Public transport systems of the future: Enhancing user acceptance

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Abstract

The recent development of new flexible mobility systems represents a promising opportunity for public transport companies to meet current challenges, such as providing mobility for all population groups while remaining profitable. In the context of the research project *Reallabor Schorndorf*, a user-centered public transport system aiming at spatial and temporal flexibility is being developed, called *Quartiersbussystem*. However, the users' valuation of the different factors of flexible mobility systems is not yet known. Since regular-users of public transport might value factors of public transport differently than irregular-users, the primary aim of this paper was to identify the factors and their valuation determining the choice of transport mode for regular-users and irregular-users. By means of a literature review and a focus group (n=9), six factors were identified that are important to the user: fare, travel time, walking distance, information availability, booking period, and shift of departure. A choice-based conjoint analysis was carried out to quantify each factors' relative importance to the user. In an online questionnaire 24 choice sets were presented to the respondents (n=521), consisting of two alternative mobility systems and an opt-out option. The travel time was the most relevant factor, followed by information availability and shift of departure. Regular-users deemed low fares more important than irregular-users, whereas short travel times were more important to irregular users. Overall, the present study contributes to our understanding of respondents' preferences of factors that are inherent to flexible mobility systems, such as the *Quartiersbussystem*.

Keywords: focus group, choice-based conjoint analysis, flexible public transport systems, Quartiersbussystem, Reallabor Schorndorf

1. Illuminating preferences of modality choice in the context of public transport

1.1 Challenges for future public transport systems

Developing strategies to meet future challenges in the context of public transport systems such as sociodemographic change and urban sprawl has been an important issue in Germany due to their large impact on mobility and economy (Eck, 2006). While mobility in Germany has substantially increased in the last decades, the increase might not solely be due to public transport. Beirão and Cabral (2007) raised concerns about increased car usage and its environmental implications. The environmental benefits public transport holds in comparison to private motorized transport, such as the bundling of passengers for a better utilization of vehicles, highlight the importance of improving the usage of public transport (Müller-Hellmann & Nickel, 2009).

One of the most important challenges public transport companies face is to ensure public mobility of all population groups, while remaining profitable and able to compete against other modes of transport, such as private transport modes (Eck, 2006). Currently, public transports are to some degree perceived insufficient in suburban areas: From the user perspective suffering from a lack of flexibility and service availability, from the operator's perspective suffering from a lack of economic benefit (Reichel, 2015; Velaga, Nelson, Wright & Farrington, 2012). To cope with such societal and economical challenges, a new user-centered system reflecting innovative and ecologically sustainable concepts of mobility is required (Eck, 2006; Reichel, 2015).

1.2 Introducing the new concept: *Quartiersbussystem*

In the light of this challenge, the German aerospace center (DLR) and its project partners are currently developing a user-centered public transport system that aims at spatial and temporal flexibility (Klötzke et al., 2018). The proposed transport system is called *Quartiersbussystem*. Aim of the *Quartiersbussystem* is to develop and implement a *Quartiersbus*, a demand-responsive bus that can be requested by phone or mobile app without fixed schedule and route (Reichel, 2015). The concept of the *Quartiersbus* is comparable to dial-a-ride services in rural areas, called *Anrufbus* or *Anruf-Auto* (Mehlert, 2001). The purpose of a *Quartiersbus* is to replace and expand current timetable-fixed buses, whenever there is less demand for public transport in certain areas or during specific periods of time. By using this system, public transport companies could extend their range effectively, while ensuring increased mobility of people living in suburban areas.

A spatially and temporally flexible public transport system could meet the challenges mentioned above: First, the economic use of public transport could be increased by enabling the adaption of provided transport to needed transport (Mucha & Sommer, 2014; König & Grippenkoven, 2017). Second, the perceived lack of flexibility and service availability on the user's perspective is addressed by exclusively operating according to the actual demand, resulting in a more attractive public transport (König, Wegener, Pelz & Grippenkoven, 2017). Third, the use of private, motorized transport modes is expected to decrease by bypassing its usage to and from public transport stops (Mucha & Sommer, 2014; König & Grippenkoven, 2017). By this means, the environmental benefits held by public transport are expected to increase even more (Müller-Hellmann & Nickel, 2009).

1.3 Reallabor Schorndorf

The *Quartiersbussystem* is being developed and tested in the context of the research project "*Reallabor Schorndorf*" ("Living lab Schorndorf") (Klötzke et al., 2018). The project is subsidized by the Ministry of Science, Research and Arts of Baden-Württemberg and started in February 2016 with a run time of three years. The project is realized in Schorndorf, a small town located 26 km from Stuttgart. The project is carried out by research institutes (DLR, University of Stuttgart, University of Applied Sciences in Esslingen), the local public transport association (Verkehrs- und Tarifverband Stuttgart), the local bus operator and the municipality of Schorndorf. The methodological approach of this project is based on a living lab that has iteratively evolved around the user and other stakeholders. Living labs can be defined as methods of transdisciplinary science (Brandies et al., 2017). In the sense of a transdisciplinary approach, scientific and non-scientific knowledge of local stakeholders, like the inhabitants of Schorndorf, are integrated in the process of the entire project including the requirements analysis and prototyping (Holm, et al., 2012). Until now interviews with local experts were carried out to identify requirements for the bus concept (Gallego, 2017). Using Co-Creation, inhabitants are involved in the phase of prototyping (Klötzke, et al., 2016). The bus started to operate in December 2017. Subsequently the pilot operation is accompanied by intensive research and evaluation studies.

1.4 Analyzing users' preferences

When introducing and implementing new products and services to the market, it is essential to take customer preferences into account during the development (Baier & Brusch, 2009). To ensure customer preference consideration, the preferences need to be determined early in the development. There are several techniques, which offer an experimental approach to user preferences. These techniques, such as conjoint analysis and functional measurement, usually belong to stated preference methods (Louviere, 1988; Kroes & Sheldon, 1988). During the last decades, stated preference methods and especially the conjoint analysis, gained considerable attention in many fields of research: The conjoint analysis is commonly used in transport research and one of the most employed standard procedures in consumer research to determine customer preferences (Baier & Brusch, 2009; Hensher, 1994; Jianrong, Wei & Bing, 2011; Knapp, 1997, Louviere, 1988; Skiera & Gensler, 2002). Its aim is to explain the customers' preferences for different product concepts and to quantify the value or utility of product factors (Baier & Brusch, 2009; Hensher, Rose & Green, 2015). The following example illustrates the approach of a conjoint analysis as well as the kind of question it allows to answer.

Take a company that wants to develop a new camera that fits customers' preferences. To determine what camera characteristics are important for the user and how important these are, a conjoint analysis is employed. By means of interviews the company already found out that *price, resolution, design,* and *brand* are important characteristics. Since developing the perception of a brand is beyond the scope of designing a camera, the brand cannot be influenced by the company, this aspect is not further considered for the conjoint analysis. The three remaining characteristics price, resolution and design are called *factors,* or *attributes* within the conjoint analysis. Each factor can take different values. These values need to be represented by different *levels*. In this example, the levels of the resolution are three megapixels, four megapixels and five megapixels. The different product concepts are created by combining one level of each factor. One concept product might be a camera with four megapixels, familiar design and a price of 175€. An overview of the described factors and levels, as well as three concept products is given in Table 1. During the conjoint analysis participants are typically asked to choose from, rank or rate the presented product concepts (Jianrong, Wei & Bing, 2011). Figure 1 shows how the product concepts may be presented to participants during a conjoint analysis. By decomposing the respondents' preferences of product concepts into preferences of the underlying factors and levels, each factors' contribution to the respondents' choice can be quantified (Baier & Brusch, 2009).

Table 1

Overview of the factors and levels of three concept cameras

	Product A	Product B	Product C
Price	175€	225€	200€
Brand	Canon	Nikon	Sony
Resolution	4 MP	5 MP	3 MP
Design	familiar	unusual	familiar

Note: This table gives an overview of the factors and levels described above. Price, brand, resolution, and design are the factors. The specifications of the factors, e.g. 175€ for price, are the levels. A fictional product solely defined by a level for each factor, is the product concept (e.g. product A).

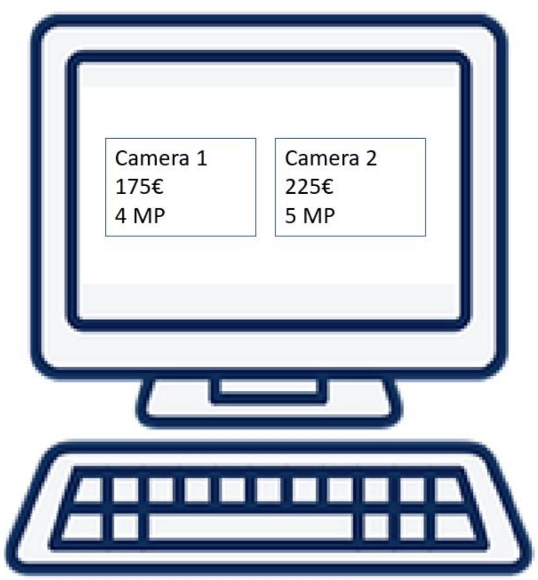

Figure 1. Typical presentation of two product concepts during a conjoint analysis

1.5 The Present Study

In order to reach the goals of *Reallabor Schorndorf* and to increase public transportation usage, the system design should particularly focus on user acceptance. According to the *Gap model of transit service quality*, establishing user satisfaction means reducing the gap between perceived and expected service (Jianrong, Wei & Bing, 2011). However, previous studies (see, Jianrong, et al., 2011) of transport modality choice, have suffered from a lack of clarity in establishing the factors that are critical to the expected service by the user. Also, the service expected by the user might be different for flexible mobility systems than for conventional public transport. As a result, a systematic understanding and weight of the various factors contributing to user acceptance of flexible mobility systems, such as price, and comfort, is still lacking. Therefore, the aim of the present study is to identify and investigate the factors critical for modality choice in the context of the *Quartiersbus*.

Since the results of a conjoint analysis are solely based on the factors under investigation, a pre-study focusing on an adequate selection of factors is carried out. Recommended techniques to initially identify factors are *literature review*, *observational field work* and *interviews* (Kløjgaard and colleagues, 2012). In this pre-study, a literature review provides an overview of the factors used for comparable conjoint analyses investigating transport modality choice. Kløjgaard and colleagues (2012) strongly recommend using two or more qualitative techniques when identifying factors for preference elicitation experiments; as important aspects could be neglected otherwise. Therefore, a qualitative follow-up investigation of the important factors must be carried out after the literature review. In this study, a focus group is used to enhance and complete the understanding of critical factors. Nonetheless, the present thesis and the *Reallabor Schorndorf* are limited in terms of practical issues: For example, it is not within the scope of this study to include factors, such as congestion, as this cannot be altered in the *Reallabor Schorndorf.*

The weight of the factors critical for modality choice is expected to differ between regular-users and non- or occasional users (hereinafter called irregular-users) of public transport modes. The preferences of both will be compared in this study; since it is important to maintain regular-users and to recruit irregular-users to increase usage of public transport. The primary aim of this paper is to identify the factors and their valuation determining the usage of public transport modes for regular-users and irregular-users. The first research question that is examined, asks which aspects of the flexible transport service affect travelers' appraisal of the mobility service. Secondly, it is investigated which factors provide the basis for regular-users and irregular-users to make trade-offs between the service characteristics of the *Quartiersbus*? The results might contribute to the identification of requirements, that new flexible transportation systems must fulfil to be attractive for regular-users and irregular-users, and thus contribute to a user-centered service. Furthermore, the study aims to propose a design of the operational concept of the *Quartiersbus* at *Reallabor Schorndorf.*

2. Pre- Study

2.1 Literature Review

It is evidently clear that the selection of factors and levels is crucial for conducting a conjoint analysis (Kløjgaard, Bech & Søgaard, 2012; Reiners, 1996). Previous research identified a large number of factors influencing the modality choice of travelers.

In a study by Jianrong and colleagues (2011), the passenger's preference of the bus service has been investigated by using a conjoint analysis. The following factors were used: *reliability,* *headway, walking time, price, indoor environment* and *stop environment*. They found *reliability* to be of greatest importance to the respondents. The importance of *walking time* and *indoor environment* were evaluated roughly equal but little attention was given to *price* and *stop environment* (Jianrong, et al., 2011). However, it is important to note that the study lacks clarity in describing how factors and levels were selected in the first place.

