not equal to zero. With the t-test the null hypothesis, H_0, is tested. The null hypothesis states that the true value of the parameter is equal to zero. Because the t-test is lower than 1.96 the null hypothesis cannot be rejected at the 95% confidence level (Bierlaire, 2016a). Still, the parameters are expected to have a role in the true model and are therefore kept in the final specification. By doing this, an attempt has been made to minimise a specification error (type II error), which causes more damage to the model than the loss of efficiency caused by including an insignificant parameter in the model (type I error) (Bierlaire, 2016a).

The estimated parameter for in-vehicle travel time is slightly higher for Flexi than for express bus part of the Combi alternative, meaning that travel time of Flexi is perceived more negative than travel time with the express bus.

Access time of Flexi is perceived as more negative than access time of Combi. The estimated parameters for cost for the two alternatives are quite similar. An increase in cost is valued almost equally negative for Combi as for Flexi.

The socio-demographic parameters can be interpreted as follows. Men have a lower preference towards Flexi than women, and men have a higher preference for Combi and bus than for Flexi. Individuals under 30 have the highest preference for Combi. Individuals between 30 and 60 years old have a higher preference for Combi than individuals over 60. Individuals under 30 prefer Flexi more than individuals older than 30. Relative to the other alternatives, individuals that are under 30 have a higher preference for Combi and Flexi than for bus, and have the highest preference for Combi. It can be concluded that individuals under 30 are more willing to use Combi and Flexi as an alternative for bus than older individuals.

Individuals with a driving licence prefer Flexi and Combi over bus. Individuals with a driving licence have a higher preference for Combi than individuals without a driving licence. Individuals with a driving licence also have a higher preference for Flexi than individuals without a driving licence. Having a driving licence probably makes them less dependent on the current bus service.

Having a high distrust in transport services without fixed schedules results in a lower preference for Flexi. Individuals with a high distrust in transport services without fixed schedules have a lower preference for Flexi than for Combi and bus.

Finally, the sigma for new modes is significant. Meaning that a nest is present between the Flexi alternative and the Combi alternative. The nest captures what Flexi and Combi intuitively have in common, but is not captured in the deterministic part of utility (Chorus, 2017). It is assumed that it captures the fact that both Combi and Flexi are (relatively) new forms of transport for respondents. The sigma captures the correlation between unobserved utilities of the two modes as well as the correlations between choices that are made over time by the same individual (Chorus, 2017).

The parameter estimates give utils gained or lost by a one unit increase of the attribute. To determine which of the attributes contributes the most to the total utility, given its estimated parameter and the range of attribute values, the parameter values are multiplied with the attribute range. Table 6.7 provides the relative importance of the parameters as well as the 95% confidence interval of the parameter estimates.

Combi cost has the largest impact on utility for the range used, varying the cost over the range used in the experiment results in a -1.704 loss in utility. After the cost of Combi, travel time Flexi, cost of Flexi and travel time bicycle have the highest impact on utility for the range that is used in the experiment.

TABLE 6.7: Attribute contribution to utility

Name	**Value**	**95% C.I.**		**Attribute range**	**Utility range**		**Relative importance**
β_{CCombi}	-0.426	-0.422	-0.426	4	-0.639	-2.343	-1.704
$\beta_{TTFlexi}$	-0.106	-0.105	-0.106	16	-2.544	-4.24	-1.696
β_{CFlexi}	-0.416	-0.411	-0.416	4	-0.624	-2.288	-1.664
$\beta_{TTBikeCombi}$	-0.148	-0.147	-0.148	10	-0.296	-1.776	-1.48
$\beta_{ATFlexi}$	-0.174	-0.170	-0.174	8	-0.696	-2.088	-1.392
$\beta_{ATCombi}$	-0.117	-0.115	-0.117	8	-0.234	-1.17	-0.936
$\beta_{TTBusCombi}$	-0.0858	-0.0844	-0.0858	10	-1.8876	-2.7456	-0.858
$\beta_{BACombi}$	0.053	0.055	0.053	10	0.0532	0.5852	0.532
$\beta_{MBTFlexi}$	-0.0105	-0.0102	-0.0105	50	-0.105	-0.630	-0.525
β_{HCombi}	-0.008	-0.008	-0.008	50	-0.0814	-0.4884	-0.407
$\beta_{DDFlexi}$	-0.011	-0.0098	-0.011	12	-0.033	-0.165	-0.132

6.4.1 Changes in utilities

The parameter outcomes are used to calculate the changes in utilities for every attribute level. Figure 6.1 visualises the changes in utility for the different attributes. Steep lines represent attributes with a large impact on utility per unit change. The length of the lines corresponds with the attribute range used in the choice experiment. As was concluded in Section 6.4, cost has the largest decrease in utility per unit and minimum booking time, departure delay and headway have the lowest decrease in utility per unit change. In-vehicle travel time of Flexi and bus have the largest impact on utility for the attribute level range used in the choice experiment. Figure 6.1 gives a good illustration of the impact on the utility of the attributes studied.

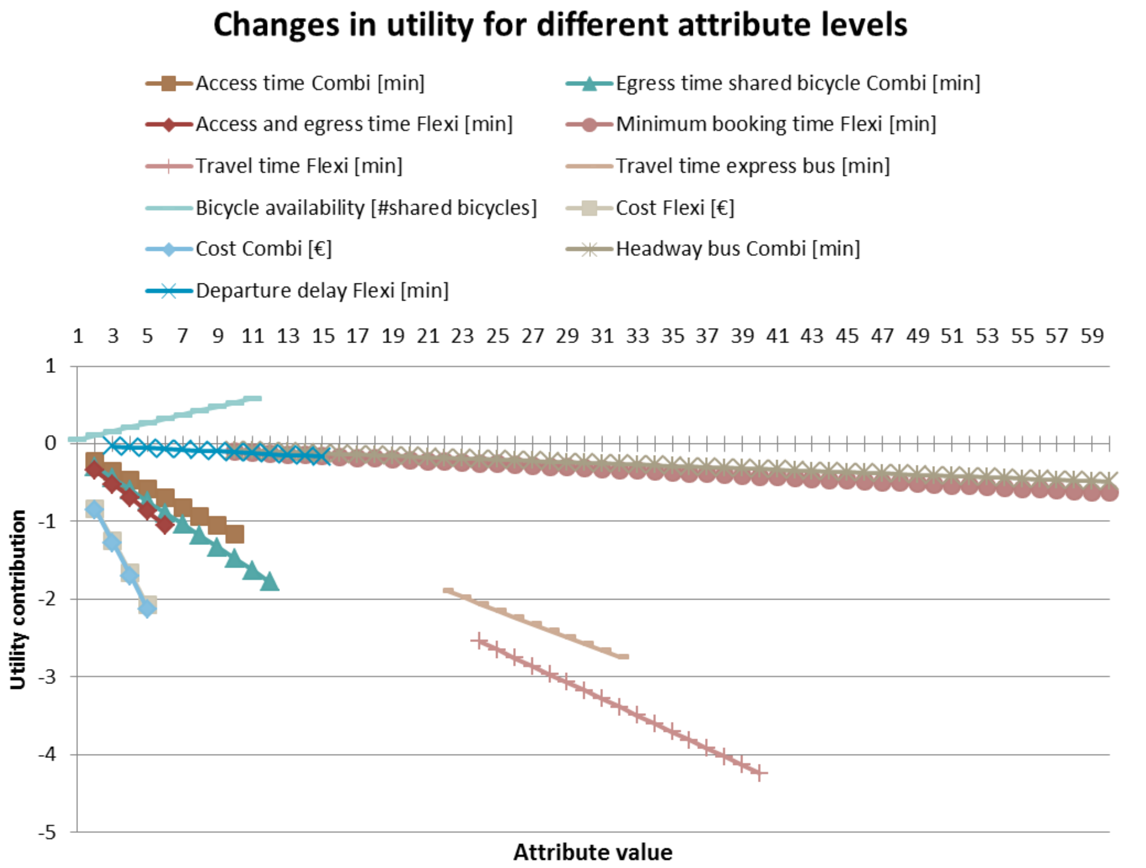


FIGURE 6.1: Changes in utility for different attribute levels

6.5 Value of Travel Time Savings

For the time components the Value of Travel Time Savings (VoTTS) is calculated. The Value of Travel Time Savings measures the value of one unit of travel time reduction in monetary units. In other words, how much money travellers are willing to pay for a reduction in travel time. The VoTTS can be calculated from the estimated parameters values of the choice model, equation 6.8 shows the calculation of the VoTTS. Table 6.8 shows the calculated VoTTS for the travel time with express bus, shared bicycle and Flexi. Also, the VoTTS for access times of Flexi and Combi are calculated.

$$VoTTS = \frac{\beta_{time}}{\beta_{cost}} \tag{6.8}$$

TABLE 6.8: Values of Travel Time Savings for Flexi and Combi

Value of Travel Time Savings	Value	Unit
In-vehicle travel time express bus Combi	€12.08	€/ hour
In-vehicle travel time Flexi	€15.29	€/ hour
Travel time shared bicycle	€20.85	€/ hour
Access and egress time Flexi	€25.10	€/ hour
Access time Combi	€16.48	€/ hour

Respondents are willing to pay €20.85 for one hour of shared bicycle travel time saved. The VoTTS of shared bicycle travel time is much higher than the VoTTS of express bus travel time and Flexi travel time.

The ratio of shared bicycle travel time to express bus travel time is 1.72 (20.985/12.08). This means that a greater dis-utility is associated with cycling than with time spent inside the vehicle.

The VoTTS of access time of Flexi is about 6 euros higher than the VoTTs of access time of Combi. This means that respondents have a higher dis-utility towards access time of Flexi than towards access time of Combi. In the experiment the ranges for access time were different for Combi and Flexi, this might have influenced the estimated VoTTS.

The VoTTS of access time of Flexi is higher than the VoTTS for in-vehicle time of Flexi. Existing studies have found evidence that the VoTTS for walking time (access time) is greater than the dis-utility associated with the time spent inside a vehicle. Wardman (2004) found that the VoTTS for walking is around two times higher than the VoTTS for in-vehicle time. The ratio for Flexi in this study is 1.64 (25.10/15.29). In this study the walking times for Flexi were small, this can explain the lower ratio.

The calculated VoTTS obtained from the model differs from the VoTTS estimated for public transport in previous research. In previous research, the average VoTTS for bus, tram and metro was estimated at €7.42 per hour (Kennisinstituut voor Mobiliteitsbeleid, 2017). The differences between the in VoTTS for bus, tram and metro and Combi and Flexi could be caused by the fact that Flexi and Combi are more personalised modes or because travellers in rural populations are willing to pay more for improved transport services than average travellers.

6.6 Model with generic parameters

A model with generic parameters was estimated to get a better understanding of the estimated values for the alternative specific constants. Because of the use of generic parameters it was possible to include a utility function for bus. By doing this, the provided values for access time, travel time, headway and cost for the bus alternative are no longer captured in the ASC of bus. The utility functions of the model with generic parameters are given in Equation 6.9 to 6.11. The model outcomes are presented in Table 6.9.

$$\begin{aligned} V_{\text{Combi}} = & ASC_{\text{Combi}} + \beta_{\text{AT}} * AT_{\text{Combi}} + \beta_{\text{TT}} * TTBus_{\text{Combi}} + \beta_{\text{TTBikeCombi}} * TTBike_{\text{Combi}} \\ & + \beta_{\text{C}} * C_{\text{Combi}} + \beta_{\text{H}} * H_{\text{Combi}} + \beta_{\text{BACombi}} * BA_{\text{Combi}} + \beta_{\text{LicenceCombi}} * Licence \\ & + \beta_{\text{Age1Combi}} * Age1 + \beta_{\text{Age2Combi}} * Age2 + \sigma_{NewMode} \end{aligned} \tag{6.9}$$

$$\begin{aligned} V_{\text{Flexi}} = & ASC_{\text{Flexi}} + 2 * \beta_{\text{AT}} * AT_{\text{Flexi}} + \beta_{\text{TT}} * TT_{\text{Flexi}} + \beta_{\text{C}} * C_{\text{Flexi}} + \beta_{\text{MBTFlexi}} * MBT_{\text{Flexi}} \\ & + \beta_{\text{DDFlexi}} * DD_{\text{Flexi}} + \beta_{\text{Licence\_Flexi}} * Licence + \beta_{\text{Age1\_Flexi}} * Age1 \\ & + \beta_{\text{Gender\_Flexi}} * Gender + \beta_{\text{ST4\_Flexi}} * ST4 + \sigma_{NewMode} \end{aligned} \tag{6.10}$$

$$V_{\text{bus}} = ASC_{\text{bus}} + 2 * \beta_{\text{AT}} * 4 + \beta_{\text{TT}} * 37 + \beta_{\text{C}} * 3 + \beta_{\text{H}} * 60 \tag{6.11}$$

TABLE 6.9: Model estimation of extended ML EC model with generic parameters

Model	# of observations	# of parameters	ρ^2	$\bar{\rho}^2$	Null LL	Final LL	LRS
ML EC extended generic parameters	990	18	0.315	0.298	-1087.626	-745.491	684.271

The estimated values for the ASCs of the model with generic parameters and the model with attribute specific parameters are presented in Table 6.10. The values for the ASCs of Combi and Flexi are no longer positive as in the previous estimated models, but are negative now that the attributes access time, travel time, cost and headway are included in the utility function of the bus. In both models the ASC of bus is fixed to zero. In the model with alternative specific attributes, the ASC of bus has the lowest value. In the model with generic parameters the ASCs of Combi and Flexi are lower than the ASC of the bus alternative. In this model the fixed values for access time, travel time, cost and headway, that were presented to the respondents are not captured in the ASC. If all attribute values are equal to zero, bus would be the most preferred option.

TABLE 6.10: Parameter estimates of ASCs

	Extended ML EC with attribute specific parameters	Extended ML EC with generic parameters
ASC Combi	2.170	-3.81
ASC Flexi	4.710	-1.61
ASC bus	0	0

The model with generic parameters is estimated to get a better understanding of the ASCs. Although the model with generic parameters has a good performance, models with attribute specific parameters are used in the remainder of this study because they provide more information on the (small) differences between preferences for the attributes of the alternatives.

Conclusion

In this chapter sub-questions 1, 2, 3 and 4 are answered. Before answering these sub-questions, several choice models are estimated. The model that explains the data best is the mixed logit model with an error component and socio-demographic variables.

1. *Do attitudes towards flexibility and reliability influence the mode choice of bus travellers between rural bus, demand responsive transport services and a multimodal alternative that combines express bus and bike-sharing?* No latent factor for attitude towards flexibility and reliability was estimated. Instead, the statements were directly incorporated into the choice model. One statement proved to have a significant influence on the utility of Flexi. Individuals with a high distrust in transport services without fixed schedules have a lower preference for Flexi than individuals that trust transport services without fixed schedules. Furthermore, individuals with a high distrust in transport services without fixed schedules have a lower preference for Flexi than for the modes with fixed schedules, Combi and bus.

2. Do personal characteristics influence the mode choice of bus travellers between rural bus, demand responsive transport services and express bus services with bike-sharing as last mile transport? Yes, the socio-demographic variables age, gender and driving licence possession have an influence on mode choice. Men have a lower preference for Flexi than woman and men have a lower preference for Flexi than they have for Combi and bus.

Individuals under 30 have the highest preference for Combi followed by Flexi. Individuals between 30 and 60 years old have a higher preference for Combi than individuals over 60. Individuals that are younger than 30 have a higher preference for Flexi than individuals over 30. It can be concluded that individuals under 30 are more willing to use Combi and Flexi as an alternative for bus than older individuals.

Individuals with a driving licence prefer Flexi and Combi over the bus. Individuals with a driving licence have a higher preference for Combi and Flexi than individuals without a driving licence. Having a driving licence probably makes them less dependent on the current bus service.

3. Which mode attributes influence the mode choice of bus travellers between rural bus, demand responsive transport services and express bus services with bike-sharing as last mile transport? The mode attributes minimum booking time, access time, cost and in-vehicle travel time have a negative influence on the utility of Flexi.

The mode attributes travel time bus, access time, travel time bike and cost proved to have a negative influence on the utility of Combi. Bicycle availability has a positive effect on the utility of Combi.

Cost has the largest influence on utility per unit change, followed by access and egress time of Flexi and shared bicycle travel time. In-vehicle time of Flexi has the highest relative importance, closely followed by in-vehicle travel time with express bus of the Combi alternative.

4. What are the values of time for an express bus service with bike-sharing as last mile transport and a demand responsive transport services service? In-vehicle travel time is valued higher for Flexi than for Combi, the VoTTS are €15.29 and €12.08, respectively. In line with literature, access and egress times are valued higher than in-vehicle times. The VoTTS of access and egress time of Flexi is €25.10. Access and egress times of Combi are valued lower, the VoTTS of access time is €16.48 and the VoTTS of shared bicycle egress time is €20.85.

In the next chapter the sensitivity of the choice model towards operational characteristics is explored.

Part III

Application and results

7 Implications for network design

This chapter explores how sensitive the estimated choice model is towards changes in the design characteristics of the alternatives. First, the sensitivity of various design characteristics is tested in two situations. In the first situation the modal shares of Combi, Flexi and bus are simulated. These simulations give an indication of the effect of different design characteristics on the preferences for Combi, Flexi and bus. This situation provides knowledge on the preference of bus users for the alternatives Combi and Flexi relative to their preference for bus.

In the second situation, bus is excluded from all simulations to provide insight into the modal split in the scenario that bus is no longer available. However, notion should be taken to the fact that in the choice experiment respondents were never asked to choose an alternative if bus was no longer available. From the stated choice experiment it is concluded that 15% of the bus users do not consider Flexi and Combi in their modal portfolio. In the setting of the choice experiment, 71% of respondents consider Combi as a mode of transport and 68% of the respondents consider Flexi as a mode of transport. The preference for one of the modes depends on the values for the associated mode attributes as well as on the socio-demographic characteristics of the individual. In the forecasts, the assumption is made that all individuals shift to Flexi or Combi if the bus service is cancelled.

Next, several scenarios are developed and tested. The results of these scenarios will provide practical recommendations for the network design of Combi and Flexi.

7.1 Simulation of choice probabilities

The mixed logit model with the estimated parameter values is used to perform scenario analyses. The mixed logit probability function, presented in Equation 7.1, is used to compute the choice probabilities of the alternatives.

$$P_{ni} = \int L_{ni}(\beta) f(\beta) d\beta \tag{7.1}$$

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

$$L_{ni}(\beta) = \frac{e^{V_{ni}(\beta)}}{\sum_{j=1}^{J} e^{V_{nj}(\beta)}}$$

and $f(\beta)$ is a density function. $V_{ni}(\beta)$ is the observed portion of utility based on the parameters β. With a mixed logit model the logit function is evaluated at different β's with $f(\beta)$ as the mixing distribution (Train, 2009).

However, the integral of choice probabilities of mixed logit does not have a closed form, and needs to be simulated. To compute Equation 7.1, Equation 7.2 is simulated. The simulation of Equation 7.2 consists of making R draws v_n^r from density $f(v_n)$, calculating P_{ni} for each draw and averaging the results (Train, 2009). Equation 7.1 and 7.2 are adopted from Train (2009).

$$\check{P}_{ni}(\beta) = \frac{1}{R}\sum_{r=1}^{R} P_{ni}(\beta) \mid v_n^r \qquad (7.2)$$

The utility functions of Combi, Flexi and bus are provided in Equations 7.3, 7.4 and 7.5.

$$\begin{aligned} V_{\text{combi}} =& 2.170 + -0.117 * AT_{\text{combi}} + -0.0858 * TTBus_{\text{combi}} + -0.148 * TTBike_{\text{combi}} \\ &+ -0.00814 * H_{\text{combi}} + 0.0532 * BA_{\text{combi}} + -0.416 * C_{\text{combi}} + 1.32 * Licence \\ &+ 1.92 * Age1 + 1.35 * Age2 + \sigma_{NewMode} \end{aligned} \qquad (7.3)$$

$$\begin{aligned} V_{\text{Flexi}} =& 4.71 + -0.174 * AT_{\text{Flexi}} + -0.106 * TT_{\text{Flexi}} + -0.0105 * MBT_{\text{Flexi}} \\ &+ -0.011 * DD_{\text{Flexi}} + -0.416 * C_{\text{Flexi}} + -0.846 * Gender + 1.26 * Licence \\ &+ 1.13 * Age1 + -0.374 * ST4 + \sigma_{NewMode} \end{aligned} \qquad (7.4)$$

$$V_{\text{bus}} = 0 \qquad (7.5)$$

Where:

$$\sigma_{NewMode} \sim N(0, 2.06)$$

7.2 Design characteristics

Prior to designing the scenarios, the main characteristics of public transport network design are discussed. In network design a balance between opposing objectives is needed. The biggest difference exists between the user's optimum and the operator's optimum. The operator prefers the smallest possible network, while the user prefers the shortest possible travel time (van Nes, 2015). The main design dilemmas and their relation to the network design of Flexi and Combi are reviewed in this section.

The four design dilemmas defined by Van Goeverden and Van den Heuvel (1993) are discussed: short access times versus short in-vehicle times, short in-vehicle times versus short waiting times, short waiting times versus minimisation of transfers and minimisation of transfers versus short travel times. Additionally, some design dilemmas specific for the presented modes Flexi and Combi are addressed.

In public transport network design, stop density has an impact on access times. In a network with high stop density, access times are lower than in a network with low stop density. On the other hand, if a service has to stop at every stop this leads to very low operational speed and thus large in-vehicle travel time (van Nes, 2015).

The network density affects the waiting time of passengers. If the network has a high density, routes are direct and in-vehicle times are short. Conversely, there will be less busses per link, resulting in low frequencies and long waiting times (van Nes, 2015).

Line density influences the dilemma between short waiting times and the minimisation of transfers. High line density results in few transfers, but simultaneously causes low frequencies and long waiting times (van Nes, 2015).

The fourth and last design dilemma is the dilemma minimisation of transfers versus short travel times. If a transport network has multiple levels, the travel times are short. At the same time, different network levels lead to transfers between the network levels (van Nes, 2015).

When designing the Combi network, decisions have to be made regarding the express bus and bicycle part. The total in-vehicle time of Combi is affected by the number of stops and the density of the network. Networks with a low stop density and a low network density can offer short in-vehicle times and high frequencies. If the express bus service operates at a high network level and operates at high speed, this will result in having longer access and egress times. Furthermore, the bicycle fleet should be in line with the demand for bicycles. If passengers are not certain there is a bicycle available for their trip, this has a negative influence on utility.

The Flexi service has no fixed route or fixed schedules, different dilemmas apply to the design of the Flexi network than to the design of the Combi network. The minimum booking time of Flexi depends on the time it takes a vehicle to go to the pick-up place of the passenger. If the network area is large and there are not enough vehicles to fulfil demand, the minimum booking time will be high. The operator should make a trade-off between minimum booking times and fleet size.

The Flexi network has no fixed route, the in-vehicle time of Flexi is affected by the number of detours made to pick-up additional passengers. The operator has to decide what the maximum additional travel time caused by picking up additional passengers is, and has to adjust the fleet size to the demand. The density of the pick-up points of Flexi influences the size of the detours and thereby the in-vehicle travel time. Pick-up points can be the passenger's doorstep, fixed public transport stops or intersections. If the pick-up points are the passenger's doorstep, stop density is high and detours are large. When passengers can only select large intersections as pick-up points, the stop density is lower and detours are smaller.

Previous tests with DRT services show that it is difficult to make DRT services financially viable (Ryley et al., 2014). To make Flexi attractive and affordable for public transport users and simultaneously cost efficient for public transport operators, subsidies are probably needed.

The above mentioned design characteristics are used as policy and design measures to create different scenarios.

7.3 Reference scenario

In the following sections, multiple scenarios are developed to test the sensitivity of certain design characteristics on model shares. Various scenarios are tested to explore the sensitivity of the choice model to different operational characteristics. The impact of the following operational characteristics is explored: travel cost of Flexi and Combi, in-vehicle travel time of Flexi and Combi, access and egress times of Flexi and shared bicycle travel time of Combi.

A reference scenario is used, see Table 7.1. Average values for the operational characteristics of Flexi are chosen that are based on existing similar services, see Subsection 4.2.2. For Combi, the shared bicycle travel time is set on 6 minutes, which corresponds with an egress distance of 1.4 kilometres (assuming an average cycling speed of 14 km/h).

TABLE 7.1: Reference scenario

Reference scenario	Combi	Flexi	Bus
Access time [min]	6	4	4
In-vehicle travel time [min]	26	32	37
Egress time [min]		4	4
Shared bicycle travel time [min]	6		
Minimum booking time [min]		30	
Headway [min]	30		60
Cost [€]	3.50	3.50	3.00
Bicycle availability	6		
Departure delay [min]		0-10	

7.4 Sensitivity analyses

In this section the sensitivity of the attributes cost, in-vehicle time, access and egress time of Flexi and shared bicycle travel time is tested.

The utility contributions of departure delay, headway, minimum booking time, bicycle availability and access time of Combi are small (see Table 6.7 and Figure 6.1) and therefore the effect of these five design characteristics is not tested in the sensitivity analyses.

7.4.1 Modal share between Combi, Flexi and bus

In this section the influence of changes in the operational characteristics of Flexi and Combi on the model split between Combi, Flexi and bus is explored.

