INSTITUTE OF TRANSPORTATION - TECHNISCHE UNIVERSITÄT MÜNCHEN

M.Sc. in Transportation Systems

MASTER'S THESIS

Stated preference survey design and pre-test for valuing influencing factors for bicycle use

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Heather Twaddle

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Abstract

The personal and societal benefits of bicycle mobility are numerous and well known. Quantitative estimates of the influence of bicycle trip characteristics and the features of other modes of transportation on the choice to travel by bicycle are imperative in predicting the outcome of bicycle transportation policies and measures. However, little quantitative research has been carried out to investigate these factors. In a step towards providing these quantitative estimates, a methodology for a two-phase stated choice experiment investigating mode choice behaviour based on reference scenarios is presented.

Revealed choice data is collected in a first phase using a newly developed time-use-travel diary, in which respondents note their activities and trips from one day. The trip information collected in the time-use-travel diaries is used to create individualized reference scenarios. Three alternatives, the car, a generalized public transportation alternative including the bus, tram, U-Bahn and S-Bahn, and the bicycle are investigated. The attributes included in the stated choice experiment are the travel time, parking fee and an all-inclusive driving cost for the car alternative, the access time, ride time and fare for the public transportation option, and the travel time, percentage of travel time on dedicated bicycle infrastructure and the availability of secure parking at the destination for the bicycle option. Pivoted attribute levels are selected based on the findings of previous research and a heterogeneous/homogeneous efficient experimental design is constructed. The sample is segmented based on the mode of transportation reported in the time-use-travel diary.

The methodology used proves to be useful and statistically relevant. However, the two-phase survey instrument is found to be cumbersome and work intensive. Recommendations for improvement include the development of an online version of the paper and pencil time-use-travel diary as well as automating the coding and the estimation of the attributes of non-selected alternatives. The attributes and attribute levels included in the experimental design appear to reflect the choice behaviour of the car and public transportation users but not bicyclists.

Scope:

The scope of this thesis includes:

- a thorough review of previous research concerning bicycle transportation and mode choice;
- an in-depth review of discrete choice analysis and the current stated choice experimental methods;

- the recruitment of a pre-test sample of respondents;
- the design of a time-use-travel diary and the adaptation of the instruction documents for the diary;
- the distribution and collection of the paper and pencil time-use-travel diaries;
- the coding of trip information collected in the time-use-travel diaries;
- the estimation of the attributes of non-selected modes of transportation using online trip planning tools for all the trips recorded in the diaries;
- the identification of relevant attributes used to describe the selected modes of transportation and the selection of appropriate attribute levels for the choice experiment;
- the development of an individualized stated choice experiment using the reference scenarios defined for each of the respondents;
- the creation of a personal questionnaire adapted from personal and household questionnaires distributed by the Mobilität in Deutschland for various research projects (Mobilität in Deutschland 2011);
- the creation and distribution of an online survey containing the personal questionnaire and the stated choice experiment;
- a qualitative evaluation of the overall effectiveness of the survey instruments, the distribution and collection processes, the method of coding the trip data and estimating the attributes of the alternatives and the stated choice experimental design;
- and suggestions for future improvements.

Objective:

The overarching goal of this thesis is to provide a methodology for collecting mode choice data for situations where the bicycle is included as an individual mode. The collection of such data would make it possible to understand the influence of bicycle trip attributes and the attributes of other modes of transportation on the choice to travel by bicycle. The impact of policy measures and infrastructure design on bicycle use could then be quantitatively predicted using modelling software. The costs and benefits of bicycle promotion plans, infrastructure revisions and other transportation projects could then be more accurately assessed. In working toward this goal, the objective of this thesis is to design and pre-test a methodology for a two-phase stated choice experiment using reference alternatives. The entire survey process is formulated and then assessed beginning with the recruitment of a pre-test sample and concluding with the data collection from the online stated choice experiment. The objective is to deliver a qualitative analysis of the effectiveness of the time-use-travel diary, the coding process used to generate the reference scenarios and the stated choice experimental design, as well as offer suggestions for improvement.

Approach:

The choice experiment is constructed based on the most current methods of stated choice experimental design, which include the use of reference scenarios to increase the realism and familiarity of the choice situations. This method has been found to increase the validity of the choice data and improve the robustness of the resulting mode choice model. Because trip information from the respondents is required to create the individualized reference scenarios, the survey is carried out in two phases. This method has been found to produce excellent statistical results, but often at the expense of a cumbersome distribution and coding process. Nevertheless, an attempt is made to reap the statistical advantages of implementing such a method while minimizing the logistical difficulties. The experimental design of the stated choice experiment is constructed using a homogeneous/heterogeneous efficient design. Revealed preference data is collected from the sample using a time-use-travel diary, which is a combination of the conventional time-use and travel diaries. The time-use-travel diary is designed to capitalize on the strengths of both types of diaries while avoiding the pitfalls associated with each.

1. INTRODUCTION

The advantages of bicycling for transportation on both the personal and societal level are numerous and well known. On a personal level, the bicycle offers a fast, inexpensive and convenient alternative for short to medium length trips. On a societal level, problems stemming from excessive automobile mobility, including congestion, air pollution, urban sprawl, noise pollution and climate change, can be counteracted by shifting car trips to the bicycle. Furthermore, the health benefits reaped by bicyclists through physical activity as well as by society as a whole through air quality improvements provide additional motivation for the promotion and support of bicycle use. Although the benefits of bicycle mobility are well known, little quantitative research has been carried out to investigate the effects of bicycle trip characteristics and the features of other modes of transportation on the choice to bicycle. This knowledge is imperative in understanding the outcome of transportation measures and policies aimed at increasing the mode share of the bicycle.

Previous research in the field of bicycle transportation has mainly examined the factors influencing cyclist’s route choice and frequency of bicycle use (Stinson & Bhat 2004; Aultman-Hall 1996; Dill & Carr 2003; Menghini et al. 2009). Most of these studies have used stated choice experiments as an instrument to gather information from cyclists themselves. The information collected in these studies is useful in determining which policies and measures are favourable for cyclists, but not for those who do not bicycle or do not bicycle regularly. Typically, it is assumed that the preferences of cyclists can be extrapolated to the rest of the population. As a result of this assumption, the policies and measures that are favourable for cyclists are also presumed to positively influence the mode share of bicycles.

Little research has been carried out to examine mode choice with the bicycle as an independent alternative. This type of research is difficult to conduct because of the extremely low modal split of bicycling in North America and the overall lack of such research in Europe (Kuhnimhof, Chlond & Huang 2010). Furthermore, it has been suggested that the attributes influencing bicycle use are difficult to include in a standard discrete choice model because of the large role of unobservable latent variables (Johansson, Heldt & Johansson 2006; Heinen, van Wee & Maat 2010). In other words, when considering the choice to travel by bicycle, unobservable attributes such as the attitude and personality traits of the decision maker may have a disproportionately large influence on the outcome of the decision in comparison to observable attributes such as travel time or cost.

The intention of this project is to provide a methodology for collecting mode choice data for situations where the bicycle is included as an individual mode. The collection of such data would make it possible to understand the influence of bicycle trip attributes and the attributes of other modes of transportation on the choice to travel by bicycle. The impact of policy measures and infrastructure design on bicycle use could then be quantitatively predicted using modelling software. The costs and benefits of bicycle promotion plans, infrastructure revisions and other transportation projects could then be more accurately assessed. In working toward this goal, a two-phase stated choice experiment using reference alternatives is constructed and qualitatively evaluated. The entire survey process is formulated and then assessed beginning with the recruitment of a pre-test sample and concluding with the data collection from the online stated choice experiment.

Research Problem:

> Create, implement and qualitatively assess a methodology for using a stated choice experiment based on reference alternatives to quantitatively estimate the independent influence of bicycle transportation attributes and the attributes of other modes of transportation on the choice to travel by bicycle.

Research Questions:

The following research questions are answered in the course of this research project.

1. *What are the outcomes of a pre-test of the newly developed time-use-travel diaries to collect trip and activity information from a sample of respondents?*

   Provide a qualitative assessment of the survey instrument and the distribution and collection logistics. Code the reported trips and the estimate the attributes of the non-selected transportation alternatives. Offer suggestions for improvement of the time-use-travel diary.

2. *How can a significantly relevant stated choice experiment investigating bicycle mode choice be designed in the presence of a reference scenario?*

   Completely construct a methodology for taking the reference alternatives compiled from Research Question 1 and using them to create an individualized stated choice experiment.

3. *What are the outcomes of a pre-test of the stated choice experiment developed from Research Question 2?*

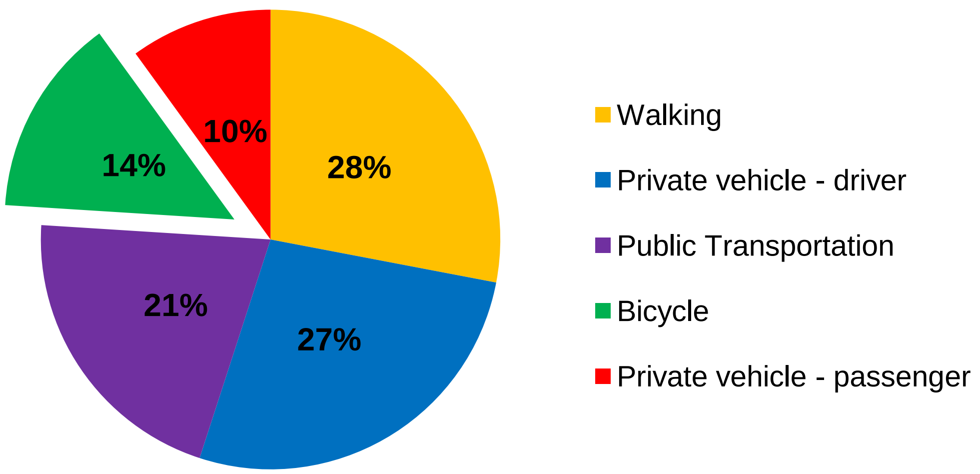
   Provide a qualitative assessment of the stated choice experimental design and the results obtained from a pre-test of the experiment and offer suggestions for improvement based on the outcomes of the pre-test.

The pre-test of the survey instruments is carried out in Munich, Germany. Munich is located in the state of Bavaria, and has a population of 1.3 million inhabitants, making it the third largest city in Germany (Landeshauptstadt München 2010).

Although Munich is located near the Alps, the city itself is characterized by a level landscape with gentle slopes near the banks of the river Isar. The weather in Munich is classified as continental, but is strongly influenced by the city's proximity to the Alps. The summers are warm, but can have a significant amount of rain, and the winters are cold with moderate snowfall. Nevertheless, the weather patterns and landscape in Munich make it a pleasant city for bicycling, particularity in the spring, summer and autumn months.

Currently, 80% of Munich's population owns a bicycle and 14% of the trips made in Munich are made using a bicycle (Landeshauptstadt München 2010). The current modal split in Munich is shown in Figure 1. The city is working hard to further improve the cycling network in Munich with the goal of increasing the mode share of bicycling to 17% by 2015 (Landeshauptstadt München 2010). An extensive bicycle marketing campaign, "Radeln ist cool", was initiated in April 1010 with the intention of promoting the bicycle as a fast, inexpensive, fun and healthy means of transport. In addition, the car oriented mobility that has been dominant in Germany over the last decades is being increasingly replaced by multimodal transportation behaviour (Kuhnimhof, Chlond & von der Ruhren 2006; Nobis 2007). Multimodal transportation behaviour is characterized by the consideration of trip characteristics and the subsequent section of the mode of transportation that is best suited to that trip, rather than the reliance on one mode of transportation for all trips (Kuhnimhof, Chlond & Huang 2010). The strong presence of the bicycle in Munich and the multimodal transportation behaviour of the inhabitants make this city an ideal location for studying mode choice behaviour with the bicycle included as an independent mode.

Figure 1: Modal split in Munich, Germany in 2008



Source: Landeshauptstadt München (2010)

Chapter 2 of this thesis provides a detailed overview of previous literature. The first section of this chapter, Section 2.1 summarizes previous research concerning bicycle transportation. Section 2.2 gives a brief overview of the theory of discrete choice analysis. The final section of Chapter 2, Section 2.3 provides a detailed introduction to stated choice experimental design.

Chapter 3 gives a detailed description of the methodology used in this research project. The sample recruitment is summarized in Section 3.1, the design of the time-use-travel diaries is explained in Section 3.2, the means of distribution and collection for the time-use-travel diaries is outlined in Section 3.3. The coding of the time-use-travel diaries and the estimation of the attributes of non-selected alternatives is given in Section 3.4, the design of the stated choice experiment is explained in detail in Section 3.5, information about the personal questionnaire is included in Section 3.6 and the online distribution of the stated choice experiment and the personal questionnaire is described in Section 3.6.

The response to the survey (Section 4.1) and the results obtained from the time-use-travel diaries (Section 4.2) and the stated choice experiment (Section 4.3) are provided in Chapter 4. A discussion of the project methodology and the results obtained from the survey follows in Chapter 5. The sample recruitment is discussed in Section 5.1, the time-use-travel diary in Section 5.2 and the stated choice experiment in Section 5.3. Chapter 6 provides conclusions derived from the entire research project.

2. LITERATURE REVIEW

A review of previous research is carried out in three main topic areas; bicycle transportation, choice modelling and stated choice survey design. A comprehensive and thorough review of the findings and research methods used in bicycle transportation research is presented first in Section 2.1. In order to account for the locality of bicycle transport, the findings from research undertaken in Europe have been given particular attention. However, because the vast majority of quantitative bicycle research has been carried out in North America, findings and methods used in these studies are also presented. A brief presentation of choice modelling fundamentals is presented in Section 2.2. Because the scope of this research project focuses on the development of a stated choice survey rather than on a meticulous review of choice modelling methods, this section only provides an overview of the basic theory and the development of the multinomial logit (MNL) model. Section 2.3 gives a review of stated choice survey design with particular focus on the theory behind the methods used in this research project.

2.1. Bicycle Transportation Research Review

Previous research has identified many factors that influence bicycle use. According to Heinen, van Wee and Maat (2010) in their comprehensive review of bicycle literature, the factors affecting bicycling for utilitarian purposes can be subdivided into five groups; the built environment, the natural environment, socio-economic variables, psychological factors and transportation related factors including cost, time, effort and safety. These five groups of influencing factors are adopted as a framework for this research review. The transportation related factors section is expanded to include destination facilities for cyclists including parking facilities as well as shower and change rooms. For each section, a small summary of the findings is given. A table containing a more comprehensive review of the findings of a selected number of studies is included in Appendix A.

Although a comprehensive overview of the literature is given in this section, particular emphasis is placed on factors that are responsive to change in policy or infrastructure provision. The natural environment, for instance, may indeed play a significant role in the choice to travel by bicycle, but is difficult or impossible to change to favour bicycle transport. As such, less attention is placed on this group of factors in the literature review.

2.1.1. Built Environment

The build environment has a very strong effect on bicycle use. Characteristics of the built environment that have been found to positively influence the choice to travel by bicycle include; a dense urban form and a mixture of functions (Parkin, Ryley & Jones 2007; Pucher & Buehler 2006), short trip lengths (Abraham et al. 2002; Aultman-Hall 1996; Hunt & Abraham 2007), the availability of dedicated bicycle infrastructure (Stinson & Bhat 2003; Garrard, Rose & Kai Lo 2008; Twaddle, Hall & Bracic 2010) and the type of infrastructure available (Dill 2009; Krizek 2006).

One of the most important determinants of bicycle choice is the distance or duration of the trip (Abraham et al. 2002; Hunt & Abraham 2007; Heinen, van Wee & Maat 2010; Kuhnimhof, Chlond & Huang 2010). Kuhnimhof et al. (2010) suggested a 'radius of non-modal transport' or RNMT, which describes the maximum distance a person is willing to travel using non-motorized modes of transportation. They found that in Germany, the mean and median RNMT are 4.6 km and 3.0 km respectively (Kuhnimhof, Chlond & Huang 2010). Other research has suggested that some people are willing to travel further by bicycle than others, with women travelling significantly shorter distances than men (Garrard, Rose & Kai Lo 2008). City density, which has a large influence on trip distance, has also been found to be significantly related to the modal share of bicycling (Buehler & Pucher 2011; Parkin, Ryley & Jones 2007; Pucher & Buehler 2006).

Many studies have investigated the influence of the type of bicycle facility on the route choice of cyclists. However, it is difficult to draw a cohesive conclusion from the findings of these studies. Some research indicates that cyclists prefer off-road facilities, or routes that are separated from car traffic (Stinson & Bhat 2003; Abraham et al. 2002; Hunt & Abraham 2007), while results from other research suggest that cyclists prefer to use the most direct route regardless of type of infrastructure (Aultman-Hall 1996). One aggregated study of cycling in a selection of American cities concluded that there is no significant relationship between the type of infrastructure available and the level of bicycling (Buehler & Pucher 2011). Some studies have found that the infrastructure preferences vary with the gender (Garrard, Rose & Kai Lo 2008), or level of experience of the cyclist (Hunt & Abraham 2007). Additionally, the preference for a given type of infrastructure is highly related to the objective or subjective safety offered by that type of infrastructure (Heinen, van Wee & Maat 2010). However, although there seems to be a relationship between the existence of bicycle infrastructure, regardless of the type of infrastructure, and the level of bicycle commuting, the causality of such a relationship is difficult to determine. Pucher et al. (2008) suggest that the building of bicycle infrastructure may occur mainly the response to an increase in bicycling, not the cause.

Several other factors have been found to influence the route choice of cyclists. The majority of bicycle route choice studies utilize some method of route tracking, generally GIS, and compare the routes travelled by cyclists to non-selected alternative routes. The characteristics of the selected route are then compared with the characteristics of the non-selected routes. The findings of such research projects indicate unanimously that cyclists avoid steep grades (Aultman-Hall 1996; Menghini et al. 2009). The influence of the number of traffic lights on the selected route was found to be insignificant in Switzerland (Menghini et al. 2009), while cyclists in Canada were found to use traffic controls to turn from a street with less traffic to one with heavier traffic (Aultman-Hall 1996).

2.1.2. Natural Environment

The effects of a number of natural environmental factors, including the topography, climate and weather have been investigated in previous research projects. As would be expected, hilliness negatively impacts bicycle use (Parkin, Ryley & Jones 2007; Heinen, van Wee & Maat 2010). One study by Stinson and Bhat (2005) found the preference for grade was related to the level of experience of the cyclist, with more experienced cyclists preferring hilly environments to flat or mountainous ones, while inexperienced cyclists showed a preference for flat environments.

The climate of a region, the seasonal variation in weather, as well as daily weather conditions have all been found to influence the overall mode share of bicycling and the number of cyclist on a given day. The impact of rain on the choice to travel by bicycle has been investigated by a number of studies. However, the findings of these studies are somewhat contradictory, with one group finding no significant relationship between the number of days of rain per year in a city and the bicycling rate in that city (Buehler & Pucher 2011; Dill & Carr 2003), and another group concluding that rain has a significantly negative impact on bicycling rates (Kuhnimhof, Chlond & Huang 2010; Nankervis 1999). Other unfavourable weather conditions, such as severely cold or hot weather have been found to negatively affect bicycle use (Nankervis 1999; Ortúzar, Iacobelli & Valeze 2000). A number of studies have concluded that the seasons have an impact on the propensity to cycle, with most people bicycling in the summer (Stinson & Bhat 2004; Nankervis 1999).

2.1.3. Socio-Economic Variables

The findings of previous research project do not provide any consistent conclusions about the influence of personal and household characteristics on the choice to travel by bicycle. In general, the effects of socio-economic variables on the propensity to travel by bicycle seem to be dependent on the region of study (Pucher & Buehler 2008). Furthermore, it has been suggested that psychological factors may be more important in predicting bicycling levels than socio-economic variables (Johansson, Heldt & Johansson 2006).

Many studies, particularly in North America, have concluded that gender is a strong determinant of bicycle use. Women have been found to travel by bicycle less often than men (Aultman-Hall 1996; Garrard, Rose & Kai Lo 2008; Krizek, Johnson & Tilahun 2005; Stinson & Bhat 2005), and when they do travel by bicycle, travel a shorter distance on average than men (Twaddle, Hall & Bracic 2010; Aultman-Hall 1996). Other research has found no significant difference in either the likelihood of men and women bicycling (Kuhnimhof, Chlond & Huang 2010; de Geus 2007; Abraham et al. 2002) or the distance covered by male and female cyclists (Garrard, Crawford & Hakman 2006).

The influence of age on bicycle use is equally uncertain. While the findings from some research indicate that the propensity to travel by bicycle decreases with age (Dill & Voros 2007; Twaddle, Hall & Bracic 2010), other studies have found no significant relationship between age and travelling by bicycle (Abraham et al. 2002; de Geus 2007; Stinson & Bhat 2003; Buehler & Pucher 2011; Kuhnimhof, Chlond & Huang 2010). There does seem to be a relationship between being a student and travelling by bicycle, with aggregated research indicating that cities with a large portion of students also tend to have a higher bicycle mode share (Buehler & Pucher 2011) and disaggregated research finding that students tend to bicycle more often than non-students (Kuhnimhof, Chlond & Huang 2010).

The relationships between bicycle use and the income and education of a person are also quite ambiguous. Some research suggests that income may be positively correlated with bicycle use because wealthier people have more money to spend on a bicycle and tend to be more concerned with their health (Heinen, van Wee & Maat 2010). On the other hand, people with more money are more likely to own a car, which, as discussed in the next paragraph, is one of the strongest deterrents from bicycle use (Pucher & Buehler 2008). In general, previous research has indicated that people with more education are less likely to travel by bicycle (de Geus 2007; Parkin, Ryley & Jones 2007).

The most clear and consistently verified socio-economic factor that influences bicycle use is vehicle availability, both that of car and bicycle. Car ownership and availability have been found to have a strong negative correlation with bicycle use (Stinson & Bhat 2005; Stinson & Bhat 2004; Parkin, Ryley & Jones 2007; Dill & Voros 2007). As would be expected, bicycle ownership has been found to have a positive influence of the choice to travel by bicycle (Dill & Voros 2007).

2.1.4. Psychological Factors

Several psychological factors have been found to influence mode choice including attitude, social norms and personal habits (Heinen, van Wee & Maat 2010). Although this is a relatively new field of research with regard to transportation mode choice, initial findings suggest that psychological factors may be more explanatory in mode selection than socio-economic factors such as gender and age (Johansson, Heldt & Johansson 2006). This may be particularly true for the choice to bicycle, as socio-economic variables have been found by many studies to be inadequate predictors of bicycle use (Kuhnimhof, Chlond & Huang 2010; Abraham et al. 2002; de Geus 2007).

Attitudinal factors such as the preference for convenience, comfort, flexibility and environmental concern have been found to influence mode choice (Johansson, Heldt & Johansson 2006), although no work was found that examined the influence of these attitudinal factors on bicycle use. The attitude of a person toward different modes of transportation has been found to affect their mode choice (Dill & Voros 2007). Dill and Voros (2007) found that people who are positive about travelling by bicycle and people who dislike driving a car are more likely to use a bicycle. The social norms perceived by a person also have a strong influence on their choice to bicycle or not. Cyclists are significantly more likely than non-cyclists to perceive social support for bicycling and to have a bicycling partner (de Geus 2007).

The existence of habits has been found to greatly influence a person's mode choice. Although discrete choice modelling is based on the assumption that people use rational choice when facing a decision (Ben-Akiva & Lerman 1985), research indicates that people may not consider every factor or alternative when making repetitive decisions. Instead, they rely on the decision making process that they employed last time they were required to make the choice (Bamberg & Schmidt 1994). However, because it is generally not possible for a person to meet all their transportation needs using a bicycle, bicyclists have been found to be multimodal people who are comfortable evaluating the characteristics of each trip and then selecting the most suitable mode of transportation (Kuhnimhof, Chlond & Huang 2010).

2.1.5. Transportation Related Factors

Transportation related factors include those that can be directly included in utility models of mode choice, the most common of which are cost and travel time. Because travelling by bicycle is generally a very low cost activity (Bergström & Magnussen 2003), with no costs associated with fuel or parking, the cost portion of these utility functions is typically derived from alternative modes of transportation that are cost intensive (Hunt & Abraham 2007). In aggregated studies, the price of gasoline has been found to be positively correlated with the mode share of bicycling in a region (Pucher & Buehler 2006; Buehler & Pucher 2011). The cost of public transportation has also been found to have an effect on bicycle use (Heinen, van Wee & Maat 2010). One study of fare-free public transport concluded that reducing or eliminating the public transport fares draws many more bicyclists from their bicycles than drivers from their cars (Storchmann 2003). Only one study was found that estimated the value of time spent bicycling. Abraham et al. (2002) estimated that bicyclists in Calgary, Canada value time spent bicycling on a path in a park area at $4/hour (≈2.9 €/hour) and time spent bicycling on an arterial road at $17/hour (≈12.1 €/hour). In general, research findings have indicated that cyclists are particularly sensitive to travel time (Abraham et al. 2002; Wardman, Tight & Page 2007; Kuhnimhof, Chlond & Huang 2010).

2.1.6. Destination Facilities

The provision of safe and secure parking at the destination has been found by several studies to increase the likelihood of commuting by bicycle (Abraham et al. 2002; Stinson & Bhat 2004). According to Abraham et al. (2007), the most preferred type of bicycle parking facility are bicycle lockers, followed by bicycle enclosures and bicycle racks. Many studies also suggest that the value placed on parking facilities by bicyclists may vary by socio-economic factors and bicycle cost (Abraham et al. 2002; Hunt & Abraham 2007; Dickinson et al. 2003).

The availability of facilities for cyclists at the destination has been found in some studies to increase the likelihood of travelling by bicycle. Research done in North America tends to indicate that the availability of showers and lockers at the workplace has a small, but significant influence on the attractiveness of bicycling (Hunt & Abraham 2007; Abraham et al. 2002). However, research done in the United States found that both the provision of shower and change rooms at the destination had an insignificant effect on the likelihood to travel by bicycle (Stinson & Bhat 2004). Only one European study was found in the literature review that examined the effect of destination showers and change rooms on the likelihood to commute by bicycle. In Belgium, de Geus (2007) found that the availability of cyclist facilities at the workplace is associated with bicycle commuting.

2.1.7. Remarks

Although the body of research concerning bicycle transportation is steadily growing, there is relatively little research that has investigated the bicycle in a mode choice context. The very low model split of bicycles in most North American cities has made it difficult to gather sufficient data for bicycle choice modelling (Kuhnimhof, Chlond & Huang 2010). In Europe, where the bicycling levels make it possible to collect such data, there are few research projects that quantitatively analyse bicycling. However, it must be noted that this is a review of the research that is available in English. There may very well be research done in other European languages that pertain to bicycle mode choice.

2.2. Review of Choice Modelling

The following section gives a brief overview of the fundamental principles of choice modelling and remarks regarding the topic.

2.2.1. Overview of Choice Modelling

Discrete choice modelling is an econometric means of predicting the behaviour of users based on individual choice behaviour theory (Ben-Akiva & Lerman 1985). In order to predict such behaviour, parameterized utility functions are used. These utility functions are a combination of independent, observables variables and unknown weighting parameters. The parameter values are estimated from a sample of observed choices made by decision makers when faced with a given choice situation. In discrete choice theory, when making a decision, users are faced with a set of mutually exclusive and collectively exhaustive alternatives. According to Ben-Akiva and Lerman, individual choice behaviour is composed of four elements (Ben-Akiva & Lerman 1985):

1. **Characteristics of the decision maker:** This element consists of the personal characteristics of the decision maker that affect the outcome of the decision. Such characteristics may include the personal income, age, gender, social class, etc. of the decision maker.
2. **Available alternatives:** All of the alternatives available to the decision maker amass to create the choice situation from which the decision maker must choose. In transportation models, the choice set is discontinuous, meaning there are a discrete number of alternatives within the choice set.
3. **Attributes of the alternative**: The attributes of an alternative are the characteristics or features of that alternative that influence its overall utility. Examples of transportation related attributes include travel time, cost, number of transfers or stops and waiting time.
4. **Decision rule:** The decision rule is the theoretical method that the decision maker utilizes to choose between the available alternatives. Many theories exist to model the decision rule including dominance theory, satisfaction theory, and lexicographic rules. However, the most commonly used theory is utility maximization, which assumes that a person will choose the alternative that offers the greatest personal utility for that individual.

The preceding four elements are based on the assumption that people act rationally when making a decision. The use of rational behaviour involves employing a constant and calculated decision process to accomplish short or long term personal goals. Such behaviour stands in contrast to impulsiveness, in which decisions are made based on a mood or state of mind at any given time (Ben-Akiva & Lerman 1985).

The theory of utility maximization holds that each discrete alternative within a choice set is associated with a certain level of utility. This level of utility is a sum of the given attributes associated with that option, the respective weighting of these attributes and a random element, which acknowledges the incompleteness of the attribute set (Louviere, Hensher & Swait 2000). Although the utility is theoretically a unit less measure, the term utils is often used to describe the amount of utility derived from an alternative. Mathematically, the utility of any given alternative *i* for any given individual q is a combination of a systematic element V_{iq}, and a random element ε_{iq}, as shown in Equation 2.2.1.

Equation 2.2.1

$$U_{iq} = V_{iq} + \varepsilon_{iq}$$ (Hensher, Rose & Greene 2005)

Where: U_{iq} = is the utility derived for person q by selecting alternative i

V_{iq} = systematically derived element of the i^{th} alternative for person q

ε_{iq} = error component

i = alternative

q = person

The systematic element of Equation 2.2.1 can be more precisely described as a linear additive function of the attributes and their respective weightings as shown by Equation 2.2.2.

Equation 2.2.2

$$V_{iq} = \sum_{k=1}^{K} \beta_{iq} X_{ikq}$$ (Hensher, Rose & Greene 2005)

Where: V_{iq} = systematically derived element of the i^{th} alternative for person q

β_{iq} = alternative specific utility parameter

X_{ikq} = independent attribute

i = alternative

k = attribute associated with alternative i

q = person

It is assumed that person q will choose option A over option B if and only if the utility of option A is greater than that of option B, or $U_{Aq} > U_{Bq}$. Expanding this equation using Equation 2.2.1 yields;

Equation 2.2.3

$$V_{Aq} + \varepsilon_{Aq} > V_{Bq} + \varepsilon_{Bq}$$ or;

Equation 2.2.4

$$V_{Aq} - V_{Bq} > \varepsilon_{Bq} - \varepsilon_{Aq}$$ (Hensher, Rose & Greene 2005)

The error component of the utility ε_{iq} describes the unobservable idiosyncrasies in taste and preference that differ between individuals (Louviere, Hensher & Swait 2000). Because the error component by definition cannot be estimated, the right hand part of equation 2.2.4 cannot be calculated. Instead, the probability that the difference between $V_{Aq}$and V_{Bq} is greater than the difference between $\varepsilon_{Bq}$and $\varepsilon_{Aq}$is determined. Although the analyst cannot know the distribution of ε_{Aq} or ε_{Bq}, both distributions are assumed to be related to the choice probability according to a defined distribution. A random utility model is generated to depict the probability that a given person will select option A over B based on the assumption that $\varepsilon_{Bq} - \varepsilon_{Aq}$ varies according to some predefined distribution.

In order to operationalize the theory of individual choice behaviour, a number of axioms have been developed. The most important of these axioms is the Independence-from-Irrelevant-Alternatives (IIA) axiom, which holds that the ratio of the probability of choosing one alternative over the probability of choosing the other is not affected by the presence or absence of other alternatives (Ben-Akiva & Lerman 1985). This axiom implies that all the random elements in the utility functions ε_{iq} are independent across the alternatives and share an identical distribution. One of the most commonly used distributions, and the distribution that has been used as a basis for this project, is the extreme value type one (EV1) distribution. By applying the definition of the EV1 distribution, the basic multinomial logit (MNL) model can be formed. In this model the probability of selecting alternative i is given in Equation 2.2.5.

Equation 2.2.5

$$P_i = \frac{\exp{(V_i)}}{\sum_{j=1}^{J} exp(V_j)}$$ (Hensher, Rose & Greene 2005)

Where: P_i = is the probability of selecting alternative i

V_i = systematically derived element of alternative i

V_i = systematically derived element of alternative j

i = alternative

j = other alternatives

Finally, the β parameters contained in the systematically derived element of the utility functions are predicted using maximum likelihood estimation (MLE), which uses statistical methods to determine the population parameters that most often produce an observed sample.

2.2.2. Remarks

Due to the depth and breadth of the field of discrete choice modelling, it is not possible to give a detailed review of choice modelling theory in this thesis. The fundamental equations used for analysis in this research project are provided and explained, but if the reader is interested in obtaining a full theoretical background on stated choice methods, the following sources provide a comprehensive overview of the subject; Ben-Akiva and Lerman 1985, Hensher, Rose and Greene 2005, Louviere, Hensher and Swait 2000.

2.3. Review of Stated Choice Methods

Stated choice experiments are used widely today to determine the independent influence of various factors on the decisions made by individuals facing a choice situation (ChoiceMetrics 2011). The ability to predict the individual and aggregated response to an action is very important in calculating the expected costs and benefits of that action (Louviere, Hensher & Swait 2000). A brief overview of the types of choice data available and the methods used to design stated choice experiments are given in this section.

Historically, there have been two methods for collecting choice data, revealed preference data sources and stated choice experiments. Revealed preference data is collected by observing behaviour in the present market. Although such data is highly reliable and has good face validity, it tends to be expensive and tedious to collect. There are also several statistical limitations of revealed preference data, including the inherent relationship between factors and the embodiment of personal and market constraints (Louviere, Hensher & Swait 2000). Furthermore, the existing situation often does not provide enough variability in the explanatory variables to gain a statistically significant understanding of their influence. Conversely, stated choice experiments are valuable because the behavioural response to a choice situation that does not yet exist can be inferred (Hensher 1994). In transportation related studies this can be a very useful quality because the effect of a new policy or measure can be estimated before it is implemented. Furthermore, in designing a stated choice experiment, a researcher is able to select and isolate the factors of influence that are of interest for the research project. Unlike data that is collected from revealed preference sources, collinearity in the variables can be avoided by properly designing the stated choice experiment.

The methods used to design statistically robust stated choice experiments have developed considerably since such experiments were first introduced to the field of transportation research nearly 20 years ago (Louviere, Hensher & Swait 2000). The experimental design of any choice experiment involves the planned manipulation of attribute levels to yield a statistically relevant output.

2.3.1. Selection of the Alternatives, Attributes and Attribute Levels

In creating an experimental design, the researcher must first define the alternatives, attributes and attribute levels that are to be included in the choice situations. In order to fulfil the global utility maximizing rule, a universal but finite list of all the existing alternatives must be compiled. If a complete list is deemed to be too extensive to create a practical choice experiment, the list of alternatives must be culled (Hensher, Rose & Greene 2005). The first and most statistically correct method of limiting the number of alternatives presented to each respondent is to randomly select a number of alternatives from the universal set of alternatives to assign to each participant. A second approach is for the analyst to make a subjective selection of the significant alternatives. This approach eliminates all the alternatives that are deemed insignificant or those that are thought to be only a significant choice for a small portion of the population. Although this method makes the experimental design easier to handle and allows the analyst to focus on attributes that are of interest for the research project, the global utility maximisation assumption is violated.