Gardner and Abraham (2007) conducted a grounded theory analysis with regular private car users. Even though no conjoint analysis has been conducted in their study, they investigated the most important motives of car usage in an extensive and qualitative manner. The results could reveal factors keeping potential customers from using public transport. The following five core motives to sustain car usage have been identified: *minimizing journey time; achieving positive and/or avoiding negative journey-based affect; minimizing physical and psychological effort; creating personal space; and minimizing financial expenditure* (Gardner & Abraham, 2007). For the purpose of this study, these core motives to sustain car usage can be transferred into the following five factors most important for the respondents' modality choice*: journey time, journey-based affect, effort, personal space* and *price.*

Hensher and Prioni (2002) proposed a method of measuring the effectiveness of a service in satisfying passengers. They introduced a set of factors able to capture customer satisfaction and conducted a stated preference experiment. The participants evaluated different concept products, proving most selected factors significant. *Service Reliability, fares, walking time,* and *travel time* were significant. *Onboard safety, driver attitude, information at the bus stop,* and *bus frequency* were also statistically strong factors. The *cleanliness of the bus* was only significant when treated as dichotomous factor. *Waiting safety* was not (but almost) significant and the *infrastructure at the* *bus stop, air conditioning*, and *access to the bus* were not of major influence on customer satisfaction.

The results of the conjoint analysis by Knapp (1997) implied that flexibility of transport modality is most important for the user. Three underlying factors where summed up to the category flexibility: *frequency*, *travel registration,* and *operating period*. The factor *number of stops*, belonging to the category outer comfort, was also deemed important. Surprisingly, the category classical factors (*travel time, travel costs*) was only on third place. The last and least important category of inner comfort and travel route included the following factors: *baggage allowance, contact to other travelers, activity opportunities, travel route* and *seat availability*.

Overall, these studies highlight the complexity of investigating underlying factors of decision making processes in modality choices. Two of the studies found that *reliability* is one of the most important factors for the user (Hensher & Prioni, 2002; Jianrong, et al., 2011). Also, all the studies considered the temporal aspect of traveling. While Jianrong and colleagues (2011) focused on *walking time*, Gardner and Abraham (2007) as well as Knapp (1997) investigated the overall *travel time*. Hensher and Prioni (2002) separated *access time* and *bus time*. Even though the studies use different wording, it seems that time is recurrently an important factor. Another repeatedly used factor is *price*. Although there is mixed evidence of its relative importance, *price* has been investigated in all studies. Jianrong and colleagues (2011) examined the broad term *indoor environment*. Even though the other studies did not use this term, they did include aspects of the indoor environment, such as *air conditioning, seat availability,* and *personal space*. Only two studies mentioned the *stop environment/ infrastructure at bus stop* (Jianrong et al., 2011; Hensher & Prioni, 2002). For both studies, the *stop environment* was perceived as one of the least important factors. The remaining factors (*effort, based affect, onboard safety, information at the* *bus stop, access to a bus, baggage allowance, contact to other travelers, activity opportunities, frequency, operating period, travel route, and travel registration*) were not mentioned in more than one study. Interestingly, the factors *frequency, travel registration* and the *operating period* were rated most important by the respondents in the study by Knapp (1997). However, these factors were not mentioned in any other study.

This section provides a summary of literature that investigates factors critical to modality choice. Table 2 provides an overview of all factors that have been mentioned in the literature previously discussed. This provides a starting point for further qualitative factor identification, in this case a focus group, even though there is no commonly accepted set of important factors in the literature.

Table 2

Overview of the factors mentioned in examined literature

Literature	Factors
Jianrong and colleagues (2011)	Reliability Headway Walking time Price Indoor environment Stop environment
Gardner & Abraham (2007)	Journey time Journey based affect Effort Personal space Price Service reliability
Hensher & Prioni (2002)	Fare Walking time Travel time Onboard safety Driver attitude

	Information at bus stop Bus frequency Cleanliness of the bus Waiting safety Infrastructure at bus stop Air conditioning Access to the bus
Knapp (1997)	Frequency Travel registration Operating period Number of stops Travel time Travel costs Baggage allowance Contact to other travelers Activity opportunities Travel route Seat availability

2.2 Methods

As Kløjgaard, Bech and Søgaard (2012) emphasize the importance of a qualitative process for the design of a choice experiment, a two-stepped method was chosen to identify factors and levels. First, a literature review was presented to provide an overview of factors and corresponding levels of modality choice used in comparable studies. Then, a focus group was conducted to adapt the preselected factors and levels, to add important factors, and to exclude irrelevant factors (Baier & Brusch, 2002).

2.2.1 Participants. Nine participants (6 female, 3 male, mean age: 51.67, SD = 22.5 years) of the city of Braunschweig took part in the focus group. Participants were acquired by distributing flyers at local supermarkets and other public places. Informed consent was obtained from all participants. The Ethics Committee of the University of Twente approved that the study is in accordance with the standards listed in the faculties' Protocol about Ethics and Research.

2.2.2. Procedure. At the start, the participants received the informed consent form and a sociodemographic questionnaire (see Appendix A and Appendix B). The participants were informed that participation was voluntary and that there were no risks involved in participation. Furthermore, they were told that the focus group was recorded for data collection purposes and that data collection and processing was anonymous. Then, the researchers introduced themselves and the project. The participants were told that the German Aerospace Center is currently developing a new public transport system and that the focus group aims at investigating the aspects of public transport modes that are important to the users. A PowerPoint presentation provided comprehensive examples to support the understanding of the aim and purpose of the focus group. The PowerPoint presentation was visible during the whole session to support the participants' understanding. After the introduction, a gamified approach was used to activate the participants and to excite reflection about transport mode choice: The participants were asked to sit around a table with a map on a wooden board of the city of Braunschweig as shown in Figure 2. Several nails were prepared on the busy transportation spots of Braunschweig. To encourage mental engagement with modality choices, the participants were asked to trace the travel route they took to the DLR. Colored strings were knotted around the nails, each color represented a specific mode of transport. In order to show the participants how to do this task, the researchers started first. After all participants completed the task, they were randomly split into two groups. For a more active and analytic mental overview of the own habits of modality choice, each participant was asked to complete a mobility diary, stating which modes of transport they had used during the last week (see Appendix C). Next, the repertory grid method was employed (Hemmecke, 2012; Rao, 2014). During the repertory grid method we used, the participants were asked to write down the differences between several modes of transport (bus- car; bus- bicycle; bus- tram) that came to their mind on a pin-board, as shown in Figure 3. After the repertory grid task, the two groups could inspect the results of the other group. Next, the participants were asked to engage in a discussion about the factors mostly influencing their modality choice. The participants were invited to write the factors on the pin-board. Each participant then received five stickers. The task was to allocate the stickers to the factors they found most important. They were informed that they were free to allocate two or more stickers to one factor, whenever the factor was particularly important to them. During the next phase, the groups reunited and discussed about the factors that were identified in each group. The last phase of the focus group session was to think about and discuss levels of the most important factors. Moreover, the participants were asked to think about exclusion criteria for each factor. For example, an exclusion criterium for the factor price was 10€. This means that the participants would refuse to pay 10 € for public transport within the area of Braunschweig. After the last discussion, the participants were free to ask questions and could provide their e-mail address for follow-up information.

Figure 2. The figure shows a participant tracing his arrival route with the colored strings.

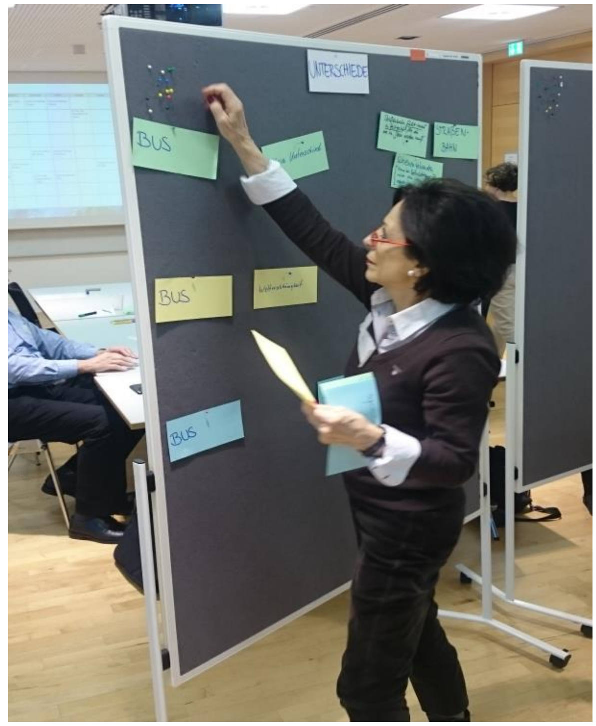

Figure 3. The figure shows a participant adding a difference between the bus and the bicycle, during the repertory grid method.

2.3 Results

During the focus group a total of 25 factors were mentioned. All 25 factors are summarized in Table 3. Table 3 also gives an overview of the corresponding valuation of each factor per group. The factor spontaneity was mentioned by the first group, while the second group specified spatial and temporal flexibility to be important. The first group further agreed on two important factors, which were not mentioned by the second group: weather and positive journey-based affect. Both groups independently agreed on a total of six factors influencing their modality choice: total time expenses, environmental friendliness, fare, baggage allowance, comfort of the vehicle, and healthiness. Figure 4 shows the valuation per group of each factor that received stickers, meaning that each of the factors has been valued to be under the five most important factors determining the modality choice by a participant.

Table 3

Overview of all identified factors and the corresponding valuation per group

Factors	Group 1 (n=4)	Group 2 (n=5)
Availability of a car	7	-
Total time expenses	6	3
Environmental friendliness	2	0
Spontaneity	5	-
Weather	2	-
Fare	2	0
Baggage allowance	1	3
Positive journey-based affect	0	-
Comfort of the vehicle	1	2
Healthiness	2	0
Spatial flexibility	-	4
Temporal flexibility	-	3
Reachability of travel destinations	-	4
Stress	-	1
Reliability	-	0
Safety	-	0
Privacy	-	0
Transfer time	-	0
Number of transfers	-	0

Presence of others	-	0
Information availability	-	0
Activity opportunities	-	0
Modernity of the vehicle	-	0
Availability during evening hours	-	0
Predictability	-	0

Note: This table gives an overview of all factors identified during the focus group session, as well as the number of stickers allocated to the factors by the group members. The value zero indicates that the factor has been mentioned by the group but did not receive any sticker of a group member. Factors with no assigned value were not mentioned by the group.

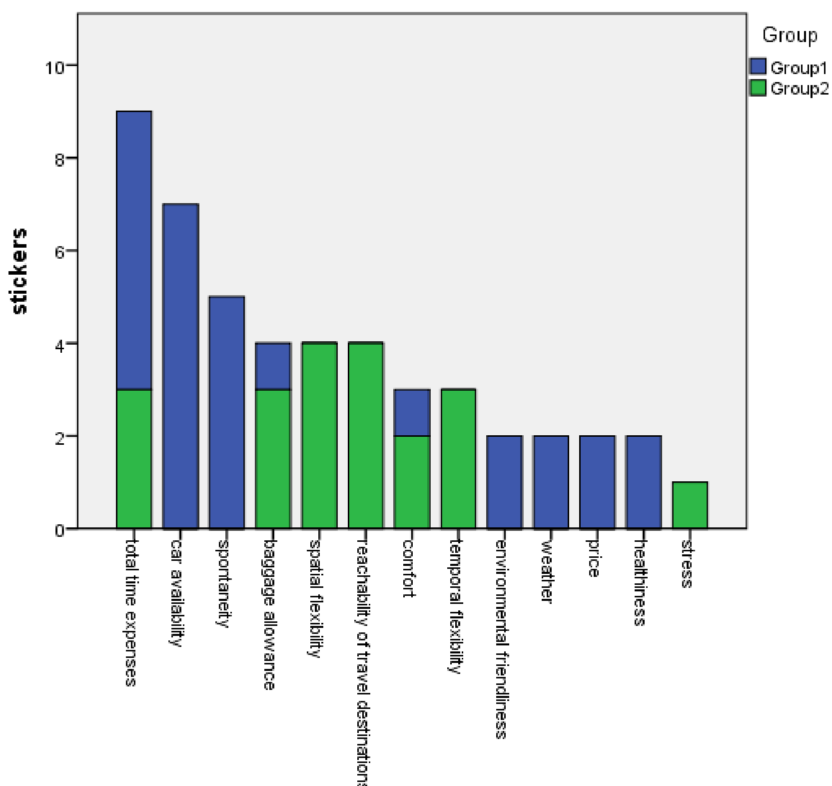

Figure 4. Bar chart showing all factors that were under the five most important factors for minimum one participant as well as the overall valuation per group.

