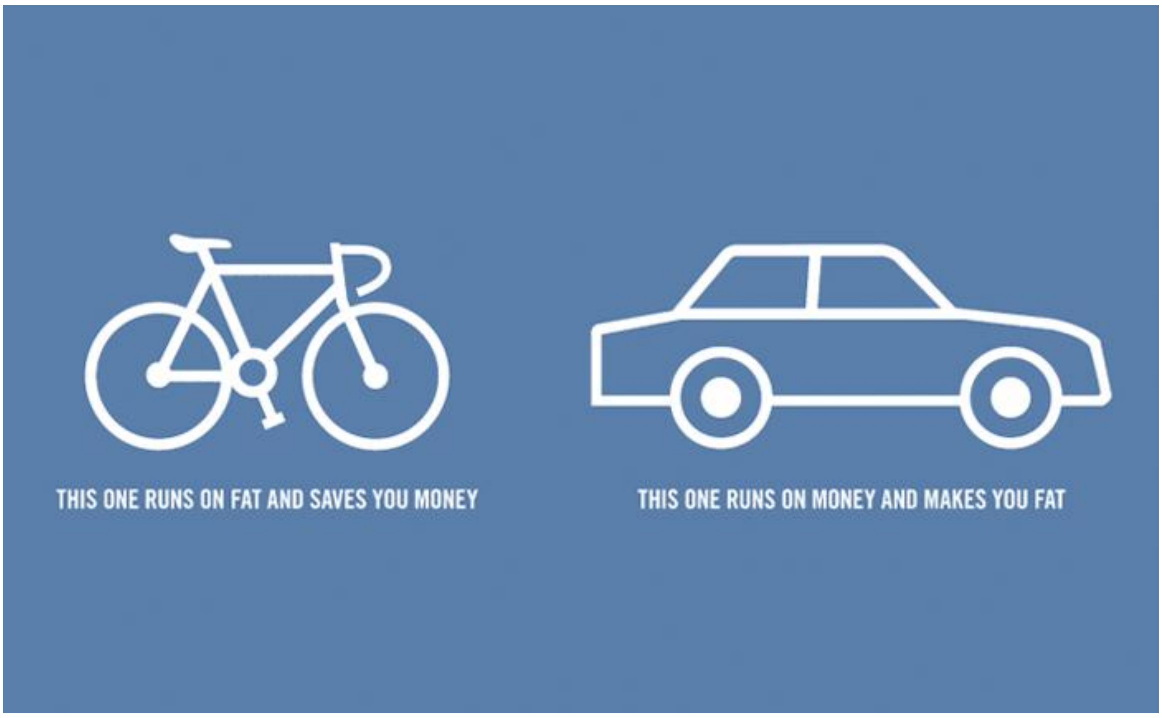
The value of time and comfort in bicycle appraisal

A stated preference research into the cyclists' valuation of travel time reductions and comfort improvements in the Netherlands



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Executive Summary

Due to the recent attention from the government in reducing congestion by investing in cycling infrastructure, there is a growing need for knowledge on cycling and assessment tools. A cost-benefit analysis tool is available to assess cycling infrastructure investments, but important key figures such as the value of time are missing. The aim of this research is to fill one of the gaps in bicycle appraisal by setting the following research objective:

"The objective of this research is to estimate the valuation of travel time savings and comfort improvements for cycling."

The cyclists' value of time and comfort were not estimated before in the Netherlands. Only a few international studies are available, with two Swedish studies specifically focusing on the cyclists' value time. Based on these experiences, a similar research approach has been designed.

To achieve the objective, a literature review was provided on the cyclists' value of time. Secondly, an adaptive stated choice experiment was constructed. This experiment consisted of 15 combined mode/route choice questions in which the respondent was confronted with two cycle routes, a car and public transport alternative. 523 cyclists from the region Arnhem Nijmegen and Breda Etten-Leur correctly filled in the experiment, which was made available online. Thereafter, a descriptive analysis and model analysis were conducted. The model analysis used a mixed logit model to estimate the coefficients that influence the choice behavior. The mixed logit model takes into account the panel effect of a stated preference experiment and the nested structure of a combined mode/route choice experiment. Finally, the resulting model led to the calculation of elasticities, choice probabilities and the performance of a scenario analysis.

This research estimated values of time and comfort for commuting and other recreational travel (i.e. shopping or visiting family). For commuting, the cyclists' value of time is estimated at €13,43 per hour on a standard cycle route and €9,80 per hour at a comfortable cycle route. Different values of time are found since cycling on a comfortable cycle route is more convenient in comparison to a standard cycle route. The difference between both values of time resembles the value of comfort for a route quality improvement from standard to comfortable. The value of comfort is valued at €3,63 per hour. For other recreational travel, the cyclists' value of time at €10,26 per hour on a standard cycle route and €7,57 per hour at a comfortable cycle route. The value of comfort is valued at €2,69 per hour.

A new finding that can be applied in cost-benefit analyses is the value of comfort. If, for example, a road section that takes only 5 minutes is improved from standard to comfortable cycle route quality, the value of comfort which can be used in a cost-benefit analysis is €0,30 per commuting trip and €0,22 for an other recreational trip. Comfort is valued strongly and indicates that cyclists also value a quality improvement even though travel times remain unchanged. When applying the value of comfort it is important to consider the actual quality improvement of a route and adjust the value of comfort to this improvement.

The cyclists' values of time are higher in comparison to the value of time for car and public transport. Travel time spent cycling is comparatively onerous and unproductive. In comparison to the few previous cyclists' value of time studies abroad, the Dutch value of time and comfort are lower. The culture and context of cycling in the Netherlands is different from Sweden. First of all, there is a complete cycle network available in the Netherlands. Adding new links to the cycle network would have less effect in comparison to the Swedish case. In comparison to

Sweden, low-income groups cycle more often in the Netherlands, increasing the marginal utility of costs and decreasing the valuations. The Dutch are positive towards cycling and it is often associated with low costs, self-reliance and reliable travel times. In comparison to other countries, cycling is more convenient in the Netherlands, which is caused by the higher bicycle usage and the recognition of cyclists by all road users.

Furthermore, evidence is found for the influence of several socio-economic characteristics, cycling attitudes and travel contexts on the cyclists' value of time. Higher values of time are found among cyclists with higher incomes. Lower values of time are found among cyclists who cycle because it is healthy, fun and convenient, cyclists who travel more than 30 minutes, cyclists who cycle 4-5 days per week to work and cyclists who already cycle on a good quality cycle route.

The collected data also allows the estimation of elasticities and choice probabilities. The results showed that cyclists have low sensitivity to changes in car and PT alternatives, such as the costs of travel. Furthermore, a quality improvement itself influences the choice probabilities even though cycling travel times are not reduced and most of the generated trips originate from car and public transport users.

The novelty of this research in the Netherlands means that there were no standard conventions available for the performance of this type of research. An inherent problem of all cyclists' value of time studies is the absence of cycling costs in the choice experiment, resulting in the use of a mode choice experiment. Therefore, the value of time is not actually a value of time, but a willingness to accept a smaller cost difference between cycling and the alternative mode of transport in case of a travel time reduction. Encountered challenges that are specifically related to this research are:

- The respondents were assumed not to know their car and public transport costs. Therefore, the costs of car and public transport were imputed variables estimated with trip distance. This introduces an ecological fallacy effect. If the distance increases, car and public transport probabilities increase. However, costs also increase with distance, while car and public transport probabilities decrease due to the higher costs;
- Short distance cyclists are more often indifferent for the stated choice experiment questions due to the adaptive nature of the experiment;
- The sample is characterized by an above average trip distance, introducing the risk of a cyclists self-selection with less time pressure and a positive cycling attitude (low value of time). No accurate information is available on the attitude toward cycling among the Dutch cycling population, which could be incorporated in the sample weighting.

Regarding the validity of the research, it is important to emphasize here that much research is validated through a reflection on previous work, but is not available for this study due to its novelty in the Netherlands. The results should be interpreted as a first exploration on the cyclists' value of time and comfort in the Netherlands. The results, interpretation and discussion provide a broader view on the cyclists' value of time and comfort and can serve as a benchmark for future research.

Furthermore, the results are best fit to be used in situations where cycling trip distances are above average (i.e. along fast cycle route). Most data is collected in the region Arnhem Nijmegen, making the results best fit for use in this region. Application of these values in other regions requires the consideration of the travel context that influences the value of time. The value of time and comfort are estimated using stated preference data. The results are compared to the revealed preference data. Although there is not a very good fit between both data sets, both data sets do show comparable values for the valuation of travel time and the valuation of cycling with respect to car and public transport.

This study provided a first insight into the cyclists' value of time and comfort for the Netherlands. Following the already mentioned issues, further research is required to fully operationalize the found values. Recommendations for further research are:

- Combine the cyclists' value of time study with the value of time studies on car and public transport to assure that the values of time can be put next to each other with more confidence and based on a larger sample;
- Combine the cyclists' value of time study with the application in transport models. The outcomes of these types of studies provide many figures that can be used in transport modelling. Future cyclists' value of time studies are advised to explicitly take into account the possibilities to integrate findings in transport models;
- Investigate the elasticities for considering car drivers and inquisitive cyclists. Information on the elasticities of non-frequent cyclists can provide useful insights into the modal shift due to the construction of a shorter and more comfortable cycle route;
- Estimate the value of time and comfort for short distance cyclists, using a different experimental set-up that can cope with the travel time indifference for short trips.

Acknowledgements

In the Netherlands, we possess 35.000 kilometers of dedicated cycle infrastructure, 34% of our daily trips are made per bicycle and all together, we own 19 million bicycles. It is not an exaggeration to say that cycling plays an important role in our daily lives. The bicycle has shaped our country over the last century. Its influence can be found in many fields. We can see it in the way cities are built up, we can also see it in the very young age we let our children cycle to school and even our prime minister who cycles to work. We are a cycling nation.

Because of our history with cycling, it is even more particular that the policy tools for assessing cycle infrastructure are limited available in comparison to other modes of transport. Over the last couple of years, we do see a development towards better policy tools, for example with the social cost-benefit for cycling investments. The planning of cycle infrastructure is receiving more attention, especially since it can be used as one of many measures to reduce congestion on the Dutch road network.

I had the possibility to do my master thesis at the City Region Arnhem Nijmegen. The City Region is doing very good work with their development of fast cycle routes throughout the region and can be seen as one of the leading areas in the Netherlands. I am very pleased to be able to witness the process of developing fast cycle routes and try to contribute to an improved policy tool by determining the value of time and comfort for cyclists.

I have to admit, my master thesis was not easy. The cyclist's value of time had not been studied previously in the Netherlands. The novelty of this research introduced many challenges. However, problems are there to be solved and have been part of my learning process. I hope my findings will provide a good insight in the value of time and the importance of cycling comfort for cycling for the City Region and other organizations that are working with bicycle cost-benefit analysis and will contribute to the construction of a good cycle network.

Special thanks go to all my colleagues at the City Region Arnhem Nijmegen and in particular my supervisor Sjors van Duren for a pleasant and educational time. Sjors was able to guide help at difficult moments and he was able to let me reflect on my own work. His role as process manager in the development of fast cycle routes also gave me a very good insight in how work is done. I would also like to thank my supervisors from the University of Twente, Lissy La Paix and Karst Geurs for their constructive feedback, which brought my research to a higher level. Others who I would like to thank for their contributions are Kees van Ommeren (Decisio), Martijn Lelieveld (Decisio), Pim Warffemius (KiM), Bart Christiaens (Tibs Advies) and all the participants of the pilot survey and the final survey.

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Content

Chapter 1 Introduction

1.1 Project Framework

Over the last couple of years, cycling in the Netherlands is receiving more attention, especially as a measure to reduce congestion. The Ministry of Transport, Public Works and Water Management and later the Ministry of Infrastructure and the Environment both initiated policy programs (FileProof[1] and Beter Benutten[2]) to reduce congestion through different infrastructural and behavior changing measures. One of the measures is Fiets Filevrij[3], which stimulates commuters who live within 15 kilometers from their work to change their mode of transport into cycling. In all congested areas, studies have been conducted to find cycle routes with high potential to reduce car congestion. The program started in 2006 with five fast cycle routes and currently there are 28 routes for which construction is either being studied, in progress, or completed (Figure 1). On top of the nationwide Fiets Filevrij program, local governments also took the initiative to construct fast cycle routes of their own.

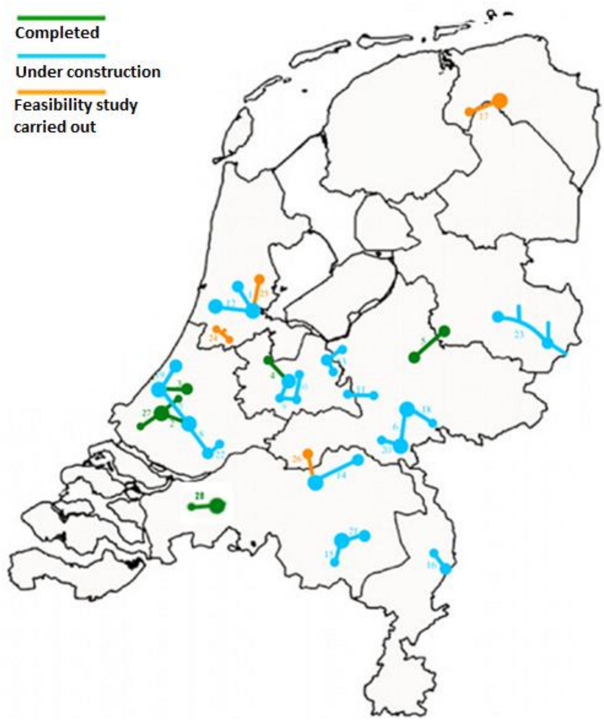

Figure 1 Dutch fast cycle Routes (Adapted from: www.fietsfilevrij.nl)

Due to the recent attention from the government in reducing congestion by investing in cycling infrastructure, there is a growing need for knowledge on cycling and assessment tools. Commissioned by the Ministry of Infrastructure and the Environment, Decisio started a study on the possible use of the OEI-methodology (Overview effects infrastructure) for social cost-benefit analysis on cycling measures. They concluded that a social cost-benefit analysis can be helpful and there is a good basis to do so. This has led to the web tool MKBA-fiets[4]. However, in addition to the generally accepted indicators, it also makes use of different assumptions. Therefore, this

[1] For more information: (Ministerie van Verkeer en Waterstaat, 2008) (In Dutch)
[2] For more information: www.beterbenutten.nl/english
[3] For more information: www.fietsfilevrij.nl (In Dutch)
[4] For more information: http://www.fietsberaad.nl/mkba-fiets/ (In Dutch)

tool does not give an "universal truth", but it does give the policy maker a 'feeling' for the social benefits related to cycling investments (Fietsberaad, 2014). Decisio (2012) concludes with the recommendation to perform a study on the value of time for cyclists as this has never been studied properly in the Netherlands and there is little knowledge available from abroad.

1.2 Objective and research questions

The aim of this research is to fill one of the gaps in bicycle appraisal by setting the following research objective:

"The objective of this research is to estimate the valuation of travel time savings and comfort improvements for cycling."

To achieve this objective, the following research questions are defined:

1. What is the current practice in the Netherlands regarding the use of the cyclists' value of time in bicycle cost-benefit analyzes?
2. What are the international experiences with respect to the determination of the cyclists' value of time and comfort?
3. How do personal- and trip characteristics influence the cyclists' value of time and comfort?
4. Which monetized value place Dutch cyclists on the reduction of travel time and improvement of cycle route comfort?
5. What is the influence of income, travel context and the attitude towards cycling on the cyclists' value of time and comfort?
6. What are the elasticities of cyclists for changes in characteristics of alternatives?

1.3 Research approach

To answer all research questions and achieve the objective, a research approach is developed. This approach provides a theoretical and practical view on the cyclists' value of time and comfort. Hereafter VoT and VoC

Chapter 2 will present a literature review on the cyclists' VoT and VoC. In the chapter, the current practice in the Netherlands regarding the use of the cyclists' VoT in bicycle cost-benefit analyzes is presented (research question 1). Secondly, this chapter provides a literature background on the cyclists' VoT and an overview of the personal- and trip characteristics that are found to influence choice behavior (research question 3 and 5). Thirdly, this chapter presents the findings from the few previous cyclists' VoT studies available (research question 2). This chapter ends with a reflection on elements influencing the research design.

Chapter 3 introduces the research design to derive the cyclists' VoT and VoC (research objective). Based on the findings from chapter 2 and the research objective, a data collection plan and questionnaire are constructed to collect all data required for the analyzes (research questions 3 to 5).

Chapter 4 introduces the modelling approach, referring to literature on stated choice experiments and discrete choice modes, to process the data collected from the questionnaire and the tools required to analyze the data (research questions 3 to 6)

Chapter 5 provides a descriptive analysis of collected data. The purpose of this chapter is to find evidence in the data on the personal- and trip characteristics that are expected to influence the cyclists' VoT and VoC (research question 3 and 5). Next to the findings from the literature, this chapter will provide the input for the model analysis

Chapter 6 focusses on the model analysis, constructing multinomial and mixed logit models that describe the cyclists' choice behavior. More specifically, the models assess the influence of income, travel context and the attitude towards cycling on the cyclists' VoT and VoC. The findings in the model analyzes will be contrasted to the current cyclists' VoT practice in the Netherlands and the cyclists' values of time found abroad (research question 3 to 5). Chapter 6 continues with the application of the final model. Through the calculation of choice probabilities, the cyclists' direct- and cross-elasticities on the change of the alternative's characteristics can be assessed (research question 6).

Chapter 7 concludes with the findings from this study, providing an answer on all research questions and the research objective. This chapter also includes a discussion on the results and recommendations for further research.

Chapter 2 Literature review value of time and comfort

This chapter provides a literature review on the cyclists' VoT and VoC. The literature review provides a theoretical answer on research questions and therefore provides a basis to which the findings from the choice experiment can be reflected on. Paragraph 2.1 describes the current practice in the Netherlands regarding the use of the cyclists' VoT in bicycle cost-benefit analyzes. Paragraph 2.2 and 2.3 review in detail those personal and trip characteristics that influence the cyclists' VoT and VoC. Paragraph 2.4 reflects on previous experiences regarding cyclists' VoT studies and gives an overview of the found valuations. Paragraph 2.5 reflects on elements influencing the research design.

2.1 The Dutch experience with the cyclists' value of time

In 2000, it became mandatory in the Netherlands for large infrastructural projects, which are financed by the central government to perform an 'ex ante' evaluation with a social cost-benefit analysis according to the standardized OEI-methodology (Overview effects infrastructure). The OEI-methodology consists out of a format and guidelines for the assessment of different welfare effects, which also includes the value of time (Eijgenraam, Koopmans, Tang, & Venster, 2000).

The social cost-benefit analysis is a popular policy tool as it creates insights into the effects of policy measures and enables better-founded policy decisions, makes complex effects of policies on different elements understandable and creates support for the outcome of the policy process, increases transparency and the accountability of the government. However, there are downsides to its use as it is often difficult to monetize the effects and there is no consensus among the professionals on the exact role of a social cost-benefit analysis in decision-making (Mouter, Annema, & Wee, 2013).

The OEI-methodology is compulsory to analyze the social costs and benefits for large infrastructure projects. For bicycle infrastructure, this method is not compulsory and has only been scarcely used due to the low investment costs of these projects. Commissioned by the Ministry of Infrastructure and the Environment, Decisio (2012) performed a study to assess the use of the OEI-methodology for bicycle investments. They conclude that it is a useful tool to help decision-making. It structures the decision-making process and provides objective information. However, since the OEI-methodology was never used for bicycle appraisal it is not clear which indicators to include and, for example, which VoT to use. The social cost-benefit analysis for cycling investments can give a good indication of the width of results and it is possible to compare and prioritize the different bicycle projects in the Netherlands. A better understanding of the different indicators should ease the use of a social cost-benefit analysis for bicycle projects in the future.