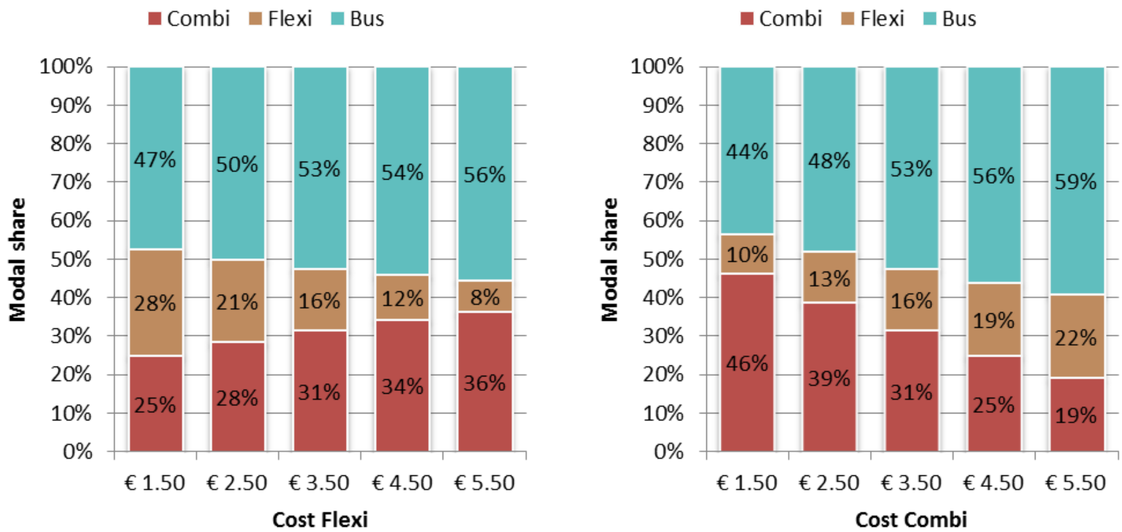
Sensitivity cost Flexi

Figure 7.1a displays the sensitivity of Flexi cost on the modal split. Decreasing the cost of Flexi with two euros results in an increase of modal share of 12%, increasing the cost with two euros results in a decrease of 8%. With increasing Flexi cost, the share of Bus and Combi increase with the same share.

Sensitivity cost Combi

The sensitivity of the cost of Combi on the modal split is visualised in Figure 7.1b. Varying the cost of Combi has a large effect on the modal split of Combi and bus, and a smaller effect on the share of Flexi. When the cost of Combi is €1.50, Combi has a higher (+2%) share than the bus. Combi and bus have the same modal share at when the cost of combi is €1.65. Varying the cost of Combi has a larger effect on the bus share than on the Flexi share. Varying the cost of Combi has a smaller influence on the modal share, than varying the cost of Flexi has.

Even if the costs of Combi are high, €5.50, the modal share is still 19%. The conclusion is drawn that individuals are willing to trade comfort, in other words not having to cycle, for a lower fare.



(A) Sensitivity cost Flexi (B) Sensitivity cost Combi

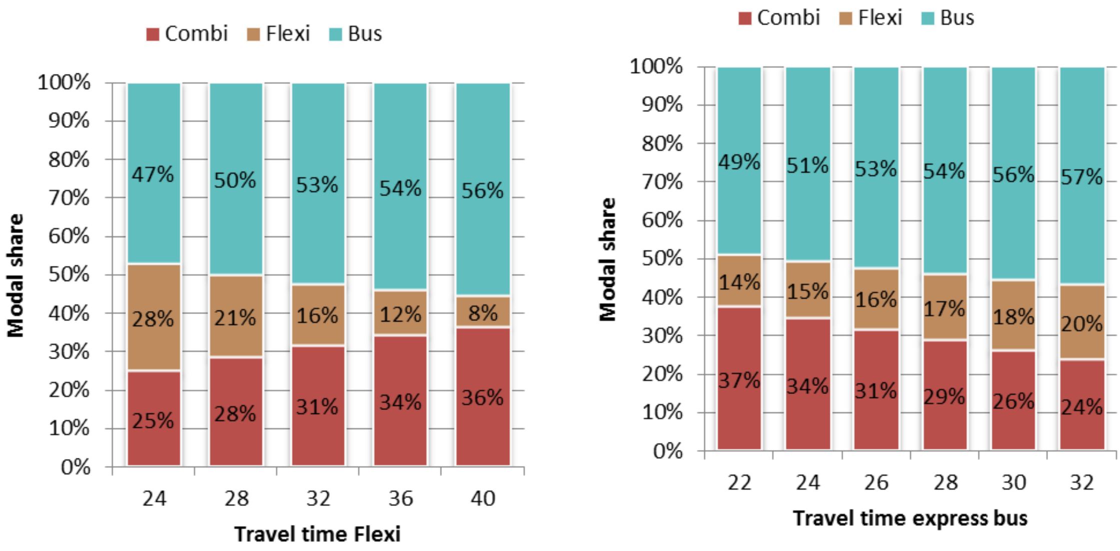
FIGURE 7.1: Sensitivity cost

Sensitivity in-vehicle time Flexi

The influence of the in-vehicle travel time of Flexi on modal split is visualised in Figure 7.2a. Changing the in-vehicle time of Flexi with 4 minutes has a similar effect on modal split as changing the cost of Flexi with 1 euro. An 8 minute decrease in travel time (compared to the reference scenario) results in a 12% increase in modal share of Flexi. If the travel time of Flexi is 26 minutes, both Combi and Flexi have a modal share of 26%. Changing the travel time of Flexi has a slightly larger effect on the share of Combi than on the share of bus. Shorter in-vehicle times can attract more passengers to Flexi.

Sensitivity in-vehicle time express bus Combi

The sensitivity of the in-vehicle time of express bus of Combi on the modal split is visualised in Figure 7.2b. A 4 minute decrease of vehicle time increases the model share with 6%. Changes in express bus travel time have a similar effect on the modal share of Flexi as on the modal share of bus. For the largest in-vehicle time tested, 32 minutes, the share of Combi is 24%. For the lowest in-vehicle time it is 37%.



(A) Sensitivity in-vehicle travel time Flexi

(B) Sensitivity in-vehicle travel time express bus Combi

FIGURE 7.2: Sensitivity in-vehicle travel time

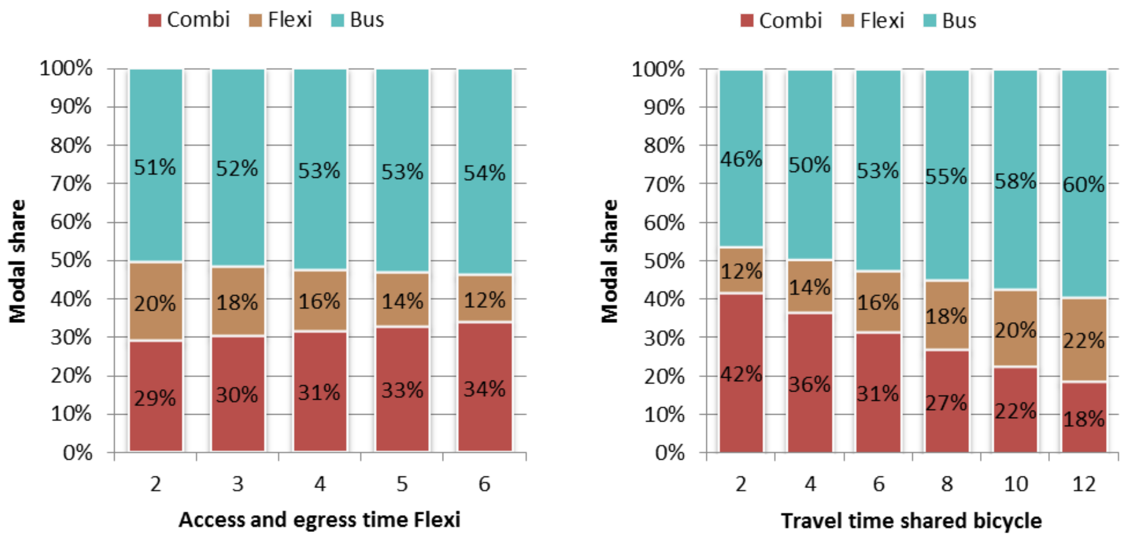
Sensitivity access and egress time Flexi

The sensitivity of combined access and egress time of Flexi on the modal split is visualised in Figure 7.3b. When the access time is very low, 2 minutes of walking on both sides of the trip, the share of Flexi is 20%. This is an increase of 4% relative to the reference scenario. With increasing access and egress times, slightly more individuals shift to Combi than to bus. This outcome suggests that people have a larger preference for Flexi when access times are very low.

Sensitivity shared bicycle travel time Combi

The influence of shared bicycle travel time on modal split is visualised in Figure 7.3a. A lower shared bicycle travel time attracts travellers from bus and Flexi towards Combi. If bicycle travel time is 2 minutes the share of Combi is 42%. When the bicycle travel time is 12 minutes, the share of Combi decreases to 18%.

Designing the Combi network in such a way that the egress time with the shared bicycle is low, can attract travellers from bus to Combi.



(A) Sensitivity access and egress time Flexi (B) Sensitivity egress time shared bicycle Combi

FIGURE 7.3: Sensitivity access and egress times

7.4.2 Modal share between Combi and Flexi

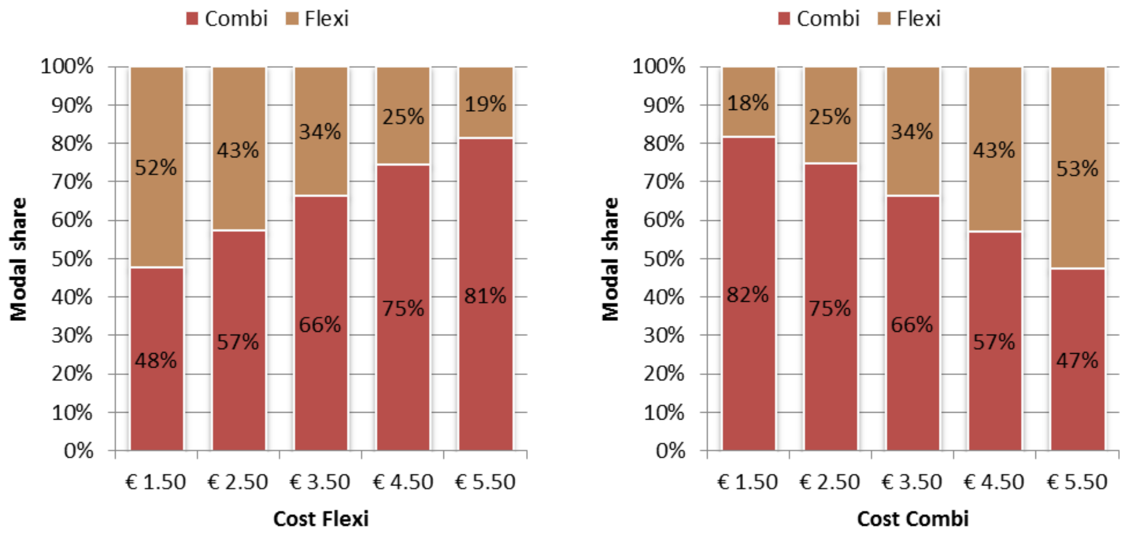
The influence of operational characteristics on modal split between Combi and Flexi is explored and visualised. Bus is excluded from the analyses and the assumption is made that all individual shift to Combi or Flexi when the bus service is cancelled. The same attributes are tested as in the previous section.

Sensitivity cost Flexi

The cost of Flexi vary from €1.50 to €5.50, this is visualised in Figure 7.4a. Lowering the fare of Flexi with 2 euros increases the share of Flexi with 18% to 52%. Lowering the costs of Flexi with one unit has the same effect on the modal share as increasing the costs of Combi with one unit.

Sensitivity cost Combi

The sensitivity of the cost of Combi on the modal split is explored and visualised in Figure 7.4b. The cost of Combi varies from €1.50 to €5.50. Decreasing cost with 2 euros, increases the share of Combi with 15%. This effect is slightly smaller than the effect of decreasing the cost of Flexi with 2 euros. However, if Combi and Flexi have an equal fare, Combi is more popular.



(A) Sensitivity cost Flexi

(B) Sensitivity cost Combi

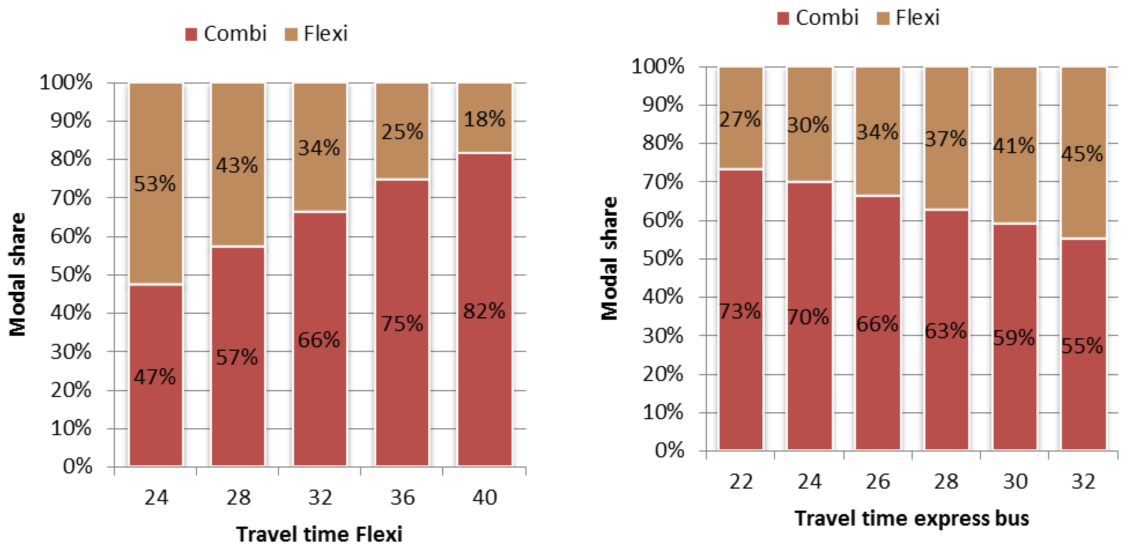
FIGURE 7.4: Sensitivity cost (scenario without bus)

Sensitivity in-vehicle time flexi

In Section 6.4 it was concluded that in-vehicle time of Flexi has a high relative importance. In this scenario the impact of varying in-vehicle times is explored. A reduction of in-vehicle travel time can attract more Flexi users, Figure 7.5a illustrates this. A 4 minute decrease in travel time increases the modal share of Flexi with 9%. When the travel time of Flexi is almost 25 minutes, Flexi and Combi both have a share of 50%.

Sensitivity in-vehicle travel time bus Combi

In this scenario, the model split for different values of in-vehicle travel time of bus is explored. Figure 7.5b displays the model split under various express bus travel times. To accomplish lower in-vehicle times, the operational speed of the express bus needs to increase. Operational speed can be increased when the number of stops decreases. For the lowest tested in-vehicle time of 22 minutes the share of Combi is 73%. Four minutes less in-vehicle results in a 7% increase in modal share.



(A) Sensitivity in-vehicle travel time Flexi

(B) Sensitivity in-vehicle travel time express bus Combi

FIGURE 7.5: Sensitivity in-vehicle travel times (scenario without bus)

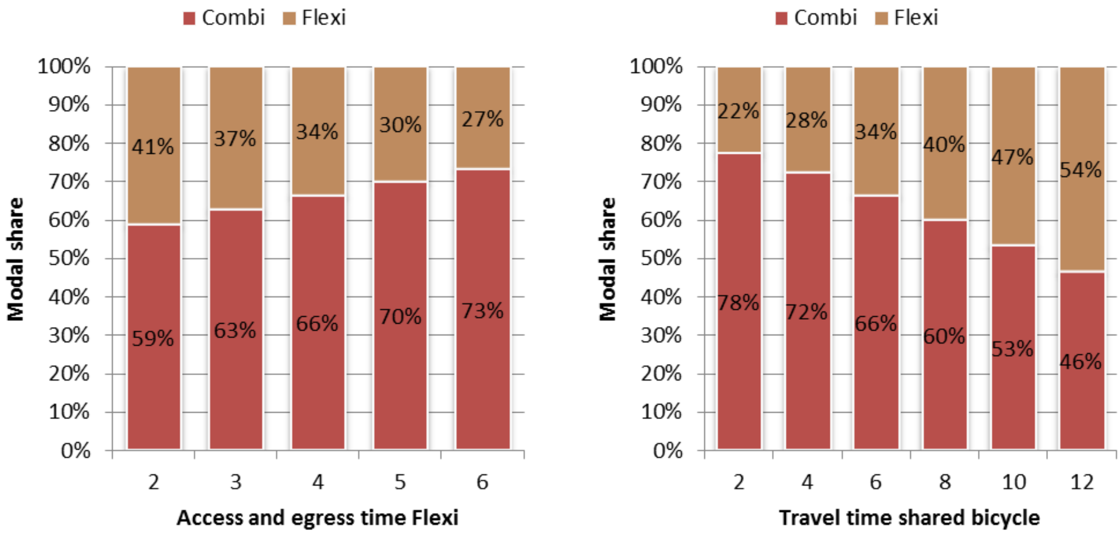
Sensitivity access and egress time Flexi

In this scenario, the sensitivity of access and egress times of Flexi on mode choice is explored, illustrated in Figure 7.6a. The combined access and egress time in the reference scenario is eight minutes, four minutes of walking on both sides of the trip. For an access and egress time of four minutes, the share of Flexi is 34%. If walking times are decreased to 2 minutes of walking on each side of the trip, the share of Flexi increases with 7% to 41%.

Sensitivity shared bicycle travel time

To explore the effect of shared bicycle travel time on the modal split, in this scenario the shared bicycle time is varied between 2 and 12 minutes. The effect on modal split is illustrated in Figure 7.6b. When bicycle travel time is 11 minutes, Combi and Flexi both have half of the modal share.

Even if the bicycle travel time is high, bus users are still choosing Combi. Assumed was that respondents would have a higher aversion towards cycling, but for 10 minutes of cycling still 53% of bus users prefers Combi over Flexi



(A) Sensitivity access and egress time Flexi (B) Sensitivity egress time shared bicycle Combi

FIGURE 7.6: Sensitivity access and egress times (scenario without bus)

7.4.3 Conclusion sensitivity analyses

From the previously presented simulations, it can be concluded which operational characteristics need to be changed to let Combi and Flexi compete with bus. Within the attribute ranges tested, the operational characteristics shared bicycle travel time and cost Combi have the largest influence on the shift away from bus.

Travellers that are attracted to Flexi are a bit more likely to shift to Combi if the circumstances of Flexi get less attractive. Making Combi more attractive has a larger effect on the share of bus than making Flexi more attractive has on the share of bus. In conclusion, Combi can compete more with bus than Flexi can compete with bus.

In the second situation, where it is assumed that the bus service is cancelled and all bus passengers choose one of the proposed alternatives, Combi has a higher modal share than Flexi in the reference scenario. In the reference scenario the share of Combi is 66% and the share of Flexi is 37%.

To attract more passengers to Combi operators should focus on lowering fares and decreasing the shared bicycle time.

If an operator wants to attract more passengers to Flexi, decreasing the cost of Flexi, decreasing access and egress times and greatly decreasing the in-vehicle travel time of Flexi are the most effective methods.

Because of the setting of the simulation, a decrease in the utility of one of the alternative automatically resulted in an increase of the other alternative. It was proven that it is difficult to increase the share of Flexi, if an operator wants to have a higher share of Flexi improvements in more than one operational characteristic are needed, for example a lower stop density and lower fares. The next section discusses scenarios with improvements in multiple design characteristics.

7.5 Scenario analyses

In this section, five scenarios are developed and tested to help operators choose a strategy for the network design of Flexi and Combi. As in the previous section, the scenarios are tested for two situations. A situation where the three alternatives Combi, Flexi and bus are present. And another situation where the bus service is cancelled and the assumption is made that all passengers shift to Combi or Flexi. The five developed scenarios will be explained in the following paragraphs. The same reference scenario is used as in the sensitivity analyses.

7.5.1 Scenario 1: high frequency Combi network

In the first scenario the Combi network is highly developed. The access time is long, 8 minutes (approximately 670 meters), and in-vehicle times are short. In this scenario the bus operates at a speed of approximately 30 km/h. The cycling distance is 1,4 kilometres, equal to 6 minutes of cycling. The express bus departs every 10 minutes. For the bus users that are not able or willing to use Combi, that has shared bicycle as an egress mode, the Flexi service can be offered to meet the mobility needs of those public transport users. The access and egress times are very low, 2 minutes walking on both sides of the trip. All attribute values of this scenario are displayed in Table 7.2.

In the situation with all three alternatives, Combi has a modal share of 46%, see Figure 7.7, an increase of 15% compared to the reference scenario. Flexi has a share of 11%. Compared to the reference scenario the share of bus decreased with 9% to 44%. Offering Combi at high speed with high frequencies will attract bus users to Combi.

In the second situation, were the assumption is made that all bus travellers shift to Combi or Flexi when the regular bus service is cancelled, Combi has a share of 78%. This is an increase of 12% compared to the reference scenario, see Figure 7.8. Flexi has a share of 22%.

Offering high speeds and high frequencies is an effective way to attract passengers to Combi. To offer high speed, the stop distance needs to be high. To offer a service at a high frequency, more vehicles are needed (but when operation speed increases the number of vehicles needed decreases again) and operational costs are higher.

TABLE 7.2: Scenario 1: high frequency Combi network

Scenario 1	**Combi**	**Flexi**	**Bus**
Access time [min]	**8** (+2)	**2** (-2)	4
In-vehicle travel time [min]	**22** (-4)	**35** (+3)	37
Egress time [min]		**2** (-2)	4
Shared bicycle travel time [min]	6		
Minimum booking time [min]		**15** (-15)	
Headway [min]	**10** (-20)		60
Cost [€]	3.50	3.50	3.00
Bicycle availability	6		
Departure delay [min]		0-10	

7.5.2 Scenario 2: fast express bus with long egress times

In the second scenario, the express bus has a high speed like in Scenario 1. In this scenario the access time is shorter, but egress time with shared bicycle is longer. The shared bicycle time is 8 minutes, almost 2 kilometres. In this scenario the cost of Combi is set on €2.50. For all attribute values, see Table 7.3

The modal shares in the situation with three alternatives are presented in Figure 7.7 and the modal shares in the situation without regular bus are visible in Figure 7.8. In the first situation, the share of bus is decreased with 5% compared to the reference scenario. Flexi has a decrease of 3%, resulting in a share of 13%. The modal share of Combi is 40%.

In the situation without bus, the share of Combi is 76% and the share of Flexi 24%. The share of Combi is slightly lower than in Scenario 1.

As was clear from the previous scenario, high speed attracts users to Combi. Also lowering the cost has a positive effect on the utility of Combi. Even if the egress time is high, Combi is still popular. As was seen in the sensitivity analyses, respondents are willing to trade comfort for lower fares. Operators can offer a Combi service with high access and egress times at low fares and still attract a lot of users.

TABLE 7.3: Scenario 2: fast express bus with long egress times

Scenario 2	**Combi**	**Flexi**	**Bus**
Access time [min]	6	4	4
In-vehicle travel time [min]	**22** (-4)	32	37
Egress time [min]		4	4
Shared bicycle travel time [min]	**8** (+2)		
Minimum booking time [min]		30	
Headway [min]	30		60
Cost [€]	**2.5** (-1)	3.50	3.00
Bicycle availability	6		
Departure delay [min]		0-10	

7.5.3 Scenario 3: high density Flexi network

In Scenario 3 the Flexi network is improved. Access and egress times are very short, 2 minutes on each side of the trip (approximately 170 meters). Also, the in-vehicle time is lower than in the reference scenario. The minimum booking time is set at 15 minutes. See Table 7.4 for all attribute values.

In this scenario Flexi is more popular than Combi, the modal share of Flexi is 29% and the modal share of Combi is 24%. The regular bus is still very popular with a share of 47%, a decrease of 6% compared to the reference scenario. Also in the situation without bus Flexi has a higher modal share than Combi, 54% and 46% respectively. See Figure 7.7 and Figure 7.8 for all modal shares.

To accommodate a Flexi service with smaller in-vehicle times and access times, the vehicle can not make too many detours and stops. Making detours and stops increases the in-vehicle time. The fleet size should be sufficiently large.

TABLE 7.4: Scenario 3: high density Flexi network

Scenario 3	**Combi**	**Flexi**	**Bus**
Access time [min]	6	**2** (-2)	4
In-vehicle travel time [min]	26	**28**(-4)	37
Egress time [min]		**2** (-2)	4
Shared bicycle travel time [min]	6		
Minimum booking time [min]	30	**15** (-15)	
Headway [min]			60
Cost [€]	3.50	3.50	3.00
Bicycle availability	6		
Departure delay [min]		0-10	

7.5.4 Scenario 4: node-to-node Flexi network

In this scenario a node-to-node Flexi network is proposed. Instead of picking passengers up close to their doorstep as was done in the previous scenario, in this scenario central and easy to reach points are chosen as Flexi stops. The in-vehicle time of Flexi is low, but the access and egress times are higher than in the previous scenario. See Table 7.5 for all attribute values.

The modal shares are presented in Figure 7.7 and Figure 7.8. The share of Flexi increases with 19% compared to the reference scenario. The share of bus decreases with 9% compared to the reference scenario.

To decrease the in-vehicle time of Flexi, the number of detours and stops should be limited and enough vehicles should be available to meet the demand.

TABLE 7.5: Scenario 4: node-to-node Flexi network

Scenario 4	**Combi**	**Flexi**	**Bus**
Access time [min]	6	4	4
In-vehicle travel time [min]	26	**24** (-8)	37
Egress time [min]		4	4
Shared bicycle travel time [min]	6		
Minimum booking time [min]	30	30	
Headway [min]			60
Cost [€]	3.50	**2.50** (-1)	3.00
Bicycle availability	6		
Departure delay [min]		0-10	

7.5.5 Scenario 5: best of both worlds

In the previous scenarios one of the two alternatives was improved. In this scenario both Combi and Flexi are improved to see if this has a larger effect on the shift from bus towards the alternatives. Scenario 2 and 4 are combined to form Scenario 5, see Table 7.6.

Again, the results of the scenario analyses are presented in Figure 7.7 and Figure 7.8. Scenario 5 has the lowest share of bus, 41%. Even if both the alternatives are made more attractive, the share of the regular bus is still high. In the situation with regular bus present, Combi and Flexi almost have an equal modal share, 28% and 30% respectively.