2.4 Discussion: Selection of final factors and levels

In the literature (Knapp, 1997; Kløjgaard et al., 2012; Hair, Black, Babin & Anderson, 2013) several characteristics are strongly recommended for the selected factors and levels. In order to select factors and levels that meet the recommended characteristics and are suitable for the present study, the author established the following three rules:

(1) The factors should be changeable (Knapp, 1997) during the design process of the operational mobility system.

(2) It should be possible and ethically acceptable to make trade-offs with the factors (Kløjgaard et al., 2012).

(3) Inter-attribute correlation should be avoided (Hair at al., 2013).

The first rule aims at establishing the context in which the factors need to be suitable. As described above, the *Reallabor Schorndorf* evolves around the idea of a demand-responsive bus without fixed schedule and route. The context of the new systems operational concept is relatively limited compared to studies that investigate public transport in general. Therefore, a lot of the factors found in the literature, as well as factors mentioned during our focus group are omitted. Table 4 shows the application of these rules for all factors mentioned in the examined literature and by the focus group. The removal of *frequency* is a good illustration of applying the first rule. Even though *frequency* is the most mentioned attribute within the examined literature, it is not suitable for this study. While *frequency* seems to be an important factor when it comes to conventional public transport, it is not suitable for a demand responsive mobility system without fixed schedule.

Table 4

Overview of omitted factors

Rule	Description	Attribute
(1) not changeable	The factors are external circumstances.	Availability of a car[1] Weather[1] Healthiness[1]
(1) Not part of the operational system.	The factors are rather features of the vehicles and stop environment	Environmental friendliness[1] Comfort of the vehicle[1] Modernity of the vehicle[1] Personal space[2] Baggage allowance[1,3] Activity opportunities[1,3] Air Conditioning[4] Ease of Access[4] Cleanliness[4] Indoor environment[5]
		Contact to other travelers[3] Travel registration[3] Privacy[1] Presence of others[1] Driver attitude[4] Positive journey-based affect[1,2] Stress[1] effort[2]
	The factors are not applicable to the new concept.	Number of stops[3] Travel route[3] Stop environment[4, 5] Frequency[3, 4, 5]
(1) Not yet part of the operational system.	The factors will be considered once the existing system is tested in the field.	Seat availability[3] Operating Period[3] Availability during evening hours[1] Reachability of travel destinations[1] transfer time[1] Number of transfers[1] Spatial flexibility[1]

(2) No trade-offs should/ can be made.	The factors are considered prerequisites.	Reliability[1,4, 5] Predictability[1] Safety[1] (waiting/ onboard) [4]
(3) Dependency	The factors are (largely) dependent on factors that have already been chosen.	Total time expenses[1] spontaneity[1]

12345

The second rule ensures that trade-offs can be made between the factors. For example, the attribute *safety* is removed based on this rule, because no one should trade safety standards in exchange for e.g. low fares. Safety should rather be prerequisite of any mobility service than an attribute ready for trade-offs.

The third rule is essential as inter-attribute correlation leads to a lack of uniqueness for each level causing unreliable estimates. Furthermore, correlated factors create unbelievable combinations in the choice sets (Hair et al., 2013). The avoidance of inter-attribute correlation finds most application when selecting among the short-listed factors. Since most remaining factors are related to the topics time and flexibility, special caution for dependency is required for selecting among these factors. The three factors related to time are *walking time, journey time,* and *total time expenses*. While the focus group placed most value on *total time expenses*. The *walking time* and *journey time* have been mentioned repeatedly in the literature (Jianrong et al., 2011; Gardner &

[1] Focus group
[2] Gardner & Abraham (2007)
[3] Knapp (1997)
[4] Hensher & Prioni (2002)
[5] Jianrong & colleagues (2011)

Abraham, 2007; Hensher & Prioni, 2002; Knapp, 1997). Since *walking time* and *journey time* are important aspects of the operational system and are not dependent on each other, they are the first two factors chosen. Consequently, the removal of *total time expenses* is inevitable according to the third rule of dependency. The *walking time* is defined by the time the user needs to walk to reach his destination, or to catch the bus. It can also be thought of the spatial accuracy in which the *Quartiersbus* is able to pick up and take the user to his desired destination. The *journey time* is defined by the total amount of the time the user spends in the *Quartiersbus*. As *temporal flexibility* is one of the *Quartiersbus*' key features, it is also one of the most interesting aspects of the *Quartiersbus*. Furthermore, *temporal flexibility* was mentioned by the focus group and was one of the second valued factors of the second group. In our study, *temporal flexibility* is captured with the third identified attribute *shift of departure*. By selecting *shift of departure* instead of temporal *flexibility*, the attribute gains intuitiveness of its practical result. Even though every attribute is explained and defined to the respondents beforehand, the expression *temporal flexibility* might cause confusion. It seems much more convenient and intuitive for the respondent, to be questioned about the acceptance of departing ten minutes later, compared to a *temporal flexibility* of plus ten minutes. The third attribute *shift of departure* is defined as the time deviation of actual departure from the preferred departure the user has specified. The fourth attribute is the *booking period*, as it is a practical issue of the concept. It is important to know whether the users want to use the system as spontaneous as a taxi, and whether they are open to trade-offs in this respect. Moreover, it is represented within the factor *spontaneity* mentioned during the focus group. The last two factors which have been selected are *fare* and *information availability.* Both have been mentioned in the literature as well as by the focus group. Moreover, the weights of both are relevant to the concept of the system and are compensatory related to the other selected factors (Baier & Brusch, 2002). The levels of the six factors have been identified and tested by means of follow-up emails to the participants of the focus group, as well as pre-tests of the Conjoint Analysis. Moreover, the range of some levels were determined by the context they are used in. For example, the levels of the fare should ideally be cheaper than taxicabs and more expensive than conventional public transport. Also, the involvement of a booking period of zero minutes has been left out. This concept would depend on many vehicles on the streets comparable to taxicabs, which is not yet feasible for the project. An overview of the final factors and corresponding level is given in Table 5.

Table 5

Final factors *and corresponding levels*

Factors	Level 1	Level 2	Level 3	Level 4
Fare	2,50€	3,00€	3,50€	4,00€
Booking period	5 min	10 min	30 min	-
Walking distance	0 m	300 m	500 m	-
Information availability	none	few	many	-
Shift of departure	+0 min	+10 min	+20 min	-
Travel Time	10 min	20 min	30 min	-

Note: This table shows all factors and their corresponding levels which are used in this conjoint analysis. The levels of *information availability* are defined as follows: None: the user does not receive any information about the details of his journey; Few: the user receives broad information about the journey, e.g. arrival period; Many: the user receives detailed information about his journey, e.g. reasons for current delays.

3. Conjoint Analysis

3.1 Theoretical Background

Research into user preferences has a long history. Being a method that portrays the consumers' decisions as trade-offs among multi attribute products and services, the conjoint analysis caught considerable attention since the mid-1970s. Around the 1980s the usage rates of the conjoint analysis ten folded (Hair et al., 2013). Along with increasing usage rates in marketing, the conjoint analysis also spread to many other areas, such as pricing and industrial marketing (Hair et al., 2013).

The growing and widespread usage of the conjoint analysis led to the development of different alternative conjoint methodologies. The three conjoint methodologies include the traditional conjoint, adaptive conjoint and choice-based conjoint (Hair et al., 2013). The methodologies differ with regard to the number of factors, level of analysis, permitted model form and the choice task. In this study a choice-based conjoint is carried out. The choice task of the choice-based conjoint consists of profiles presented in sets rather than one by one, therefore providing increased realism. However, the number of factors is limited (usually to six), because of the increased complexity of the task. The small number of factors does not limit this study, since it was concluded previously that the six selected factors form a sufficient representation of the new mobility concept. In contrast to the other conjoint methodologies, the choice-based conjoint allows for statistical analysis of interaction effects and the estimations can be multi-level, such that estimates can be obtained on population and individual level (Hair et al., 2013).

As described in section 1.5, the aim of the following conjoint analysis is to estimate the utility of each factor for regular- and irregular-users of public transport. However, the valuation of factors might not only differ based on prior public transport usage: The valuation of the factors is also dependent on the context of the decision to be made. For example, the respondents' valuation of a 3.50 € fare is expected to be different for a route of 5 km as opposed to 20 km. Also, differences might be caused depending on the purpose of a journey, for example whether the customer needs to be on time for an appointment or not. Therefore, two scenarios differing in their purpose were created. The first scenario was having a doctor's appointment in the inner city 5 km away from your home. The second scenario was to go shopping for a gift for a friend and drinking some coffee with friends in the inner city, 5 km away.

3.2 Methods

3.2.1 Participants. In total, 529 individuals from all over Germany completed a web-based survey. Participants were acquired by sharing the link of the survey on social media platforms, such as Facebook and Twitter. The link has been shared by the German aerospace center (DLR) and several public transport companies. Eight of the respondents were excluded as they fell under the age restriction of 18 years. The final sample (N = 521) consisted of 300 male (57.8%) and 210 female (40.5 %) respondents with a mean age of 45.33 (SD = 17.15 years). The gender of eleven respondents was unknown due to missing data. Nearly half of the participants reported working full-time (45.9 %), while 11.9 % were part-time working, 19.3 % were retired and 17.7 % were still in education. A minority of participants declared being unemployed (1.7 %), currently staying at home (1.9 %), or being home-maker (0.4 %). A majority of the participants reported having a driver's license (88.1 %) and at least one car (78.3 %; 42.8 % having one car, 35.5% having two or more cars). Slightly less than a third of the sample (29.8 %) indicated to use public transport at least once a week, the others being irregular-users (using public transport less than once a week). Each of the 16 federal states was represented, though only one participant reported being from

Saarland. Most represented federal states were Lower Saxony (18 %), Baden-Wuerttemberg (15 %), North Rhine Westphalia (9.8 %) and Bavaria (9.4 %). Overall, 29 % of the participants did not report the federal state they are coming from. Informed consent was obtained from all participants. The Ethics Committee of the University of Twente approved that the study is in accordance with the standards listed in the faculties' Protocol about Ethics and Research.

3.2.2 Experimental Design. Due to the large quantity of possible factor combinations (namely 3 x 3 x 3 x 3 x 3 x 4), a fractional factorial design has been employed opposed to a full factorial design. The fractional factorial design and the choice sets were created with the AlgDesign package in R (Wheeler, 2015), as described by Aizaki and Nishimura (2008). This resulted in full profile (FP) choice sets, where every alternative displays a level for every factor in the study.

3.2.3 Task. The web-based survey consisted of 24 choice sets with three alternatives each, including an opt-out option. The choice sets were presented to the participants in random order to avoid order effects. Completing the survey took approximately 20 minutes. The survey started with the informed consent, declaring that participation is voluntary, and that the respondent is of age (≥18 years old). Then, one of two scenarios (between-subjects-design) was introduced to the participants to describe the context of the choice situation. All factors and levels were introduced and explained to the participants by means of descriptions and images. Figure 5 shows how the factor *shift of departure* and its levels was explained to the respondents. Figure 6 shows one of the choice sets of the survey.