Once the analyst has determined which alternatives will be included in the choice situations, the attributes that influence the choice must be considered (Hensher, Rose & Greene 2005). In selecting the attributes, the analyst must consider which factors have a significant impact on the preference formation of the decision maker (Louviere, Hensher & Swait 2000). The attributes included in the choice experiment may be common among the alternatives, such as departure time, or may be alternative specific, such as the access time or the number of transfers on a public transportation journey. There are several factors to consider in defining attributes. Firstly, it is important that the attribute descriptions are unambiguous (Hensher, Rose & Greene 2005). The clarity of the attributes and the levels associated with each attribute are of utmost important in communicating the choice situation to the decision maker. By including an ambiguous variable, the degree of unobservable variance in the decision making process of the respondents is likely to increase (Hensher, Rose & Greene 2005). Furthermore, the applicability of the results is reduced if attribute ambiguity exists because of a lack of clarity and directness.

According to Hensher, Rose and Green (2005, pp. 106), it is import to be cautious of cognitive inter-attribute correlations. Although such correlations are not statistical in nature, a relationship between two variables may exist in the perception of the choice makers. One example of this is the intrinsic expectation of decisions makers that the service or quality of a good is related to its price (Louviere, Hensher & Swait 2000). Another transportation related example of such an inter-attribute correlation could be the relationship between the comfort of public transportation and the fare. Such cognitive correlations lead to decision makers using one attribute to make assumptions about the other features of the option, which reduces the ability of the analyst to discern the individual influence of the given attribute on the decision outcome.

The number of attributes that may significantly affect the preference formation of the decision makers can be quite extensive. However it is beneficial to limit the number of attributes that are included in a choice experiment for a number of reasons (Louviere, Hensher & Swait 2000). Firstly, the workload of the respondent increases in relation to the number of attributes included in the choice situation. This tends to result in respondent fatigue, which leads to the respondent putting less effort into evaluating all aspects of the choice situation. As a consequence, the quality of the choice data decreases. Secondly, the experimental design of the choice experiment increases in size and complexity with the number of attributes and attribute levels included. By limiting both the number of attributes included in the experiment and the number of attributes that are used to describe those attributes, the experimental design can be limited to a more manageable size (ChoiceMetrics 2011).

Finally, the selection of the attribute levels has a large influence on the statistical power of the stated choice experiment (ChoiceMetrics 2011). The number of attribute levels included in the experimental design affects the ability of the analyst to distinguish non-linear relationships between the value of the attribute and the derived utility (Hensher, Rose & Greene 2005). For example, if the analyst includes only two levels to describe an attribute, they will have no alternative but to conclude that the relation between attribute level and derived utility is linear. As more attribute levels are added to the experimental design, it becomes possible to detect more complex utility relationships (Hensher, Rose & Greene 2005). However, as mentioned previously, the size and complexity of the experimental design increases with the number of included attribute levels. Therefore, the analyst must find a balance between choosing enough attribute levels to discern the nature of the relationship between the attribute and the derived utility derived and restraining the size of the experimental design (ChoiceMetrics 2011).

In addition to setting the number of attribute levels, the maximum and minimum attribute levels must be carefully considered. The values selected for the maximum and minimum attribute levels must reflect reality in order to create feasible and realistic choice situations for the decision makers. On the other hand, it has been found that models tend to perform poorly for attribute values that are outside of the range used in the stated choice experiment (Louviere, Hensher & Swait 2000). There are several methods used for determining which extremes should be used in the experiment. The first of which is to use revealed preference data to determine realistic maximum and minimum values (Hensher, Rose & Greene 2005). The analyst may also choose to use focus groups to determine which attribute levels seem realistic, and which fall out of the scope of feasibility. Another method commonly used by analysts is to review the extreme attribute levels used in previous experiments and to assess the modelling results obtained by using these values.

2.3.2. Experimental Design

The experimental design of a stated choice experiment is the method the analyst uses to distribute the attribute levels amongst the choice situations and then distribute these choice situations to the decision makers (survey respondents). The design of the stated choice experiment has a very large impact on the subsequent ability of the analyst to draw conclusions about the independent influence of the selected attributes on the observed choices (ChoiceMetrics 2011). In addition, the experimental design largely affects the statistical power of any models derived from the data collected in the experiment (Hensher, Rose & Greene 2005). There are numerous methods that an analyst can employ to design a stated choice experiment; the most commonly used methods have been summarized in the following sections.

Particular emphasis has been placed on efficient experimental design in this literature review because there has been an inclination toward this type of design by experts in recent years. There are many statistical advantages to using efficient designs, particularly when designing stated choice experiments from revealed preference data. The full factorial and orthogonal designs will be introduced, but only the efficient design will be fully explained owing to the fact that an efficient design has been used in the experiment.

2.3.3. Full Factorial Design

Full factorial designs are the most comprehensive type of choice experiment design because all of the possible choice situations are considered. Each respondent is presented with all of the possible choice situations and is asked to select one of the alternatives. Because all of the possible treatment combinations are considered, it is statistically possible to evaluate all of the main and interaction effects of the attributes and attribute levels included in the model (Louviere, Hensher & Swait 2000). However, the number of treatment situations quickly becomes quite large as the number of alternatives, attributes and attribute levels increase. In general, the total number of combinations that are considered in a full factorial design can be calculated using Equation 2.2.2.1.

Equation 2.2.2.1

$$S^{ff} = \prod_{j=1}^{J} \prod_{k=1}^{K} l_{jk}$$

(ChoiceMetrics 2011)

Where: S^{ff} = total number of choice situations

J = Alternatives

K = Attributes of the alternatives

l = Levels within the attributes

Because each decision maker is presented with each of the choice situations in a basic full factorial experimental design, the workload for the respondent becomes excessively large in all but the smallest experiments (Hensher, Rose & Greene 2005). In addition, as the number of choice situations presented to a respondent increases, the amount of effort the respondent puts into pragmatically analysing the alternatives and into selecting the most favourable alternative has been found to decrease (Louviere, Hensher & Swait 2000). One possibility for reducing the number of choice situations presented to each respondent is to divide the choice situations among the respondents instead of assigning all situations to all respondents. This method, however, tend to lead to biased outcomes (ChoiceMetrics 2011). Another option for limiting the number of treatment situations that are presented to each decision maker is to systematically select the most important situations for producing the desired statistical results (ChoiceMetrics 2011). There are a number of methods that are used for selecting the most important choice situations. The two most common designs, orthogonal designs and efficient (or optimal) designs are presented in the following sections.

2.3.4. Fractional Factorial / Orthogonal Design

Orthogonal designs are traditionally the most commonly used form of fractional factorial stated choice experimental design. According to ChoiceMetrics (2011) an experimental design is orthogonal if two requirements are satisfied; the attribute levels are balanced[1] and each of the attribute columns in the design is uncorrelated with the other columns. A problem definition for finding an orthogonal design is given by ChoiceMetrics (2011, p. 65):

> "Given feasible orthogonal coded attribute levels $\Lambda_{\mathrm{jk}}$for all j and k, given a minimum number of choice situations S, determine the smallest balanced design X with $X_{jks} \in \Lambda_{\mathrm{jk}}$ such that $\sum_{\mathrm{s}=1}^{\mathrm{S}} \mathrm{x_{jks}}\,\mathrm{x_{jks}} = 0, \forall(\mathrm{j}_1, \mathrm{k}_1) \neq (\mathrm{j}_2, \mathrm{k}_2)$ is satisfied."

In creating an orthogonal fractional factorial choice experiment, the analyst will typically make use of orthogonal coding for the labelling of the attribute levels because this form of coding makes it less complicated for the analyst to create the experimental design. Orthogonal coding is achieved when the sum of a column of attribute levels equals zero. For example, the attribute levels for an attribute with two levels could be (and conventionally would be) assigned the values 1 and -1. The attribute levels of an attribute with three levels would be labelled 1, 0 and -1. Conventionally, only odd numbers are used in orthogonal coding and the number five is not used

The task of using orthogonal coding to create an orthogonal fractional factorial design tends to be a tedious process (ChoiceMetrics 2011). A minimum number of choice situations must be included in order to satisfy the conditions of attribute

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[1] Attribute balance refers to a condition that all of the attribute levels are included the same number of times in the experimental design.

balance and degrees of freedom[2]. The minimum number of choice situations that must be included is six, but depending on the number of alternatives, attributes, and attribute levels included in the experimental design, the minimum number of choice situations can be significantly higher (Louviere, Hensher & Swait 2000). In order to reduce the number of choice situations that are assigned to each survey respondent, a method known as *blocking* is used to orthogonally split the design into several smaller designs (Hensher, Rose & Greene 2005). Each of the smaller designs is no longer orthogonal within itself, but the sum of the designs maintains orthogonality.

However, recent developments in stated choice experimental design theory, namely the introduction and improvement of efficient stated choice designs, have highlighted several shortcomings of the orthogonal fractional factorial method. In practise, it is atypical to maintain orthogonality within the data set when it is used to create choice models for several reasons (ChoiceMetrics 2011). Firstly, orthogonality is lost when data is not collected for any of the choice situations. If blocking is used and one respondent does not complete their choice task, the orthogonality of the entire data set is compromised (Louviere, Hensher & Swait 2000). Secondly, the transition from design codes to orthogonal codes may cause a loss of orthogonality (ChoiceMetrics 2011). For example, if fare attribute is considered for public transportation and the attribute levels are set at 0.00 €, 0.50 €, 2.00 € and 5.00 €, the subsequent orthogonal codes -3, -1, 1 and 3 would not accurately represent the quantitative differences between the levels.

ChoiceMetrics (2011) notes that the use of orthogonal designs is best suited for analysis using linear models. However, when discrete choice models are used, the authors suggest that efficient experimental designs may be preferable, even when limited information is available concerning the β parameters.

2.3.5. Efficient Design

The theory of efficient or optimal experimental designs is presented in this section. It has been argued in recent literature that if any information exists regarding the β parameters in the utility functions specified in the model, an efficient experimental design will always outperform an orthogonal design (ChoiceMetrics 2011). This applies even if only the sign of the parameters are known or can be assumed logically.

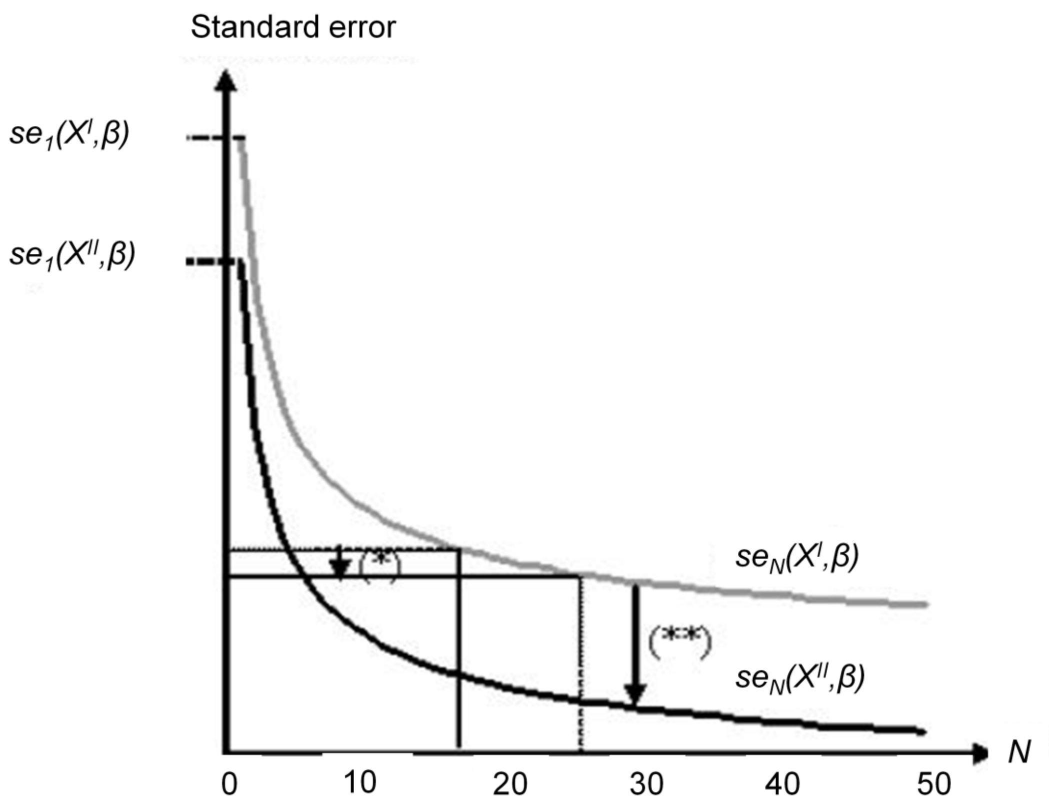
The underlying principle of an orthogonal fractional factorial method is to create statistically independent or uncorrelated attributes in the experimental design. While the construction process of an orthogonal fractional factorial experiment minimizes

[2] The degrees of freedom in an experimental design are the number of observations in a sample minus the number of β parameters that are estimated (Hensher, Rose & Greene 2005).

the correlation between the attributes to zero, no effort is made to improve the statistical efficiency of the design (Hensher, Rose & Greene 2005). In contrast, efficient designs do not explicitly minimize the correlation between the attributes in the construction process, although this occurs implicitly in the minimization of the determinant of the variance-covariance matrix. Instead, they aim at increasing the statistical efficiency of the experimental design (ChoiceMetrics 2011). The underlying principle of an efficient design is to minimize the standard error of the parameter estimates predicted from the stated choice experiment.

One of the major advantages of an efficient design over an orthogonal fractional factorial design is the ability of the analyst to produce estimates with small standard error values with a relatively small sample size (Rose & Bliemer 2004). As shown in Figure 2, the efficiency of a design has much more impact on the standard error (X^I has a higher design efficiency than X^{II}) than the number of respondents.

Figure 2: Standard error as a function of sample size



Source: ChoiceMetrics 2011

An efficient design is generated based on the fact that it is possible to derive the AVC (Asymptotic variance-covariance) matrix if the β parameters are known (Louviere, Hensher & Swait 2000). The roots of this matrix are the asymptotic standard errors, which are minimized to increase the statistical efficiency of the experimental design (ChoiceMetrics 2011). Mathematically speaking, the AVC matrix, often denoted as

Ω_N, is the negative inverse of the Fisher Information Matrix, which itself is the second derivative of the log-likelihood function. The log-likelihood function of an MNL model (which is the only type of model that will be analysed in this research project) is given below.

Equation 2.3.2

$$L = \sum_{n=1}^{N} \sum_{s=1}^{S} \sum_{j=1}^{J} y_{njs} \ln\left(P_{njs}\right) + c$$ (Hensher, Rose & Greene 2005)

Where: L = log-likelihood

y_{njs} = the column matrix indicating whether alternative j was selected by respondent n in the choice situation s

P_{njs} = choice probability from the choice model

c = constant

The AVC matrix can then be derived by taking the negative inverse of the second derivative of Equation 2.3.2. Although a mathematical derivation of the preceding sentence will not be provided[3], the resulting equation for Ω_N is given below.

Equation 2.3.3

$$\Omega_N = \left[\sum_{m=1}^{M} \sum_{j=1}^{J} x'_{njs} P_{njs} x_{njs} \right]^{-1}$$ (Hensher, Rose & Greene 2005)

Where: Ω_N = the AVC matrix

x_{njs} = attribute levels of each alternative j is for respondent n in the choice situation s

P_{njs} = choice probability from the choice model

[3] If the reader is interested in obtaining more information about the derivation of the AVC matrix, he/she is referred to *The design of stated choice experiments: the state of practice* by John M. Rose and Michiel C.J. Bliemer (Rose & Bliemer 2004).

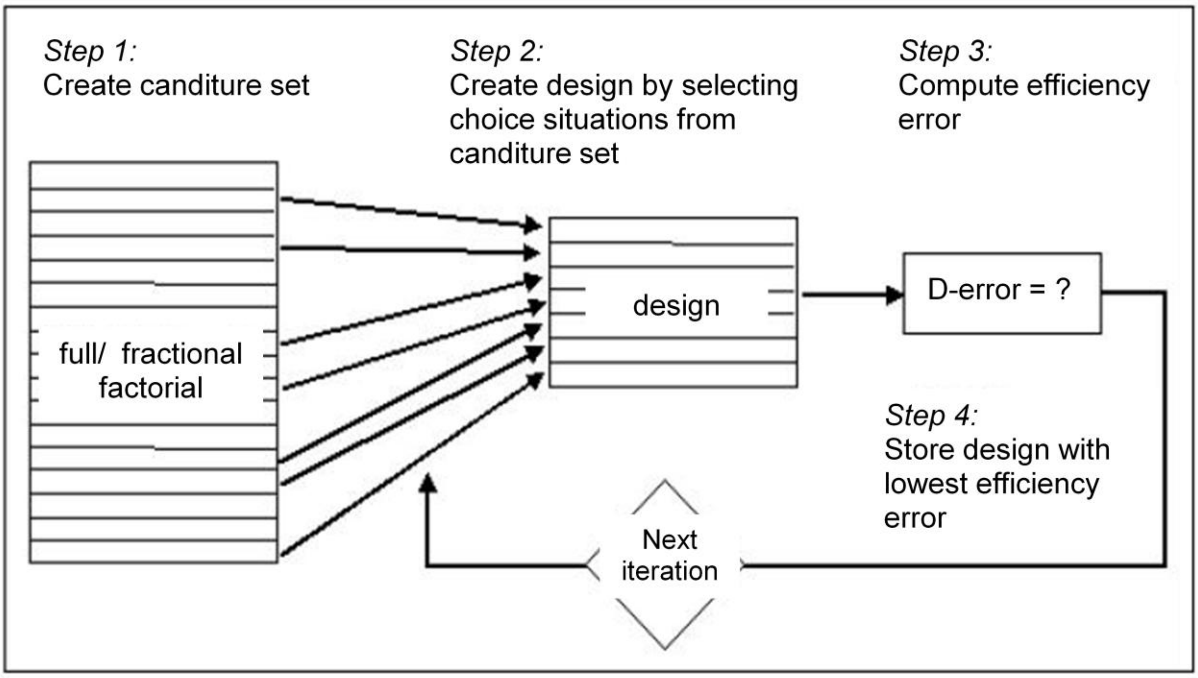
The D-error, which is the most commonly used measure of the efficiency of an efficient stated choice experimental design, is then calculated by taking the determinant of Equation 2.3.3 (Hensher, Rose & Greene 2005). The aim is to maximize the efficiency of the design by minimizing the D-error. Although there are other methods of estimating the efficiency of an experimental design, including the A-error and S-error measures, only this measure will be reviewed in the scope of this research project[4].

According to ChoiceMetrics (2011), there are three different types of D-error values that vary depending on the level of information available regarding the β parameters (known as priors in this case). If no priors information is available, the β parameter estimates (referred to as $\tilde{\beta}$ in the literature) are assumed to be zero. In this case a D_z-error is calculated. Alternatively, if there is information available concerning the β parameters, and this information is deemed to be reasonably accurate, a D_p-error can be calculated. Lastly, if there is information about the β parameters, but this information is uncertain, a D_b-error can be determined. Using slightly varying algorithms, all three D-errors can be reduced to produce efficient experimental designs. As would be assumed, the level of efficiency of the resulting designs varies according to the quality of the information available concerning the priors.

One of the most common methods of producing an efficient choice experiment is to use the iterative process depicted in Figure 3. The algorithm is designed to systematically arrange a set of choice situations from the full factorial design and calculate the D-error (whichever of the three types of D-error that may be). The design is then systematically adjusted to reduce the D-error. This loop continues until a set number of iterations are performed or the analyst discontinues the algorithm.

[4] For more information about such error measures please see *Stated Choice Methods: Analysis and Application* by Louviere, Hensher and Swait (2000) or the Ngene 1.1 User Manual and Reference Guide (ChoiceMetrics 2011).

Figure 3: Flow chart for the modified Federov algorithm



Source: ChoiceMetrics 2011

2.3.6. Building SP Experiments from RP Data

Recent literature has suggested that the realism of a choice situation used in a choice experiment can be greatly increased by building the alternatives from an existing situation (Starmer 2000). The use of a reference alternative may produce more meaningful data at the disaggregated level because the participant is able to frame the choice task with some existing memory (Rose et al. 2008).

Although the benefits of using a reference situation to build a stated choice experiment are gaining recognition, the methods employed to integrate revealed preference data are inconsistent with current techniques of generating SP experiment (Rose et al. 2008). Firstly, it is difficult to use fixed attribute levels in stated choice experiments that are built from RP data. This difficulty stems from the complexity of setting attribute levels that make cognitive sense to all respondents and reflect the curve of indifference for all respondents. For example, if one respondent reports a trip that took 2 minutes, another reports 10 minutes, and another respondent reports a trip that took 30 minutes, it is difficult to set attribute levels for the attribute trip duration that are appropriate to all three respondents. As the sample becomes larger, it is increasingly difficult to set suitable attribute levels.

There are two common ways of circumventing the problem described previously. The sample may be divided into separate segments based on the reported value of one or more variables. It is then possible to use an identical experimental design[5] for all the segments with varied attribute levels that reflect the reported values of the variables. A second and more commonly used method of avoiding this issue is to pivot the attribute levels around the reported values using set percentages. This method is advantageous because the resulting attribute levels will be more akin to those expected by the decision maker and thus will create more realistic choice situations (Hensher, Rose & Greene 2005). When designing a pivoted stated choice experiment, it is important to carefully consider the percentages used to pivot the observed values as they will have a strong impact on the attribute levels presented to the respondents and the usability of the resulting data. It must be noted that the model estimates resulting from this type of choice experiment will be in the form of percentage changes from a current level (Hensher, Rose & Greene 2005). In other words, it will not be possible to estimate the effect of an absolute change in a given factor; only the effect of a percent change will be estimable. Furthermore, it is only advisable to use the resulting model to predict the effect of percentile changes within the experimental boundaries.

According to Rose et al. (2008), there are five main methods of implementing pivoted percentages into a stated choice experimental design. The first of which is to use a conventional fractional factorial orthogonal design using attribute levels varied by percentage rather than absolute values. The process of creating such an experimental design is the same as used for absolute values. However, the efficiency of such a design is very low because the design is not optimized considering the actual attribute values presented to the respondents (Rose et al. 2008). The efficiency, or the D-error value associated with an orthogonal design, was found to be more than ten times larger than those calculated for the other four design methods, suggesting that this design will produce larger asymptotic standard errors.

The second method of implementing a stated choice experiment using a reference scenario is to determine population averages for all the attributes included in the experimental design and pivot around these values. Although this method was found to produce a much lower D-error value than the orthogonal design, the reliability of the parameter estimates for the cost attributes was found to be worse than the subsequent three methods (Rose et al. 2008).

The third method is an extension of the second method and involves segmenting to population and determining segment specific averages for the different attributes. This method produced results similar to those of the second method.

[5] It is also possible to create completely different experimental designs for the different segments.

The fourth method of building a stated choice experiment from revealed preference data is to use a two-phase survey instrument. Such an instrument typically collects RP data from respondents in a paper and pencil survey in a first step and uses this data to create a stated choice experiment in a second phase. This two-phase method has been found to be excellent from a statistical standpoint because a data specific efficient design can be generated by minimizing the values within the AVC matrix using the same data set used in the model estimation (Rose et al. 2008). However, such a survey can be difficult to carry out logistically and is subject to drop-outs, or respondents who take part in the first phase of the survey, but do not complete the SP experiment (Hensher, Rose & Greene 2005). According to Rose et al. (2008), although the reliability of the parameter estimates decreases with the percentage of dropouts, this decrease is only marginal.

The fifth method involves the optimization of the efficiency at the individual level. Although this method was found to produce the lowest D-error value (Rose et al. 2008), the level of work required to produce such a survey is very large, unless an automated process is used.

Granting that stated choice experiments built from revealed preference data are gaining recognition due to their advantages with regards to the decision making behaviour of the respondents, the methodology used to create such designs is still in the early phases of development. It is possible to create stated choice experiments from reference scenarios using some choice experiment building tools such as Ngene. However, these methods are still somewhat restrictive.

2.3.7. Remarks

The theory of stated choice experiment design is very extensive, and as such, it was not possible to include all aspects of the theory in this review. If the reader is interested in learning more about stated choice experimental design he/she is referred to the text book *Applied Choice Analysis: A Primer* by David A. Hensher, John M. Rose and William H. Greene (2005), or *Stated Choice Methods: Analysis and Application* by Jordan J. Louviere, David A. Hensher and Joffre D. Swait (2000).

3. RESEARCH METHODOLOGY

The methodology used in this research project draws from state-of-the-art practice in bicycle research, mode choice research and stated choice survey design presented in Chapter 2. In order to increase the realism of the stated choice experiments for the respondent, features of an actual trip made by each of the respondents are used to develop individualized choice situations. The strategy used in this survey to create personalized choice situations is to implement a two-phase process, where trip information is gathered from the respondents as a first step, and an efficient stated choice experiment is created and redistributed to the respondents in a second step.

The following sections explain in detail the way in which the survey logistics and the experimental design are undertaken. This includes a description of the sample recruitment, the procedure used to construct, distribute and collect the time-use-travel diaries, the coding of reported trips and non-selected alternatives and the method of creating and distributing stated choice experiment and personal questionnaires.

3.1. Sample Recruitment

When the scope of the survey was set, it was decided that a sample of 50 respondents is required to provide an adequate assessment of the survey design. No attempt was made to recruit a representative sample of respondents because the intention of the trial survey is not to collect usable data, but to test the recruitment process as well as the survey design and methodology. Two survey invitation letters were written (one in German and one in English) that outlined the intentions of the research, the requirements of the respondent and participation instructions. Both versions of the survey invitation letters have been included in Appendix B. Entry in a draw for one of three 50 € gift certificates to Schuster Sporthaus, a sporting and outdoor goods shop in Munich, was offered as incentive for participation. The number of gift certificates was later raised from three to five in an attempt in increase the attractiveness of participating in the survey. People interested in participating in the survey were instructed to send an email to radverkehr@mobil-tum.de, an email address created for the administration of this research project. The participants were instructed to include their mailing address. The time-use-travel diary survey package was then sent to this mailing address. However, a considerable number of respondents sent an email confirming their intention to take part in the survey without stating their mailing address. A response was sent to these people asking explicitly for their mailing address.

Respondents were recruited in two ways. Firstly, because the required number of participants is relatively small, friends and family members of the people working on the ‘Radverkehr heute und morgen’ project who live in Munich were asked if they would be willing to take part in the survey. These people were also asked if they had any roommates, colleagues, friends, etc. who also may be interested in taking part in the survey. Using this method, 44 people agreed to take part in the survey. Moreover, seven of the people who agreed to take part in the survey, were also willing to distribute questionnaires to people at their work or homes and encourage these people to take part in the survey. A total of 37 additional revealed preference questionnaires were distributed using this method.

Secondly, survey invitations were mailed to 500 personal addresses in Munich that were purchased online from Schober Group (www.schober.com). The purchased addresses did not offer a representative sample, but only included people who have made their address commercially available in the past. Contact information was only provided for people over the age of 18 and only for one person per household. According to the website, contact information is available for 237,643 people in Munich. However, this recruitment method was not particularly successful; only four people responding by email to indicate their interest in taking part in the survey, accounting for a response rate of less than 1%. A small number of survey invitations did not reach their destination and were returned to the sender.

A survey hotline was available for the entire duration of the survey, from August 22nd through October 31st, 2011. The intention of the hotline was to answer any questions that might arise while the respondents were either filling out the time-use-travel diary or completing the online survey. The hotline was announced first in the information letter and then online in the introduction to the online survey.

Respondents were originally asked to fill out the time-use-travel diary on any weekday between August 22nd and September 2nd, 2011, preferably on a Tuesday, Wednesday or Thursday. This time-frame was later extended, and then eliminated in order to counteract a low response rate.

3.2. Time-Use-Travel Diary Design

The first phase of the two step research process involved designing a survey instrument to gather detailed activity and trip information from the respondents. There are two methods that have been used in past research projects to collect such information, time-use diaries and travel diaries. Travel diaries are used most commonly in transportation research, and ask respondents to record information about each trip made during a pre-set time frame. Collected trip information usually includes spatial information, such as the origin and destination locations, the purpose of the trip, the mode used, the time and duration of the trip and the approximate distance of the trip. Well known travel diaries used for transportation research in Germany include Mobilität in Deutschland (MiD) and the Deutsche Mobilitätspanel (MOP). Although travel diaries adequately provide the spatial and trip characteristic data that is needed for transport research, respondents have been found to omit trips from the travel diary in an attempt to reduce the work load of the survey (Hubert, Armoogum & Madre 2008). In contrast, time-use surveys have not been commonly used in transportation research projects in the past. This type of survey asks respondents to record all of their daily activities, including trips, in predetermined time intervals (generally five or ten minutes). Such surveys are thought to be advantageous because the respondent is not able to reduce the workload of the survey by omitting trips. However, trips or other activities that are shorter than the preset recording interval may not be reported in a time-use survey. Furthermore, time-use surveys used in the past have failed to collect the spatial trip information that is crucial in transportation modelling.

The time-use-travel diary used in this research project was designed as a combined time-use-travel diary. This was done in an attempt to draw from the advantages of both types of surveys while avoiding their respective weaknesses. The diary is based on the design of time-use surveys, but places a strong focus on both spatial and trip specific information. The time-use diary instructions and form used in the 'Zeitverwendung in Deutschland 2001/2002' (Time use in Germany 2001/2002) research project (Statistisches Bundesamt Deutschland 2010), were used as a template for the design of the time-use-travel diary. However, the columns of the diary that asked for the people who were present during each activity or trip were removed, and several columns were added to collect travel specific information. For each activity or trip in the time-use-travel diary respondents are asked to indicate:

- the main activity;
- the mode of transportation or the address of the activity;
- any other additional activity;
- the cost of the activity;
- the cost of parking;

- and the enjoyment of the activity or trip (1-5 Likert Scale).

Several additional columns were added to collect information from people who used a bicycle for a trip. Bicycle specific information collected in the time-use-travel diary included:

- the type of bicycle parking used (options included public space, bicycle rack, covered bicycle rack, a bicycle parking house and another parking facility);
- the type of infrastructure used for the largest portion of the trip (options included speed limit 30 km/h zones, bicycle lane on the road, street without a bicycle lane, bicycle lane on the sidewalk, bicycle path in a green area, a combined pedestrian and bicycle path and another type of infrastructure);
- the availability of showering facilities at the destination;
- and the use of showering facilities at the destination if available.

During the design phase of time-use-travel diary, two alternative diaries were created, a 10-minute interval version, which utilized a preset time interval, and a free interval version, which allowed respondents the freedom to record the start and end times of each trip or activity. The free interval version was created in an attempt to reduce the likelihood of trips being omitted from the diary because they are shorter than the preset interval. The free interval version of the time-use-travel diary has been included in Appendix C (German version) and D (English version). The 10-minute interval version is available on the accompanying CD.

A small qualitative pre-test of the two time-use-travel diaries was carried out on a convenience sample of seven test respondents. Test respondents were asked to read the instructions for both prototypes and were shown a filled out example of both versions. They were then asked which version they would prefer filling out and whether they would be more likely to omit information on one of the versions. The test respondents were also asked if they had any general comments or suggestions about the overall layout of the diary form or the survey instructions. The test respondents unanimously agreed that they would prefer filling out the free interval version and indicated that they would not be likely to omit information from either of the versions. Based on the results of the small pre-test and in an attempt to maximize the number of survey respondent, it was decided to use the free interval time-use-travel diary. Several small adjustments were made to the layout of the diary form and the wording of the instruction text based on the comments and suggestions of the test respondents.

A space for comments about the survey was provided for the respondents on the last page of the diary. Respondents were asked to enter any suggestions they may have for the further development of the survey or indicate any difficulties they had in filling out the survey in the provided space.

3.3. Time-Use-Travel Diary Distribution and Collection

A time-use-travel diary package was sent by mail to each person that emailed their address to the ‘Radverkehr heute und morgen’ email address. Additional time-use-travel diary packages were distributed by hand by the seven survey participants who agreed to further distribute the survey. A total of 85 time-use-travel diaries were distributed either by mail or by hand on Tuesday, August 16th, 2011. In the following weeks several more people indicated an interest in taking part in the survey, and subsequently, 12 more survey packages were distributed after the initial delivery date. Each time-use-travel diary package contained a shortened information letter, an instruction document containing an example of a correctly completed time-use-travel diary, a time-use-travel diary form, a short questionnaire sheet and a stamped and addressed return envelope. Because the survey packages were distributed to people who had not previously emailed their intention to take part in the survey, respondents were asked to state their email address and their name on the front of the survey package, making it possible to distribute the subsequent online survey link. The documents that were sent to the survey respondents in the time-use-travel diary package have been included in Appendix C. Distribution of the survey packages was concluded on Friday September 16th, 2011, after a total of 97 survey packages were assembled and distributed. Respondents were instructed to insert the filled out time-use-travel diary, the diary cover page and the questionnaire sheet into the provided return envelope and mail it back as quickly as possible.

3.4. Coding the Time-Use-Travel Diaries and Estimation of Non-Selected Alternatives

All of the trips that were reported in the time-use-travel diaries were coded using SPSS. A total of 44 variables were created to describe the trips reported in the diaries and the attributes of the non-selected alternatives. The resulting SPSS file is available on the accompanying CD (file: RP Dataset.sav).

Several variables were introduced to describe the characteristics of the reporting day and the respondent. These variables included:

- the assigned respondent identification number (1-48);
- the reporting date;
- the weekday of the reporting date (Monday, Tuesday, Wednesday, etc.);
- whether the reporting day was considered normal or unusual;
- if the reporting day was unusual, the reason that the day was not normal;
- and the weather on the reporting day (overall).

Several additional variables were created to describe the details of each individual trip made during the reporting day. Data for the trip variables was taken directly from the time-use-travel diary. These variables included;

- the assigned tour identification number[6] of the trip;
- the assigned trip identification number;
- the start address;
- the type of start location (e.g. home, work, school, shopping, etc.);
- the start time;
- the end address;
- the type of end locations (e.g. home, work, school, shopping, etc.);
- the end time;
- the mode used;
- if the person used a car,
    - the size class of the vehicle,
    - the cost of parking at the destination,
    - and whether the person was a driver or passenger;
- if the person used a bicycle,
    - the type of bicycle parking used,
    - the type of infrastructure used on the trip (a serious of binary variables),

[6] Tours are defined as a group of trips made by a respondent that start at home, reach one activity or more, and end back at home.

    - the availability of showering facilities at the destination,
    - and the use of showering facilities at the destination;
- the cost of the activity at the destination;
- and the enjoyment rating of the journey (1-5 Likert Scale).

Three additional variables were calculated or deduced from the information recorded in the time-use-travel diaries:

- the duration of the trip;
- the purpose of the trip;
- and the duration of the activity at the destination.