Decisio made a bicycle CBA web tool available, which includes the different aspects that are part of the CBA in a generalized and simplified form (Fietsberaad, 2014). They point out that this tool is not fit for detailed analysis, but does provides insight into the size of the effects. Table 1 shows the output of the bicycle CBA as developed and by Decisio. For the cyclists' VoT Decisio (2013) uses a margin of €6,74 - €14,03, with an estimated mean of €10,85. The €6,74 is derived from the VoT for bus/tram/metro, as the average speed of cycling and bus/tram/metro are close to each other. In an earlier cyclists' VoT study in Sweden, a value of €14,03 was found.

Interest is growing among policy makers, consultants and scientists in the Netherlands for the bicycle CBA, who endorse the need for a cyclists' value of time. Decisio (2012), Mouter (2013), KiM (2014) and Handy, Wee, and Kroesen (2014) are examples of organizations and scientists who endorse the need for a value of time for cyclist.

Output	Explanation
Investments	The investment costs
Operation and maintenance costs	Costs for operation and maintenance
Travel time savings cyclists	The monetized benefits for the reduction of cycling travel time.
Travel time and reliability savings cars	The monetized benefits for car traffic due to a modal shift from car to bicycle.
Travel cost savings cyclists	A change in total cycling kilometers leads to a change in total travel costs for cyclists.
Absenteeism reduction	A change in total cycling kilometers leads to a change is absenteeism and a change in labor productivity.
Health benefits	A change in total cycling kilometers leads to a change in public health.
Excise tax car traffic	The modal shift from car to bicycle leads to less car kilometers and a change in tax income
PT Subsidies	The modal shift from PT to bicycle leads to less PT kilometers and could lead to a lower amount of PT subsidies required.
External effects	A change in total cycling/car/PT kilometers leads to a change noise, emissions and traffic safety.

Table 1 Outcomes of a bicycle cost-benefit analysis (Fietsberaad, 2014).

2.2 What is the cyclists' value of time and comfort?

For the interpretation of previous VoT studies, choice behavior studies and the choice experiment results it is important to introduce the various aspects of the value of time and to point out what the value of time actually measures.

In short, the monetary valuation of a travel time saving consists of three components: the resource value of time (the utility that could be attained if the travel time was used for some other activity, also called the opportunity value), the direct utility of travel time (compared to some reference activity), and the marginal utility of money (Börjesson & Eliasson, 2012).

$$Value\ of\ time = \frac{(resource\ value\ of\ time - direct\ utility\ of\ travel\ time)}{Marginal\ utility\ of\ money}$$

Travel time contributes to the resistance to travel, because time spent traveling could be used for other purposes (resource value of time). In other words, there is an opportunity value to save travel time. If travel time is shortened for cyclists, the generalized cost is reduced and the total utility, or consumer surplus, is increased.

The generalized cost of travel is not only affected by travel time, but also by a change in the risk of accidents, convenience, relaxation and exercise (direct utility of travel time). This is one of the reasons why different values of time are expected for various modes and environments. Driving your own car is relaxing and comfortable for some people. For others, public transport provides better opportunities to read or rest. Time spend cycling can have a direct effect on the well-being and health of the traveler, but can also be experienced as bothersome and dangerous.

On top of the resource value of time and the direct utility of travel time, the individual's income affects the marginal utility of money and therefore the VoT. The VoT differs between cycling and other modes and thus depends both on the differences in the individual's, route and mode characteristics (WSP, 2009). The VoC is derived from the VoT as being the difference between the VoT for cycling two routes who differ in comfort. Comfort affects the direct utility of travel time and therefore, different VoT's exists.

$$Value\ of\ comfort = Value\ of\ time_{low\ comfort\ level} - Value\ of\ time_{high\ comfort\ level}$$

2.3 Factors influencing the cyclists' value of time and comfort

Understanding the explanatory variables for cycling enables one to specify in more detail the user effects to be included in the bicycle cost-benefit analysis. It helps to identify those variables that are actually considered and valued by the cyclists. These valuations should be taken into account in the choice experiment.

The variables influencing the choice of mode and cycle route of the traveler can be categorized, following Rietveld and Daniel (2004), in the categories 'individual features and socio-cultural factors' and 'factors that have an impact on the generalized costs of cycling'.

2.3.1 Individual features and socio-cultural factors

Extensive literature is available on the individual features of the trip maker. Large differences have been found between high and low bicycle use countries (Instituut voor Mobiliteit, 2008). For high bicycle use countries, it has been found that gender and age do not play any significant role in the propensity of one to cycle. Börjesson and Eliasson (2012) did found in Sweden that elderly have a higher direct utility of travel (lower value of time) than younger people due to the internalization of the health benefits. The equal distribution of age is probably a result of youngsters who do not have the possibility to choose a different mode and elderly who are positively biased towards cycling due to the health benefits (Björklund & Mortazavi, 2013). Stinson and Bhat (2004) also found that the health benefits are an important consideration among cyclists to travel per bicycle.

The attitude towards cycling has a significant influence on the VoT and VoC. Hunt and Abraham (2007) found in a Canadian study that the VoT diminishes as experience rises. The experience difference can be translated in the difference in perception on cycling. Non-cyclists perceive cycling as exhausting and dangerous, while frequent-cyclists perceive cycling as fun and relaxing. The direct utility of travel is higher for cyclists with a positive attitude towards cycling (Stinson & Bhat, 2004). Mobycon (2006) found in a survey for the city of Delft, Netherlands, that non-student cyclists cycle because it is fun, healthy and convenient. Only the students showed a different choice behavior, being led by costs and travel time. Important to consider is the self-selection among cyclists. Cyclists with a positive attitude towards cycling are in most cases already cycling. If new cyclists are attracted due to an implemented policy plan, the cycling attitudes of these 'new' cyclists are lower than for the existing cyclists. The 'new' cyclists have a lower direct utility of cycling travel time and a higher VoT (Börjesson & Eliasson, 2012). However, this effect could be smaller in the Netherlands as 84% of the Dutch have a positive image of cycling (Harms, Jorritsma, & Kalfs, 2007). Furthermore, Heinen, Maat, and Wee (2009) showed that not only the attitude of the cyclist himself, but also the attitude of his colleagues towards cycling affect the propensity to cycle.

An unclear and much debated characteristic is the influence of income on cycling, see Instituut voor Mobiliteit (2008), Börjesson and Eliasson (2012), Stinson and Bhat (2004) and Wardman, Tight, and Page (2007) for the differing effects of income. Related to income is education and also for education the effects are not clear. Wardman et al. (2007) could not find any difference among skilled and unskilled workers, while the Instituut voor Mobiliteit (2008) did found a higher propensity to cycle among the higher educated worker. In general, a higher income is expected to lower the marginal utility of costs and a higher VoT. Another characteristic that influences the marginal utility of costs is the household size. When there are more family dependents, there is effectively less spendable income available for travel, which increases the marginal utility of costs (Börjesson & Eliasson, 2012).

Mackie, Jara-Díaz, and Fowkes (2001) point out some major influences on the VoT in the context of activity patterns. These are the time at which the journey is made, the characteristics of the journey (congested, repetitive or free-flow and novel), the journey purpose and the journey length. Paleti, Vovsha, Givon, and Birotker (2013) found that the time pressure during the trip affects the resource value of time. It is therefore reasonable to expect different values of time for different trip purposes (i.e. Significance, VU University Amsterdam, and John Bates Services (2013))

The last important factor to include here is the availability of the car, as it decreases the propensity to cycle (Stinson & Bhat, 2004). Captives who are bound to a bicycle are more likely to have a lower resource value of time than non-captives are.

2.3.2 Factors influencing the generalized costs of cycling

Rietveld and Daniel (2004) state that the monetary costs, travel time, physical needs, risk of injury, risk of theft, comfort and personal security are among the factors that impact the generalized costs of cycling.

Travel time is one of the essential attributes of a trip and influences mode and route choice in different ways (Börjesson & Eliasson, 2012; Hunt & Abraham, 2007; Wardman et al., 2007). An important differentiation are the different forms of travel time as travel time can be broken down in in-vehicle time, waiting time, walking time and transfer time (Ortúzar & Willumsen, 2002). Each of these times can have a different valuation. Depending on the travel time between origin and destination, other modes of transport are preferred. For cycling holds that the propensity to cycle diminishes as travel time rises (Stinson & Bhat, 2004). In the Netherlands 50% of the commuting travel up to 5 kilometers is cycling, 25% up to 10 kilometers and 10% up to 15 kilometers. A new development is the electrical bicycle (Esch, Bot, Goedhart, & Scheres, 2013). Oijen, Lankhuijzen, and Boggelen (2012) showed that pedelec owners cycle more often and longer distances. Hendriksen et al. (2008) found that the average travel distance can increase from 6,8 to 8,9 kilometers.

Cyclists have no direct costs, i.e. cycling itself does not cost money. Bicycle purchase, maintenance, and ferry fares are costs for the cyclists, but do not directly affect route or mode choice. However, a cost element has to be included in the stated choice experiment to be able to monetize all valuations. There are several methods available to monetize these valuations, see Litman (2013). A possible solution can be found in the approach of a similar study by Börjesson and Eliasson (2012) and Björklund and Mortazavi (2013). In their stated choice experiments, they presented the respondent with mode alternatives, comparing cycling to a motorized alternative and presenting cost savings that could be achieved through cycling. Indirectly they were able to monetize the valuation of travel time and facilities. Another option is to present option values, i.e. is the respondent willing to accept a higher housing tax if he or she receives an improved bicycle network? Heinen (2011) emphasize that the bicycle costs have to been seen relative to the costs of other modes of transportation. For example, a free public transport pass or car parking negatively affects cycling frequencies.

One of the comfort factors that influences bicycle usage is the quality of the cycling road and this is found to be valued highly by cyclists (Table 2). Valuations vary across the following three types of cycling roads: the segregated cycle lane, the non-segregated cycle lane and the roads with no cycle facilities path (Börjesson & Eliasson, 2012; Ortúzar & Willumsen, 2002; Rizzi, Limonado, & Steimetz, 2012; Stinson & Bhat, 2004; Wardman et al., 2007). The route type affects the direct utility of travel. Related to the route type, Börjesson and Eliasson (2012) found each stop along a route increases the disutility of the route. In general, the direct utility is higher for cycle routes with a higher quality and therefore the VoT is lower for cycling on a high quality cycle route. The VoT difference between two quality levels is defined as the VoC. The cycle route quality is in general defined by consistency, directness, attractiveness, safety and comfort (CROW, 2014).

Other less influential comfort factors that affect the direct utility of travel time are the presence of cycling destination facilities (i.e. bicycle parking and showers)(Heinen et al., 2009; Stinson & Bhat, 2004). Where secured bicycle parking is higher valued than unsecured bicycle parking and showers are only valued for commuting trips (Hunt & Abraham, 2007).

Dangerous cycling conditions are partly related to the road type, as the absence of cycling facilities is often more dangerous for the cyclists (Schepers, Heinen, Methorst, & Wegman, 2013). Because of its relation to road type, this attribute is not necessary to include in the stated choice experiment, but one remark is relevant to place. Stinson and Bhat (2004) found that non-cyclists perceive cycling as more dangerous than cyclists. This will result in different valuations for cyclists and non-cyclists. This is a potential problem when evaluating cycle route improvements. However, the amount of people who actually change their mode of transport due to bicycle improvements is generally small and could be ignored (e.g. Börjesson and Eliasson (2012), Decisio (2012), Wardman et al. (2007)).

2.4 Cyclists' value of time, results from previous studies

There are only a few previous studies devoted to cyclists' VoT. Table 2 summarizes these studies by presenting the country of origin, the data used and the found values of time and comfort. The different international studies show cyclists' VoT that are higher than for other modes. Börjesson and Eliasson (2012) explain that time spent cycling is comparatively onerous and unproductive. Therefore, the direct utility of cycling time is likely to be lower in comparison to other modes, which increases the VoT. Börjesson and Eliasson furthermore find that the VoT is lower on a bicycle path in comparison to cycling in mixed traffic. The lower VoT is a result of a higher direct utility of cycling that the cyclists experience on a higher quality cycle route.

The VoC depends on the absolute level of the cyclist' VoT. Therefore, the comparison is best made through the calculation of ratios between time coefficients for different route qualities. Table 2 includes these ratios, which are relative to cycling on the highest quality level (off-road cycle path).

Wardman et al. (2007) derived the time coefficient for cycling in mixed traffic using RP and SP data. The SP coefficient was systematically lower, possibly due to a strategic bias. They adjusted their SP time coefficients according to this difference, which resulted in consistency between the RP and SP data and travel time valuations are much more reasonable.

All stated choice experiment studies faced issues regarding the monetizing method. Since cycling itself does not have any direct costs, a different approach is required. The studies from Sweden and Norway all use a set-up in which the cycling alternative is contrasted to a motorized alternative (car or PT). In these experiments, the cost coefficient is a generalization of the cost coefficient for car and public transport and the VoT is a willingness to accept a smaller cost difference between cycling and the alternative transport mode for a shorter travel time. The VoC is a willingness to accept a smaller cost difference between cycling and the alternative transport mode for a higher cycle route quality. The VoT is found to be influenced by the alternative transport mode, from which the costs are derived. The cyclists' VoT study of Björklund and Mortazavi (2013) finds higher VoTs in comparison to the study of Börjesson and Eliasson (2012), who both use the same experiment set-up. Björklund and Mortazavi explain that the alternative mode of transport was more often the car. Björklund and Mortazavi considered this effect by only calculating a VoT for respondents with PT as alternative mode and found similar valuations in comparison to the study of Börjesson and Eliasson. Therefore, it is important to consider the implication of the different valuation of car and public transport costs. The use of the cost difference car – cycling has an upwards effect on the VoT.

Furthermore, Björklund and Mortazavi (2013) state that the high valuations are a result of a large share of commuting trips and relatively short trips in the sample. Cycling facilities are also highly valued. Wardman et al. (2007) state that the high valuations for cycling facility improvements are related to the perceived greater effort, more hazardous and unattractive travelling conditions when cycling in mixed traffic in relation to traveling by car or public transport.

Börjesson and Eliasson (2012) and Björklund and Mortazavi (2013) both found a lower VoT in their studies among cyclists who consider the health benefits of cycling. They both explain that the health benefits are internalized as a direct utility of cycling travel time.

Source	**Cou-ntry**	**Year of study**	**βCost relative to**	**Cycling Mixed Traffic**	**Cycling Cycle lane**	**Cycling On-road cycle path**	**Cycling Off-road cycle path**	**Car**	**PT**
Decisio (2012)	NL	2012	Estimation	€6,74 - €14,03				-	-
Nordic Council of Ministers (2005)	SE	2005	Estimation	€13,46	-	€10,46		-	-
Börjesson and Eliasson (2012)	SE	2008	Cost PT (87%) Cost Car (13%)	€15,90 1.51x	-	€10,50 1.00x		€8,70	
Björklund and Mortazavi (2013)[5]	SE	2011	Cost PT (38%) Cost Car (62%)	€25,08 1.49x	€25,85 1.54x	€18,37 1.09x	€16,83 1.00x	€16,72	€6,93
Wardman et al. (2007)[6]	UK	1999	n/a	€13,80 3.48x	€6,62 1.67x	€4,32 1.09x	€3,96 1.00x	-	-
Stangeby (1997)[7]	NO	1996	Cost Car	€7,08				€3,96	-
Ramerdi, Flügel, Samstad, and Killi (2010)[8]	NO	2009	Cost PT (n/a) Cost Car (n/a)	€15,60				€10,56	€7,20

Table 2 Overview of previous studies with a value of time and comfort ratio estimation for cycling

[5] Using the exchange rate 0,11 EUR/SEK
[6] Using the exchange rate 1,20 EUR/GPB
[7] Using the exchange rate 0,12 EUR/NOK
[8] Using the exchange rate 0,12 EUR/NOK

2.5 Influencing elements on research design

Louviere, Hensher, and Swait (2000) provide an extensive overview on the theory of stated choice experiments. There are different elements that influence research design and have to be taken into account while constructing the data collection instrument, which will be addressed in this paragraph.

2.5.1 Data collection

To prevent miscommunication on sampling frames, it is important specifically describe the universe of respondents from which a finite sample is draws. Secondly, there must be learned how a trip maker thinks about the decision process, how they gather information about alternatives, when they make decisions, etc. The goal of this step is to gain at least the following information:

- The attributes and levels of interest;
- Personal characteristics that affect choice;
- Sources of utility differences;
- Choice set characteristics, including size, and;
- Whether different decision rules are used, and if so, why and when.

A point of attention is the segmentation of the population in several market segments. Market segments often exhibit differing preferences, so better description of market behavior can be obtained by considering them. All market segments together should capture the whole cycling population to ensure representativeness.

Because the expectation is that some target segments occur relatively infrequently in a simple random sample, it often more efficient to use an exogenously stratified random sample (ESRS). With an ESRS, the sampling frame is divided in mutually exclusive groups, each representing a proportion of the population.

Regarding the required sample size, there is no straightforward and objective answer to the calculation of sample size in every situation. Defining sample size is a problem of tradeoffs as (Ortúzar & Willumsen, 2002):

- A much too large sample may imply data-collection and analysis process which is too expensive given the study objective and its required degree of accuracy;
- A far too small sample may imply results which are subject to an unacceptably high degree of variability reducing the value of the whole exercise

The benefit of stated choice experiments is the statistical efficiency compared to revealed preference experiments, in the sense that each interviewee produces not just one observation but several on the same context. Therefore, samples are typically smaller than for comparable RP studies (Bradley, 1988). However, the fact that each interview results in 15 stated responses to the same number of (hypothetical) choice situations creates variation in responses within each individual. For a good representative model, information on the variations that occur between as well as within individuals is needed, and only an adequately sized and representative sample can do this (Ortúzar & Willumsen, 2002). Swanson, Pearmain, and Loughead (1992) suggests that 75 – 100 interviews per segment would be appropriate.

After designing and testing the questionnaire, the sampling frame is decided upon and the sample size calculated, data can be collected. At this stage, the principle decisions that have to be made involve the respondent recruitment method, how to bring respondent and instrument together and the response collection mechanism. Tilahun, Levinson, and Krizek (2007) emphasize the use of an adaptive survey, as it allows the presentation of choices that the individual can actually consider while removing alternatives that the respondent will surely not consider.

Wardman et al. (2007) emphasize that response rates can be improved through the provision of incentives or reminders.

2.5.2 Stated preference experiment design

Monetizing method

There are several considerations to take into account while constructing the experiment. The most important consideration is the monetizing method. To derive a cyclists' value of time and comfort, a cost, time and comfort attribute needs to be included in the choice experiment. The inclusion of the cost attributes raises important questions: 'what are the costs with respect to cycling?' and 'how are the different effects of cycling monetized?' Litman (2013) describes different methods for monetizing costs and benefits for active travel, for example:

- The direct cost of cycling (i.e. bicycle parking and ferry-fares);
- The indirect cost of cycling (i.e. depreciation of the bicycle and maintenance costs);
- The saved costs due to not traveling by car or public transport;
- The option value (i.e. investment costs of cycling infrastructure as tax increase).