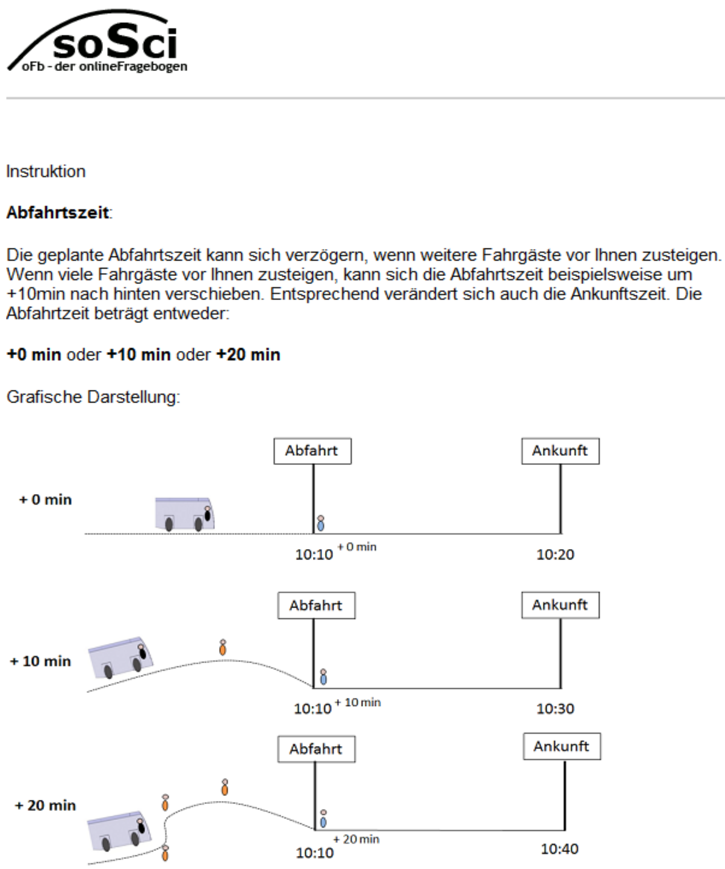

Figure 5. Screenshot of the introduction of the factor *shift of departure* and its levels

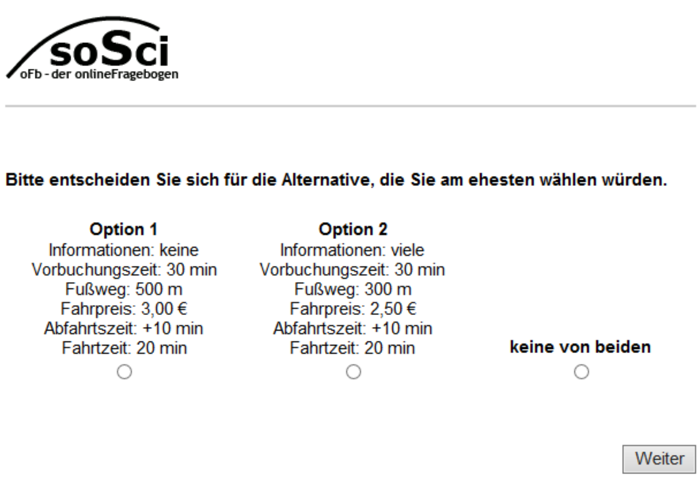

Figure 6. Screenshot of one of the choice sets presented to the respondents

3.2.4 Apparatus. The web-based survey was programmed with SoSci Survey (Leiner, 2014), which is an online tool for designing and implementing online questionnaires.

3.2.6 Data analysis. A conditional logit model has been applied by using the statistical software R, as described by Aizaki and Nishimura (2008). The parameters of the model are estimated with the maximum likelihood estimation (MLE) by using the $clogit()$ function included in the package survival in R.

The regression model consists of dummy variables of the factors (see Table 5), as well as interaction effects with scenario and prior usage of public transport. Furthermore, the model is extended by additional interaction effects, such as age and gender, to avoid estimation of an underfitted model and possibly missing important effects (see Table 7). While underfitted models tend to miss important effects, overfitted models contain too many parameters to be justified by the data (Burnham & Anderson, 2004). Usage of an overfitted model tends to impair predictive accuracy of the regression model, possibly leading to a failure of predicting future observations. Since the focus of this study is to predict future choices of transport modes as accurate as possible, it is important to prevent model overfitting and to select the model by predictive accuracy. As the present study is explorative in nature and focuses on predictive accuracy rather than replicability, model pruning is intentionally not based on p values, which focuses on hypothesis testing (Burnham & Anderson, 2004). A method for selecting the model with the best predictive accuracy is the leave-one-out cross-validation (LOOCV) (Shao, 1993). However, the LOOCV is computational expensive and its' complexity further increases with large datasets (Shao, 1993). An easier to compute alternative to LOOCV is the Akaike information criterion (AIC), as Stone (1977) has demonstrated that the AIC is asymptotically equivalent to the LOOCV. Therefore, model selection by AIC seems well suited for the present study.

The AIC is based on information theory and offers an estimate of the relative discrepancy between full reality and each of the candidate models (Burnham and Anderson, 2004). In the literature (Burnham & Anderson, 2004), two Akaike information criteria are described: the first-order criterion (AIC) and the second-order criterion (AIC_c). Generally, AIC_c should be used when the number of parameters (K) is large relative to sample size (n). Burnham and Anderson (2004) proposed using AIC_c unless $\frac{n}{K} > 40$ for the model with the most parameters. In our case, the AIC_c is needed when one of the models exceeds a minimum of 14 parameters.

3.3 Results

3.3.1 Data preparation. Eight individuals were excluded from the study on the basis of lacking the required age of 18 years. Also, datasets without completed choice tasks were excluded. The data has been formatted as demonstrated by Aizaki and Nishimura (2008) to consider the stratification of the choices, see Figure 7. Additionally, dummy variables of each factor were created. These dummy variables have been added to enable the estimation of main effects for each level, instead of each factor. The variables comprising one factor, are used for the estimation of interaction effects. Furthermore, two new binary variables were created. The variable userpub (regular-user of public transport) indicates whether the respondent uses public transport on a weekly basis. The variable scenariodoc specifies which scenario was introduced to the respondent. In order to prevent model estimation for newborn, the variable age has been shifted. After shifting, a value of zero corresponds to an age of 18 years in the variable Ageshft. The R code of the data analysis can be found in Appendix D.

STR Interview-Nummer (fortlaufend)	RES	ASC	Fare	Fare2.5	Fare3.0	Fare3.5	Fare4.0
101	0	1	1	1	0	0	0
101	1	1	4	0	0	0	1
101	0	0	0	0	0	0	0
102	0	1	1	1	0	0	0
102	1	1	2	0	1	0	0
102	0	0	0	0	0	0	0
103	0	1	2	0	1	0	0
103	1	1	1	1	0	0	0
103	0	0	0	0	0	0	0
104	1	1	3	0	0	1	0
104	0	1	4	0	0	0	1

Figure 7. The dataset after formatting. STR is a stratification variable that indicates the respondent as well as the question ($STR = 100 \; x \; N + Q$). The variable RES indicates which alternative the respondent has chosen, where the value 1 indicates that the alternative has been selected and the value 0 indicates that the alternative has not been chosen. ASC is an alternative specific constant, where 1 specifies the alternatives and 0 the none-of-these option (Aizaki & Nishimura, 2008). Each factor is indicated by its own variable, where the values indicate the level, as well as, three (in case of fare four) dummy variables for each level.

3.3.2 Data exploration. Associations among person-level variables are visually provided in Figure 8, which can be found in the section Figures. Overall, there are no strong linear associations among person-level variables. However, there is a negative association between public transport usage and car possibility. The association between rare use of public transport systems, and possession of both, driver's license, and car (called *car possibility*) is plausible.

In order to test whether the associations might cause multicollinearity, the variance inflation factor (VIF) was estimated (James, Witten, Hastie & Tibshirani, 2017). The package car in R enables the estimation of the VIF. Table 6 shows the variance inflation factor for the person-level variables.

Table 6

Testing for multicollinearity using VIF

Predictor variables	Variance inflation factor (VIF)
Usage of public transport	1.19
Scenario	1.02
Age	1.14
Gender	1.01
Mobility impairment	1.09
Level of education	1.02
Car possibility	1.17

Note: The VIF is approximately 1 for all person-level variables. Thus, the variance of the estimated coefficient of e.g. car possibility is inflated by factor 1.17, because of collinearity. VIFs that are close to 1, are not further considered to cause problems due to collinearity.

3.3.3. Model selection. Table 7 shows all variables in the extended model that are tested for interaction effects with the factors, as well as an indication of their inclusion after model pruning. In our case, model pruning is done by the AICc, since the extended model contains far more than 14 parameters, as shown in Table 7.

Table 7

Overview of added variables and interaction effects

Variable	Description	Interaction effects (IA) in extended model	IA after model pruning
ageshft	shifted numerical variable indicating the respondents age, starting at 0 for 18 year olds	: Fare	
		: walking distance	y
		: travel time	y
		: shift of departure	y
		: booking period	y
		: information availability	y
Gender	na: missing value	: Fare	
	0: male	: walking distance	
	1: female	: travel time	
		: shift of departure	
		: booking period	
		: information availability	y
Usage of public transport	na: missing value	: Fare	y
	0: usage of public transport less than once a week	: walking distance	
		: travel time	y
	1: weekly usage of public transport	: shift of departure	
		: booking period	
		: information availability	
Scenario	na: missing value	: Fare	y
	0: shopping	: walking distance	y
	1: doctors appointment	: travel time	y

		: shift of departure	y
		: booking period	y
		: information availability	
Mobility impairment	na: missing value 0: no physical mobility impairment 1: impaired physical mobility	: walking distance	y
Car possibility	na: missing value 0: respondent does not own a driver's license and/or a car 1: respondent owns a driver's license and car	: Fare : walking distance : travel time : shift of departure : booking period : information availability	 y
Level of education	na: missing value 0: left school before graduation 1: pupil, basic school qualification, secondary school certificate, completed vocational training 2: general qualification for university entrance 3: higher education degree	:Fare	y

Note: The effect of the variables (ageshft, gender, usage of public transport, scenariodoc and car possibility) on the respondents valuation of each attribute is included into the extended model. Furthermore, it is tested wether the level of education interacts with fare, and wether mobility impairment interacts with the walking distance. Interaction effects kept in the model after pruning are indicated with y (yes).

3.3.4. Final Model. It is important to note, that the model is estimated with treatment contrasts. The main effects are estimations for the reference group with the following attributes: gender: male, 18 years of age, irregular usage of public transport and no mobility impairment. The interaction effects indicate how the factors' influence is changing relative to the reference group. Also, the highest of level of each attribute is a reference level and set to zero. Accordingly, each coefficient indicates the change of the factors' influence relative to the highest level. Therefore, the highest level of each factor is not represented in Table 8.

The main effects of the conditional logit model are shown in Table 8. A decrease of fare from 4.00€ to 3.50€ increases the odds of preference by factor 1.6 (exp(ß) = 1.63). Decreasing fare from 4 € to 3 € or even 2.5 € doubles (exp(ß) = 2.1) and triples (exp(ß) = 3.1) the odds of preference, respectively. A decrease of the walking distance from 500m to 300m increase the odds of preference by half (exp(ß) = 1.5). Providing a door-to-door service instead of walking distances of 500m increases the odds of preference by factor 1.73 (exp(ß) = 1.73). Enhancing the booking period from 10 minutes to 30 minutes increases the odds of preference by more than one third (exp(ß) = 1.36). A 5 minutes booking period, instead of 30 minutes, increases the odds of preference by factor 1.53 (exp(ß) = 1.53). Decreasing the shift of departure from 20 minutes to 10 minutes increases the odds of preference by more than half (exp(ß) = 1.63). Comparing a 20 minutes shift of departure to no shift, more than triples the odds of preference (exp(ß) = 3.13). A 10 minutes reduction of travel time from 30 minutes to 20 minutes doubles the Odds of preference (exp(ß) = 2.17), while a reduction from 30 minutes to 10 minutes more than quadruples the odds of preference (exp(ß) = 4.45). Offering few or no information instead of many decreases the odds of preference by more than one third (exp(ß) = 0.62) and two thirds (exp(ß) = 0.31), respectively.

Table 8

Results of Conditional Logistic Regression: main effects

Factor	Level	ß	Exp(ß)	Se(ß)	Lower .104	Upper 99.896
Fare	2.50 €	1.13	3.1	0.1	2.31	4.16
	3.00 €	0.74	2.1	0.07	1.67	2.64
	3.50 €	0.5	1.63	0.06	1.37	1.94
Walking Distance	0 m	0.55	1.73	0.08	1.34	2.23
	300 m	0.4	1.5	0.06	1.26	1.78
Booking Period	5 min	0.42	1.53	0.08	1.19	1.96
	10 min	0.31	1.36	0.05	1.16	1.59
Shift of departure	0 min	1.14	3.13	0.06	2.5	3.92
	10 min	0.49	1.63	0.09	1.37	1.94
Travel time	10 min	1.49	4.45	0.09	3.39	5.83
	20 min	0.78	2.17	0.05	1.85	2.56
Info availability	None	-1.18	0.31	0.08	0.24	0.39
	Few	-0.48	0.62	0.05	0.53	0.72

Note: The last level of each factor is the reference level. The credible intervals were corrected according to Bonferroni.

In addition to revealing the impact of each level, the conjoint analysis also enables the estimation of the relative importance of each factor (Hair et al., 2013). The relative importance of each factor is calculated as described by Hair and colleagues (2013), results and most important steps of the calculation process are provided in Table 9.

Table 9

Relative importance of factors

Factor	Minimum	Maximum	Range	Importance
Fare	0	1.13	1.13	19.12 %
Walking Distance	0	0.55	0.55	9.31 %
Booking Period	0	0.42	0.42	7.11 %
Shift of departure	0	1.14	1.14	19.29 %
Travel time	0	1.49	1.49	25.21 %
Info availability	-1.18	0	1.18	19.97 %

Travel time accounted for about 25% of the variation in utility scores, and is thus, the most important factor contributing to the respondents choices. Information availability, shift of departure and fare, explain each around 19% of the variation. The least important factors were walking distance and booking period with 9% and 7 %, respectively.