Finally, several variables were added to the dataset that estimated the characteristics of the non-selected alternatives. Depending on the mode used by the respondent for the reported trip, a selection of the following variables was estimated:

- the distance by car;
- the travel time by car;
- the distance by bicycle;
- the travel time by bicycle;
- the access time to public transport by foot;
- the travel time by public transport;
- the mode of public transport used;
- the number of transfers required using public transport;
- and the cost of a one way ticket for the trip.

The characteristics of the non-selected alternatives were estimated differently depending on the mode of transport that was reported by the respondent. The characteristics of alternative modes of transportation were only estimated for reported trips that were made by car, public transport or bicycle. Trips that were made by foot were generally found to be too short for a feasible car or public transport alternative to exist. Regardless of the mode used for the trip, the travel distance for the car and bicycle was estimated by entering the origin and destination addresses into the Google Maps © direction web tool, with the car option selected for trips made by a car, and the walking option selected for trips made by bicycle. The walking option was used for bicycle trips to account for the fact that bicycles can travel through parks and other areas that are not accessible by cars. The rest of the process varied depending on the mode that was used for the reported trip. Table 1 provides a summary of methods used to estimate the variable values.

Table 1: Coding of Alternative Modes of Transportation

<table>
<tr><th>Mode Used / Variable</th><th>Car</th><th>Public Transportation</th><th>Bicycle</th></tr>
<tr><td>Distance by car</td><td colspan="3">Estimated using origin and destination addresses and Google Maps © directions web tool (with car option selected)</td></tr>
<tr><td>Travel time by car</td><td>Value taken as reported in time-use-travel dairy</td><td colspan="2">Estimated using origin and destination addresses and Google Maps © directions web tool (with car option selected)</td></tr>
<tr><td>Distance by bicycle</td><td colspan="3">Estimated using origin and destination addresses and Google Maps © directions web tool (with walking option selected)</td></tr>
<tr><td>Travel time by bicycle</td><td colspan="2">Estimated using origin and destination addresses and Google Maps © directions web tool (with walking option selected) and Equation 3.4.1</td><td>Value taken as reported in time-use-travel dairy</td></tr>
<tr><td>PuT Access time</td><td rowspan="5">Estimated using origin and destination addresses, trip start time and the MVV online trip planning tool</td><td rowspan="5">Value taken from time-use-travel diary when available and estimated using origin and destination addresses, trip start time and the MVV online trip planning tool when not available</td><td rowspan="5">Estimated using origin and destination addresses, trip start time and the MVV online trip planning tool</td></tr>
<tr><td>PuT Travel time</td></tr>
<tr><td>PuT Mode</td></tr>
<tr><td>PuT Transfers</td></tr>
<tr><td>PuT Fare</td></tr>
</table>

For respondents who used either a car or public transportation for their reported trip, the travel time for the bicycle alternative was calculated using the following equation:

Equation 3.4.1

$$Travel\ Time_{bicycle} = \frac{\left(Distance_{bicycle} * detour\ factor\right) * 60}{\overline{Speed}_{bicycle}}$$

Where $Distance_{bicycle}$ was estimated using Google Maps © (km)

$detour\ factor$ = 1.12

$\overline{Speed}_{bicycle}$ = 11.78 km/h

The detour factor was adopted from the results of a GPS tracking research project done in Guelph, Canada (Aultman-Hall 1996). Aultman-Hall found that the average cyclist rode 3.7 km on a one-way bicycle commute, and this distance was an average of 0.4 km longer than the shortest possible route. Therefore:

$$detour\ factor = \frac{3.7\ km}{3.7\ km - 0.4\ km} = 1.12$$

The mean speed factor $\overline{Speed}_{bicycle}$ was taken from another GPS tracking research project that took place in Zurich, Switzerland (Menghini et al. 2009). This speed represents the average bicycling speed by a person over a one week observation period. The average speed includes any time stopped during the trip. This study also compared the trip distance of the selected route to alternative routes, but did not specifically compare the selected route to the shortest possible route.

3.5. Stated Choice Survey Design

A stated choice experiment was designed to estimate the effects of various bicycle transportation factors and the characteristics of alternative modes of transportation on mode choice. The data collected in the time-use-travel dairies was incorporated into the stated choice experimental design to create a realistic choice situation for each survey participant. The experimental design of the choice experiment was created using Ngene, a software that is distributed by ChoiceMetrics (www.choice-metrics.com). The procedure for setting up a choice experiment suggested by Hensher, Rose and Greene (2005, p 100-156) was used as a guideline for generating the experimental design used for this choice experiment. The following section describes the alternatives, attributes and attribute levels that were selected for assessment and provides an explanation for why such variables were included. The following sections explain the experimental design used for the stated choice survey and the rationalization behind the selected methods.

3.5.1. Relevant Alternatives, Attributes and Attribute Levels

As described in Section 2.3, a universal but finite list of all the existing alternatives must be compiled in order to fulfil the global utility maximizing rule. However, if the complete list is deemed to be too large to create a practical choice experiment, the list of alternatives must be culled (Hensher, Rose & Greene 2005). Because the list of modes of transportation that could be used in Munich is quite long, and includes at least 20 alternatives, it was necessary to use subjective judgement to select the most significant alternatives to include in the choice experiment. It was decided to include three transportation mode alternatives in the choice experiment, the car, an all encompassing public transportation alternative including the bus, tram, U-Bahn and S-Bahn, and the bicycle. It was decided not to include walking as an alternative in the choice situation, even though trips by foot account for 28% of the trips made in Munich (Landeshauptstadt München 2010). This alternative was omitted because a distance that is comfortably covered by foot is typically much shorter than that covered by public transportation, private car or bicycle. In the estimation of the characteristics of the alternative modes of transportation for the trips reported in the time-use-trip diaries, it was concluded that the majority of the trips made by foot did not have a possible public transportation alternative[7]. Moreover, in many cases, the estimated travel time for driving was greater than the walk time reported in the travel diary due to restricted one-way streets. Similarly, the walking alternatives for trips

[7] In such cases the MVV trip planning web tool suggested a walking route.

made by a public transport mode or by car generally did not have a feasible walking alternative. However, as this omission is in violation of the global maximizing condition, some explanatory power of the model is lost.

Once the alternatives to be included in the choice experiment were decided upon, it was necessary to determine which attributes should be included to describe each of the alternatives. Although it may have been possible to include common attributes to describe some or all of the attributes, it was decided to use only alternative specific attributes in this trial experimental design. This approach was chosen in order to be able to assess the suitability of the attributes and the attribute levels selected for each alternative autonomously. However, it would be difficult to create common attributes for most of the attributes included for three reasons. Firstly, a number of the attributes only pertained to one alternative, an example of which is the percentage of dedicated bicycle infrastructure available on the trip. Clearly this attribute was only relevant for explaining the bicycle option and not the car or public transport alternatives. Secondly, as found in many previous mode choice experiments, the influence of similar attributes on the total utility of different modes tends to be different. For example, travel time was included as a factor in all three alternatives; however, previous research has indicated that the β parameters differ depending on the mode. For instance, the travelling by bicycle has been found to be more onerous per minute than time spent driving a car or riding public transport (Heinen, van Wee & Maat 2010). In order to be able to calculate the β parameters individually for the three alternatives, it was decided to use alternative specific travel time attributes. Finally, the levels associated with a common attribute may vary for different alternatives, making it necessary to create individual attributes. An example of this can be made by once again referring to travel time. Depending on the trip characteristics, the travel time by bicycle, car and public transportation tend to be quite different. However, because this experimental design makes use of revealed preference data and attribute levels that are pivoted around a reported value, it may be possible to use common attribute levels for the different alternatives. As stated previously, this was not done in this experiment in order to be able to analyse the attributes and attribute levels independently.

In an attempt to make the experimental design more manageable, efficient and balanced, it was decided to include three attributes for each of the alternatives. Each of the attributes was described by two, three or six levels. The attribute levels were adopted from previous research projects that yielded results with high validity. As discussed in Section 2.3, the attribute levels should be selected in such a way that they reflect the estimation of the indifference curve. If the attribute levels are correctly selected, the variation of the attribute levels in the different choice situations will marginally influence the decision of the respondent. The attributes organized by alternative as well as the selected attribute levels will be presented in the next sections along with a justification for their inclusion.

Car

There is a considerable amount of research available that has analysed the influence of various car attributes on mode choice (Vrtic et al. 2009; Ortúzar, Iacobelli & Valeze 2000; Bamberg & Schmidt 1994). In the literature review section of the report, the findings from mode choice studies that included the bicycle have been presented. The experimental design of these studies, along with the statistical output and validity of the resulting models, has been closely examined in an attempt to select the most relevant attributes. The attribute levels used in these studied have also been used as a guideline for those used in this choice experiment.

Car Travel Time

The vast majority of the mode choice studies that were reviewed included travel time as an attribute describing all of the modes included in the experiment. As expected, the results of mode choice stated choice experiments indicate that the travel time β parameter was both significant and relatively large in absolute value (König & Axhausen 2002; Ortúzar, Iacobelli & Valeze 2000; Vrtic et al. 2009). Furthermore, the travel time by car is an attribute that is responsive to policy change. Various push measures aim at extending the car travel time by reducing speed limits, introducing traffic-calming measures and closing off certain roads for, and hence decrease the utility of the car option.

The car travel time attribute was integrated into the stated choice experiment as a pivoted attribute. The absolute value attribute levels could not be used because of the wide range of car travel times included in the experiment. The car travel times reported by the respondents or estimated using Google maps (© Google), were used as a reference attribute level. The pivoting values were adopted from Vrtic et al. 2009, who used a similar attribute in their mode choice analysis and produced a robust model from their results. The pivoted attribute levels included for the car travel time attribute were -10%, 0% (reference scenario) and +25%.

Parking Fee

The decision to include the cost of parking as a separate attribute was made based on several pieces of information. Two mode choice studies were found in the research review that included parking fees, Vrtic et al. (2009) and Ortuzar, Iacobelli and Valeze (2000), both found the independent influence of a parking fee to be significant and relatively large. Vrtic et al. (2009) found that the absolute value of the parking fee β parameter was more than 2.5 times greater than that of the fuel cost component. Secondly, parking control is one of the most commonly used *push measures*, or measures that encourage people to use alternative modes of transportation rather than driving (or riding as a passenger) in a private car. The introduction of parking fees or the increase in the cost of parking are some of the quickest and simplest means of controlling parking and supporting alternative modes of transportation such as the bicycle. Because this attribute is so responsive to policy change, the independent influence of the parking fee on the mode choice decision was of particular interest.

The parking fee attribute was originally intended to be included as a pivoted attribute which used the parking fee reported in the time-use-travel diary as a base for the stated choice experiment. If the respondent did not use a car for their trip, the intent was to use the typical Munich parking rate of 0.50 € per 12 minutes for parking in the city centre, and the duration of their activity as reported in the time-use-travel diary to estimate a parking fee. However, the majority of the respondents who did use a car for one of their reported trips did not indicate a parking fee. Additionally, the long duration of many of the reported activities made it unfeasible to use a parking fee rate of 0.50 € per 12 minutes. If a person reported travelling to work, where they stayed for eight hours, the resulting parking fee of 20.00 € was deemed to be too dominating to include in the stated choice experiment. In light of these obstacles, it was decided to use fixed absolute values for the parking fee attribute levels. The attributes used were based loosely on those used in two parking studies, one done in Karlsruhe, Germany and the other in England (Axhausen & Polak 1991). The attribute levels were also questioned in the small pre-test of the stated choice experiment to ensure that they did not dominate the decision. The attribute levels used were 0.00 €, 2.00 € and 5.00 €.

All Inclusive Travel Costs

The total trip cost was included in the experimental design to assess its validity as an explanatory attribute. In the mode choice literature that was reviewed, those that included gas price used either an estimated gas cost per km (Vrtic et al. 2009) or per litre/gallon (Buehler & Pucher 2011), or used an estimated total fuel cost for the trip (Ortúzar, Iacobelli & Valeze 2000). Although Vrtic et al. (2009) found that the influence of the fuel cost was significant; the absolute value of this influence was relatively small. Ortúzar, Iacobelli & Valeze (2000) included the fuel cost in the stated choice experiment, but the model that was subsequently estimated incorporated a direct cost attribute, which included parking cost and fuel cost. Although the absolute value of this parameter was relatively large, the t-ratio hovered near the 5% significance boundary. These results suggest that the influence of gas price alone on the decision outcome is modest and in some cases barely significantly relevant. In addition, the gas price alone does not represent the entire cost imposed on a driver (or passenger) for using a car.

Furthermore, because trips shorter than 4.6 km were selected with first priority, the total gas price of any given trip was minuscule[8] in comparison to other cost factors (parking and public transportation fare). During a small pre-trial of the stated choice

[8] e.g. 4.6 km * 0.05 €/km = 0.23 €

experiment, the convenience sample of respondents indicated verbally that the small fuel cost variable did not have any influence on their decision.

For these reasons, it was decided to include an all inclusive travel cost attribute, which includes the depreciation per kilometre, the fuel cost, fixed costs associated with car ownership including insurance and tax, and variable costs including maintenance and repair. The value used as the reference point was calculated from a report prepared by the Allgemeiner Deutscher Automobil-Club e.V. (2011), which gives the average all inclusive driving cost of over 1500 vehicle models. The median value given in the report, 0.53 €/km, was calculated and used as the base line value for the stated choice experiment.

The all inclusive travel cost attribute was included with pivoted attribute levels. The attribute levels used were adopted from Vrtic et al. (2009), even though the attribute that was included in their stated choice experiment concerned fuel cost and not an all-inclusive cost. The attribute levels included are -5% (or 0.50 €/km), 0% (or 0.53 €/km – reference scenario) and 40% (or 0.74 €/km). However, because the attribute levels are pivoted using percentages rather than absolute values, it is assumed that the levels are roughly applicable to this new attribute as well. As no previous literature was found that included this attribute, it is particularly important to assess its independent influence and the suitability of the pivoted attribute levels.

Public Transportation

Many studies have investigated the influence of various public transportation related attributes on the decision outcome (Buehler & Pucher 2011; Johansson, Heldt & Johansson 2006; Kuhnimhof, Chlond & Huang 2010; König & Axhausen 2002; Vrtic et al. 2009). The attributes that are considered in these studies are wide ranging and include, travel time, access time, total wait time, number of transfers, headways or frequency of service, reliability of service, comfort, fare, and various other factors. Due to the sheer number of attributes that have been investigated concerning public transportation, it was difficult to discern the most influential attributes in a mode choice context. However, because the number of attributes and attribute levels included in a survey design quickly increase the survey complexity and data requirements, subjective decisions were made as to which attributes were the most relevant for this research project. The following sections describe the attributes that were selected and explain how these attributes were implemented in the experimental design.

Total Access Time and Total Ride Time

The total travel time of a public transportation trip is composed of an access time, a wait time, a riding time, a transfer wait time (which is a sub-component wait time), and an egress time. Previous research has indicated that the β parameters of these different segments of total public transportation time are different, or in other words, passengers tend to value the different components of a transit ride differently (Johansson, Heldt & Johansson 2006; König & Axhausen 2002; Ortúzar 2000; Vrtic et al. 2009; Vuchic 2005). In this experiment, it was decided to use two time components to describe the trip duration, the total access time, which is the sum of the access and egress time, and the ride time, which includes the ride time and transfer wait time. The wait time at the first station was neglected because it was assumed that the traveller could use the scheduling system provided by the transit service to avoid significant wait times. When considering wait time, the frequency (or headway) of service would have been a better attribute to examine because this attribute actually affects the travellers' ability to reach their destination at the desired time. However, this attribute was also disregarded for this experiment because of the relatively high frequency of public transportation service in Munich[9].

The access time was selected because it has been found to have a strong and significant influence on mode choice (Vrtic et al. 2009) and a very important predictor of public transportation use (Park & Kang 2008; Hossain, Hunt & Wirasinghe 2010). Kumnimhof, Chlond and Huang (2010) pointed out that for some trip purposes (particularly commuting) public transportation is the strongest competitor to the bicycle within the radius of non-motorized travel, particularly when a stop is very near to the home. Although the access time is not particularly responsive to short term policy measures, access time was included as an attribute because of its strong influence on public transportation use, particularly within the radius of non-motorized transport. Stringent maximum accessibility distances, or the distance from a household to the nearest public transportation stop, are enforced in Germany. These circumstances could have a limiting effect on the significance of this attribute in this study. The access time attribute levels were pivoted around a reference value by -15%, 0% (reference scenario) and +30%. The reference value was either taken from the time-use-travel diary (if reported) or estimated using the trip planner provided by the MVV.

The public transportation ride time, including transfer time if necessary, was incorporated as the second component of the public transportation travel time. Although this attribute has been found to have a lower influence per minute than the access or wait time (Park & Kang 2008; Vrtic et al. 2009; Hossain, Hunt & Wirasinghe 2010), it still has a substantial impact on the utility of a public transportation trip, partially due to the fact that the ride time is typically the longest portion of the ride (Vuchic 2005). The public transportation ride time is also more

[9] The buses, trams and U-Bahn in Munich typically run with a 5- or 10-minute headway during daytime hours and a 20-minute or 1-hour headways in the late evening and early morning. The S-Bahn generally has a 10- or 20-minute headway in the outskirts of Munich but is coordinated to offer roughly 5-minute headways within the city.

responsive to change in policy or operation than the other components. The attribute levels for ride time were pivoted around a reference value by -20%, 0% (reference scenario) and +10%. In order to provide a general idea of the total trip time, the access time and ride time were summed and displayed in a separate row in the stated choice experiment questions that were given to the respondents.

Fare

The third attribute included for the public transportation alternative was the one-way fare. Along with travel time, the cost associated with a transportation mode, or fare in the case of public transportation, has been found to be the most influential factor on mode choice (Ahern & Tapley 2008; Vuchic 2005; Ortúzar 2000). Public transportation fare may have a particularly strong influence on the choice to travel by bicycle. Storchmann (2003) found that in the few cases where fare-free public transportation service was introduced in European cities, the largest portion of new passegners attracted to public transport were previously cyclists and pedestrians, even though the fare-free concept has typically been introduced to reduce car traffic. Additionally, the public transportation fare is one of the most responsive attributes to short term policy measures. Because of this responsiveness, the influence of this attribute is of particular interest to analysts. The fare level for the public transportation alternative was pivoted around a reference value by -30%, 0% (reference scenario) and +20%. These levels were adopted from a study done by Vrtic et al. (2009). The reference value was taken as the cost of a single journey ticket from the MVV, either for one or two zones depending on the origin and destination of the reported trip.

Bicycle

The attributes included for the bicycle alternative were considerably more difficult to decide upon than those for the other two alternatives. This difficulty stemmed partially from the fact that very few stated choice experiments have been carried out that investigate bicycle use in a mode choice context. A number of studies involving stated choice experiments have been carried out to examine bicycle route choice and frequency of bicycle use. However it is not clear if the attributes included in these experiments would also be relevant for bicycle mode choice. One study was found that did examine bicycling in a mode choice context in Chile (Ortúzar, Iacobelli & Valeze 2000). However, the applicability of the results of this study is limited because of the differences in transportation behaviour in Europe and South America. Nevertheless, many of the methods used in that study were used as a guideline for the integration of a bicycle alterative in a mode choice stated choice experiment. The following sections outline the attributes that were selected to describe the bicycle alternative in the choice situation.

Bicycle Travel Time

The travel time by bicycle was included in the experimental design because travel time for all modes has been found in many studies to have a significant influence on the decision outcome (Vrtic et al. 2009; König & Axhausen 2002; Ortúzar, Iacobelli & Valeze 2000). Bicycle travel time in particular was found to have a strong and significant effect on the choice to bicycle (either route or frequency) in studies that investigated bicycle behaviour (Abraham et al. 2002; Aultman-Hall 1996; Hunt & Abraham 2007; Krizek 2006; Menghini et al. 2009; Stinson & Bhat 2005; Stinson & Bhat 2003; Tilahun 2005).

In previous studies involving bicycle travel time, the travel time was deemed to be fixed or only variable based on how strenuously the cyclist chose to ride. However, it is argued here that the bicycle travel time is responsive to policy measures. Measures such as coordinating traffic lights specifically for bicycle traffic, opening one way streets for contra flow bicycle traffic and giving bicycles the right of way on certain streets can greatly reduce the travel time for bicyclists without asking them to put more energy into their trip.

This attribute was implemented in the experimental design as a pivoted attribute. The reference level (0%) was either taken from the time-use-travel diary or calculated using an assumed average speed of 11.78 km/h (see Section 3.4 for derivation of this speed) and a trip distance estimated using Google maps (© Google). Because no previous work was found that included a changing bicycle travel time in the mode choice stated choice experiment, the pivoting percentage levels were loosely based off of those used for the car and public travel times. These levels were, -15%, 0% and +15%.

Percentage of Dedicated Bicycle Infrastructure on the Trip

The preference of bicyclists concerning the type of infrastructure used for their bicycle journey has been included in many of the bicycle route choice and frequency stated choice experiments in the past. Overall, the findings of these studies indicate that the availability of dedicated bicycle infrastructure is important in selecting a bicycle route. However, beyond this general conclusion, the findings are mixed concerning which type of infrastructure cyclists prefer, whether it is bicycle lanes on sidewalks, separated bicycle lanes, bicycle paths in green areas, traffic calmed streets, streets with no parking permitted, etc..

As dedicated bicycle infrastructure was found to have a significant influence on bicycle choices it was decided to include this attribute in this experimental design. However, because of the mixed findings concerning more detailed subdivisions of dedicated bicycle infrastructure, it was decided to use this attribute in its general form. Bicycle infrastructure was not included as an attribute in the bicycle inclusive mode choice study done by Ortuzar, Iacobelli & Valeze (2000). In their experiment, Hunt and Abraham (2001) used a uniform distribution of travel times between a set maximum and minimum and assigned respondnents a combined trip with two types of infrastructure, each described by a randomly selected travel time. This method was adapted for this study, but because the total travel time was already decided, the percentage of the trip spent on bicycle infrastructure was used as a tool to derive the time spent on infrastructure dedicated to bicycle use. The percentages of dedicated bicycle infrastrure that were included in the experimental design were 0%, 20%, 40%, 60%, 80% and 100%. In order to make this attribute clear to the respondents, the percentage of dedicated bicycle infrastructure was converted to time spent on dedicated infractucture and time spent riding in mixed traffic.

Attribute ambiguity was thought to be a potential problem for respondents in using this attribute to shape their decision. In order to provide the respondents with an idea of what was meant by dedicated bicycle infrastructure, various pictures of different infrastructure types were provided in a special information page available on the stated choice experiment (accessible to the respondents by clicking on the i button positioned under the bicycle alternative description).

Availability of Secure Parking at the Destination

The availability of secure parking at the destination has been found to have a significant impact on bicycle use by several studies in North America (Abraham et al. 2002; Hunt & Abraham 2007; Stinson & Bhat 2003). However, no research known to the author has been done in Europe to confirm if secure parking is also an important consideration for European cyclists. This attribute was modelled after one used in the research project done by Hunt and Abraham (2001) in Edmonton, Canada. A binary attribute was created (No secure parking = 0, secure parking = 1) and implemented into the survey design. As with dedicated bicycle infrastructure, attribute ambiguity was thought to be a potential problem for the secure parking attribute. As reported by Hunt and Abraham (2001) some of the respondents may have seen the attribute level ‘no secure parking’ as unrealistic because cyclists can almost always lock their bicycle to a fence or pole at their destination. In order to improve upon this point, a definition of secure parking was provided for the respondents (accessed by clicking on the i button positioned under the bicycle alternative description). If no secure parking was provided, respondents were advised that they would have to park their bicycle in public space wherever possible.

Attributes Not Included

It was originally intended to investigate the influence of the availability of showers and lockers at the destination on the likelihood to travel by bicycle. However, in the revealed preference section of the research, it was found that only very few of the respondents indicated using a shower or change facility at their destination. Furthermore, the availability of showers and change rooms is typically only applicable to work trips. Because all trip purposes were included in the experiment, it was not logical to include the availability of showers in the choice experiment. For this reason, and in an effort to reduce the number of attributes included in the stated choice experiment, it was decided to exclude the shower and change room attribute.

Summary of Attribute and Attribute Levels

Table 2 provides a summary of the attributes and attribute levels that were described in the previous sections. The attribute levels that contain a – or + sign are pivoted attributes. Those that do not contain either sign are not pivoted attributes.

Table 2: Alternative, attribute and attribute level summary

Alternative	Attribute	Attribute Levels	Source
Car	Travel Time	-10%, 0%, +25%	(Vrtic et al. 2009)
	Parking Fee	0 €, 2 €, 5 €	Created for this experiment
	Total Cost	-5%, 0%, +40%	(Vrtic et al. 2009)
Public Transportation	Access Time	-15%, 0%, +30%	(Vrtic et al. 2009)
	Ride Time	-20%, 0%, +10%	Created for this experiment
	Fare	-30%, 0%, +20%	(Vrtic et al. 2009)
Bicycle	Travel Time	-15%, 0%, +15%	Created for this experiment
	Dedicated Bicycle Infrastructure	0%, 20%, 40%, 60%, 80%, 100%	Created for this experiment
	Bicycle Parking	Yes, No	(Abraham et al. 2002)
	Showers	Yes, No	(Abraham et al. 2002)

3.5.2. Model Specification

Once the alternatives, attributes and attribute levels to be included in the choice experiment were determined, it was possible to specify the model. The modelling framework that was used for this research project was a discrete choice analysis. This was selected because data was gathered using a stated choice experiment, which asks respondents to choose between three discrete alternatives. In making his or her choice, each respondent is assumed to maximize their personal utility and select the mode alternative that provides the highest utility. The utility function is comprised of a deterministic and a random component. The deterministic portion of the utility function can be described as a vector of preference parameters, and a vector of alternative attributes and personal characteristics of the decision maker. The assumed distribution of random component sets the structure of the model and the form of the choice situation. This analysis utilized a multinomial logit (MNL) model, which assumes that the error components of the utility function are independently distributed type one extreme values. The MNL model is the most commonly used model and has many advantages including its simple and straightforward specification. Although it may be beneficial to make use of more sophisticated and complex models in future work done with this methodology, the MNL model made it possible to evaluate the experimental design without adding unwanted complexity. Moreover, the MNL model may indeed be most suitable for this project because none of the alternatives are deemed to be significantly correlated.

As discussed in Section 2.2, a utility function is composed of a systematic component, which is a linear additive equation containing the factors of influence and a weighting parameter, as well as an error component. The utility functions used in this choice experiment are formed as follows:

Equation 3.5.1:

$$U_{car} = V_{car} + \varepsilon_{car}$$

$$U_{PuT} = V_{PuT} + \varepsilon_{PuT}$$

$$U_{bike} = V_{bike} + \varepsilon_{bike}$$

As also described in Section 2.2, the assumptions are made about the distribution of the error component over a given population. In order to fulfil the Independence-from-Irrelevant-Alternatives (IIA) axiom, the distribution of all error terms defined in the choice model must be identical. In this case, as a multinomial logit model has been selected, an EV1 distribution forms the basis of the choice model. By making such assumptions about the error component, it is possible to focus on the systematic component of the utility function. The systematic portions of the three equations can be expanded to include the attributes and their weighting parameters, as shown below.

Equation 3.5.2:

$$V_{car} = \beta_{0car} + \beta_{1car} * car\ travel\ time + \beta_{2car} * parking\ fee + \beta_{3car} * travel\ cost$$

$$V_{PuT} = \beta_{0PuT} + \beta_{1PuT} * access\ time + \beta_{2PuT} * PuT\ travel\ time + \beta_{3PuT} * fare$$

$$V_{bike} = \beta_{1bike} * bicycle\ travel\ time + \beta_{2bike} * infrastructure + \beta_{3bike} * parking$$

3.5.1. Using Revealed Data to Create the Stated Choice Experiment

An individualized stated choice situation was generated for each of the respondents by selecting one of the reported trips in the time-use-travel diary. The trip was selected based on the mode of transport used and the length of the trip. Research in Germany has estimated that the mean maximum radius for non-motorized transport, which is usually defined by bicycle use, is 4.6 km (Kuhnimhof, Chlond & Huang 2010). While the average person will select a motorized mode of transport for trips reaching outside this radius, active modes of transportation are a viable option within this radius. For this reason, reported trips that were less than 4.6 km were selected with first priority for analysis. However, if a respondent did not report a trip less than 4.6 km in their time-use-travel diary, trips of all lengths were included as second priority. The length of the trip was estimated using the origin and destination addresses given by the respondent and the Google Maps © direction tool. The second criterion for trip selection was the mode of transportation used by the respondent. Because of the disproportionate number of bicycle trips reported in the time-use-travel diaries, trips made by car were selected with first priority, followed by those made by any mode of public transportation, and finally by those made by bicycle. If a respondent did not make a trip using a car, bicycle or public transport, they were excluded from the stated choice experiment.

The reference values used in the pivoted experimental design were taken from the time-use-travel diaries. The coding of the time-use-travel diaries and the method used to estimate the attribute levels of the alternatives that were not used in the reported trip has been explained in Section 3.4. These values were used in conjunction with the pivoted percentage values given in Table 2 to create the choice situations for the respondents. A more detailed description of the data is found in Table 3.

3.5.1. Segmentation of Respondents

In order to increase the rationality of stated choice survey and to limit the choice situations to those that would yield useful statistical information, it was decided to place some restriction on the assignment of the attribute levels based on the mode the respondent reported using in the time-use-travel diary. This segmentation of respondents was implemented for two reasons. Firstly, if the respondent was presented with a choice situation that contained the alternative that they had used in their reported trip, only with an increased overall utility, it was assumed that this respondent would very likely choose this alternative again. This assumption is aligned with the notion of utility balance, which dictates that a choice situation in a stated choice experiment should contain alternatives with relatively comparable overall utilities. If the respondent revealed a preference for one of the alternatives, the theory of rational behaviour stipulates that this alternative held the most utility for that respondent. By further increasing the utility of this alternative, the likelihood that the decision maker would choose another alternative is theoretically nonexistent, unless the utility of the other alternatives is drastically increased. For this reason, the attributes with pivoted values were restricted based on the mode used in the time-use-travel diary. For the alternative that was used in the diary, only pivoted attribute levels that maintained or decreased the overall utility of that alternative were included. This methodology was also applied to the parking fee attribute that describes the car alternative. The higher parking fee attribute levels, namely 2.00 € and 5.00 €, were included for the car user segment and the lower two attribute levels, 0.00 € and 2.00 €, were included for the bicycle and public transportation users. This was done in an attempt to maintain a near utility balance in the choice situations. The second benefit of segmenting the respondents by reported mode was the subsequent reduction in the D-error of the experimental design. This reduction in D-error was the result of a decrease in the number of attribute levels included for each of the attributes. It was also thought that the segmentation of the respondents would lead to lower standard deviations in the attribute levels used in the experimental design, but as shown in Table 4 this was not the case. However, this is likely in part due to the small sample size, and it is assumed that if a large, representative sample was collected, the standard deviation of the attributes would be smaller for a segmented sample than for the entire sample.

Table 3 gives the distribution of the attribute levels according to the segmentation of the sample, based on the mode reported in the time-use-travel diary. Table 4 provides information about the attributes and attribute levels included in the stated choice experiment. The attribute levels that contain a – or + sign are pivoted attributes. Those that do not contain either sign are not pivoted attributes.

Table 3: Attribute levels based on mode reported in time-use-travel diary

		Car	***Public Transport***	***Bicycle***
Alternative	**Attribute**	**Attribute Levels**		
Car	Travel Time	±0%, +25%	-10%, ±0%	-10%, ±0%
	Parking Fee	2 €, 5 €	0 €, 2 €	0 €, 2 €
	Total Cost	±0%, +40%	-5%, ±0%	-5%, ±0%
Public Transportation	Access Time	-15%, ±0%	±0%, +30%	-15%, ±0%
	Travel Time	-20%, ±0%	+0%, ±10%	-20%, ±0%
	Fare	-30%, ±0%	±0%, 20%	-30%, ±0%
Bicycle	Travel Time	-15%, ±0%	-15%, ±0%	±0%, 15%
	Percentage of Bicycle Infrastructure	0%, 20%, 40%, 60%, 80%, 100%		
	Bicycle Parking	Yes, No		

Table 4: Statistics of the attributes included in the stated choice experiment

	Alternative	Attribute	Minimum	Mean	Maximum	Std. Deviation
Bicycle Segment (n=144)	Car	Travel Time (min)	3.000	8.938	19.000	4.000
		Parking Fee (€)	0.000	1.000	2.000	1.003
		All-inclusive Cost (€)	0.554	2.467	5.565	1.396
	Public Transport	Access Time (min)	4.000	11.958	24.000	4.799
		Ride Time (min)	1.000	9.146	26.000	5.531
		Fare	0.800	1.998	5.000	0.751
	Bicycle	Travel Time (min)	5.000	19.771	46.000	9.632
		Infrastructure	0.000	0.500	1.000	0.343
		Secure Parking	0.000	0.500	1.000	0.502
Public Transportation Segment (n=78)	Car	Travel Time (min)	3.000	11.577	22.000	5.514
		Parking Fee (€)	0.000	1.000	2.000	1.006
		All-inclusive Cost (€)	0.554	3.077	6.572	1.762
	Public Transport	Access Time (min)	1.000	11.846	31.000	9.009
		Ride Time (min)	2.000	15.692	28.000	7.603
		Fare	1.200	2.638	3.000	0.459
	Bicycle	Travel Time (min)	6.000	26.038	60.000	15.797
		Infrastructure	0.000	0.500	1.000	0.344
		Secure Parking	0.000	0.500	1.000	0.503
Car Segment (n=30)	Car	Travel Time (min)	6.000	16.400	31.000	8.165
		Parking Fee (€)	2.000	3.500	5.000	1.526
		All-inclusive Cost (€)	0.477	5.520	15.359	4.936
	Public Transport	Access Time (min)	2.000	8.700	16.000	5.305
		Ride Time (min)	2.000	16.400	37.000	12.582
		Fare	0.800	1.880	5.000	1.351
	Bicycle	Travel Time (min)	4.000	40.700	100.000	34.861
		Infrastructure	0.000	0.500	1.000	0.347
		Secure Parking	0.000	0.500	1.000	0.509
Entire Sample (n=252)	Car	Travel Time (min)	3.000	10.643	31.000	5.661
		Parking Fee (€)	0.000	1.298	5.000	1.346
		All-inclusive Cost (€)	0.477	3.019	15.359	2.409
	Public Transport	Access Time (min)	1.000	11.536	31.000	6.509
		Ride Time (min)	1.000	12.036	37.000	8.042
		Fare	0.800	2.182	5.000	0.832
	Bicycle	Travel Time (min)	4.000	24.202	100.000	17.739
		Infrastructure	0.000	0.500	1.000	0.342
		Secure Parking	0.000	0.500	1.000	0.501

3.5.2. Experimental Design

Once the alternatives, attributes and attribute levels were defined and the model specification was decided upon, it was possible to continue with the experimental design of the choice experiment. Before the design was begun, the theory of stated choice experimental design was thoroughly reviewed and a comprehensive overview is presented in Section 2.3. After reviewing the classes of design that are available for stated choice experiments, an efficient design was selected because of the statistical advantages characteristic of this design class. It is arguable that when estimates of the β parameters of the utility functions are available, an efficient design will always be statistically superior to an orthogonal fractional factorial design, even if these estimates are only the sign of the parameter (ChoiceMetrics 2011). Because all of the β parameters included in the utility functions specified for this model (Equation 3.5.2) could either be roughly estimated from the results of previous experiments, or could be derived from these results, an efficient design was selected. Efficient designs are particularly well suited for experiments that incorporate pivoting attribute levels. The advantage of using efficient designs over orthogonal fractional factorial designs in experiments with pivoted attribute levels is the propensity for utility balance among the alternatives in a choice situation. This tendency toward utility balance is important because of the large range of attribute values taken from the revealed preference data. Indeed, efficient designs are the only type of experimental design that are recommended for pivoted attribute experiments by the authors of the Ngene user manual (ChoiceMetrics 2011, pp. 157-169). In a comparison of design methods that were applied to stated choice experiments built from revealed preference data, Rose et al. (2008, p. 402) noted that "overall, the orthogonal design performed very poorly when applied to the empirical data set".