In the situation were only Combi and Flexi are present, the modal share of Combi is 49% and the share of Flexi is 51%. Although, the Combi mode has larger access and egress times than Flexi, Flexi and Combi have an almost equal modal share.

TABLE 7.6: Scenario 5: best of both worlds

Scenario 5	**Combi**	**Flexi**	**Bus**
Access time [min]	6	4	4
In-vehicle travel time [min]	**22** (-4)	**24** (-8)	37
Egress time [min]		4	4
Shared bicycle travel time [min]	**8** (+2)		
Minimum booking time [min]	30	30	
Headway [min]			60
Cost [€]	**2.50** (-1)	**2.50** (-1)	3.00
Bicycle availability	6		
Departure delay [min]		0-10	

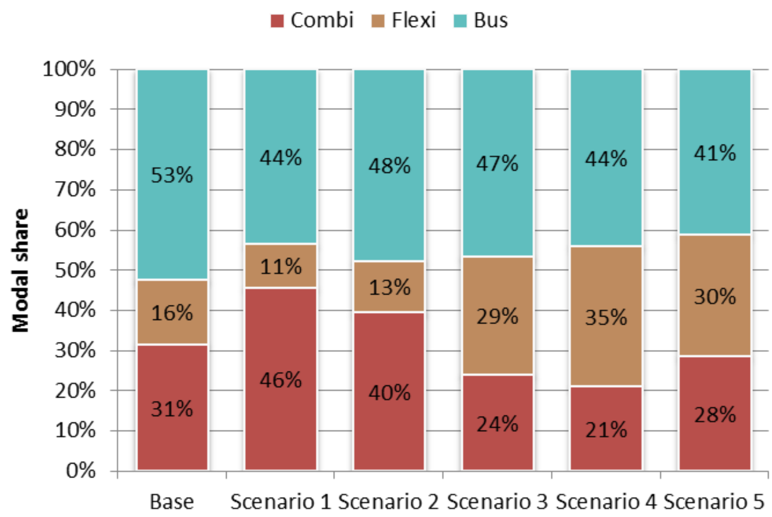


FIGURE 7.7: Scenario analysis

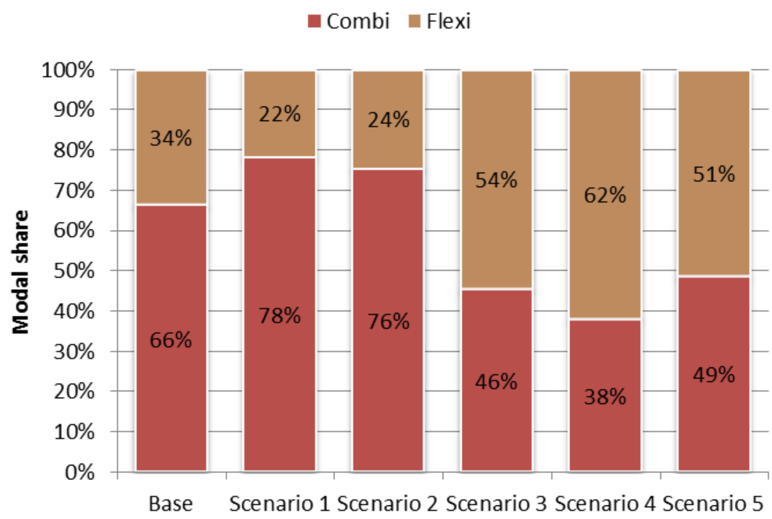


FIGURE 7.8: Scenario analysis without bus service

7.5.6 Conclusion

In the scenarios tested the lowest share of bus was 41%. Based on the modal portfolios, 85% of the bus users are willing to shift from bus to Combi or Flexi. In the scenario analyses a share of bus of 20% could only be achieved in the most ideal circumstances from the traveller's perspective, this resulted in an unrealistic scenario with very low cost, low in-vehicle travel times and low access and egress times, therefore this scenario is not reported.

Based on the results from the tested scenarios, it can be concluded that it is easier to have a high Combi share than a high share of Flexi. Scenario 1, which has a lower shared bicycle egress time than Scenario 2, predicted the highest share of Combi. Both scenarios have lower in-vehicle times than the reference scenario, this also attracts users to Combi.

Bus users prefer a node-to-node Flexi network that has lower in-vehicle time but larger access and egress times, over a door-to-door Flexi network. When both Combi and Flexi are made attractive, Combi and Flexi both have a share of approximately 50%.

For the operator to achieve low in-vehicle times the right balance of stop density and network density needs to be found. A low stop density results in short in-vehicle times, but also leads to high access times. High access times have a negative effect on the utility of both Combi and Flexi. Low network densities, the total length of public transport links per square kilometre, result in high frequencies and short waiting times. On the other hand, low network densities lead to longer in-vehicle times.

Regarding the fares of Flexi and Combi, lower fares will attract more costumers. However, public transport operators should decide for which fare they can operate a cost-effective service. DRT services exist that are driven by volunteers, for example TwentsFlex, this can reduce the operating costs for operators.

8 Discussion

In this section the validity of the results and the differences with expectations are discussed. First, some limitations of the research design are discussed. Next, the results of this study are compared with previous work.

8.1 Limitations in research design

Some decisions were made in the design of the research that may have affected the outcome of the research. The conclusions presented in Section 9.1 have to be interpreted while keeping the setting of the experiment in mind. The next paragraphs present some limitations of the research.

First, the bus was included in the choice experiment to prevent respondents from being afraid that their current bus service would be cancelled. Because invitations to the survey were handed out at bus stations with permission of a Dutch public transport operator, it was not possible to directly ask respondents for their behaviour if their bus service was cancelled. Because of this limitation, it was not possible to observe if respondents are willing to use Combi or Flexi when the regular bus is cancelled or shift to other forms of transportation. Instead, this research gives insights into the preference of bus users for Combi and Flexi relative to the bus.

In Section 7.4.2 the assumption was made that all bus users shift to Combi or Flexi in case the bus service is cancelled to be able to predict the modal share between Combi and Flexi. In the choice experiment, 15% of the respondents always choose bus, in Section 7.4.2 it was assumed that these respondents also shift to Combi or Flexi if the bus service is cancelled. When interpreting the conclusions of Section 7.4.2 this assumption should be kept in mind, because it might have influenced the modal shares.

Second, for simplicity reasons, the bus alternative had fixed attribute levels. Because of this, no parameters are estimated for bus. The utility function of bus only included an alternative specific constant. The influence of changes in the attribute levels of the bus on the mode choice of bus users cannot be measured with the models with alternative specific attributes estimated in this study. Because fixed values for travel time, access time, frequency and costs for bus were given in the choice experiment, these values are represented in the ASC of bus. The only possibility to estimate the complete utility function of bus is with the use of generic attributes, this was done in Section 6.6.

Third, the choice experiment was set up in a way that respondents always had to choose one of the three available alternatives. It was not possible to choose to not make the trip or use other forms of transport if all alternatives were unattractive for the respondent. Because of this, thresholds for attribute levels corresponding with no longer willing to use any of the alternatives cannot be calculated.

Fourth, the context of the choice experiment presented to the respondents included the weather forecast at the time of the trip. In the condition of the experiment the temperature was 16 degrees Celsius and there was no rainfall. Other weather forecasts could have resulted in different parameter values for the active parts of the trip. Research of Böcker and Thorsson (2014) proved that temperature and precipitation influence the mode choice of travellers in the Netherlands. Precipitation has a negative influence on the choice for bicycle and cycling shares peak on days with a maximum air temperature between 20 and 25 degrees Celsius Böcker and Thorsson (2014).

Reactions from respondents indicated that respondents did not only base their preference for bicycle availability on the number of bicycles available. Respondents took the bicycle travel time into account when assessing the bicycle availability. They stated that they preferred very short shared bicycle travel times if the bicycle availability at the beginning of the trip was low. They stated that they considered covering the distance on foot if no bicycle was available for the egress part of the trip.

8.2 Comparison with previous work

In this subsection the results of the research are compared with findings from previous research.

Zijlstra et al. (2018) performed a small choice experiment where bus users were asked to choose between two public transport solutions, the solutions varied in type of service (door-to-door or stop-to-stop), punctuality, fare, travel time, presence of fellow passengers and frequency (fixed schedule or demand responsive).

Cost proved to be the most important explanatory factor for mode choice. This is in line with the results found in our study that cost has a high impact on utility per unit.

Other findings from Zijlstra et al. (2018) were that respondents assess unreliability in departure times as very negative. In our study punctuality was not found to have a significant effect at a 95% confidence interval on the preference for Flexi. It was assumed that this would negatively affect the utility of Flexi.

Zijlstra et al. (2018) found that respondents preferred a fixed schedule over booking in advance. A higher minimum booking time was found to have a larger negative impact than shorter booking times, the same result was found in our research. In our study the parameter estimate for frequency was found to be not significant at the 95% confidence interval, so no comparison between the utility of frequency and minimum booking time can be made.

Ryley et al. (2014) simulated mode share of DRT services against bus or car travel from mixed logit models with panel data. They investigated six DRT service variants including a service linking rural settlements to a market town. For this scenario, they assumed a passenger journey length of 11 to 13 kilometres, journey time of 30 minutes (speed 25-30 km/h), a 10 minute waiting time and egress time of 10 minutes. In the tested scenario the bus service had a journey time of 20 minutes and a return fare of £8.00 (€10.00). Three different return fares were tested: £5.00 (€6.30), £8.00 (€10.00) and £11.00 (€13.80). DRT had a mode share of 63%, 38% and 18% for a return fare of £5, £8 and £11 respectively.

In the scenario tested by Ryley et al. (2014) bus has a shorter journey time than DRT, 20 minutes versus 30 minutes. For an equal return fare, the share of DRT is still relatively high with 38%. If DRT had a lower fare than bus, the share was much bigger. In the model of Ryley et al. (2014) the differences between the values of the ASCs of bus and DRT are much smaller than in the model estimated in our study.

A similar simulation was run with the model estimated in this research. The assumption is made that in the situation without a Combi service, all travellers choose between Flexi and bus and do not shift to another mode. See Appendix D.1 for all attribute values. In this scenario the share of Flexi was 24% and the bus share was 76%, see Appendix D.1 for the complete simulation report. In our study lowering the cost had a smaller effect on the share of Flexi than it had in the study of Ryley et al. (2014).

The study of Ryley et al. (2014) differs from our study in terms of the variables used in the choice experiment and the survey location. Furthermore, the share of respondents without a driving licence was much higher (88%).

Another study that assesses the demand for DRT is the study of Frei et al. (2017). In this study, the demand for flexible transit in the Chicago regions is assessed. A stated preference survey was conducted where respondents could choose between traditional public transport, car and a hypothetical flexible transport service. From the different policies tested, reducing the in-vehicle time proved to be the policy that resulted in the greatest shift towards DRT. Even when time saving is compensated with a price increase, the shift towards DRT holds. This suggests that users are willing to pay for a significant saving in in-vehicle time.

In this research reducing the in-vehicle time of Flexi with four minutes had the same effect on modal share as decreasing the cost with 1 euro. When decreasing the in-vehicle time with 8 minutes and at the same time increasing the cost with 2 euros, the share of Flexi was equal to share of Flexi in the base scenario, see the simulation report in Appendix D. This suggests that the respondents from our study are not willing to pay for a significant saving in in-vehicle time.

Other findings of Frei et al. (2017) are that individuals between 51-69 are the most likely of all age groups to choose DRT. Individuals between 18 and 34 were also more likely to choose DRT, but to a lesser extent. The possible reason for this according to Frei et al. (2017) is that people in those age groups have more flexible schedules than individuals between 35 and 50.

In our research, opposing results are found, namely that individuals under 30 have a higher preference for DRT than individuals over 30. It is presumed that younger individuals are more open to try out new modes.

Not all findings from our study match findings from previous research. The finding that cost and in-vehicle time have a large impact on the preference for DRT like services corresponds with the findings in this survey. The differences in results are probably the result of different experiment settings. None of the experiments included the same alternatives in the choice set as this research, and none of the studies included an alternative similar to Combi. The experiments of Ryley et al. (2014) and Frei et al. (2017) were also not conducted in the Netherlands, but in the United Kingdom and the United States of America. The first research targeted urban respondents but the second research targeted respondents in the City of Chicago.

9 Conclusions and recommendations

This research investigated the preferences of bus users in rural areas for alternative public transport. The conclusions of the research are presented in Section 9.1. In Section 9.2, recommendations for practice and future research are presented.

9.1 Conclusions

This study answered the following research question:

"What are the preferences of bus users in rural areas of the Netherlands for a demand responsive transport service and a multimodal alternative that combines express bus and bike-sharing?"

Two alternatives for the bus were investigated: a demand responsive transport service called "Flexi" and a multimodal transport mode that combined an express bus service with shared bicycles for last mile transport, called "Combi". A stated choice experiment was executed to find the preference of bus users for bus, Combi and Flexi.

To help answer the main research question, several sub-questions were formulated. The main research question will be answered based on the answers to the sub-questions presented in the following section.

1. Do attitudes towards flexibility and reliability influence the mode choice of bus travellers between rural bus, demand responsive transport services and a multimodal alternative that combines express bus and bike-sharing?

Because no latent variable for flexibility and reliability could be derived, the attitudinal statements were directly incorporated into the choice model. One of the six attitudinal statements proved to have a significant influence on the utility of Flexi. Individuals with a high distrust in transport services without fixed schedules have a lower preference for Flexi than individuals that trust transport services without fixed schedules. Logically, individuals that have no trust in transport services without fixed schedules have a higher preference for the alternatives with fixed schedules, Combi and bus. Furthermore, 96% of the respondents indicated that they like fixed schedules, 44% of the respondents state they do not trust transport services without fixed schedules. What can be concluded is that fixed schedules are highly appreciated. The fact that Flexi does not have a fixed schedule might make this mode less attractive.

2. Do personal characteristics influence the mode choice of bus travellers between rural bus, demand responsive transport services and a multimodal alternative that combines express bus and bike-sharing?

Several socio-demographic variables were added to the choice model to test which personal characteristics have a significant influence on the mode choice. Age, driving licence possession and gender proved to have an influence on the mode choice between Combi, Flexi and bus.

Of all age groups, individuals under 30 are most likely to choose Combi, individuals between 30 and 60 are also more likely to choose Combi but to a lesser extent than individuals under 30. Individuals under 30 are the most likely to choose for Flexi compared to individuals of other ages. From all alternatives, individuals under 30 have the highest preference for Combi followed by Flexi. It is assumed that younger individuals are more open to try out new forms of public transport. Furthermore, it is assumed that younger individuals have a higher preference for Flexi than older individuals because their schedule is more flexible. The fact that individuals over 60 have the lowest preference for Combi might be because the alternative has shared bicycles for the egress part of the trip, this takes physical effort which might be not preferred for individuals over 60.

Individuals with a driving licence have a higher preference for Combi and Flexi than individuals without a driving licence. Bus users with a driving licence probably are not dependent on Combi and Flexi for all their trips, and might have the possibility to use other means of transport for trips where reliability is very important. Presumably, bus users without a driving licence are captives of public transport and therefore more dependent on the current bus service. This might result in having a lower preference for Combi and Flexi, that possibly have lower reliability.

Last, gender proved to influence the preference for Flexi. Men are less likely to choose Flexi than women and are more likely to choose Combi or bus.

3. Which mode attributes influence the mode choice of bus travellers between rural bus, demand responsive transport services and a multimodal alternative that combines express bus and bike-sharing? In the choice experiment attributes that apply to all alternatives, such as access and egress time, travel time, cost and headway, were included. Also, attributes specific for the introduced alternatives Combi and Flexi were included. Shared bicycle travel time and bicycle availability were included for Combi and minimum booking time, departure delay and travel time deviation were included for Flexi. The attribute travel time deviation was removed from the choice model because it had a positive sign where a negative sign was expected, possibly respondents did not understand this attribute.

All mode attributes had a negative effect on utility, except for bicycle availability. Bicycle availability has a positive effect on the utility of Combi. The access time of Flexi is perceived as more negative than the access time of Combi. In-vehicle time of Flexi is perceived slightly more negative than in-vehicle time of express bus. An increase in cost is valued almost equally negative for Combi as for Flexi.

Cost has the largest influence on utility per unit change, followed by access and egress time of Flexi and shared bicycle travel time. In-vehicle time of Flexi has the largest impact on utility for the attribute level range used in the choice experiment, closely followed by in-vehicle travel time with express bus of the Combi alternative.

The mode attributes specific for Combi and Flexi have a much lower influence on the utility of Combi and Flexi than the general attributes access and egress time, in-vehicle travel time and cost. Implying that the attributes specific for Combi and Flexi, such as departure delay, minimum booking time and bicycle availability, have a smaller influence on the mode choice of bus users than generic attributes.

4. What are the values of time for an express bus service with bike-sharing as last mile transport and a demand responsive transport services service?

The values of travel time savings were calculated for the different trip parts. Bus users value access and egress time higher than in-vehicle times, this is in line with previous research (Wardman, 2004). The obtained VoTTS of in-vehicle time of express bus is 12.18 euro per hour. The obtained VoTTS of Flexi is higher, 15.37 euro per hour. This suggests that bus users associate more negative utility for travelling by Flexi than by express bus. This is possibly due to the fact that longer travel times of Flexi are caused by picking up additional passengers and thus are perceived more negative than longer travel times with express bus which are not caused by additional passengers.

Individuals are willing to pay more for one minute of access time of Flexi saved than for one minute of access time of Combi saved, €0.42 and €0.27 respectively. More disutility is associated with the shared bicycle as an egress mode of Combi than walking as an access mode, individuals are willing to pay €0.35 for a minute saved of cycling with a shared bicycle and €0.27 for a minute saved of walking time.

5. Which changes in design characteristics can attract bus users towards demand responsive transport services and express bus services with bike-sharing as last mile transport?

Within the attribute level ranges used in the choice experiment, the effect of varying values for various attributes was tested. In the designed reference scenario that included Combi, Flexi and bus with realistic attribute values, bus has the highest modal share (53%), followed by Combi (31%) and Flexi (16%).

More passengers can be attracted to Combi if the in-vehicle times are short, shared bicycle travel times are short and costs are low. From the network design perspective it is not possible to lower all these design characteristics at the same time. To decrease shared bicycle travel time, the stop distance has to decrease. A decrease in stop distance also results in longer in-vehicle travel times. The effect on utility of one minute change in travel time is lower than the effect of one minute change in shared bicycle travel time. Suggesting that it is more beneficial for operators to decrease the stop distance so that egress time with the shared bicycle is short than to focus on lowering in-vehicle travel times. However, operators must be careful that the positive effects of shorter access times are not cancelled out by the longer in-vehicle times.

The modal share of Flexi can be increased by decreasing the in-vehicle travel time and offering the service at a lower fare. The in-vehicle time is not only dependent on the stop density of the Flexi network, but also on the number and length of detours made to pick-up additional passengers. To decrease in-vehicle time stop density should be lower and detours should be kept small. With decreased stop density, access times increase which has a negative effect on the preference for Flexi. However, from scenario 4 and 5 it was concluded that a node-to-node Flexi network results in a higher share of Flexi than a network with very short access times but longer in-vehicle times.

To come back to the main research question, both mode characteristics as personal characteristics influence the preferences of bus users for Combi and Flexi. Cost have the largest negative effect per unit (€) on the preference for Flexi and Combi, followed by access and egress times. Walking as an access mode has larger negative effect on the preference for Flexi than for Combi. The in-vehicle travel time has the largest negative effect on the total utility of the alternatives within the ranges used in this study. In-vehicle time of Flexi is perceived as more negative than in-vehicle time of express bus.

The networks of Combi and Flexi can be designed in such a way that the modes are more attractive for bus users. However, in all the scenarios tested the conventional bus still has a high modal share. Suggesting that although the design characteristics of Flexi and Combi networks are made more attractive, still a large number of individuals prefers the conventional bus service over Combi and Flexi.

9.2 Recommendations

Recommendations for practice and future research are presented in this section.

9.2.1 Recommendations for practice

In the following subsections, recommendations for transport operators and authorities for network design and on the potential users of Flexi and Combi are given.

Recommendations for network design

Based on the parameter interpretation, sensitivity analyses and scenario analyses it can be concluded that cost, access and egress times and in-vehicle time have the largest effect on the preferences for Combi and Flexi. Public transport operators that want to attract passengers to Combi should mainly focus on lowering cost and egress time with shared bicycles. The most passengers can be attracted to Flexi by having low access times, low in-vehicle travel times and low cost.

The network design characteristic that has an influence on the access and egress times and on the in-vehicle times of Combi is the stop distance. The stop distance of the Combi network should be sufficiently large to be able to have a high operating speed, but at the same time the shared bicycle egress time cannot be too long. A large stop-density will result in longer access and egress times, this also has a negative effect on the utility of Combi.

Saving two minutes of access time has the same impact on utility as saving three minutes of in-vehicle time. Short stop spacing results in low access times, but at the same time more stops imply larger in-vehicle time. Therefore, the operator or designer of the network should find the optimum value for access time and in-vehicle time that minimises the total negative contribution to utility.

Travellers associate a higher disutility per minute of egress time with shared bicycle than per minute of access time, however by bike a larger distance can be covered per minute than on foot, so on the egress side longer distances are accepted than on the access side.

The in-vehicle time of Flexi is affected by the stop density and the number and size of the detours made to pick-up additional passengers. To keep in-vehicle time low, a node-to-node Flexi service is advised. Furthermore, research should be done to find the optimal fleet size and dispatching scheme.

Simulation models can help operators find the optimal fleet size and dispatching scheme, previous research looked into this. Winter, Cats, Correia, and van Arem (2018) for example developed a simulation tool for the operation of automated DRT systems that can determine the fleet size and system costs. Sreekantan Nair, Cats, van Oort, and Hoogendoorn (2018) developed a multimodal route choice and assignment model for combined fixed and flexible public transport services that can report modal shifts and the effect of varying fleet size.

In the sample, a very small number of individuals indicated that their health hinders them with walking and cycling. No correlations between health hindrance and preference for the alternatives were found, possibly because of the small number of respondents with health problems. In reality, Combi cannot be used by travellers with mobility restrictions. To offer public transport to all public transport users, Combi cannot operate alone. Furthermore, Combi is not an ideal mode of transportation for travelling with small children or with luggage. If a bus network is replaced by a public transport service similar to Combi, operators are advised to to operate an additional transport service like Flexi to provided mobility for all travellers.

Potential users

Several personal characteristics were found to have a positive influence on the preference for Combi and Flexi, an overview is given in Table 9.1. Individuals that have one or more of the followings characteristics are more likely to be a user of Flexi than individuals who do not have these characteristics: being younger than 30, being female and having a driving licence.

Individuals with the following characteristics are more likely to be a potential user of Combi: being younger than 30 and to a lesser extent being between 30 and 60 and having a driving licence.

The attitudinal statements have shown that bus users like transport services with fixed schedules and that a large group of respondents has no trust in public transport without fixed schedules. When promoting Flexi, the benefits of having no fixed schedule should be highlighted. Because Flexi has flexible routes and schedules, travellers can travel between any combination of Flexi stops at the time they want. Fixed rural bus lines do not offer so much flexibility.

TABLE 9.1: Personal characteristics influencing mode choice

	Combi		Flexi	Bus
		-	Male	
++	Age 15-29	+	Age 15-29	
+	Age 30-59			
+	Driving licence	+	Driving licence	

9.2.2 Recommendations for future research

This subsection provides recommendations for further research into the preferences for alternatives for the bus.

This study tried to explain the effects of reliability and flexibility on mode choice, only two of the four mode attributes related to flexibility and reliability were found to have an effect on mode choice at the 95% significance level. It is assumed that although not all attributes proved to be significant, they do play a role in the decisions making process of travellers. To better understand the reliability and flexibility aspects of on-demand public transport, more research into these factors is needed.

The choice model in this research was estimated on a relatively small sample. Because of the small sample, it was not always possible to sort the sample into smaller groups based on similar observed characteristics. If a new experiment is conducted with a larger sample, using a research panel or surveying in multiple buses in rural areas, the choice behaviour due to personal characteristics can be better explained.

In this study, only the preferences for alternatives compared to the current state of the network are investigated. For future research, it is interesting to find the preference for Combi and Flexi (or other alternatives) in case fixed bus services are cancelled. It is interesting to see if the assumption that all travellers shift to the alternatives holds, or if travellers will find other means of transport.

This research proved that bus users highly value short access times of Flexi. The effect of offering Flexi as a door-to-door service was not tested. For future research, it is interesting to see if offering Flexi as door-to-door service has an impact on the preference for this mode.

This research mainly focused on the preferences of the bus users. It is also interesting to research if individuals that make no use of public transport at the moment are also willing to make use of Flexi and Combi services.

Last, no research is done into the economic feasibility of Flexi and Combi. Only insights on the willingness of rural bus users to use alternatives are gathered in this study. For operators it is important to also have information on the economic feasibility of new public transport services before implementing them, this is an interesting and important topic for future research.