The interaction effects are displayed in Table 10. Overall, the interaction effects seemed to be minor, as the coefficients are all relatively close to 0. Two interaction effects with regular use of public transport were found. The odds of preference were about a tenth lower for regular-users than for irregular-users after an increase of fare of one unit (exp(ß) = 0.89). In contrast, the odds of preference were higher for regular-users than for irregular-users after an increase of travel time. The odds were close to one (exp(ß) = 1.1) and the confidence interval was narrow without intercepting one (CI [1.01, 1.2]).

Table 10

Results of Conditional Logistic Regression: Interaction effects

Factor	IA variable	ß	Exp(ß)	Se(ß)	Lower .104	Upper 99.896
Fare	: userpub	-0.11	0.89	0.02	0.83	0.96
	: Scenariodoc	0.06	1.06	0.03	0.98	1.14
	: education	-0.06	0.94	0.01	0.91	0.97
Walking Distance	: Scenariodoc	0.1	1.1	0.04	0.98	1.24
	: age	-0.01	0.99	0.00	0.98	0.99
	: mobility impairment	-0.14	0.87	0.04	0.77	0.99
Booking Period	: Scenariodoc	0.07	1.07	0.04	0.96	1.21
	: age	0.01	1.01	0.00	1.003	1.01
Shift of departure	: Scenariodoc	-0.1	0.91	0.03	0.82	1.002
	: age	0.003	1.003	0.00	1.001	1.01
Travel time	: userpub	0.1	1.1	0.03	1.01	1.2
	: scenariodoc	-0.06	0.94	0.03	0.84	1.04
	: age	0.01	1.01	0.001	1.002	1.01
Info availability	: age	-0.01	0.99	0.00	0.99	0.995
	: gender	-0.06	0.95	0.02	0.89	1.01
	: car possibility	0.11	1.12	0.02	1.04	1.2

Note: The credible intervals were corrected according to Bonferroni.

The age of the respondents interacted with five of six factors. With increasing age, the preference for short walking distances intensified (ß = -0.01), which was also true for respondents with mobility impairments (ß = -0.14). Also, the preference for many information decreased with age (ß = -0.01). Positive interaction coefficients were found for travel time and age (ß = 0.01), shift of departure and age (ß = 0.003), as well as, booking period and age (ß = 0.01). The confidence intervals were particularly narrow (not exceeding a range of .01) and did not include a value of one. At first, these interaction effects with age might seem minor, however, it is important to note that the effects represent changes for only one year.

Interestingly, with increasing fare, the odds of preference were lower for higher educated respondents (exp(ß) = 0.94), than for lower educated respondents. Also, with increasing information availability, the odds of preference are higher for people who have the possibility to drive by car (exp(ß) = 1.12).

All confidence intervals of interaction with the scenario and gender include the value 1. Consequently, it is reasonable to assume that the Odds of preference might not differ between the scenarios and gender, and the effects described below need to be interpreted with caution. The coefficients of shift of departure and travel time are negative (ß = - 0.1; - 0.06), indicating that a short shift of departure and travel time is more relevant for the doctors' appointment scenario than the shopping scenario. Even though this effect should be interpreted with caution, it is important to note that the confidence interval leans below one, exceeding one not until the third decimal (CI [0.82,1.002]). Also, a pronounced tendency of preferring short shifts of departure in the case of a doctors' appointment, seems plausible. Preferences for low fares, small walking distances, and short booking periods are smaller for the doctors' appointment scenario, than for the shopping scenario (ß = 0.06; 0.1; 0.07). The preference for many information is more pronounced for men than for women (ß = - 0.06).

4. General Discussion

4.1 Summary of findings

The aim of the present study was to identify the factors and their valuation determining the usage of public transport modes for regular-users and irregular-users. The following research questions were answered: Which aspects of the flexible transport service affect travelers' appraisal of the mobility service? Which factors provide the basis for regular-users and irregular-users to make trade-offs between the service characteristics of the *Quartiersbus*?

By means of a literature review and a focus group, six factors of the *Quartiersbus* have been identified: fare, travel time, shift of departure, booking period, walking distance and information availability.

As mentioned in Section 3.3.4, the present study estimates the model with treatment contrasts, thus requiring interpretation of the main effects for the reference group of 18-year-old males, who use public transport irregularly and have no mobility impairments. With the highest relative importance, travel time seemed to be the most relevant factor to the respondents. Such high importance of travel time is in contradiction to findings of other studies (Xiong, Hetrakul & Zhang, 2014; Eboli & Mazzulla, 2008). However, travel time was valued less important by regular-users of public transport. Also, it seems that with increasing age the importance of travel time declines as well. While travel time seemed to be most important for an 18-year-old, it is only on third place for a 60-year-old, with a total decline from of 7.4 % relative importance. Information availability was found to have the second largest impact on the respondents' preferences, closely followed by shift of departure and fare. The high importance of information provision for travelers is supported by previous research in the field of public transport (Dziekan & Kottenhoff, 2007; Eboli & Mazzulla, 2008; Reed, 1995). Also, the respondents seemed to be sensitive to shifts of departure that are due to the entry or exit of other travelers. This finding is in line with research investigating travelers' valuation of public transports reliability (Eboli & Mazzulla, 2008; Jianrong, 2011). Fare was only on fourth place in terms of relevance. The rather low importance of fare is consistent with the studies of Jianrong and colleagues (2011) and Knapp (1997), though evidence about the relative importance of fare is mixed (Gardner & Abrahamse, 2007; Malodia & Singla, 2016). As regular-users were more sensitive to fare than the reference group, fare is expected to gain importance when including both user groups. Walking distance and booking period explained the least variation of utility scores in the study with 9% and 7%, respectively. While the walking distance was not deemed important by the reference groups of 18 years old participants, its' valuation seems to increase with age, as well as, for respondents with mobility impairments. These interaction effects might explain the seeming contradiction to Jianrong and colleagues (2011), who found walking time to be more important than fare. Unfortunately, the study by Jianrong and colleagues (2011) lacks an adequate description of their respondents, making it impossible to compare the estimations of walking distance importance, given a certain age. On the other hand, the low importance of walking distance for young respondents is consistent with the findings of Eboli and Mazzulla (2008) who carried out a stated preference experiment with students concerning bus public transport.

In contrast to walking distance, factors related to time or time management, do not seem to bother older respondents as much as younger respondents. One explanation could be that already retired respondents might be more flexible regarding time and time management, suggesting a nonlinear relationship. Moreover, information availability becomes less important with increasing age. This finding is consistent with that of Wilkowska, Farrokhikhiavi, Ziefle and Vallée (2014), who found that younger users of ridesharing schemes place more value on detailed information provision than older users. As information in our study is explicitly provided via mobile app, decline of importance could be explained by older respondents not feeling confident using the app.

Only two of six factors seem to be valued differently by regular- and irregular-users of public transport: Fare and travel time. Low fares seem to be more important for regular-users, whereas short travel times are more important to irregular-users. These effects are quite expected, as Gardner and Abrahamse (2007) highlighted the importance of minimizing travel time as motive in sustaining car usage. Also, reforms in the city of Seoul increased bus usage by 700.000 people per day with a redesign of the bus system. Besides a decline in monthly bus accidents, one of the major improvements of the new system was an increase of bus speed by 33 percent and on certain corridors up to 100 percent (Pucher, Kim & Song, 2005), probably greatly reducing travel time.

Overall, the interaction effects seem to be minor, except for the observed effects of age. Especially, the interaction effects with scenario and gender are uncertain, as indicated by the confidence limits. Consequently, it is reasonable to assume that the odds of preference might not differ between scenarios and gender. Also, Hensher and Prioni (2002) confirm the uncertainty of scenario interactions as they did not find an effect of trip purpose on respondents' stated preferences, either. This is good news, because the less groups of users differ in their priorities of a new mobility system, the easier to design an optimal service for everyone.

4.2 Limitations

Several limitations of this study need to be considered. First, there was no verification whether all respondents did understand the instructions and the factors. One respondent indicated in the free text field of the survey that he/she was confused about the booking period, asking whether it is possible to book the vehicle two weeks in advance. To our knowledge, only one respondent was confused about a factor, however, there may be other respondents who did not comment on unclear instructions.

Second, the Conjoint analysis requires factors, but the interaction effects were estimated as if the levels were metric (Aizaki & Nishimura, 2008). By doing so the interaction effects are assumed to be linear, though they should not be interpreted in a strictly metric sense. Applying an alternative approach that is not based on the assumption of factors is proposed. The estimation of a linear mixed-effects logistic regression with metric predictors, instead of predefined factor levels is possible by leaving out the none-of-these option, and force the respondents to choose between two alternatives. Also, this would enable the identification of sweet spots, which is extremely valuable information for the design of new systems.

Third, the level intervals were not equidistant within all factors. For example, levels of booking period are 5 minutes, 10 minutes, and 30 minutes. Since the interaction effects are estimated as if the levels were metric, the interpretation might be more intuitive if the levels were equidistant. However, the value of a factor is unlikely to increase linearly with minutes (or corresponding unit), anyhow, due to ceiling effects. Also, recommendations of equidistant levels of the factors were not found in the literature.

Finally, the study was limited to the operational system of the mobility concept. Other factors that might contribute to the decision process are not included. Especially, considering the differences between regular- and irregular-users of public transport, this limitation might have contributed to the few interaction effects that have been found. There may be many more differences between regular- and irregular-users which are not related to the operational concept.

4.3 The Optimal Design

From the respondents' perspective an optimal design for a new spatial and temporal flexible mobility system would be: a door-to-door service, without shifts of departure, provision of much detailed information, no required booking period, fares as low as possible, and a travel time as short as possible. However, the mobility system has to be feasible and economical from the operators' perspective, also. Therefore, an optimal design is balanced between providing maximum satisfaction to the user while remaining feasible and economical for the public transport company.

For illustration purposes, a design is presented in the following section, which is expected to be competitively viable. A fictional character Thomas, 60 years-old lives in Schorndorf and wants to travel from *Goethestraße* to *Im Rank* in *Plüderhausen*, which is a total distance of 5 kilometers. The conventional public transport system suggests traveling by bus line 248 in 14 minutes, from bus stop *Schorndorf Reinhold-Maier Platz* to bus stop *Plüderhausen Birkenallee*. Both stops are approximately 500 meters away from starting point and destination. According to the defined levels of information availability, bus lines in Germany provide little information. The bus ticket costs 2.90€ and booking is not required. Also, shifts of departure are not planned. Based on the findings, an approximate utility score of the journey can be estimated by adding all utility scores of the corresponding levels (Hair et al., 2013). According to the model in our study, the overall utility score of this journey is around 2.8. This is just a rough approximation, since the values of e.g. 14 minutes and 2.90€ are not equal to the predefined levels of the model. According to the maximum utility model, Thomas is expected to choose an alternative option, if the options utility score is higher than 2.8 (Hair et al., 2013).

Since the most important factor for the respondents is travel time, it is suggested to provide a travel time of 10 minutes. According to the present model, walking distance is even more important for respondents that are 45-years-old or older. Therefore, providing a door-to-door service is advisable in all areas where the average age is not particularly low. Detailed information provision on its own is of high value to the users, but it also counteracts negative valuation of other factors. Reed (1995) found that detailed information provision extends the users' acceptable waiting time. Therefore, it is suggested to invest into detailed and fast information provision, to remain more flexible regarding shifts of departure. Since the booking period was the least influential factor on the users' preferences, a booking period of 30 minutes seems reasonable. A higher booking period might also allow for advanced route planning and more efficient route bundling. Consequently, it might also lead to shorter travel times and earlier information provision for the customer, both of which is more valuable to the customer than the booking period itself. In summary, the design presented here is a door-to-door service providing a travel time of 10 minutes, many information, 20 minutes shift of departure are possible, fare of 2,50€, and a booking period of 30 minutes. By adding the corresponding coefficients of the proposed design, the approximate overall utility of the design is estimated to be 3.69 (Hair et al., 2013). Accordingly, Thomas is expected to prefer the new flexible transport system over conventional public transport. Of course, this design proposal is only one possibility to design a flexible mobility system, balanced between user satisfaction and feasibility. Also, the operators feasibility of a system is largely dependent on other aspects, such as traffic density or federal grants.

4.4 Further research

Travel time has been found being the most important factor in this study. Yet, there is no knowledge of an acceptable length of detours. Thus, more research is required investigating the length of detours that is still acceptable for customers. The next iteration should thrive for an exact quantification by using metric predictors and possibly finding a sweet spot for detours.