In order to use an efficient design for this experiment, it was necessary to identify β parameters in previous studies that could be used as base $\tilde{\beta}$ estimates. An attempt was made to locate studies undertaken in or near Germany to account for differences in transportation behaviour between different countries. However, it was not possible to locate European literature that quantitatively investigated the β parameters for all of the attributes. In these cases, β parameters from other counties (namely Chile and Canada) were used. The use of these parameters is justified by the fact that only rough estimates are required for the efficient design (particularly if a Bayesian method is employed).Although the β constants used in the car and public transportation alternative utility functions have been included for completeness, the Ngene user manual states that due to the large standard deviations characteristic of constants, such values should not be included in the D-error calculation (ChoiceMetrics 2011, p. 92). Estimates of the β parameter for each attribute, the literature source they were adopted from and any notes concerning the use of the β parameters have been included in Tables 5, 6 and 7.

Table 5: Estimates of the β parameter values used for the car alternative in the experimental design

β parameter	Source	Notes
Car constant: $\beta_{0car} = 0.214$ utils	Vrtic et al. 2009	This constant was included in an experiment that analysed mode choice between the car and public transportation in Switzerland. Because of the proximity of Germany to Switzerland and the similarities in transportation behaviour in the two counties, this parameter can be used with some confidence.
Car travel time: $\beta_{1car} = -0.038$ utils/minute	Vrtic et al. 2009	The β parameter calculated by the Vrtic et al. (2009) model was given per hour. This value was converted to utils/minute in order to be compatible with the travel times used in this experimental design.
Parking fee: $\beta_{2car} = -0.251$ utils/Euro	Vrtic et al. 2009	The β parameter estimated by Vrtic et at. (2009) was given in Swiss Francs. It was converted to a Euro estimate using a conversion rate of 0.83 Euro/CHF. The conversion rate was taken from www.xe.com on August 12, 2011.
All-inclusive travel cost: $\beta_{3car} = -0.097$ utils/Euro	Vrtic et al. 2009	The attribute included in the study done by Vrtic et al. concerned fuel price and not an all-inclusive travel cost including other sources of cost such as depreciation, repair and maintenance. As such, this value is not intended to be an accurate estimation, only a reference value for use in the efficient design of the choice situation. Because the value is not highly accurate, some efficiency will be lost from the design. However, because this is only a trial version of the stated choice experiment, the results of the survey can be used to calculate a better estimate for the β parameter. This in turn can be used in subsequent runs of this survey design. The β parameter estimated by Vrtic et at. (2009) was given in Swiss Francs. It was converted to a Euro estimate using a conversion rate of 0.83 Euro/CHF. The conversion rate was taken from www.xe.com on August 12, 2011.

Table 6: Estimates of the β parameter values used for the public transportation alternative in the experimental design

β parameter	Source	Notes
Public transportation constant: $\beta_{0PuT} = -2.088 \text{ utils}$	Ortúzar, Iacobelli & Valeze 2000	No public transportation mode constant β parameter was found in the literature review for research that was done in Germany or countries exhibiting similar transportation behaviour. The parameter calculated by Ortuzar, Iacobelli and Valeze (2000) is likely too large (in absolute value) to properly represent the situation in Germany. This likely reduces the efficiency of the stated choice experimental design. However, it provides a useful starting point and can be improved upon by estimating the β parameter from the data collected in the course of this project.
Access time: $\beta_{1PuT} = -0.043$ utils/minute	Vrtic et al. 2009	The β parameter estimated by the Vrtic et al. (2009) model was given per hour (-2.608 utils/hour). This value was converted to utils/minute in order to be compatible with the travel times used in this experimental design.
Public transportation ride time: $\beta_{2PuT} = -0.032$ utils/minute	Vrtic et al. 2009	The β parameter estimated by the Vrtic et al. (2009) model was given per hour (-1.897 utils/hour). This value was converted to utils/minute in order to be compatible with the travel times used in this experimental design.
Fare: $\beta_{3PuT} = -0.116$ utils/Euro	Vrtic et al. 2009	The β parameter estimated by Vrtic et at. (2009) was given in Swiss Francs (-0.097 utils/CHF). It was converted to a Euro estimate using a conversion rate of 0.83 Euro/CHF. The conversion rate was taken from www.xe.com on August 12, 2011.

Table 7: Estimates of the β parameter values used for the public transportation alternative in the experimental design

Bicycle travel time: $\beta_{1bike} = -0.039$ utils/minute	Ortúzar, Iacobelli & Valeze 2000	There were no European studies found that estimated the utility value of a minute spent bicycling. Although a number of studies done in North America estimated the β parameters for riding on different types of bicycle facilities, the value estimated by Ortúzar, Iacobelli and Valeze (2000) was selected because it was the only study that investigated bicycling in a mode choice context. However, because the transportation behaviour in Chile is quite different compared to Germany, this value is very likely inaccurate, introducing a level of error into the experimental design. The sign of the parameter is likely correct (as all travel times should be negatively weighted), which meets the minimum criteria for a D_b-error estimation.
Bicycle infrastructure: $\beta_{2bike} = 0.300$ utils/ portion (decimal between 0-1) of the trip on bicycle infrastructure	Hunt and Abraham 2001	The β parameter for this attribute was not directly available in the literature, and thus had to be derived from related values that were estimated by Hunt and Abraham (2001). The findings of this study revealed that cyclists value time spent on bicycle paths and bicycle lanes at an average of -0.0165 utils/minute and time spent on a road at -0.0551 utils/minute. A ratio of the two values gives a relative value of bicycle infrastructure compared to riding with mixed traffic: $\frac{Time\ on\ bicycle\ infrastructure}{Time\ with\ mixed\ traffic} = \frac{-0.0165\ utils/minute}{-0.0551\ utils/minute} = 0.300$ The resulting value was used as a β parameter to describe the value of an entire trip being made on infrastructure dedicated to bicycles. A linear relationship was assumed between the percentage of the trip that took place on bicycle infrastructure and the amount of utility gained from that percentage. The $infrastructure$ (or x component of the V_{bike} equation) was then input as a decimal value between 0 and 1.
Bicycle parking: $\beta_{3bike} = 1.459$ utils/ bicycle availability	Hunt and Abraham 2001	The β parameter for the availability of secure bicycle parking was adopted from a very similar attribute implemented by Hunt and Abraham (2001) in Canada.

Although the advantages of using efficient designs for experiments with pivoted attribute levels are well known, the incorporation of pivoted attribute levels based on revealed preference data are unfortunately not completely supported by the current methods of generating choice experiments (Rose et al. 2008). For this reason, the experimental design was created using a combination of Excel and Ngene. Once the attributes, attribute levels and segmentation were decided upon, it was possible to create an Excel file that combined the reference value data and the pivot level information to create the choice situations. Firstly, a matrix was set up containing the reference scenario for all the respondents. These values were either taken directly from the time-use-travel diary or were estimated using the origin and destination location (using the method described in Table 1). The attribute levels for the non-pivoting attributes (parking fee, dedicated bicycle infrastructure and bicycle parking) and the pivot percentages for the pivoting attributes (all other attributes) were input into a second matrix. The matrices were then combined to create a single matrix containing the attribute level values for all the respondents. These values were then taken in combination with the estimated β parameters to create the code input into Ngene to develop an efficient experimental design. The code was created following the methodology suggested in the Ngene user manual (ChoiceMetrics 2011, pp. 157-169). The Excel file that was used to create the Ngene code is included on the CD that accompanies this thesis report (file: Ngene code builder.xlsx).

In order to create individualized choice situations for all of the respondents, it was necessary to utilize a method for building choice sets with different reference values and hence different attribute levels into the same experimental design. This can be done using Ngene in two ways. According to ChoiceMetrics (2011), the first method, known as a homogeneous pivot design, generates a single design that can be used for all respondents while applying their different attribute level values. The second method, heterogeneous pivot design, generates a new experimental design for each of the respondents based on the notion that different segments face different reference alternatives (ChoiceMetrics 2011). For both types of pivot design, a fisher information matrix (or the determinant of the AVC matrix) must be specified along with the weight given to each data segment. A combination of both types of pivot design is also possible and was implemented in this experimental design. The respondents were grouped into three segments; those who used the car for their reported trip, those who used a bicycle and those who used public transportation. A heterogeneous pivot design was built to account for the fact that these segments selected different reference modes. In addition, the different segments were faced with different attribute levels, as shown in Table 3, and as such could not be included in a homogeneous design. However, within each of the segments, a homogeneous pivot design was used because the respondents did not face different reference alternatives. Each of the respondents was given the same weighting in the fisher information matrix. The resulting form of the fisher matrix is shown in Equation 3.5.3.

Equation 3.5.3:

homogeneous pivot design

$$
\begin{aligned}
;fisher(choice) \\
&= car\left(driver1\left[{}^{1}/_{N}\right], driver2\left[{}^{1}/_{N}\right] \ldots\right) \\
&+ PuT\left(transit1\left[{}^{1}/_{N}\right], transit2\left[{}^{1}/_{N}\right] \ldots\right) \\
&+ \ bicycle(cyclist1\left[{}^{1}/_{N}\right], cyclist2[{}^{1}/_{N}] \ldots)
\end{aligned}
\Bigg\} \text{Heterogeneous pivot design}
$$

Where car, PuT and $bicycle$ = heterogeneous pivot designs

$driver1{,}2, transit1{,}2,$ and $cyclist1{,}2$ = homogenous pivot design

N = total number of segments (respondents in this case)

Note: the homogeneous portions of the fisher information matrix were extended to include all of the respondents belonging to each of the segments.

The literature that was reviewed did not offer an explicit recommendation as to the number of choice situations that should be included in a choice set for one respondent. However, the previous experiments that were reviewed tended to include between two and 12 choice situations, depending on the complexity of the choice task. The choice situation that is presented to the respondents in this experiment is fairly complex because it involves three alternatives as opposed to two. Each of the alternatives is described by a relatively large number of attributes, which further complicates the decision making process. However, as the choice situations were built from a trip described by the respondent in their time-use-travel diary, the respondent did not have to put a great deal of effort into imagining the situation. In consideration of these factors, a subjective decision was made to include six choice situations in each choice set in this experimental design.

The outline of the Ngene code used to create the heterogeneous/homogeneous experimental design is shown and briefly explained in Figure 4. A complete Ngene code has been included in Appendix J of this report.

Figure 4: Structure of the Ngene code used to construct the experimental design

```
Design
;alts(n) = car, put, bike
.....
;alts(N) = car, put, bike
```
} Definition of the alternatives for each segmentation

```
;rows = 6
```
→ Number of choice situation in a choice set

```
;eff = choice(mnl,d)
```
→ Efficient design based on an MNL model and optimized based on the D-error

```
;fisher(choice) = car (c[1/N], ... C[1/N] ) + put (p[1/I], ... P[1/I]) + bike (b[1/I], ... B[1/I])
```

```
;model(c):
;model(p):
;model(b):
.......
;model(C):
;model(P):
;model(B):
```
} Utility functions with β parameter estimates and attribute levels calculated using the Excel code generator

Where: n = number of segments/respondents

Using the pivoted attribute levels and the code structure outlined in Figure 4, a D-error of 0.569 was derived after 20,000 iterations of swapping. This value is approximately three times larger than the value obtained in the homogeneous example given in the Ngene manual (ChoiceMetrics 2011, p. 165) and seven times larger than the heterogeneous example (ChoiceMetrics 2011, p. 167). However because some of the β parameters used in the experimental design were not deemed to be particularly accurate, this D-error was subjectively accepted and the output was used to create the choice sets. If this experimental design is reused, new β parameters should be estimated using the results of this pre-test. The experimental designs shown in Table 8, 9 and 10 were produced by using the Ngene code structure shown above.

Table 8: Experimental design for the car segment

Choice Situation	Car Attributes			Public Transport Attribute			Bicycle Attributes		
	Travel Time	Parking Fee	Travel Cost	Access Time	Travel Time	Fare	Travel Time	% Bicycle Infra.	Secure Parking
1	0%	2.00 €	+40%	-15%	-20%	0%	0%	40%	1
2	+25%	5.00 €	0%	-15%	-20%	-30%	0%	100%	0
3	+25%	2.00 €	0%	0%	-20%	-30%	0%	60%	1
4	0%	2.00 €	+40%	0%	0%	0%	-15%	20%	1
5	0%	5.00 €	+40%	0%	0%	-30%	-15%	80%	0
6	+25%	5.00 €	0%	-15%	0%	0%	-15%	0%	0

Table 9: Experimental design for the public transportation segment

Choice Situation	Car Attributes			Public Transport Attribute			Bicycle Attributes		
	Travel Time	Parking Fee	Travel Cost	Access Time	Travel Time	Fare	Travel Time	% Bicycle Infra.	Secure Parking
1	-10%	0.00 €	-5%	0%	0%	20%	0%	0%	1
2	0%	0.00 €	-5%	+30%	+10%	0%	-15%	40%	1
3	-10%	2.00 €	0%	0%	0%	20%	0%	80%	0
4	0%	2.00 €	0%	+30%	0%	0%	-15%	20%	0
5	-10%	2.00 €	-5%	+30%	+10%	0%	-15%	100%	0
6	0%	0.00 €	0%	0%	+10%	20%	0%	60%	1

Table 10: Experimental design for the bicycle segment

Choice Situation	Car Attributes			Public Transport Attribute			Bicycle Attributes		
	Travel Time	Parking Fee	Travel Cost	Access Time	Travel Time	Fare	Travel Time	% Bicycle Infra.	Secure Parking
1	0%	0.00 €	0%	-15%	-20%	0%	0%	20%	0
2	-10%	2.00 €	-5%	0%	0%	-30%	+15%	60%	1
3	0%	0.00 €	-5%	0%	0%	0%	0%	80%	1
4	-10%	2.00 €	0%	-15%	-20%	-30%	+15%	0%	0
5	-10%	2.00 €	-5%	0%	-20%	-30%	+15%	40%	1
6	0%	0.00 €	0%	-15%	0%	0%	0%	100%	0

The complete experimental design is included in Appendix I.

The output from Ngene was copied into Excel to construct the survey instruments. In order to prevent any influence of the order of the choice situations on the outcome of the decision makers, it is recommended by Hensher, Rose and Greene (2005) to randomize the choice sets before they are distributed to the respondents. This was done using the program Excel after the experimental design had been compiled using Ngene. Each of the choice situations in the choice sets was assigned a random number. The choice sets were then autonomously ordered by this random number (in ascending value).

The survey instrument itself was then designed in Excel. An introduction graphic (.jpeg file) was created for each of the respondents to remind them of the trip they reported in their time-use-travel diary. Six graphics (.jpeg files) were constructed to describe the choice situations in the choice set for each of the respondents. An example of an introduction graphic and a choice situation that was presented to one of the respondents is given in Figure 5 and Figure 6 respectively. The graphics were each uploaded onto the online survey instrument, Unipark. An internal referencing system was used to direct each respondent to their individualized choice set during the online questionnaire. A full choice situation, as presented to one respondent, can be found in Appendix D. An English translation of the example graphic and the choice situation can be found in Appendix F. The experimental design for all respondents in tabular form can be found in Appendix I.

Figure 5: Example of an introduction page containing an introduction graphic

Entscheidungssituationen zum Verkehrsmittel

Ihnen werden nun sechs Entscheidungssituationen vorgestellt. Jede der Situationen beschreibt eine Fahrt, die Sie in Ihr Tagebuch eingetragen haben. **Startpunkt, Zielort und Zweck der Fahrt sind identisch zur tatsächlichen Fahrt**.

Bitte erinnern Sie sich an den folgenden Weg, den Sie in Ihrem Tagebuch festgehalten haben.

Von: Deisenhofener Straße 44
Nach: Maria Theresia Straße 21
Zweck: Erreichen des Arbeitsplatzes

Ihnen stehen folgende Verkehrsmittel zur Auswahl

Auto		Öffentliche Verkehrsmittel		Fahrrad	
Gesamtzeit Autofahren	12 min	Gesamtreisezeit	26 min	Gesamtzeit Radfahren	20 min
Parkgebühren	?	davon Gehzeit	15 min		
Fahrtkosten	2,65 €	davon Fahrzeit	11 min		
		Fahrpreis	2,50 €		

Sie haben ein Fahrrad als Verkehrsmittel für diesen Weg benutzt.

Stellen Sie sich vor mehrere Faktoren im Verkehrssystem haben sich verändert:

- Das allgemeine Straßennetz (Einfluss auf Fahrzeit mit dem Auto)
- Parkgebühren am Zielort
- Die Gesamtfahrtkosten (durch Änderungen von Kraftstoffpreisen, Versicherungsgebühren und Steuern)
- Das öffentliche Verkehrsnetz (Einfluss auf Gehzeiten, Fahrzeiten sowie Preise für Fahrkarten)
- Die Verfügbarkeit von Radwegen sowie die Trennung von Radwegen und Autoverkehr
- Veränderte Fahrzeiten für Radfahrer (Beispielsweise durch Öffnung von Einbahnstraßen für Radfahrer oder der grünen Welle für Radfahrer)

Nun müssen Sie Ihre Verkehrsmittelwahl überdenken. In den folgenden sechs Situationen müssen Sie sich zwischen dem Auto, den öffentlichen Verkehrsmitteln und dem Fahrrad entscheiden. Bitte schauen Sie sich die Besonderheiten jeder Option genau an und wählen Si diejenige Option, für die Sie sich auch in der Realität entscheiden würden. Bitte berücksichtigen Sie, dass **die sechs Entscheidungen unabhängig voneinander sind** und **an unterschiedlichen Tagen stattfinden**. Daher können Sie das Verkehrsmittel unabhängi von den anderen drei Situationen wählen.

i Bitte klicken Sie hier für mehr Informationen

Figure 6: Example of a choice situation as presented to a respondent

SZENARIO 1: Ihnen stehen folgende Verkehrsmittel zur Auswahl

Auto		
Gesamtzeit Autofahren		12 min
Gesamtkosten		2,65 €
davon	Parkgebühren	0,00 €
	Fahrtkosten	2,65 €

Öffentliche Verkehrsmittel		
Gesamtreisezeit		22 min
davon	Gehzeit	13 min
	Fahrzeit	9 min
Fahrpreis		2,50 €

Fahrrad		
Gesamtzeit Radfahren		20 min
davon	auf abgetrennten Fahrradwegen	4 min
	mit Autoverkehr gemischt	16 min
Verfügbarkeit von sicheren Parkplätze am Zielort		Nein

Bitte klicken Sie auf die Informationssymbole für mehr Informationen über die jeweiligen Möglichkeiten.

Welches Verkehrsmittel würden Sie in dieser Situation wählen?

○ Auto ○ Öffentliche Verkehrsmittel ○ Fahrrad

3.6. Personal Survey

A personal survey was distributed in addition to the time-use-travel diary and the stated choice experiment to collect socio-economic information from the respondents. It was necessary to collect this information because according to the theory of discrete choice, the utility of an alternative is defined by both the socio-economic characteristics of the decision maker and the choice task factors (or the alternatives and attributes of those alternatives) (Hensher & Greene 2003). It was not possible to collect information on a household level for this project because the survey was distributed to individual people rather than entire households. There were only a couple of cases where all members of a household responded to the survey.

The questions in the personal questionnaire were adapted from personal and household questionnaires that were written and distributed by the Mobilität in Deutschland, which is a country-wide transportation research project carried out in Germany (Mobilität in Deutschland 2010). Socio-economic information collected in the personal questionnaire included age, gender, income, level of education, current employment status, and the current living situation (alone, with a partner or children, etc.). Information concerning personal transportation behaviour was also collected including: the frequency of car, public transportation and bicycle use, the walking time from the household to the nearest bus, tram and U-Bahn / S-Bahn / regional train station, the type of public transportation ticket used most frequently, the ownership of a bicycle, the number of cars in the household, the size of the car if there was a car in the household, and availability of that car to the respondent, the reason for not owning a car if there was no car in the household, and the possession of a valid driver’s licence. An additional question was included that enquired about the importance of safety, comfort, convenience, flexibility and environmental impact on the mode choice decision. The complete survey as distributed to the respondents (in German) can be found in Appendix D. An English translation of the survey has been included in Appendix E.

The personal questionnaire was distributed online with the stated choice experiment rather than as a paper and pencil survey with the time-use-travel diary. This decision was made in an attempt to reduce the workload of the respondents, save paper and capitalize on automatic coding. The only drawback of this decision was that no personal information was collected from respondents who filled out a time-use-travel diary but failed to complete the second portion of the survey. The online personal survey was developed using the online survey program Unipark (Globalpark AG 2011).

3.7. Stated Choice and Personal Questionnaire Distribution

The personal questionnaire and the stated choice experiment were distributed to the respondents as a single online survey. An online survey instrument, Unipark, was used to construct and distribute the personal questionnaire and the stated choice experiment. The personal questionnaire questions were created using the various pre-programmed question formats that are offered by Unipark. The stated choice information page and the choice situations were constructed using the user defined question format. An html code was written to display a .jpeg file. As described in Section 3.5, each of the choice situations were formatted in Excel and were saved individually as .jpeg files. These .jpeg files were then uploaded into the Unipark media folder according to the respondent ID. A total of 301 .jpeg files were created and uploaded into the Unipark media folder. The html code written for stated choice information and choice situations incorporated a dynamic element, known as a wildcard in Unipark, to select the appropriate .jpeg file based on the respondent ID.

Using Unipark, it is possible to create and distribute surveys to a predetermined sample of people. As the stated choice experiments were individualized for the respondents, it was important to make use of this feature for this survey. The respondents name and email, documented on the time-use-travel diary by the respondent, was used to create individual respondent profiles in Unipark. A respondent ID, or group number in Unipark, was assigned to each respondent so that the choice sets could be organized. This information also made it possible to email a link to the survey and a password for accessing the survey to the respondents.

Using Unipark, a link to the online survey and a password was emailed automatically to the 48 people who had returned a time-use-travel diary on September 23rd, 2011. A link containing only the personal questionnaire was sent to the five respondents who did not submit enough information or did not make any trips long enough to construct a choice experiment. A reminder email was sent to the 12 participants who had not yet completed the survey on October 10th, 2011.

4. RESULTS

The following section summarizes the results of the time-use-travel diary and the stated choice experiment. A selection of descriptive analysis of the data collected is also provided. However, as the objective of the thesis is to provide a qualitative assessment of the survey instruments, an in depth descriptive or inferential statistical analysis is not undertaken.

4.1. Response to the Survey

A total of 97 time-use-travel packages were distributed to potential survey participants. However, of these 97 packages, only 56 were distributed to people who had agreed to take part in the survey before receiving a survey package. The rest of the packages were given to the family, friends and colleagues of the seven survey respondents who had agreed to further distribute survey packages. A total of 48 time-use-travel diaries were completed and returned by mail, accounting for a 49% return rate for the first phase of the survey process for all survey packages that were prepared[10]. However, when considering that only 56 people agreed to participate before they were given a survey package (44 people originally and 12 people in the following weeks), the response rate increases to 86%.

Of the 48 people who returned a time-use-travel diary, 5 people failed to include addresses for their activities. Individualized stated choice experiments were created for the remaining 43 respondent. Of those 43 respondents, 40 completed the online personal questionnaire and stated choice experiment, accounting for a second phase response rate of 93% for the people who correctly filled out the time-use-travel diary. Although a stated choice experiment could not be created for the people who did not correctly fill out their time-use-travel diary, these five people were still sent a personal questionnaire online. Of these five people, four completed the online survey.

[10] This figure excludes the response rate of the survey invitation letters that were sent to the 500 purchased addresses and the emails that were sent to friends and family of the research team.

4.2. Time-Use-Travel Diary Results

The time-use-travel diaries were analysed to provide an overview of the trips recorded by the respondents. Of the 48 people who returned time-use-travel diaries, 45 diaries could be coded. The three diaries that could not be coded did not contain any origin and destination information. Two diaries contained all the necessary information for coding but consisted only of walking trips. As mentioned in Section 3.5, walking trips were not included in the stated choice experiment because the length of these trips is usually too short to compete with the car or public transportation. They were, however, included in the analysis of the time-use-travel diaries. A total of 227 trips were reported in the 45 valid time-use-travel diaries. However, trips were omitted from analysis if the respondent did not spend at least one minute at a destination. These trips were omitted because they were made for another reason other than utilitarian travel and would likely not be substituted with another mode of transportation. A total of 224 utilitarian trips remained in the dataset. Table 11 provides a statistical summary of the data collected in the time-use-travel diaries.

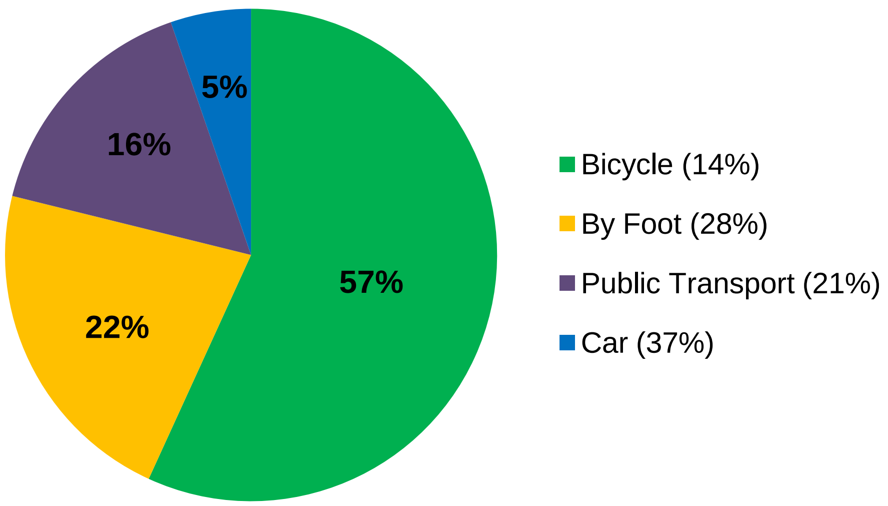
The mode of transportation reported by the respondent is important to consider because the respondents were segmented based on this factor. More than half of the trips reported by respondents in their time use travel diaries were made using a bicycle. The mode of transportation used for the reported trips is shown in Figure 7. The actual modal splits of the four modes estimated in 2010 by the City of Munich (Landeshauptstadt München 2010) are bracketed after the mode label. The proportion of reported trips made by bicycle in this survey is considerably higher than the 14% of trips that are made by bicycle in Munich according to the City of Munich (Landeshauptstadt München 2010). This is likely due to the fact that the survey was advertised as focusing on bicycling in Munich, and as such, respondents who are particularity interested and active in bicycling were likely more inclined to participate in the survey.

Table 11: Summary of trips reported by respondents

Segment	Factor	Min.	Mean	Max.	Std. Deviation
All respondents (n=224)	Reported trips	2.000	4.870	9.000	1.733
	Reported tours	1.000	1.522	3.000	0.586
Car trips (n=12)	Car travel time (min)	5.000	15.000	40.000	12.247
	Activity duration (hh:mm)	0:05	5:05	12:05	5:12
	Enjoyment (1-5, 5 being very enjoyable)	1.000	3.167	5.000	1.115
Public transportation trips (n=35)	Travel time*[11] (min)	10.000	31.886	70.000	12.813
	Activity duration (hh:mm)	0:05	4:41	15:35	4:35
	Enjoyment (1-5, 5 being very enjoyable)	2.000	3.385	5.000	1.023
Bicycle trips (n=127)	Travel time (min)	3.000	17.157	75.000	12.178
	Activity duration (hh:mm)	0:01	4:58	18:20	4:51
	Enjoyment (1-5, 5 being very enjoyable)	1.000	3.772	5.000	0.977
Walking trips (n=50)	Travel time (min)	2.000	8.580	30.000	6.289
	Activity duration (hh:mm)	0:02	2:51	14:35	3:46
	Enjoyment (1-5, 5 being very enjoyable)	1.000	3.409	5.000	0.923

[11] The majority of the respondents who reported a public transportation trip did not separate their travel time into access time and ride time. In these cases, the reported duration of the trip was coded as indicated in the time-use-travel diary. If the respondent did indicate their walking time to the station, this was added to their riding time to create a total trip duration value.

Figure 7: Mode of transportation used for reported trip



All of the respondents completed their diary on a weekday, as instructed, with five respondents filling it out on a Monday, 12 on a Tuesday, 12 on a Wednesday, 12 on a Thursday and six on a Friday. The majority of the respondent filled out their survey on a completely normal day (42 people or 87.5% of the sample). One respondent failed to return the accompanying information sheet, which provided the information pertaining to the normality of the day. The remaining five people or 10.4% of the respondents completed their survey on an unusual day. Four of these people were on vacation while filling out the survey, while one respondent had another, unspecified reason for the reporting day being unusual.

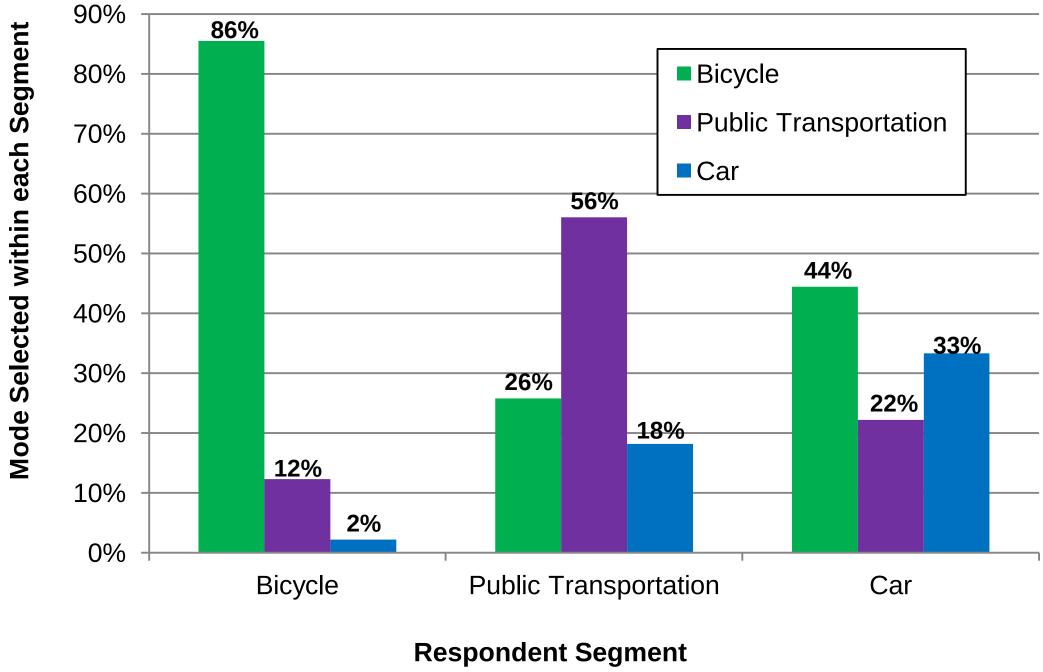
As would be expected for a survey that began in August and ended in September, the weather reported by the respondents was quite temperate. Half of the respondents (50.0%) stated that the weather was generally sunny, 28.3% indicated that there was a light cloud cover, 15.2% reported a cloudy day and 6.5% reported rain. However, there were several inconsistencies in the data collected for the weather variable. For example, nine respondents chose Thursday September 1st, 2011 as a reporting day. One respondent reported that the weather was sunny, one said there was a light cloud cover, five indicated that the weather was cloudy and two people said that it was rainy.

The respondent were asked to indicate if there was an available shower facility at each of their destinations and whether they used that facility or not. This question was included in order to determine if, and to what extent, showering facilities are available at destination locations and if cyclists use these facilities when they are available. As would be expected, showering facilities were only available to the respondents at a personal residence (home or visiting) or at work. It is thought that the 7% of respondents who indicated that no shower was available upon their return home misunderstood the question or made a mistake in filling out the diary.