The most commonly used method for monetizing time saving valuation is the use of direct costs. However, as mentioned in paragraph 2.4, where car and public transport users have direct costs per kilometer traveled, this is not the case for cycling. Some cyclists pay for parking their bicycle at a guarded bicycle parking, but this is difficult to relate to the distance traveled. The depreciation of the bicycle is on average 0,07 €/km (Hendriksen & Gijlzwijk, 2010), but this cost element is often not considered by the cyclists in a cycling route choice consideration. Option value refers to the value people place on having an option available that they currently do not use. However, the option value faces several difficulties when used for value of time estimations. Lower valuations are expected to be found, due to a difference in short-term (trip based costs) and long-term (monthly costs) considerations of the respondent (WSP, 2009). Another difficulty is to derive a cost per minute from a monthly cost as the bicycle frequency differs from person to person.

What remains is the use of the cost savings due to not traveling by car or public transport, as this is also used in previous cyclists' value of time studies. The respondent will be presented with the possibility to cycle or the possibility to travel by a different mode of transport, which does have a fuel or fare cost. As mentioned in paragraph 2.4, an important complication to this approach is the cost reference, which influences the value of time.

Important considerations concerning a mode choice set-up are:

- The label or name of the alternative itself conveys information to decision makers;
- Significantly different alternative-specific attribute effects for some alternatives;
- Violation of the IIA property of simple MNL models.

Choice card design

A key design issue is complexity. Experience has shown that people give the most reliable responses when asked to consider simultaneous changes in up to three attributes only (Huber & Hanson, 1987). When more than four attributes are presented to the respondent, it is found that the respondent simplify his choices (Carson et al., 1994; Saelensminde, 1999).

The amount of choice cards is a function of the experimental design. An experimental design is usually 'orthogonal'. It ensures that the attribute combinations presented are varied independent from each other. The advantage is that the effect of each attribute on the responses is more easily identified. The number of attributes (a) and the number of levels each one can take (n) determine a factorial design (n^a).In a full factorial design is it possible to recover all main and interactions effects.

Many researchers advise against making respondents evaluate sixty-four choices because of data quality concern. As the burden on the respondents grows, it is likely that the quality of the data that they provide decreases. In most studies, respondents evaluate up to sixteen choice sets. It is recommended to act conservatively. A major benefit of only considering the main effects is the reduction of complexity in the survey, while still accounting for 80% or more of the data variance (Ortúzar & Willumsen, 2002).

Instead of a full factorial design, a fractional factorial design can be used for this. The prerequisite for a fractional factorial design is to choose profiles that have the properties of being both balanced (all combinations occur the same number of times) and orthogonal (the effects of any factor balance out across the effects of the other factors). However, Fowkes and Wardman (1988) state that in some cases it might be beneficial to sacrifice some purity in the experimental design (i.e. lose complete orthogonality) if one gains in realism. For example, through the inclusion of a dominant choice card, this validates if the respondent understood the questionnaire.

Furthermore, Banzhaf, Johnson, and Matthews (2001) advises the inclusion of a no choice option as it avoids the forced choice, allowing the respondent to select another alternative if they do not prefer any of the options in the choice set

Chapter 3 Research Design

This chapter elaborates on the findings and considerations from the literature review through the introduction of the research design for the estimation of the cyclists' VoT and VoC. Paragraph 3.1 describes the data collection, which includes the sampling frame from which respondents will be recruited and the recruitment method. Paragraph 3.2 describes the questionnaire and paragraph 3.3 describes in further detail the design of the stated choice experiment.

3.1 Data collection

Paragraph 2.5.1 introduces important considerations that have to be taken into account in the data collection. Paragraph 3.1.1 elaborates on the sample segmentation and sample size; paragraph 3.1.2 elaborates on the sampling method and the case study area and paragraph 3.1.3 elaborates on the recruitment method.

3.1.1 Segmentation of the sample

In the case of cycling, an important segmentation is made through the travel motives, which is in accordance with previous VoT studies in the Netherlands (KiM, 2013). Statistics Netherlands (2013) found the following trip purposes to be dominant for cycling and these ratios are required to attain overall representativeness:

- 23% - Shopping;
- 19% - Education;
- 19% - Sport and recreation;
- 16% - Commuting;
- 23% - Other purposes.

Not all segments are fit for analysis in a stated choice experiment. In the case of recreational cyclists who make round trips, the cyclists often do not have the necessity to arrive earlier at their destination. Time is not a factor of influence and thus the VoT and VoC cannot be derived.

The segments for which a VoT and VoC can be derived and have a policy relevance with respect to the reduction of road congestion are cyclists with a commuting, educational and other recreational trip purpose. Other recreational trips are defined as non-round trips that contain a recreational component, i.e. visiting shopping centers, sport clubs and family. Within each segment, representativeness should be obtained according to the cycling population characteristics (Age, gender, income, etc.).

Using this segmentation, the objective of the experiment is to collect data on commuting, educational and other recreational cyclists. For each segment, a minimum of 100 respondents is required to be able to find valid results.

3.1.2 Sampling method and study area description

Because the expectation is that some target segments occur relatively infrequently in a simple random sample, it necessary to use an exogenously stratified random sample (ESRS). With an ESRS, the sampling frame is divided in mutually exclusive groups, each representing a proportion of the population.

Due to limitations in time and means, this experiment will primarily focus on sampling respondents whom are most interesting for policy makers. The city region Arnhem Nijmegen differentiates between four target segments:

- Stubborn car driver;
- Considering car driver;
- Inquisitive cyclist;
- Carefree cyclist.

The considering car driver and inquisitive cyclists have the highest potential to start cycling (more often) when a fast cycle route is constructed. Investing in stubborn car drivers is time consuming and unprofitable, due to their habitual behavior. Carefree cyclists already cycles, but most not be forgotten as they also value travel time reductions and cycle route quality improvements.

This study will focus on the carefree cyclists, the inquisitive cyclist and the considering car driver. The sampling frames are a database, containing the mail addresses of 1.065 cyclists in the region Arnhem – Nijmegen and Breda – Etten-Leur; and students in the city of Nijmegen. A second sampling frame is introduced since the email database underrepresent students.

The cyclists in the database were recruited in the past through a baseline measurement for one of the fast cycle routes. In the baseline measurement, the respondents were asked if they were willing to participate in follow-up studies. It is important to keep in mind that the carefree cyclist could be overrepresented since all respondents in the database were recruited as cyclists. Breda – Etten-Leur has the only completed fast cycle route of all interview locations. Surveys shows that the Breda – Etten-Leur route is the highest valued fast cycle route (SOAB, 2013). Respondents from this route are added to the mail database to allow a comparison between regions that presumably differ in the composition of the four types of travelers as defined by the city region Arnhem Nijmegen.

Fast Cycle Route	Progress	Municipality	Bicycle share
Breda – Etten-Leur	Opened	Breda	21%
		Etten-Leur	20%
Arnhem – Zevenaar (De Liemers)	Under Construction	Zevenaar	26%
		Duiven	22%
		Westervoort	21%
		Arnhem	17%
Arnhem – Nijmegen (RijnWaalpad)	Under Construction	Arnhem	17%
		Lingewaard	30%
		Overbetuwe	21%
		Nijmegen	23%
Nijmegen – Beuningen	Under Construction	Nijmegen	23%
		Beuningen	21%
Nijmegen – Mook – Cuijk	To be constructed	Nijmegen	23%
		Heumen	19%
		Mook en Middelaar	16%
		Cuijk	20%

Table 3 Overview of the sampled fast cycle routes, the progress on the construction, the corresponding municipalities and their bicycle mode share (Research voor beleid, 2006).

Table 3 provides per (planned) fast cycle route, an overview of the municipalities from which data will be collected. The table shows the current bicycle mode shares and the current standings regarding the construction of fast cycle routes. The lowest bicycle shares are found along the route Nijmegen – Cuijk, where the construction of the fast cycle route is yet to start. Urbanized city centers and rural areas and villages along the route characterize all routes.

3.1.3 Recruitment method

For the recruitment of commuters and other recreational cyclists, all 1.065 cyclists in the mail database are sent an invitation to fill in the questionnaire. Students are recruited with flyers. Flyers were distributed among 450 addresses of student dormitories throughout the city of Nijmegen. An incentive is provided through the possibility to win a €25,- gift card and additionally a reminder is sent to all cyclists in the mail database.

3.2 Questionnaire

The survey consists out of three consecutive parts; questions regarding the current travel behavior of the respondent (revealed preference), questions regarding the individual's characteristics and attitudes towards cycling and the stated preference experiment. The subjects of all questions are summarized in Table 4. The complete survey, as presented to the respondent, and the underlying calculations and routings are presented in appendix A and B.

The questionnaire will be a computer-aided survey. The major benefit is the possibility to construct adaptive surveys, which increases choice set realism. An adaptive survey uses the actual travel situation of the respondent and makes relative changes to their choice alternatives.

Question	Subject
Screening & trip purpose assignment	
1	Bicycle use per trip purpose
2	Bicycle frequency per trip purpose
3	Type of cycling trip
Cycling travel behavior	
4	Departure Time
5	Bicycle type
6	Cycling Travel time
7	Cycling Trip distance
8	Origin postal code
9	Destination postal code
10	Familiarity with fast cycle routes
11	Distribution of travel time over cycle route types
12	Paid for parking bicycle
13	Paid amount
14	Route assessment questions
15-27	Importance of route/mode aspects on cycle propensity
Car and public transport travel behavior	
28	Trip frequency per car and public transport
29	Car travel time
30	Public transport travel time
31	Public transport ticket type
Choice experiment	
32-46	SP experiment
47	Most important consideration during SP experiment
Socio-economic characteristics	
48	Gender
49	Age
50	Household composition
51	Driver's license
52	Other driver's license in household
53	Motor vehicle ownership
54	Education
55	Income

Table 4 Overview of questions / subjects in questionnaire

3.2.1 Revealed Preference

The questions regarding the current travel behavior of the respondent serve multiple purposes:

- Validation of the stated preference model estimation with revealed preference data;
- Control the distribution of the respondents over the different segments;
- Determine the base levels for the attribute in the stated choice experiment.

To validate the SP model analysis, the model outcomes are compared to the actual choice behavior. The final SP model will also be estimated with RP data only. The actual mode and route choice of the respondent should be documented with all attributes that are also being used in the stated choice experiment.

The benefit of a computer-aided adaptive survey is the ability to specify questions to the respondent's context. The first questions in the questionnaire collect information on the respondent's bicycle use per trip purpose. For the subsequent questions, the questionnaire assigns the respondent to one of the trip purposes for which the respondent uses the bicycle. Furthermore, the revealed preference section collects information on the current travel situation, which is the input for the reference situation in the stated choice experiment (i.e. travel time, costs and mode availability).

3.2.2 The individual's characteristics and attitudes

The socio-economic characteristic and attitude questions serve two purposes. The first purpose is to assess the representativeness of the sample. The second purpose is to assess the influence of the socio-economic characteristics and attitudes on the choice behavior.

Paragraph 2.3 discussed the socio-economic characteristics that influence choice behavior. The socio-economic characteristics to take into account for the assessment of representativeness are age, income, education, trip purpose, car availability and the attitude towards cycling.

It was found in previous work that the direct utility of cycling travel time is higher for travelers who internalize the health benefits in their choice consideration (paragraph 2.4). Therefore, the questionnaire includes thirteen questions in which the respondents are asked, on a 5-point scale, how important different route and mode aspects in their mode/route considerations. Through a factor analysis groups of factors can be made, reducing the number of attributes to be included in the choice model with a higher explanatory value (paragraph 4.4.4).

Considerations assessed in the questionnaire:

- Cycling is good for my health;
- I enjoy cycling;
- I can take a shower at my destination;
- I can easily park my bicycle;
- I can access a secured bicycle parking at my destination;
- Cycling the fastest way of transportation;
- I'm not bound to fixed departure times;
- Cycling is good for the environment;
- I avoid congestion;
- I have to pay for parking my car;
- Public transport is too expensive;
- Public transport is too full;
- The weather.

3.3 Stated preference experiment

The purpose of the stated preference section is to derive the cyclists' VoT and VoC. There are many considerations to be taken into account while constructing the experiment, which have been addressed in paragraph 2.5.2 These considerations include the monetizing method, the attributes and attribute levels to include and the design of the choice cards. The following sections describe the stated preference experiment design.

3.3.1 Monetizing Method

To meet the research objective, a cost, time and comfort attribute needs to be included in the choice experiment. The inclusion of the cost attributes raises important questions: 'what are the costs with respect to cycling?' and 'how are the different effects of cycling monetized?'

Following the experiences from previous work (paragraph 2.4) and complications regarding the different approaches (paragraph 2.5.2), this study will use a combined route/mode choice experiment. The cost difference between car / public transport and cycling will be used to be able to monetize the effects.

3.3.2 Selection of alternatives, attributes and attribute levels

Table 5 presents an overview of all alternatives, attributes and attribute levels used in the choice experiment. Due to complexity restrictions, the only attributes included in the choice experiment are travel time, travel costs and cycling comfort (paragraph 2.5.2). The starting point for the number of attribute levels is three, as it enables the presentation of a current, better and worse state. The alternatives, attributes and attribute levels are elaborated under the following headings.

Attribute		Attribute Levels *Unless stated, all percentages are with respect to the actual costs/travel times of the respondent for that mode.*	Levels
Mode Alternatives		Car, Public Transport, A comfortable and long cycle route (1), A uncomfortable and short cycle route (2), Other	5
Travel Time Cycling (1)		If the RP route quality is comfortable: -25%, ±0%, +25% If the RP route quality is uncomfortable: +10%, +20%, +30% with respect to 'Travel Time Cycling (2)'	3
Travel Time Cycling (2)		If the RP route quality is comfortable: -10%, -20%, -30% with respect to 'Travel Time Cycling (1)' If the RP route quality is uncomfortable: -25%, ±0%, +25%	3
Travel Time Alternative	Car	-15%, ±0%, +15%	3
	PT	-20%, ±0%, +20%	
Cost Cycling (1+2)		±0%	1
Cost Alternative	Car	-30%, ±0%, +30%	3
	PT	-30%, ±0%, +30%	
Difference in Cycle Route Quality		Comfortable vs. Uncomfortable Comfortable vs. Standard Standard vs. Uncomfortable	3

Table 5 attributes of stated choice experiment

Mode alternatives. Following the decision to use a mode choice experiment and the objective to estimate the value of comfort, the respondent is presented with five different alternatives. Two cycle routes, to assess the route quality valuation, and car and public transport, to assess the cyclists' VoT. The car is only included in the choice experiment if the respondent actually used the car over the last year for his trip. Also included is a no choice option, labeled 'I would choose another mode of transportation'.

Travel Time. Travel times are all related to the actual travel times of the modes experienced by the respondent. For cycling, first is determined what the respondent's current cycle route is. For the current quality level, the current, +25% and -25% travel time is used. For the other cycle route in the stated preference experiment a -10%, -20% and -30% travel time difference is used when the alternative route quality is worse and a +10%, +20% and +30% travel time difference is used when the alternative route quality is better. This way, the better cycle route quality is always slower in travel time than the lower cycle route quality. In other words, are you willing to cycle on a longer route if the route quality increases?

Since the main interest is the interaction between cycling and its alternatives and to keep the number of choice cards low, the attribute levels for car and public transport will be linked to each other for travel time and travel costs. Meaning that a low car travel time will always be associated with a low public transport travel time in the choice cards.

Travel Costs. For the cycling costs, the respondent is asked if and how much he or she has paid for parking their bicycle. This value is presented at both cycle alternatives in the SP and is not being varied over the different choice cards as only a few cyclists encounter costs. The cost variation is present in the car and public transport costs.

Due to respondent fatigue and methodological difficulties, the respondent is not asked for his actual travel costs in the questionnaire. When the respondent never travels by public transport or when the respondent receives a travel cost reimbursement, the propensity of knowing these costs is low. Therefore, an estimated guess for the travel costs is made based on the distance between origin and destination.

Cycle route quality. The cyclists' VoT varies per type of cycling road. The largest differences are found among the segregated cycle lane, the non-segregated cycle lane and the roads with no cycle facilities path (paragraph 2.4). The choice experiment will include a trade-off between time and comfort to derive the value of comfort. The non-segregated cycle lane or fast cycle route should therefore not be associated with the option with the shortest travel time. To prevent confusion when a fast cycle route is the slowest alternative, the following definitions are used instead in the choice experiment:

- Comfortable cycle route: A non-stop, comfortable and save route where cyclists have priority on crossings and experience a pleasant ride;
- Standard cycle route: A fairly direct and reasonable comfortable route where cyclists have priority on several crossings and sometimes need to stop;
- Uncomfortable cycle route: An uncomfortable and unsafe route, where cyclists get little priority, many times require to stop and the chances of an accident are higher.

To keep the number of choice cards low, the difference between quality levels is used instead of the quality level itself. The three levels are Comfortable vs. Uncomfortable, Comfortable vs. Standard and Standard vs. Uncomfortable. The mode alternatives have two cycle routes, where one alternative will always be associated with the most comfortable quality level available and one alternative with the least comfortable quality level available.

3.3.3 The choice cards

With five alternatives and five three-level attributes, a 5^3 fractional factorial design is fit for use. Eighteen choice cards are associated with the 5^3 fractional factorial design, which is relatively large. During the pilot phase, equal answering patterns were found among pairs of choice cards. As in some cases it is beneficial to sacrifice some purity in the experimental design to increase realism, the 'duplicates' are replaced by one dominant choice card, which brings the total number of choice cards to fifteen. In the dominant choice card (#5 in Table 6), the car and public transport modes are made very attractive and the cycle route with the highest quality level is faster than the lowest quality cycle route. Table 6 shows the resulting 15 choice cards.

#	Cycling Comfort Level (1 vs 2)	If RP cycling comfort is high		If RP cycling comfort is low		Car		Public Transport	
		Time Cycling 1	Time Cycling 2	Time Cycling 1	Time Cycling 2	Time	€	Time	€
1	High vs. Low	-25%	-10%	+10%	-25%	-15%	-30%	-20%	-30%
2	High vs. Low	+25%	-10%	+30%	-25%	+15%	RP	+20%	RP
3	High vs. Low	-25%	-20%	+10%	RP	-15%	+30%	-20%	+30%
4	High vs. Low	RP	-30%	+20%	+25%	RP	-30%	RP	-30%
5	High vs. Low	+25%	RP	-45%	-35%	-40%	-45%	-40%	-45%
6	High vs. Mid	-25%	-10%	+10%	-25%	RP	RP	RP	RP
7	High vs. Mid	RP	-20%	+20%	RP	+15%	+30%	+20%	+30%
8	High vs. Mid	+25%	-30%	+30%	+25%	-15%	-30%	-20%	-30%
9	High vs. Mid	RP	-10%	+20%	-25%	+15%	-30%	+20%	-30%
10	High vs. Mid	-25%	-30%	+10%	+25%	RP	+30%	RP	+30%
11	Mid vs. Low	RP	-10%	+20%	-25%	-15%	+30%	-20%	+30%
12	Mid vs. Low	+25%	-20%	+30%	RP	RP	-30%	RP	-30%
13	Mid vs. Low	-25%	-30%	+10%	+25%	+15%	RP	+20%	RP
14	Mid vs. Low	+25%	-10%	+30%	-25%	RP	+30%	RP	+30%
15	Mid vs. Low	RP	-30%	+20%	+25%	-15%	RP	-20%	RP

Table 6 Resulting choice cards, attributes and levels

3.3.4 Presentation of choice cards

To provide the same context to all respondents, the choice experiment is preceded with an introduction. In the introduction, the respondent is explained that the objective of the experiment is to find the respondent's considerations between time, comfort and money for his or her trip. The respondent is asked to keep the following aspects in mind when filling in the choice experiment questions:

- All travel times are from door-to-door;
- The costs of the public transport include the discount if applicable;
- The public transport option offers transfer free trip with the seating available;
- All five alternatives are possible (even if they seem unrealistic);
- All costs are paid by the respondent;
- The cycling conditions are good (15 – 25 degrees, dry and little wind).