Investigating the cause of the importance decline of information availability with age, is another important area of future research. Since information was provided via mobile app, elderly people may not have felt as confident to access the information. As Díaz- Bossini and Moreno (2013) point out, elderly people experience several difficulties, if the applications are not properly designed for older people. Fortunately, there is growing awareness of the importance to design mobile interfaces for elderly people (Díaz-Bossini & Moreno, 2013). Especially new mobility systems should take these accessibility issues into account and prevent them. Information provision suitable for elderly people might equalize the interaction effect between information availability and age, thereby providing the chance to increase public transport usage by providing enough information.

As described in section 4.2, this thesis was limited to the operational concept of the *Quartiersbussystem*. Since research investigating travelers' requirements of new flexible mobility systems is a relatively young field of research, further studies exploring other aspects of these mobility systems are needed. In the light of the fast emergence of new vehicle concepts, that are not yet fully implemented into regular public transport, investigations about the influence of the vehicle type (automated or electric) might be very interesting. Customers might be more willing to try new mobility systems if the vehicles are electric or automated, may it be out of environmental considerations or curiosity. Also, further research considering other aspects of mobility systems might also find additional differences among regular- and irregular-users of public transport.

Mobility systems associated with more futuristic looking or feeling vehicles might attract interest of private transport users.

Taken together, this study extends our knowledge of respondents' preferences of factors that are inherent to flexible mobility systems, such as the *Quartiersbussystem*. The findings of this thesis are particularly relevant for a user-centered development and implementation of flexible mobility systems. However, this study provides only a first approach of investigating this relatively young field of research, as many questions remain to be answered.

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Figures

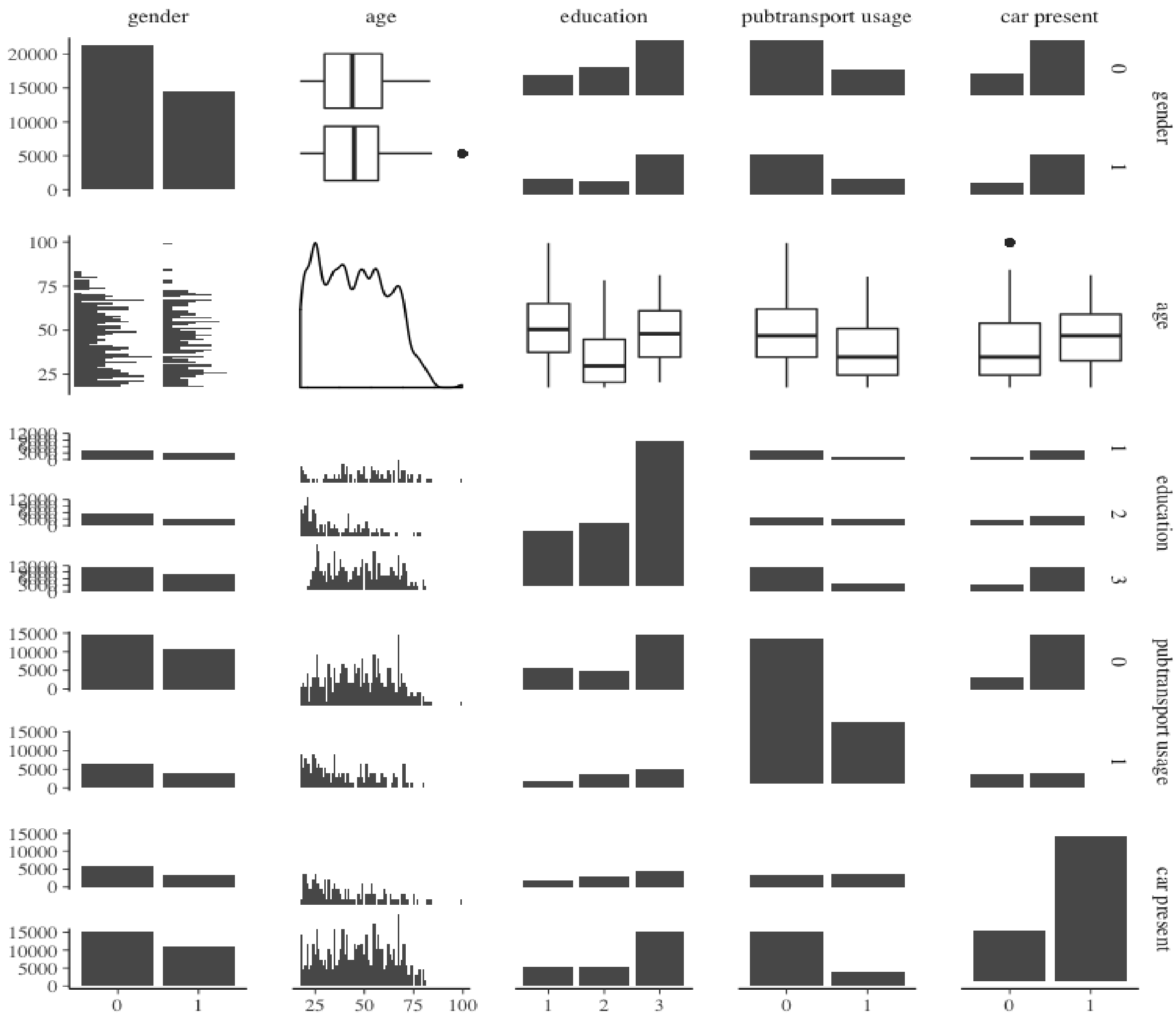

Figure 8. Matrix of plots of the intercorrelations among the person predictor variables

Appendix A

The informed consent for the focus group participants.

Einwilligungserklärung

Deutsches Zentrum
für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

Institut für Verkehrssystemtechnik

Name, Vorname:

Ich erkläre, dass ich die und diese Einwilligungserklärung zur wissenschaftlichen Studie

„Mobilitätsbefragung im ländlichen Raum“

erhalten habe.

1. Ich wurde für mich ausreichend schriftlich über die Untersuchung informiert. Ich erkläre, dass ich freiwillig an der Befragung teilnehme und meine Teilnahme zu jeder gewünschten Zeit beenden kann.
2. Mir ist bekannt, dass die erhobenen Daten anonymisiert und in elektronischer Form gespeichert werden, so dass für externe Personen nicht zu erkennen ist, welcher Teilnehmer welche Daten geliefert hat. Die Daten können im Rahmen wissenschaftlicher Forschungsvorhaben ausgewertet werden.
3. Ich bin damit einverstanden, dass die im Rahmen der wissenschaftlichen Untersuchung über mich erhobenen Daten ausgewertet werden.
4. Ich bin darüber informiert wurden, dass Video- und Fotoaufnahmen von mir gemacht werden. Ich weiß, dass wenn ich nicht abgebildet sein möchte, ich dies der Workshopleiterin mitteilen kann.
5. Es gibt keine richtigen oder falschen Antworten während der Fokusgruppe. Das Ziel ist es, viele verschiedene Meinungen und Standpunkte von den Teilnehmern zu erfahren. Wir erhoffen uns ehrliche Antworten, auch wenn Ihre Meinung von der Mehrheit abweicht. Wir bitten Sie, alle Aussagen der Teilnehmer vertraulich zu behandeln.

Ich habe diese Erklärung gelesen und verstanden.

______________, den ____________________ ______________________
(Ort) (Datum) (Unterschrift)

Das Original dieser Einwilligungserklärung verbleibt beim DLR.
Eine Kopie wird dem Probanden auf Wunsch ausgehändigt.

Appendix B

The sociodemographic questionnaire for the focus group participants.

Soziodemografischer Fragebogen

Um die Ergebnisse des Workshops anschließend auswerten zu können, benötigen wir ein paar Informationen zu den Teilnehmern. Die Daten dienen ausschließlich einer Analyse der Repräsentativität. Sie werden anonym ausgewertet und vertraulich behandelt.

Geschlecht: □ weiblich □ männlich

Alter: ______ Jahre

Was ist Ihre derzeitige berufliche Situation?
□ Vollzeit/ Teilzeit erwerbstätig
□ in Ausbildung (Schüler, Student, etc.)
□ nicht erwerbstätig / im Ruhestand

Sind Sie im Besitz eines Führerscheins? □ Ja □ Nein

Besitzen Sie in Ihrem Haushalt ein Auto? □ Ja □ Nein

Sind Sie im Besitz einer ÖPNV-Zeitkarte (z.B. Semesterticket, Monatsticket)? □ Ja □ Nein

Sind Sie aufgrund gesundheitlicher Probleme in Ihrer Mobilität eingeschränkt? □ Ja □ Nein

Wie häufig benutzen Sie die folgenden Verkehrsmittel für ihre alltäglichen Wege über 1 km Länge?

	(fast) täglich	An 1 bis 3 Tagen pro Woche	An 1 bis 3 Tagen im Monat	Seltener als monatlich	Nie oder fast nie
Fahrer	1	2	3	4	5
Beifahrer	1	2	3	4	5
Bus	1	2	3	4	5
Zu Fuß	1	2	3	4	5
Fahrrad/ E-Bike	1	2	3	4	5
Straßen-bahn	1	2	3	4	5

Appendix C

The mobility diary that has been done during the focus groups

Mein Mobilitätstagebuch

Uhrzeit	Montag	Dienstag	Mittwoch	Donnerstag	Freitag	Samstag	Sonntag
07:00							
09:00							
11:00							
13:00							
15:00							
17:00							
19:00							
21:00							
23:00							

Flyer for the focus group

DLR Deutsches Zentrum für Luft- und Raumfahrt

Workshop für Forschungsprojekt zur Nutzung von Verkehrsmitteln

Diskutieren Sie mit!

Liebe Braunschweiger und Braunschweigerinnen,

Für ein Forschungsprojekt suchen wir Teilnehmer, um in einem 2- bis 3-stündigen Workshop über Fragen der Mobilität und der Nutzung verschiedener Verkehrsmittel zu diskutieren.
Wir interessieren uns dabei für die ausschlaggebenden Beweggründe, ein Verkehrsmittel zu nutzen oder nicht zu nutzen. Der Workshop wird von einer Psychologiestudentin der Universität Twente mit Unterstützung einer Doktorandin des Deutschen Zentrums für Luft- und Raumfahrt, Institut für Verkehrssystemtechnik durchgeführt.

Gesucht werden für den Workshop 12 bis 16 Teilnehmer jeglichen Alters und Geschlechts. Um möglichst unterschiedliche Bedürfnisse und Anforderungen an Mobilität im Workshop diskutieren zu können, möchten wir besonders auch Menschen, die in ihrer Mobilität eingeschränkt sind, herzlich zum Workshop einladen.

Für die Verpflegung mit Getränken und Snacks wird gesorgt.
Eine Aufwandsentschädigung kann nicht gezahlt werden.

Datum:	**Donnerstag, 23. März**
Uhrzeit:	16:30 – 19:00 Uhr
Ort:	Deutsches Zentrum für Luft- und Raumfahrt e.V. Lilienthalplatz 7 38108 Braunschweig

Um Anmeldung wird gebeten!
Per E-Mail an alexandra.koenig@dlr.de oder telefonisch unter 05312953676.