4.3. Stated Choice Experiment Results

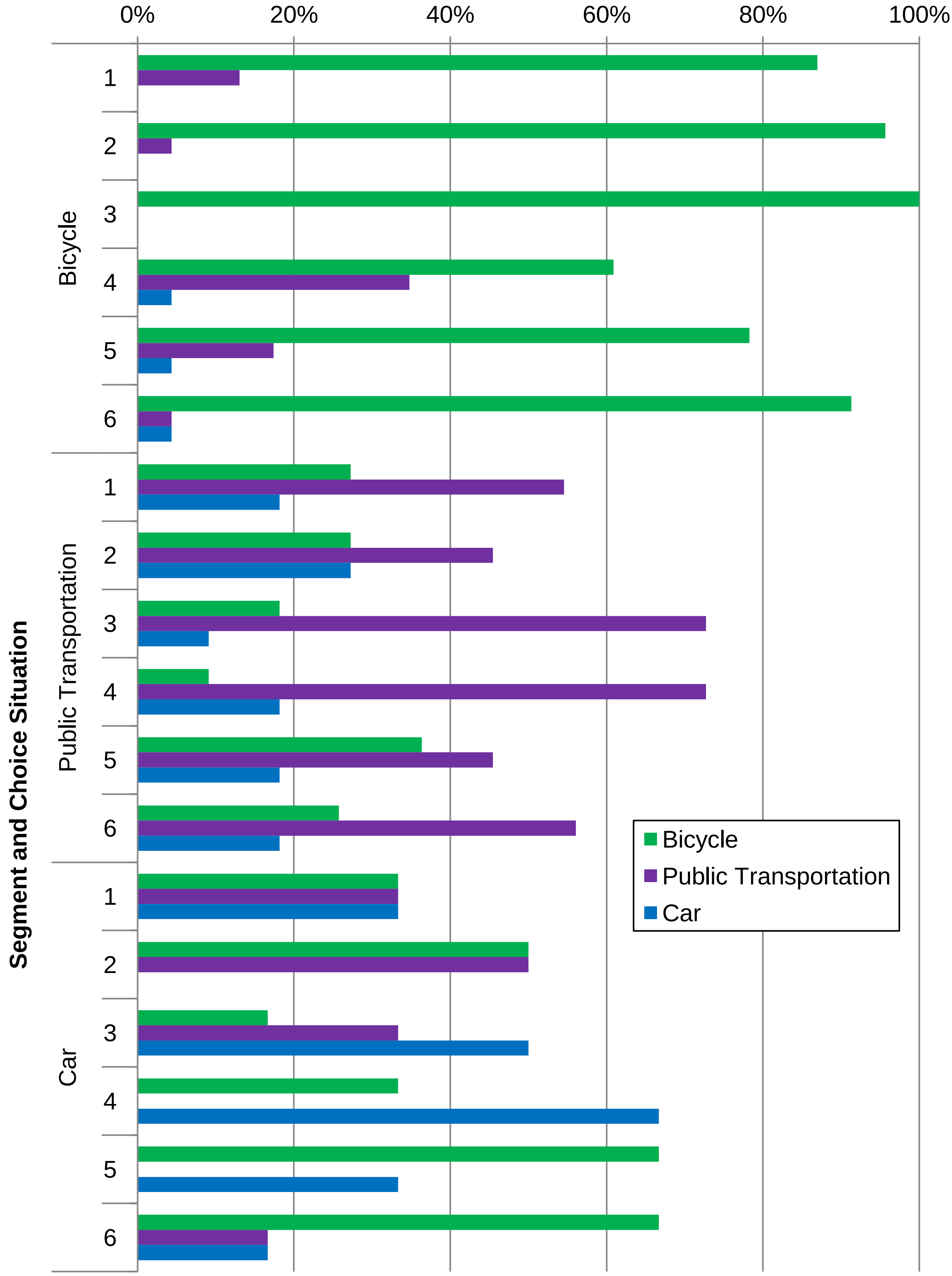
A total of 40 respondents completed the stated choice experiment, and as each choice experiment included six choice situations, choice data was collected for 240 choice situations. Of the 240 decisions that were made, 151 (62.9%) were made for the bicycle, 62 (25.8%) were made for public transport, and 27 (11.3%) were made for the car. When facing the choice situations 167 respondents (69.6%) selected the same mode as they used for their reported trip. If the respondent selected the same mode for all of the choice situations that they faced, and this selected mode was the same as the mode used in their reported trip, the respondent was asked if it would be possible for them to switch modes in any situation. Of the 40 respondents, 17 (38.6%) decided for the same mode as they used in their reported trip for all six of the choice situations. Three of the respondents, or 17.6% percent of the people who decided on the mode used in their reported trip for all six choice situations, and 7.5% of the entire sample, reported that they would not be able to change modes in any situation. All three of these captive riders had reported using a bicycle for their trip in the time-use-travel diary. This equates to a significant portion of the sample, 14 people (35%), selecting the same mode of transportation from the choices presented in all six situations of the choice set. Figure 8 shows the aggregated outcomes of the choice situations by the segment of the sample. As shown in the figure, the sample was segmented based on the mode used for their reported trip. The three segments were given slightly different choice sets to account for the assumption that a decision maker would not select a different alternative than used in their reference scenario if the attribute levels of that alternative improved (see Section 3.5). In other words, respondents in the bicycle segment only faced choice situations where the bicycle attributes were equal to or worse than the reported trip, and the car and public transportation attributes were equal to or better than the estimated attribute levels in the reference scenario. The same principle was applied to the car and public transportation segments.

Figure 8: Mode selected by the different segments of respondents



The outcomes displayed in Figure 8 indicate that the bicycle segment was very inclined to select the bicycle option in the choice situation even though there was a theoretical shift in utility to the other two options. The public transportation showed a similar inclination but to a lesser degree. The car segment was the only group that selected the two alternative modes of transportation with a higher frequency than the car. Figure 9 shows the decision outcomes based on respondent segment and choice situation.

Figure 9: Decision by respondent segment and choice situation



Although the estimation of the β parameters was not included in the scope of this thesis, Figure 9 is useful in determining the choice situations in which utility balance was achieved. According to Figure 9, a utility balance was best achieved for the car segment, particularly for choice situations 1 and 3. The utility balance for the public transportation also appears to be acceptable. However, the utility for the bicycle segment is quite unbalanced, with the bicycle dominating the choice situation in all six of the situation.

The respondents were given the opportunity to leave a comment on any of the pages the survey. Three of the respondents chose to do so and their comments have been included below:

- Die Änderungen der Fahrzeiten/Preise/Wegbeschaffung sollte man besser darstellen, sonst ist das ja auch ein Suchspiel... Außerdem ist es ein großer Unterschied ob man neben 2 Fahrspuren und Parkstreifen noch mit dem Rad unterwegs ist (Orleansstraße nördlich) oder ob da keiner parkt, 3 Spuren da sind und eine breite rot lackierte Fahrradspur existiert (Orleansstraße südlich). Das sollte man differenziert betrachten.

  (The changes in travel time/price/trip characteristics should be organized better. Otherwise it is a game of searching for the values...In addition, there is a big different travelling with a bicycle on a street with two driving lanes and a parking lane (Orleansstraße north) or if there is no parking, three lanes and a wide, red-marked bicycle lane (Orleansstraße south). This should be differentiated.)

- It's hard to beat a bike on a 2 km ride with almost no traffic, no matter how the prices or roads change

- ... die Entscheidung, ob Fahrrad oder Öffentliche Verkehrsmittel ist manchmal nicht ganz leicht gefallen, beide sind für mich recht gleichwertig / gleichberechtigt. Entscheidend ist vielmehr oft bspw die Wetterlage oder die Kleidung (mit Rock und Blazer radelt sichs nicht so gut)

  (... the choice between the bicycle and public transportation is sometimes not easy to make because they are quite equal for me. Often, the decisive factor is weather or clothing (it is not so easy to cycle in a skirt and blazer).

5. DISCUSSION

The following section consists of a discussion about the sample recruitment, the design of the time-use-travel diary and the stated choice experiment, and about the outcomes from both data collection methods. The methodology used to create an individualized stated choice experiment from reference scenarios is qualitatively analysed. The distribution and collection methods are also discussed.

5.1. Sample Recruitment

The method used to recruit participants to this research project was not particularly successful. Although the target of 50 test survey participants was nearly reached, the systematic approach of mass emailing survey invitations to colleagues, friends and family, as well as mailing survey invitations to 500 commercially purchased addresses did not yield this result. After being sent the survey invitation, many friends and family members were contacted personally or by phone and were asked directly if they would take part in the survey and if they could provide their mailing address. An overly long invitation letter, a complicated sign-up process and an inconvenient timeframe for participation are all thought to have negatively affected survey participation.

The original invitation letter, which was sent out as an email attachment to friends and family of the ‘Radverkehr heute und morgen’ research team and was posted to the 500 commercially provided addresses, was two pages long and contained very specific participation information. This version of the letter is attached in Appendix B. The length of the letter, as well as the level of detail of the information could be one reason for the low response to the invitation. It may also be a reason that the people who did respond to the invitation by email often neglected to include their mailing address in the email. Several features of the survey invitation letter were improved to encourage a larger and more representative sample of people to take part in the survey. The letter was shortened, reorganized, reformatted and simplified in an attempt to make it more manageable and less daunting for potential survey participants. The improved invitation letter (see Appendix B) is one page long, does not contain any banking information for the research department, focuses on the participation incentive and provides only the necessary details. Additionally, the excessive focus on bicycle transportation in the original invitation letter may have discouraged non-cyclists or people who bicycle infrequently from participating in the survey. In order to attract a more representative sample of respondents, the improved invitation letter presents the research project as an investigation of model choice in Munich rather than a bicycle transportation study. Non-cyclists are explicitly invited to participate in the survey.

In addition to the long, detailed formation letter, the complicated sign-up process may have exacerbated the low participation rate. Upon reading the information letter, potential survey participants were asked to send an email containing their mailing address to the email address set up for the research project. Instead of sending the invitation letter as an attachment to an email or as a hard copy, it may be preferable to put the text of the letter directly in the body of an email or to contact potential participants by phone rather than by mail. It may also be worthwhile to explore automatic means of asking people for their mailing address when they email back their intention to take part in the survey. Another possibility is to abandon the use of hard copy time-use-travel diaries in favour of digital diaries that can be filled out online. This would eliminate the need for collecting mailing addresses from the respondents and would streamline the sign-up process.

Finally, the timing of the distribution of the invitation letters and time-use-travel diaries is thought to have negatively affected the survey response rate. The summer school vacation in Bavaria took place between July 30th and September 12th, 2011, while the lecture free period at TU München took place from July 30th to October 17th, 2011. Many students and families are not in Munich during this time, and if they are in Munich, may not follow a normal schedule. If the survey was to be conducted using a larger sample of respondents, it would be preferable to carry out the survey during a time of year when there are no conflicting holidays or celebrations. In addition, it may be advantageous to conduct the survey in two or more waves at different points in the year. This would make it possible to observe differences in bicycling behaviour under different seasonal conditions (weather, scheduling difference due to holiday, etc.).

A survey hotline was made available to all participants for the entire duration of the survey (between August 22nd and October 30th, 2011). During this time, none of the participants called the hotline. This may be due to the fact that the majority of the survey participants were friends or family of the ‘Radverkehr heute und morgen’ team and could ask in person if they had any difficulty with the diary or online questionnaire. However, it may also be that the information documents provided with the time-use-travel diaries and the information buttons offered in the online questionnaire provide adequate information for the respondents and a survey hotline is not necessary.

5.2. Time-Use-Travel Diary

One of the objectives of this research project was to design and test a combined time-use-travel diary that would capitalize on the advantages of both time-use and travel diaries while avoiding the respective pitfalls of each. Although the majority of the survey respondents filled out the diary without many problems, there were some areas that seemed to cause some confusion among the respondents.

Firstly, three of the 48 respondents did not enter any locality information, or if they did, did not specify addresses, but referred to places such as ‘home’, ‘work’, ‘store’, etc.. The lack of this information made it impossible to estimate the characteristics of the alternative modes of transportation, which as a result, eliminated these three respondents from the SP portion of the survey. In order to reduce the number of respondents who failed to enter address information in a subsequent survey, the heading in the column in the diary could be changed from ‘Verkehrsmittel / Ort der Aktivität’ to ‘Verkehrsmittel / Adresse der Aktivität’ (from ‘Mode of transportation / Location of activity’ to ‘Mode of transportation / Address of activity’). It could also be more clearly stated in the instructions that the address information is critical to the analysis of the data. However, one possible reason for neglecting to enter address information is the wish to maintain privacy on the part of the respondent. If this is the case, changing the heading of the column or rewording the instructions will not have an impact on the number of respondents who do not give address information.

Secondly, there was a considerable amount of confusion among the participants as to how to fill out the bicycle infrastructure used column. Many people filled out every type of infrastructure that they used along their route, while others followed the instructions and only indicated the type of infrastructure that they used for the largest portion of their trip. However, because so many people indicated using more than one type of infrastructure, the revealed preference data was coded in such a way that all types of infrastructure used by the respondent could be recorded if they indicated using more than one type of infrastructure. This was done by using a 0/1 variable for each type of infrastructure separately. Unfortunately, by using this method, the detail of information collected from people who only entered the most used infrastructure was somewhat lower. For this reason, it is recommended asking all participants to mark down all the types of infrastructure that they used along their route.

Several respondents commented on the overall lack of space in the time-use-travel diary. The respondents had a particular problem with the height of the entry rows and the width of the space provided for the ‘Main activity’ and the ‘Secondary Activity’ columns. None of the respondents used both of the sides of paper that were provided in the time-use-travel diary and the vast majority did not use all of the rows provided on the first page. If the survey was carried out using a larger sample of respondents, it may be better to decrease the number of rows per page, increase the height of the rows and omit the second page.

5.3. Stated Choice Experiment

The individualized stated choice experimental design constructed in the course of this research project was only partially successful in collecting relevant choice data. However, the outcomes of the stated choice experiment pre-test and the qualitative analysis of these outcomes will make it possible to improve the experimental design, and therefore increase the value of the resulting choice data, for future surveys.

The first issue with the experimental design was the apparent lack of utility balance achieved in the choice situations. Although an attempt was made to encourage respondents to select a different mode than selected for their reported trip by concurrently increasing the overall utility of the alternative modes and decreasing the utility of the mode used in the reported trip, a large portion of the respondents opted for the same mode in the various choice situations. In total 69.6% of the choice situations prompted the respondent to select the same mode as used in their reference scenario. This tendency was particularly notable in the bicycle user group. In 85.5% of the choice situations, the respondents who used a bicycle in their reference scenario also selected the bicycle regardless of the offered alternatives and conditions. Over half of the choice situations (56.1%) faced by the public transportation segment respondents prompted the reselection of the public transportation alternative. This finding suggests that the design for the bicycle segment clearly was dominated by one alternative. The experimental design for the public transportation segment was also dominated by one mode, but this domination was less distinct. The domination of one alternative could be caused by a number of faults in the experimental design of the choice situations.

Firstly, the attributes selected for all three modes included in the experimental design may not have been the key influencing factors on mode choice. For bicyclists in particular, the choice to travel by bicycle may not be based on the travel time of the other modes or the cost of using these other modes. The choice to travel by bicycle may be based more on the enjoyment of bicycling, the weather, the characteristics of the activity, or any number of other attributes (trip, personal or latent) that were not included in the experimental design. This was suggested by one of the comments received from a survey participant. This participant noted that the utility offered by the bicycle and public transportation alternatives are quite equal for them. The selection between the two is influenced by daily factors such as the weather and the clothing. This finding supports the claim made in previous research that the choice to travel by bicycle may not be influenced as strongly by observable trip or personal characteristics as the choice to travel by other modes of transportation is (Heinen, van Wee & Maat 2010; Johansson, Heldt & Johansson 2006).

Secondly, even if the attributes selected do significantly influence mode choice, the outcome of the stated choice experiment may not reflect this significantly if the attribute levels included in the experimental design are not properly selected to concur with the indifference curves of the respondents. Because the pivot levels used in the experimental design were adopted from research studies done by other scientists and were not derived specifically for this research project, the pivot percentages and the absolute value attribute levels very well may not have reflected the indifference curves of the decision makers. A quantitative analysis of the results would be necessary to estimate pivot percentages and absolute attribute levels that would produce a better utility balance in the choice situations.

Although the experimental designs for the bicycle and public transportation segments suffered from utility imbalance, the design for the car segment seemed to produce fairly balanced results. This suggests that the attribute and attribute levels included in the car segment experimental design may be adequate for the β parameter estimations.

Overall the use of an efficient design process was deemed to be appropriate. However, the true statistical outcomes of this decision cannot be assessed until the data is used to estimate β parameters in a model. The attrition rate was not found to be a significant problem because of the relatively high secondary response rate of 93%.

One drawback of the survey implementation process was that it was not possible to incorporate information collected in the personal questionnaire in the design of the stated choice experiments. For example, each of the respondents was presented with a choice situation that included all three mode alternatives. However, if information was available beforehand about bicycle and car ownership, it would be possible to remove either the car or bicycle alternative if the respondent did not own a car or bicycle. Furthermore, because the stated choice experiment was presented to the respondent after the questions in the personal questionnaire that enquired about bicycle and car ownership, the respondents may have viewed the subsequent inclusion of these options as unrealistic if they did not own a car or bicycle. Two of the respondents commented on this flaw.

As a quantitative analysis of the data collected in the stated choice experiment was not included in the scope of this project, it is not possible to determine conclusively if the selected attributes had a significant influence on the decision of the respondent. The next step in this research project would be the estimation of the β parameters from the data collected. These parameters could then replace the parameters that were adopted from previous research and used in the efficient design of this choice experiment. By implementing more precise β parameters in the efficient design, better utility balance would be built into the choice situations.

A further recommendation for future work would be the use of focus groups to identify important influencing factors on the choice to travel by bicycle. Because the stated choice experiment was carried out online, it was not possible to ask the respondents about the factors that influenced mode choice, specifically with regard to cycling. The quantitative estimation of the influencing factors of bicycle transportation is a very new area of research and as such no precedent has been set as to the factors that have the most influence. As the number of factors that may influence the choice to travel by bicycle is extremely large, it may be worthwhile to carry out a number of stated choice experiments examining the influence of the various factors separately.

6. CONCLUSIONS

The methodology that was used to develop an individualized stated choice experiment that investigated the choice to travel by bicycle was successful in some areas but could be improved in others. The two-phase process that was used to construct a stated choice experiment from a reference situation was found to be cumbersome and work intensive.

The methods used to recruit the sample of participants needed for the pre-test of the survey instruments was found to be very ineffective. An overly long invitation letter, a complicated sign-up process and an inconvenient timeframe for participation are all thought to have negatively affected survey participation. If such a survey were to be carried out using a larger sample of respondents, it is advised that a different, more streamlined method for recruitment be used. Additionally, because the completion of both the time-use-travel diary and the online survey requires a significant amount of time and effort on the part of the respondent, it may be necessary to introduce a monetary incentive for participation if a large representative sample is needed.

The instrument used to collect the reference scenario information, the time-use-travel diary was found to be an overall effective tool. The layout of the diary could be amended to provide more room for the respondents to describe their trips and activities. Better instructions and labelling for the 'Verkehrsmittel/Ort der Aktivität' (Mode of transportation/Location of activity) could reduce the potential for respondents to omit address information. It may be worthwhile to revise the columns of the questionnaire regarding bicycle infrastructure used, as there was some confusion amongst respondents as to how this should be filled out.

Although the time-use-travel diary instrument was adequate in collecting revealed preference data, there is a potential to improve the entire survey process by changing the paper and pencil format of the diary to an online version. The digitalization of the time-use-travel diary would streamline the recruitment process and would greatly diminish the work load of distributing and collecting the time-use-travel diaries and then coding the data. The overall cost of the survey would also be significantly reduced because there would be no need for printing or posting the invitation letters or the survey documents.

The outcome of the stated choice experiment indicates that the attributes and attribute levels that were included in the choice situations may need to be revised. The experimental design of the choice situations that were presented to the segment of respondents who had used a bicycle for their reported trip was dominated by the bicycle option. This lack of utility balance is likely due to the fact that it is difficult to identify the observable factors that influence the choice to bicycle. The results of this pre-test suggest that either insignificant attributes were included in the experimental design for bicycle users, or the attribute levels did not reflect the indifference curves of this sample. Focus groups could be used in future work to help identify the factors that do indeed influence mode choice on the part of bicyclist. The utility balance of the experimental design of the other two segments (car users and public transportation users) appears to be much better. Still, the attribute levels and experimental design could be improved to better estimate the β parameters of the utility functions.

The method of building choice situations from a reference scenario familiar to the respondent may be advantageous from a choice behaviour standpoint, but is difficult to implement using the stated choice experiment building software that is currently available. The process used in this project to code time-use-diaries, estimate the reference scenarios for all the respondents and use this information to design individualized stated choice experiment was complicated and work intensive. If such a method were to be undertaken for a larger sample size, the workload would quickly become unmanageable. For this reason, if such a technique were used for a larger sample of respondents, it may be worthwhile to take several steps to simplify the procedure. The reference scenarios could be aggregated based on trip length, which would reduce the work load at the cost of slightly reducing the efficiency of the experimental design. It is also recommended to implement a programming algorithm to automatically perform several steps of the procedure.

There are several improvements that could be made to the procedure and experimental design generated in this project to increase the statistical relevance of the choice data collected from the stated choice experiment. However, the methodology developed in this project provides a solid base for the development of further stated choice experiments that investigate bicycle use.

LIST OF ACRONYMS

AVC	Asymptotic Variance Covariance
IIA	Independence of Irrelevant Alternatives
IID	Independent and Identically Distributed Terms
MLE	Maximum Likelihood Estimation
MNL	Multinomial Logit
MVV	Münchner Verkehrs- und Tarifverbund
PuT	Public Transportation
RP	Revealed Preference
SC	Stated Choice

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APPENDIX A – BICYCLE LITERATURE REVIEW TABLES

Bicycle Research Studies Concerning Route Choice and Infrastructure Preference

Source	Location	Factors Investigated	Data Type	Main Findings
Abraham et al., Investigation of bicycling sensitivities, 2002	Canada - Calgary	**Route Factors** - Trip duration **Infrastructure Preferences** - Arterial roads - Arterial road with wide curb lane - Arterial road with bicycle lane - Residential road - Bicycle path along arterial road - Pathway in park area	SP	- The average cyclist prefers off-street facilities and low traffic residential roads - Cyclists most prefer riding on pathways in park areas and least prefer bicycling on arterial roads - The addition of a bicycle facility on a road significantly decreases the disutility of every minute spent bicycling on that road
Aultman-Hall, Commuter bicycle route choice: Analysis of major determinants and safety implications, 1996	Canada - Guelph	**Route Factors** - Number of turns - Number of signals - Turn location - Bridges - Grade - Railway crossings **Infrastructure preference** - Arterial roads - Collector roads - Local road - Off-road pathway	RP (GIS Route Tracking)	- Cyclists tend to either cycle along direct major routes or cycle along routes which allow them to avoid car traffic - Cyclists prefer not to use off-road pathways - Cyclists choose routes with more traffic signals and prefer to use a traffic signal particularly for turning movements - Cyclists prefer to avoid grades
Buehler and Pucher, Bicycling to work in 90 large American cities: new evidence on the role of bike paths and lanes, 2011	USA	**Infrastructure preference** - Bike lanes per capita - Bike paths per capita	RP	- The existence of both bicycle lanes and bicycle paths in a city is correlated with higher bicycle use - The effect of the existence or bicycle lanes and bicycle paths on bicycle use are not significantly different - There is an inelastic relationship between the existence of bicycle paths and lanes and the level of bicycle use

Bicycle Research Studies Concerning Route Choice and Infrastructure Preference (continued)

Source	Location	Factors Investigated	Data Type	Main Findings
Dill, Bicycling for transportation and health: The role of infrastructure, 2009	USA - Portland	**Infrastructure preference** Road with no bicycle infrastructure (4 divisions) - Road with bicycle lane (3 divisions) - Bicycle path - Bicycle boulevard	RP (GIS Route Tracking)	- Most important factor in choosing bicycle lane is minimized distance followed by avoiding streets with high traffic volume **-** Cyclists prefer bicycle specific infrastructure to roads with no infrastructure
Hunt and Abraham, Influences on bicycle use, 2001	Canada - Edmonton	**Infrastructure preference** - In mixed traffic - Bicycle lane - Bicycle path	SP	- Bicycle lanes are the most attractive type of infrastructure followed by bicycle paths - Infrastructure preferences are correlated with bicycling experience
Menghini et al., Route choice of cyclists in Zurich: GPS-based discrete choice models, 2009	Switzerland – Zurich	**Route Factors** - Route length - Grade - Number of traffic lights **Infrastructure preference** - Marked bicycle paths	RP	- The length and directness of the route are of utmost importance in route selection - Cyclists avoid routes with steep gradients - Cyclists select routes with marked bicycle paths - The number of traffic lights was found to be insignificant in route choice
Ortuzar, Iacobelli and Valeze, Estimating demand for a cycle way network, 2000	Chile - Santiago	**Infrastructure preference** - Cycle lane (bicycle lane) - Segregated cycle-way (bicycle path)	SP built from RP data	- No specific infrastructure conclusions were presented
Stinson and Bhat, An analysis of commuter bicyclist route choice using a stated preference survey, 2003	USA - country wide	**Infrastructure preference** - None - Wide curb lane - Bicycle lane - Separate path	SP	- Bicycle specific infrastructure is greatly preferred with cyclists showing the highest preference for bicycle lanes followed by separated paths - the value of a bicycle lane is significantly lower if there is parking permitted along the lane - Most important factor was found to be travel time

Bicycle Research Studies Concerning Route Choice and Infrastructure Preference (continued)

Source	Location	Factors Investigated	Data Type	Main Findings
Tilahun, Trails, lanes or traffic: Valuing bicycle facilities with an adaptive stated preference survey, 2005	USA - Minnesota	**Infrastructure preference** - Off-road facility - Bicycle lane (no parking) - Bicycle lane (parking) - No bicycle lane (no parking) - No bicycle lane (parking)	Adaptive SP	- Introduction of a bicycle lane is more valuable than removing parking or introducing an off-road facility - Preferences between cyclists and non-cyclists are the same
Winters et al., Motivators and deterrents of bicycling: Comparing influences on decisions to ride, 2011	Canada – Vancouver	- A list of 73 items infrastructure and route factors	Personal Survey	- Most positively influencing factors 1. the route is away from traffic noise and air pollution 2. the route has beautiful scenery 3. the route has bicycle paths separated from traffic for the entire distance - Most negatively influencing factors 1. The route is icy or snowy 2. The route has a lot of car, bus and truck traffic 3. Vehicles drive faster than 50 km/h

Bicycle Research Studies Concerning the Natural Environment

Source	Location	Factors Investigated	Data Type	Findings
Buehler and Pucher, Bicycling to work in 90 large American cities: new evidence on the role of bike paths and lanes, 2011	USA	- Temperature - Precipitation	RP	- No relationship between the amount of precipitation in a city and bicycle commuting was found - No relationships found between the number of hot or cold days and bicycle commuting - Weather is not a strong predictor of bicycle commuting

Bicycle Research Studies Concerning the Natural Environment (continued)

Source	Location	Factors Investigated	Data Type	Findings
Dill and Carr, Bicycle commuting and facilities in major U.S. cities: If you build them, commuters will use them, 2003	USA	- Days of rain per year	Census Data	- Three of the six cities with the highest level of bicycle travel (of 35 American cities) had over 100 days of rain - All of the bottom six cities also had over 100 days of all - Day of rain is likely not a reliable indicator of the level of bicycling
Kuhnimhof, Chlond and Huang, Multimodal travel choices of bicyclists: multday data analysis of bicycle use in Germany, 2010	Germany	- Bad weather (rain and cold temperatures)	RP	- Bad weather increases the chance of using a motorized mode of transport - Bicycling is more negatively affected by bad weather than walking
Nankervis, The effect of weather and climate on bicycle commuting, 1999	Australia – Melbourne	- Seasonal weather variation	RP and climatic records	- Seasonal weather patterns do have an effect on bicycling levels, but not as strongly as may be expected - Significant relationship between the daily number of cyclists and the weather (rain, wind, extreme hot or cold) was found - Commuting trips are less sensitive to weather patterns than other types of bicycle trips
Stinson and Bhat, Frequency of bicycle commuting: Internet-based survey analysis, 2004	USA	- Winter season by geographic location - Seasonal weather variation	Online Survey	- Bicycling levels were lower in the winter in areas with harsher winters (Canadian cities being the lowest, cities on the west coast of the USA being the highest) - In all regions bicycling levels were highest in the summer

Bicycle Research Studies Concerning the Socio-Economic Variables

Source	Location	Factors Investigated	Data Type	Findings
Abraham et al., Investigation of bicycling sensitivities, 2002	Canada - Calgary	- Gender - Age	SP	- No significant differences were found in bicycling preferences based on socio-economic factors - Authors suggest that these factors are not adequate in explaining differences in bicycle preferences
Buehler and Pucher, Bicycling to work in 90 large American cities: new evidence on the role of bike paths and lanes, 2011	USA	-Student - Car ownership	RP	- A high proportion of students in a population is a reliable predictor of bicycle commuting - There is a negative correlation between the average car ownership in a city and the level of bicycling
de Geus, Bicycling to work, 2007	Belgium – Brussels	- Gender - Age - Education	Personal Survey	- There was no significant difference found in the gender or age of cyclists and non-cyclists - There was a significant relationships between the level of education and being a cyclist or a non-cyclist
Kuhnimhof, Chlond and Huang, Multimodal travel choices of bicyclists: multday data analysis of bicycle use in Germany, 2010	Germany	- Gender - Age - Student - Economic activity - Population - Car availability	RP	- The likelihood of being a cyclist is highest in medium sized cities - Share of cyclists is the same in all age groups - The group with the highest share of cyclists is students - The choice to bicycle is not as highly influenced by socio-economic characteristics as public transport or private car use - Gender is not a strong predictor of the likelihood to bicycle - Private car use as a driver or a passenger increases considerably if there is a car available in the household

Bicycle Research Studies Concerning the Socio-Economic Variables (continued)

Source	Location	Factors Investigated	Data Type	Findings
Stinson and Bhat, Frequency of bicycle commuting: Internet-based survey analysis, 2004	USA	- Gender - Age - Income	Online Survey	- Men were found to be more likely to commute by bicycle than women - Age and income were not found to have a significant impact on the propensity to travel by bicycle

Bicycle Research Studies Concerning the Psychological Factors

Source	Location	Factors Investigated	Data Type	Findings
de Geus, Bicycling to work, 2007	Belgium – Brussels	- Social influence - Social norm - Social support - Self-efficacy - Perceived benefits - Perceived barriers	Personal Survey	- Cyclists indicated having more social support that non-cyclists and more often reported having a bicycling partner - Cyclists indicated a social norm for cycling more than non-cyclists and had a higher level of self-efficacy - Cyclists believed that the economic and ecological benefits were significantly higher than non-cyclist did - Non-cyclists were more likely to state health and embarrassment, external obstacles, and lack of interest as reasons not to cycle for a given trip than cyclists - Non-cyclists estimate bicycle travel time significantly higher than cyclists
Dill and Voros, Factors affecting bicycle demand: Initial survey findings from the portland region, 2007	USA – Portland	- Childhood experience with bicycling - Bicycling habit of household members, coworkers and neighbours - Barriers to bicycling - Attitudes about mobility and various modes of transport	Personal Survey	- People who cycled in their childhood were significantly more likely to be cyclists as adults - People were more likely to be cyclists is they reported that household members and coworkers also bicycled - People who are positive about bicycle riding or dislike car driving are more likely to travel by bicycle - In general, people were found to be more positive about car use than bicycle use

Bicycle Research Studies Concerning the Psychological Factors (continued)

Source	Location	Factors Investigated	Data Type	Findings
Johansson, Heldt and Johansson, The effects of attitudes and personality traits on mode choice, 2006	Sweden	- Preferences for comfort, flexibility, safety, convenience, environmental concern	RP	- Preferences for comfort and flexibility are very important in mode choice - Preference for safety is insignificant in mode choice model - Some correlation between preferences and gender and income
Stinson and Bhat, Frequency of bicycle commuting: Internet-based survey analysis, 2004	USA	- Years commuting by bicycle	Online Survey	- The number of years spent commuting by bicycle is significantly related with the propensity to do so, suggesting that like most modes of transport, bicycling is based on habit

Bicycle Research Studies Concerning the Transportation Specific Factors

Source	Location	Factors Investigated	Data Type	Findings
Abraham et al., Investigation of bicycling sensitivities, 2002	Canada - Calgary	- Parking available at destination - Cost of parking - Other facilities at destination (shower, change rooms, etc.) -Cost of other facilities	SP	- Cyclists place a high value on having secure parking at their destination and are will to ride an estimated 8.5 min on an arterial road to access a destination with secure parking - Commuters place a higher value on end of trip facilities (parking and showers) than cyclists with other purposes
Buehler and Pucher, Bicycling to work in 90 large American cities: new evidence on the role of bike paths and lanes, 2011	USA	- Gas price - Transit revenue miles	RP	- There is a relationship between higher gas prices and higher levels of bicycling - No relationship was found between the public transport supply and bicycling - There is a high elasticity between the price of gas and the number of cyclists (1% increase in gas price leads to a 5.2% increase in bicycling levels)

Bicycle Research Studies Concerning the Transportation Specific Factors (continued)

Source	Location	Factors Investigated	Data Type	Findings
Stinson and Bhat, Frequency of bicycle commuting: Internet-based survey analysis, 2004	USA	- Showers and change rooms at destination - Bicycle racks or lockers at destination - Flexibility of work hours	Online Survey	- No significant relationship was found between the availability of showers or change rooms at the work place and commuting by bicycle - The presence of bicycle parking facilities at the destination increases the likelihood to travelling by bicycle - The flexibility of work hours does not significantly affect the levels of bicycle commuting
Winters et al., Motivators and deterrents of bicycling, 2011	Canada – Vancouver	- Parking facilities at the destination - Showers and change rooms at destination	Personal Survey	- None of the parking factors included had a strong effect on the decision to travel by bicycle - Destination facilities such as showers and repair facilities were not found to influence the choice to travel by bicycle

APPENDIX B - INVITATION LETTERS

Original German Invitation Letter

Technische Universität München

Technische Universität München
80290 München · Germany

An alle potenzielle Teilnehmerinnen und Teilnehmer
des Projektes „Radverkehr heute und morgen“

Prof. Dr. Regine Gerike

mobil.TUM – Projektgruppe
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Ust.-ID-Nr.:
DE811193231

Sehr geehrte Damen und Herren,

Sie nutzen Ihr Rad nicht, oder haben gar keines? Was würde Sie dazu veranlassen, es öfters zu nutzen oder ein Rad zu kaufen?

Nutzen Sie ein Rad? Was kann die Stadt München für Sie als Radfahrer an der momentanen Verkehrssituation verbessern?

Mit Ihrer Hilfe können wir daran arbeiten, Ihnen und anderen Radfahrern das Fahrradfahren angenehmer zu gestalten. Außerdem hoffen wir dadurch mehr Menschen zum Radfahren bewegen zu können.

Wer sind wir? Eine Gruppe von jungen Verkehrs- und Mobilitätsforschern an der TU München. Wir führen im Rahmen einer Masterarbeit und ohne externe Finanzierung die Erhebung „Radverkehr heute und morgen“ durch. Ziel der Arbeit ist es, mehr über die Nutzung oder eben Nichtnutzung des Rades und die Gründe dafür zu erfahren.

Was erwartet Sie:

- ein schriftliches Tagebuch, in welchem Sie kurz Ihre Aktivitäten und Wege eines Tages niederschreiben,
- ein im Internet auszufüllender Online-Befragung, mit Fragen zu Person und Haushalt und „Was-wäre-wenn Situationen“ wie zum Beispiel: würde sich Ihre Verkehrsmittelwahl ändern, wenn es an Ihrem Arbeitsplatz überdachte Abstellplätze für Fahrräder sowie Umkleidemöglichkeiten geben würde?

Prof. Dr. Regine Gerike

mobil.TUM – Projektgruppe
Mobilität & Verkehr
Lehrstuhl für Verkehrstechnik
Fakultät für Bauingenieur-
und Vermessungswesen

Wir bitten Sie herzlich, sich die Zeit zum Ausfüllen und Zurücksenden des Tagebuches sowie für die abschließende Online-Befragung zu nehmen. Unter allen Teilnehmern der Studie verlosen wir drei Gutscheine im Wert von je 50 € für das Sporthaus Schuster in München - damit Ihnen das Radfahren noch mehr Spaß macht.

Wenn Sie an der Umfrage teilnehmen möchten, bitten wir Sie eine E-Mail mit Ihrer Anschrift an: radverkehr@mobil-tum.de zu senden. Die benötigten Unterlagen für das Tagebuch werden Ihnen dann zeitnah zugesandt.

Wir bitten Sie das Tagebuch an einem Werktag (vorzugsweise an einem Dienstag, Mittwoch oder Donnerstag) Ihrer Wahl zwischen Montag, den 22. August und Freitag, den 2. September auszufüllen. In dieser Zeit haben wir eine Hotline geschaltet.