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A Experimental design

A.1 Ngene syntax

Design
;alts = Flexi, combi, bus
;rows = 27
;orth = sim
;block = 3
;model:
$U(Flexi) = ASC_{\text{Flexi}} + \beta_{\text{AT Flexi}} * AT_{\text{Flexi}}[2,4,6] + \beta_{\text{TT Flexi}} * TT_{\text{Flexi}}[24,32,40] + \beta_{\text{C Flexi}} * C_{\text{Flexi}}[1.5,3.5,5.5] + \beta_{\text{MBT}} * MBT_{\text{Flexi}}[10,35,60] + \beta_{\text{P}} * P_{\text{Flexi}}[3,9,15] + \beta_{\text{TTD}} * TTD_{\text{Flexi}}[2,6,10]$ /
$U(Combi) = ASC_{\text{Combi}} + \beta_{\text{AT}} * AT_{\text{Combi}}[2,6,10] + \beta_{\text{TTBike Combi}} * TTBike_{\text{Combi}}[2,7,12] + \beta_{\text{TTB Combi}} * TTBus_{\text{Combi}}[22,27,32] + \beta_{\text{C Combi}} * C_{\text{Combi}}[1.5,3.5,5.5] + \beta_{\text{F Combi}} * F_{\text{Combi}}[10,35,60] + \beta_{\text{AV Combi}} * AV_{\text{Combi}}[1,6,11]$
$

A.2 Experimental design

Choice situation	AT_{Combi}	$TTBus_{\text{Combi}}$	$TTBike_{\text{Combi}}$	F_{Combi}	AV_{Combi}	C_{Combi}	AT_{Flexi}	TT_{Flexi}	MBT_{Flexi}	P_{Flexi}	TTD_{Flexi}	C_{Flexi}	Block
1	2	22	2	10	1	1.5	2	24	10	3	2	1.5	1
2	6	27	7	10	1	1.5	4	32	35	9	6	3.5	1
3	10	32	12	10	1	1.5	6	40	60	15	10	5.5	1
4	2	22	2	35	6	3.5	6	40	35	9	6	5.5	1
5	6	27	7	35	6	3.5	2	24	60	15	10	1.5	1
6	10	32	12	35	6	3.5	4	32	10	3	2	3.5	1
7	2	22	2	60	11	5.5	4	32	60	15	10	3.5	1
8	6	27	7	60	11	5.5	6	40	10	3	2	5.5	1
9	10	32	12	60	11	5.5	2	24	35	9	6	1.5	1
10	10	22	7	35	1	5.5	6	32	60	9	2	1.5	2
11	2	27	12	35	1	5.5	2	40	10	15	6	3.5	2
12	6	32	2	35	1	5.5	4	24	35	3	10	5.5	2
13	10	22	7	60	6	1.5	4	24	10	15	6	5.5	2
14	2	27	12	60	6	1.5	6	32	35	3	10	1.5	2
15	6	32	2	60	6	1.5	2	40	60	9	2	3.5	2
16	10	22	7	10	11	3.5	2	40	35	3	10	3.5	2
17	2	27	12	10	11	3.5	4	24	60	9	2	5.5	2
18	6	32	2	10	11	3.5	6	32	10	15	6	1.5	2
19	6	22	12	60	1	3.5	4	40	35	15	2	1.5	3
20	10	27	2	60	1	3.5	6	24	60	3	6	3.5	3
21	2	32	7	60	1	3.5	2	32	10	9	10	5.5	3
22	6	22	12	10	6	5.5	2	32	60	3	6	5.5	3
23	10	27	2	10	6	5.5	4	40	10	9	10	1.5	3
24	2	32	7	10	6	5.5	6	24	35	15	2	3.5	3
25	6	22	12	35	11	1.5	6	24	10	9	10	3.5	3
26	10	27	2	35	11	1.5	2	32	35	15	2	5.5	3
27	2	32	7	35	11	1.5	4	40	60	3	6	1.5	3

B Survey

B.1 Flyer

Beste reiziger,

Voor mijn afstudeeronderzoek aan de Technische Universiteit van Delft doe ik onderzoek naar openbaar vervoer in landelijke gebieden.

Als u een paar minuten tijd heeft, wil ik u vragen deel te nemen aan mijn enquête. Dit zou mij erg helpen met mijn onderzoek.

U kunt de enquête openen via onderstaande link of via de weergegeven QR-code. De enquête is ontworpen voor gebruik op een **computer** en werkt op deze manier het best. Het is ook mogelijk om de enquête in te vullen op uw tablet of smartphone.

Ik stel uw deelname zeer op prijs.

Onder de deelnemers worden **2 bol.com cadeaukaarten** verloot t.w.v. **€50,00.**

Bedankt voor uw tijd en een fijne dag gewenst,

Kristel Bronsvoort

Link:
http://bit.ly/landelijkov

FIGURE B.1: Flyer handed out to bus users

B.2 Survey

Onderzoek OV in landelijke gebieden

Beste deelnemer,

Deze enquête is onderdeel van mijn afstudeeronderzoek voor de Master Transport, Infrastructuur en Logistiek aan de TU Delft. Het doel van het onderzoek is het in kaart brengen van voorkeuren van busreizigers in landelijke gebieden.

De enquête neemt ongeveer 10-15 minuten in beslag. De informatie verkregen via deze enquête zal alleen gebruikt worden voor wetenschappelijke doeleinden. Ik stel uw bijdrage zeer op prijs.

Onder de deelnemers worden **2 bol.com cadeaubonnen van €50,00** verloot.

Hartelijk bedankt voor uw deelname,

Kristel Bronsvoort
Master student aan de Technische Universiteit Delft

Deze enquête bestaat uit 4 onderdelen: introductievragen, keuzesituaties, reiskenmerken en persoonlijke kenmerken. Lees voor u begint met het beantwoorden van de vragen nauwkeurig de aanwijzingen.

Deze enquête werkt het best als deze wordt ingevuld op een computer of tablet. Het is ook mogelijk om de enquête op een smartphone in te vullen, maar de leesbaarheid is dan minder goed.

Het is niet mogelijk de antwoorden tussentijds op te slaan en op een later tijdstip de enquête te voltooien.

Page exit logic: Skip / Disqualify Logic
IF: #1 Question "Hoe vaak gebruikt u de bus?" is one of the following answers ("Nooit") **THEN:** Disqualify and display:
Sorry, u behoort niet tot de doelgroep van deze enquête en hoeft deze niet verder in te vullen. Graag bedank ik u voor uw tijd.

Hoe vaak gebruikt u de bus? *

- ○ 4 of meer dagen per week
- ○ 1 tot 3 dagen per week
- ○ 1 tot 3 dagen per maand
- ○ 1 tot 11 dagen per jaar
- ○ Nooit

Van wat voor type busdienst maakt u het vaakst gebruik? *

- ○ Stadsdienst (rijdt binnen de stad)
- ○ Streekdienst (rijdt tussen dorpen en steden)
- ○ Belbus (rijdt alleen als er gereserveerd is)
- ○ Overig / weet ik niet

Voor welk reismotief gebruikt u de bus het vaakst? *

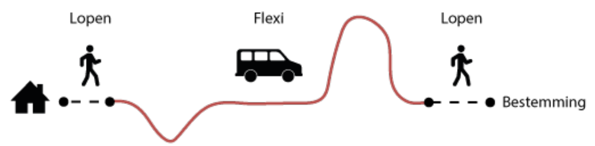
- ○ van en naar werk
- ○ zakelijk bezoek
- ○ volgen onderwijs/cursus
- ○ gezondheidzorg (bezoek ziekenhuis, huisarts, tandarts etc.)
- ○ rit in vrije tijd (winkelen, visite, sporten, etc.)
- ○ overige reismotieven

Wat was de vertrekplaats van uw laatst gemaakte busreis? *

Wat was de aankomstplaats van uw laatst gemaakte busreis? (antwoord kan gelijk zijn aan voorgaande vraag) *

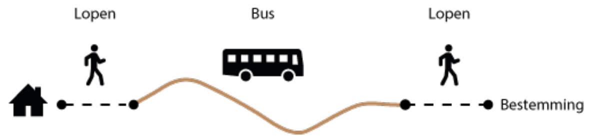
Bent u bekend met de onderstaande vervoermiddelen, en zo ja in welke mate gebruikt u deze vervoermiddelen? *

	Nee, niet mee bekend	Ja, maar ik maak er nooit gebruik van	Ja, ik heb er een aantal keer gebruik van gemaakt	Ja, ik maak hier regelmatig gebruik van
Deelfiets (bijvoorbeeld Mobike, Keobike of OV-fiets)	○	○	○	○
Vervoerservices op bestelling (bijvoorbeeld TwentsFlex, BrengFlex, Bravoflex)	○	○	○	○



Flexi

- Flexi rijdt **op bestelling** van **bushalte naar bushalte,** welke haltes dat zijn kunt u als passagier zelf kiezen.
- Via de **Flexi app** op uw smartphone of per telefoon **reserveert u een zitplaats.**
- U bepaalt zelf **wanneer** u wordt opgehaald bij de **gekozen halte** en **naar welke halte** u reist.
- Flexi maakt gebruik van **kleine busjes** met maximaal 6 zitplaatsen, het kan zijn dat u een voertuig deelt met een andere passagier.
- Tijdens de rit kan het zijn dat het voertuig een kleine omweg maakt om **andere passagiers te laten in- of uitstappen.**
- Omdat flexi flexibel is en **geen vaste dienstregeling** kent, kan het zijn dat de werkelijke vertrek- en aankomsttijden afwijken van de geplande tijden.



Bus

- Dit alternatief is vergelijkbaar met het huidige bus aanbod.

Elk alternatief heeft andere eigenschappen, op de volgende pagina's zullen deze eigenschappen toegelicht worden.

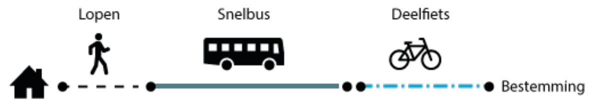
Keobike Brengflex

Let op! Het is belangrijk dat u onderstaande informatie doorneemt voordat u verder gaat met de enquête.

In het volgende deel wordt gevraagd uw voorkeur aan te geven voor een van de drie volgende vervoerswijzen:

- **Snelbus + Deelfiets**
- **Flexi**
- **Bus**

Op de volgende pagina worden deze vervoerswijzen toegelicht.



Snelbus + Deelfiets

- De **snelbus** heeft een **hogere snelheid** en **stopt minder** vaak dan de reguliere bus.
- Een deelfiets is een fiets die door **iedereen gebruikt kan worden**.
- Een deelfiets deelt u met anderen, dus dat betekent dat u weleens **mis kunt grijpen**. U kunt niet van te voren een fiets reserveren.
- **Deelfietsen** zijn aanwezig **bij bushaltes** en kunnen **bij elke eindbestemming geparkeerd** worden.
- U kunt een deelfiets op elk moment **huren via een app** op uw smartphone.

De kenmerken worden in onderstaande tabel uitgelegd:

Kenmerken	Uitleg
Totale reistijd	De totale (geplande) reistijd.
Waarvan:	
- Naar halte	Looptijd van huis naar halte in minuten.
- In voertuig	Reistijd in voertuig in minuten. Voor flexi is dit de geplande reistijd, de werkelijke reistijd kan langer zijn.
- Naar bestemming	Loop- of fietstijd van halte naar eindbestemming.
Frequentie	Tijd tussen het vertrek van twee opeenvolgende bussen (volgtijd).
Minimum boekingstijd	De minimum boekingstijd voor Flexi is het aantal minuten dat u Flexi moet bestellen voor het gewenste vertrek tijdstip.
Aantal fietsen beschikbaar	Het aantal fietsen dat aan het begin van de reis beschikbaar is bij de uitstaphalte.
Vertrek t.o.v. van afgesproken vertrek tijd	Het maximale verschil in vertrektijd. De werkelijke vertrektijd kan alle waarden tussen 0 en de maximale vertrektijd aannemen.
Reistijd t.o.v. van geplande reistijd	De maximale extra reistijd. De extra reistijd kan alle waarden tussen 0 tot de maximale extra reistijd aannemen.
Reiskosten	De totale reiskosten.

In het volgende deel krijgt u 9 keuzesituaties te zien.

De omstandigheden zijn voor elke situatie als volgt:
Stel u reist van uw **huis** naar uw **eindbestemming**. Het is **16** graden en er is **geen neerslag**. U heeft **geen (grote) bagage** bij u. Neem als reismotief **[question('value'), id='294']** in gedachten bij het beantwoorden van de vraag.

De waardes van de kenmerken verschillen per situatie. Aan u wordt gevraagd welk alternatief uw eerste keus heeft en vervolgens welk alternatief uw tweede keus heeft. Neem aan dat alle gepresenteerde alternatieven voor u beschikbaar zijn.

Let op: De waardes voor de kenmerken van bus zijn in elke situatie gelijk.

Een voorbeeld van een keuzesituatie is:

* Voorbeeld

Kenmerken	Snelbus + deelfiets	Flexi	Bus
Totale geplande reistijd	**41** min.	**48** min.	**45** min.
Waarvan:			
- Naar halte	**2** min. lopen	**4** min. lopen	**4** min. lopen
- In voertuig	**32** min.	**40** min.	**37** min.
- Naar bestemming	**7** min. fietsen	**4** min. lopen	**4** min. lopen
Frequentie	Elke **35** min.		Elke **60** min.
Minimum boekingstijd	--	**60** min.	--
Aantal fietsen beschikbaar	**11**	--	--
Vertrek t.o.v. van afgesproken vertrek tijd	--	0 tot **3** min. later	--
Reistijd t.o.v. van geplande reistijd	--	0 tot **6** min. langer	--
Reiskosten	**€1,50**	**€1,50**	**€3,00**

Wat is uw eerste keus? *

- ◯ Snelbus + deelfiets
- ◯ Flexi
- ◯ Bus

LOGIC Hidden unless: #7 Question "Wat is uw eerste keus?" is one of the following answers ("Bus")

Wat is uw tweede keus? *

- Snelbus + deelfiets
- Flexi

Stel u reist van uw huis naar uw eindbestemming. Het is 16 graden en er is geen neerslag. U heeft geen (grote) bagage bij u. Neem als reismotief [question('value'), id='294'] in gedachten bij het beantwoorden van de vraag.

Welk alternatief heeft uw voorkeur?

Kenmerken	Snelbus + deelfiets	Flexi	Bus
Totale geplande reistijd	**40** min.	**40** min.	**45** min.
Waarvan:			
- Naar halte	**6** min. lopen	**4** min. lopen	**4** min. lopen
- In voertuig	**27** min.	**32** min.	**37** min.
- Naar bestemming	**7** min. fietsen	**4** min. lopen	**4** min. lopen
Frequentie	Elke **10** min.		Elke **60** min.
Minimum boekingstijd	--	**35** min.	--
Aantal fietsen beschikbaar	**1**	--	--
Vertrek t.o.v. van afgesproken vertrek tijd	--	0 tot **9** min. later	--
Reistijd t.o.v. van geplande reistijd	--	0 tot **6** min. langer	--
Reiskosten	**€1,50**	**€3,50**	**€3,00**

LOGIC Show/hide trigger exists.

Wat is uw eerste keus? *

- Snelbus + deelfiets
- Flexi
- Bus

LOGIC Hidden unless: #11 Question "Wat is uw eerste keus?" is one of the following answers ("Snelbus + deelfiets")

Stel u reist van uw huis naar uw eindbestemming. Het is 16 graden en er is geen neerslag. U heeft geen (grote) bagage bij u. Neem als reismotief [question('value'), id='294'] in gedachten bij het beantwoorden van de vraag.

Welk alternatief heeft uw voorkeur?

Kenmerken	Snelbus + deelfiets	Flexi	Bus
Totale geplande reistijd	**26** min.	**28** min.	**45** min.
Waarvan:			
- Naar halte	**2** min. lopen	**2** min. lopen	**4** min. lopen
- In voertuig	**22** min.	**24** min.	**37** min.
- Naar bestemming	**2** min. fietsen	**2** min. lopen	**4** min. lopen
Frequentie	Elke **10** min.		Elke **60** min.
Minimum boekingstijd	--	**10** min.	--
Aantal fietsen beschikbaar	**1**	--	--
Vertrek t.o.v. van afgesproken vertrek tijd	--	0 tot **3** min. later	--
Reistijd t.o.v. van geplande reistijd	--	0 tot **2** min. langer	--
Reiskosten	**€1,50**	**€1,50**	**€3,00**

LOGIC Show/hide trigger exists.

Wat is uw eerste keus? *

- Snelbus + deelfiets
- Flexi
- Bus

LOGIC Hidden unless: #7 Question "Wat is uw eerste keus?" is one of the following answers ("Snelbus + deelfiets")

Wat is uw tweede keus? *

- Flexi
- Bus

LOGIC Hidden unless: #7 Question "Wat is uw eerste keus?" is one of the following answers ("Flexi")

Wat is uw tweede keus? *

- Snelbus + deelfiets
- Bus

LOGIC Show/hide trigger exists.

Wat is uw eerste keus? *

- ○ Snelbus + deelfiets
- ○ Flexi
- ○ Bus

LOGIC Hidden unless: #15 Question "Wat is uw eerste keus?" is one of the following answers ("Snelbus + deelfiets")

Wat is uw tweede keus? *

- ○ Flexi
- ○ Bus

LOGIC Hidden unless: #15 Question "Wat is uw eerste keus?" is one of the following answers ("Flexi")

Wat is uw tweede keus? *

- ○ Snelbus + deelfiets
- ○ Bus

LOGIC Hidden unless: #15 Question "Wat is uw eerste keus?" is one of the following answers ("Bus")

Wat is uw tweede keus? *

- ○ Snelbus + deelfiets
- ○ Flexi

Wat is uw tweede keus? *

- ○ Flexi
- ○ Bus

LOGIC Hidden unless: #11 Question "Wat is uw eerste keus?" is one of the following answers ("Flexi")

Wat is uw tweede keus? *

- ○ Snelbus + deelfiets
- ○ Bus

LOGIC Hidden unless: #11 Question "Wat is uw eerste keus?" is one of the following answers ("Bus")

Wat is uw tweede keus? *

- ○ Snelbus + deelfiets
- ○ Flexi

Stel u reist van uw huis naar uw eindbestemming. Het is 16 graden en er is geen neerslag. U heeft geen (grote) bagage bij u. Neem als reismotief [question('value'), id='294'] in gedachten bij het beantwoorden van de vraag.

Welk alternatief heeft uw voorkeur?

Kenmerken	**Snelbus + deelfiets**	**Flexi**	**Bus**
Totale geplande reistijd	**54** min.	**52** min.	**45** min.
Waarvan:			
- Naar halte	**10** min. lopen	**6** min. lopen	**4** min. lopen
- In voertuig	**32** min.	**40** min.	**37** min.
- Naar bestemming	**12** min. fietsen	**6** min. lopen	**4** min. lopen
Frequentie	Elke **10** min.		Elke **60** min.
Minimum boekingstijd	--	**60** min.	--
Aantal fietsen beschikbaar	**1**	--	--
Vertrek t.o.v. van afgesproken vertrek tijd	--	0 tot **15** min. later	--
Reistijd t.o.v. van geplande reistijd	--	0 tot **10** min. langer	--
Reiskosten	**€1,50**	**€5,50**	**€3,00**

Wat is uw tweede keus? *

- Snelbus + deelfiets
- Bus

LOGIC Hidden unless: #19 Question "Wat is uw eerste keus?" is one of the following answers ("Bus")

Wat is uw tweede keus? *

- Snelbus + deelfiets
- Flexi

Stel u reist van uw huis naar uw eindbestemming. Het is 16 graden en er is geen neerslag. U heeft geen (grote) bagage bij u. Neem als reismotief [question('value'), id='294'] in gedachten bij het beantwoorden van de vraag.

Welk alternatief heeft uw voorkeur?

Kenmerken	Snelbus + deelfiets	Flexi	Bus
Totale geplande reistijd	**40** min.	**28** min.	**45** min.
Waarvan:			
- Naar halte	**6** min. lopen	**2** min. lopen	**4** min. lopen
- In voertuig	**27** min.	**24** min.	**37** min.
- Naar bestemming	**7** min. fietsen	**2** min. lopen	**4** min. lopen
Frequentie	Elke **35** min.		Elke **60** min.
Minimum boekingstijd	--	**60** min.	--
Aantal fietsen beschikbaar	**6**	--	--
Vertrek t.o.v. van afgesproken vertrek tijd	--	0 tot **15** min. later	--
Reistijd t.o.v. van geplande reistijd	--	0 tot **10** min. langer	--
Reiskosten	**€3,50**	**€1,50**	**€3,00**

LOGIC Show/hide trigger exists.

Wat is uw eerste keus? *

- Snelbus + deelfiets
- Flexi
- Bus

Stel u reist van uw huis naar uw eindbestemming. Het is 16 graden en er is geen neerslag. U heeft geen (grote) bagage bij u. Neem als reismotief [question('value'), id='294'] in gedachten bij het beantwoorden van de vraag.

Welk alternatief heeft uw voorkeur?

Kenmerken	Snelbus + deelfiets	Flexi	Bus
Totale geplande reistijd	**26** min.	**52** min.	**45** min.
Waarvan:			
- Naar halte	**2** min. lopen	**6** min. lopen	**4** min. lopen
- In voertuig	**22** min.	**40** min.	**37** min.
- Naar bestemming	**2** min. fietsen	**6** min. lopen	**4** min. lopen
Frequentie	Elke **35** min.		Elke **60** min.
Minimum boekingstijd	--	**35** min.	--
Aantal fietsen beschikbaar	**6**	--	--
Vertrek t.o.v. van afgesproken vertrek tijd	--	0 tot **9** min. later	--
Reistijd t.o.v. van geplande reistijd	--	0 tot **6** min. langer	--
Reiskosten	**€3,50**	**€5,50**	**€3,00**

LOGIC Show/hide trigger exists.

Wat is uw eerste keus? *

- Snelbus + deelfiets
- Flexi
- Bus

LOGIC Hidden unless: #19 Question "Wat is uw eerste keus?" is one of the following answers ("Snelbus + deelfiets")

Wat is uw tweede keus? *

- Flexi
- Bus

LOGIC Hidden unless: #19 Question "Wat is uw eerste keus?" is one of the following answers ("Flexi")

Stel u reist van uw huis naar uw eindbestemming. Het is 16 graden en er is geen neerslag. U heeft geen (grote) bagage bij u. Neem als reismotief [question('value'), id='294'] in gedachten bij het beantwoorden van de vraag.

Welk alternatief heeft uw voorkeur?

Kenmerken	**Snelbus + deelfiets**	**Flexi**	**Bus**
Totale geplande reistijd	**54** min.	**40** min.	**45** min.
Waarvan:			
- Naar halte	**10** min. lopen	**4** min. lopen	**4** min. lopen
- In voertuig	**32** min.	**32** min.	**37** min.
- Naar bestemming	**12** min. fietsen	**4** min. lopen	**4** min. lopen
Frequentie	Elke **35** min.		Elke **60** min.
Minimum boekingstijd	--	**10** min.	--
Aantal fietsen beschikbaar	**6**	--	--
Vertrek t.o.v. van afgesproken vertrek tijd	--	0 tot **3** min. later	--
Reistijd t.o.v. van geplande reistijd	--	0 tot **2** min. langer	--
Reiskosten	**€3,50**	**€3,50**	**€3,00**

LOGIC Show/hide trigger exists.

Wat is uw eerste keus? *

○ Snelbus + deelfiets ○ Flexi ○ Bus

LOGIC Hidden unless: #27 Question "Wat is uw eerste keus?" is one of the following answers ("Snelbus + deelfiets")

Wat is uw tweede keus? *

○ Flexi ○ Bus

LOGIC Hidden unless: #27 Question "Wat is uw eerste keus?" is one of the following answers ("Flexi")

LOGIC Hidden unless: #23 Question "Wat is uw eerste keus?" is one of the following answers ("Snelbus + deelfiets")

Wat is uw tweede keus? *

○ Flexi ○ Bus

LOGIC Hidden unless: #23 Question "Wat is uw eerste keus?" is one of the following answers ("Flexi")

Wat is uw tweede keus? *

○ Snelbus + deelfiets ○ Bus

LOGIC Hidden unless: #23 Question "Wat is uw eerste keus?" is one of the following answers ("Bus")

Wat is uw tweede keus? *

○ Snelbus + deelfiets ○ Flexi

LOGIC Hidden unless: #31 Question "Wat is uw eerste keus?" is one of the following answers ("Snelbus + deelfiets")

Wat is uw tweede keus? *

○ Flexi ○ Bus

LOGIC Hidden unless: #31 Question "Wat is uw eerste keus?" is one of the following answers ("Flexi")

Wat is uw tweede keus? *

○ Snelbus + deelfiets ○ Bus

LOGIC Hidden unless: #31 Question "Wat is uw eerste keus?" is one of the following answers ("Bus")

Wat is uw tweede keus? *

○ Snelbus + deelfiets ○ Flexi

Wat is uw tweede keus? *

○ Snelbus + deelfiets ○ Bus

LOGIC Hidden unless: #27 Question "Wat is uw eerste keus?" is one of the following answers ("Bus")

Wat is uw tweede keus? *

○ Snelbus + deelfiets ○ Flexi

Stel u reist van uw huis naar uw eindbestemming. Het is 16 graden en er is geen neerslag. U heeft geen (grote) bagage bij u. Neem als reismotief [question('value'), id='294'] in gedachten bij het beantwoorden van de vraag.

Welk alternatief heeft uw voorkeur?

Kenmerken	**Snelbus + deelfiets**	**Flexi**	**Bus**
Totale geplande reistijd	**26** min.	**40** min.	**45** min.
Waarvan:			
- Naar halte	**2** min. lopen	**4** min. lopen	**4** min. lopen
- In voertuig	**22** min.	**32** min.	**37** min.
- Naar bestemming	**2** min. fietsen	**4** min. lopen	**4** min. lopen
Frequentie	Elke **60** min.		Elke **60** min.
Minimum boekingstijd	--	**60** min.	--
Aantal fietsen beschikbaar	**11**	--	--
Vertrek t.o.v. van afgesproken vertrek tijd	--	0 tot **15** min. later	--
Reistijd t.o.v. van geplande reistijd	--	0 tot **10** min. langer	--
Reiskosten	**€5,50**	**€3,50**	**€3,00**

LOGIC Show/hide trigger exists.

Wat is uw eerste keus? *

○ Snelbus + deelfiets ○ Flexi ○ Bus

Wat is uw tweede keus? *

○ Snelbus + deelfiets ○ Bus

LOGIC Hidden unless: #35 Question "Wat is uw eerste keus?" is one of the following answers ("Bus")

Wat is uw tweede keus? *

○ Snelbus + deelfiets ○ Flexi

Stel u reist van uw huis naar uw eindbestemming. Het is 16 graden en er is geen neerslag. U heeft geen (grote) bagage bij u. Neem als reismotief [question('value'), id='294'] in gedachten bij het beantwoorden van de vraag.