Vielen Dank für Ihr Interesse,
Tabea Bonus & Alexandra König

Appendix D

The R code of the data analysis.

```
#data preparation

D_TB_18 <-
  haven::read_sav("finaleDatenstruktur_N_521_unlabeled.sav")
save(D_TB_18, file = "D_TB_18.Rda")

load("D_TB_18.Rda")
sample_n(D_TB_18, 12)

#shift age
min(D_TB_18$age, na.rm = T)

Ageshft <- (D_TB_18$age - 18)
min(Ageshft, na.rm = T)



#data exploration

D_TB_18 %>%
  dplyr::select(STR, ASC, RES, Fare, traveltime, Info, shftdeparture, walking
distance, bookingperiod) %>%
  sample_n(12)

## associations among person predictors
#ggpairs:
D_TB_181 <- na.omit(D_TB_18)

min(D_TB_181$age, na.rm = T) ### use this to shift the variable

Ageshft1 <- (D_TB_181$age - 18)
min(Ageshft1, na.rm = T)

D_TB_181$gender <- as.factor(D_TB_181$gender)
D_TB_181$userpub <- as.factor(D_TB_181$userpub)
D_TB_181$carpossibility <- as.factor(D_TB_181$carpossibility)
D_TB_181$education <- as.factor(D_TB_181$education)
D_TB_181$ScenarioDoc <- as.factor(D_TB_181$ScenarioDoc)
D_TB_181$mobilityimpairment <- as.factor(D_TB_181$mobilityimpairment)

D_TB_181 %>%
  dplyr::select(gender, age, education, userpub, carpossibility) %>%
  GGally::ggpairs(
  upper = list(continuous = "cor", combo = "box_no_facet", discrete = "facetb
ar", na = "na"),
  lower=list(combo=wrap("facethist",binwidth=1)),
```

```
  axisLabels = c("show"),
  columnLabels = c("gender", "age", "education", "pubtransport usage", "car p
resent"),
  cardinality_threshold = 3)

#VIF
fit4 <- lm(RES~ASC + Fare + walkingdistance + bookingperiod + shftdeparture +
 traveltime + Info + userpub + ScenarioDoc + Ageshft + gender + mobilityimpai
rment + education + carpossibility, data = D_TB_18)
car::vif(fit4)



#Conjoint analysis: model selection

clogout <- clogit(RES~ASC + Fare2.5 + Fare3.0 + Fare3.5 + walkingdistance0 +
                    walkingdistance300 + bookingperiod5 + bookingperiod10 +
                    shftdeparture0 + shftdeparture10 + traveltime10 +
                    traveltime20 + Infonone + Infofew +
                    Fare:userpub + walkingdistance:userpub +
                    bookingperiod:userpub + shftdeparture:userpub +
                    traveltime:userpub + Info:userpub +
                    Fare:ScenarioDoc + walkingdistance:ScenarioDoc +
                    bookingperiod:ScenarioDoc + shftdeparture:ScenarioDoc +
                    traveltime:ScenarioDoc + Info:ScenarioDoc +
                    Fare:age + walkingdistance:age + bookingperiod:age +
                    shftdeparture:age + traveltime:age + Info:age +
                    Fare:gender + walkingdistance:gender +
                    bookingperiod:gender + shftdeparture:gender +
                    traveltime:gender + Info:gender +
                    walkingdistance:mobilityimpairment + Fare:education +
                    Fare:carpossibility + walkingdistance:carpossibility +
                    bookingperiod:carpossibility +
                    shftdeparture:carpossibility + traveltime:carpossibility
                    + Info:carpossibility +
                    strata(STR), data = D_TB_18)

AIC1 <- gofm(clogout)$AIC
K1 <- gofm(clogout)$K
AICc1 <- AIC1 + (2*K1^2+2*K1)/(521-K1-1)
AICc1

#exclude: traveltime:carpossibility
clogout2 <- clogit(RES~ASC + Fare2.5 + Fare3.0 + Fare3.5 + walkingdistance0 +
                    walkingdistance300 + bookingperiod5 + bookingperiod10 +
                    shftdeparture0 + shftdeparture10 + traveltime10 +
                    traveltime20 + Infonone + Infofew +
                    Fare:userpub + walkingdistance:userpub +
                    bookingperiod:userpub + shftdeparture:userpub +
                    traveltime:userpub + Info:userpub +
```

```
                    Fare:ScenarioDoc + walkingdistance:ScenarioDoc +
                    bookingperiod:ScenarioDoc + shftdeparture:ScenarioDoc +
                    traveltime:ScenarioDoc + Info:ScenarioDoc +
                    Fare:age + walkingdistance:age + bookingperiod:age +
                    shftdeparture:age + traveltime:age + Info:age +
                    Fare:gender + walkingdistance:gender +
                    bookingperiod:gender + shftdeparture:gender +
                    traveltime:gender + Info:gender +
                    walkingdistance:mobilityimpairment + Fare:education +
                    Fare:carpossibility + walkingdistance:carpossibility +
                    bookingperiod:carpossibility +
                    shftdeparture:carpossibility + Info:carpossibility +
                    strata(STR), data = D_TB_18)

AIC2 <- gofm(clogout2)$AIC
K2 <- gofm(clogout2)$K
AICc2 <- AIC2 + (2*K2^2+2*K2)/(521-K2-1)
AICc2

#exclude: Info:userpub
clogout3 <- clogit(RES~ASC + Fare2.5 + Fare3.0 + Fare3.5 + walkingdistance0 +
                    walkingdistance300 + bookingperiod5 + bookingperiod10 +
                    shftdeparture0 + shftdeparture10 + traveltime10 +
                    traveltime20 + Infonone + Infofew +
                    Fare:userpub + walkingdistance:userpub +
                    bookingperiod:userpub + shftdeparture:userpub +
                    traveltime:userpub + Fare:ScenarioDoc +
                    walkingdistance:ScenarioDoc + bookingperiod:ScenarioDoc +
                    shftdeparture:ScenarioDoc + traveltime:ScenarioDoc +
                    Info:ScenarioDoc + Fare:age + walkingdistance:age +
                    bookingperiod:age + shftdeparture:age + traveltime:age +
                    Info:age + Fare:gender + walkingdistance:gender +
                    bookingperiod:gender + shftdeparture:gender +
                    traveltime:gender + Info:gender +
                    walkingdistance:mobilityimpairment + Fare:education +
                    Fare:carpossibility + walkingdistance:carpossibility +
                    bookingperiod:carpossibility +
                    shftdeparture:carpossibility + Info:carpossibility +
                    strata(STR), data = D_TB_18)

AIC3 <- gofm(clogout3)$AIC
K3 <- gofm(clogout3)$K
AICc3 <- AIC3 + (2*K3^2+2*K3)/(521-K3-1)
AICc3

#exclude: Fare:carpossibility
clogout4 <- clogit(RES~ASC + Fare2.5 + Fare3.0 + Fare3.5 + walkingdistance0 +
                    walkingdistance300 + bookingperiod5 + bookingperiod10 +
                    shftdeparture0 + shftdeparture10 + traveltime10 +
```

```
                    traveltime20 + Infonone + Infofew + Fare:userpub +
                    walkingdistance:userpub + bookingperiod:userpub +
                    shftdeparture:userpub + traveltime:userpub +
                    Fare:ScenarioDoc + walkingdistance:ScenarioDoc +
                    bookingperiod:ScenarioDoc + shftdeparture:ScenarioDoc +
                    traveltime:ScenarioDoc + Info:ScenarioDoc +
                    Fare:age + walkingdistance:age + bookingperiod:age +
                    shftdeparture:age + traveltime:age + Info:age +
                    Fare:gender + walkingdistance:gender +
                    bookingperiod:gender + shftdeparture:gender +
                    traveltime:gender + Info:gender +
                    walkingdistance:mobilityimpairment + Fare:education +
                    walkingdistance:carpossibility +
                    bookingperiod:carpossibility +
                    shftdeparture:carpossibility + Info:carpossibility +
                    strata(STR), data = D_TB_18)

AIC4 <- gofm(clogout4)$AIC
K4 <- gofm(clogout4)$K
AICc4 <- AIC4 + (2*K4^2+2*K4)/(521-K4-1)
AICc4

#exclude: walkingdistance:carpossibility
clogout5 <- clogit(RES~ASC + Fare2.5 + Fare3.0 + Fare3.5 + walkingdistance0 +
                    walkingdistance300 + bookingperiod5 + bookingperiod10 +
                    shftdeparture0 + shftdeparture10 + traveltime10 +
                    traveltime20 + Infonone + Infofew + Fare:userpub +
                    walkingdistance:userpub + bookingperiod:userpub +
                    shftdeparture:userpub + traveltime:userpub +
                    Fare:ScenarioDoc + walkingdistance:ScenarioDoc +
                    bookingperiod:ScenarioDoc + shftdeparture:ScenarioDoc +
                    traveltime:ScenarioDoc + Info:ScenarioDoc +
                    Fare:age + walkingdistance:age + bookingperiod:age +
                    shftdeparture:age + traveltime:age + Info:age +
                    Fare:gender + walkingdistance:gender +
                    bookingperiod:gender + shftdeparture:gender +
                    traveltime:gender + Info:gender +
                    walkingdistance:mobilityimpairment + Fare:education +
                    bookingperiod:carpossibility +
                    shftdeparture:carpossibility + Info:carpossibility +
                    strata(STR), data = D_TB_18)

AIC5 <- gofm(clogout5)$AIC
K5 <- gofm(clogout5)$K
AICc5 <- AIC5 + (2*K5^2+2*K5)/(521-K5-1)
AICc5

#exclude: bookingperiod:carpossibility
clogout6 <- clogit(RES~ASC + Fare2.5 + Fare3.0 + Fare3.5 + walkingdistance0 +
```

```
                    walkingdistance300 + bookingperiod5 + bookingperiod10 +
                    shftdeparture0 + shftdeparture10 + traveltime10 +
                    traveltime20 + Infonone + Infofew + Fare:userpub +
                    walkingdistance:userpub + bookingperiod:userpub +
                    shftdeparture:userpub + traveltime:userpub +
                    Fare:ScenarioDoc + walkingdistance:ScenarioDoc +
                    bookingperiod:ScenarioDoc + shftdeparture:ScenarioDoc +
                    traveltime:ScenarioDoc + Info:ScenarioDoc +
                    Fare:age + walkingdistance:age + bookingperiod:age +
                    shftdeparture:age + traveltime:age + Info:age +
                    Fare:gender + walkingdistance:gender +
                    bookingperiod:gender + shftdeparture:gender +
                    traveltime:gender + Info:gender +
                    walkingdistance:mobilityimpairment + Fare:education +
                    shftdeparture:carpossibility + Info:carpossibility +
                    strata(STR), data = D_TB_18)

AIC6 <- gofm(clogout6)$AIC
K6 <- gofm(clogout6)$K
AICc6 <- AIC6 + (2*K6^2+2*K6)/(521-K6-1)
AICc6

#exclude: shftdeparture:userpub
clogout7 <- clogit(RES~ASC + Fare2.5 + Fare3.0 + Fare3.5 + walkingdistance0 +
                    walkingdistance300 + bookingperiod5 + bookingperiod10 +
                    shftdeparture0 + shftdeparture10 + traveltime10 +
                    traveltime20 + Infonone + Infofew + Fare:userpub +
                    walkingdistance:userpub + bookingperiod:userpub +
                    traveltime:userpub + Fare:ScenarioDoc +
                    walkingdistance:ScenarioDoc + bookingperiod:ScenarioDoc +
                    shftdeparture:ScenarioDoc + traveltime:ScenarioDoc +
                    Info:ScenarioDoc + Fare:age + walkingdistance:age +
                    bookingperiod:age + shftdeparture:age + traveltime:age +
                    Info:age + Fare:gender + walkingdistance:gender +
                    bookingperiod:gender + shftdeparture:gender +
                    traveltime:gender + Info:gender +
                    walkingdistance:mobilityimpairment + Fare:education +
                    shftdeparture:carpossibility + Info:carpossibility +
                    strata(STR), data = D_TB_18)

AIC7 <- gofm(clogout7)$AIC
K7 <- gofm(clogout7)$K
AICc7 <- AIC7 + (2*K7^2+2*K7)/(521-K7-1)
AICc7

#exclude: Info:ScenarioDoc
clogout8 <- clogit(RES~ASC + Fare2.5 + Fare3.0 + Fare3.5 + walkingdistance0 +
                    walkingdistance300 + bookingperiod5 + bookingperiod10 +
                    shftdeparture0 + shftdeparture10 + traveltime10 +
```

```
                    traveltime20 + Infonone + Infofew + Fare:userpub +
                    walkingdistance:userpub + bookingperiod:userpub +
                    traveltime:userpub + Fare:ScenarioDoc +
                    walkingdistance:ScenarioDoc + bookingperiod:ScenarioDoc +
                    shftdeparture:ScenarioDoc + traveltime:ScenarioDoc +
                    Fare:age + walkingdistance:age + bookingperiod:age +
                    shftdeparture:age + traveltime:age + Info:age +
                    Fare:gender + walkingdistance:gender +
                    bookingperiod:gender + shftdeparture:gender +
                    traveltime:gender + Info:gender +
                    walkingdistance:mobilityimpairment + Fare:education +
                    shftdeparture:carpossibility + Info:carpossibility +