Tel.: +49 (0) 174 7142309 (Montag – Freitag,10.00 - 20.00 Uhr)

Bitte schicken Sie das ausgefüllte Tagebuch in dem mitgesandten Rückumschlag zeitnah an uns zurück. Ein Link zu der abschließenden Online-Befragung wird Ihnen per E-Mail zugeschickt. Die Auslosung für die Gutscheine findet im Oktober statt.

Wir arbeiten strikt nach den Vorschriften des Bundesdatenschutzgesetzes und allen anderen datenschutzrechtlichen Bestimmungen. Ihre Angaben werden in anonymisierter Form ausgewertet.

Für Fragen stehen wir Ihnen unter der Email-Adresse radverkehr@mobil-tum.de gern zur Verfügung.

Herzlichen Dank für Ihre Unterstützung unserer Forschungsarbeit und die Teilnahme an dieser Untersuchung.

Mit freundlichen Grüßen,

Regine Gerike

Original English Invitation Letter

Technische Universität München

Technische Universität München
80290 München · Germany

Prof. Dr. Regine Gerike

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bylademm

IBAN-Nr.:
DE 10700500000000024866

Ust.-ID-Nr.:
DE811193231

26.07.2011
Munich, Germany

Dear Potential Survey Participant,

Non-cyclists – what would it take to get you to use a bicycle for your daily trips?

Cyclists – what could be done to make your cycling experience in Munich better?

Your input will help make it possible to determine which infrastructure improvements, policy changes or incentive offers will have the most positive impact on the cycling environment in Munich.

Who are we? We are a group of young transportation and mobility researchers at the TU München and we are carrying out an independent “Bicycling Today and Tomorrow” research project. The goal of the project is to gain an understanding of the use or non-use of cycling for daily transportation and the reasons behind these decisions.

Your part:

- Fill out a one-day written diary with information about your daily trips and activities
- Complete an online survey where you will be asked to fill out a short questionnaire and answer a series of “What if?” questions about the trips you described in your written diary

It would be a great help to us if you would take the time and effort to fill out the one-day diary and complete the online questionnaire. Participation in the study will qualify you for a draw for one of three 50 € gift certificates to Schuster Sporthaus!

If you are willing to take part in the survey, please send an email with your mailing address to radverkehr@mobil-tum.de. A travel diary form will be mailed to you.

Prof. Dr. Regine Gerike

mobil.TUM – Projektgruppe
Mobilität & Verkehr
Lehrstuhl für Verkehrstechnik
Fakultät für Bauingenieur-
und Vermessungswesen

You can complete the one-day travel diary on any work day between Monday August 22nd, 2011 and Friday September 2nd, 2011 (preferably on a Tuesday, Wednesday or Thursday). A hotline will be available during the survey (+49 (0) 174 7142309, Monday-Friday, 10:00 am - 8:00 pm).

Completed travel diaries can be returned via mail in a provided envelope (as promptly as possible please!). A link to the online survey will then be emailed to you. The draw for the gift certificates will take place in October.

We work strictly according to the provisions of the Federal Privacy Act and all other data protection regulations. Your information will be evaluated anonymously.

Questions? Please contact us at radverkehr@mobil-tum.de.

Thank you for your support of our research project and your participation in the study!

Sincerely,

Regine Gerike

Revised German Invitation Letter

Technische Universität München

Prof. Dr. Regine Gerike

mobil.TUM – Projektgruppe
Mobilität & Verkehr
Lehrstuhl für Verkehrstechnik
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www.mobil-tum.de

An alle potenziellen Teilnehmerinnen und Teilnehmer
des Projektes „Radverkehr heute und morgen“

München, 04.10.2011

Hiermit laden wir Sie herzlich zur Teilnahme an unserer Umfrage zur Verkehrsmittelwahl in München ein. Wenn Sie die Umfrage ausgefüllt an uns zurücksenden, nehmen Sie an einer Verlosung teil, bei der Sie einen von fünf **Gutscheinen für das Sporthaus Schuster in Höhe von 50 €** gewinnen können.

Der Schwerpunkt unserer Untersuchung liegt auf der Benutzung des Fahrrads und wie das Fahrrad als Verkehrsmittel in München besser unterstütz werden kann. Darüber hinaus sind wir interessiert Informationen von Einwohnern zu erhalten, die auch andere Verkehrsmittel verwenden. Auch **als Nicht-Radfahrer sind Sie also herzlich dazu eingeladen** an der Umfrage Teilzunehmen.

Was erwartet Sie:

- ein schriftliches Tagebuch, in welchem Sie kurz Ihre Aktivitäten und Wege eines Tages niederschreiben,
- ein im Internet auszufüllender Online-Befragung, mit Fragen zu Person und Haushalt und „Was-wäre-wenn Situationen“ (das Ausfüllen des online-Fragebogens nimmt ca. 7- 10 Minuten in Anspruch.)

Wenn Sie an der Umfrage teilnehmen möchten, bitten wir Sie eine E-Mail mit Ihrer Anschrift an: radverkehr@mobil-tum.de zu senden. Die benötigten Unterlagen für das Tagebuch werden Ihnen dann zeitnah zugesandt.

Bitte schicken Sie das ausgefüllte Tagebuch in dem mitgesandten Rückumschlag zeitnah an uns zurück. Ein Link zu der abschließenden Online-Befragung wird Ihnen per E-Mail zugeschickt. Die Auslosung für die Gutscheine findet im Oktober statt. Für Fragen stehen wir Ihnen unter der Email-Adresse radverkehr@mobil-tum.de gern zur Verfügung.

Herzlichen Dank für Ihre Unterstützung unserer Forschungsarbeit und die Teilnahme an dieser Untersuchung.

Mit freundlichen Grüßen,

Regine Gerike

Revised English Invitation Letter

Technische Universität München

Prof. Dr. Regine Gerike

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regine.gerike@mobil-tum.de
www.mobil-tum.de

02.11.2011
Munich, Germany

Dear Potential Survey Participant,

You are invited to participate in our survey concerning transportation mode choice in Munich. By completing the survey, you will be entered in a draw **for one of five gift certificates** to Schuster Sporthaus (50 € each).

The focus of our work is on bicycling and how this mode could be better supported in Munich. However, we are interested in gaining information from people using all modes of transport and so **you do not have to be a cyclist** to take part in this survey!

What you can expect to do:

- Record (briefly) your trips and activities in a one day written diary
- Complete an online survey where you will be asked to fill out a short questionnaire and answer a series of "What if?" questions about the trips you described in your written diary

Please return your completed one day diary via mail in a provided envelope (as promptly as possible please!). A link to the online survey will then be emailed to you. The draw for the gift certificates will take place in October.

Questions? Please contact us at radverkehr@mobil-tum.de.

Thank you for your support of our research project and your participation in the study!

Best Regards,

Regine Gerike

APPENDIX C - TIME-USE-TRAVEL DIARY SURVEY - GERMAN

As distributed to survey participants

Please see Appendix D for an English translation

Liebe Befragungsteilnehmerinnen und -teilnehmer,

mit dem Tagebuch halten Sie die wichtigste Unterlage zur Befragung „Radverkehr heute und morgen“ in den Händen. Nur durch Ihre genauen und sorgfältigen Angaben ist es möglich, die Aktivitäten und Wege von Personen darzustellen.

Wer soll ein Tagebuch führen?

Sie wurden per Zufallsauswahl ausgewählt. Ihre Teilnahme ist daher von hoher Wichtigkeit, um eine möglichst hohe Repräsentativität der Ergebnisse zu erreichen. Ihre Teilnahme ist selbstverständlich freiwillig.

Wann ist das Tagebuch zu führen?

Bitte füllen Sie das Tagebuch an einem Werktag (vorzugsweise an einem Dienstag, Mittwoch oder Donnerstag) Ihrer Wahl zwischen Montag, den 22. August und Freitag, den 2. September aus. Bitte wählen Sie wenn möglich einen typischen Tag. Außergewöhnliche Ereignisse können Sie auf Seite sechs des Tagebuchs benennen.

Was ist einzutragen?

In das Tagebuch sind alle Aktivitäten einzutragen, die mindestens 5 Minuten dauern. Die Beschreibung der Tätigkeit soll möglichst genau und ausführlich erfolgen. Achten Sie bitte darauf, dass unter einer Tätigkeit nicht nur eine körperliche Aktivität zu verstehen ist. So sind geistige Aktivitäten, wie z.B. Planung und Organisation des Haushalts (Überlegungen zum Einkauf, Planung einer Familienfeier, Tele-Shopping oder E-Banking), Gespräche oder Radio hören ebenfalls als Aktivität in das Tagebuch einzutragen.

Wege - Was ist beim Eintragen zurückgelegter Wege zu beachten?

Besonders wichtig ist die Erfassung aller Wege zwischen den Aktivitäten. Bitte tragen Sie auch kurze Wege und Wegeketten ein, z.B. zu Hause – Kind zur Kita gebracht – beim Bäcker eingekauft – Arbeit.

Am Ende des Tagebuchs haben wir noch einige ergänzende Fragen zu dem Aufzeichnungstag. Wir bitten Sie, auch diese Fragen zu beantworten.

Nach den einleitenden Seiten finden Sie Ausschnitte aus einem Mustertagebuch für eine Beispielsperson. Schauen Sie sich bitte das Beispiel an. Die Hinweise sollen Ihnen das Ausfüllen erleichtern.

Sollten Sie dennoch Probleme bei der Eintragung oder Zuordnung von Aktivitäten haben, wenden Sie sich bitte mit Ihren Fragen an die Betreuer der Studie an der TU München (radverkehr@mobil-tum.de, Telefon +49 (0) 174 7142309 (Montag – Freitag, 10.00 - 20.00 Uhr)). Wir helfen Ihnen gerne weiter.

Ihre Angaben in diesem Tagebuch werden streng vertraulich behandelt. Die Eintragungen dienen ausschließlich der statistischen Auswertung. Alle mit der Befragung beauftragten Personen sind zur Verschwiegenheit verpflichtet. Sie können also volles Vertrauen gegenüber allen Beteiligten haben.

Herzlichen Dank für Ihre Teilnahme

Ausfüllhinweise

1. Hauptaktivität

Geben Sie hier diejenige Aktivität an, die Sie zum Zeitpunkt der Ausführung als die Wichtigste einschätzen. Bei Aktivitäten, die Sie als sehr privat/persönlich einschätzen und nicht beschreiben möchten, schreiben Sie in die entsprechende Zeitzeile „persönliche Zeitverwendung“. Aus der Beschreibung der Hauptaktivität soll auch hervorgehen, wo Tätigkeiten ausgeübt wurden.

- **Erwerbstätigkeit**

  Unterscheiden Sie bitte bei der Angabe zwischen Ihrer ersten Erwerbstätigkeit und weiteren Erwerbstätigkeiten. Aufzuschreiben ist nicht, was Sie genau während Ihrer Arbeit machen, wohl aber, wann Sie Pausen machen und wie Sie diese verbringen.

- **Aus- oder Fortbildung**

  Bitte geben Sie Zeiten für Ihre Aus- oder Fortbildung auch an, wenn diese in der Erwerbsarbeitszeit liegen.

- **Wegezeiten/Verkehrsmittel**

  Ein Weg ist eine Aktivität. Für Wege tragen Sie in die Spalte Hauptaktivität bitte den Wegezweck ein, z.B. zu Bekannten gefahren. Bitte geben Sie in der Spalte „Verkehrsmittel“ das genutzte Verkehrsmittel an, auch wenn Sie sich „Zu Fuß“ fortbewegen. Falls Sie zusammen mit anderen Personen ab 18 Jahren mit dem Auto unterwegs sind, tragen Sie bitte in die Spalte „Verkehrsmittel“ ein, ob Sie selbst der Fahrer/die Fahrerin sind oder ob Sie mitfahren. Bitte tragen Sie auch die Fahrzeugklasse des Autos ein, dass Sie für die Fahrt verwendet haben (z.B.: Kleinwagen, Kompaktklasse, Mittelklasse, Oberklasse, SUV, Van etc.) Der Eintrag sieht dann beispielsweise so aus: Pkw, Fahrer, Kleinwagen. Sollten Sie für einen Weg mehrere Verkehrsmittel nutzen, so tragen Sie diese bitte als Aktivitätenfolge ein, einschließlich Umsteigezeit und –ort.

2. Gleichzeitige Aktivität (Nebenaktivität)

Wenn Sie mehr als eine Aktivität erledigen, tragen Sie die Ihnen wichtiger erscheinende Tätigkeit in die Spalte „Hauptaktivität“ und die weitere Aktivität in derselben Zeile in die Spalte „gleichzeitige Aktivität“ ein. Beachten Sie beim Eintragen, dass beide Aktivitäten nicht unbedingt die gleiche Zeitdauer haben müssen.

3. Kosten für die Aktivität

Bitte geben Sie hier die ca. Kosten an, die Ihnen für die Ausübung der Aktivität entstehen, z.B. Fahrtkosten, Eintritt, Ausgaben für Einkäufe etc. Bei Zeitkarten, Flatrate Internet/Telefon/SMS brauchen Sie keine Kosten pro Aktivität eintragen, wir erfragen diese im Personenfragebogen.

4. Parkgebühren

Bitte geben Sie hier die gesamte Parkgebühr (ca.) an, die Sie für die Parkzeit ausgeben haben.

5. Bereich “Fragen nur für Fahrradnutzung”

Die vier Spalten unter der Überschrift “ Fragen nur für Fahrradnutzung“ müssen natürlich nur ausgefüllt werden, wenn das Fahrrad für die Strecke benutzt wurde.

- **Art des Fahrradparkens**

  Bitte beschreiben Sie die Art des Fahrradparkplatzes, den Sie an Ihrem Zielort verwendet haben. Beispiele von Fahrradparkplätzen sind:

  - öffentlicher Straßenraum
  - Fahrradabstellplätze (ohne Dach)
  - überdachte Fahrradabstellplätze
  - Fahrradparkhaus
(z.B. Radlhaus Kieferngarten und Radlhaus Olympiaeinkaufszentrum)
  - Sonstige (Bitte Beschreiben Sie in diesem Fall kurz den Parkplatz.)

- **Typ des Fahrradweges**

  Bitte Beschreiben Sie den Typ des Fahrradweges, den Sie für den Überwiegenden Teil der Fahrt verwendet haben. Wenn Sie zum Beispiel einen Kilometer Straße, vier Kilometer durch einen Park und dann für weitere 500 Meter auf einem Radweg an einer Seitenstraße gefahren sind, dann geben Sie bitte „Radweg im Grünbereich oder Forstweg an. Sollte der Großteil der Fahrradfahrt auf einer Straße mit oder ohne Fahrradweg stattgefunden haben, geben Sie bitte mit an, wie hoch die Verkehrsdichte auf der Straße war (z.B.: gering, mittel, stark)

  Beispiele für die Fahrradwege sind:

  - Tempo-30-Zone
  - Radweg im Straßenbereich
  - Straße ohne Radweg
  - Gezeichneter Radweg auf dem Gehweg
  - Radweg im Grünbereich oder Forstweg
  - Gemeinsamer Rad- und Fußweg
  - Sonstiger Fahrradweg (Bitte Beschreiben Sie in diesem Fall kurz den Radweg)

Uhrzeit bitte etwa im 5-Min.-Intervall angeben von	 bis	Hauptaktivität Bitte immer nur eine Aktivität pro Zeile eintragen	Verkehrsmittel / Ort der Aktivität Bitte geben Sie den genauen Ort der Aktivität an (Adresse), bzw. das Verkehrsmittel für Wege	Gleichzeitige Aktivität Bitte die wichtigste gleichzeitige Aktivität angeben	Kosten Bitte die allgemeinen Kosten für die Aktivität angeben (z.B.: 2,49 Euro)	Park-gebühren Bitte die Kosten für Parken (z.B.: 1,50 Euro)	Fragen nur für Fahrradnutzung **Art des Parkens** 1 Öffentlicher Straßenraum 2 Fahrradabstellplätze (ohne Dach) 3 Überdachte Fahrradabstellplätze 4 Fahrradparkhaus 5 Sonstige (bitte beschreiben)	 **Typ des Fahrradweges** 1 Tempo-30-Zone 2 Radweg im Straßenbereich 3 Straße ohne Radweg + Verkehrsdichte (gering, mittel, stark) 4 Gezeichneter Radweg auf Gehweg 5 Radweg in Grünbereich / Forstweg 6 Gemeinsamer Rad- und Fußweg 7 Sonstiger (bitte beschreiben)	 **Verfügbarkeit von Duschen und/oder Umkleidungsraum am Zielort** (Ja/Nein/ weiß nicht)	 **Nutzung der Duschen und/oder Umkleidungsraum am Zielort** (Ja/Nein)	Bewertung der Fahrt/Aktivität Bitte vergeben Sie Punkte: 1 sehr unangenehm 2 unangenehm 3 neutral 4 angenehm 5 sehr angenehm
06:30	06:50	Aufstehen und Waschen	Mustergasse 1, München								2
06:50	07:05	Anziehen	"	Radio hören							3
07:05	07:30	Frühstücken	"	Nachrichten lesen							4
07:30	07:40	Sachen packen	"								3
07:40	08:05	Fahrt zur Arbeit	Pkw, Fahrer, Kompaktklasse	Radio hören							1
08:05	12:15	Erwerbstätigkeit	Zukunftsallee 99, München								4
12:15	12:25	Zu Restaurant laufen	zu Fuß	Gespräch mit Kollegen							4
12:25	13:10	Mittagsessen	Am Salatgarten 5, München	Gespräch mit Kollegen	12,50						4
13:10	13:20	zurück ins Büro laufen	zu Fuß	Telefonieren							3
13:20	17:30	Erwerbstätigkeit	Zukunftsallee 99, München								3
17:30	17:35	Fahrt zum Fitnessstudio	Pkw, Fahrer, Kompaktklasse	Radio hören		2,50					2
17:35	18:45	Sport	Trimdichplatz 15, München	Musik hören	5,00						4
18:45	18:50	Fahrt zu Supermarkt	Pkw, Fahrer, Kompaktklasse								3
18:50	19:20	Einkaufen	Einkaufstrasse 7, München		49,72						2
19:20	19:35	Fahrt nach Hause	Pkw, Fahrer, Kompaktklasse								4
19:35	19:50	Vorbereitung Abendessen	Mustergasse 1, München	Durchsehen der Post							4
19:50	20:20	Abendessen	"	Gespräch mit Partnerin							4
20:20	20:30	Fahrt ins Kino	Fahrrad	Gespräch mit Partnerin			3	2	Nein	Nein	5
20:30	22:55	Kinobesuch mit Partnerin	Hollywoodblvd 3, München		23,50						5
22:55	23:05	Fahrt nach Hause	Fahrrad	Gespräch mit Partnerin			5 Garage	3, gering	Ja	Nein	3
23:05	23:20	Planung Wochenendausflug	Mustergasse 1, München								4
23:20	23:30	zu Bett gehen	"								4
23:30	06:30	Schlafen	"								5

Ergänzende Informationen zum Tagebuch

1. Waren Sie zu Beginn des beschriebenen Tagebuchtages um 4.00 Uhr morgens zu Hause oder woanders?

   Zu Hause ☐
   Woanders ☐

2. Waren Sie am Ende des beschriebenen Tagebuchtages um 4.00 Uhr morgens zu Hause oder woanders?

   Zu Hause ☐
   Woanders ☐

3. Wie verlief der im Tagebuch beschriebene Tag?

   ganz normal ☐
   außergewöhnlich, da z.B. Urlaub, Krankheit, Familienfest ☐

   ____

4. Haben Sie an dem Tagebuchtag eine Reise unternommen, die mindestens zwei Stunden gedauert hat?

   Nein, keine Reise ☐
   Ja, Tagesreise im Inland (km einfache Fahrt) ____ km
   Ja, Tagesreise ins Ausland (km einfache Fahrt) ____ km
   Ja, Reise über Nacht im Inland (km einfache Fahrt) ____ km
   Ja, Reise über Nacht ins Ausland (km einfache Fahrt) ____ km

5. Wann haben Sie dieses Tagebuch ausgefüllt?

   Hin und wieder über den Tag verteilt ☐
   Am Ende des Tagebuchtages ☐
   Am Tag danach ☐
   Nach mehreren Tagen ☐

6. Wie war das Wetter an diesem Tag überwiegend?

   Sonnig ☐
   Leicht bewölkt ☐
   Bewölkt ☐
   Regen ☐
   Schnee ☐

Bitte senden Sie diese Seite und das ausgefüllte Tagebuch mit dem frankierten Rückumschlag zurück re

Raum für Anmerkungen (z.B. Hinweise für die weitere Bearbeitung, Schwierigkeiten beim Ausfüllen)

Erklärung zum Datenschutz und zur absoluten Vertraulichkeit Ihrer Angaben

Die Erhebung erfolgt durch die TU München im Rahmen der gleichnamigen Masterarbeit „Radverkehr heute und morgen“. Sie dient der Gewinnung statistischer Daten über Zeitverwendung und Mobilität privater Personen als Grundlage der in der zweiten Stufe der Befragung folgenden Online-Fragen zum Radverkehr. Die Zahl der angeschriebenen Personen liegt bei 500.

Bei der Studie „Radverkehr heute und morgen“ trägt die TU München die datenschutzrechtlich Verantwortung. Wir arbeiten nach den gesetzlichen Bestimmungen des Datenschutzes. Die Ergebnisse der Studie werden ausschließlich in anonymisierter Form ohne Namen und Anschrift dargestellt. Nach Eingang Ihrer Unterlagen trennen wir Adresse und Fragenteil. Beide erhalten eine Codenummer. Ihre Angaben werden ohne Adresse und getrennt von den Adressen, d.h. in anonymisierter Form, gespeichert. Namen und Adressen verbleiben an der TU München, sind aber strikt getrennt von den Interviews und werden nur bis zum Abschluss der Studie aufbewahrt. Danach werden diese Angaben gelöscht.

Sie können damit sicher sein:

- dass Ihr Name und Adresse nicht mit den Interviewdaten zusammen geführt werden. Niemand erfährt, welche Angaben Sie persönlich gemacht haben,
- dass wir Ihren Namen und Anschrift nicht an Dritte weitergeben,
- dass wir keine Einzeldaten weitergeben, die einen Rückschluss auf Ihre Person zulassen,
- dass wir Ihre Angaben ausschließlich zu Forschungszwecken nutzen.

Wir bedanken uns für Ihr Vertrauen und Ihre Mitwirkung!

Radverkehr heute und morgen

Tagebuch

von: ______________________________
Bitte Namen eintragen

Email: ______________________________
Bitte eintragen, um den Link für die abschließende Befragung zu erhalten und an der Auslosung teilzunehmen.

	TAG	MONAT	JAHR
Tagebuchtag	_ _	_ 2	0 1 1 _ _

Von der TU München auszufüllen

	Tag	Monat	Jahr
Eingangsdatum	_ _	_ 2	0 1 1 _ _
Haushalts-Nummer	_ _ _ _ _ _		
Personen-Nummer	_ _		

Uhrzeit		Hauptaktivität	Verkehrsmittel / Ort der Aktivität	Gleichzeitige Aktivität	Kosten	Park-gebühren	Fragen nur für Fahrradnutzung				Bewertung der Fahrt/Aktivität
bitte etwa im 5-Min.-Intervall angeben		Bitte immer nur eine Aktivität pro Zeile eintragen	Bitte geben Sie den genauen Ort der Aktivität an (Adresse), bzw. das Verkehrsmittel für Wege	Bitte die wichtigste gleichzeitige Aktivität angeben	Bitte die allgemeinen Kosten für die Aktivität angeben (z.B.: 2,49 Euro)	Bitte die Kosten für Parken (z.B.: 1,50 Euro)	**Art des Parkens** 1 Öffentlicher Straßenraum 2 Fahrradabstellplätze (ohne Dach) 3 Überdachte Fahrradabstellplätze 4 Fahrradparkhaus 5 Sonstige (bitte beschreiben)	**Typ des Fahrradweges** 1 Tempo-30-Zone 2 Radweg im Straßenbereich 3 Straße ohne Radweg + Verkehrsdichte (gering, mittel, stark) 4 Gezeichneter Radweg auf Gehweg 5 Radweg in Grünbereich / Forstweg 6 Gemeinsamer Rad- und Fußweg 7 Sonstiger (bitte beschreiben)	**Verfügbarkeit von Duschen und/oder Umkleidungsraum am Zielort** (Ja/Nein/ weiß nicht)	**Nutzung der Duschen und/oder Umkleidungsraum am Zielort** (Ja/Nein)	Bitte vergeben Sie Punkte: 1 sehr unangenehm 2 unangenehm 3 neutral 4 angenehm 5 sehr angenehm
von	bis										

Uhrzeit bitte etwa im 5-Min.-Intervall angeben		**Hauptaktivität** Bitte immer nur eine Aktivität pro Zeile eintragen	**Verkehrsmittel / Ort der Aktivität** Bitte geben Sie den genauen Ort der Aktivität an (Adresse), bzw. das Verkehrsmittel für Wege	**Gleichzeitige Aktivität** Bitte die wichtigste gleichzeitige Aktivität angeben	**Kosten** Bitte die allgemeinen Kosten für die Aktivität angeben (z.B.: 2,49 Euro)	**Park-gebühren** Bitte die Kosten für Parken (z.B.: 1,50 Euro)	**Fragen nur für Fahrradnutzung**				**Bewertung der Fahrt/Aktivität** Bitte vergeben Sie Punkte: 1 sehr unangenehm 2 unangenehm 3 neutral 4 angenehm 5 sehr angenehm
von	bis						**Art des Parkens** 1 Öffentlicher Straßenraum 2 Fahrradabstellplätze (ohne Dach) 3 Überdachte Fahrradabstellplätze 4 Fahrradparkhaus 5 Sonstige (bitte beschreiben)	**Typ des Fahrradweges** 1 Tempo-30-Zone 2 Radweg im Straßenbereich 3 Straße ohne Radweg + Verkehrsdichte (gering, mittel, stark) 4 Gezeichneter Radweg auf Gehweg 5 Radweg in Grünbereich / Forstweg 6 Gemeinsamer Rad- und Fußweg 7 Sonstiger (bitte beschreiben)	**Verfügbarkeit von Duschen und/oder Umkleidungsraum am Zielort** (Ja/Nein/ weiß nicht)	**Nutzung der Duschen und/oder Umkleidungsraum am Zielort** (Ja/Nein)	

APPENDIX D - ONLINE PERSONAL SURVEY AND STATED CHOICE EXPERIMENT

As distributed online to survey participants

Please see Appendix E and Appendix F for English translations

Liebe Teilnehmerin, lieber Teilnehmer,

willkommen zur Umfrage zum Thema Radverkehr heute und morgen!

Die Ergebnisse dieser Umfrage fließen in ein aktuelles Forschungsprojekt der TU München ein. Mit der Teilnahme an der Umfrage unterstützen Sie unsere Arbeit und leisten einen wertvollen Beitrag für unsere Forschung. Wir bedanken uns dafür sehr herzlich bei Ihnen!

Bitte füllen Sie den folgenden Fragebogen vollständig aus. Das Ausfüllen nimmt etwa 10 Minuten in Anspruch. Die Umfrage ist anonym.

Falls Sie Fragen haben sollten oder technische Probleme auftreten, können Sie mich gerne unter +49 (0) 174 7142309 oder radverkehr@mobil-tum.de kontaktieren.

Besten Dank für Ihre Teilnahme

Prof. Dr. Regine Gerike

mobil.TUM – Projektgruppe Mobilität & Verkehr
Lehrstuhl für Verkehrstechnik
Fakultät für Bauingenieur- und Vermessungswesen

Continue

Comment

Wie häufig benutzen Sie in der Regel die folgenden Verkehrsmittel?

	(fast) täglich	an einem bis drei Tagen pro Woche	an einem bis drei Tagen pro Monat	seltener als monatlich	nie bzw. fast nie
Fahrrad	○	○	○	○	○
Bus oder Bahn in Ihrer Region	○	○	○	○	○
Auto	○	○	○	○	○

Back Continue

Comment

The following question was only displayed if the respondent indicated using public transportation more often than never or almost never.

Welche Fahrkartenart nutzen Sie überwiegend, wenn Sie im öffentlichen Nahverkehr fahren?

- ○ Einzelfahrschein, Tageskarte, Kurzstrecke
- ○ Mehrfachkarte, Streifenkarte
- ○ Wochenkarte, Monatskarte ohne Abonnement
- ○ Monatskarte im Abonnement, Jahreskarte (Umweltabo etc.)
- ○ Jobticket, Monatskarte Ausbildungstarif etc. (Firmenabo, Studententicket)
- ○ Sonstiges

Back | Continue

Comment

Wie viele Minuten benötigen Sie zu Fuß von Ihrer Wohnung aus bis zu den nächstgelegenen Haltestellen der folgenden öffentlichen Verkehrsmittel?

Bushaltestelle	
Straßenbahnhaltestelle	
Bahnhaltestelle (U-Bahn, S-Bahn oder Regionalbahn bzw. Nahverkehrszüge)	

Back | Continue

Comment

Wie viele Pkw sind in Ihrem Haushalt vorhanden?

- ○ 0
- ○ 1
- ○ 2
- ○ 3
- ○ mehr als 3

Back | Continue

Comment

The next question was only displayed if the respondent indicated having no car available in their household.

Aus welchen der folgenden Gründe hat Ihr Haushalt kein Auto?

- ☐ Kein Auto benötigt
- ☐ Bewusster Verzicht
- ☐ Anschaffung oder Unterhalt zu teuer
- ☐ Gesundheitliche Gründe
- ☐ Altersgründe
- ☐ Aus anderen Gründen

Back | Continue

Comment

The next question was only displayed if the respondent indicated having one car or more available in their household.

Zu welcher Fahrzeugklasse gehört Ihr Auto?
Wenn mehrere Autos in Ihrem Haushalt vorhanden sind, tragen Sie bitte das Auto ein, dass Sie am meisten verwenden.

- ○ Kleinstwagen (z.B. Smart Fortwo)
- ○ Kleinwagen (z.B. Opel Corsa)
- ○ Kompaktklasse (z.B. VW Golf)
- ○ Mittelklasse (z.B. Audi A4)
- ○ Obere Mittelklasse (z.B. BMW 5er)
- ○ Oberklasse (z.B. Mercedes S-Klasse)
- ○ Geländewagen / SUV (z.B. VW Tiguan)
- ○ Sportwagen (z.B. BMW Z4)
- ○ Van (z.B. Opel Zafira)
- ○ Anderes

Back | Continue

Comment

Besitzen Sie zurzeit einen Führerschein?

- Ja
- Nein

Back | Continue

Comment

The next question was only asked if the respondent indicated having one car or more available in their household and having a drivers license.

Wie oft können Sie als Fahrer / Fahrerin über ein Auto verfügen?

- Jederzeit
- Gelegentlich
- Ausnahmsweise
- Gar nicht

Back | Continue

Comment

Besitzen Sie zurzeit ein verkehrstüchtiges Fahrrad?

- Ja
- Nein

Back | Continue

Comment

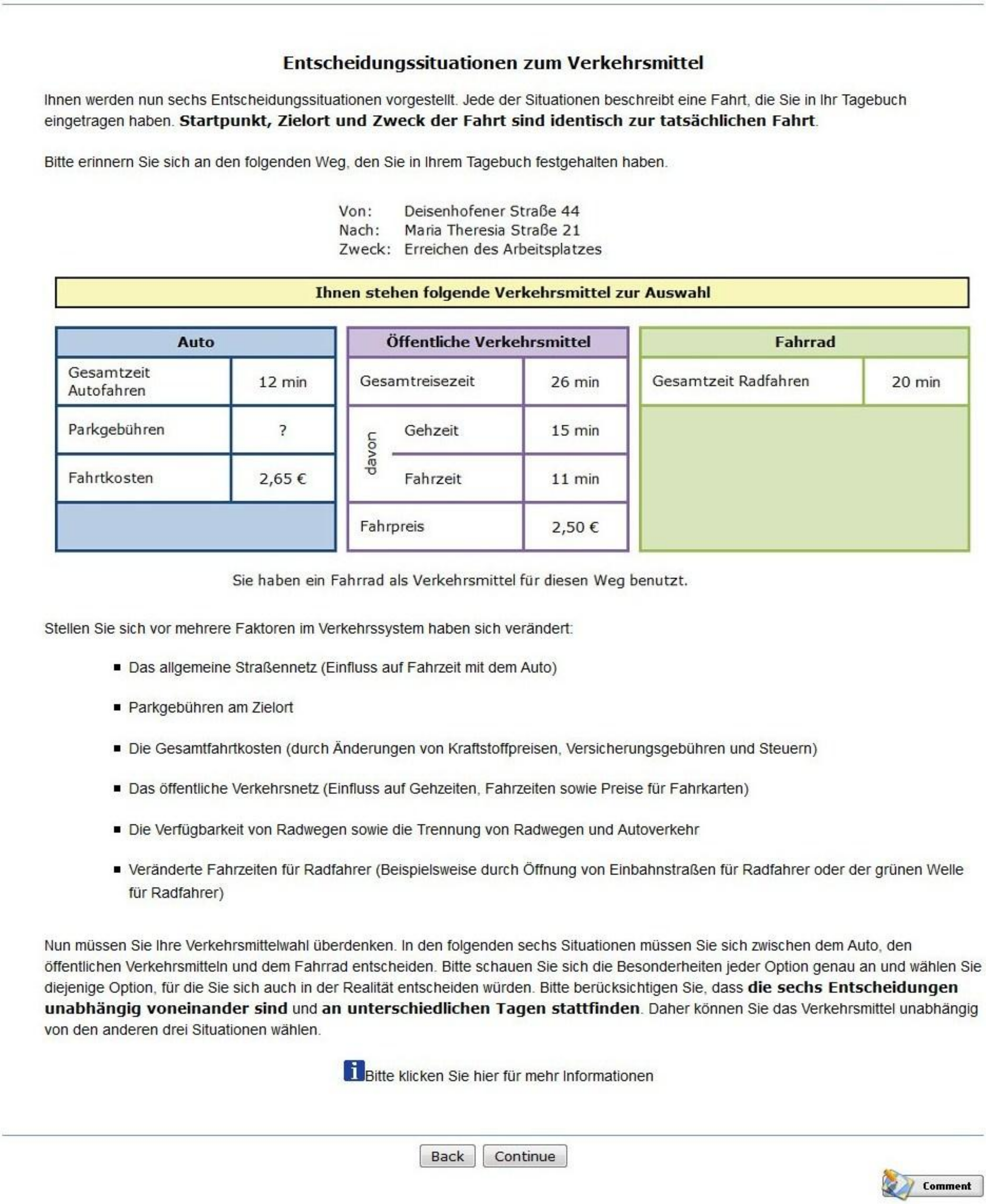
Wie wichtig sind Ihnen die folgenden Faktoren bei der Auswahl eines Verkehrsmittels?

	gar nicht wichtig				sehr wichtig
Sicherheit	○	○	○	○	○
Bequemlichkeit	○	○	○	○	○
Angemessenheit	○	○	○	○	○
Flexibilität	○	○	○	○	○
Umweltauswirkungen	○	○	○	○	○

Back Continue

Comment

The next eight slides give an example of an individualized stated choice experiment that was presented to one of the survey respondents.