Figure 2 presents an example of a choice card. The alternatives are presented as symbols and the attributes are presented in text. To emphasize the quality difference of the two cycle options, an image and extra explanation in the bottom are included.

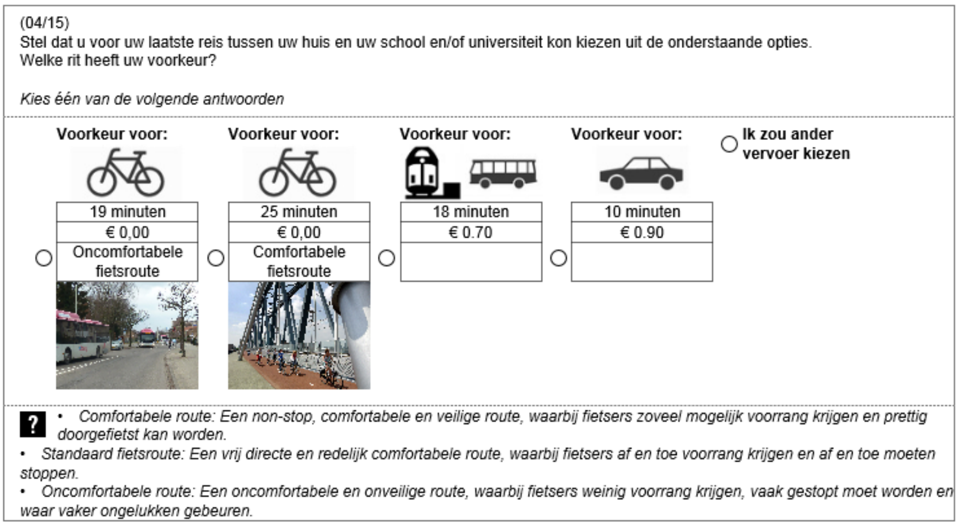

Figure 2 Example of a choice card from the choice experiment (in Dutch)

Chapter 4 Modelling Approach

In general, a discrete choice model postulate that the probability of individuals choosing a given option is a function of their socioeconomic characteristics and the relative attractiveness of the option (Ortúzar & Willumsen, 2002). To represent the attractiveness of alternatives the concept of utility is used. Alternatives do not produce utility, this is derived from their characteristics and those of the individual (Lancaster, 1966). For the derivation of the cyclists' VoT and VoC, this means that at a minimum the travel time, travel costs and cycling comfort needs to be included in the modelling.

In order to predict if an alternative will be chosen, the value of its utility must be contrasted with those of alternative options and transformed into a probability value between 0 and 1. This is the choice model. The choice model requires data input to calibrate the utility parameters. Data is generated through the stated preference experiment (paragraph 3.3). The utility parameters are the input for the value of time calculation.

The following paragraphs will discuss the theory on choice modelling. Paragraphs 4.1 to 4.3 explain the underling theory on choice modelling (utility theory, choice models, parameter estimation). Paragraph 4.4 discusses the specification of the utility function to be estimated. Finally, paragraph 4.5 discusses the tools to analyze the model estimation results.

4.1 Utility theory

The economic utility theory is based on the assumption that individuals maximize utility subject to the constraint of a limited budget and that the set of alternatives is assumed to be nonnegative continuous (Pindyck & Rubinfeld, 2009). Because we deal with a discrete set of choices, it is impossible to use the maximization techniques of calculus to derive the demand function. Thus, a different analytical approach is needed to represent discrete choice alternatives. Instead of deriving demand function, it is required to work directly with the utility function (Ben-Akiva & Lerman, 1985).

For a cycle route choice problem with two alternative routes, two utility functions are used that are expressed in terms of attributes for the alternative (x) and attributes that reflect the socioeconomic characteristics (s) of the decision maker. For example:

$$U_1 = U(x_1, s_1)$$
$$U_2 = U(x_2, s_2)$$

An additive utility function is most often used for computational convenience (Ben-Akiva & Lerman, 1985). In the case of a simple utility function in which the time (t) and cost (c) attributes are included, this gives the following linear utility function:

$$U_1 = \beta_1 t_1 + \beta_2 c_1$$
$$U_2 = \beta_1 t_2 + \beta_2 c_2$$

The utility that an individual obtains from an alternative is known to the individual but not by the researcher. The researcher observes some attributes of the alternatives, as faced by the individual, and some attributes of the individual and can specify a function that relates these observed factors to the individual's utility. This is called the systematic utility (Train, 2009).

Since there are aspects of utility that the researcher does not or cannot observe, utility is decomposed as:

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

Where ε captures the factors that affect utility but are not included in the systematic utility V. This decomposition is fully general, since ε is defined the difference between true utility U and the part of utility captured in V (Train, 2009).

Train (2009) explains that ε is unknown by the researcher and is therefore treated as random. With the joint density of the random vector $f(\varepsilon_n)$, the researcher can make probabilistic statements about the individual's choice. This probability is a cumulative distribution, the probability that each random term $\varepsilon_{n_J} - \varepsilon_{n_i}$ is below the observed quantity $V_{n_J} - V_{n_i}$. Using the density $f(\varepsilon_n)$, this cumulative probability can be rewritten as:

$$P_{ni} = \int_{\varepsilon} I(\varepsilon_{nj} - \varepsilon_{ni} < V_{ni} - V_{nj} \forall j \neq i) f(\varepsilon_n) d\varepsilon_n$$

Where I(•) is the indicator function, equaling one when the expression in parentheses is true and zero otherwise. This is a multidimensional integral over the density of the unobserved proportion of utility $f(\varepsilon_n)$. Different discrete choice models are obtained from different specifications of this density, that is, from different assumptions on the distribution of the unobserved proportion of utility. Examples of different discrete choice models are the multinomial logit, nested logit, probit and mixed logit and will be further explained in the next paragraph.

The most prominent way to think about the distribution of the unobserved proportion of utility is as follows. Consider a population of people who face the same observed utility as person n. Among these people, the values of unobserved factors differ. The density $f(\varepsilon_n)$ is the distribution of the unobserved proportion of utility within the population. Under this interpretation, the probability is the share of people who choose alternative i within the population.

4.2 Discrete choice models

In order to predict if an alternative will be chosen the value of its utility must be contrasted with those of alternative options and transformed into a probability value between zero and one (Ortúzar & Willumsen, 2002). A computation convenient and commonly used model type is the multinomial logit model (MNL) (Ben-Akiva & Lerman, 1985).

Multinomial Logit

The MNL model suffers from certain weaknesses when used in discrete choice modelling, principally when the errors are not independent (i.e. there are groups of alternatives more similar than others, such as public transport modes vs. private car). The most extreme form of this is in the so-called red bus, blue bus paradox (Mayberry, 1973). This problem is expected to occur in the current study set-up as it combines transport modes and bicycle routes in one choice experiment.

Another issue in the MNL model relates to the use of panel data. Panel data represent a repeated choice, such as the choices in this stated preference experiment. If the unobserved factors that affect individuals are independent over the repeated choices, the MNL can be used to examine panel data. However, dynamics associated with unobserved factors cannot be handled, since the unobserved factors are assumed to be unrelated over choices. In the situation where unobserved factors affect each of the individual's choices, it is advised to use a mixed logit model. These models allow unobserved factors to be correlated within the choices of one individual (Train, 2009).

Mixed Logit

According to Train (2009) the mixed logit is a highly flexible model that can approximate any random utility model. The ML model allows for random taste variation (panel effect). The ML furthermore does not exhibit independence of irrelevant alternative (IIA) or the restrictive substitution of patterns of the MNL because the ratio of mixed logit probabilities depends on all the data. An improvement in one alternative does not affect the other alternatives proportionally.

A mixed logit model is any model whose choice probabilities can be expressed in the form

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

Where $f(\beta)$ is a density function, $L_{ni}(\beta)$ is the logit probability evaluated at parametersβ.

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

$V_{ni}(\beta)$ is the observed portion of the utility, which depends on the parameters β. If utility is linear in β, then $V_{ni}(\beta) = \beta' x_{ni}$. In this case, the mixed logit probability takes its usual form:

$$P_{ni} = \int \left(\frac{e^{\beta' x_{ni}}}{\sum_j \; e^{\beta' x_{ni}}} \right) f(\beta) d\beta$$

The mixed logit probability can be derived from utility-maximizing behavior is several ways; although formally equivalent, they provide different interpretations, i.e. error components and random components (paragraph 4.4.5 and 4.4.6).

In contrast to the MNL model, the resulting integral in the ML model does not have a closed form and is evaluated numerically through simulation. Due to the simulation approach for ML models, substantial longer computational times are found for ML models. Therefore, the model analysis starts with the estimation of a MNL model. The best MNL model will be adapted to a ML model, which will be used for further analyzes.

4.3 Parameter estimation

To calibrate a discrete choice model, the maximum likelihood is most commonly used (Ben-Akiva & Lerman, 1985). The maximum likelihood estimation in this study shall be performed with the BIOGEME software (Bierlaire, 2003). For background information on the maximum likelihood method, the reader is referred Ben-Akiva and Lerman (1985) and Ortúzar and Willumsen (2002).

4.4 Model specification

When specifying the systematic component of the utility function, it is important to consider which variables enter the utility function and in which form. A linear utility function is most often used for its computational convenience (Ben-Akiva & Lerman, 1985). The specific elements of the utility function are discussed next.

4.4.1 Alternative Specific Constant

The alternative specific constant (ASC) captures the average effect on utility of all factors that are not included in the model. With the inclusion of ASC, the unobserved portion of utility, ε_{n_i}, has zero mean by construction. Since only differences in utility matter, only differences in the ASC are relevant, not their absolute levels. In the model estimation, one of the ASC can be fixed to zero. The ASC can therefore be interpret as the relative utility of the non-fixed alternative to the fixed alternative (Train, 2009).

4.4.2 Level-of-Service variables

The level-of-service (LOS) variables are the observed variables related to the choice alternatives that influence the individual's utility. The attributes generally vary over alternatives (Train, 2009). The LOS variables to include in this study are the time and cost of travel by car, public transport and bicycle. The cycling alternatives will, additionally, also have a cycling comfort related LOS variable included.

4.4.3 Socio-economic variables

The socio-economic (SE) variables are the observed variables related to the individual. Generally, the attributes of the individual do not vary over alternatives. The socio-economic variables can enter the utility function as dummy variables or interacted with LOS attributes (Train, 2009). The socio-economic characteristics that are expected to influence choice behavior are identified in paragraph 2.3 and included in the questionnaire in paragraph 3.2.

4.4.4 Attitudes

The individual's attitude toward travel forms a different category of variables. The questionnaire assessed the influence of 13 different choice considerations on the individual's choice behavior using a 5-point scale. Several choice considerations are expected to be correlated to each other or could be group to a generalized consideration. Using a factor analysis, the variability of the observed, correlated variables are described in terms of a lower number of unobserved variables called factors (e.g. Thompson (2004)).

Factors are derived using the statistical program SPSS. The following steps are followed is used for the in the factor analysis.

1. Extract initial factors (eigenvalue of 1.0 and higher);
2. Intuitively assessment of factors and total variance explained;
3. Provide number of common factors to be extracted or objective criterion for choosing number of factors;
4. Repeat 2-3;
5. Rotate and interpret;
6. Construct factor scores and use in further analysis.

The factor analysis follows an iterative approach. The number of factors and/or parameters can be changed to improve the intuitively and identifiability of the factors and the total variance explained.

4.4.5 Random coefficient

In the case of ML models, random coefficient and/or error components are used to account for the variability due to the individual's taste.

The coefficients vary over individuals in the population with density$f(\beta)$. This density is a function of parameters θ that represents the mean and covariance of the β's in the population. This specification is the same as for the MNL except that β varies over decision makers rather than being fixed. For example, cost might be divided by the individual's income to allow the value of cost to decline as income rises. The random coefficient in this example represents the variation over people with the same income in the value that they place on cost (Train, 2009).

4.4.6 Error Components

Train (2009) explains that a ML model can be used without a random component interpretation, as simply representing error components that create correlations among the utility for different alternatives. Utility is specified as

$$U_{nj} = \alpha' x_{nj} + \mu_n' z_{nj} + \varepsilon_{nj}$$

Where x_{nj} and z_{nj} are vectors of observed variables relating to alternative j, α is a vector of fixed coefficients, μ is a vector of random terms with zero mean, and ε is the independent and identical distributed random variable. The terms in z_{nj} are error components that, along with ε, define the unobserved (random) portion of utility, which can be correlated over alternatives depending on the specification of z_{nj}. For the MNL, z_{nj} is identically zero, so that there is no correlation in utility over alternatives. This lack of correlation gives rise to the IIA property and its restrictive substitution patterns. With nonzero error components, utility is correlated over alternatives.

4.5 Model analysis

As mentioned earlier, first a MNL model will be estimated. The MNL includes the ASC and LOS variables and the significant SE and attitude variables. This model is then adapted to a ML model and used for further analyzes. The different tools to select the most appropriate model specification and assess the model estimation results are discussed next

4.5.1 Rho-square

A statistic called the rho-square (or likelihood ratio index) is often used with discrete choice models to measure how well the model fit the data. More precisely, the statistic measures how well the model, with its estimated parameters, performs compared with a model in which all the parameters are zero. This comparison is made based on the log-likelihood function, evaluated at both the estimated parameters and at zero for all parameters. The rho-square is defined as (Train, 2009):

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

Where $LL(\widehat{\beta})$ is the value of the log-likelihood function at the estimated parameters and $LL(0)$ is its value when all the parameters are set equal to zero. The rho-square ranges from zero to one, where one indicates that the estimated parameters perfectly predict the choices of the sampled population. Values of ρ^2 between 0.2 and 0.4 are considered to be indicative of a good model fit (Louviere et al., 2000). The ρ^2 statistic can be improved by adjusting for degrees of freedom, which is useful when comparing different models. The adjusted ρ^2 statistic is defined as

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

Where K is the number of estimated parameters.

4.5.2 **Likelihood ratio test**

As with regressions, standard t-statistics are used to test hypothesis about individual parameters in discrete choice models, such as whether the parameter is zero. For more complex hypothesis, a likelihood ratio test can be used. To test a hypothesis, two models need to be estimated. Once with the explanatory variable included, and a second time without them. The test statistic is two times the difference between the maximum values of the log-likelihood. This value is compared with the critical chi-square value with degrees of freedom equal to the number of explanatory variables excluded from the second estimation (Train, 2009). This approach is used to find the best model specification with the LOS variables and to find significant influences of SE and attitudes on the choice behavior. When correlations between variables exist, adding both variables could turn one of the variables insignificant. The parameter with the highest added value for the model performance is kept.

4.5.3 **Scale parameter**

Train (2009) explains that in some situations, the variance of the error terms can differ per population segment (i.e. geographic regions, data sets, time, or other factors). The variance of the errors cannot be normalized to the overall level of utility, since the variance is different in different segments. Instead, the overall scale of utility is fixed for one segment and the variance for each segment is estimated relative to the fixed segment.

For the interpretation of the model estimation results it is useful to recognize that the estimated parameters are actually estimates of the 'original' coefficient β^* divided by the scale parameter λ. The coefficients that are estimated indicate the effect of each observed variable relative to the variance of the unobserved factors. A larger variance in unobserved factors leads to smaller coefficients, even if the observed factors have the same effect on utility (i.e. higher λ means lower β even if β^* is the same).

The implementation of the scale parameter in the BIOGEME model estimation results in the coefficient estimations for the fixed segment and scale parameters for the other segments. The VoT and VoC for the scaled segments are estimated through the multiplication of the fixed segment's VoT and VoC by the scale parameter.

4.5.4 **Value of time and value of comfort estimation**

One of the key analyses in this study is the estimation of the VoT and VoC. The VoT originates as the marginal rate of substitution (MRS) in the field of microeconomics (Ben-Akiva & Lerman, 1985). The MRS is the maximum amount of a good that a consumer is willing to give up in order to obtain one additional unit of another good (Pindyck & Rubinfeld, 2009). The concept of MRS has evolved in the field of transport economics into a VoT.

In the most general form, the VoT is the amount of money that a person is willing to pay to save one unit of travel time. The mathematical equation looks like:

$$VoT = \frac{\beta_{time}}{\beta_{cost}}$$

Where β_{time} represents the marginal utility of time and β_{cost} utility of cost. The model analysis estimates all parameter values from which the VoT can be estimated. As explained in paragraph 3.3.2, the choice experiment does not contain a cycling cost parameter. Instead, a parameter for the cost difference car – cycling and PT – cycling will be estimated in accordance with previous cyclists' VoT studies. The formula for the VoT estimation is:

$$VoT_{relative\ to\ car} = \frac{\beta_{time}}{\beta_{costdifference\ car-cycling}} \qquad VoT_{relative\ to\ PT} = \frac{\beta_{time}}{\beta_{costdifference\ PT-cycling}}$$

Because of the used approach, it is important to consider that the results from this calculation is not really a VoT, it is a willingness to accept a smaller cost difference between cycling and its alternative (paragraph 2.4).

Another key analysis in this study is the estimation of the VoC. In the most general form, the VoC is the amount of money that a person is willing to pay to cycle on more comfortable cycle route. The three comfort levels from the choice experiment will be interacted with the cycling travel time in the model analysis. Therefore, the cyclists' VoT is available for cycling on each of the three comfort levels. The definition of the he VoC is the VoT difference between the old route (low quality) and the new route (high quality)

$$VoC = VoT_{old\ cycle\ route} - VoT_{new\ cycle\ route}$$

4.5.5 **Elasticities**

Elasticity is defined as the percentage change in the choice probability of an alternative with respect to a one-percent change in the explanatory variable (Koppelman & Bhat, 2006). To account for every individual, the weighted average of every individual's elasticities are taken

$$Elasticity = \frac{\sum_{n=1}^{n} \frac{\partial f(x_n)}{\partial x_n} * w_n}{\sum_{n=1}^{n} w_n}$$

There is some ambiguity in the computation of this elasticity in terms of whether it should be normalized using the original probability-attribute combination or the new probability-attribute combination. Elasticities are not only a function of the parameter value for the attribute in utility, they are also a function of the attribute level at which the elasticity is being computed. This confusion can be avoided by computing elasticities for very small changes, the so-called point elasticity.

Elasticity is divided in direct- and cross-elasticity. The direct elasticity measures the percent change in the choice probability of an alternative, with respect to a percent change in the attribute level of that alternative. Cross-elasticity is defined as the proportional change in the choice probability of an alternative with respect to a proportional change in some attribute of another alternative.

Elasticities cannot be derived for ordinal or categorical variables. An alternative is to calculate the incremental change in each probability with respect to a one-unit change in an ordered variable or a category shift for categorical variables.

Chapter 5 Descriptive analysis

This chapter performs the first analyzes towards the estimation of the cyclists' VoT and VoC. The purpose of this chapter is to find evidence in the data on the personal- and trip characteristics that are expected to influence the cyclists' VoT and VoC. The data has been collected according to the recruitment method as described in the previous chapter. Paragraph 5.1 describes the data selection process since incomplete and incorrectly filled in questionnaires cannot be used for analysis. Paragraph 5.2 presents the resulting response rates from the recruitment. Paragraph 5.3 provides a descriptive analysis of the remaining data. This paragraph also includes the factor analysis for the attitudes and concludes with the input for the model analysis. Finally, paragraph 5.4 assesses the representativeness of each segment and interview location.

5.1 Data selection

In total 677 (partly) filled in questionnaires were collected. Before the collected data can be used, several data processing steps are required. To start, unusable responses need to be separated from the usable responses. Secondly, data is imputed or corrected and new variables are derived. The result is an unweighted data set that, after weighting, can be used to analyze the cyclists' choice behavior.

5.1.1 Removal unusable responses

If one the following elements were present in the data entry answer, the data entry is removed:

- The questionnaire was not completely filled in;
- The respondent filled in a questionnaire for a round trip (same origin and destination).