Welk alternatief heeft uw voorkeur?

Kenmerken	Snelbus + deelfiets	Flexi	Bus
Totale geplande reistijd	**54** min.	**28** min.	**45** min.
Waarvan:			
- Naar halte	**10** min. lopen	**2** min. lopen	**4** min. lopen
- In voertuig	**32** min.	**24** min.	**37** min.
- Naar bestemming	**12** min. fietsen	**2** min. lopen	**4** min. lopen
Frequentie	Elke **60** min.		Elke **60** min.
Minimum boekingstijd	--	**35** min.	--
Aantal fietsen beschikbaar	**11**	--	--
Vertrek t.o.v. van afgesproken vertrek tijd	--	0 tot **9** min. later	--
Reistijd t.o.v. van geplande reistijd	--	0 tot **6** min. langer	--
Reiskosten	**€5,50**	**€1,50**	**€3,00**

LOGIC Show/hide trigger exists.

Wat is uw eerste keus? *

○ Snelbus + deelfiets ○ Flexi ○ Bus

Stel u reist van uw huis naar uw eindbestemming. Het is 16 graden en er is geen neerslag. U heeft geen (grote) bagage bij u. Neem als reismotief [question('value'), id='294'] in gedachten bij het beantwoorden van de vraag.

Welk alternatief heeft uw voorkeur?

Kenmerken	Snelbus + deelfiets	Flexi	Bus
Totale geplande reistijd	**40** min.	**52** min.	**45** min.
Waarvan:			
- Naar halte	**6** min. lopen	**6** min. lopen	**4** min. lopen
- In voertuig	**27** min.	**40** min.	**37** min.
- Naar bestemming	**7** min. fietsen	**6** min. lopen	**4** min. lopen
Frequentie	Elke **60** min.		Elke **60** min.
Minimum boekingstijd	--	**10** min.	--
Aantal fietsen beschikbaar	**11**	--	--
Vertrek t.o.v. van afgesproken vertrek tijd	--	0 tot **3** min. later	--
Reistijd t.o.v. van geplande reistijd	--	0 tot **2** min. langer	--
Reiskosten	**€5,50**	**€5,50**	**€3,00**

LOGIC Show/hide trigger exists.

Wat is uw eerste keus? *

○ Snelbus + deelfiets ○ Flexi ○ Bus

LOGIC Hidden unless: #35 Question "Wat is uw eerste keus?" is one of the following answers ("Snelbus + deelfiets")

Wat is uw tweede keus? *

○ Flexi ○ Bus

LOGIC Hidden unless: #35 Question "Wat is uw eerste keus?" is one of the following answers ("Flexi")

Stel u reist van uw huis naar uw eindbestemming. Het is 16 graden en er is geen neerslag. U heeft geen (grote) bagage bij u. Neem als reismotief [question('value'), id='294'] in gedachten bij het beantwoorden van de vraag.

Welk alternatief heeft uw voorkeur?

Kenmerken	**Snelbus + deelfiets**	**Flexi**	**Bus**
Totale geplande reistijd	**39** min.	**44** min.	**45** min.
Waarvan:			
- Naar halte	**10** min. lopen	**6** min. lopen	**4** min. lopen
- In voertuig	**22** min.	**32** min.	**37** min.
- Naar bestemming	**7** min. fietsen	**6** min. lopen	**4** min. lopen
Frequentie	Elke **35** min.		Elke **60** min.
Minimum boekingstijd	--	**60** min.	--
Aantal fietsen beschikbaar	**1**	--	--
Vertrek t.o.v. van afgesproken vertrek tijd	--	0 tot **9** min. later	--
Reistijd t.o.v. van geplande reistijd	--	0 tot **2** min. langer	--
Reiskosten	**€5,50**	**€1,50**	**€3,00**

LOGIC Show/hide trigger exists.

Wat is uw eerste keus? *

- Snelbus + deelfiets
- Flexi
- Bus

LOGIC Hidden unless: #43 Question "Wat is uw eerste keus?" is one of the following answers ("Snelbus + deelfiets")

Wat is uw tweede keus? *

- Flexi
- Bus

LOGIC Hidden unless: #43 Question "Wat is uw eerste keus?" is one of the following answers ("Flexi")

LOGIC Hidden unless: #39 Question "Wat is uw eerste keus?" is one of the following answers ("Snelbus + deelfiets")

Wat is uw tweede keus? *

- Flexi
- Bus

LOGIC Hidden unless: #39 Question "Wat is uw eerste keus?" is one of the following answers ("Flexi")

Wat is uw tweede keus? *

- Snelbus + deelfiets
- Bus

LOGIC Hidden unless: #39 Question "Wat is uw eerste keus?" is one of the following answers ("Bus")

Wat is uw tweede keus? *

- Snelbus + deelfiets
- Flexi

LOGIC Hidden unless: #47 Question "Wat is uw eerste keus?" is one of the following answers ("Snelbus + deelfiets")

Wat is uw tweede keus? *

- ○ Flexi
- ○ Bus

LOGIC Hidden unless: #47 Question "Wat is uw eerste keus?" is one of the following answers ("Flexi")

Wat is uw tweede keus? *

- ○ Snelbus + deelfiets
- ○ Bus

LOGIC Hidden unless: #47 Question "Wat is uw eerste keus?" is one of the following answers ("Bus")

Wat is uw tweede keus? *

- ○ Snelbus + deelfiets
- ○ Flexi

Wat is uw tweede keus? *

- ○ Snelbus + deelfiets
- ○ Bus

LOGIC Hidden unless: #43 Question "Wat is uw eerste keus?" is one of the following answers ("Bus")

Wat is uw tweede keus? *

- ○ Snelbus + deelfiets
- ○ Flexi

Stel u reist van uw huis naar uw eindbestemming. Het is 16 graden en er is geen neerslag. U heeft geen (grote) bagage bij u. Neem als reismotief [question('value'), id='294'] in gedachten bij het beantwoorden van de vraag.

Welk alternatief heeft uw voorkeur?

Kenmerken	**Snelbus + deelfiets**	**Flexi**	**Bus**
Totale geplande reistijd	**41** min.	**44** min.	**45** min.
Waarvan:			
- Naar halte	**2** min. lopen	**2** min. lopen	**4** min. lopen
- In voertuig	**27** min.	**40** min.	**37** min.
- Naar bestemming	**12** min. fietsen	**2** min. lopen	**4** min. lopen
Frequentie	Elke **35** min.		Elke **60** min.
Minimum boekingstijd	--	**10** min.	--
Aantal fietsen beschikbaar	**1**	--	--
Vertrek t.o.v. van afgesproken vertrek tijd	--	0 tot **15** min. later	--
Reistijd t.o.v. van geplande reistijd	--	0 tot **6** min. langer	--
Reiskosten	**€5,50**	**€3,50**	**€3,00**

LOGIC Show/hide trigger exists.

Wat is uw eerste keus? *

- ○ Snelbus + deelfiets
- ○ Flexi
- ○ Bus

Wat is uw tweede keus? *

○ Snelbus + deelfiets ○ Bus

LOGIC Hidden unless: #51 Question "Wat is uw eerste keus?" is one of the following answers ("Bus")

Wat is uw tweede keus? *

○ Snelbus + deelfiets ○ Flexi

Stel u reist van uw huis naar uw eindbestemming. Het is 16 graden en er is geen neerslag. U heeft geen (grote) bagage bij u. Neem als reismotief [question('value'), id='294'] in gedachten bij het beantwoorden van de vraag.

Welk alternatief heeft uw voorkeur?

Kenmerken	Snelbus + deelfiets	Flexi	Bus
Totale geplande reistijd	**39** min.	**32** min.	**45** min.
Waarvan:			
- Naar halte	**10** min. lopen	**4** min. lopen	**4** min. lopen
- In voertuig	**22** min.	**24** min.	**37** min.
- Naar bestemming	**7** min. fietsen	**4** min. lopen	**4** min. lopen
Frequentie	Elke **60** min.		Elke **60** min.
Minimum boekingstijd	--	**10** min.	--
Aantal fietsen beschikbaar	**6**	--	--
Vertrek t.o.v. van afgesproken vertrek tijd	--	0 tot **15** min. later	--
Reistijd t.o.v. van geplande reistijd	--	0 tot **6** min. langer	--
Reiskosten	**€1,50**	**€5,50**	**€3,00**

LOGIC Show/hide trigger exists.

Wat is uw eerste keus? *

○ Snelbus + deelfiets ○ Flexi ○ Bus

Stel u reist van uw huis naar uw eindbestemming. Het is 16 graden en er is geen neerslag. U heeft geen (grote) bagage bij u. Neem als reismotief [question('value'), id='294'] in gedachten bij het beantwoorden van de vraag.

Welk alternatief heeft uw voorkeur?

Kenmerken	Snelbus + deelfiets	Flexi	Bus
Totale geplande reistijd	**40** min.	**32** min.	**45** min.
Waarvan:			
- Naar halte	**6** min. lopen	**4** min. lopen	**4** min. lopen
- In voertuig	**32** min.	**24** min.	**37** min.
- Naar bestemming	**2** min. fietsen	**4** min. lopen	**4** min. lopen
Frequentie	Elke **35** min.		Elke **60** min.
Minimum boekingstijd	--	**35** min.	--
Aantal fietsen beschikbaar	**1**	--	--
Vertrek t.o.v. van afgesproken vertrek tijd	--	0 tot **3** min. later	--
Reistijd t.o.v. van geplande reistijd	--	0 tot **10** min. langer	--
Reiskosten	**€5,50**	**€5,50**	**€3,00**

LOGIC Show/hide trigger exists.

Wat is uw eerste keus? *

○ Snelbus + deelfiets ○ Flexi ○ Bus

LOGIC Hidden unless: #51 Question "Wat is uw eerste keus?" is one of the following answers ("Snelbus + deelfiets")

Wat is uw tweede keus? *

○ Flexi ○ Bus

LOGIC Hidden unless: #51 Question "Wat is uw eerste keus?" is one of the following answers ("Flexi")

Stel u reist van uw huis naar uw eindbestemming. Het is 16 graden en er is geen neerslag. U heeft geen (grote) bagage bij u. Neem als reismotief [question('value'), id='294'] in gedachten bij het beantwoorden van de vraag.

Welk alternatief heeft uw voorkeur?

Kenmerken	**Snelbus + deelfiets**	**Flexi**	**Bus**
Totale geplande reistijd	**41** min.	**44** min.	**45** min.
Waarvan:			
- Naar halte	**2** min. lopen	**6** min. lopen	**4** min. lopen
- In voertuig	**27** min.	**32** min.	**37** min.
- Naar bestemming	**12** min. fietsen	**6** min. lopen	**4** min. lopen
Frequentie	Elke **60** min.		Elke **60** min.
Minimum boekingstijd	--	**35** min.	--
Aantal fietsen beschikbaar	**6**	--	--
Vertrek t.o.v. van afgesproken vertrek tijd	--	0 tot **3** min. later	--
Reistijd t.o.v. van geplande reistijd	--	0 tot **10** min. langer	--
Reiskosten	**€1,50**	**€1,50**	**€3,00**

LOGIC Show/hide trigger exists.

Wat is uw eerste keus? *

○ Snelbus + deelfiets ○ Flexi ○ Bus

LOGIC Hidden unless: #59 Question "Wat is uw eerste keus?" is one of the following answers ("Snelbus + deelfiets")

Wat is uw tweede keus? *

○ Flexi ○ Bus

LOGIC Hidden unless: #59 Question "Wat is uw eerste keus?" is one of the following answers ("Flexi")

LOGIC Hidden unless: #55 Question "Wat is uw eerste keus?" is one of the following answers ("Snelbus + deelfiets")

Wat is uw tweede keus? *

○ Flexi ○ Bus

LOGIC Hidden unless: #55 Question "Wat is uw eerste keus?" is one of the following answers ("Flexi")

Wat is uw tweede keus? *

○ Snelbus + deelfiets ○ Bus

LOGIC Hidden unless: #55 Question "Wat is uw eerste keus?" is one of the following answers ("Bus")

Wat is uw tweede keus? *

○ Snelbus + deelfiets ○ Flexi

LOGIC Hidden unless: #63 Question "Wat is uw eerste keus?" is one of the following answers ("Snelbus + deelfiets")

Wat is uw tweede keus? *

- Flexi
- Bus

LOGIC Hidden unless: #63 Question "Wat is uw eerste keus?" is one of the following answers ("Flexi")

Wat is uw tweede keus? *

- Snelbus + deelfiets
- Bus

LOGIC Hidden unless: #63 Question "Wat is uw eerste keus?" is one of the following answers ("Bus")

Wat is uw tweede keus? *

- Snelbus + deelfiets
- Flexi

Wat is uw tweede keus? *

- Snelbus + deelfiets
- Bus

LOGIC Hidden unless: #59 Question "Wat is uw eerste keus?" is one of the following answers ("Bus")

Wat is uw tweede keus? *

- Snelbus + deelfiets
- Flexi

Stel u reist van uw huis naar uw eindbestemming. Het is 16 graden en er is geen neerslag. U heeft geen (grote) bagage bij u. Neem als reismotief [question('value'), id='294'] in gedachten bij het beantwoorden van de vraag.

Welk alternatief heeft uw voorkeur?

Kenmerken	**Snelbus + deelfiets**	**Flexi**	**Bus**
Totale geplande reistijd	**40** min.	**44** min.	**45** min.
Waarvan:			
- Naar halte	**6** min. lopen	**2** min. lopen	**4** min. lopen
- In voertuig	**32** min.	**40** min.	**37** min.
- Naar bestemming	**2** min. fietsen	**2** min. lopen	**4** min. lopen
Frequentie	Elke **60** min.		Elke **60** min.
Minimum boekingstijd	--	**60** min.	--
Aantal fietsen beschikbaar	**6**	--	--
Vertrek t.o.v. van afgesproken vertrek tijd	--	0 tot **9** min. later	--
Reistijd t.o.v. van geplande reistijd	--	0 tot **2** min. langer	--
Reiskosten	**€1,50**	**€3,50**	**€3,00**

LOGIC Show/hide trigger exists.

Wat is uw eerste keus? *

- Snelbus + deelfiets
- Flexi
- Bus

Wat is uw tweede keus? *

- ○ Snelbus + deelfiets ○ Bus

LOGIC Hidden unless: #67 Question "Wat is uw eerste keus?" is one of the following answers ("Bus")

Wat is uw tweede keus? *

- ○ Snelbus + deelfiets ○ Flexi

Stel u reist van uw huis naar uw eindbestemming. Het is 16 graden en er is geen neerslag. U heeft geen (grote) bagage bij u. Neem als reismotief [question('value'), id='294'] in gedachten bij het beantwoorden van de vraag.

Welk alternatief heeft uw voorkeur?

Kenmerken	**Snelbus + deelfiets**	**Flexi**	**Bus**
Totale geplande reistijd	**41** min.	**32** min.	**45** min.
Waarvan:			
- Naar halte	**2** min. lopen	**4** min. lopen	**4** min. lopen
- In voertuig	**27** min.	**24** min.	**37** min.
- Naar bestemming	**12** min. fietsen	**4** min. lopen	**4** min. lopen
Frequentie	Elke **10** min.		Elke **60** min.
Minimum boekingstijd	--	**60** min.	--
Aantal fietsen beschikbaar	**11**	--	--
Vertrek t.o.v. van afgesproken vertrek tijd	--	0 tot **9** min. later	--
Reistijd t.o.v. van geplande reistijd	--	0 tot **2** min. langer	--
Reiskosten	**€3,50**	**€5,50**	**€3,00**

LOGIC Show/hide trigger exists.

Wat is uw eerste keus? *

- ○ Snelbus + deelfiets ○ Flexi ○ Bus

Stel u reist van uw huis naar uw eindbestemming. Het is 16 graden en er is geen neerslag. U heeft geen (grote) bagage bij u. Neem als reismotief [question('value'), id='294'] in gedachten bij het beantwoorden van de vraag.

Welk alternatief heeft uw voorkeur?

Kenmerken	**Snelbus + deelfiets**	**Flexi**	**Bus**
Totale geplande reistijd	**39** min.	**44** min.	**45** min.
Waarvan:			
- Naar halte	**10** min. lopen	**2** min. lopen	**4** min. lopen
- In voertuig	**22** min.	**40** min.	**37** min.
- Naar bestemming	**7** min. fietsen	**2** min. lopen	**4** min. lopen
Frequentie	Elke **10** min.		Elke **60** min.
Minimum boekingstijd	--	**35** min.	--
Aantal fietsen beschikbaar	**11**	--	--
Vertrek t.o.v. van afgesproken vertrek tijd	--	0 tot **3** min. later	--
Reistijd t.o.v. van geplande reistijd	--	0 tot **10** min. langer	--
Reiskosten	**€3,50**	**€3,50**	**€3,00**

LOGIC Show/hide trigger exists.

Wat is uw eerste keus? *

- ○ Snelbus + deelfiets ○ Flexi ○ Bus

LOGIC Hidden unless: #67 Question "Wat is uw eerste keus?" is one of the following answers ("Snelbus + deelfiets")

Wat is uw tweede keus? *

- ○ Flexi ○ Bus

LOGIC Hidden unless: #67 Question "Wat is uw eerste keus?" is one of the following answers ("Flexi")

Stel u reist van uw huis naar uw eindbestemming. Het is 16 graden en er is geen neerslag. U heeft geen (grote) bagage bij u. Neem als reismotief [question('value'), id='294'] in gedachten bij het beantwoorden van de vraag.

Welk alternatief heeft uw voorkeur?

Kenmerken	**Snelbus + deelfiets**	**Flexi**	**Bus**
Totale geplande reistijd	**40** min.	**44** min.	**45** min.
Waarvan:			
- Naar halte	**6** min. lopen	**6** min. lopen	**4** min. lopen
- In voertuig	**32** min.	**32** min.	**37** min.
- Naar bestemming	**2** min. fietsen	**6** min. lopen	**4** min. lopen
Frequentie	Elke **10** min.		Elke **60** min.
Minimum boekingstijd	--	**10** min.	--
Aantal fietsen beschikbaar	**11**	--	--
Vertrek t.o.v. van afgesproken vertrek tijd	--	0 tot **15** min. later	--
Reistijd t.o.v. van geplande reistijd	--	0 tot **6** min. langer	--
Reiskosten	**€3,50**	**€1,50**	**€3,00**

LOGIC Show/hide trigger exists.

Wat is uw eerste keus? *

○ Snelbus + deelfiets ○ Flexi ○ Bus

LOGIC Hidden unless: #75 Question "Wat is uw eerste keus?" is one of the following answers ("Snelbus + deelfiets")

Wat is uw tweede keus? *

○ Flexi ○ Bus

LOGIC Hidden unless: #75 Question "Wat is uw eerste keus?" is one of the following answers ("Flexi")

LOGIC Hidden unless: #71 Question "Wat is uw eerste keus?" is one of the following answers ("Snelbus + deelfiets")

Wat is uw tweede keus? *

○ Flexi ○ Bus

LOGIC Hidden unless: #71 Question "Wat is uw eerste keus?" is one of the following answers ("Flexi")

Wat is uw tweede keus? *

○ Snelbus + deelfiets ○ Bus

LOGIC Hidden unless: #71 Question "Wat is uw eerste keus?" is one of the following answers ("Bus")

Wat is uw tweede keus? *

○ Snelbus + deelfiets ○ Flexi

LOGIC Hidden unless: #79 Question "Wat is uw eerste keus?" is one of the following answers ("Snelbus + deelfiets")

Wat is uw tweede keus? *

○ Flexi ○ Bus

LOGIC Hidden unless: #79 Question "Wat is uw eerste keus?" is one of the following answers ("Flexi")

Wat is uw tweede keus? *

○ Snelbus + deelfiets ○ Bus

LOGIC Hidden unless: #79 Question "Wat is uw eerste keus?" is one of the following answers ("Bus")

Wat is uw tweede keus? *

○ Snelbus + deelfiets ○ Flexi

Wat is uw tweede keus? *

○ Snelbus + deelfiets ○ Bus

LOGIC Hidden unless: #75 Question "Wat is uw eerste keus?" is one of the following answers ("Bus")

Wat is uw tweede keus? *

○ Snelbus + deelfiets ○ Flexi

Stel u reist van uw huis naar uw eindbestemming. Het is 16 graden en er is geen neerslag. U heeft geen (grote) bagage bij u. Neem als reismotief [question('value'), id='294'] in gedachten bij het beantwoorden van de vraag.

Welk alternatief heeft uw voorkeur?

Kenmerken	**Snelbus + deelfiets**	**Flexi**	**Bus**
Totale geplande reistijd	**40** min.	**48** min.	**45** min.
Waarvan:			
- Naar halte	**6** min. lopen	**4** min. lopen	**4** min. lopen
- In voertuig	**22** min.	**40** min.	**37** min.
- Naar bestemming	**12** min. fietsen	**4** min. lopen	**4** min. lopen
Frequentie	Elke **60** min.		Elke **60** min.
Minimum boekingstijd	--	**35** min.	--
Aantal fietsen beschikbaar	**1**	--	--
Vertrek t.o.v. van afgesproken vertrek tijd	--	0 tot **15** min. later	--
Reistijd t.o.v. van geplande reistijd	--	0 tot **2** min. langer	--
Reiskosten	**€3,50**	**€1,50**	**€3,00**

LOGIC Show/hide trigger exists.

Wat is uw eerste keus? *

○ Snelbus + deelfiets ○ Flexi ○ Bus

Wat is uw tweede keus? *

- Snelbus + deelfiets
- Bus

LOGIC Hidden unless: #83 Question "Wat is uw eerste keus?" is one of the following answers ("Bus")

Wat is uw tweede keus? *

- Snelbus + deelfiets
- Flexi

Stel u reist van uw huis naar uw eindbestemming. Het is 16 graden en er is geen neerslag. U heeft geen (grote) bagage bij u. Neem als reismotief [question('value'), id='294'] in gedachten bij het beantwoorden van de vraag.

Welk alternatief heeft uw voorkeur?

Kenmerken	Snelbus + deelfiets	Flexi	Bus
Totale geplande reistijd	**41** min.	**36** min.	**45** min.
Waarvan:			
- Naar halte	**2** min. lopen	**2** min. lopen	**4** min. lopen
- In voertuig	**32** min.	**32** min.	**37** min.
- Naar bestemming	**7** min. fietsen	**2** min. lopen	**4** min. lopen
Frequentie	Elke **60** min.		Elke **60** min.
Minimum boekingstijd	--	**10** min.	--
Aantal fietsen beschikbaar	**1**	--	--
Vertrek t.o.v. van afgesproken vertrek tijd	--	0 tot **9** min. later	--
Reistijd t.o.v. van geplande reistijd	--	0 tot **10** min. langer	--
Reiskosten	**€3,50**	**€5,50**	**€3,00**

LOGIC Show/hide trigger exists.

Wat is uw eerste keus? *

- Snelbus + deelfiets
- Flexi
- Bus

Stel u reist van uw huis naar uw eindbestemming. Het is 16 graden en er is geen neerslag. U heeft geen (grote) bagage bij u. Neem als reismotief [question('value'), id='294'] in gedachten bij het beantwoorden van de vraag.

Welk alternatief heeft uw voorkeur?

Kenmerken	Snelbus + deelfiets	Flexi	Bus
Totale geplande reistijd	**39** min.	**36** min.	**45** min.
Waarvan:			
- Naar halte	**10** min. lopen	**6** min. lopen	**4** min. lopen
- In voertuig	**27** min.	**24** min.	**37** min.
- Naar bestemming	**2** min. fietsen	**6** min. lopen	**4** min. lopen
Frequentie	Elke **60** min.		Elke **60** min.
Minimum boekingstijd	--	**60** min.	--
Aantal fietsen beschikbaar	**1**	--	--
Vertrek t.o.v. van afgesproken vertrek tijd	--	0 tot **3** min. later	--
Reistijd t.o.v. van geplande reistijd	--	0 tot **6** min. langer	--
Reiskosten	**€3,50**	**€3,50**	**€3,00**

LOGIC Show/hide trigger exists.

Wat is uw eerste keus? *

- Snelbus + deelfiets
- Flexi
- Bus

LOGIC Hidden unless: #83 Question "Wat is uw eerste keus?" is one of the following answers ("Snelbus + deelfiets")

Wat is uw tweede keus? *

- Flexi
- Bus

LOGIC Hidden unless: #83 Question "Wat is uw eerste keus?" is one of the following answers ("Flexi")

Stel u reist van uw huis naar uw eindbestemming. Het is 16 graden en er is geen neerslag. U heeft geen (grote) bagage bij u. Neem als reismotief [question('value'), id='294'] in gedachten bij het beantwoorden van de vraag.

Welk alternatief heeft uw voorkeur?

Kenmerken	**Snelbus + deelfiets**	**Flexi**	**Bus**
Totale geplande reistijd	**40** min.	**36** min.	**45** min.
Waarvan:			
- Naar halte	**6** min. lopen	**2** min. lopen	**4** min. lopen
- In voertuig	**22** min.	**32** min.	**37** min.
- Naar bestemming	**12** min. fietsen	**2** min. lopen	**4** min. lopen
Frequentie	Elke **10** min.		Elke **60** min.
Minimum boekingstijd	--	**60** min.	--
Aantal fietsen beschikbaar	**6**	--	--
Vertrek t.o.v. van afgesproken vertrek tijd	--	0 tot **3** min. later	--
Reistijd t.o.v. van geplande reistijd	--	0 tot **6** min. langer	--
Reiskosten	**€5,50**	**€5,50**	**€3,00**

LOGIC Show/hide trigger exists.