Entscheidungssituationen zum Verkehrsmittel

Ihnen werden nun sechs Entscheidungssituationen vorgestellt. Jede der Situationen beschreibt eine Fahrt, die Sie in Ihr Tagebuch eingetragen haben. **Startpunkt, Zielort und Zweck der Fahrt sind identisch zur tatsächlichen Fahrt**.

Bitte erinnern Sie sich an den folgenden Weg, den Sie in Ihrem Tagebuch festgehalten haben.

Von: Deisenhofener Straße 44
Nach: Maria Theresia Straße 21
Zweck: Erreichen des Arbeitsplatzes

Ihnen stehen folgende Verkehrsmittel zur Auswahl

Auto		Öffentliche Verkehrsmittel		Fahrrad	
Gesamtzeit Autofahren	12 min	Gesamtreisezeit	26 min	Gesamtzeit Radfahren	20 min
Parkgebühren	?	Gehzeit	15 min		
Fahrtkosten	2,65 €	Fahrzeit	11 min		
		Fahrpreis	2,50 €		

Sie haben ein Fahrrad als Verkehrsmittel für diesen Weg benutzt.

Stellen Sie sich vor mehrere Faktoren im Verkehrssystem haben sich verändert:

- Das allgemeine Straßennetz (Einfluss auf Fahrzeit mit dem Auto)
- Parkgebühren am Zielort
- Die Gesamtfahrtkosten (durch Änderungen von Kraftstoffpreisen, Versicherungsgebühren und Steuern)
- Das öffentliche Verkehrsnetz (Einfluss auf Gehzeiten, Fahrzeiten sowie Preise für Fahrkarten)
- Die Verfügbarkeit von Radwegen sowie die Trennung von Radwegen und Autoverkehr
- Veränderte Fahrzeiten für Radfahrer (Beispielsweise durch Öffnung von Einbahnstraßen für Radfahrer oder der grünen Welle für Radfahrer)

Nun müssen Sie Ihre Verkehrsmittelwahl überdenken. In den folgenden sechs Situationen müssen Sie sich zwischen dem Auto, den öffentlichen Verkehrsmitteln und dem Fahrrad entscheiden. Bitte schauen Sie sich die Besonderheiten jeder Option genau an und wählen Sie diejenige Option, für die Sie sich auch in der Realität entscheiden würden. Bitte berücksichtigen Sie, dass **die sechs Entscheidungen unabhängig voneinander sind** und **an unterschiedlichen Tagen stattfinden**. Daher können Sie das Verkehrsmittel unabhängig von den anderen drei Situationen wählen.

Bitte klicken Sie hier für mehr Informationen

Back Continue

Comment

SZENARIO 1: Ihnen stehen folgende Verkehrsmittel zur Auswahl

Auto		
Gesamtzeit Autofahren		12 min
Gesamtkosten		2,65 €
davon	Parkgebühren	0,00 €
	Fahrtkosten	2,65 €

Öffentliche Verkehrsmittel		
Gesamtreisezeit		22 min
davon	Gehzeit	13 min
	Fahrzeit	9 min
Fahrpreis		2,50 €

Fahrrad		
Gesamtzeit Radfahren		20 min
davon	auf abgetrennten Fahrradwegen	4 min
	mit Autoverkehr gemischt	16 min
Verfügbarkeit von sicheren Parkplätze am Zielort		Nein

Bitte klicken Sie auf die Informationssymbole für mehr Informationen über die jeweiligen Möglichkeiten.

Welches Verkehrsmittel würden Sie in dieser Situation wählen?

○ Auto ○ Öffentliche Verkehrsmittel ○ Fahrrad

Back Continue

Comment

SZENARIO 2: Ihnen stehen folgende Verkehrsmittel zur Auswahl

Auto		
Gesamtzeit Autofahren		11 min
Gesamtkosten		4,52 €
davon	Parkgebühren	2,00 €
	Fahrtkosten	2,52 €

Öffentliche Verkehrsmittel		
Gesamtreisezeit		26 min
davon	Gehzeit	15 min
	Fahrzeit	11 min
Fahrpreis		1,80 €

Fahrrad		
Gesamtzeit Radfahren		23 min
davon	auf abgetrennten Fahrradwegen	14 min
	mit Autoverkehr gemischt	9 min
Verfügbarkeit von sicheren Parkplätze am Zielort		Ja

Bitte klicken Sie auf die Informationssymbole für mehr Informationen über die jeweiligen Möglichkeiten.

Welches Verkehrsmittel würden Sie in dieser Situation wählen?

○ Auto ○ Öffentliche Verkehrsmittel ○ Fahrrad

Back Continue

Comment

SZENARIO 3: Ihnen stehen folgende Verkehrsmittel zur Auswahl

Auto		
Gesamtzeit Autofahren		12 min
Gesamtkosten		2,52 €
davon	Parkgebühren	0,00 €
	Fahrtkosten	2,52 €

Öffentliche Verkehrsmittel		
Gesamtreisezeit		26 min
davon	Gehzeit	15 min
	Fahrzeit	11 min
Fahrpreis		2,50 €

Fahrrad		
Gesamtzeit Radfahren		20 min
davon	auf abgetrennten Fahrradwegen	16 min
	mit Autoverkehr gemischt	4 min
Verfügbarkeit von sicheren Parkplätze am Zielort		Ja

Bitte klicken Sie auf die Informationssymbole für mehr Informationen über die jeweiligen Möglichkeiten.

Welches Verkehrsmittel würden Sie in dieser Situation wählen?

○ Auto ○ Öffentliche Verkehrsmittel ○ Fahrrad

Back Continue

Comment

SZENARIO 4: Ihnen stehen folgende Verkehrsmittel zur Auswahl

Auto		
Gesamtzeit Autofahren		11 min
Gesamtkosten		4,65 €
davon	Parkgebühren	2,00 €
	Fahrtkosten	2,65 €

Öffentliche Verkehrsmittel		
Gesamtreisezeit		22 min
davon	Gehzeit	13 min
	Fahrzeit	9 min
Fahrpreis		1,80 €

Fahrrad		
Gesamtzeit Radfahren		23 min
davon	auf abgetrennten Fahrradwegen	0 min
	mit Autoverkehr gemischt	23 min
Verfügbarkeit von sicheren Parkplätze am Zielort		Nein

Bitte klicken Sie auf die Informationssymbole für mehr Informationen über die jeweiligen Möglichkeiten.

Welches Verkehrsmittel würden Sie in dieser Situation wählen?

○ Auto ○ Öffentliche Verkehrsmittel ○ Fahrrad

Back Continue

Comment

SZENARIO 5: Ihnen stehen folgende Verkehrsmittel zur Auswahl

Auto		
Gesamtzeit Autofahren		11 min
Gesamtkosten		4,52 €
davon	Parkgebühren	2,00 €
	Fahrtkosten	2,52 €

Öffentliche Verkehrsmittel		
Gesamtreisezeit		24 min
davon	Gehzeit	15 min
	Fahrzeit	9 min
Fahrpreis		1,80 €

Fahrrad		
Gesamtzeit Radfahren		23 min
davon	auf abgetrennten Fahrradwegen	9 min
	mit Autoverkehr gemischt	14 min
Verfügbarkeit von sicheren Parkplätze am Zielort		Ja

Bitte klicken Sie auf die Informationssymbole für mehr Informationen über die jeweiligen Möglichkeiten.

Welches Verkehrsmittel würden Sie in dieser Situation wählen?

○ Auto ○ Öffentliche Verkehrsmittel ○ Fahrrad

Back Continue

Comment

SZENARIO 6: Ihnen stehen folgende Verkehrsmittel zur Auswahl

Auto		
Gesamtzeit Autofahren		12 min
Gesamtkosten		2,65 €
davon	Parkgebühren	0,00 €
	Fahrtkosten	2,65 €

Öffentliche Verkehrsmittel		
Gesamtreisezeit		24 min
davon	Gehzeit	13 min
	Fahrzeit	11 min
Fahrpreis		2,50 €

Fahrrad		
Gesamtzeit Radfahren		20 min
davon	auf abgetrennten Fahrradwegen	20 min
	mit Autoverkehr gemischt	0 min
Verfügbarkeit von sicheren Parkplätze am Zielort		Nein

Bitte klicken Sie auf die Informationssymbole für mehr Informationen über die jeweiligen Möglichkeiten.

Welches Verkehrsmittel würden Sie in dieser Situation wählen?

○ Auto ○ Öffentliche Verkehrsmittel ○ Fahrrad

Back Continue

Comment

The next question was only displayed if the respondent selected the same mode of transportation for all six choice situations and this mode was the same as the mode indicated in the time-use-travel diary.

Hätten Sie ein anderes Verkehrsmittel für diesen Weg wählen können?

- Ja
- Nein

Continue

Comment

Wie alt sind Sie?

Jahre

Sind Sie....

- Männlich
- Weiblich

Back Continue

Comment

Leben Sie in Ihrem Haushalt ...

- allein
- mit Partner, Kindern oder anderen Personen
- oder leben Sie nicht in einem Privathaushalt (in einem Wohnheim, etc.)

Back Continue

Comment

Was ist Ihre derzeitige Hauptbeschäftigung?

- Berufstätige(r) - Vollzeit
- Berufstätige(r) - Teilzeit (11 bis unter 35 Stunden/ Woche)
- Auszubildende(r)
- Schüler(in)
- Student(in)
- Zurzeit arbeitslos
- Vorübergeh. freigest. (z.B. Mutterschaftsurl., Elternzeit)
- Hausfrau | Hausmann
- Rentner(in) | Pensionär(in)
- Wehr- oder Zivildienstleistende(r), Freiwilligendienst
- Andere Tätigkeit

Back Continue

Comment

Welchen höchsten allgemeinbildenden Schul-, Fachhochschul- oder Universitätsabschluss haben Sie?

- Schule beendet ohne Abschluss
- Volks- oder Hauptschulabschluss | POS 8. Klasse
- Mittlere Reife | Realschulabschluss | POS 10. Klasse
- Fachhochschulreife | Berufsausbildung mit Abitur
- Hochschulreife | Abitur | EOS 12. Klasse
- Anderer Abschluss
- Bin noch Schüler | Schülerin
- Fachhochschul- oder Universitätsabschluss

Back Continue

Comment

Wie hoch ist das monatliche Nettoeinkommen Ihres Haushalts in Euro ungefähr?
Bitte beziehen Sie alle im Haushalt verfügbaren Einkommensarten ein – also die monatliche Summe aus Lohn, Gehalt, Einkommen aus selbständiger Tätigkeit, Rente oder Pension, jeweils nach Abzug von Steuern und Sozialversicherungsbeiträgen für alle Haushaltsmitglieder. Dazu gehören auch Leistungen wie Kindergeld, Wohngeld oder Sozialhilfe oder sonstige Einkünfte.

- Bis unter 500 € pro Monat
- 500 € bis unter 900 €
- 900 € bis unter 1.500 €
- 1.500 € bis unter 2.000 €
- 2.000 € bis unter 2.600 €
- 2.600 € bis unter 3.000 €
- 3.000 € bis unter 3.600 €
- 3.600 € bis unter 4.000 €
- 4.000 € bis unter 4.600 €
- 4.600 € bis unter 5.000 €
- 5.000 € bis unter 5.600 €
- 5.600 € bis unter 6.000 €
- 6.000 € bis unter 6.600 €
- 6.600 € bis 7.000 €
- Mehr als 7.000 € pro Monat

Back Continue

Comment

Ihre Antworten wurden gespeichert. Herzlichen Dank für Ihre Teilnahme!

Sie nehmen nun an der Verlosung der Gutscheine teil.

Comment

APPENDIX E - PERSONAL QUESTIONNAIRE - ENGLISH

Personal Questionnaire

1. Please indicate how often you normally use the following modes of transportation. Please make one selection in each cross!

	(almost) Daily	1-3 days per week	1-3 days per month	Less than once a month	Never or almost never
Bicycle					
Car					
Bus, tram or train in your region					

2. How many minutes does it take to walk from your home to the nearest stations of the following modes of public transportation? Please enter the duration of your trip by foot! If two modes share a stop please enter the duration twice!

Bus Stop	_mins
Tram Station	_mins
Train Station (*U-Bahn, S-Bahn or Regional Train)*	_mins

3. (Filter: only if question 1: Bus, tram or train in your region = more often than never or almost never) Which type of ticket do you normally used when you use public transportation?

   1 Single ticket, day ticket, short ride ticket
   2 Multi-trip ticket, stripe ticket
   3 Weekly ticket, monthly ticket, monthly ticket without subscription
   4 Monthly ticket with subscription, yearly ticket (Umweltabo etc.)
   5 Job ticket, Semester ticket etc. (Firmenabo, Studententicket)
   6 Other

4. How many cars are available in your household?

   0 No car available
   1 1
   2 2
   3 3
   4 More than 3 cars

5. (Filter: only if 4 = 0) Why is there no car available in your household?

1	No car needed
2	Consciously avoid
3	Acquisition or maintenance is too expensive
4	Health reason
5	Age reason
6	Another reason

6. Do you have a driver's license?

1	Yes
2	No

7. (Filter: only if 6 = 1 and 4 > 0) How often is a car available for you to use as a driver or passenger?

1	Any time
2	Occasionally
3	Rarely
4	Never

8. (Filter: only if 4 > 0) Which class of vehicle does your car belong to? If there is more than one car in your household, enter the class of the car that you use most often.

1	Mini car (e.g. Smart Fortwo)
2	Small car (e.g. Opel Corsa)
3	Compact class (e.g. VW Golf)
4	Mid-class (e.g. Audi A4)
5	Large mid-class (e.g. BMW 5er)
6	Large class (e.g. Mercedes S-Klasse)
7	SUV (e.g. VW Tiguan)
8	Sport car (e.g. BMW Z4)
9	Van (e.g. Opel Zafira)
10	Other

9. Do you own a functioning bicycle?

1	Yes
2	No

10. When considering a mode of transportation how important are the following considerations?

Safety

Not important at all | | | | Very Important

1	2	3	4	5

Comfort

Not important at all | | | | Very Important

1	2	3	4	5

Convenience

Not important at all | | | | Very Important

1	2	3	4	5

Flexibility

Not important at all | | | | Very Important

1	2	3	4	5

Environmental Impact

Not important at all | | | | Very Important

1	2	3	4	5

11. How old are you?

12. Are you ...
    1 male
    2 female

13. Do you live in your household ...
    1 alone
    2 with a partner, children or another person
    3 or do you live household that is not private (in a dorm, etc.)

14. What is your current employment situation?
    1 Employed – full time
    2 Employed – part time (11 to less than 35 hours/week)
    3 Apprenticeship
    4 Pupil (including pre-school)
    5 Student (university or college)
    6 Currently unemployed
    7 Temporary leave (e.g. maternity leave, paternity leave)
    8 Housewife | Househusband
    9 Retiree
    10 Military or civil service, voluntary service
    11 Other
15. What level of education do you have?
    1 School without graduation
    2 Primary or secondary school
    3 Secondary school
    4 High school | Apprenticeship with graduation
    5 High school with graduation
    6 Other degree
    7 Still a student
    8 College of university degree
16. What is your household net monthly income in Euros (roughly)? Please include all types of income, including monthly wage, salary, income from self-employment, pension, child allowance, housing benefit or social assistance, and other income after deducting taxes and social security contributions for all household members.
    1 Up to 500 € per month
    2 500 € to less than 900 €
    3 900 € to less than 1,500 €
    4 1,500 € to less than 2,000 €
    5 2,000 € to less than 2,600 €
    6 2,600 € to less than 3,000 €
    7 3,000 € to less than 3,600 €
    8 3,600 € to less than 4,000 €
    9 4,000 € to less than 4,600 €
    10 4,600 € to less than 5,000 €
    11 5,000 € to less than 5,600 €
    12 5,600 € to less than 6,000 €
    13 6,000 € to less than 6,600 €
    14 6,600 € to 7,000 €
    15 More than 7,000 € per month
    97 Answer refused

APPENDIX F - STATED CHOICE EXPERIMENT – ENGLISH

The following figure is the English translation of the reference scenario that was presented to the respondents before they began the stated choice experiment

from: Uhlandstraße 15, Stephanskirchen
to: Habichtstraße 3
purpose: shopping

You had the following choice of transportation modes

Car		Public Transportation			Bicycle	
Total driving time	5 min	Total travel time		21 min	Total cycling time	13 min
Parking fee	?	of that	Walking time	10 min		
Travel costs	1.22 €		Riding time	11 min		
		Fare		2.50 €		

You used a car for this trip

The following is an English translation of a choice situation presented to one of the respondents.

SCENARIO 1: You now have the following choice of transportation modes

Car			Public Transportation			Bicycle		
Total driving time		6 min	Total travel time		18 min	Total cycling time		13 min
Total cost		3.71 €	of that	Walking time	9 min	of that	On dedicated bicycle ways	5 min
of that	Parking fee	2.00 €		Riding time	9 min		Mixed with traffic	8 min
	Travel costs	1.71 €	Fare		2.50 €	Availability of secure parking at the destination		Yes

APPENDIX G - STATED CHOICE EXPERIMENT - ADDITIONAL INFORMATION - GERMAN

As available to survey participants by clicking

Please see Appendix H for an English translation

The following information was presented when the respondent clicked on the i on the stated choice survey introduction page.

Die Informationen zur Beförderung in der Tabelle wurden auf einen der beiden Wege gesammelt:

1. Für das Verkehrsmittel, das Sie für die Fahrt in ihrem Tagebuch verwendet haben, wurde direkt der Tagebucheintrag verwendet.
2. Für weitere Verkehrsmittel, die nicht in Ihrem Tagebuch verwendet wurden, wurden die Start- und Zieladresse für eine annäherungsweise Wahl der Verkehrsmittel verwendet.

   Die Option Auto wurde mit Google maps (© Google) entwickelt. Die schnellste Route sowie die Fahrstrecke und –zeit wurden ermittelt.

   Die Option öffentliche Verkehrsmittel wurde mit dem Webtool für Fahrplanauskünfte des Münchner Verkehrs- und Tarifverbunds entwickelt. ((http://www.mvv-muenchen.de/de/home/fahrgastinformation/index.html). Die Fahrstrecken, Start- und Zielorte sowie Startzeiten aus Ihrem Tagebuch wurden in die Fahrplanauskunft eingegeben. Bei mehreren möglichen Optionen wurde für die Auswertung die Schnellste ausgewählt.

   Die Option Fahrrad wurde mit Google maps (© Google) entwickelt. Eine Fahrzeit basierend auf einer Durchschnittsgeschwindigkeit von 12 km/h (inklusive Anhalten, Ampeln etc.) und der kürzesten Strecke zwischen Start- und Zielort wurde verwendet.

The following information was presented when the respondent clicked on the i under the public transportation option.

Merkmal: Option öffentliche Verkehrsmittel

Die Option öffentliche Verkehrsmittel wurde mit dem Webtool für Fahrplanauskünfte des Münchner Verkehrs- und Tarifverbund entwickelt (http://www.mvv-muenchen.de/de/home/fahrgastinformation/index.html). Die Fahrstrecken, Start- und Zielorte sowie Startzeiten aus Ihrem Tagebuch wurden in die Fahrplanauskunft eingegeben. Bei mehreren möglichen Optionen wurde für die Auswertung die Schnellste ausgewählt. Die gesamte Gehzeit, Fahrzeit, die Anzahl der Umstiege und der Fahrpreis wurden für experimentelle Zwecke angepasst.

Gesamtgehzeit:

Die Gesamtgehzeit entspricht der Summe der Gehzeiten von Ihrem Startort zur verwendeten Haltestelle sowie der Gehzeit von der Zielhaltestelle zum Zielort.

Gesamtfahrzeit:

Dies ist die gesamte Fahrzeit die mit verschiedenen öffentlichen Verkehrsmitteln gefahren wurde (U-Bahn, Bus, Tram, S-Bahn).

Fahrpreis:

Der Fahrpreis entspricht der MVV Einzelfahrt für die von Ihnen angegebene Strecke.

The following information was presented when the respondent clicked on the i under the car option.

Merkmal: Option Auto

Gesamtzeit Autofahren:

Die Fahrzeit wurde anhand des Start- und Zielortes ihres Tagebuchs ermittelt. Falls Sie keine Autostrecke angegeben hatten, wurde Google directions (© Google) verwendet um eine geschätzte Fahrzeit zu erhalten. Für experimentelle Zwecke wurde diese Fahrzeit angepasst.

Parkgebühren:

Die hier ausgewiesen Parkgebühren sind die Gesamtkosten, die Sie an Ihrem Bestimmungsort während der Dauer Ihres Aufenthaltes zu bezahlen hätten.

Fahrtkosten:

Die Gesamtbetriebskosten wurden anhand der Strecke und der vom ADAC ermittelten Durchschnittskosten von 53 Cent pro Kilometer errechnet (ADAC Autokosten 2011). Dieser Durchschnittswert wurde aus über 1500 Fahrzeugtypen ermittelt. Weitere Informationen hierzu finden Sie im entsprechenden Bericht des ADAC (http://www.adac.de/_mm/pdf /autokostenuebersicht_47085.pdf).

The following information was presented when the respondent clicked on the button under the bicycle option.

Merkmal: Option Fahrrad

Gesamtzeit Radfahren:

Die Fahrtzeit mit dem Fahrrad wurde auf eine von zwei Arten ermittelt:

1) Die von Ihnen im Tagebuch angegebene Fahrzeit mit dem Fahrrad wurde verwendet

2) Eine Fahrzeit basierend auf einer Durchschnittsgeschwindigkeit von 12 km/h (inklusive Anhalten, Ampeln etc.) und der kürzesten Strecke zwischen Start- und Zielort, die mit Google maps (© Google) ermittelt wurde, wurde verwendet.

Anmerkung: Wenn die angegebene Fahrzeit mit dem Fahrrad in der neuen Situation kürzer ist als in der Realität, stellen Sie sich vor, dass Verbesserungen für einen schnelleren Fahrradverkehr vorgenommen wurden. Beispiele für derartige Verbesserungen beinhalten die Synchronisation von Ampeln, um Radfahrern ein Fahren ohne Anhalten zu ermöglichen und die Öffnung von Einbahnstraßen für Radfahrer.

davon auf abgetrennten Fahrradwege:

Hierbei handelt es sich um die Minuten, die Ihre neue Fahrstrecke entweder auf speziell markierten oder räumlich vom restlichen Verkehr getrennten Fahrradwegen stattfinden würde. Dort wo keine markierten oder ausgewiesenen Fahrradwege sind, müssen sich Radfahrer ihren Weg mit anderen Verkehrsteilnehmern (Autos, Straßenbahnen, Fußgänger, etc.) teilen.

Beispiele für Gehsteigmarkierungen sind:

Quelle: Blue Europe (http://blueeurope.blogspot.com/

Quelle: Hamburgize.com (http://hamburgize.blogspot.com

Beispiele für räumlich getrennte Radwege sind:

Quelle: District Citzens Cycling (http://dccycling.blogspot.com)

Quelle: Velo-city (©Thomas Hasan)

Verfügbarkeit von sicheren Parkplätzen am Zielort:

Eine sichere Parkmöglichkeit für Fahrräder beinhaltet Einrichtungen, die speziell für das Abstellen von Fahrrädern errichtet wurden und ein sicheres Anschließen von Rädern ermöglicht. Beispiele sind: Fahrradständer, überdachte Fahrradständer und Fahrrad Parkhäuser. Wenn kein ausgewiesener Abstellplatz für Fahrräder vorgesehen ist, müssen Radfahrer Ihr Rad an einer freien Stelle abstellen.

APPENDIX H - STATED CHOICE EXPERIMENT - ADDITIONAL INFORMATION - ENGLISH

The following information was presented when the respondent clicked on the i button on the stated choice survey introduction page.

The transportation information presented in the table was collected in one of two ways:

1 For the mode that was used for the trip in your trip diary, the information was taken directly from the diary.

2 For the alternative modes that were not used in your trip diary, the start and end addresses provided in your diary were used to estimate the characteristics of the modes. This was done using different methods for the three modes.

   a. The car option was developed using Google maps (© Google). The fastest route was selected and the distance and trip duration given by Google maps was used.

   b. The public transportation option was developed with the trip planning web tool provided by the MVV (Münchner Verkehrs- und Tarifverbund- http://www.mvvmuenchen.de/de/home/fahrgastinformation/index.html). The start location and end location as well as the start time indicated in your time-use-travel diary were entered into the trip planning tool. When more than one option was given by the web tool, the fastest option was selected.

   c. The bicycle option was developed using Google maps (© Google). The travel time was based on an average speed of 12 km/h (including stops, traffic lights, etc.) and the shorted route between the start and end location was selected.

The following information was presented when the respondent clicked on the i button under the bicycle option.

Additional Information: Bicycle Option

Total time cycling:
The time cycling was calculated in one of two ways:

1) If a bicycle was used for the trip reported in the time-use-travel dairy, the travel time reported in the diary was used.
2) For trips not made by a bicycle in the time-use-travel diary, a travel time based on an average speed of 12 km/h (including stops, traffic lights, etc.) and the shortest route between the start and end locations indicated by Google maps (© Google) was used.

Note: If the given bicycle travel is shorter than that experienced in reality, imagine that improvements were made to increase the average speed of bicycle transportation. Examples of such improvement include the synchronization of traffic lights for bicycles to allow cyclists to travel without stopping, or the opening of one-way streets for bicycle traffic in both directions.

Percentage of bicycle trip on designated bicycle infrastructure:

This is the percentage of your new bicycle trip that will take place either on a marked or physically separated bicycle way. Where no designated bicycle ways exist, cyclists must share the road or sidewalk with other users (cars, trams, pedestrians, etc.).

Examples of marked bicycle ways:

Source: Blue Europe (http://blueeurope.blogspot.com/

Source: Hamburgize.com (http://hamburgize.blogspot.com

Examples for physically separated bicycle ways:

Source: District Citzens Cycling (http://dccycling.blogspot.com)

Source: Velo-city (©Thomas Hasan)

Availability of secure parking at the destination:
Secure parking for bicycles includes facilities that were built specifically for parking bicycles and allow for the secure and safe locking of a bicycle. Examples of secure bicycle parking include bicycle racks, covered bicycle racks and bicycle parking houses. If no designated parking area is provided for bicycles, cyclists have to park their bicycles in public space (i.e. on a pole or fence).

The following information was presented when the respondent clicked on the i button under the public transportation option.

Additional Information: Public Transportation Option

The public transportation option was developed with the trip planning web tool provided by the MVV (Münchner Verkehrs- und Tarifverbund http://www.mvvmuenchen.de/de/home/fahrgastinformation /index.html). The start location and end location as well as the start time indicated in your time-use-travel diary were entered into the trip planning tool. When more than one option was given by the web tool, the fastest option was selected. The total walking time, travel time and the fare were adjusted for experimental purpose.

Total walking time:
The total walking time is the sum of the walking time from your house to the beginning public transportation stop and the time from the end public transportation stop to your destination.

Total travel time:
This is the time spent travelling on one or more public transportation mode (U-Bahn, Bus, Tram, and S-Bahn).

Fare:
The price corresponds to the MVV single ticket for the route you travelled.

The following information was presented when the respondent clicked on the i button under the car option.

Additional Information: Car Option

Total travel time:

If a car was used in the trip recorded in your one day diary, the travel time was taken from your diary. If the recorded trip was made using a different mode of transportation, the travel time was estimated using you start and end addresses and Google maps (© Google). The travel time was then adjusted for experimental purpose.

Parking fee:

The parking fee shown is the amount you would have to pay to park your vehicle for your entire stay at your destination.

Travel cost:

The total travel cost of the trip was estimated using an average cost of 53 cents per kilometre, which was calculated by ADAC (ADAC Autokosten 2011). This average was calculated from data from over 1500 vehicles in Germany. For more information please see the report prepared by the ADAC (http://www.adac.de/_mm/pdf/autokostenuebersicht_47085.pdf).

APPENDIX I – EXPERIMENTAL DESIGN

Respondent	Original Mode	Choice Situation	Car Attributes			Public Transport Attribute			Bicycle Attributes		
			Travel Time	Parking Fee	Travel Cost	Access Time	Travel Time	Fare	Travel Time	% Bicycle Infrastructure	Secure Parking
1	Bicycle	2	-10%	2.00 €	-5%	0%	0%	-30%	+15%	60%	1
	Bicycle	4	-10%	2.00 €	0%	-15%	-20%	-30%	+15%	0%	0
	Bicycle	6	0%	0.00 €	0%	-15%	0%	0%	0%	100%	0
	Bicycle	5	-10%	2.00 €	-5%	0%	-20%	-30%	+15%	40%	1
	Bicycle	3	0%	0.00 €	-5%	0%	0%	0%	0%	80%	1
	Bicycle	1	0%	0.00 €	0%	-15%	-20%	0%	0%	20%	0
3	Bicycle	6	0%	0.00 €	0%	-15%	0%	0%	0%	100%	0
	Bicycle	5	-10%	2.00 €	-5%	0%	-20%	-30%	+15%	40%	1
	Bicycle	3	0%	0.00 €	-5%	0%	0%	0%	0%	80%	1
	Bicycle	1	0%	0.00 €	0%	-15%	-20%	0%	0%	20%	0
	Bicycle	4	-10%	2.00 €	0%	-15%	-20%	-30%	+15%	0%	0
	Bicycle	2	-10%	2.00 €	-5%	0%	0%	-30%	+15%	60%	1
4	Bicycle	6	0%	0.00 €	0%	-15%	0%	0%	0%	100%	0
	Bicycle	5	-10%	2.00 €	-5%	0%	-20%	-30%	+15%	40%	1
	Bicycle	1	0%	0.00 €	0%	-15%	-20%	0%	0%	20%	0
	Bicycle	2	-10%	2.00 €	-5%	0%	0%	-30%	+15%	60%	1
	Bicycle	3	0%	0.00 €	-5%	0%	0%	0%	0%	80%	1
	Bicycle	4	-10%	2.00 €	0%	-15%	-20%	-30%	+15%	0%	0
5	Bicycle	1	0%	0.00 €	0%	-15%	-20%	0%	0%	20%	0
	Bicycle	3	0%	0.00 €	-5%	0%	0%	0%	0%	80%	1
	Bicycle	6	0%	0.00 €	0%	-15%	0%	0%	0%	100%	0
	Bicycle	2	-10%	2.00 €	-5%	0%	0%	-30%	+15%	60%	1
	Bicycle	5	-10%	2.00 €	-5%	0%	-20%	-30%	+15%	40%	1
	Bicycle	4	-10%	2.00 €	0%	-15%	-20%	-30%	+15%	0%	0
6	Bicycle	4	-10%	2.00 €	0%	-15%	-20%	-30%	+15%	0%	0
	Bicycle	3	0%	0.00 €	-5%	0%	0%	0%	0%	80%	1
	Bicycle	2	-10%	2.00 €	-5%	0%	0%	-30%	+15%	60%	1
	Bicycle	6	0%	0.00 €	0%	-15%	0%	0%	0%	100%	0
	Bicycle	1	0%	0.00 €	0%	-15%	-20%	0%	0%	20%	0
	Bicycle	5	-10%	2.00 €	-5%	0%	-20%	-30%	+15%	40%	1

Respondent	Original Mode	Choice Situation	Car Attributes			Public Transport Attribute			Bicycle Attributes		
			Travel Time	Parking Fee	Travel Cost	Access Time	Travel Time	Fare	Travel Time	% Bicycle Infrastructure	Secure Parking
7	Car	5	0%	5.00 €	+40%	0%	0%	-30%	-15%	80%	0
	Car	3	+25%	2.00 €	0%	0%	-20%	-30%	0%	60%	1
	Car	6	+25%	5.00 €	0%	-15%	0%	0%	-15%	0%	0
	Car	4	0%	2.00 €	+40%	0%	0%	0%	-15%	20%	1
	Car	1	0%	2.00 €	+40%	-15%	-20%	0%	0%	40%	1
	Car	2	+25%	5.00 €	0%	-15%	-20%	-30%	0%	100%	0
8	Bicycle	2	-10%	2.00 €	-5%	0%	0%	-30%	+15%	60%	1
	Bicycle	5	-10%	2.00 €	-5%	0%	-20%	-30%	+15%	40%	1
	Bicycle	4	-10%	2.00 €	0%	-15%	-20%	-30%	+15%	0%	0
	Bicycle	1	0%	0.00 €	0%	-15%	-20%	0%	0%	20%	0
	Bicycle	3	0%	0.00 €	-5%	0%	0%	0%	0%	80%	1
	Bicycle	6	0%	0.00 €	0%	-15%	0%	0%	0%	100%	0
9	Bicycle	6	0%	0.00 €	0%	-15%	0%	0%	0%	100%	0
	Bicycle	4	-10%	2.00 €	0%	-15%	-20%	-30%	+15%	0%	0
	Bicycle	2	-10%	2.00 €	-5%	0%	0%	-30%	+15%	60%	1
	Bicycle	3	0%	0.00 €	-5%	0%	0%	0%	0%	80%	1
	Bicycle	5	-10%	2.00 €	-5%	0%	-20%	-30%	+15%	40%	1
	Bicycle	1	0%	0.00 €	0%	-15%	-20%	0%	0%	20%	0
10	Bicycle	5	-10%	2.00 €	-5%	0%	-20%	-30%	+15%	40%	1
	Bicycle	6	0%	0.00 €	0%	-15%	0%	0%	0%	100%	0
	Bicycle	1	0%	0.00 €	0%	-15%	-20%	0%	0%	20%	0
	Bicycle	4	-10%	2.00 €	0%	-15%	-20%	-30%	+15%	0%	0
	Bicycle	2	-10%	2.00 €	-5%	0%	0%	-30%	+15%	60%	1
	Bicycle	3	0%	0.00 €	-5%	0%	0%	0%	0%	80%	1
11	Bicycle	3	0%	0.00 €	-5%	0%	0%	0%	0%	80%	1
	Bicycle	2	-10%	2.00 €	-5%	0%	0%	-30%	+15%	60%	1
	Bicycle	6	0%	0.00 €	0%	-15%	0%	0%	0%	100%	0
	Bicycle	1	0%	0.00 €	0%	-15%	-20%	0%	0%	20%	0
	Bicycle	5	-10%	2.00 €	-5%	0%	-20%	-30%	+15%	40%	1
	Bicycle	4	-10%	2.00 €	0%	-15%	-20%	-30%	+15%	0%	0