5.1.2 Imputation / Correction of the data

If one the following elements were present in the respondent's answer, his entry was complemented:

- The destination postal code was not filled in a 4-digit format, but as a description;
- The user-comment at the end gave reason for adjusting some of the answers;
- The respondent stated a 0-minute travel time by car. This is changed into 'not available';
- The average cycling speed has been calculated with the travel time and travel distance. If unrealistic speeds were found, the data was corrected for possible punctuation errors.

5.1.3 New variables

The following variables are derived from the respondent's answers:

- The most frequently used cycle route quality (relates to the share of time spend on the different quality levels of cycling, question 11 in paragraph 3.2);
- The most frequently used mode (RP Choice) is derived from the trip frequencies for each individual mode of transport. In case of equal frequencies, the respondent is assigned a RP choice in the following order: Public transport, car, cycling;
- Factor scores are derived for the 13 attitude questions. The factors combine coherent attitudes, increasing the explanatory value in the model estimation;
- Interview location is derived using the postal codes. Except for students, the educational trip purpose is grouped as a separate category.

523 filled in questionnaires remains fit for analysis after the data selection.

5.2 Response rates

The email invitations and flyers were distributed in June 2014. Three weeks after the initial mail invitation, a reminder was sent. Based on the mail addresses that were filled in by the respondent and the postal code information, it was possible to trace back the recruitment method for most respondents. Not all respondents could be traced back due to the unavailability of a mail address or the unavailability to assign an origin and destination to one specific recruitment method. An overview of the recruitment methods and the corresponding response rates are shown in Table 7.

Based on the total response, the response rate lies somewhere between 35% and 50% with 523 correctly filled in questionnaires. Especially the mail recruitment shows an exceptional high response, which could be the result of a pro-cycling attitude in the sample (many people in the mail database are willing to participate in a follow-up cycling survey). The student flyering shows much lower response rates. Possible reasons for the low response are:

- The period of flyering coincided with the beginning of the university holiday season;
- Students are less motivated to participate in the questionnaire;
- Due to the flyering at student dormitories, not all students are cyclists.

Location	Mail/Flyers sent	Completed questionnaires	Response rate
Region Arnhem – Nijmegen	793 (mail)	310 + ?	39% + ?
Breda – Etten-Leur	272 (mail)	83	31%
Student flyering	450 (flyer)	19 + ?	5% + ?
Unknown if recruited as student or as cyclists in region Arnhem-Nijmegen	-	111	-
Total	**Mail: 1.065 Flyers: 450**	**523**	**35% - 50%**

Table 7 Overview of the recruitment methods and response rates

5.3 Descriptive analysis

The 523 completely filled in questionnaires can be differentiated over the three target segments of interest. In the descriptive analysis, data will be differentiated over the three target segments and the interview locations. Paragraph 5.3.1 starts with a general reflection on the collected data, the three subsequent paragraphs describe the data collected on the level-of-service variables, socio-economic characteristics and attitudes. The descriptive analysis will compare the results per revealed preference (RP) choice and stated preference (SP) choice to find those attributes influencing choice behavior. The subsequent paragraphs discuss the level-of-service, socio-economic and attitude characteristics in more detail.

5.3.1 General description of data

Taking into account the target of 100 respondents per segment, not enough data is collected on the student sample for an accurate model analysis (Table 8). Furthermore, the commenting section from the questionnaire showed that some respondents misinterpreted the educational trip purpose. For example, some respondents filled in the educational questionnaire for a trip to yoga class. The influence of these respondents in the model analysis will be minimalized through weighting (paragraph 5.4.2). However, the effective sample size after weighting will therefore be even less than 92. A descriptive analysis will be provided on the educational sample, but accurate model estimations cannot be expected from this sample.

	Breda – Etten-Leur	Arnhem – Nijmegen	Total
Commute	60	237	297
Education	n/a	n/a	92
Other Recreational	23	111	134

Table 8 Distribution of filled in questionnaires over trip purpose and interview location

Table 9 and Table 10 show per sample and combined, the most frequently used mode of the respondent (RP Choice) and an aggregation of all choices made in the choice experiment (SP choice), expressed as a percentage of the whole sample. In the RP choice, the respondent is assigned to a fast cycle route (HQ), a standard cycle route (MQ) or to cycling on a public road (LQ). In the SP choice, the respondent was able to choose between a comfortable and slow cycle route (Cycling 1) or cycling on an uncomfortable and fast cycle route (Cycling 2). In the SP choice, the respondent was also able to choose a non-choice option 'other' if the presented choice alternatives were all not viable for the respondent.

Almost all respondents use the bicycle as most dominant mode of transport. Although most respondents also travel by car and public transport, they use these modes less frequent (Table 11). Converted into a discrete mode choice, the results show a large dominance of bicycle users. Therefore, the results show that only in one percent of all SP situations public transport was chosen. The non-choice option was only chosen 7 out of 7845 times. Following the travelers classification from the city region Arnhem Nijmegen, it can be said that the carefree cyclist who always cycles is dominantly present in the sample.

The travel frequencies show that commuting trips are often made 4 to 5 times per week, while other recreational are more often made on weekly basis. The RP and SP choices show in comparison to commuters that other recreational travelers choose more often to travel by car and students travel more often on fast and uncomfortable routes. Furthermore, students travel less by car and more by public transport.

	Breda - Etten-Leur					Arnhem - Nijmegen					All				
	Car	PT	Cycling HQ	Cycling MQ	Cycling LQ	Car	PT	Cycling HQ	Cycling MQ	Cycling LQ	Car	PT	Cycling HQ	Cycling MQ	Cycling LQ
Commute	18%	2%	57%	15%	8%	11%	2%	35%	41%	11%	13%	2%	39%	36%	10%
Education											9%	10%	27%	48%	7%
Other Recreational	39%	9%	35%	13%	4%	22%	4%	27%	35%	13%	25%	4%	28%	31%	11%

Table 9 Distribution of RP choices in percentage per trip purpose and interview location

	Breda - Etten-Leur					Arnhem - Nijmegen					All				
	Car	PT	Cycling 1	Cycling 2	Other	Car	PT	Cycling 1	Cycling 2	Other	Car	PT	Cycling 1	Cycling 2	Other
Commute	6%	0%	56%	38%	1%	6%	2%	48%	44%	0%	6%	1%	50%	43%	0%
Education											2%	1%	46%	51%	0%
Other Recreational	16%	0%	52%	32%	0%	10%	1%	51%	38%	0%	11%	1%	51%	37%	0%

Table 10 Distribution of SP choices in percentage per trip purpose and interview location

	Commute					Education					Other Recreational				
	4-5 days per week	1-3 days per week	1-3 days per month	< 1 day per month	never	4-5 days per week	1-3 days per week	1-3 days per month	< 1 day per month	never	4-5 days per week	1-3 days per week	1-3 days per month	< 1 day per month	never
Cycling	73%	25%	1%	1%	0%	38%	23%	24%	15%	0%	16%	61%	21%	2%	0%
Car	2%	17%	20%	46%	15%	1%	7%	10%	40%	42%	3%	19%	25%	41%	12%
Public Transport	1%	2%	10%	33%	54%	3%	10%	9%	41%	37%	2%	4%	6%	40%	49%

Table 11 Respondent's travel frequencies per trip purpose and per mode of transport

Mobycon (2006) found in a survey for the city of Delft, Netherlands, that most cyclists cycle because it is fun, healthy and convenient. Only students showed noticeably different choice behavior, being led by costs and travel time, which could also explain the findings from this survey.

The RP choices show that respondents from the region Breda – Etten-Leur travel far more often on a fast cycle route. This is also reflected in the answering patterns from the choice experiment, as respondents from Breda – Etten-Leur choose more often to travel on the comfortable and slow route in comparison to the respondents from the region Arnhem – Nijmegen.

Elaborating on the comparison between interview locations, Figure 3 shows the average scores individuals gave to different route aspects per interview location. The descriptive statistics show that the scores from the Arnhem – Nijmegen sample are systematically lower in comparison to the Breda – Etten-Leur sample scores. Cycling on a qualitative good cycle route increases the assessment score of the route and the propensity to choose to cycle on the most comfortable route in the choice experiment.

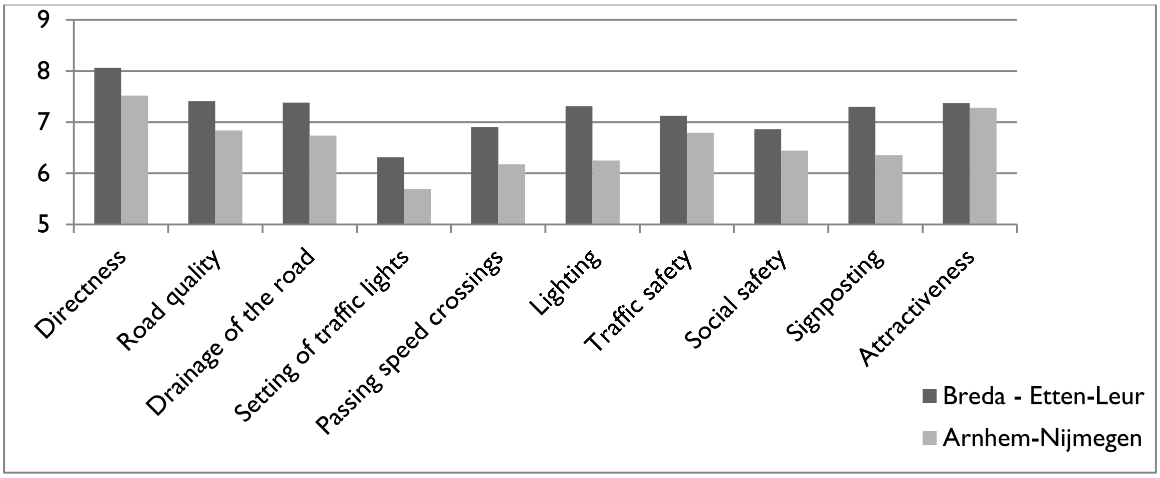

Figure 3 Comparison route assessments per interview location

5.3.2 **Level-of-service characteristics**

Travel Time

Table 12 shows for the SP alternatives, the average characteristics of the choice cards when each choice alternative was chosen and the average RP travel times. The table shows that the respondents' average cycling commuting travel time is 10 minutes longer than the respondents' educational travel time and 13 minutes longer than the respondents' other recreational travel time. On average, the actual cycling travel time from the commute sample is 32 minutes, which is much higher than the Dutch average of 17 minutes cycling per commuting trip (Centraal Bureau voor de Statistiek, 2013). Commuters are recruited from a sampling frame that focused on fast cycle routes (paragraph 3.1). Users of these routes cycle on average longer distances.

Up to a certain cycling travel time, the car and public transport are not being considered as alternatives (Table 13). People just cycle. Only when cycling travel times are getting higher, people start considering the motorized alternatives. Depending on the costs and time that can be saved, people start changing their mode of transport. Table 12 also shows this effect in the average SP choice situation when the respondent choses to cycle. For example, the commuting respondents were on average willing to cycle 32 minutes on a comfortable cycle route, despite the car alternative being on average 17 minutes faster. The travel time distributions for the other mode alternatives are shown in Appendix C. Similar results are found in these plots, where it is interesting to note that high shares of respondents who choose to cycle are also found for short car and public transport travel times. This supports the statement that people only starts considering car and public transport when cycling takes too long.

		SP Choice	Car (min)	Car (€)	PT (min)	PT (€)	Cycling 1 (min)	Cycling 2 (min)
Commute	RP		22.4	-	40.1	-	31.7	
	SP	Car	**19,1**	**2,4**	33,2	3,1	44,3	35,6
		PT	18,2	3,2	**26,9**	**2,1**	38,9	31,2
		Cycling 1	15,0	3,0	30,1	2,7	**32,5**	25,4
		Cycling 2	18,2	3,1	33,6	3,0	35,9	**25,9**
Educational	RP		19.4		34.2		21.0	
	SP	Car	**18,6**	**2,8**	27,6	3,2	50,1	33,3
		PT	14,8	1,5	**16,8**	**1,8**	35,8	25,2
		Cycling 1	16,6	1,9	22,0	1,9	**20,8**	16,5
		Cycling 2	18,4	4,0	28,1	2,0	24,4	**18,0**
Other Recreational	RP		12.6		24.9		18.6	
	SP	Car	**13.1**	**2.2**	20.3	2.3	33.7	23.6
		PT	11.1	0.9	**11.8**	**1.5**	28.5	19.9
		Cycling 1	10.7	1.8	15.1	1.9	**16.7**	13.3
		Cycling 2	12.3	2.9	17.7	2.1	21.7	**16.2**

Table 12 Average RP travel times and average SP travel times and costs when each alternative is chosen

Even though most people cycle, comfort preferences and the maximum cycle distance for which people do not consider other mode alternatives do differ per trip purpose. The results indicate for commuting travel that a comfortable route is preferred above a fast route, but the preferences is weakening as travel times increase. If the base travel time is already high, people are less willing to accept additional travel time to increases their cycle comfort.

With respect to the commuters, students prefer the comfortable and slow route less for very short trip distances. The willingness to accept discomfort is higher among students. For other recreational trip purposes, the opposite effect is found. For all trip distances, other recreational cyclists have a higher preference for comfort. Applying the theory of paragraph 2.2, a possible explanation is that students are less sensitive for the risks of accidents, which results in a relative high direct utility of travel time on uncomfortable routes. Other recreational cyclists have, on the contrary, a higher preference for comfort. Possibly, since they are more often cycling with heavy loads (i.e. groceries) which make maneuvering and stopping more exhausting.

Travel Cost

Table 12 shows that the cost of car and public transport in the choice experiment are on average €0,40 to €1,- lower when the respondent chose these modes in comparison to not choosing car and public. The lower costs indicate that there might be an influence between the costs of car and public transport and the propensity to cycle. The cost distribution plots can be found in Appendix C.

The distribution of bicycle parking costs is not included here, since almost none of the respondents stated to have bicycle-parking costs. The explanatory value of this attribute is low.

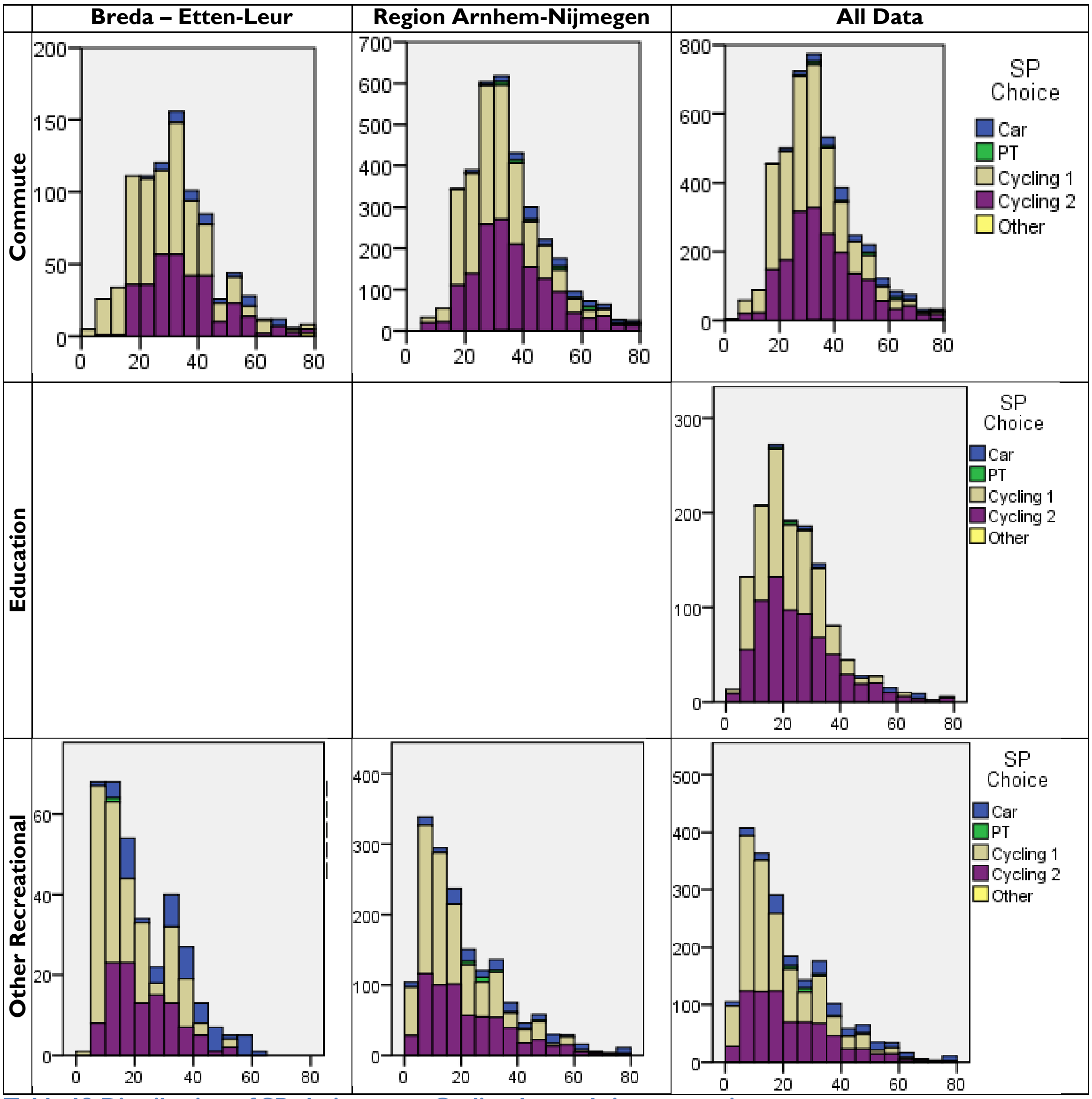

Table 13 Distribution of SP choices over Cycling 1 travel times per trip purpose

5.3.3 Socio-economic characteristics

The questionnaire collected data on several socio-economic characteristics. For each socio-economic characteristic, the distributions over the RP and SP choices have been assessed. Appendix C includes the full analysis with correspondent plots. Table 14 summarizes the findings from the analysis. The table presents for each socio-economic which class has the strongest association with one of the SP choices. Take as example the motor vehicle ownership in Table 15, the strongest association in the commuting sample has been found between owning two or more cars and choosing car in the choice experiment.

The data have also been assessed on correlations between socio-economic characteristics. The results indicate correlations among the following pairs 'Income and Education level' and 'Income and Car Ownership'. A higher income lowers the marginal utility of money (paragraph 2.2). Therefore, a high education level and owning cars would also show a lower marginal utility of money and a higher value of time.

Since paragraph 5.3.1 showed that different choice behavior exists between the two interview locations for commuting and other recreational travel, the socio-economic characteristics were also tested on significant differences between interview locations. For each attribute, a chi-square test was used to assess if there are significant differences between the samples. No significant differences were found between the two samples in the other recreational data. In the commuting data a significant difference was found in the education level. The Arnhem – Nijmegen sample is higher educated.