Wat is uw eerste keus? *

- Snelbus + deelfiets
- Flexi
- Bus

LOGIC Hidden unless: #91 Question "Wat is uw eerste keus?" is one of the following answers ("Snelbus + deelfiets")

Wat is uw tweede keus? *

- Flexi
- Bus

LOGIC Hidden unless: #91 Question "Wat is uw eerste keus?" is one of the following answers ("Flexi")

LOGIC Hidden unless: #87 Question "Wat is uw eerste keus?" is one of the following answers ("Snelbus + deelfiets")

Wat is uw tweede keus? *

- Flexi
- Bus

LOGIC Hidden unless: #87 Question "Wat is uw eerste keus?" is one of the following answers ("Flexi")

Wat is uw tweede keus? *

- Snelbus + deelfiets
- Bus

LOGIC Hidden unless: #87 Question "Wat is uw eerste keus?" is one of the following answers ("Bus")

Wat is uw tweede keus? *

- Snelbus + deelfiets
- Flexi

LOGIC Hidden unless: #95 Question "Wat is uw eerste keus?" is one of the following answers ("Snelbus + deelfiets")

Wat is uw tweede keus? *

○ Flexi ○ Bus

LOGIC Hidden unless: #95 Question "Wat is uw eerste keus?" is one of the following answers ("Flexi")

Wat is uw tweede keus? *

○ Snelbus + deelfiets ○ Bus

LOGIC Hidden unless: #95 Question "Wat is uw eerste keus?" is one of the following answers ("Bus")

Wat is uw tweede keus? *

○ Snelbus + deelfiets ○ Flexi

Wat is uw tweede keus? *

○ Snelbus + deelfiets ○ Bus

LOGIC Hidden unless: #91 Question "Wat is uw eerste keus?" is one of the following answers ("Bus")

Wat is uw tweede keus? *

○ Snelbus + deelfiets ○ Flexi

Stel u reist van uw huis naar uw eindbestemming. Het is 16 graden en er is geen neerslag. U heeft geen (grote) bagage bij u. Neem als reismotief [question('value'), id='294'] in gedachten bij het beantwoorden van de vraag.

Welk alternatief heeft uw voorkeur?

Kenmerken	**Snelbus + deelfiets**	**Flexi**	**Bus**
Totale geplande reistijd	**39** min.	**48** min.	**45** min.
Waarvan:			
- Naar halte	**10** min. lopen	**4** min. lopen	**4** min. lopen
- In voertuig	**27** min.	**40** min.	**37** min.
- Naar bestemming	**2** min. fietsen	**4** min. lopen	**4** min. lopen
Frequentie	Elke **10** min.		Elke **60** min.
Minimum boekingstijd	--	**10** min.	--
Aantal fietsen beschikbaar	**6**	--	--
Vertrek t.o.v. van afgesproken vertrek tijd	--	0 tot **9** min. later	--
Reistijd t.o.v. van geplande reistijd	--	0 tot **10** min. langer	--
Reiskosten	**€5,50**	**€1,50**	**€3,00**

LOGIC Show/hide trigger exists.

Wat is uw eerste keus? *

○ Snelbus + deelfiets ○ Flexi ○ Bus

Wat is uw tweede keus? *

○ Snelbus + deelfiets ○ Bus

LOGIC Hidden unless: #99 Question "Wat is uw eerste keus?" is one of the following answers ("Bus")

Wat is uw tweede keus? *

○ Snelbus + deelfiets ○ Flexi

Stel u reist van uw huis naar uw eindbestemming. Het is 16 graden en er is geen neerslag. U heeft geen (grote) bagage bij u. Neem als reismotief [question('value'), id='294'] in gedachten bij het beantwoorden van de vraag.

Welke alternatief heeft uw voorkeur?

Kenmerken	Snelbus + deelfiets	Flexi	Bus
Totale geplande reistijd	**40** min.	**36** min.	**45** min.
Waarvan:			
- Naar halte	**6** min. lopen	**6** min. lopen	**4** min. lopen
- In voertuig	**22** min.	**24** min.	**37** min.
- Naar bestemming	**12** min. fietsen	**6** min. lopen	**4** min. lopen
Frequentie	Elke **35** min.		Elke **60** min.
Minimum boekingstijd	--	**10** min.	--
Aantal fietsen beschikbaar	**11**	--	--
Vertrek t.o.v. van afgesproken vertrek tijd	--	0 tot **9** min. later	--
Reistijd t.o.v. van geplande reistijd	--	0 tot **10** min. langer	--
Reiskosten	**€1,50**	**€3,50**	**€3,00**

LOGIC Show/hide trigger exists.

Wat is uw eerste keus? *

○ Snelbus + deelfiets ○ Flexi ○ Bus

Stel u reist van uw huis naar uw eindbestemming. Het is 16 graden en er is geen neerslag. U heeft geen (grote) bagage bij u. Neem als reismotief [question('value'), id='294'] in gedachten bij het beantwoorden van de vraag.

Welk alternatief heeft uw voorkeur?

Kenmerken	Snelbus + deelfiets	Flexi	Bus
Totale geplande reistijd	**41** min.	**36** min.	**45** min.
Waarvan:			
- Naar halte	**2** min. lopen	**6** min. lopen	**4** min. lopen
- In voertuig	**32** min.	**24** min.	**37** min.
- Naar bestemming	**7** min. fietsen	**6** min. lopen	**4** min. lopen
Frequentie	Elke **10** min.		Elke **60** min.
Minimum boekingstijd	--	**35** min.	--
Aantal fietsen beschikbaar	**6**	--	--
Vertrek t.o.v. van afgesproken vertrek tijd	--	0 tot **15** min. later	--
Reistijd t.o.v. van geplande reistijd	--	0 tot **2** min. langer	--
Reiskosten	**€5,50**	**€3,50**	**€3,00**

LOGIC Show/hide trigger exists.

Wat is uw eerste keus? *

○ Snelbus + deelfiets ○ Flexi ○ Bus

LOGIC Hidden unless: #99 Question "Wat is uw eerste keus?" is one of the following answers ("Snelbus + deelfiets")

Wat is uw tweede keus? *

○ Flexi ○ Bus

LOGIC Hidden unless: #99 Question "Wat is uw eerste keus?" is one of the following answers ("Flexi")

Stel u reist van uw huis naar uw eindbestemming. Het is 16 graden en er is geen neerslag. U heeft geen (grote) bagage bij u. Neem als reismotief [question('value'), id='294'] in gedachten bij het beantwoorden van de vraag.

Welk alternatief heeft uw voorkeur?

Kenmerken	**Snelbus + deelfiets**	**Flexi**	**Bus**
Totale geplande reistijd	**39** min.	**36** min.	**45** min.
Waarvan:			
- Naar halte	**10** min. lopen	**2** min. lopen	**4** min. lopen
- In voertuig	**27** min.	**32** min.	**37** min.
- Naar bestemming	**2** min. fietsen	**2** min. lopen	**4** min. lopen
Frequentie	Elke **35** min.		Elke **60** min.
Minimum boekingstijd	--	**35** min.	--
Aantal fietsen beschikbaar	**11**	--	--
Vertrek t.o.v. van afgesproken vertrek tijd	--	0 tot **15** min. later	--
Reistijd t.o.v. van geplande reistijd	--	0 tot **2** min. langer	--
Reiskosten	**€1,50**	**€5,50**	**€3,00**

LOGIC Show/hide trigger exists.

Wat is uw eerste keus? *

○ Snelbus + deelfiets ○ Flexi ○ Bus

LOGIC Hidden unless: #107 Question "Wat is uw eerste keus?" is one of the following answers ("Snelbus + deelfiets")

Wat is uw tweede keus? *

○ Flexi ○ Bus

LOGIC Hidden unless: #107 Question "Wat is uw eerste keus?" is one of the following answers ("Flexi")

LOGIC Hidden unless: #103 Question "Wat is uw eerste keus?" is one of the following answers ("Snelbus + deelfiets")

Wat is uw tweede keus? *

○ Flexi ○ Bus

LOGIC Hidden unless: #103 Question "Wat is uw eerste keus?" is one of the following answers ("Flexi")

Wat is uw tweede keus? *

○ Snelbus + deelfiets ○ Bus

LOGIC Hidden unless: #103 Question "Wat is uw eerste keus?" is one of the following answers ("Bus")

Wat is uw tweede keus? *

○ Snelbus + deelfiets ○ Flexi

LOGIC Hidden unless: #111 Question "Wat is uw eerste keus?" is one of the following answers ("Snelbus + deelfiets")

Wat is uw tweede keus? *

○ Flexi ○ Bus

LOGIC Hidden unless: #111 Question "Wat is uw eerste keus?" is one of the following answers ("Flexi")

Wat is uw tweede keus? *

○ Snelbus + deelfiets ○ Bus

LOGIC Hidden unless: #111 Question "Wat is uw eerste keus?" is one of the following answers ("Bus")

Wat is uw tweede keus? *

○ Snelbus + deelfiets ○ Flexi

Page entry logic:
This page will show when: ((((((((#7 Question "Wat is uw eerste keus?" is not one of the following answers ("Snelbus + deelfiets") AND #11 Question "Wat is uw eerste keus?" is not one of the following answers ("Snelbus + deelfiets")) AND #15 Question "Wat is uw eerste keus?" is not one of the following answers ("Snelbus + deelfiets")) AND #19 Question "Wat is uw eerste keus?" is not one of the following answers ("Snelbus + deelfiets")) AND #23 Question "Wat is uw eerste keus?" is not one of the following answers ("Snelbus + deelfiets")) AND #27 Question "Wat is uw eerste keus?" is not one of the following answers ("Snelbus + deelfiets")) AND #31 Question "Wat is uw eerste keus?" is not one of the following answers ("Snelbus + deelfiets")) AND #35 Question "Wat is uw eerste keus?" is not one of the following answers ("Snelbus + deelfiets")) AND #39 Question "Wat is uw eerste keus?" is not one of the following answers ("Snelbus + deelfiets"))

In de vorige keuzesets heeft u het alternatief **snelbus+deelfiets** nooit als eerste keus geselecteerd. Waarom heeft u dit alternatief nooit als eerste keus gekozen? *

☐ Ik wil geen deelfiets gebruiken

☐ Ik wil niet fietsen

☐ Ik heb geen smartphone

☐ Ik vind deze optie niet betrouwbaar

☐ Ik vind het te duur

☐ Ik moet te ver lopen naar de halte

☐ Een van de andere alternatieven heeft altijd mijn voorkeur

☐ Anders, namelijk

*

Wat is uw tweede keus? *

○ Snelbus + deelfiets ○ Bus

LOGIC Hidden unless: #107 Question "Wat is uw eerste keus?" is one of the following answers ("Bus")

Wat is uw tweede keus? *

○ Snelbus + deelfiets ○ Flexi

Stel u reist van uw huis naar uw eindbestemming. Het is 16 graden en er is geen neerslag. U heeft geen (grote) bagage bij u. Neem als reismotief [question('value'), id='294'] in gedachten bij het beantwoorden van de vraag.

Welk alternatief heeft uw voorkeur?

Kenmerken	**Snelbus + deelfiets**	**Flexi**	**Bus**
Totale geplande reistijd	**41** min.	**48** min.	**45** min.
Waarvan:			
- Naar halte	**2** min. lopen	**4** min. lopen	**4** min. lopen
- In voertuig	**32** min.	**40** min.	**37** min.
- Naar bestemming	**7** min. fietsen	**4** min. lopen	**4** min. lopen
Frequentie	Elke **35** min.		Elke **60** min.
Minimum boekingstijd	--	**60** min.	--
Aantal fietsen beschikbaar	**11**	--	--
Vertrek t.o.v. van afgesproken vertrek tijd	--	0 tot **3** min. later	--
Reistijd t.o.v. van geplande reistijd	--	0 tot **6** min. langer	--
Reiskosten	**€1,50**	**€1,50**	**€3,00**

LOGIC Show/hide trigger exists.

Wat is uw eerste keus? *

○ Snelbus + deelfiets ○ Flexi ○ Bus

In de vorige keuzesets heeft u het alternatief **snelbus+deelfiets** nooit als eerste keus geselecteerd. Waarom heeft u dit alternatief nooit als eerste keus gekozen? *

- ☐ Ik wil geen deelfiets gebruiken
- ☐ Ik wil niet fietsen
- ☐ Ik heb geen smartphone
- ☐ Ik vind deze optie niet betrouwbaar
- ☐ Ik vind het te duur
- ☐ Ik moet te ver lopen naar de halte
- ☐ Een van de andere alternatieven heeft altijd mijn voorkeur
- ☐ Anders, namelijk

*

Page entry logic:
This page will show when: ((((((((#43 Question "Wat is uw eerste keus?" is not one of the following answers ("Flexi") AND #47 Question "Wat is uw eerste keus?" is not one of the following answers ("Flexi")) AND #51 Question "Wat is uw eerste keus?" is not one of the following answers ("Flexi")) AND #55 Question "Wat is uw eerste keus?" is not one of the following answers ("Flexi")) AND #59 Question "Wat is uw eerste keus?" is not one of the following answers ("Flexi")) AND #63 Question "Wat is uw eerste keus?" is not one of the following answers ("Flexi")) AND #67 Question "Wat is uw eerste keus?" is not one of the following answers ("Flexi")) AND #71 Question "Wat is uw eerste keus?" is not one of the following answers ("Flexi")) AND #75 Question "Wat is uw eerste keus?" is not one of the following answers ("Flexi"))

In de vorige keuzesets heeft u het alternatief **flexi** nooit als eerste keus geselecteerd. Waarom heeft u dit alternatief nooit als eerste keus gekozen? *

- ☐ Ik heb geen smartphone
- ☐ Ik vind deze optie niet betrouwbaar
- ☐ Ik wil niet van te voren een zitplaats reserveren
- ☐ Ik vind het te duur
- ☐ Ik moet te ver lopen naar de halte
- ☐ Ik vind flexi te ingewikkeld
- ☐ Een van de andere alternatieven heeft altijd mijn voorkeur
- ☐ Anders, namelijk

*

Page entry logic:
This page will show when: ((((((((#7 Question "Wat is uw eerste keus?" is not one of the following answers ("Flexi") AND #11 Question "Wat is uw eerste keus?" is not one of the following answers ("Flexi")) AND #15 Question "Wat is uw eerste keus?" is not one of the following answers ("Flexi")) AND #19 Question "Wat is uw eerste keus?" is not one of the following answers ("Flexi")) AND #23 Question "Wat is uw eerste keus?" is not one of the following answers ("Flexi")) AND #27 Question "Wat is uw eerste keus?" is not one of the following answers ("Flexi")) AND #31 Question "Wat is uw eerste keus?" is not one of the following answers ("Flexi")) AND #35 Question "Wat is uw eerste keus?" is not one of the following answers ("Flexi")) AND #39 Question "Wat is uw eerste keus?" is not one of the following answers ("Flexi"))

In de vorige keuzesets heeft u het alternatief **flexi** nooit als eerste keus geselecteerd. Waarom heeft u dit alternatief nooit als eerste keus gekozen? *

- ☐ Ik heb geen smartphone
- ☐ Ik vind deze optie niet betrouwbaar
- ☐ Ik wil niet van te voren een zitplaats reserveren
- ☐ Ik vind het te duur
- ☐ Ik moet te ver lopen naar de halte
- ☐ Ik vind flexi te ingewikkeld
- ☐ Een van de andere alternatieven heeft altijd mijn voorkeur
- ☐ Anders, namelijk

*

Page entry logic:
This page will show when: ((((((((#43 Question "Wat is uw eerste keus?" is not one of the following answers ("Snelbus + deelfiets") AND #47 Question "Wat is uw eerste keus?" is not one of the following answers ("Snelbus + deelfiets")) AND #51 Question "Wat is uw eerste keus?" is not one of the following answers ("Snelbus + deelfiets")) AND #55 Question "Wat is uw eerste keus?" is not one of the following answers ("Snelbus + deelfiets")) AND #59 Question "Wat is uw eerste keus?" is not one of the following answers ("Snelbus + deelfiets")) AND #63 Question "Wat is uw eerste keus?" is not one of the following answers ("Snelbus + deelfiets")) AND #67 Question "Wat is uw eerste keus?" is not one of the following answers ("Snelbus + deelfiets")) AND #71 Question "Wat is uw eerste keus?" is not one of the following answers ("Snelbus + deelfiets")) AND #75 Question "Wat is uw eerste keus?" is not one of the following answers ("Snelbus + deelfiets"))

In de vorige keuzesets heeft u het alternatief **flexi** nooit als eerste keus geselecteerd. Waarom heeft u dit alternatief nooit als eerste keus gekozen? *

- ☐ Ik heb geen smartphone
- ☐ Ik vind deze optie niet betrouwbaar
- ☐ Ik wil niet van te voren een zitplaats reserveren
- ☐ Ik vind het te duur
- ☐ Ik moet te ver lopen naar de halte
- ☐ Ik vind flexi te ingewikkeld
- ☐ Een van de andere alternatieven heeft altijd mijn voorkeur
- ☐ Anders, namelijk *

Geef aan in hoeverre u het met de volgende stellingen eens bent: *

	Sterk mee eens	Eens	Neutraal	Oneens	Sterk mee oneens
Ik wijzig gemakkelijk op het laatste moment mijn plannen als de omstandigheden veranderen	○	○	○	○	○
Ik vind het prettig als een vervoerdienst een vaste dienstregeling heeft	○	○	○	○	○
Ik vind het belangrijk dat een vervoerdienst/vervoermiddel spontaan gebruikt kan worden zonder planning	○	○	○	○	○
Ik heb geen vertrouwen in een vervoerdienst zonder vaste dienstregeling	○	○	○	○	○
Ik vind het belangrijk dat een vervoerdienst altijd even lang over dezelfde reis doet	○	○	○	○	○
Ik vind betrouwbaarheid belangrijker dan snelheid	○	○	○	○	○

Bent u in het bezit van een rijbewijs? *

- ○ Ja
- ○ Nee

Bent u in het bezit van een smartphone? (meerdere antwoorden mogelijk) *

- ☐ Ja, met toegang tot wifi
- ☐ Ja, met toegang tot 3G of 4G netwerk
- ☐ Nee

Page entry logic:
This page will show when: ((((((((#79 Question "Wat is uw eerste keus?" is not one of the following answers ("Snelbus + deelfiets") AND #83 Question "Wat is uw eerste keus?" is not one of the following answers ("Snelbus + deelfiets")) AND #87 Question "Wat is uw eerste keus?" is not one of the following answers ("Snelbus + deelfiets")) AND #91 Question "Wat is uw eerste keus?" is not one of the following answers ("Snelbus + deelfiets")) AND #95 Question "Wat is uw eerste keus?" is not one of the following answers ("Snelbus + deelfiets")) AND #99 Question "Wat is uw eerste keus?" is not one of the following answers ("Snelbus + deelfiets")) AND #103 Question "Wat is uw eerste keus?" is not one of the following answers ("Snelbus + deelfiets")) AND #107 Question "Wat is uw eerste keus?" is not one of the following answers ("Snelbus + deelfiets")) AND #111 Question "Wat is uw eerste keus?" is not one of the following answers ("Snelbus + deelfiets"))

In de vorige keuzesets heeft u het alternatief **snelbus+deelfiets** nooit als eerste keus geselecteerd. Waarom heeft u dit alternatief nooit als eerste keus gekozen? *

- ☐ Ik wil geen deelfiets gebruiken
- ☐ Ik wil niet fietsen
- ☐ Ik heb geen smartphone
- ☐ Ik vind deze optie niet betrouwbaar
- ☐ Ik vind het te duur
- ☐ Ik moet te ver lopen naar de halte
- ☐ Een van de andere alternatieven heeft altijd mijn voorkeur
- ☐ Anders, namelijk *

Page entry logic:
This page will show when: ((((((((#79 Question "Wat is uw eerste keus?" is not one of the following answers ("Flexi") AND #83 Question "Wat is uw eerste keus?" is not one of the following answers ("Flexi")) AND #87 Question "Wat is uw eerste keus?" is not one of the following answers ("Flexi")) OR #91 Question "Wat is uw eerste keus?" is not one of the following answers ("Flexi")) AND #95 Question "Wat is uw eerste keus?" is not one of the following answers ("Flexi")) AND #99 Question "Wat is uw eerste keus?" is not one of the following answers ("Flexi")) AND #103 Question "Wat is uw eerste keus?" is not one of the following answers ("Flexi")) AND #107 Question "Wat is uw eerste keus?" is not one of the following answers ("Flexi")) AND #111 Question "Wat is uw eerste keus?" is not one of the following answers ("Flexi"))

Met welk geslacht kunt u zich identificeren? *

- ○ Man
- ○ Vrouw
- ○ Anders

Wat is uw geboortejaar? *

Welke omschrijving vindt u het beste bij uzelf passen? *

- ○ Schoolgaand / studerend
- ○ Full time werkend
- ○ Part time werkend
- ○ Werkloos
- ○ Gepensioneerd
- ○ Anders / wil ik niet zeggen

Wat is uw hoogst afgeronde opleiding? *

- ○ Basisonderwijs
- ○ Middelbaar onderwijs
- ○ MBO
- ○ HBO
- ○ WO Bachelor
- ○ WO Master of hoger
- ○ Anders / wil ik niet zeggen

Wat is de 4-cijferige postcode van uw woonadres? *

Van welke voertuigen bent u eigenaar? *

- ☐ Auto
- ☐ Fiets
- ☐ Elektrische fiets
- ☐ Brommer/Scooter
- ☐ Motorfiets
- ☐ Geen van bovenstaande voertuigen

Hoe vaak maakt u een reis voor de onderstaande doeleinden?
*

	4 of meer dagen per week	1 tot 3 dagen per week	1 tot 3 dagen per maand	1 tot 11 dagen per jaar	nooit
Van en naar werk	○	○	○	○	○
Volgen onderwijs/cursus	○	○	○	○	○
Vrije tijd (winkelen, visite, sporten, etc.)	○	○	○	○	○
Gezondheidzorg (bezoek ziekenhuis, huisarts, tandarts etc.)	○	○	○	○	○

Hoe vaak maakt u een reis met de onderstaande vervoersmiddelen?
*

	4 of meer dagen per week	1 tot 3 dagen per week	1 tot 3 dagen per maand	1 tot 11 dagen per jaar	nooit
Auto	○	○	○	○	○
Fiets	○	○	○	○	○
Trein	○	○	○	○	○

In hoeverre belemmert uw gezondheid u bij ... ? *

	Heel erg	Enigzins	Vrijwel niet	Helemaal niet	Weet niet / wil niet zeggen
Lopen	○	○	○	○	○
Fietsen	○	○	○	○	○

Wat is uw totale persoonlijke bruto jaarinkomen? *

- Minder dan 10.000 euro
- 10.000 - 19.999 euro
- 20.000 - 29.999 euro
- 30.000 - 39.999 euro
- 40.000 - 49.999 euro
- 50.000 - 59.999 euro
- 60.000 - 69.999 euro
- 70.000 - 79.999 euro
- Meer dan 80.000 euro
- Weet ik niet / wil ik niet zeggen

Dit is het einde van de ênquete.
Hartelijk dank voor uw tijd.

Wilt u kans maken op een van de twee bol.com cadeaukaarten t.w.v. €50.00? (Zo ja, vul hieronder uw e-mailadres in)

Wilt u op de hoogte worden gesteld over de resultaten van dit onderzoek? (Zo ja, vul hieronder uw e-mailadres in)

Vragen en/of opmerkingen:

Bedankt voor uw deelname!