                    strata(STR), data = D_TB_18)

AIC8 <- gofm(clogout8)$AIC
K8 <- gofm(clogout8)$K
AICc8 <- AIC8 + (2*K8^2+2*K8)/(521-K8-1)
AICc8

#exclude: Fare:gender
clogout9 <- clogit(RES~ASC + Fare2.5 + Fare3.0 + Fare3.5 + walkingdistance0 +
                    walkingdistance300 + bookingperiod5 + bookingperiod10 +
                    shftdeparture0 + shftdeparture10 + traveltime10 +
                    traveltime20 + Infonone + Infofew + Fare:userpub +
                    walkingdistance:userpub + bookingperiod:userpub +
                    traveltime:userpub + Fare:ScenarioDoc +
                    walkingdistance:ScenarioDoc + bookingperiod:ScenarioDoc +
                    shftdeparture:ScenarioDoc + traveltime:ScenarioDoc +
                    Fare:age + walkingdistance:age + bookingperiod:age +
                    shftdeparture:age + traveltime:age + Info:age +
                    walkingdistance:gender + bookingperiod:gender +
                    shftdeparture:gender + traveltime:gender + Info:gender +
                    walkingdistance:mobilityimpairment + Fare:education +
                    shftdeparture:carpossibility + Info:carpossibility +
                    strata(STR), data = D_TB_18)

AIC9 <- gofm(clogout9)$AIC
K9 <- gofm(clogout9)$K
AICc9 <- AIC9 + (2*K9^2+2*K9)/(521-K9-1)
AICc9

#exclude: bookingperiod:gender
clogout10 <- clogit(RES~ASC + Fare2.5 + Fare3.0 + Fare3.5 + walkingdistance0
                    + walkingdistance300 + bookingperiod5 + bookingperiod10 +
                    shftdeparture0 + shftdeparture10 + traveltime10 +
                    traveltime20 + Infonone + Infofew + Fare:userpub +
                    walkingdistance:userpub + bookingperiod:userpub +
                    traveltime:userpub + Fare:ScenarioDoc +
                    walkingdistance:ScenarioDoc + bookingperiod:ScenarioDoc +
```

```
                    shftdeparture:ScenarioDoc + traveltime:ScenarioDoc +
                    Fare:age + walkingdistance:age + bookingperiod:age +
                    shftdeparture:age + traveltime:age + Info:age +
                    walkingdistance:gender + shftdeparture:gender +
                    traveltime:gender + Info:gender +
                    walkingdistance:mobilityimpairment + Fare:education +
                    shftdeparture:carpossibility + Info:carpossibility +
                    strata(STR), data = D_TB_18)

AIC10 <- gofm(clogout10)$AIC
K10 <- gofm(clogout10)$K
AICc10 <- AIC10 + (2*K10^2+2*K10)/(521-K10-1)
AICc10

#exclude: traveltime:gender
clogout11 <- clogit(RES~ASC + Fare2.5 + Fare3.0 + Fare3.5 + walkingdistance0
                    + walkingdistance300 + bookingperiod5 + bookingperiod10 +
                    shftdeparture0 + shftdeparture10 + traveltime10 +
                    traveltime20 + Infonone + Infofew + Fare:userpub +
                    walkingdistance:userpub + bookingperiod:userpub +
                    traveltime:userpub + Fare:ScenarioDoc +
                    walkingdistance:ScenarioDoc + bookingperiod:ScenarioDoc +
                    shftdeparture:ScenarioDoc + traveltime:ScenarioDoc +
                    Fare:age + walkingdistance:age + bookingperiod:age +
                    shftdeparture:age + traveltime:age + Info:age +
                    walkingdistance:gender + shftdeparture:gender +
                    Info:gender + walkingdistance:mobilityimpairment +
                    Fare:education + shftdeparture:carpossibility +
                    Info:carpossibility +
                    strata(STR), data = D_TB_18)

AIC11 <- gofm(clogout11)$AIC
K11 <- gofm(clogout11)$K
AICc11 <- AIC11 + (2*K11^2+2*K11)/(521-K11-1)
AICc11

#exclude: walkingdistance:userpub
clogout12 <- clogit(RES~ASC + Fare2.5 + Fare3.0 + Fare3.5 + walkingdistance0
                    + walkingdistance300 + bookingperiod5 + bookingperiod10 +
                    shftdeparture0 + shftdeparture10 + traveltime10 +
                    traveltime20 + Infonone + Infofew + Fare:userpub +
                    bookingperiod:userpub + traveltime:userpub +
                    Fare:ScenarioDoc + walkingdistance:ScenarioDoc +
                    bookingperiod:ScenarioDoc + shftdeparture:ScenarioDoc +
                    traveltime:ScenarioDoc + Fare:age + walkingdistance:age +
                    bookingperiod:age + shftdeparture:age + traveltime:age +
                    Info:age + walkingdistance:gender + shftdeparture:gender
                    + Info:gender + walkingdistance:mobilityimpairment +
                    Fare:education + shftdeparture:carpossibility +
```

```
                    Info:carpossibility +
                    strata(STR), data = D_TB_18)

AIC12 <- gofm(clogout12)$AIC
K12 <- gofm(clogout12)$K
AICc12 <- AIC12 + (2*K12^2+2*K12)/(521-K12-1)
AICc12

#exclude: bookingperiod:userpub
clogout13 <- clogit(RES~ASC + Fare2.5 + Fare3.0 + Fare3.5 + walkingdistance0
                    + walkingdistance300 + bookingperiod5 + bookingperiod10 +
                    shftdeparture0 + shftdeparture10 + traveltime10 +
                    traveltime20 + Infonone + Infofew + Fare:userpub +
                    traveltime:userpub + Fare:ScenarioDoc +
                    walkingdistance:ScenarioDoc + bookingperiod:ScenarioDoc +
                    shftdeparture:ScenarioDoc + traveltime:ScenarioDoc +
                    Fare:age + walkingdistance:age + bookingperiod:age +
                    shftdeparture:age + traveltime:age + Info:age +
                    walkingdistance:gender + shftdeparture:gender +
                    Info:gender + walkingdistance:mobilityimpairment +
                    Fare:education + shftdeparture:carpossibility +
                    Info:carpossibility +
                    strata(STR), data = D_TB_18)

AIC13 <- gofm(clogout13)$AIC
K13 <- gofm(clogout13)$K
AICc13 <- AIC13 + (2*K13^2+2*K13)/(521-K13-1)
AICc13

#exclude: Fare:age
clogout14 <- clogit(RES~ASC + Fare2.5 + Fare3.0 + Fare3.5 + walkingdistance0
                    + walkingdistance300 + bookingperiod5 + bookingperiod10 +
                    shftdeparture0 + shftdeparture10 + traveltime10 +
                    traveltime20 + Infonone + Infofew + Fare:userpub +
                    traveltime:userpub + Fare:ScenarioDoc +
                    walkingdistance:ScenarioDoc + bookingperiod:ScenarioDoc +
                    shftdeparture:ScenarioDoc + traveltime:ScenarioDoc +
                    walkingdistance:age + bookingperiod:age +
                    shftdeparture:age + traveltime:age + Info:age +
                    walkingdistance:gender + shftdeparture:gender +
                    Info:gender + walkingdistance:mobilityimpairment +
                    Fare:education + shftdeparture:carpossibility +
                    Info:carpossibility +
                    strata(STR), data = D_TB_18)

AIC14 <- gofm(clogout14)$AIC
K14 <- gofm(clogout14)$K
AICc14 <- AIC14 + (2*K14^2+2*K14)/(521-K14-1)
AICc14
```

```
#exclude: walkingdistance:gender
clogout15 <- clogit(RES~ASC + Fare2.5 + Fare3.0 + Fare3.5 + walkingdistance0
                    + walkingdistance300 + bookingperiod5 + bookingperiod10 +
                    shftdeparture0 + shftdeparture10 + traveltime10 +
                    traveltime20 + Infonone + Infofew + Fare:userpub +
                    traveltime:userpub + Fare:ScenarioDoc +
                    walkingdistance:ScenarioDoc + bookingperiod:ScenarioDoc +
                    shftdeparture:ScenarioDoc + traveltime:ScenarioDoc +
                    walkingdistance:Ageshft + bookingperiod:Ageshft +
                    shftdeparture:Ageshft + traveltime:Ageshft + Info:Ageshft
                    + shftdeparture:gender + Info:gender +
                    walkingdistance:mobilityimpairment + Fare:education +
                    shftdeparture:carpossibility + Info:carpossibility +
                    strata(STR), data = D_TB_18)

AIC15 <- gofm(clogout15)$AIC
K15 <- gofm(clogout15)$K
AICc15 <- AIC15 + (2*K15^2+2*K15)/(521-K15-1)
AICc15

#exclude: shftdeparture:gender
clogout16 <- clogit(RES~ASC + Fare2.5 + Fare3.0 + Fare3.5 + walkingdistance0
                    + walkingdistance300 + bookingperiod5 + bookingperiod10 +
                    shftdeparture0 + shftdeparture10 + traveltime10 +
                    traveltime20 + Infonone + Infofew + Fare:userpub +
                    traveltime:userpub + Fare:ScenarioDoc +
                    walkingdistance:ScenarioDoc + bookingperiod:ScenarioDoc +
                    shftdeparture:ScenarioDoc + traveltime:ScenarioDoc +
                    walkingdistance:Ageshft + bookingperiod:Ageshft +
                    shftdeparture:Ageshft + traveltime:Ageshft + Info:Ageshft
                    + Info:gender + walkingdistance:mobilityimpairment +
                    Fare:education + shftdeparture:carpossibility +
                    Info:carpossibility +
                    strata(STR), data = D_TB_18)

AIC16 <- gofm(clogout16)$AIC
K16 <- gofm(clogout16)$K
AICc16 <- AIC15 + (2*K16^2+2*K16)/(521-K16-1)
AICc16

#exclude shftdeparture:Automöglichkeit -> Final
clogout17 <- clogit(RES~ASC + Fare2.5 + Fare3.0 + Fare3.5 + walkingdistance0
                    + walkingdistance300 + bookingperiod5 + bookingperiod10 +
                    shftdeparture0 + shftdeparture10 + traveltime10 +
                    traveltime20 + Infonone + Infofew + Fare:userpub +
                    traveltime:userpub + Fare:ScenarioDoc +
                    walkingdistance:ScenarioDoc + shftdeparture:ScenarioDoc +
                    traveltime:ScenarioDoc + bookingperiod:ScenarioDoc +
                    bookingperiod:Ageshft + shftdeparture:Ageshft +
```

```
                    walkingdistance:Ageshft + Info:Ageshft +
                    traveltime:Ageshft + Info:gender +
                    walkingdistance:mobilityimpairment + Fare:education +
                    Info:carpossibility +
                    strata(STR), data = D_TB_18)
AIC17 <- gofm(clogout17)$AIC
K17 <- gofm(clogout17)$K
AICc17 <- AIC17 + (2*K17^2+2*K17)/(521-K17-1)
AICc17

## [1] 20392.74

#do not exclude: shftdeparture:gender, traveltime:ScenarioDoc, ScenarioDoc:bo
okingperiod, Fare:ScenarioDoc, Info:carpossibility,
#shftdeparture:carpossibility, Info:gender + bookingperiod:age + shftdepartur
e:age + traveltime:age + Fare:userpub + traveltime:userpub



#final model

clogoutfin <- clogit(RES~ASC + Fare2.5 + Fare3.0 + Fare3.5 + walkingdistance0
                    + walkingdistance300 + bookingperiod5 + bookingperiod10 +
                    shftdeparture0 + shftdeparture10 + traveltime10 +
                    traveltime20 + Infonone + Infofew + Fare:userpub +
                    traveltime:userpub + Fare:ScenarioDoc +
                    walkingdistance:ScenarioDoc + shftdeparture:ScenarioDoc +
                    traveltime:ScenarioDoc + bookingperiod:ScenarioDoc +
                    bookingperiod:Ageshft + shftdeparture:Ageshft +
                    walkingdistance:Ageshft + Info:Ageshft +
                    traveltime:Ageshft + Info:gender +
                    walkingdistance:mobilityimpairment + Fare:education +
                    Info:carpossibility +
                    strata(STR), data = D_TB_18)

summary(clogoutfin)

#alpha correction according to Bonferroni
#1-(0.05/24) = 0.9979167
exp(confint.default(clogoutfin, level = 0.9979167))



#preferences of 60-year-old man
min(D_TB_18$age, na.rm = T)

Ageshft60 <- (D_TB_18$age - 60)
min(Ageshft60, na.rm = T)

clogoutfin60 <- clogit(RES~ASC + Fare2.5 + Fare3.0 + Fare3.5 +
                    walkingdistance0 + walkingdistance300 + bookingperiod5 +
```

```
                    bookingperiod10 + shftdeparture0 + shftdeparture10 +
                    traveltime10 + traveltime20 + Infonone + Infofew +
                    Fare:userpub + traveltime:userpub + Fare:ScenarioDoc +
                    walkingdistance:ScenarioDoc + shftdeparture:ScenarioDoc +
                    traveltime:ScenarioDoc + bookingperiod:ScenarioDoc +
                    bookingperiod:Ageshft60 + shftdeparture:Ageshft60 +
                    walkingdistance:Ageshft60 + Info:Ageshft60 +
                    traveltime:Ageshft60 + Info:gender +
                    walkingdistance:mobilityimpairment + Fare:education +
                    Info:carpossibility +
                    strata(STR), data = D_TB_18)
clogoutfin60
```