Socio-economic characteristic	Commute	Education	Other recreational
Gender	Female (+)→ Car	Female (+)→ Car	
Age	Under 35 (+)→ Car / PT Above 51 (+)→ Cycling		Under 35 (+)→ PT
Education	HBO, WO (+)→ Car / PT	LO, LBO, MBO (+)→ Cycling	LO, LBO, MBO (+)→ Car / Cycling 1
Income	Less than €2.500 p/m (+)→ Car / PT	Less than €625 p/m (+)→ Cycling	Less than €3.125 p/m (+)→ Cycling
Household size	1 to 3 persons (+)→ Car	1 person (+)→ Cycling	1 and 2 person (+)→ Cycling 1
Motor vehicle ownership	2 and more cars (+)→ Car	2 and more cars (–)→ PT	0 cars (+)→ Cycling 2 and more cars (+)→ Car / PT

Table 14 Summary of influences of specific socio-economic characteristics

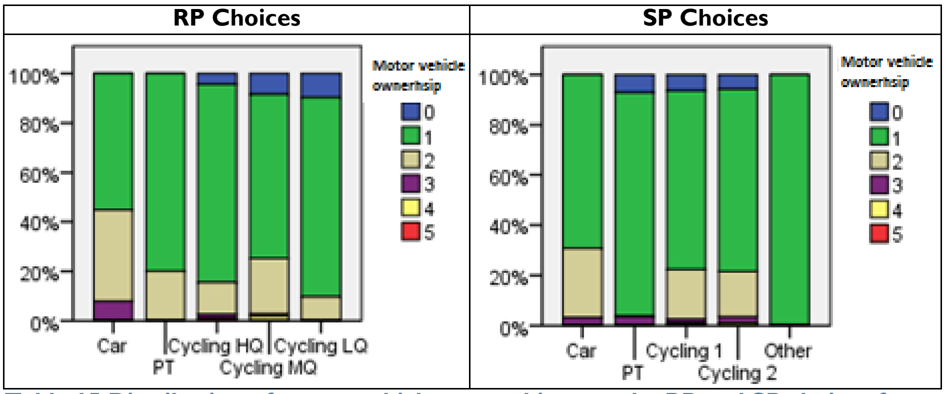

Table 15 Distribution of motor vehicle ownership over the RP and SP choices for commuting travel

5.3.4 **Attitudes**

The respondent was asked to indicate how important thirteen different considerations are in his choice to cycle (Paragraph 3.2). A factor analysis is used on the commuting data to combine the thirteen different considerations in a few attributes with a higher explanatory value.

For each trip purpose, a separate factor analysis is performed, following the approach from paragraph 4.4.4. The attitudes are grouped in different factors, which possess a higher explanatory value. For the commuting trip purpose, this resulted in five factors with 70% of the variance explained. For the educational trip purpose, this resulted in four factors with 65% of the variance explained. For the other recreational trip purpose, this resulted in five factors with 73% of the variance explained. The resulting component matrices are shown in Table 16, Table 17 and Table 18. Several factors do not differ per trip purpose. For these factors, generalized definitions can be used. The interpretation of all factors is shown in Table 19.

	Factors				
	A	B	C	D	E
I enjoy cycling	,894				
Cycling is good for my health	,874				
Cycling is good for the environment	,778				
I can easily park my bicycle	,552				
Public transport is too full		,863			
Public transport is too expensive		,762			
Cycling the fastest way of transportation			,852		
I'm not bound to fixed departure times			,562		
I can take a shower at my destination				,845	
I can access a secured bicycle parking at my destination				,699	
The weather					,935

Table 16 Component matrix - commuting data (values below 0,400 are left out)

	Factors			
	A	G	C	D
Cycling is good for my health	,869			
Cycling is good for the environment	,868			
I enjoy cycling	,813			
Public transport is too expensive		,783		
Public transport is too full		,684		
I have to pay for parking my car		,622		
I avoid congestion		,496		
The weather		,433		
Cycling the fastest way of transportation			,836	
I can easily park my bicycle			,689	
I'm not bound to fixed departure times	,420		,535	
I can take a shower at my destination				,801
I can access a secured bicycle parking at my destination				,782

Table 17 Component matrix - Education data (values below 0,400 are left out)

	Factors				
	A	H	F	C	D
Cycling is good for the environment	,819				
Cycling is good for my health	,807				
I enjoy cycling	,794				
I have to pay for parking my car		,856			
I avoid congestion		,722			
The weather		,494			
I can take a shower at my destination			,815		
Public transport is too full			,767		
Cycling the fastest way of transportation				,938	
I can access a secured bicycle parking at my destination					,940

Table 18 Component matrix - other recreational trip data (values below 0,400 are left out)

	Factor	Description
A	**Enjoyability of cycling**	Respondents who score high on this factor choose the bicycle (or do not choose the car) because cycling is an enjoyable, healthy and environmental mode of transport.
B	**Considering public transport**	Respondents who score high on this factor choose the bicycle because the public transport is too full or too expensive.
C	**Travel Time**	Respondents who score high on this factor choose the bicycle because it is the fastest mode available and the respondent is not bound to fixed departure times.
D	**Destination Facilities**	Respondents who score high on this factor let their mode choice depend on the cycling facilities at the destination.
E	**The weather**	Respondents who score high on this factor consider the weather when choosing the bicycle.
F	**Shower/Full public transport**	Respondents who score high on these two factors consider public transport and the possibility to shower in their mode choice.
G	**Considering all modes**	Respondents who score high on this factor choose (not) to cycle because of the (un)attractiveness of the other modes of transport.
H	**Considering the car**	Respondents who score high on this factor choose (not) to cycle because of the (un)attractiveness of the car.

Table 19 Definitions of the factors

The resulting factor scores are contrasted with the RP and SP choices, the corresponding plots can be found in the attitude section of Appendix C. Table 20 summarizes the findings from the analysis. The table presents for each socio-economic which class has the strongest association with one of the SP choices. Take as example the weather attitude. The weather attitude is defined as: "Respondents who score high on this factor consider the weather when choosing the bicycle." Table 21 shows that a high factor score for this factor is associated with choosing more often car and public transport in the choice experiment.

Attitude	Commute	Education	Other
A. Enjoyability of cycling	(+)→ Cycling	(+)→ Cycling	(+)→ Cycling 1
B. Considering public transport	(+)→ Car / PT		
C. Travel Time	(+)→ Cycling	(+)→ Cycling	(+)→ Cycling 2
D. Destination Facilities	(+)→ Cycling 1	(+)→ Car	(–)→ Car
E. The weather	(+)→ Car / PT		
F. Shower / Full public transport			(+)→ Car / PT
G. Considering all modes		(+)→ Car	
H. Considering the car			(+)→ Car

Table 20 Summary of influences of specific attitudes

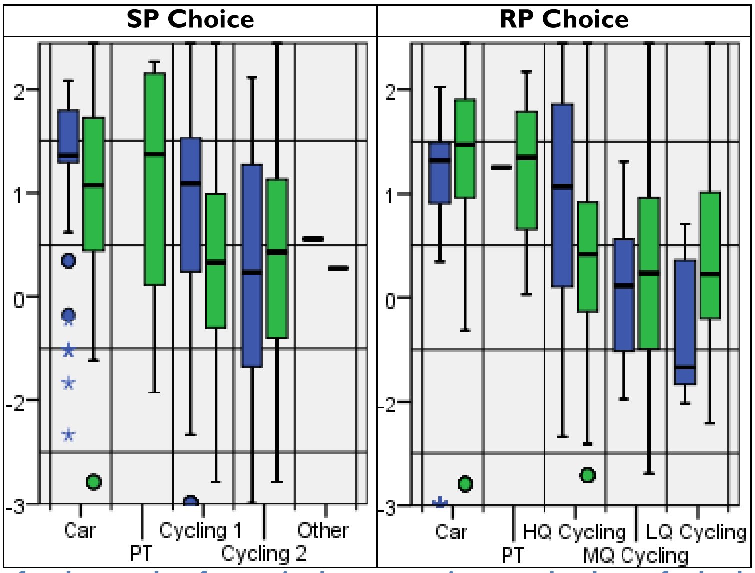

Table 21 Box-plots for the weather factors in the commuting sample, shown for both Breda - Etten-Leur (Blue) and region Arnhem - Nijmegen (Green)

Since paragraph 5.3.1 showed that different choice behavior exists between the two interview locations for commuting and other recreational travel, the attitudes were also tested on significant differences between interview locations. For different pairs of factors, a chi-square test was used to assess if there are significant differences between the samples. No significant differences were found between the two samples in the other recreational data. In the commuting data, a significant difference was found in the travel time factor. The Arnhem – Nijmegen respondents have a significant higher factor score for travel time. Respondents from the Arnhem – Nijmegen sample consider more often the time component in comparison to respondents from Breda – Etten-Leur. A possible explanation is the difference in progress on the fast cycle routes (paragraph 3.1.2). The fast cycle route between Breda – Etten-Leur has already been completed and could therefore attract more cyclists for whom the comfort aspects are more important than the cycling travel time. For the other factors in the commuting sample, no significant differences could be found. The difference further emphasize that different choice behavior exists depending on the interview location.

5.4 Representativeness and weight factors

A sample is representative when specific socio-economic characteristics that are decisive cyclists' VoT and VoC are present in the same ratio in the sample and the population (Mouter, 2013). The unweighted sample is compared with information from OViN, which contains information on thousands of trips made in the Netherlands (Centraal Bureau voor de Statistiek, 2014). From this data, the cycling populations for the three different trip purposes are derived. Weight factors are calculated for each trip purpose to be able to estimate valuations that are valid for the target population.

The OViN database consist out of approximately 0,3% of the total population (135762 unique data entries). This database enables the determination of the cycling population. For the determination, only the trips from home to destination will be used, as this has also been the reference trip for the choice experiment. The return trip will not be included in the population determination. For each of the three researched trip purposes, different populations will be determined. The determination is described in the Table 22. The OViN database itself is not representative, but it does contain weight factors for households, persons and trips to gain representativeness. The person weighting will be applied in this procedure since the sample also contains data on person level. The population is determined on national and Arnhem Nijmegen scale to account for regional differences.

Trip Purposes	Determination procedure
Commuting	Trip Purpose = Commuting Trip Direction = Home to Work Main mode of transportation = Bicycle Regional weighting = (1) NL, (2) WGR+ Region Arnhem-Nijmegen
Students	Trip Purpose = Education Trip Direction = Home to School/University Main mode of transportation = Bicycle Unpaid Occupation = Student Regional weighting = (1) NL
Other recreational trip purposes	Trip Purpose = Shopping, visits and other social recreational Trip Direction = Home to shopping center/visit/other leisure destination Main mode of transportation = Bicycle Regional weighting = (1) NL, (2) WGR+ Region Arnhem-Nijmegen

Table 22 Procedure to determine trip purpose specific cycling population characteristics

The socio-economic characteristics to take into account are age, income, education, trip purpose, car availability and health attitude (paragraph 2.3). The income classes that are used in this experiment do not coincide with the classes used in OViN and can therefore not be used. Paragraph 2.3.1 debates on a possible correlation between education and income, which has been found in the collected data (paragraph 5.3.3). Therefore, education level will be used to account for the income effects. OViN does not have information on cycling attitudes, which is a possible risk in the weighting of the sample. As the (long distance) cyclists in the collected data might have an above average attitude towards cycling, which result in a lower VoT. The main and secondary socio-economic characteristics that can be compared to each other are shown in Table 23.

Comparable socio-economic characteristics		Yes	No
Influence on VoT and VoC according to literature	Yes	Age Education level Motor vehicle ownership (Car Availability)	Income Attitudes
	No	Household size / composition Gender	

Table 23 Socio-economic characteristics that can be compared between population and sample

5.4.1 Commuting

Table 24 presents the socio-economic characteristics for the population, determined on national and Arnhem Nijmegen scale, and the socio-economic characteristics for the sample.

		Population		Sample		
		NL	Region Arnhem Nijmegen	Total	Region Arnhem Nijmegen	Breda-Etten-Leur
Age	Age -35	40%	43%	12%	12%	15%
	Age 36 - 50	30%	32%	38%	38%	38%
	Age 51+	30%	25%	49%	49%	47%
Education level	LBO	26%	18%	7%	6%	14%
	MBO	36%	38%	32%	29%	45%
	HBO, WO	38%	41%	61%	65%	42%
Motor Vehicle Ownership	0	21%	18%	6%	6%	5%
	1	55%	52%	72%	72%	73%
	2+	24%	30%	22%	23%	22%
Household Size	1	18%	24%	12%	12%	12%
	2	31%	26%	34%	35%	30%
	3	17%	19%	19%	18%	22%
	4	22%	22%	27%	25%	32%
	5+	12%	9%	8%	10%	5%
Gender	Male	48%	60%	55%	55%	57%
	Female	52%	40%	45%	45%	43%

Table 24 Sample and population characteristics for the commuting cyclists

Table 24 indicates a different composition of the sample in comparison to the population. Since household size and gender are expected to be of lesser influence and both attributes are approximately equal to each other, no weighting will be applied on these two attributes. A tri-proportional fitting is used to weight the sample to the population according to the attributes age, education and motor vehicle ownership. Different combination of population and sample can be made. The OViN data provides nationwide information and specific information for the Arnhem – Nijmegen region. Table 25 shows the resulting weight factors. Depending on the socio-economic characteristics of the respondent, a different set of weight factors will be applied.

Sample	All	Region Arnhem Nijmegen
Population	NL	Region Arnhem Nijmegen
Weight factors for education		
LBO	7,1	5,7
MBO	1,5	1,7
HBO/WO	0,4	0,4
Weight factors for age categories		
Age -35	6,4	7,3
Age 35 - 50	0,8	0,9
Age 51+	0,4	0,4
Weight factors for motor vehicle ownership		
0	2,6	2,1
1	0,8	0,7
2+	1,1	1,3

Table 25 Weight factors for the different attributes and combinations of populations and samples

5.4.2 **Education**

Table 26 presents the socio-economic characteristics for the population, determined on national scale, and the socio-economic characteristics for the sample.

		Population NL	Sample Total
Age	Age 0 – 20	82%	13%
	Age 21 - 35	17%	45%
	Age 36+	1%	42%
Education level	LBO or less	67%	4%
	MBO	25%	33%
	HBO, WO	8%	63%
Motor Vehicle Ownership	0	21%	41%
	1	40%	46%
	2+	39%	13%
Household Size	1	12%	39%
	2	9%	33%
	3	18%	9%
	4	33%	11%
	5+	28%	9%
Gender	Male	49%	65%
	Female	51%	35%

Table 26 Sample and population characteristics for the studying cyclists

Table 26 indicates a different composition of the sample in comparison to the population. Since household size and gender are expected to be of lesser influence to each other, no weighting will be applied on these two attributes.

Few difficulties occur in the composition of the sample. Cyclists who cycle to, for example, their yoga classes have also filled in the questionnaire with an educational trip purpose. This explains the high share of higher educated and elderly in the sample. Weighting the data should reduce the influence of these respondents. The data recruitment focused on the recruitment of Radboud University students in Nijmegen. However, OViN also includes all levels of education in their student database, which lead to a population composition with more people under the age of 20.

The very low share of LBO and lower educated makes a weighting on education questionable. Education is included as an influential socio-economic characteristic as it is a measure of someone's income (and travel budget). For students it can be assumed that they do not have a full time paid function, so education as measure of one's travel budget does not apply.

A bi-proportional fitting is used to weight the sample to the population according to the attributes age and motor vehicle ownership. Table 27 shows the resulting weight factors. Depending on the socio-economic characteristics of the respondent, a different set of weight factors will be applied.

Sample Population	All NL
Weight factors for age categories	
Age 0 – 20	6.53
Age 21 - 35	0.34
Age 36+	0.01
Weight factors for motor vehicle ownership	
0	0.32
1	1.49
2+	4.50

Table 27 Weight factors for the different attributes and combinations of populations and samples

5.4.3 Other recreational

Table 28 presents the socio-economic characteristics for the population, determined on national and Arnhem Nijmegen scale, and the socio-economic characteristics for the sample.

		Population		Sample		
		NL	Region Arnhem Nijmegen	Total	Region Arnhem Nijmegen	Breda-Etten-Leur
Age	Age -35	37%	35%	10%	11%	9%
	Age 36 - 50	20%	20%	33%	33%	30%
	Age 51+	42%	45%	57%	56%	61%
Education level	LBO	44%	30%	7%	7%	9%
	MBO	29%	36%	21%	22%	17%
	HBO, WO	27%	34%	72%	71%	74%
Motor Vehicle Ownership	0	23%	26%	11%	12%	4%
	1	54%	58%	60%	62%	52%
	2+	23%	15%	29%	26%	64%
Household Size	1	21%	34%	13%	13%	9%
	2	34%	29%	42%	42%	39%
	3	13%	11%	11%	13%	4%
	4	20%	20%	24%	21%	39%
	5+	12%	6%	10%	11%	9%
Gender	Male	38%	42%	45%	43%	57%
	Female	62%	48%	55%	57%	43%

Table 28 Sample and population characteristics for the commuting cyclists

Table 28 indicates a different composition of the sample in comparison to the population. Since household size and gender are expected to be of lesser influence and both attributes are approximately equal to each other, no weighting will be applied on these two attributes. A tri-proportional fitting is used to weight the sample to the population according to the attributes age, education and motor vehicle ownership. Different combination of population and sample can be made. The OViN data provides nationwide information and specific information for the Arnhem – Nijmegen region. Table 29 shows the resulting weight factors. Depending on the socio-economic characteristics of the respondent, a different set of weight factors will be applied.

Sample	All	Region Arnhem Nijmegen
Population	NL	Region Arnhem Nijmegen
Weight factors for education		
LBO	15,46	9,41
MBO	0,96	1,52
HBO/WO	0,18	0,34
Weight factors for age categories		
Age -35	9,65	6,07
Age 35 - 50	0,57	0,55
Age 51+	0,45	0,66
Weight factors for motor vehicle ownership		
0	5,05	3,10
1	0,80	0,80
2+	0,72	0,52

Table 29 Weight factors for the different attributes and combinations of populations and samples

Chapter 6 Model analysis

This chapter estimates the VoT and VoC for the different target segments. Paragraph 6.1 describes the model specification process. Paragraph 6.2 discusses the final model, the resulting parameter values and the estimation of the VoT and VoC. Paragraph 6.3 explores the final model to find the influence of income, travel context and the attitude towards cycling on the cyclists' VoT and VoC. Paragraph 6.4 discusses additional model analyzes such as the RP model estimation and finally paragraph 6.5 applies the model for the calculation of elasticities and choice probabilities.

Not enough data is collected for the educational trip purpose to come to a valid and accurate result (paragraph 2.5). Less than 100 respondents are available, which also includes trips to yoga centers etc. (paragraph 5.3.2.1) Therefore, no separate model analysis will be performed. The education sample is explored in paragraph 6.4 using an approach with scale parameters.

6.1 Model specification

Both multinomial logit (MNL) and mixed logit (ML) models will be estimated. Before the estimation, the model needs to be specified. The basic model consists out of alternative specific constants (ASC) and level-of-service (LOS) parameters. The extended MNL model includes the individual's socio-economic characteristics (SE) and attitudes. The mixed logit models can be further extended with error components (EC) and/or random components (RC). See paragraph 4.4 for an elaboration of these definition.

6.1.1 Basic model specification

The basic model specification includes the ASC and LOS parameters describing each alternative. The most important consideration at this point is the derivation of a VoT and the inclusion of the comfort aspect.

To coincide with previous cyclists' VoT studies, the time parameters will be interacted with route quality level. The quality levels are the three different comfort classes used in this study: comfortable cycle route (HQ), standard cycle route (MQ), Uncomfortable cycle route (LQ) (paragraph 3.3.2).

The SP questionnaire format uses two cycling alternatives, which also needs to be represented in the model specification. Therefore, the model specification differentiates the following alternatives:

- Car;
- Public Transport;
- Cycling 1, the comfortable but slow cycle route (associated with HQ and MQ cycling);
- Cycling 2, the uncomfortable but fast cycle route (associated with MQ and LQ cycling);
- Other, which represents the 'I don't choose to travel' choice.

Due to the set-up of the experiment, no costs of cycling are available (paragraph 3.3.2). Therefore, the costs of the alternative modes of transport are used as cost difference 'Car/PT – Cycling' variables in the cycling utility function. The introduction of the cost difference variable in the cycling utility functions brings an important implication to the VoT and VoC calculation. The Cyclists' VoT and VoC will not be related to the cycling costs, but it will be related to the car and/or PT costs (paragraph 4.5.4).