C Model results

C.1 Multinomial Logit base model

C.1.1 Biogeme syntax

```
from biogeme import *
from headers import *
from loglikelihood import *
from statistics import *

# Parameters to be estimated
ASC_COMBI      = Beta('ASC_COMBI',0,-1000,1000,0)
ASC_DRT        = Beta('ASC_DRT',0,-1000,1000,0)
ASC_BUS        = Beta('ASC_BUS',0,-1000,1000,1)
BETA_ATC       = Beta('BETA_ATC',0,-1000,1000,0)
BETA_TTBusC    = Beta('BETA_TTBusC',0,-1000,1000,0)
BETA_TTBikeC   = Beta('BETA_TTBikeC',0,-1000,1000,0)
BETA_FC        = Beta('BETA_FC',0,-1000,1000,0)
BETA_AVC       = Beta('BETA_AVC',0,-1000,1000,0)
BETA_CC        = Beta('BETA_CC',0,-1000,1000,0)
BETA_ATDRT     = Beta('BETA_ATDRT',0,-1000,1000,0)
BETA_TTDRT     = Beta('BETA_TTDRT',0,-1000,1000,0)
BETA_MBTDRT    = Beta('BETA_MBTDRT',0,-1000,1000,0)
BETA_PDRT      = Beta('BETA_PDRT',0,-1000,1000,0)
#BETA_TTDDRT        = Beta('BETA_TTDDRT ',0,-1000,1000,0)
BETA_CDRT      = Beta('BETA_CDRT',0,-1000,1000,0)

V1 = ASC_COMBI + BETA_ATC * ATC + BETA_TTBusC * TTBusC + BETA_TTBikeC * TTBikeC + BETA_FC * FC + BETA_AVC * AVC + BETA_CC * CC
V2 = ASC_DRT + BETA_ATDRT * ATDRT + BETA_TTDRT * TTDRT + BETA_MBTDRT * MBTDRT + BETA_PDRT * PDRT + BETA_CDRT * CDRT
V3 = ASC_BUS

#Exclude
exclude = ( (gender == -1) + (Age1 == -1) ) > 0
BIOGEME_OBJECT.EXCLUDE = exclude

# Associate utility functions with the numbering of alternatives
V = {1: V1,
     2: V2,
     3: V3}

AV1 = 1
AV2 = 1
AV3 = 1

# Associate the availability conditions with the alternatives
av = {1: AV1,
      2: AV2,
      3: AV3}

# The choice model is a logit, with availability conditions
logprob = bioLogLogit(V,av,Choice1)

# Defines an itertor on the data
rowIterator('obsIter')
```

```
# Define the likelihood function for the estimation
BIOGEME_OBJECT.ESTIMATE = Sum(logprob,'obsIter')

# Statistics
nullLoglikelihood(av,'obsIter')
choiceSet = [1,2,3]
cteLoglikelihood(choiceSet,Choice1,'obsIter')
availabilityStatistics(av,'obsIter')

BIOGEME_OBJECT.FORMULAS['Bus + Bike Utility'] = V1
BIOGEME_OBJECT.FORMULAS['DRT utility'] = V2
BIOGEME_OBJECT.FORMULAS['Bus utility'] = V3
```

C.1.2 Estimation outcomes

Parameter number	Description	Coeff. estimate	Robust Asympt. std. error	t-stat	p-value
1	ASC_{Combi}	3.42	0.635	5.39	0.00
2	ASC_{Flexi}	3.37	0.508	6.64	0.00
3	$\beta_{\text{access time Combi}}$	-0.0870	0.0235	-3.70	0.00
4	$\beta_{\text{access time Flexi}}$	-0.116	0.0490	-2.37	0.02
5	$\beta_{\text{availability bicycle Combi}}$	0.0411	0.0186	2.21	0.03
6	$\beta_{\text{cost Combi}}$	-0.324	0.0490	-6.61	0.00
7	$\beta_{\text{cost Flexi}}$	-0.315	0.0548	-5.75	0.00
8	$\beta_{\text{headway Combi}}$	-0.00640	0.00365	-1.75	0.08
9	$\beta_{\text{minimum booking time Flexi}}$	-0.00863	0.00422	-2.04	0.04
10	$\beta_{\text{departure delay Flexi}}$	-0.00831	0.0172	-0.48	0.63
11	$\beta_{\text{travel time bike Combi}}$	-0.109	0.0188	-5.80	0.00
12	$\beta_{\text{travel time bus Combi}}$	-0.0647	0.0189	-3.42	0.00
13	$\beta_{\text{travel time Flexi}}$	-0.0798	0.0138	-5.77	0.00

Summary statistics

Number of observations = 990

Number of excluded observations = 18

Number of estimated parameters = 13

$$\mathcal{L}(\beta_0) = -1087.626$$

$$\mathcal{L}(\hat{\beta}) = -913.086$$

$$-2[\mathcal{L}(\beta_0) - \mathcal{L}(\hat{\beta})] = 349.080$$

$$\rho^2 = 0.160$$

$$\bar{\rho}^2 = 0.149$$

C.2 Nested Logit model

C.2.1 Biogeme syntax

```
from biogeme import *
from headers import *
from loglikelihood import *
from statistics import *
from nested import *

# Parameters to be estimated
ASC_COMBI       = Beta('ASC_COMBI',0,-1000,1000,0)
ASC_DRT         = Beta('ASC_DRT',0,-1000,1000,0)
ASC_BUS         = Beta('ASC_BUS',0,-1000,1000,1)
BETA_ATC        = Beta('BETA_ATC',0,-1000,1000,0)
BETA_TTBusC     = Beta('BETA_TTBusC',0,-1000,1000,0)
BETA_TTBikeC    = Beta('BETA_TTBikeC',0,-1000,1000,0)
BETA_FC         = Beta('BETA_FC',0,-1000,1000,0)
BETA_AVC        = Beta('BETA_AVC',0,-1000,1000,0)
BETA_CC         = Beta('BETA_CC',0,-1000,1000,0)
BETA_ATDRT      = Beta('BETA_ATDRT',0,-1000,1000,0)
BETA_TTDRT      = Beta('BETA_TTDRT',0,-1000,1000,0)
BETA_MBTDRT     = Beta('BETA_MBTDRT',0,-1000,1000,0)
BETA_PDRT       = Beta('BETA_PDRT',0,-1000,1000,0)
BETA_CDRT       = Beta('BETA_CDRT',0,-1000,1000,0)

### Definition of utility functions:
V1 = ASC_COMBI + BETA_ATC * ATC + BETA_TTBusC * TTBusC + BETA_TTBikeC * TTBikeC + BETA_FC * FC + BETA_AVC
 * AVC + BETA_CC * CC
V2 = ASC_DRT + BETA_ATDRT * ATDRT + BETA_TTDRT * TTDRT + BETA_MBTDRT * MBTDRT + BETA_PDRT * PDRT +
BETA_CDRT * CDRT
V3 = ASC_BUS

#Exclude
exclude = ( (gender == -1) + (Age1 == -1) ) > 0
BIOGEME_OBJECT.EXCLUDE = exclude

# Associate utility functions with the numbering of alternatives
V = {1: V1,
     2: V2,
     3: V3}

AV1 = 1
AV2 = 1
AV3 = 1

# Associate the availability conditions with the alternatives
av = {1: AV1,
      2: AV2,
      3: AV3}

```

```
### Definition of the nests:
#1:Nests parameter

NEST_NEWMODE = Beta('NEST_NEWMODE',1,1.0,10,0)

#2: list of alternatives
NO_NEWMODE = 1.0 , [ 3]
NEWMODE = NEST_NEWMODE , [ 1, 2]
nests = NO_NEWMODE, NEWMODE

# The choice model is a nested logit, with availability conditions
logprob = lognested(V,av,nests,Choice1)

# Defines an itertor on the data
rowIterator('obsIter')

# Statistics
nullLoglikelihood(av,'obsIter')
choiceSet = [1,2,3]
cteLoglikelihood(choiceSet,Choice1,'obsIter')
availabilityStatistics(av,'obsIter')

# Define the likelihood function for the estimation
BIOGEME_OBJECT.ESTIMATE = Sum(logprob,'obsIter')
BIOGEME_OBJECT.PARAMETERS['optimizationAlgorithm'] = "CFSQP"

#print utility function
BIOGEME_OBJECT.FORMULAS['Bus + Bike Utility'] = V1
BIOGEME_OBJECT.FORMULAS['DRT utility'] = V2
BIOGEME_OBJECT.FORMULAS['Bus utility'] = V3
```

C.2.2 Estimation outcomes

Parameter number	Description	Coeff. estimate	Robust Asympt. std. error	t-stat	p-value
1	$\text{ASC}_{\text{Combi}}$	3.03	0.548	5.54	0.00
2	$\text{ASC}_{\text{Flexi}}$	2.69	0.519	5.18	0.00
3	$\beta_{\text{access time Combi}}$	-0.0725	0.0200	-3.63	0.00
4	$\beta_{\text{access time Flexi}}$	-0.0983	0.0387	-2.54	0.01
5	$\beta_{\text{availability bicycle Combi}}$	0.0300	0.0159	1.89	0.06
6	$\beta_{\text{cost Combi}}$	-0.253	0.0526	-4.81	0.00
7	$\beta_{\text{cost Flexi}}$	-0.242	0.0525	-4.61	0.00
8	$\beta_{\text{headway Combi}}$	-0.00523	0.00286	-1.82	0.07
9	$\beta_{\text{minimum booking time Flexi}}$	-0.00597	0.00331	-1.80	0.07
10	$\beta_{\text{departure delay Flexi}}$	-0.00511	0.0126	-0.41	0.69
11	$\beta_{\text{travel time bike Combi}}$	-0.0872	0.0189	-4.62	0.00
12	$\beta_{\text{travel time bus Combi}}$	-0.0601	0.0150	-4.00	0.00
13	$\beta_{\text{travel time Flexi}}$	-0.0622	0.0132	-4.73	0.00
14	$\text{Nest}_{\text{NewMode}}$	1.54	0.322	4.78	0.00

Summary statistics

Number of observations = 990

Number of excluded observations = 18

Number of estimated parameters = 14

$$\mathcal{L}(\beta_0) = -1087.626$$
$$\mathcal{L}(\hat{\beta}) = -910.281$$
$$-2[\mathcal{L}(\beta_0) - \mathcal{L}(\hat{\beta})] = 354.691$$
$$\rho^2 = 0.163$$
$$\bar{\rho}^2 = 0.150$$

C.3 Mixed Logit error component model

C.3.1 Biogeme syntax

```
from biogeme import *
from headers import *
from loglikelihood import *
from statistics import *

# Parameters to be estimated
ASC_COMBI       = Beta('ASC_COMBI',0,-1000,1000,0)
ASC_DRT         = Beta('ASC_DRT',0,-1000,1000,0)
ASC_BUS         = Beta('ASC_BUS',0,-1000,1000,1)
BETA_ATC        = Beta('BETA_ATC',0,-1000,1000,0)
BETA_TTBusC     = Beta('BETA_TTBusC',0,-1000,1000,0)
BETA_TTBikeC    = Beta('BETA_TTBikeC',0,-1000,1000,0)
BETA_FC         = Beta('BETA_FC',0,-1000,1000,0)
BETA_AVC        = Beta('BETA_AVC',0,-1000,1000,0)
BETA_CC         = Beta('BETA_CC',0,-1000,1000,0)
BETA_ATDRT      = Beta('BETA_ATDRT',0,-1000,1000,0)
BETA_TTDRT      = Beta('BETA_TTDRT',0,-1000,1000,0)
BETA_MBTDRT     = Beta('BETA_MBTDRT',0,-1000,1000,0)
BETA_PDRT       = Beta('BETA_PDRT',0,-1000,1000,0)
BETA_CDRT       = Beta('BETA_CDRT',0,-1000,1000,0)
NEWMODE_mean    = Beta('NEWMODE_mean',0,-1000,1000,1)
NEWMODE_std     = Beta('NEWMODE_std',0,-1000,1000,0)

# Define random parameters
NEWMODE_rnd = NEWMODE_mean + NEWMODE_std * bioDraws('NEWMODE_rnd')

#Utility functions
V1 = ASC_COMBI + BETA_ATC * ATC + BETA_TTBusC * TTBusC + BETA_TTBikeC * TTBikeC + BETA_FC * FC + BETA_AVC
 * AVC + BETA_CC * CC + NEWMODE_rnd
V2 = ASC_DRT + BETA_ATDRT * ATDRT + BETA_TTDRT * TTDRT + BETA_MBTDRT * MBTDRT + BETA_PDRT * PDRT +
BETA_CDRT * CDRT + NEWMODE_rnd
V3 = ASC_BUS

#Exclude
exclude = ( (gender == -1) + (Age1 == -1) ) > 0
BIOGEME_OBJECT.EXCLUDE = exclude

# Associate utility functions with the numbering of alternatives
V = {1: V1,
     2: V2,
     3: V3}

AV1 = 1
AV2 = 1
AV3 = 1
```

```
# Associate the availability conditions with the alternatives
av = {1: AV1,
      2: AV2,
      3: AV3}

# The choice model is a logit, with availability conditions
prob = bioLogit(V,av,Choice1)

# Iterator on individuals, that is on groups of rows.
metaIterator('personIter','__dataFile__','panelObsIter','ID')

# For each item of personIter, iterates on the rows of the group.
rowIterator('panelObsIter','personIter')

#Conditional probability for the sequence of choices of an individual
condProbIndiv = Prod(prob,'panelObsIter')

# Integration by simulation
probIndiv = MonteCarlo(condProbIndiv)

# Likelihood function
loglikelihood = Sum(log(probIndiv),'personIter')
BIOGEME_OBJECT.ESTIMATE = loglikelihood
BIOGEME_OBJECT.PARAMETERS['NbrOfDraws'] = "1000"
BIOGEME_OBJECT.PARAMETERS['optimizationAlgorithm'] = "BIO"
BIOGEME_OBJECT.PARAMETERS['RandomDistribution'] = "HALTON"
BIOGEME_OBJECT.PARAMETERS['numberOfThreads'] = "4"
BIOGEME_OBJECT.DRAWS = { 'NEWMODE_rnd': ('NORMAL', 'ID') }
BIOGEME_OBJECT.STATISTICS['Number of individuals'] = Sum(1,'personIter')

# Statistics
nullLoglikelihood(av,'panelObsIter')
choiceSet = [1,2,3]
cteLoglikelihood(choiceSet,Choice1,'panelObsIter')
availabilityStatistics(av,'panelObsIter')

#print utility function
BIOGEME_OBJECT.FORMULAS['Bus + Bike Utility'] = V1
BIOGEME_OBJECT.FORMULAS['DRT utility'] = V2
BIOGEME_OBJECT.FORMULAS['Bus utility'] = V3
```

C.3.2 Estimation outcome

Parameter number	Description	Coeff. estimate	Robust Asympt. std. error	t-stat	p-value
1	$\text{ASC}_{\text{Combi}}$	4.60	0.841	5.48	0.00
2	$\text{ASC}_{\text{Flexi}}$	4.40	0.716	6.14	0.00
3	$\beta_{\text{access time Combi}}$	-0.116	0.0282	-4.10	0.00
4	$\beta_{\text{access time Flexi}}$	-0.155	0.0645	-2.40	0.02
5	$\beta_{\text{availability bicycle Combi}}$	0.0500	0.0262	1.91	0.06
6	$\beta_{\text{cost Combi}}$	-0.416	0.0651	-6.39	0.00
7	$\beta_{\text{cost Flexi}}$	-0.395	0.0790	-4.99	0.00
8	$\beta_{\text{headway Combi}}$	-0.00810	0.00514	-1.58	0.11
9	$\beta_{\text{minimum booking time Flexi}}$	-0.0103	0.00479	-2.15	0.03
10	$\beta_{\text{departure delay Flexi}}$	-0.00979	0.0194	-0.50	0.61
11	$\beta_{\text{travel time bike Combi}}$	-0.146	0.0212	-6.89	0.00
12	$\beta_{\text{travel time bus Combi}}$	-0.0853	0.0224	-3.81	0.00
13	$\beta_{\text{travel time Flexi}}$	-0.101	0.0179	-5.63	0.00
14	σ $\text{NeWMode}_{\text{std}}$	2.20	0.220	9.98	0.00

Summary statistics

Number of observations = 990

Number of excluded observations = 18

Number of estimated parameters = 14

$$\mathcal{L}(\beta_0) = -1087.626$$
$$\mathcal{L}(\hat{\beta}) = -765.805$$
$$-2[\mathcal{L}(\beta_0) - \mathcal{L}(\hat{\beta})] = 643.643$$
$$\rho^2 = 0.296$$
$$\bar{\rho}^2 = 0.283$$

C.4 Extended Mixed Logit error component model

C.4.1 Biogeme syntax

```
from biogeme import *
from headers import *
from loglikelihood import *
from statistics import *

# Parameters to be estimated
ASC_COMBI        = Beta('ASC_COMBI',0,-1000,1000,0)
ASC_DRT          = Beta('ASC_DRT',0,-1000,1000,0)
ASC_BUS          = Beta('ASC_BUS',0,-1000,1000,1)
BETA_ATC         = Beta('BETA_ATC',0,-1000,1000,0)
BETA_TTBusC      = Beta('BETA_TTBusC',0,-1000,1000,0)
BETA_TTBikeC     = Beta('BETA_TTBikeC',0,-1000,1000,0)
BETA_FC          = Beta('BETA_FC',0,-1000,1000,0)
BETA_AVC         = Beta('BETA_AVC',0,-1000,1000,0)
BETA_CC          = Beta('BETA_CC',0,-1000,1000,0)
BETA_ATDRT       = Beta('BETA_ATDRT',0,-1000,1000,0)
BETA_TTDRT       = Beta('BETA_TTDRT',0,-1000,1000,0)
BETA_MBTDRT      = Beta('BETA_MBTDRT',0,-1000,1000,0)
BETA_PDRT        = Beta('BETA_PDRT',0,-1000,1000,0)
BETA_CDRT        = Beta('BETA_CDRT',0,-1000,1000,0)

BETA_LICENCE_C   = Beta('BETA_LICENCE_C',0,-1000,1000,0)
BETA_AGE1_C      = Beta('BETA_AGE1_C',0,-1000,1000,0)
BETA_AGE2_C      = Beta('BETA_AGE2_C',0,-1000,1000,0)

BETA_GENDER_DRT  = Beta('BETA_GENDER_DRT',0,-1000,1000,0)
BETA_LICENCE_DRT= Beta('BETA_LICENCE_DRT',0,-1000,1000,0)
BETA_AGE1_DRT    = Beta('BETA_AGE1_DRT',0,-1000,1000,0)
BETA_ST4_DRT     = Beta('BETA_ST4_DRT',0,-1000,1000,0)

NEWMODE_mean     = Beta('NEWMODE_mean',0,-1000,1000,1)
NEWMODE_std      = Beta('NEWMODE_std',0,-1000,1000,0)

# Define random parameters
NEWMODE_rnd = NEWMODE_mean + NEWMODE_std * bioDraws('NEWMODE_rnd')

#Utility functions
V1 = ASC_COMBI + BETA_ATC * ATC + BETA_TTBusC * TTBusC + BETA_TTBikeC * TTBikeC + BETA_FC * FC + BETA_AVC
 * AVC + BETA_CC * CC\
 + BETA_LICENCE_C * licence + BETA_AGE1_C * Age1 + BETA_AGE2_C * Age2 \
 + NEWMODE_rnd

V2 = ASC_DRT + BETA_ATDRT * ATDRT + BETA_TTDRT * TTDRT + BETA_MBTDRT * MBTDRT + BETA_PDRT * PDRT +
BETA_CDRT * CDRT\
 + BETA_GENDER_DRT * gender + BETA_LICENCE_DRT * licence + BETA_AGE1_DRT * Age1 \
 + BETA_ST4_DRT * ST4 \
 + NEWMODE_rnd

V3 = ASC_BUS

```

```
#Exclude
exclude = ( (gender == -1) + (Age1 == -1) ) > 0
BIOGEME_OBJECT.EXCLUDE = exclude

# Associate utility functions with the numbering of alternatives
V = {1: V1,
     2: V2,
     3: V3}

AV1 = 1
AV2 = 1
AV3 = 1

# Associate the availability conditions with the alternatives
av = {1: AV1,
      2: AV2,
      3: AV3}

# The choice model is a logit, with availability conditions
prob = bioLogit(V,av,Choice1)

# Iterator on individuals, that is on groups of rows.
metaIterator('personIter','__dataFile__','panelObsIter','ID')

# For each item of personIter, iterates on the rows of the group.
rowIterator('panelObsIter','personIter')

#Conditional probability for the sequence of choices of an individual
condProbIndiv = Prod(prob,'panelObsIter')

# Integration by simulation
probIndiv = MonteCarlo(condProbIndiv)

# Likelihood function
loglikelihood = Sum(log(probIndiv),'personIter')
BIOGEME_OBJECT.ESTIMATE = loglikelihood
BIOGEME_OBJECT.PARAMETERS['NbrOfDraws'] = "1000"
BIOGEME_OBJECT.PARAMETERS['optimizationAlgorithm'] = "BIO"
BIOGEME_OBJECT.PARAMETERS['RandomDistribution'] = "HALTON"
BIOGEME_OBJECT.PARAMETERS['numberOfThreads'] = "4"
BIOGEME_OBJECT.DRAWS = { 'NEWMODE_rnd': ('NORMAL', 'ID') }
BIOGEME_OBJECT.STATISTICS['Number of individuals'] = Sum(1,'personIter')

# Statistics
nullLoglikelihood(av,'panelObsIter')
choiceSet = [1,2,3]
cteLoglikelihood(choiceSet,Choice1,'panelObsIter')
availabilityStatistics(av,'panelObsIter')
```

```
#print utility function
BIOGEME_OBJECT.FORMULAS['Bus + Bike Utility'] = V1
BIOGEME_OBJECT.FORMULAS['DRT utility'] = V2
BIOGEME_OBJECT.FORMULAS['Bus utility'] = V3
```

C.4.2 Estimation outcome

Parameter number	Description	Coeff. estimate	Robust Asympt. std. error	t-stat	p-value
1	$\text{ASC}_{\text{Combi}}$	2.17	1.05	2.07	0.04
2	$\text{ASC}_{\text{Flexi}}$	4.71	0.948	4.97	0.00
3	$\beta_{\text{AGE1}_{\text{Combi}}}$	1.92	0.687	2.79	0.01
4	$\beta_{\text{AGE1}_{\text{Flexi}}}$	1.13	0.524	2.16	0.03
5	$\beta_{\text{AGE2}_{\text{Combi}}}$	1.35	0.586	2.30	0.02
6	$\beta_{\text{access time Combi}}$	-0.117	0.0278	-4.20	0.00
7	$\beta_{\text{access time Flexi}}$	-0.174	0.0643	-2.70	0.01
8	$\beta_{\text{availability bicycle Combi}}$	0.0532	0.0273	1.95	0.05
9	$\beta_{\text{cost Combi}}$	-0.426	0.0673	-6.33	0.00
10	$\beta_{\text{cost Flexi}}$	-0.416	0.0809	-5.15	0.00
11	$\beta_{\text{headway Combi}}$	-0.00814	0.00523	-1.56	0.12
12	$\beta_{\text{GENDER}_{\text{Flexi}}}$	-0.846	0.295	-2.87	0.00
13	$\beta_{\text{LICENCE}_{\text{Combi}}}$	1.32	0.491	2.69	0.01
14	$\beta_{\text{LICENCE}_{\text{Flexi}}}$	1.26	0.456	2.77	0.01
15	$\beta_{\text{minimum booking time Flexi}}$	-0.0105	0.00492	-2.14	0.03
16	$\beta_{\text{departure delay Flexi}}$	-0.0110	0.0200	-0.55	0.58
17	$\beta_{\text{ST4}_{\text{Flexi}}}$	-0.374	0.125	-3.00	0.00
18	$\beta_{\text{travel time bike Combi}}$	-0.148	0.0211	-7.00	0.00
19	$\beta_{\text{travel time bus Combi}}$	-0.0858	0.0221	-3.88	0.00
20	$\beta_{\text{travel time Flexi}}$	-0.106	0.0180	-5.86	0.00
21	$\sigma\text{NewMode}_{\text{std}}$	2.06	0.208	9.92	0.00

Summary statistics

Number of observations = 990

Number of excluded observations = 18

Number of estimated parameters = 21

$$\mathcal{L}(\beta_0) = -1087.626$$

$$\mathcal{L}(\hat{\beta}) = -744.925$$

$$-2[\mathcal{L}(\beta_0) - \mathcal{L}(\hat{\beta})] = 685.402$$

$$\rho^2 = 0.315$$

$$\bar{\rho}^2 = 0.296$$

C.5 Multinomial Logit second choice model

C.5.1 Biogeme syntax

```
from biogeme import *
from headers import *
from loglikelihood import *
from statistics import *

# Parameters to be estimated
ASC_COMBI       = Beta('ASC_COMBI',0,-1000,1000,0)
ASC_DRT         = Beta('ASC_DRT',0,-1000,1000,0)
ASC_BUS         = Beta('ASC_BUS',0,-1000,1000,1)
BETA_ATC        = Beta('BETA_ATC',0,-1000,1000,0)
BETA_TTBusC     = Beta('BETA_TTBusC',0,-1000,1000,0)
BETA_TTBikeC    = Beta('BETA_TTBikeC',0,-1000,1000,0)
BETA_FC         = Beta('BETA_FC',0,-1000,1000,0)
BETA_AVC        = Beta('BETA_AVC',0,-1000,1000,0)
BETA_CC         = Beta('BETA_CC',0,-1000,1000,0)
BETA_ATDRT      = Beta('BETA_ATDRT',0,-1000,1000,0)
BETA_TTDRT      = Beta('BETA_TTDRT',0,-1000,1000,0)
BETA_MBTDRT     = Beta('BETA_MBTDRT',0,-1000,1000,0)
BETA_PDRT       = Beta('BETA_PDRT',0,-1000,1000,0)
BETA_CDRT       = Beta('BETA_CDRT',0,-1000,1000,0)

V1 = ASC_COMBI + BETA_ATC * ATC + BETA_TTBusC * TTBusC + BETA_TTBikeC * TTBikeC + BETA_FC * FC + BETA_AVC * AVC + BETA_CC * CC
V2 = ASC_DRT + BETA_ATDRT * ATDRT + BETA_TTDRT * TTDRT + BETA_MBTDRT * MBTDRT + BETA_PDRT * PDRT + BETA_CDRT * CDRT
V3 = ASC_BUS

#Exclude
exclude = ( (Choice ==  1) + (gender == -1) + (Age1 == -1) ) > 0
BIOGEME_OBJECT.EXCLUDE = exclude

# Associate utility functions with the numbering of alternatives
V = {1: V1,
     2: V2,
     3: V3}

AV1 = AV1
AV2 = AV2
AV3 = AV3

# Associate the availability conditions with the alternatives
av = {1: AV1,
      2: AV2,
      3: AV3}

# The choice model is a logit, with availability conditions
logprob = bioLogLogit(V,av,Answer)
```

```
# Defines an itertor on the data
rowIterator('obsIter')

# DEfine the likelihood function for the estimation
BIOGEME_OBJECT.ESTIMATE = Sum(logprob,'obsIter')

# Statistics

nullLoglikelihood(av,'obsIter')
choiceSet = [1,2,3]
cteLoglikelihood(choiceSet,Answer,'obsIter')
availabilityStatistics(av,'obsIter')

BIOGEME_OBJECT.FORMULAS['Bus + Bike Utility'] = V1
BIOGEME_OBJECT.FORMULAS['DRT utility'] = V2
BIOGEME_OBJECT.FORMULAS['Bus utility'] = V3
```

C.5.2 Estimation outcome

Parameter number	Description	Coeff. estimate	Robust Asympt. std. error	t-stat	p-value
1	ASC_{Combi}	1.80	0.666	2.70	0.01
2	ASC_{Flexi}	1.37	0.490	2.80	0.01
3	$\beta_{\text{access time Combi}}$	-0.0421	0.0252	-1.67	0.10
4	$\beta_{\text{access time Flexi}}$	-0.0219	0.0468	-0.47	0.64
5	$\beta_{\text{availability bicycle Combi}}$	-0.0238	0.0199	-1.20	0.23
6	$\beta_{\text{cost Combi}}$	-0.230	0.0503	-4.57	0.00
7	$\beta_{\text{cost Flexi}}$	-0.164	0.0487	-3.36	0.00
8	$\beta_{\text{headway Combi}}$	0.00317	0.00384	0.82	0.41
9	$\beta_{\text{minimum booking time Flexi}}$	-0.00258	0.00374	-0.69	0.49
10	$\beta_{\text{departure delay Flexi}}$	-0.0194	0.0156	-1.24	0.21
11	$\beta_{\text{travel time bike Combi}}$	-0.0284	0.0200	-1.42	0.16
12	$\beta_{\text{travel time bus Combi}}$	-0.0416	0.0201	-2.07	0.04
13	$\beta_{\text{travel time Flexi}}$	-0.0359	0.0121	-2.98	0.00