Respondent	Original Mode	Choice Situation	Car Attributes			Public Transport Attribute			Bicycle Attributes		
			Travel Time	Parking Fee	Travel Cost	Access Time	Travel Time	Fare	Travel Time	% Bicycle Infrastructure	Secure Parking
12	Public Transportation	6	0%	0.00 €	0%	0%	+10%	20%	0%	60%	1
	Public Transportation	3	-10%	2.00 €	0%	0%	0%	20%	0%	80%	0
	Public Transportation	5	-10%	2.00 €	-5%	+30%	+10%	0%	-15%	100%	0
	Public Transportation	1	-10%	0.00 €	-5%	0%	0%	20%	0%	0%	1
	Public Transportation	2	0%	0.00 €	-5%	+30%	+10%	0%	-15%	40%	1
	Public Transportation	4	0%	2.00 €	0%	+30%	0%	0%	-15%	20%	0
13	Public Transportation	3	-10%	2.00 €	0%	0%	0%	20%	0%	80%	0
	Public Transportation	2	0%	0.00 €	-5%	+30%	+10%	0%	-15%	40%	1
	Public Transportation	5	-10%	2.00 €	-5%	+30%	+10%	0%	-15%	100%	0
	Public Transportation	1	-10%	0.00 €	-5%	0%	0%	20%	0%	0%	1
	Public Transportation	4	0%	2.00 €	0%	+30%	0%	0%	-15%	20%	0
	Public Transportation	6	0%	0.00 €	0%	0%	+10%	20%	0%	60%	1
14	Public Transportation	1	-10%	0.00 €	-5%	0%	0%	20%	0%	0%	1
	Public Transportation	4	0%	2.00 €	0%	+30%	0%	0%	-15%	20%	0
	Public Transportation	6	0%	0.00 €	0%	0%	+10%	20%	0%	60%	1
	Public Transportation	3	-10%	2.00 €	0%	0%	0%	20%	0%	80%	0
	Public Transportation	2	0%	0.00 €	-5%	+30%	+10%	0%	-15%	40%	1
	Public Transportation	5	-10%	2.00 €	-5%	+30%	+10%	0%	-15%	100%	0
15	Bicycle	3	0%	0.00 €	-5%	0%	0%	0%	0%	80%	1
	Bicycle	6	0%	0.00 €	0%	-15%	0%	0%	0%	100%	0
	Bicycle	1	0%	0.00 €	0%	-15%	-20%	0%	0%	20%	0
	Bicycle	4	-10%	2.00 €	0%	-15%	-20%	-30%	+15%	0%	0
	Bicycle	2	-10%	2.00 €	-5%	0%	0%	-30%	+15%	60%	1
	Bicycle	5	-10%	2.00 €	-5%	0%	-20%	-30%	+15%	40%	1
16	Bicycle	1	0%	0.00 €	0%	-15%	-20%	0%	0%	20%	0
	Bicycle	6	0%	0.00 €	0%	-15%	0%	0%	0%	100%	0
	Bicycle	5	-10%	2.00 €	-5%	0%	-20%	-30%	+15%	40%	1
	Bicycle	3	0%	0.00 €	-5%	0%	0%	0%	0%	80%	1
	Bicycle	2	-10%	2.00 €	-5%	0%	0%	-30%	+15%	60%	1
	Bicycle	4	-10%	2.00 €	0%	-15%	-20%	-30%	+15%	0%	0

Respondent	Original Mode	Choice Situation	Car Attributes			Public Transport Attribute			Bicycle Attributes		
			Travel Time	Parking Fee	Travel Cost	Access Time	Travel Time	Fare	Travel Time	% Bicycle Infrastructure	Secure Parking
17	Bicycle	6	0%	0.00 €	0%	-15%	0%	0%	0%	100%	0
	Bicycle	3	0%	0.00 €	-5%	0%	0%	0%	0%	80%	1
	Bicycle	4	-10%	2.00 €	0%	-15%	-20%	-30%	+15%	0%	0
	Bicycle	1	0%	0.00 €	0%	-15%	-20%	0%	0%	20%	0
	Bicycle	5	-10%	2.00 €	-5%	0%	-20%	-30%	+15%	40%	1
	Bicycle	2	-10%	2.00 €	-5%	0%	0%	-30%	+15%	60%	1
18	Bicycle	3	0%	0.00 €	-5%	0%	0%	0%	0%	80%	1
	Bicycle	6	0%	0.00 €	0%	-15%	0%	0%	0%	100%	0
	Bicycle	5	-10%	2.00 €	-5%	0%	-20%	-30%	+15%	40%	1
	Bicycle	1	0%	0.00 €	0%	-15%	-20%	0%	0%	20%	0
	Bicycle	2	-10%	2.00 €	-5%	0%	0%	-30%	+15%	60%	1
	Bicycle	4	-10%	2.00 €	0%	-15%	-20%	-30%	+15%	0%	0
20	Bicycle	1	0%	0.00 €	0%	-15%	-20%	0%	0%	20%	0
	Bicycle	2	-10%	2.00 €	-5%	0%	0%	-30%	+15%	60%	1
	Bicycle	3	0%	0.00 €	-5%	0%	0%	0%	0%	80%	1
	Bicycle	4	-10%	2.00 €	0%	-15%	-20%	-30%	+15%	0%	0
	Bicycle	5	-10%	2.00 €	-5%	0%	-20%	-30%	+15%	40%	1
	Bicycle	6	0%	0.00 €	0%	-15%	0%	0%	0%	100%	0
21	Public Transportation	4	0%	2.00 €	0%	+30%	0%	0%	-15%	20%	0
	Public Transportation	5	-10%	2.00 €	-5%	+30%	+10%	0%	-15%	100%	0
	Public Transportation	1	-10%	0.00 €	-5%	0%	0%	20%	0%	0%	1
	Public Transportation	6	0%	0.00 €	0%	0%	+10%	20%	0%	60%	1
	Public Transportation	2	0%	0.00 €	-5%	+30%	+10%	0%	-15%	40%	1
	Public Transportation	3	-10%	2.00 €	0%	0%	0%	20%	0%	80%	0
22	Bicycle	6	0%	0.00 €	0%	-15%	0%	0%	0%	100%	0
	Bicycle	5	-10%	2.00 €	-5%	0%	-20%	-30%	+15%	40%	1
	Bicycle	2	-10%	2.00 €	-5%	0%	0%	-30%	+15%	60%	1
	Bicycle	3	0%	0.00 €	-5%	0%	0%	0%	0%	80%	1
	Bicycle	1	0%	0.00 €	0%	-15%	-20%	0%	0%	20%	0
	Bicycle	4	-10%	2.00 €	0%	-15%	-20%	-30%	+15%	0%	0

Respondent	Original Mode	Choice Situation	Car Attributes			Public Transport Attribute			Bicycle Attributes		
			Travel Time	Parking Fee	Travel Cost	Access Time	Travel Time	Fare	Travel Time	% Bicycle Infrastructure	Secure Parking
23	Public Transportation	3	-10%	2.00 €	0%	0%	0%	20%	0%	80%	0
	Public Transportation	2	0%	0.00 €	-5%	+30%	+10%	0%	-15%	40%	1
	Public Transportation	1	-10%	0.00 €	-5%	0%	0%	20%	0%	0%	1
	Public Transportation	4	0%	2.00 €	0%	+30%	0%	0%	-15%	20%	0
	Public Transportation	6	0%	0.00 €	0%	0%	+10%	20%	0%	60%	1
	Public Transportation	5	-10%	2.00 €	-5%	+30%	+10%	0%	-15%	100%	0
24	Bicycle	2	-10%	2.00 €	-5%	0%	0%	-30%	+15%	60%	1
	Bicycle	6	0%	0.00 €	0%	-15%	0%	0%	0%	100%	0
	Bicycle	3	0%	0.00 €	-5%	0%	0%	0%	0%	80%	1
	Bicycle	5	-10%	2.00 €	-5%	0%	-20%	-30%	+15%	40%	1
	Bicycle	1	0%	0.00 €	0%	-15%	-20%	0%	0%	20%	0
	Bicycle	4	-10%	2.00 €	0%	-15%	-20%	-30%	+15%	0%	0
25	Car	5	0%	5.00 €	+40%	0%	0%	-30%	-15%	80%	0
	Car	4	0%	2.00 €	+40%	0%	0%	0%	-15%	20%	1
	Car	6	+25%	5.00 €	0%	-15%	0%	0%	-15%	0%	0
	Car	3	+25%	2.00 €	0%	0%	-20%	-30%	0%	60%	1
	Car	2	+25%	5.00 €	0%	-15%	-20%	-30%	0%	100%	0
	Car	1	0%	2.00 €	+40%	-15%	-20%	0%	0%	40%	1
27	Bicycle	6	0%	0.00 €	0%	-15%	0%	0%	0%	100%	0
	Bicycle	2	-10%	2.00 €	-5%	0%	0%	-30%	+15%	60%	1
	Bicycle	4	-10%	2.00 €	0%	-15%	-20%	-30%	+15%	0%	0
	Bicycle	3	0%	0.00 €	-5%	0%	0%	0%	0%	80%	1
	Bicycle	1	0%	0.00 €	0%	-15%	-20%	0%	0%	20%	0
	Bicycle	5	-10%	2.00 €	-5%	0%	-20%	-30%	+15%	40%	1
28	Bicycle	2	-10%	2.00 €	-5%	0%	0%	-30%	+15%	60%	1
	Bicycle	4	-10%	2.00 €	0%	-15%	-20%	-30%	+15%	0%	0
	Bicycle	5	-10%	2.00 €	-5%	0%	-20%	-30%	+15%	40%	1
	Bicycle	3	0%	0.00 €	-5%	0%	0%	0%	0%	80%	1
	Bicycle	6	0%	0.00 €	0%	-15%	0%	0%	0%	100%	0
	Bicycle	1	0%	0.00 €	0%	-15%	-20%	0%	0%	20%	0

Respondent	Original Mode	Choice Situation	Car Attributes			Public Transport Attribute			Bicycle Attributes		
			Travel Time	Parking Fee	Travel Cost	Access Time	Travel Time	Fare	Travel Time	% Bicycle Infrastructure	Secure Parking
29	Bicycle	2	-10%	2.00 €	-5%	0%	0%	-30%	+15%	60%	1
	Bicycle	5	-10%	2.00 €	-5%	0%	-20%	-30%	+15%	40%	1
	Bicycle	1	0%	0.00 €	0%	-15%	-20%	0%	0%	20%	0
	Bicycle	4	-10%	2.00 €	0%	-15%	-20%	-30%	+15%	0%	0
	Bicycle	3	0%	0.00 €	-5%	0%	0%	0%	0%	80%	1
	Bicycle	6	0%	0.00 €	0%	-15%	0%	0%	0%	100%	0
30	Bicycle	3	0%	0.00 €	-5%	0%	0%	0%	0%	80%	1
	Bicycle	4	-10%	2.00 €	0%	-15%	-20%	-30%	+15%	0%	0
	Bicycle	5	-10%	2.00 €	-5%	0%	-20%	-30%	+15%	40%	1
	Bicycle	6	0%	0.00 €	0%	-15%	0%	0%	0%	100%	0
	Bicycle	1	0%	0.00 €	0%	-15%	-20%	0%	0%	20%	0
	Bicycle	2	-10%	2.00 €	-5%	0%	0%	-30%	+15%	60%	1
31	Public Transportation	4	0%	2.00 €	0%	+30%	0%	0%	-15%	20%	0
	Public Transportation	1	-10%	0.00 €	-5%	0%	0%	20%	0%	0%	1
	Public Transportation	6	0%	0.00 €	0%	0%	+10%	20%	0%	60%	1
	Public Transportation	5	-10%	2.00 €	-5%	+30%	+10%	0%	-15%	100%	0
	Public Transportation	2	0%	0.00 €	-5%	+30%	+10%	0%	-15%	40%	1
	Public Transportation	3	-10%	2.00 €	0%	0%	0%	20%	0%	80%	0
32	Public Transportation	5	-10%	2.00 €	-5%	+30%	+10%	0%	-15%	100%	0
	Public Transportation	4	0%	2.00 €	0%	+30%	0%	0%	-15%	20%	0
	Public Transportation	6	0%	0.00 €	0%	0%	+10%	20%	0%	60%	1
	Public Transportation	3	-10%	2.00 €	0%	0%	0%	20%	0%	80%	0
	Public Transportation	1	-10%	0.00 €	-5%	0%	0%	20%	0%	0%	1
	Public Transportation	2	0%	0.00 €	-5%	+30%	+10%	0%	-15%	40%	1
33	Car	5	0%	5.00 €	+40%	0%	0%	-30%	-15%	80%	0
	Car	3	+25%	2.00 €	0%	0%	-20%	-30%	0%	60%	1
	Car	2	+25%	5.00 €	0%	-15%	-20%	-30%	0%	100%	0
	Car	4	0%	2.00 €	+40%	0%	0%	0%	-15%	20%	1
	Car	6	+25%	5.00 €	0%	-15%	0%	0%	-15%	0%	0
	Car	1	0%	2.00 €	+40%	-15%	-20%	0%	0%	40%	1

Respondent	Original Mode	Choice Situation	Car Attributes			Public Transport Attribute			Bicycle Attributes		
			Travel Time	Parking Fee	Travel Cost	Access Time	Travel Time	Fare	Travel Time	% Bicycle Infrastructure	Secure Parking
34	Bicycle	5	-10%	2.00 €	-5%	0%	-20%	-30%	+15%	40%	1
	Bicycle	2	-10%	2.00 €	-5%	0%	0%	-30%	+15%	60%	1
	Bicycle	6	0%	0.00 €	0%	-15%	0%	0%	0%	100%	0
	Bicycle	3	0%	0.00 €	-5%	0%	0%	0%	0%	80%	1
	Bicycle	1	0%	0.00 €	0%	-15%	-20%	0%	0%	20%	0
	Bicycle	4	-10%	2.00 €	0%	-15%	-20%	-30%	+15%	0%	0
35	Bicycle	4	-10%	2.00 €	0%	-15%	-20%	-30%	+15%	0%	0
	Bicycle	2	-10%	2.00 €	-5%	0%	0%	-30%	+15%	60%	1
	Bicycle	1	0%	0.00 €	0%	-15%	-20%	0%	0%	20%	0
	Bicycle	6	0%	0.00 €	0%	-15%	0%	0%	0%	100%	0
	Bicycle	5	-10%	2.00 €	-5%	0%	-20%	-30%	+15%	40%	1
	Bicycle	3	0%	0.00 €	-5%	0%	0%	0%	0%	80%	1
36	Public Transportation	4	0%	2.00 €	0%	+30%	0%	0%	-15%	20%	0
	Public Transportation	6	0%	0.00 €	0%	0%	+10%	20%	0%	60%	1
	Public Transportation	5	-10%	2.00 €	-5%	+30%	+10%	0%	-15%	100%	0
	Public Transportation	3	-10%	2.00 €	0%	0%	0%	20%	0%	80%	0
	Public Transportation	2	0%	0.00 €	-5%	+30%	+10%	0%	-15%	40%	1
	Public Transportation	1	-10%	0.00 €	-5%	0%	0%	20%	0%	0%	1
37	Car	5	0%	5.00 €	+40%	0%	0%	-30%	-15%	80%	0
	Car	2	+25%	5.00 €	0%	-15%	-20%	-30%	0%	100%	0
	Car	6	+25%	5.00 €	0%	-15%	0%	0%	-15%	0%	0
	Car	4	0%	2.00 €	+40%	0%	0%	0%	-15%	20%	1
	Car	1	0%	2.00 €	+40%	-15%	-20%	0%	0%	40%	1
	Car	3	+25%	2.00 €	0%	0%	-20%	-30%	0%	60%	1
38	Public Transportation	3	-10%	2.00 €	0%	0%	0%	20%	0%	80%	0
	Public Transportation	6	0%	0.00 €	0%	0%	+10%	20%	0%	60%	1
	Public Transportation	1	-10%	0.00 €	-5%	0%	0%	20%	0%	0%	1
	Public Transportation	4	0%	2.00 €	0%	+30%	0%	0%	-15%	20%	0
	Public Transportation	2	0%	0.00 €	-5%	+30%	+10%	0%	-15%	40%	1
	Public Transportation	5	-10%	2.00 €	-5%	+30%	+10%	0%	-15%	100%	0

Respondent	Original Mode	Choice Situation	Car Attributes			Public Transport Attribute			Bicycle Attributes		
			Travel Time	Parking Fee	Travel Cost	Access Time	Travel Time	Fare	Travel Time	% Bicycle Infrastructure	Secure Parking
39	Bicycle	4	-10%	2.00 €	0%	-15%	-20%	-30%	+15%	0%	0
	Bicycle	1	0%	0.00 €	0%	-15%	-20%	0%	0%	20%	0
	Bicycle	3	0%	0.00 €	-5%	0%	0%	0%	0%	80%	1
	Bicycle	2	-10%	2.00 €	-5%	0%	0%	-30%	+15%	60%	1
	Bicycle	6	0%	0.00 €	0%	-15%	0%	0%	0%	100%	0
	Bicycle	5	-10%	2.00 €	-5%	0%	-20%	-30%	+15%	40%	1
40	Public Transportation	6	0%	0.00 €	0%	0%	+10%	20%	0%	60%	1
	Public Transportation	2	0%	0.00 €	-5%	+30%	+10%	0%	-15%	40%	1
	Public Transportation	5	-10%	2.00 €	-5%	+30%	+10%	0%	-15%	100%	0
	Public Transportation	1	-10%	0.00 €	-5%	0%	0%	20%	0%	0%	1
	Public Transportation	4	0%	2.00 €	0%	+30%	0%	0%	-15%	20%	0
	Public Transportation	3	-10%	2.00 €	0%	0%	0%	20%	0%	80%	0
41	Public Transportation	6	0%	0.00 €	0%	0%	+10%	20%	0%	60%	1
	Public Transportation	5	-10%	2.00 €	-5%	+30%	+10%	0%	-15%	100%	0
	Public Transportation	2	0%	0.00 €	-5%	+30%	+10%	0%	-15%	40%	1
	Public Transportation	3	-10%	2.00 €	0%	0%	0%	20%	0%	80%	0
	Public Transportation	1	-10%	0.00 €	-5%	0%	0%	20%	0%	0%	1
	Public Transportation	4	0%	2.00 €	0%	+30%	0%	0%	-15%	20%	0
42	Public Transportation	1	-10%	0.00 €	-5%	0%	0%	20%	0%	0%	1
	Public Transportation	4	0%	2.00 €	0%	+30%	0%	0%	-15%	20%	0
	Public Transportation	2	0%	0.00 €	-5%	+30%	+10%	0%	-15%	40%	1
	Public Transportation	6	0%	0.00 €	0%	0%	+10%	20%	0%	60%	1
	Public Transportation	3	-10%	2.00 €	0%	0%	0%	20%	0%	80%	0
	Public Transportation	5	-10%	2.00 €	-5%	+30%	+10%	0%	-15%	100%	0
43	Public Transportation	6	0%	0.00 €	0%	0%	+10%	20%	0%	60%	1
	Public Transportation	5	-10%	2.00 €	-5%	+30%	+10%	0%	-15%	100%	0
	Public Transportation	2	0%	0.00 €	-5%	+30%	+10%	0%	-15%	40%	1
	Public Transportation	3	-10%	2.00 €	0%	0%	0%	20%	0%	80%	0
	Public Transportation	1	-10%	0.00 €	-5%	0%	0%	20%	0%	0%	1
	Public Transportation	4	0%	2.00 €	0%	+30%	0%	0%	-15%	20%	0

Respondent	Original Mode	Choice Situation	Car Attributes			Public Transport Attribute			Bicycle Attributes		
			Travel Time	Parking Fee	Travel Cost	Access Time	Travel Time	Fare	Travel Time	% Bicycle Infrastructure	Secure Parking
44	Car	1	0%	2.00 €	+40%	-15%	-20%	0%	0%	40%	1
	Car	6	+25%	5.00 €	0%	-15%	0%	0%	-15%	0%	0
	Car	4	0%	2.00 €	+40%	0%	0%	0%	-15%	20%	1
	Car	5	0%	5.00 €	+40%	0%	0%	-30%	-15%	80%	0
	Car	2	+25%	5.00 €	0%	-15%	-20%	-30%	0%	100%	0
	Car	3	+25%	2.00 €	0%	0%	-20%	-30%	0%	60%	1
45	Bicycle	1	-10%	0.00 €	-5%	0%	0%	20%	0%	0%	1
	Bicycle	3	-10%	2.00 €	0%	0%	0%	20%	0%	80%	0
	Bicycle	4	0%	2.00 €	0%	+30%	0%	0%	-15%	20%	0
	Bicycle	5	-10%	2.00 €	-5%	+30%	+10%	0%	-15%	100%	0
	Bicycle	6	0%	0.00 €	0%	0%	+10%	20%	33	60%	1
	Bicycle	2	0%	0.00 €	-5%	+30%	+10%	0%	-15%	40%	1
46	Car	4	0%	2.00 €	+40%	0%	0%	0%	-15%	20%	1
	Car	3	+25%	2.00 €	0%	0%	-20%	-30%	0%	60%	1
	Car	1	0%	2.00 €	+40%	-15%	-20%	0%	0%	40%	1
	Car	6	+25%	5.00 €	0%	-15%	0%	0%	-15%	0%	0
	Car	5	0%	5.00 €	+40%	0%	0%	-30%	-15%	80%	0
	Car	2	+25%	5.00 €	0%	-15%	-20%	-30%	0%	100%	0

APPENDIX J – NGENE CODE USED TO PRODUCE EXPERIMENTAL DESIGN

Design
;alts(1) = car, put, bike
;alts(3) = car, put, bike
;alts(4) = car, put, bike
;alts(5) = car, put, bike
;alts(6) = car, put, bike
;alts(7) = car, put, bike
;alts(8) = car, put, bike
;alts(9) = car, put, bike
;alts(10) = car, put, bike
;alts(11) = car, put, bike
;alts(12) = car, put, bike
;alts(13) = car, put, bike
;alts(14) = car, put, bike
;alts(15) = car, put, bike
;alts(16) = car, put, bike
;alts(17) = car, put, bike
;alts(18) = car, put, bike
;alts(20) = car, put, bike
;alts(21) = car, put, bike
;alts(22) = car, put, bike
;alts(23) = car, put, bike
;alts(24) = car, put, bike
;alts(25) = car, put, bike
;alts(27) = car, put, bike
;alts(28) = car, put, bike
;alts(29) = car, put, bike
;alts(30) = car, put, bike
;alts(31) = car, put, bike
;alts(32) = car, put, bike
;alts(33) = car, put, bike
;alts(34) = car, put, bike
;alts(35) = car, put, bike
;alts(36) = car, put, bike
;alts(37) = car, put, bike
;alts(38) = car, put, bike
;alts(39) = car, put, bike
;alts(40) = car, put, bike
;alts(41) = car, put, bike
;alts(42) = car, put, bike
;alts(43) = car, put, bike
;alts(44) = car, put, bike
;alts(45) = car, put, bike
;rows = 6
;eff = choice(mnl,d)
;fisher(choice) = bike (1[0.024], 3[0.024], 4[0.024], 5[0.024], 6[0.024], 8[0.024], 9[0.024], 10[0.024], 11[0.024], 15[0.024], 16[0.024], 17[0.024], 18[0.024], 20[0.024], 22[0.024], 24[0.024], 27[0.024], 28[0.024], 29[0.024], 30[0.024], 34[0.024], 35[0.024], 45[0.016], 39[0.024]) + put (13[0.024], 14[0.024], 21[0.024], 23[0.024], 31[0.024], 32[0.024], 36[0.024], 38[0.024], 40[0.024], 41[0.024], 42[0.024], 43[0.024], 12[0.024]) + car (25[0.024], 33[0.024], 44[0.024], 37[0.024], 7[0.024])

;model(1):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[9,10] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[2.7189,2.862] /
U(put)= β0PuT[-2.088] + β1PuT[-0.043] *ACCESS[6,7] + β2PuT[-0.032]*PuTTT[17,21] + β3PuT[-0.116]*FARE[1.8,2.5] /
U(bike) = β1bike[-0.039]* BIKETT[20,23] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike [1.459] * BPARK[0,1]

;model(3):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[14,15] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[3.8266,4.028] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[17,20] + β2PuT[-0.032]*PuTTT[14,17] + β3PuT[-0.116]*FARE[1.8,2.5] /
U(bike) = β1bike[-0.039]* BIKETT[30,35] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(4):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[5,6] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[1.4098,1.484] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[11,13] + β2PuT[-0.032]*PuTTT[9,11] + β3PuT[-0.116]*FARE[1.8,2.5] /
U(bike) = β1bike[-0.039]* BIKETT[13,15] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(5):

U(car) = β0car[0.214] + β1car[-0.038]*CARTT[5,6] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[1.4098,1.484] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[11,13] + β2PuT[-0.032]*PuTTT[9,11] + β3PuT[-0.116]*FARE[1.8,2.5] /
U(bike) = β1bike[-0.039]* BIKETT[25,29] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(6):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[5,6] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[1.9133,2.014] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[11,13] + β2PuT[-0.032]*PuTTT[9,11] + β3PuT[-0.116]*FARE[1.8,2.5] /
U(bike) = β1bike[-0.039]* BIKETT[15,17] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(7):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[25,31] + β2car[-0.251]*PARK[2,5] + β3car[-0.097]*COST[10.971,15.3594] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[13,15] + β2PuT[-0.032]*PuTTT[21,26] + β3PuT[-0.116]*FARE[3.5,5] /
U(bike) = β1bike[-0.039]* BIKETT[85,100] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(8):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[7,8] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[1.7119,1.802] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[7,8] + βpCARTT[-0.032]*PuTTT[11,14] + β3PuT[-0.116]*FARE[1.8,2.5] /
U(bike) = β1bike[-0.039]* BIKETT[20,23] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(9):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[10,11] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[2.97065,3.127] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[4,5] + βPuTTT[-0.032]*PuTTT[6,7] + β3PuT[-0.116]*FARE[1.8,2.5] /
U(bike) = β1bike[-0.039]* BIKETT[30,35] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(10):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[15,17] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[5.08535,5.353] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[13,15] + βPuTTT[-0.032]*PuTTT[21,26] + β3PuT[-0.116]*FARE[1.8,2.5] /
U(bike) = β1bike[-0.039]* BIKETT[25,29] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(11):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[5,6] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[1.007,1.06] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[7,8] + β2PuT[-0.032]*PuTTT[7,9] + β3PuT[-0.116]*FARE[1.8,2.5] /
U(bike) = β1bike[-0.039]* BIKETT[10,12] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(12):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[20,22] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[3.27275,3.445] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[24,31] + β2PuT[-0.032]*PuTTT[9,10] + β3PuT[-0.116]*FARE[2.5,3] /
U(bike) = β1bike[-0.039]* BIKETT[33,39] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(13):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[17,19] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[6.2434,6.572] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[13,17] + β2PuT[-0.032]*PuTTT[23,25] + β3PuT[-0.116]*FARE[2.5,3] /
U(bike) = β1bike[-0.039]* BIKETT[51,60] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(14):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[17,19] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[4.58185,4.823] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[6,8] + β2PuT[-0.032]*PuTTT[15,17] + β3PuT[-0.116]*FARE[2.5,3] /
U(bike) = β1bike[-0.039]* BIKETT[40,47] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(15):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[3,4] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[0.55385,0.583] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[7,8] + β2PuT[-0.032]*PuTTT[1,2] + β3PuT[-0.116]*FARE[0.8,1.2] /
U(bike) = β1bike[-0.039]* BIKETT[5,6] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(16):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[14,15] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[3.3231,3.498] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[9,11] + β2PuT[-0.032]*PuTTT[8,10] + β3PuT[-0.116]*FARE[1.8,2.5] /
U(bike) = β1bike[-0.039]* BIKETT[20,23] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(17):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[11,12] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[2.5175,2.65] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[13,15] + β2PuT[-0.032]*PuTTT[9,11] + β3PuT[-0.116]*FARE[1.8,2.5] /
U(bike) = β1bike[-0.039]* BIKETT[20,23] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(18):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[4,5] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[0.8056,0.848] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[11,13] + β2PuT[-0.032]*PuTTT[1,2] + β3PuT[-0.116]*FARE[0.8,1.2] /
U(bike) = β1bike[-0.039]* BIKETT[5,6] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(20):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[8,9] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[2.26575,2.385] /

U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[6,7] + β2PuT[-0.032]*PuTTT[6,8] + β3PuT[-0.116]*FARE[1.8,2.5] /
U(bike) = β1bike[-0.039]* BIKETT[15,17] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(21):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[11,12] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[2.66855,2.809] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[20,26] + β2PuT[-0.032]*PuTTT[20,22] + β3PuT[-0.116]*FARE[2.5,3] /
U(bike) = β1bike[-0.039]* BIKETT[22,26] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(22):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[14,16] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[5.28675,5.565] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[15,18] + β2PuT[-0.032]*PuTTT[14,18] + β3PuT[-0.116]*FARE[1.8,2.5] /
U(bike) = β1bike[-0.039]* BIKETT[35,40] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(23):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[3,4] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[0.55385,0.583] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[7,9] + β2PuT[-0.032]*PuTTT[2,3] + β3PuT[-0.116]*FARE[1.2,1.4] /
U(bike) = β1bike[-0.039]* BIKETT[6,7] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]
;model(24):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[17,19] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[4.78325,5.035] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[20,24] + β2PuT[-0.032]*PuTTT[11,14] + β3PuT[-0.116]*FARE[1.8,2.5] /
U(bike) = β1bike[-0.039]* BIKETT[40,46] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(25):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[20,25] + β2car[-0.251]*PARK[2,5] + β3car[-0.097]*COST[6.943,9.7202] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[8,9] + β2PuT[-0.032]*PuTTT[30,37] + β3PuT[-0.116]*FARE[1.8,2.5] /
U(bike) = β1bike[-0.039]* BIKETT[61,72] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(27):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[6,7] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[1.2084,1.272] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[4,5] + β2PuT[-0.032]*PuTTT[7,9] + β3PuT[-0.116]*FARE[1.8,2.5] /
U(bike) = β1bike[-0.039]* BIKETT[10,12] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(28):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[8,9] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[2.36645,2.491] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[18,21] + β2PuT[-0.032]*PuTTT[6,8] + β3PuT[-0.116]*FARE[1.8,2.5] /
U(bike) = β1bike[-0.039]* BIKETT[12,14] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(29):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[7,8] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[2.66855,2.809] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[9,11] + β2PuT[-0.032]*PuTTT[3,4] + β3PuT[-0.116]*FARE[1.8,2.5] /
U(bike) = β1bike[-0.039]* BIKETT[10,12] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(30):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[8,9] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[1.76225,1.855] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[12,14] + β2PuT[-0.032]*PuTTT[6,7] + β3PuT[-0.116]*FARE[0.8,1.2] /
U(bike) = β1bike[-0.039]* BIKETT[20,23] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(31):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[6,7] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[1.76225,1.855] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[9,12] + β2PuT[-0.032]*PuTTT[10,11] + β3PuT[-0.116]*FARE[2.5,3] /
U(bike) = β1bike[-0.039]* BIKETT[14,17] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(32):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[11,12] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[3.3231,3.498] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[5,7] + β2PuT[-0.032]*PuTTT[25,28] + β3PuT[-0.116]*FARE[2.5,3] /
U(bike) = β1bike[-0.039]* BIKETT[27,32] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(33):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[12,15] + β2car[-0.251]*PARK[2,5] + β3car[-0.097]*COST[3.551,4.9714] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[3,4] + β2PuT[-0.032]*PuTTT[18,22] + β3PuT[-0.116]*FARE[0.8,1.2] /
U(bike) = β1bike[-0.039]* BIKETT[29,34] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(34):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[7,8] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[2.06435,2.173] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[11,13] + β2PuT[-0.032]*PuTTT[7,9] + β3PuT[-0.116]*FARE[1.8,2.5] /
U(bike) = β1bike[-0.039]* BIKETT[15,17] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(35):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[5,6] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[0.95665,1.007] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[15,18] + β2PuT[-0.032]*PuTTT[2,3] + β3PuT[-0.116]*FARE[0.8,1.2] /
U(bike) = β1bike[-0.039]* BIKETT[10,12] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(36):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[6,7] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[1.15805,1.219] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[3,4] + β2PuT[-0.032]*PuTTT[14,15] + β3PuT[-0.116]*FARE[2.5,3] /
U(bike) = β1bike[-0.039]* BIKETT[9,10] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(37):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[10,13] + β2car[-0.251]*PARK[2,5] + β3car[-0.097]*COST[1.06,1.484] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[14,16] + β2PuT[-0.032]*PuTTT[2,3] + β3PuT[-0.116]*FARE[0.8,1.2] /
U(bike) = β1bike[-0.039]* BIKETT[8,9] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(38):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[9,10] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[2.46715,2.597] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[1,2] + β2PuT[-0.032]*PuTTT[20,22] + β3PuT[-0.116]*FARE[2.5,3] /
U(bike) = β1bike[-0.039]* BIKETT[21,25] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(39):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[9,10] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[4.07835,4.293] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[10,12] + β2PuT[-0.032]*PuTTT[9,11] + β3PuT[-0.116]*FARE[3.5,5] /
U(bike) = β1bike[-0.039]* BIKETT[20,23] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(40):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[16,18] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[5.99165,6.307] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[21,27] + β2PuT[-0.032]*PuTTT[25,28] + β3PuT[-0.116]*FARE[2.5,3] /
U(bike) = β1bike[-0.039]* BIKETT[45,53] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(41):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[5,6] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[1.4098,1.484] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[1,2] + β2PuT[-0.032]*PuTTT[15,17] + β3PuT[-0.116]*FARE[2.5,3] /
U(bike) = β1bike[-0.039]* BIKETT[9,10] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(42):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[7,8] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[1.86295,1.961] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[5,7] + β2PuT[-0.032]*PuTTT[5,6] + β3PuT[-0.116]*FARE[2.5,3] /
U(bike) = β1bike[-0.039]* BIKETT[9,11] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(43):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[14,15] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[3.67555,3.869] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[18,23] + β2PuT[-0.032]*PuTTT[10,11] + β3PuT[-0.116]*FARE[2.5,3] /
U(bike) = β1bike[-0.039]* BIKETT[25,29] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(44):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[6,7] + β2car[-0.251]*PARK[2,5] + β3car[-0.097]*COST[0.477,0.6678] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[2,3] + β2PuT[-0.032]*PuTTT[2,3] + β3PuT[-0.116]*FARE[0.8,1.2] /
U(bike) = β1bike[-0.039]* BIKETT[4,5] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

;model(45):
U(car) = β0car[0.214] + β1car[-0.038]*CARTT[5,6] + β2car[-0.251]*PARK[0,2] + β3car[-0.097]*COST[1.007,1.06] /
U(put)= β0put[-2.088] + β1PuT[-0.043] *ACCESS[16,19] + β2PuT[-0.032]*PuTTT[1,2] + β3PuT[-0.116]*FARE[0.8,1.2] /
U(bike) = β1bike[-0.039]* BIKETT[15,17] + β2bike[0.300] * PATHS[0,0.2,0.4,0.6,0.8,1] + β3bike[1.459] * BPARK[0,1]

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STATEMENT

A methodology for the quantitative estimation of the independent influence of various mode and trip attributes is proposed, tested and qualitatively evaluated. A stated choice experiment based on reference scenarios is used as a tool to collect choice information.

München, November 04, 2011

Signature

Heather A. Twaddle