Several model specification set-ups were tested, differing in the inclusion of the cost difference variable (Table 86 in appendix D for the different model estimation results). The results show that the cost difference Car-Bicycle has a negative sign, which means that a more expensive car alternative makes cycling less attractive. Therefore, the cost difference Car-Bicycle cannot be used for VoT and VoC calculations. The cost difference PT-Bicycle contributes most to the model-fit and shows a positive sign, indicating that a more expensive PT alternative makes cycling more attractive. The following utility functions will be part of the basic model

$$U_{Car} = ASC_{Car} + \beta_{Time\ Car} * Time_{Car} + \beta_{Cost\ Car} * Cost_{Car} + \varepsilon_{car}$$
$$U_{PT} = ASC_{PT} + \beta_{Time\ PT} * Time_{PT} + \beta_{Cost\ PT} * Cost_{PT} + \varepsilon_{PT}$$
$$U_{Cycling\ 1} = ASC_{C1} + \beta_{Time} * Time_{Cycling\ 1} + \delta_{Cycle\ quality=MQ} + \beta_{Cost\ differences\ PT-Cycling\ 1} * Cost_{PT} + \varepsilon_{cycling}$$
$$U_{Cycling\ 2} = ASC_{C2} + \beta_{Time} * Time_{Cycling\ 2} + \delta_{Cycle\ quality=MQ} + \beta_{Cost\ differences\ PT-Cycling\ 2} * Cost_{PT} + \varepsilon_{cycling}$$
$$U_{Other} = ASC_{Other}$$

6.1.2 Extended model specification

Paragraph 5.3.3 and 5.3.4 concluded with the SE and attitudes that show the strongest influence on choice behavior. These findings are added to the basic model specification to determine which SE and attitudes actually influence choice behavior. For both the commuting and other recreational trip purpose, each characteristic is added stepwise to the basic MNL model specification to assess its influence on the model performance. Two criteria are used in the decision to keep parameters: Log-likelihood test and parameter significance (paragraph 4.5.2).

When the final MNL model is specified, the model is tested as ML model. Simulation with a large number of draws is performed to estimate the parameter values for the ML models. The number of draws to use is a trade-off between computational time and accuracy (Hensher & Greene, 2002). Stable results with the highest rho-square and log-likelihood were found while using 125 draws. Models with a higher number of draws use longer estimation times and the (significant) parameter values remain almost equal (Table 88 in appendix D).

The ML model adds error components to the model specification, which takes into account the effect of one respondent giving multiple observations (paragraph 4.4.6). Therefore, any falsely significant SE and LOS coefficients in the MNL model will turn insignificant in the ML model and vice versa. Table 30 and Table 31 show the final MNL and ML model estimation results for both the commuting and the other recreational trip purpose. The final models are weighted according to the Dutch cycling population, as described in paragraph 5.4.

The inclusions of random components for the significant attitudes have also been tested for the commuting trip purpose (paragraph 4.4.5). In summary, all means (betas) are significant higher than zero with differing deviations (sigma) (Table 87 in appendix D). Therefore, the positive influence of the attitudes on specific modes of transport applies to most commuters. The improvement of the model due to the RC inclusion is limited (higher rho-square and log-likelihood, but no differences in the VoT and VoC estimations). Set against the extra computational power required for the RC and the limited improvement in the parameter reliability, the RC will be left out of the model specification in the further model analysis.

Appendix D also includes a comparison between the weighted and unweighted ML model estimation (Table 89). The results indicate a small difference between the estimated coefficients. The unweighted VoT is higher and the VoC lower in comparison to the weighted VoT and VoC, presumably caused by an overrepresentation of respondents with an HBO/WO educational level.

Parameter	Trip Purpose / Model Type / Weighting / Draws / Affected Utility	Commute / MNL Extended / Dutch cycling Population / n/a / value	value	Commute / ML Extended / Dutch cycling Population / 125 / value	t-test
ASC Cycling 1	Cycling 1	7,21	13,3	8,85	11,63
ASC Cycling 2	Cycling 2	6,42	12,25	7,88	10,34
ASC Car	Car	3,5	5,01	5,7	7,66
ASC Other	Other	0		0	
ASC PT	PT	2,8	2,59	3,05	2,42
βCost Car	Car	0,356	1,28	0,0103	0,05
βCost PT	PT	-0,412	-1,29	-0,213	-0,79
βCostdif. PT-C1	Cycling 1	0,392	2,27	0,248	2,03
βCostdif. PT-C2	Cycling 2	0,149	0,87	0,203	1,62
βTime Car	Car	-0,0483	-4,48	-0,101	-5,77
βTime HQ Cycling	Cycling 1	-0,0614	-12,98	-0,0405	-7,86
βTime MQ Cycling	Cycling 1	-0,0734	-12,1	-0,0555	-9,38
βTime LQ Cycling	Cycling 2	-0,0407	-10,61	-0,0239	-5,65
βTime PT	PT	-0,0648	-3,09	-0,113	-4,13
δAge>50	Cycling 1	0,672	5,55	0,48	3,13
δEducation=HBO||WO	PT	2,56	3,16		
δHousehold<=3	Car	0,885	3,53		
δMvh. Own >=2	Car	0,855	3,43		
βAtt A (Enjoyability of cycling)	Cycling 1 & 2	0,486	3,7	0,648	5,53
βAtt B (Considering PT)	PT	0,7	3		
βAtt C (Travel Time)	Cycling 1	-0,161	-2,56		
βAtt D (Cycling dest. facilities)	Cycling 1	0,605	8,58	0,262	3,38
βAtt E (The Weather)	Car	0,578	4,12	1,11	8,62
ε Car	Car			1,8	11,29
ε PT	PT			2,94	8,64
ε Cycling	Cycling 1 & 2			-2,15	-8,49
Number of observations		4455		4455	
Number of respondents		297		297	
Log-Likelihood		-3712,28		-3.451	
Likelihood ratio test		7443,469		7.076	
Rho-square		0,501		0,506	
Adjusted rho-square		0,498		0,503	
VoT Cycling HQ	Cycling 1	€ -9,40 p/h		€ -9,80 p/h	
VoT Cycling MQ	Cycling 1	€ -11,23 p/h		€ -13,43 p/h	

Table 30 Final MNL and ML models for commuting travel

Parameter	Trip Purpose Model Type Weighting Draws Affected Utility	Other Recreational MNL Extended Dutch cycling Population n/a value	 t-test	Other Recreational ML Extended Dutch cycling Population 125 value	 t-test
ASC Cycling 1	Cycling 1	16,1	30,72	16,2	24,72
ASC Cycling 2	Cycling 2	14,6	25,37	15,4	23,51
ASC Car	Car	13,7	19,51	11,6	28,37
ASC Other	Other	0		0	
ASC PT	PT	13,4	9,75	10,4	9
βCost Car	Car	0,249	1,18	-0,361	-1,35
βCost PT	PT	-0,678	-0,79	-0,653	-1,25
βCostdif. PT-C1	Cycling 1	0,593	2,4	0,348	2,05
βCostdif. PT-C2	Cycling 2	0,492	1,9	0,301	1,66
βTime Car	Car	-0,0654	-2,01	-0,0629	-2,99
βTime HQ Cycling	Cycling 1	-0,0821	-7,42	-0,0439	-5,36
βTime MQ Cycling	Cycling 1	-0,102	-6,93	-0,0595	-6,37
βTime LQ Cycling	Cycling 2	-0,0391	-3,38	-0,0399	-9,13
βTime PT	PT	-0,051	-1,01	-0,114	-1,86
δHousehold<=2	Cycling 1	0,542	2,38	2,73	3,22
δMvh. Own >=2	Car	1,4	3,26		
βAtt A (Enjoyability of cycling)	Cycling 1	0,745	4,88		
βAtt C (Travel Time)	Cycling 2	0,337	2,21		
βAtt D (Cycling dest. facilities)	Cycling 1	0,205	2,15		
βAtt H (Considering Car)	Car	-0,621	-3,31		
ε Car	Car			3,29	6,95
ε PT	PT			2,81	5,27
ε Cycling	Cycling 1 & 2			-2,07	-7,8
Number of observations		2010		2010	
Number of respondents		134		134	
Log-Likelihood		-1.500		-1.585	
Likelihood ratio test		3.281		3.194	
Rho-square		0.522		0,502	
Adjusted rho-square		0.516		0,497	
VoT Cycling HQ	Cycling 1	€ -8,31 p/h		€ -7,57 p/h	
VoT Cycling MQ	Cycling 1	€ -10,32 p/h		€ -10,26 p/h	

Table 31 Final MNL and ML models for other recreational travel

6.2 Model analysis

The final model estimation results will be discussed in detail.

6.2.1 General choice behavior

Both trip purposes indicate that cycling is the most preferred alternative. Among the cycle route alternatives, cycling 1 is the most preferred alternative. The results further indicate that among the same cycling alternative, cycling on the highest comfort level is perceived as least negative. The travel time valuations in the cycling 1 alternative are more negative in comparison to the travel time valuations in the cycling 2 alternative. When travel times increase, the willingness to accept a longer travel time for more cycling comfort is decreasing.

To visualize the willingness to accept a longer travel time, the cycling ASC's and time valuations are used to derive utility graphs that depict the change in cycling utility as travel time increases (Figure 4). The graphs indicate among others that:

- Cycling on a comfortable cycle route is the most preferred alternative up to a cycling travel time of 25 minutes for commuting and 18 minutes for other recreational cycling. When the comfortable travel times are higher, the most preferred alternative depends on the travel time of the other cycle route;
- When no comfortable cycle route is available, the standard cycle route is the most preferred alternative up to a cycling travel time of 18 minutes for commuting and 14 minutes for other recreational cycling.

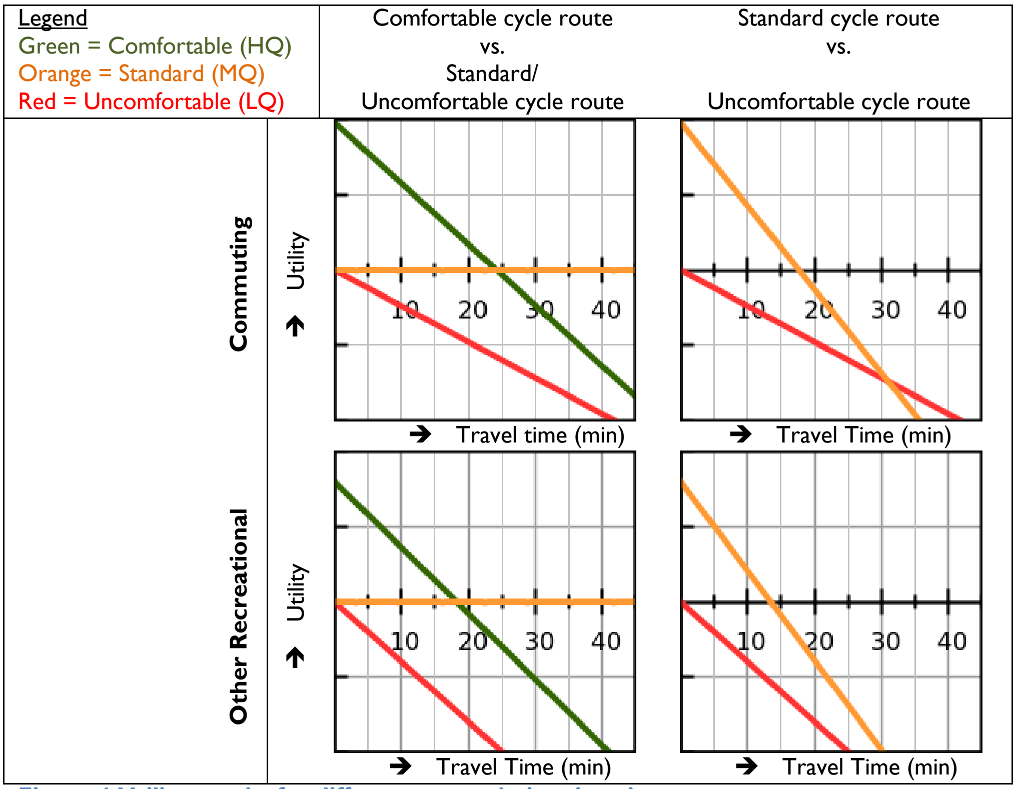

Figure 4 Utility graphs for different route choice situations

6.2.2 **Valuation of travel costs / cost difference**

The model estimation results show insignificant valuations for car and PT costs and the cost difference between cycling 2 and PT. The only significant value found in the model estimation is the cost between cycling 1 and PT.

Two causes contribute to the insignificance of the parameters. First, the results suffer from an ecological fallacy effect (Ortúzar & Willumsen, 2002). The ecological fallacy effect is caused since the cost variable is an imputed variable from the trip distance. Trip distance has a positive correlation with the propensity to travel by car and public transport. Therefore, a positive correlation between costs and the propensity to travel by car and public transport exists. On an individual level, the propensity to travel by car and public transport decrease with costs; however, the opposite is shown when all data is aggregated. Secondly, costs are relative unimportant to the respondent. In the questionnaire, the respondents were asked which consideration was most important for them in the SP choice experiment. Figure 5 shows that less than 10% of the respondents stated that costs were their main consideration. Travel time and the subjective aspects comfort and health are more important travel considerations. This finding supports the fact that not all cost variables were found to be significant due to its relative unimportance.

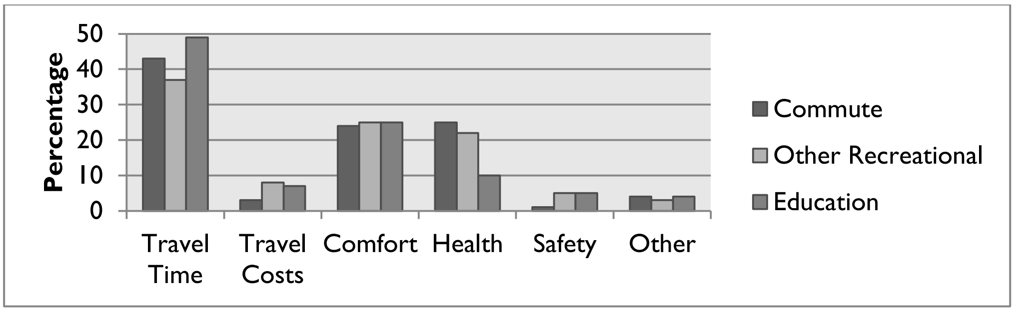

Figure 5 Most important consideration in SP mode/route choice per trip purpose

6.2.3 **Travel time valuations (and value of comfort)**

The results for both models indicate that spending one minute in car and public transport gives more disutility than cycling. The cycling travel times are interacted with the three different comfort classes to account for the different types of routes one can encounter.

It is possible to derive the travel time the respondent is willing to accept per minute extra for a comfort increase by comparing the cycling travel time coefficients with each other. For commuting, the cyclists are willing to accept 1.37 times the travel time on a standard cycle route if he or she can benefit from a comfortable cycle route. The ratio with respect to an uncomfortable route cannot be derived due to set-up of the experiment. The 1.37 ratio would mean that a commuting cyclist equally prefers to cycle 27½ minute on a comfortable route or 20 minutes on a standard cycle route. This is a large difference; however, it is important to consider that this ratio only applies when the whole alternative route is comfortable to cycle on. The actual comfort ratio that can be used depends on the quality level of the cycle route alternatives and will therefore lie between 1.00 and 1.37. For small traffic situations, the 1.37 ratio would mean that the commuting cyclist is willing to take a detour if he or she can avoid a busy intersection or if he or she can cycle through a more attractive environment. For other recreational traffic the same comfort ratio is estimated at 1.36

The VoC can be expressed in a monetary value, being the difference between two VoTs, or as ratio between the VoTs. To compare to VoC to other studies who find other VoTs, the best comparisons are made using the comfort ratios. The ratio between cycling on a standard and comfortable cycle route is best comparable to the ratios of cycling on a bicycle lane and bicycle path from paragraph 2.4. Björklund and Mortazavi (2013) found for commuting travel in Sweden that one minute travel on a bicycle lane is valued equally as cycling 1.54 minutes on a separate bicycle path. Wardman et al. (2007) found for the same situation a ratio of 1.67 in the United Kingdom. These ratios are higher than the 1.37 for commuting and 1.36 for other recreational travel found in this study.

The culture and context of cycling in the Netherlands is different from other countries and result in a lower comfort ratio in the Dutch case. First of all, there is a complete cycle network available in the Netherlands. Adding new links to the cycle network would have less effect in comparison to the Swedish and British case. Furthermore, the Dutch have the highest bicycle ownership per capita in the world (BOVAG-RAI Mobility Foundation, 2011). Cyclists are found among all segments of the population, although less among immigrants (KiM, 2008). In comparison to Sweden and the United Kingdom, low-income groups cycle more often in the Netherlands, increasing the marginal utility of costs and decreasing the valuations. A cultural difference is found in the perception of cycling. Harms et al. (2007) studied the image of mobility among the Dutch and found that 84% of the Dutch have a positive opinion of the bicycle. The bicycle is often associated with low costs, self-reliance and reliable travel times (it always gets you there on time). In comparison to other countries, cycling on a standard cycle route (bicycle lane) is more convenient in the Netherlands, which is caused by the higher bicycle usage and the recognition of cyclists by all road users.

6.2.4 **Socio-economic and attitude influences on travel behavior.**

For commuting travel, a significant influence is found for being above the age of 50 on the propensity to cycle on a comfortable, but slow, cycle route. This finding coincides with the findings from Börjesson and Eliasson (2012) who found that elderly have a lower VoT due to a higher valuation of health benefits.

The following significant commuting attitudes are found:

- Commuters who take the positive health effects into account and who enjoy cycling have a higher probability to cycle;
- Commuters who consider the presence of bicycle facilities (secured parking, showers, etc.) at the destination have a higher probability to travel on a slower and more comfortable cycle route;
- Commuters who consider the weather have a higher probability to travel by car.

These findings coincide with a recent study conducted by Heinen et al. (2009) who showed that the bicycle commute mode choice and the bicycle commute frequency is strongly influenced by the facilities provided by the employer and the attitudes of the employer, co-worker and the worker him or herself.

For other recreational travel, the only significant influence that was found is related to motor vehicle ownership. In accordance with the literature, travelers who possess more than one car in their household have a higher propensity to travel by car (i.e. Stinson and Bhat (2004)).

The MNL models showed more influences that were significant. However, some attributes turn insignificant in the ML models, which indicates that some attributes were artificially significant due to the unaccounted panel effects in the MNL model. The attributes that turned insignificant in the ML are therefore not included in this paragraph.

Due to relative small sample sizes, the unobserved variance in the data is relative large. The coefficients that are estimated indicate the effect of each observed variable relative to the variance of the unobserved factors. A larger variance in unobserved factors leads to smaller and more insignificant coefficients. This does not mean that the other socio-economic characteristics and attitudes from paragraph 5.3.3 and 5.3.4 do not influence choice behavior; there is not enough data available to be sure of their influences on travel behavior.

6.2.5 **Error components**

The ML is a highly flexible model, which allows for random taste variations, unrestricted substitutions patterns and correlation in unobserved factors over time (paragraph 4.2). In the model specification, error components (EC) are added to account for the panel effects. The ML model estimations include a generalized error component for the two cycling alternatives, which accounts for the correlation between these two alternatives (paragraph 4.4.6).

The variance of the EC is statistically different from zero, revealing the presence of unobserved heterogeneity effects regarding the multiple SP responses by the same individual. As shown in Figure 5, there is a spread of objective and subjective aspects that influence choice behavior.