Summary statistics
Number of observations = 990
Number of excluded observations = 1026
Number of estimated parameters = 13

$$\mathcal{L}(\beta_0) = -686.216$$
$$\mathcal{L}(\hat{\beta}) = -626.183$$
$$-2[\mathcal{L}(\beta_0) - \mathcal{L}(\hat{\beta})] = 120.065$$
$$\rho^2 = 0.087$$
$$\bar{\rho}^2 = 0.069$$

C.6 Extended Mixed Logit error component model with generic parameters

C.6.1 Biogeme syntax

```
from biogeme import *
from headers import *
from loglikelihood import *
from statistics import *

# Parameters to be estimated
# alternative specific constants
ASC_COMBI        = Beta('ASC_COMBI',0,-1000,1000,0)
ASC_DRT          = Beta('ASC_DRT',0,-1000,1000,0)
ASC_BUS          = Beta('ASC_BUS',0,-1000,1000,1)

#linear components
BETA_AT          = Beta('BETA_AT',0,-1000,1000,0)
BETA_TT          = Beta('BETA_TT',0,-1000,1000,0)
BETA_F           = Beta('BETA_FC',0,-1000,1000,0)
BETA_AVC         = Beta('BETA_AVC',0,-1000,1000,0)
BETA_C           = Beta('BETA_C',0,-1000,1000,0)
BETA_MBTDRT      = Beta('BETA_MBTDRT',0,-1000,1000,0)
BETA_PDRT        = Beta('BETA_PDRT',0,-1000,1000,0)
BETA_TTBike      = Beta('BETA_TTBike',0,-1000,1000,0)

#socio economics variables
BETA_LICENCE_C       = Beta('BETA_LICENCE_C',0,-1000,1000,0)
BETA_AGE1_C          = Beta('BETA_AGE1_C',0,-1000,1000,0)
BETA_AGE2_C          = Beta('BETA_AGE2_C',0,-1000,1000,0)

BETA_GENDER_DRT      = Beta('BETA_GENDER_DRT',0,-1000,1000,0) #significant
BETA_LICENCE_DRT     = Beta('BETA_LICENCE_DRT',0,-1000,1000,0)
BETA_AGE1_DRT        = Beta('BETA_AGE1_DRT',0,-1000,1000,0)

BETA_ST4_DRT     = Beta('BETA_ST4_DRT',0,-1000,1000,0)

#random constant
NEWMODE_mean     = Beta('NEWMODE_mean',0,-1000,1000,1)
NEWMODE_std      = Beta('NEWMODE_std',0,-1000,1000,0)

# Define random parameters
NEWMODE_rnd = NEWMODE_mean + NEWMODE_std * bioDraws('NEWMODE_rnd')

V1 = ASC_COMBI + BETA_TT * TTBusC + BETA_F * FC + BETA_AVC * AVC + BETA_C * CC + BETA_TTBike * TTBikeC + BETA_AT * ATC\
 + BETA_LICENCE_C * licence + BETA_AGE1_C * Age1 + BETA_AGE2_C * Age2 \
 + NEWMODE_rnd

V2 = ASC_DRT + BETA_TT * TTDRT + BETA_MBTDRT * MBTDRT + BETA_PDRT * PDRT + BETA_C * CDRT + 2 * BETA_AT * ATDRT\
 + BETA_GENDER_DRT * gender + BETA_LICENCE_DRT * licence + BETA_AGE1_DRT * Age1 \
 + BETA_ST4_DRT * ST4 \
 + NEWMODE_rnd

```

```
V3 = ASC_BUS + BETA_TT * TTBus + BETA_F * FreqBus + BETA_C * Cbus + 2 * BETA_AT * ATBUS\

#Exclude
exclude = ( (gender == -1) + (Age1 == -1) ) > 0
BIOGEME_OBJECT.EXCLUDE = exclude

# Associate utility functions with the numbering of alternatives
V = {1: V1,
     2: V2,
     3: V3}

AV1 = 1
AV2 = 1
AV3 = 1

# Associate the availability conditions with the alternatives
av = {1: AV1,
      2: AV2,
      3: AV3}

# The choice model is a logit, with availability conditions
prob = bioLogit(V,av,Choice1)

# Iterator on individuals, that is on groups of rows.
metaIterator('personIter','__dataFile__','panelObsIter','ID')

# For each item of personIter, iterates on the rows of the group.
rowIterator('panelObsIter','personIter')

#Conditional probability for the sequence of choices of an individual
condProbIndiv = Prod(prob,'panelObsIter')

# Integration by simulation
probIndiv = MonteCarlo(condProbIndiv)

# Likelihood function
loglikelihood = Sum(log(probIndiv),'personIter')
BIOGEME_OBJECT.ESTIMATE = loglikelihood
BIOGEME_OBJECT.PARAMETERS['NbrOfDraws'] = "1000"
BIOGEME_OBJECT.PARAMETERS['optimizationAlgorithm'] = "BIO"
BIOGEME_OBJECT.PARAMETERS['RandomDistribution'] = "HALTON"
BIOGEME_OBJECT.PARAMETERS['numberOfThreads'] = "4"
BIOGEME_OBJECT.DRAWS = { 'NEWMODE_rnd': ('NORMAL', 'ID') }
BIOGEME_OBJECT.STATISTICS['Number of individuals'] = Sum(1,'personIter')

# Statistics
nullLoglikelihood(av,'panelObsIter')
choiceSet = [1,2,3]
cteLoglikelihood(choiceSet,Choice1,'panelObsIter')
```

```
availabilityStatistics(av,'panelObsIter')

#print utility function
BIOGEME_OBJECT.FORMULAS['Bus + Bike Utility'] = V1
BIOGEME_OBJECT.FORMULAS['DRT utility'] = V2
BIOGEME_OBJECT.FORMULAS['Bus utility'] = V3
```

C.6.2 Estimation outcome

Parameter number	Description	Coeff. estimate	Robust Asympt. std. error	t-stat	p-value
1	$\text{ASC}_{\text{Combi}}$	-3.81	0.727	-5.24	0.00
2	$\text{ASC}_{\text{Flexi}}$	-1.61	0.821	-1.96	0.05
3	β_{AGE1C}	1.92	0.690	2.78	0.01
4	$\beta_{\text{AGE1Flexi}}$	1.13	0.522	2.17	0.03
5	β_{AGE2C}	1.35	0.589	2.29	0.02
6	$\beta_{\text{access time}}$	-0.104	0.0229	-4.53	0.00
7	$\beta_{\text{availability bicycle Combi}}$	0.0519	0.0270	1.92	0.05
8	β_{Cost}	-0.421	0.0593	-7.11	0.00
9	$\beta_{\text{Headway Combi}}$	-0.00834	0.00527	-1.58	0.11
10	$\beta_{\text{GENDERFlexi}}$	-0.848	0.294	-2.89	0.00
11	β_{LICENCEC}	1.31	0.492	2.68	0.01
12	$\beta_{\text{LICENCE Flexi}}$	1.26	0.456	2.77	0.01
13	$\beta_{\text{minimum booking time Flexi}}$	-0.0104	0.00490	-2.12	0.03
14	$\beta_{\text{Departure delay Flexi}}$	-0.0115	0.0199	-0.58	0.56
15	β_{ST4Flexi}	-0.376	0.124	-3.03	0.00
16	$\beta_{\text{travel time}}$	-0.0999	0.0157	-6.38	0.00
17	$\beta_{\text{Travel time bike Combi}}$	-0.149	0.0214	-6.94	0.00
18	$\text{NEWMODE}_{\text{std}}$	2.06	0.208	9.92	0.00

Summary statistics

Number of observations = 990

Number of excluded observations = 18

Number of estimated parameters = 18

$$\mathcal{L}(\beta_0) = -1087.626$$
$$\mathcal{L}(\hat{\beta}) = -745.491$$
$$-2[\mathcal{L}(\beta_0) - \mathcal{L}(\hat{\beta})] = 684.271$$
$$\rho^2 = 0.315$$
$$\bar{\rho}^2 = 0.298$$

C.7 Simulation model

C.7.1 Biogeme syntax

```
from biogeme import *
from headers import *
from loglikelihood import *
from statistics import *

#estimated parameters
#Flexi
ASC_DRT = Beta('ASC_DRT',4.70774,-1000,1000,0,'ASC_DRT' )
BETA_ATDRT = Beta('BETA_ATDRT',-0.173933,-1000,1000,0,'BETA_ATDRT' )
BETA_TTDRT = Beta('BETA_TTDRT',-0.105752,-1000,1000,0,'BETA_TTDRT' )
BETA_MBTDRT = Beta('BETA_MBTDRT',-0.0105482,-1000,1000,0,'BETA_MBTDRT' )
BETA_PDRT = Beta('BETA_PDRT',-0.0110236,-1000,1000,0,'BETA_PDRT' )
BETA_CDRT = Beta('BETA_CDRT',-0.416186,-1000,1000,0,'BETA_CDRT' )
#Sociodemographics Flexi
BETA_GENDER_DRT = Beta('BETA_GENDER_DRT',-0.846411,-1000,1000,0,'BETA_GENDER_DRT' )
BETA_LICENCE_DRT = Beta('BETA_LICENCE_DRT',1.26221,-1000,1000,0,'BETA_LICENCE_DRT' )
BETA_AGE1_DRT = Beta('BETA_AGE1_DRT',1.1324,-1000,1000,0,'BETA_AGE1_DRT' )
BETA_ST4_DRT = Beta('BETA_ST4_DRT',-0.37441,-1000,1000,0,'BETA_ST4_DRT' )
#Combi
ASC_COMBI = Beta('ASC_COMBI',2.17461,-1000,1000,0,'ASC_COMBI' )
BETA_ATC = Beta('BETA_ATC',-0.116572,-1000,1000,0,'BETA_ATC' )
BETA_TTBusC = Beta('BETA_TTBusC',-0.0858477,-1000,1000,0,'BETA_TTBusC' )
BETA_TTBikeC = Beta('BETA_TTBikeC',-0.147924,-1000,1000,0,'BETA_TTBikeC' )
BETA_FC = Beta('BETA_FC',-0.00813728,-1000,1000,0,'BETA_FC' )
BETA_AVC = Beta('BETA_AVC',0.0532122,-1000,1000,0,'BETA_AVC' )
BETA_CC = Beta('BETA_CC',-0.426335,-1000,1000,0,'BETA_CC' )
#Sociodemographics Combi
BETA_LICENCE_C = Beta('BETA_LICENCE_C',1.31818,-1000,1000,0,'BETA_LICENCE_C' )
BETA_AGE1_C = Beta('BETA_AGE1_C',1.92051,-1000,1000,0,'BETA_AGE1_C' )
BETA_AGE2_C = Beta('BETA_AGE2_C',1.35036,-1000,1000,0,'BETA_AGE2_C' )
#Bus
ASC_BUS = Beta('ASC_BUS',0,-1000,1000,1,'ASC_BUS' )
#Error component
NEWMODE_mean = Beta('NEWMODE_mean',0,-1000,1000,1,'NEWMODE_mean' )
NEWMODE_std = Beta('NEWMODE_std',2.05906,-1000,1000,0,'NEWMODE_std' )

# Code for the sensitivity analysis
names = ['ASC_COMBI','ASC_DRT','BETA_AGE1_C','BETA_AGE1_DRT','BETA_AGE2_C','BETA_ATC','BETA_ATDRT',
'BETA_AVC','BETA_CC','BETA_CDRT','BETA_FC','BETA_GENDER_DRT','BETA_LICENCE_C','BETA_LICENCE_DRT',
'BETA_MBTDRT','BETA_PDRT','BETA_ST4_DRT','BETA_TTBikeC','BETA_TTBusC','BETA_TTDRT','NEWMODE_std']
values = [[1.10164,0.482274,-0.40773,-0.202712,-0.327953,-0.0121389,-0.0107029,-0.00210666,-0.0156465,-
0.0108148,-0.00135205,0.0465464,-0.119411,-0.110662,-0.000851499,-0.00274764,-0.000716201,-0.00794324,-
0.0152636,-0.00312749,-0.0401443],[0.482274,0.898583,-0.162683,-0.20669,-0.00237128,-0.00440653,-
0.0220584,-0.00120369,-0.010519,-0.0106531,-0.000598384,-0.0259679,-0.040419,-0.103609,-0.00056059,-
0.00285114,-0.0534875,-0.00577315,-0.00661438,-0.00894829,-0.0332927],[-0.40773,-0.162683,0.472469,
0.253073,0.248192,0.00332582,-0.00121435,6.24838e-005,0.00351695,-0.00468906,0.000469817,-0.0394694,-
0.0244235,-0.0149879,0.000491174,0.00104771,0.00032349,-0.00118964,-0.000340631,-0.000451546,0.0425282
],[-0.202712,-0.20669,0.253073,0.274063,0.0347012,0.00186199,-0.00319516,0.000120769,0.00348354,-
6.99473e-005,-5.84165e-005,-0.00836756,-0.0188288,0.00355361,0.000322609,0.00108928,-0.000342523,-
```

```
6.99473e-005,-5.84165e-005,-0.00836756,-0.0188288,0.00355361,0.000322609,0.00108928,-0.000342523,-
0.000793428,7.38391e-005,-0.000348078,0.0300175],[-0.327953,-0.00237128,0.248192,0.0347012,0.343216,
0.00394657,0.0032783,0.000133478,-0.0010155,-0.00663256,0.000520049,-0.0455943,0.00426798,-0.000153546,
0.000339506,-0.000397338,-0.00999521,0.00012775,0.00167007,0.00083421,0.0067546],[-0.0121389,-0.00440653,
0.00332582,0.00186199,0.00394657,0.000770781,0.000358637,1.34151e-005,3.97506e-006,0.000463357,-
2.50489e-006,-0.00156246,-0.000360798,0.000795883,1.12517e-005,-3.18949e-005,-0.000281005,0.000216169,
0.000184738,5.00342e-005,0.00037882],[-0.0107029,-0.0220584,-0.00121435,-0.00319516,0.0032783,0.000358637
,0.00413985,0.00023439,-0.000814595,-5.28934e-005,0.000142102,-0.00273475,-0.00632604,-0.00154611,-
4.47789e-005,-0.000201479,0.000944429,0.000395702,0.0002764,0.000343394,0.000451844],[-0.00210666,-
0.00120369,6.24838e-005,0.000120769,0.000133478,1.34151e-005,0.00023439,0.000746713,-0.000150271,
0.000150533,-1.01654e-005,0.000766281,-0.000685846,-0.000603307,-9.03288e-006,-4.94595e-006,-0.000416938
,-3.11845e-005,-1.69598e-005,6.35508e-005,0.0010327],[-0.0156465,-0.010519,0.00351695,0.00348354,-
0.0010155,3.97506e-006,-0.000814595,-0.000150271,0.00453593,0.00179428,1.28993e-005,-0.0046423,-
0.00333713,0.00183032,3.6737e-005,0.00017132,-0.000337036,7.40427e-005,9.14986e-005,0.000168159,
0.00152583],[-0.0108148,-0.0106531,-0.00468906,-6.99473e-005,-0.00663256,0.000463357,-5.28934e-005,
0.000150533,0.00179428,0.0065418,-2.77717e-005,-1.71844e-005,-0.000663182,0.00213729,-9.86519e-006,
9.43007e-005,0.000387326,0.000324669,0.000318643,-0.000384681,0.00164135],[-0.00135205,-0.000598384,
0.000469817,-5.84165e-005,0.000520049,-2.50489e-006,0.000142102,-1.01654e-005,1.28993e-005,-2.77717e-005,
2.73763e-005,-0.000289618,-8.49822e-005,-2.31839e-005,1.15861e-006,-3.19082e-006,3.19858e-005,
1.71516e-006,2.33924e-006,4.54403e-006,-7.17824e-005],[0.0465464,-0.0259679,-0.0394694,-0.00836756,-
0.0455943,-0.00156246,-0.00273475,0.000766281,-0.0046423,-1.71844e-005,-0.000289618,0.0867868,0.00827071
,-0.0242617,-2.3727e-005,-0.00052571,0.00242196,-0.00037766,9.35932e-006,0.000214081,-0.0149313],[-
0.119411,-0.040419,-0.0244235,-0.0188288,0.00426798,-0.000360798,-0.00632604,-0.000685846,-0.00333713,-
0.000663182,-8.49822e-005,0.00827071,0.24075,0.168108,-0.000115796,0.000437546,0.0027779,-0.00682587,-
0.000139392,-0.00139534,0.0108835],[-0.110662,-0.103609,-0.0149879,0.00355361,-0.000153546,0.000795883,-
0.00154611,-0.000603307,0.00183032,0.00213729,-2.31839e-005,-0.0242617,0.168108,0.208172,-0.00025124,
0.00109709,-0.000918055,0.000719296,0.00022633,-0.000657137,0.0150561],[-0.000851499,-0.00056059,
0.000491174,0.000322609,0.000339506,1.12517e-005,-4.47789e-005,-9.03288e-006,3.6737e-005,-9.86519e-006,
1.15861e-006,-2.3727e-005,-0.000115796,-0.00025124,2.42234e-005,3.63114e-006,-2.68172e-005,-3.11191e-007,
9.54041e-006,-5.98179e-006,-4.94116e-005],[-0.00274764,-0.00285114,0.00104771,0.00108928,-0.000397338,-
3.18949e-005,-0.000201479,-4.94595e-006,0.00017132,9.43007e-005,-3.19082e-006,-0.00052571,0.000437546,
0.00109709,3.63114e-006,0.000399844,-5.19967e-005,5.20184e-005,6.23008e-005,-3.45173e-005,0.000475363],[-
0.000716201,-0.0534875,0.00032349,-0.000342523,-0.00999521,-0.000281005,0.000944429,-0.000416938,-
0.000337036,0.000387326,3.19858e-005,0.00242196,0.0027779,-0.000918055,-2.68172e-005,-5.19967e-005,
0.0156167,0.00015441,8.55621e-005,-1.94347e-005,-0.00105622],[-0.00794324,-0.00577315,-0.00118964,-
0.000793428,0.00012775,0.000216169,0.000395702,-3.11845e-005,7.40427e-005,0.000324669,1.71516e-006,-
0.00037766,-0.000682587,0.000719296,-3.11191e-007,5.20184e-005,0.00015441,0.000447132,0.000211026,
8.92425e-005,-5.08739e-006],[-0.0152636,-0.00661438,-0.000340631,7.38391e-005,0.00167007,0.000184738,
0.0002764,-1.69598e-005,9.14986e-005,0.000318643,2.33924e-006,9.35932e-006,-0.000139392,0.00022633,
9.54041e-006,6.23008e-005,8.55621e-005,0.000211026,0.000488595,9.09144e-005,-0.000356994],[-0.00312749,-
0.00894829,-0.000451546,-0.000348078,0.00083421,5.00342e-005,0.000343394,6.35508e-005,0.000168159,-
0.000384681,4.54403e-006,0.000214081,-0.00139534,-0.000657137,-5.98179e-006,-3.45173e-005,-1.94347e-005,
8.92425e-005,9.09144e-005,0.000325133,-9.45797e-005],[-0.0401443,-0.0332927,0.0425282,0.0300175,0.0067546
,0.00037882,0.000451844,0.0010327,0.00152583,0.00164135,-7.17824e-005,-0.0149313,0.0108835,0.0150561,-
4.94116e-005,0.000475363,-0.00105622,-5.08739e-006,-0.000356994,-9.45797e-005,0.0430804]]
vc = bioMatrix(21,names,values)
BIOGEME_OBJECT.VARCOVAR = vc
```

```
# Define random parameters
NEWMODE_rnd = NEWMODE_mean + NEWMODE_std * bioDraws('NEWMODE_rnd')

#Define attribute levels
ATC_sim     = DefineVariable('ATC_sim',2) #2-10
TTBusC_sim  = DefineVariable('TTBusC_sim',22) #22-32
TTBikeC_sim = DefineVariable('TTBikeC_sim',2) #2-12
FC_sim      = DefineVariable('FC_sim',10) # 10-60
CC_sim      = DefineVariable('CC_sim',1.5) #1.5-5.5
AVC_sim     = DefineVariable('AVC_sim',11) #1-11

ATDRT_sim   = DefineVariable('ATDRT_sim',2) #2-6
TTDRT_sim   = DefineVariable('TTDRT_sim',24) #24-40
MBTDRT_sim  = DefineVariable('MBTDRT_sim',10) # 10-60
CDRT_sim    = DefineVariable('CDRT_sim',1.5) #1.5-5.5
PDRT_sim    = DefineVariable('PDRT_sim',3) #3-15

#Utility functions
COMBI = ASC_COMBI + BETA_ATC * ATC_sim + BETA_TTBusC * TTBusC_sim + BETA_TTBikeC * TTBikeC_sim + BETA_FC * FC_sim + BETA_AVC * AVC_sim + BETA_CC * CC_sim\
 + BETA_LICENCE_C * licence + BETA_AGE1_C * Age1 + BETA_AGE2_C * Age2 \
 + NEWMODE_rnd

FLEXI = ASC_DRT + BETA_ATDRT * ATDRT_sim + BETA_TTDRT * TTDRT_sim  + BETA_MBTDRT * MBTDRT_sim + BETA_PDRT * PDRT_sim + BETA_CDRT * CDRT_sim\
 + BETA_GENDER_DRT * gender + BETA_LICENCE_DRT * licence + BETA_AGE1_DRT * Age1 \
 + BETA_ST4_DRT * ST4 \
 + NEWMODE_rnd

BUS = ASC_BUS

#Exclude
exclude = ( (gender == -1) + (Age1 == -1) ) > 0
BIOGEME_OBJECT.EXCLUDE = exclude

# Associate utility functions with the numbering of alternatives
V = {1: COMBI,
     2: FLEXI,
     3: BUS}

AV1 = 1
AV2 = 1
AV3 = 1

# Associate the availability conditions with the alternatives
av = {1: AV1,
      2: AV2,
      3: AV3}

```

```
rowIterator('obsIter')
#No need for estimating the model (it is already estimated).
#We want to obtain the individual probabilities and the market shares
prob1 = MonteCarlo(bioLogit(V,av,1))
prob2 = MonteCarlo(bioLogit(V,av,2))
prob3 = MonteCarlo(bioLogit(V,av,3))

#Simulation output
simulate = { '01 Prob. COMBI': prob1,
 '02 Prob. FLEXI': prob2,
 '03 Prob. BUS': prob3}
 #'ProbTotal': Pro}
BIOGEME_OBJECT.SIMULATE = Enumerate(simulate,'obsIter')
BIOGEME_OBJECT.PARAMETERS['NbrOfDraws'] = "1000"
BIOGEME_OBJECT.PARAMETERS['RandomDistribution'] = "HALTON"
BIOGEME_OBJECT.DRAWS = { 'NEWMODE_rnd': ('NORMAL') }
```

D Additional simulation reports

D.1 Simulation without Combi

TABLE D.1: Additional scenario without Combi

	Flexi	Bus
Access time [min]	4	4
In-vehicle travel time [min]	37	37
Egress time [min]	4	4
Shared bicycle travel time [min]		
Minimum booking time [min]	60	
Headway [min]		60
Cost [€]	3.00	3.00
Bicycle availability		
Departure delay [min]	0-10	

TABLE D.2: Simulation report simulation without Combi

Simulation report
Number of draws for Monte-Carlo: 1000
Type of draws: HALTON
Number of draws for sensitivity analysis: 100
Aggregate values

	02 Prob. Flexi	02 Prob. Flexi: 90% CI		03 Prob. Bus	03 Prob. Bus: 90% CI	
Total	26.7324	21.5402	28.9451	83.2676	81.0549	88.4598
Average	0.243022	0.19582	0.263137	0.756978	0.736863	0.80418
Non zeros	110			110		
Non zeros average	0.243022	0.19582	0.263137	0.756978	0.736863	0.80418
Minimum	0.0464329	0.0211534	0.0461268	0.535662	0.466747	0.56953
Maximum	0.464338	0.43047	0.533253	0.953567	0.953873	0.978847

D.2 Simulation low in-vehicle time high cost Flexi

TABLE D.3: Additional scenario low in-vehicle time high cost Flexi

	Combi	**Flexi**	**Bus**
Access time [min]	6	4	4
In-vehicle travel time [min]	26	**24**	37
Egress time [min]		4	4
Shared bicycle travel time [min]	6		
Minimum booking time [min]		30	
Headway [min]	30		60
Cost [€]	3.50	**5.50**	3.00
Bicycle availability	6		
Departure delay [min]		0-10	

TABLE D.4: Simulation report low in-vehicle time high cost Flexi

Simulation report
Number of draws for Monte-Carlo: 1000
Type of draws: HALTON
Number of draws for sensitivity analysis: 100
Aggregate values

	01 Prob. Combi	01 Prob. Combi: 90% CI		02 Prob. Flexi	02 Prob. Flexi: 90% CI		03 Prob. Bus	03 Prob. Bus: 90% CI	
Total	34.5261	30.3851	35.8059	17.7762	17.4689	25.7035	57.6977	50.9039	59.7353
Average	0.313873	0.276228	0.325508	0.161602	0.158809	0.233668	0.524525	0.462763	0.543048
Non zeros	110			110			110		
Non zeros average	0.313873	0.276228	0.325508	0.161602	0.158809	0.233668	0.524525	0.462763	0.543048
Minimum	0.0963537	0.0679024	0.112676	0.0412772	0.0299082	0.0613466	0.355263	0.239645	0.361883
Maximum	0.468043	0.490353	0.575908	0.358766	0.379254	0.499965	0.842152	0.794621	0.889043