6.2.6 **Value of time and comfort**

The model specification from paragraph 6.1.2 results in the estimation of the coefficients required for the estimation and monetization of the cyclists' VoT and VoC relative to public transport. In other words, the VoT and VoC is the willingness to accept a smaller cost difference between cycling and public transport if cycling travel times are reduced or cycling comfort is improved. An important consideration while assessing these results is the discussion from paragraph 2.4, where was found that the VoT depends on the alternative mode to which travel cost are related. More specifically, when using PT costs in the cyclists' VoT and VoC estimation the valuations will be lower in comparison to using car costs.

Regarding the interpretation of the cost difference, this could be a price reduction of public transport or a cost increase for cycling. Due to the insignificance of the cost parameters car, PT and cycling 2, it is only possible to estimate the cyclists' commuting VoT for cycling on a comfortable and standard cycle route.

Table 32 shows the cyclists' VoTs and VoCs that are calculated with the model estimation results and the VoTs for other modes of transport according to Significance et al. (2013). The cyclists' VoT for cycling on a standard cycle route is higher than the cyclists' VoT for cycling on a comfortable route. This finding is in accordance with the previous studies from Sweden and the United Kingdom (paragraph 2.4) and is caused by a difference in the direct utility of cycling travel time. Cycling on a standard cycle route is perceived as more bothersome and dangerous in comparison to cycling on a comfortable cycle route. The difference between both cyclists' VoTs resembles the VoC for a route quality improvement from standard to comfortable.

The cyclists' VoT for cycling on a standard cycle route is higher than the VoT for car, train and bus/tram/metro. The higher cyclists' VoT is in accordance with the previous studies from

Sweden and the United Kingdom (paragraph 2.4) and is presumably caused by a higher income among cyclists' and travel time spent cycling is comparatively onerous and unproductive in comparison to car and PT travel. An improved cycle route quality increases the direct utility of cycling travel time and decreases the VoT to be almost equal to car VoT.

Trip Purpose		Cycling		*Car*	*Train*	*Bus/Tram/Metro*
Commute	VoT	Comfortable route	€ 9,80 p/h	*€ 9,25 p/h*	*€ 11,50 p/h*	*€ 7,75 p/h*
		Standard route	€ 13,43 p/h			
	VoC	Standard → Comfortable	€ 3,63 p/h			
Other Recreational	VoT	Comfortable route	€ 7,57 p/h	*€ 7,50 p/h*	*€ 7,00 p/h*	*€ 6,00 p/h*
		Standard route	€ 10,26 p/h			
	VoC	Standard → Comfortable	€ 2,69 p/h			

Table 32 Values of time and comfort per trip purpose for cycling and the value of time for other modes of transport in the Netherlands

The cyclists' VoT for commuting can also be compared to previous cyclists' VoT studies (paragraph 2.4). The used methodology is best comparable to the study of Börjesson and Eliasson (2012) in Stockholm since they also used the costs of the alternative mode of transport, which was public transport for 87% of the respondents. Börjesson and Eliasson found a VoT of €10,50 for cycling on a segregated bicycle path, which is similar to the €9,80 for cycling on a comfortable cycle route in this study, and a VoT of €15,90 for cycling in mixed traffic, which does not have a comparable valuation in this study. Cycling on a standard cycle route, which can be interpreted as cycling on a bicycle lane, is estimated at €13,43 in this study, which is in-between the VoT for cycling in mixed traffic and the VoT for cycling on a segregated bicycle path in Börjesson and Eliasson's study. Following the argumentation from paragraph 6.2.3, the Cyclists' VoTs from this study are lower in comparison to Sweden because:

- Low-income groups cycle more often in the Netherlands. A higher marginal utility of costs result in lower valuations;
- Cycling on a standard cycle route is more convenient in the Netherlands. The higher direct utility of cycling travel time result in lower valuations.

The VoTs for other recreational travel are lower than the VoTs for commuting travel. This coincides with the Dutch VoTs for car and public transport as estimated by Significance et al. (2013). The VoTs also coincide with the theory of Paleti et al. (2013) who state that the VoT depends on activity patterns. Time pressure during an other recreational trip is lower in comparison to a commuting trip, which decreases the resource value of time and the VoT.

A short example is used to illustrate the VoC. For the most frequently observed commuting travel time per bicycle, 25 minutes, a quality improvement from standard to comfortable is valued at €1,51,- per trip. This is a high value, however it is important to consider that this value only applies when the whole route is improved. Therefore, the VoC should only be used for the road section that is improved. For example, if a road section that takes only 5 minutes is improved, the value of comfort that should be used in the CBA is €0,30 per commuting trip and €0,22 for an other recreational trip.

The discussion on the VoC in contrast to previous studies is included in paragraph 6.2.3, as this is best done with travel time ratios instead of the monetary values. In theory, it would also be possible to estimate the VoT for car and public transport for the cyclist sample. Unfortunately, insignificant cost and time coefficients prevent a valid comparison. A note on this comparison is included in appendix E.

6.3 Exploring the final model

With the final ML model available, additional analyzes are performed to assess the effect of context variables on the VoT and VoC. Depending on the type of exploration, separate models or scale parameters will be estimated.

First, the interview location is assessed. The cycling population in the region Arnhem – Nijmegen has a different composition than the Dutch cycling population. The cycling population in Arnhem – Nijmegen has a younger and higher educated composition (paragraph 5.4). On top of that, regional differences could influence the VoT. For example, the differences is progress on the construction of fast cycle routes.

The second exploration focusses on the current cycle route of each individual. The hypothesis is that cycling on a high quality cycle route increases the direct utility of travel time and therefore decreases the VoT.

The third exploration assesses the income effects. Income influences the marginal utility of money. Individuals with higher incomes have a lower marginal utility of money and therefore the hypothesis is that this group has a higher VoT.

The fourth exploration assesses the influence of considering the health benefits on the VoT. If cyclists consider the health benefits of cycling in their mode choice, this should increase the direct utility of cycling. For this exploration, the attitude 'enjoyability of cycling' will be used which combines the considerations health benefits, joy and relaxation of cycling.

The fifth exploration assesses the influence of trip distance on the VoT. The hypothesis for this exploration is; the longer the distance, the larger the time advantages of the car and PT, and consequently the lower the resource value of time of a traveler has to be if he or she is to choose to cycle.

The final exploration assesses the influence of trip frequency on the VoT. The hypothesis is that respondents who travel less frequent have different choice considerations than frequent cyclists, resulting in a higher VoT. For example, frequent cyclists could have less money available to travel by car / PT, have a more positive attitude towards cycling and less time pressure.

6.3.1 Interview Location

Choice behavior can differ per interview location. Therefore, the final ML models are estimated for, and weighted according to, the region Arnhem – Nijmegen. The other available region, Breda – Etten-Leur, does not have enough data available for a separate estimation, but a comparison between the final model and the Arnhem – Nijmegen model would also provide information on the Breda – Etten-Leur region.

For commuting travel, the model estimation only allows a VoT estimation with 90% significance instead of 95%. Therefore, these VoTs should be interpreted as mere indications. The VoT for cycling relative to PT is estimated at €11,24 per hour on a standard cycle route and €8,61 per hour at a comfortable cycle route. The VoC, cycling on a comfortable cycle route instead of a standard cycle route, is valued at €2,63 per hour. Due to insignificant cost parameters, no VoT can be calculated for the other recreational trip purpose. The found valuations are lower in the region Arnhem – Nijmegen, compared to the Dutch population.

Furthermore, commuters in the region Arnhem-Nijmegen are less willing to accept more travel time for more cycling comfort. The comfort ratio was estimated at 1.37 for the Netherlands, while this value is 1,31 for the region Arnhem Nijmegen (paragraph 6.2.3), which indicates that the travelers in the region Arnhem – Nijmegen are relatively less sensitive for cycling on the most comfortable cycle route. Paragraph 5.3.1 found that respondents from Breda – Etten-Leur travel more often on a comfortable cycle route and have systematically higher route assessment scores. A higher route quality could affect more than only the direct utility of travel. The availability of a comfortable (and often fast) route also attracts more ´new´ cyclists (i.e. the considering car driver and inquisitive cyclists from paragraph 3.1.2) for whom the route is attractive enough to choose. These 'new' cyclists have a higher resource value of time, which increases the VoT (Börjesson & Eliasson, 2012). Therefore, it can be said that the level of self-selection depends on the quality of the cycle route and affects the regional VoT.

	Trip Purpose	Commute		Other Recreational	
	Model Type	ML Extended		ML Extended	
	Weighting	Arnhem – Nijmegen population		Arnhem – Nijmegen population	
	Draws	125		125	
Parameter	Affected Utility	value	t-test	value	t-test
ASC Cycling 1	Cycling 1	7,99	8,44	16	33,35
ASC Cycling 2	Cycling 2	7,16	7,53	15,4	32,23
ASC Car	Car	5,35	5,68	12,6	20,65
ASC Other	Other	0		0	
ASC PT	PT	3,13	2,08	10,5	2,7
βCost Car	Car	0,102	0,4	-0,473	-2,12
βCost PT	PT	-0,188	-0,67	-1,43	-3,87
βCostdif. PT-C1	Cycling 1	0,294	1,85	0,197	1,05
βCostdif. PT-C2	Cycling 2	0,26	1,64	0,0538	0,29
βTime Car	Car	-0,103	-5,27	-0,0366	-2,33
βTime HQ Cycling	Cycling 1	-0,0422	-7,1	-0,0454	-5,25
βTime MQ Cycling	Cycling 1	-0,0551	-8,07	-0,0621	-6,11
βTime LQ Cycling	Cycling 2	-0,0282	-11,08	-0,0422	-8,97
βTime PT	PT	-0,136	-4,37	-0,0455	-0,27
δAge>50	Cycling 1	0,53	3,1		
δMotor Vehicle Ownership >=2	Car			1,15	2,17
βAtt A (Enjoyability of cycling)	Cycing 1 & 2	0,341	1,77		
βAtt D (Cycling destination facilities)	Cycling 1	0,205	2,37		
βAtt E (The weather)	Car	1,25	5,79		
ε Car	Car	-2,22	-5,8	3,64	4,91
ε PT	PT	3,87	5,75	-3,45	-2,7
ε Cycling	Cycling 1 & 2	-1,13	-6,02	-0,765	-2,42
Number of observations		3555		1665	
Number of respondents		237		111	
Log-Likelihood		-2.796.448		-1.316.563	
Likelihood ratio test		5.528.881		2.619.194	
Rho-square		0,497		0,499	
Adjusted rho-square		0,494		0,492	
VoT Car				€ 4,64 p/h	
VoT Cycling HQ	Cycling 1	€ -8,61 p/h	90% sig.		
VoT Cycling MQ	Cycling 1	€ -11,24 p/h	90% sig.		

Table 33 ML model estimation results for Arnhem - Nijmegen sample

6.3.2 Assessment of current cycle route

The following exploration tests the hypothesis that cycling on a high quality cycle route increases the direct utility of travel time and therefore decreases the VoT. Paragraph 2.3 described the influence of comfort on the VoT and Börjesson and Eliasson (2012) argue that self-selection takes place on different routes. For this exploration, the route assessment scores (Figure 3 from paragraph 5.3.1) are averaged per respondent. The average scores can be seen as an indication for the cycling comfort level. Several segmentations have been tested. The clearest results were achieved at a delimiter of seven for the average score. The model estimation results are shown in Table 34.

	Trip Purpose	Commute		Other Recreational	
	Model Type	ML Extended		ML Extended	
	Group 1	Route Avr. < 7		Route Avr. < 7	
	Group 2	Route Avr. > 7		Route Avr. > 7	
Parameter	Affected Utility	value	t-test	value	t-test
ASC Cycling 1	Cycling 1	8.30	10.05	18,5	5,86
ASC Cycling 2	Cycling 2	7.41	9.34	17,6	5,88
ASC Car	Car	5.34	7.18	13,5	6,33
ASC Other	Other	0		0	
ASC PT	PT	2.86	2.47	13,5	4,78
βCost Car	Car	0.0298	0.15	-0,179	-0,78
βCost PT	PT	-0.170	-0.71	-0,722	-1,49
βCostdif. PT-C1	Cycling 1	0.235	2.04	0,5	2,68
βCostdif. PT-C2	Cycling 2	0.191	1.59	0,453	2,31
βTime Car	Car	-0.0994	-5.73	-0,105	-3,24
βTime HQ Cycling	Cycling 1	-0.0417	-7.19	-0,0491	-4,57
βTime MQ Cycling	Cycling 1	-0.0546	-8.16	-0,0664	-5,35
βTime LQ Cycling	Cycling 2	-0.0268	-10.27	-0,0432	-8,13
βTime PT	PT	-0.110	-4.32	-0,0964	-1,46
δAge>50	Cycling 1	0.428	2.79		
δHousehold<=2	Cycling 1			2,29	2,88
βAtt A (Enjoyability of cycling)	Cycling 1 & 2	0.602	5.72		
βAtt D (Cycling dest. facilities)	Cycling 1	0.256	3.63		
βAtt E (The Weather)	Car	1.04	7.60		
ε Car	Car	1.68	10.17	3,99	4,71
ε PT	PT	2.75	8.96	1,56	4,82
ε Cycling	Cycling 1 & 2	-1.95	-8.05	2,7	5,65
Scale parameter for Group 2		1.17	8.06	0,803	4,54
Number of observations		4455		2010	
Number of respondents		297		134	
Log-Likelihood		-3450		-1590	
Likelihood ratio test		7077		3183	
Rho-square		0,506		0,500	
Adjusted rho-square		0,503		0,495	
VoT Cycling HQ Group 1	Cycling 1	€ -10,64 p/h		€ -5,89 p/h	
VoT Cycling MQ Group 1	Cycling 1	€ -13,94 p/h		€ -7,97 p/h	
VoT Cycling HQ Group 2	Cycling 1	€ -12,45 p/h		€ -4,73 p/h	
VoT Cycling MQ Group 2	Cycling 1	€ -16,31 p/h		€ -6,40 p/h	

Table 34 ML model estimation results using route assessment segmentation

The scale parameter estimated a value of 1.17 (commute) and 0.803 (other recreational) for cyclists with an average route assessment score above 7, which indicates that the VoT is 17 % higher while commuting and 20% lower when traveling with an other recreational trip purpose.

A more comfortable cycle route should increase the direct utility of travel time and decrease the value of time (Table 35). For commuting travel, the opposite is found. The descriptive statistics show that cyclists from the Breda – Etten-Leur sample are overrepresented in the commuting group with a route assessment above the score of seven. The previous subparagraph found that the VoT for cyclist in the region Arnhem – Nijmegen is lower than the Dutch average, which is presumably caused by the self-selection of cyclists with a lower resource value of time to cycle on cycle routes that are systematically scored less in comparison to the other sampled region (Breda – Etten-Leur). Respondents assess the Breda – Etten-Leur route with a higher score, which indicates a higher route quality. The higher route quality attracts travelers with a higher resource value of time to start cycling. Since Breda – Etten-Leur respondents are overrepresented in the high route assessment score group; the found VoT is higher than expected.

	Commuting		Other Recreational	
Route assessment score	< 7	≥7	< 7	≥7
Breda – Etten-Leur	15%	30%	17%	17%
Arnhem – Nijmegen	85%	70%	83%	83%

Table 35 Distribution of interview locations over the assessed route assessment scores

The interview locations are equally distributed over both route assessment groups in the other recreational sample. The results indicate that the VoT is lower for the respondents who give a higher score to their cycle route, which confirms that the higher cycle route quality increases the direct utility of travel and therefore decreases the VoT.

The hypothesis that cycling on a high quality cycle route increases the direct utility of travel time and therefore decreases the VoT can be accepted for other recreational travel. For commuting travel, the hypothesis cannot be accepted due to a skewed distribution of the two interview locations.

6.3.3 Income

In the testing of different socio-economic characteristics as dummy variables, income did not show any significant influence on choice behavior. Different studies did show that income has an upwards effect on the VoT. For example, Significance et al. (2013) and Börjesson and Eliasson (2012). A higher income would decrease the marginal utility of costs and increase the VoT.

Regarding income and cycling, self-selection has to be taken into account since travelers with a high resource value of time and low marginal utility of money tend to choose faster and more expensive modes. The self-selection causes the average VoT to be higher on faster and more expensive modes (and vice versa).The effect of income is tested in the final ML model. The best model performance is found where the sample is split up between a household income under €2.500 and above €2.500 per month. The results are shown in Table 36. The scale parameter estimated a value of 1.07 (commute) and 1.13 (other recreational) for incomes above €2.500 per month indicates that the VoT for this group, in comparison to lower incomes, is 7% higher for commuting and 13% higher for other recreational travel. This finding is in accordance with previous studies, see for example Small (2012). The higher value of time leads to a lower marginal utility of costs and therefore a higher VoT.

6.3.4 Health attitude

The socio-economic and attitudes section already showed a positive correlation between the attitude towards the enjoyability of cycling (healthy, joy, relaxing) and the probability to cycle. Travelers who cycle for the health benefits have a higher direct utility of travel time, which decreases the VoT. Börjesson and Eliasson (2012) found that cyclists see cycling as an important way to exercise and they do consider the health benefits. They argue that the health benefits are internalized as a positive utility for cycling, which results in a lower VoT when individuals consider health benefits.

Parameter	Trip Purpose Model Type Group 1 Group 2 Affected Utility	Commute ML Extended Income < €2.500 Income > €2.500 value	 t-test	Other Recreational ML Extended Income < €2.500 Income > €2.500 value	 t-test
ASC Cycling 1	Cycling 1	8.34	3.45	14,2	4,17
ASC Cycling 2	Cycling 2	7.45	3.41	13,5	4,31
ASC Car	Car	5.33	3.35	9,32	4,4
ASC Other	Other	0		0	
ASC PT	PT	2.93	2.05	9,98	4,1
βCost Car	Car	0.0299	0.15	-0,239	-1,31
βCost PT	PT	-0.205	-0.79	-0,463	-1,11
βCostdif. PT-C1	Cycling 1	0.227	1.68	0,301	1,62
βCostdif. PT-C2	Cycling 2	0.188	1.45	0,227	1,12
βTime Car	Car	-0.0966	-3.16	-0,0591	-1,93
βTime HQ Cycling	Cycling 1	-0.0415	-3.18	-0,0413	-2,9
βTime MQ Cycling	Cycling 1	-0.0544	-3.26	-0,0563	-3,02
βTime LQ Cycling	Cycling 2	-0.0267	-3.18	-0,0375	-3,03
βTime PT	PT	-0.106	-2.70	-0,0825	-1,81
δAge>50	Cycling 1	0.444	2.22		
δHousehold<=2	Cycling 1			1,54	2,15
βAtt A (Enjoyability of cycling)	Cycling 1 & 2	0.588	2.77		
βAtt D (Cycling dest. facilities)	Cycling 1	0.243	2.39		
βAtt E (The Weather)	Car	1.03	3.30		
ε Car	Car	1.65	3.29	3,78	2,91
ε PT	PT	2.71	3.32	-1,49	-3,44
ε Cycling	Cycling 1 & 2	-1.95	-3.40	1,88	2,88
Scale parameter for Group 2		1.07	3.27	1,13	2,86
Number of observations		4455		2010	
Number of respondents		297		134	
Log-Likelihood		-3453		-1.703	
Likelihood ratio test		7073		2.956	
Rho-square		0.506		0,465	
Adjusted rho-square		0.503		0,459	
VoT Cycling HQ Group 1	Cycling 1	€ 10,97 p/h	90% sig		
VoT Cycling MQ Group 1	Cycling 1	€ 14,38 p/h	90% sig		
VoT Cycling HQ Group 2	Cycling 1	€ 11,74 p/h	90% sig		
VoT Cycling MQ Group 2	Cycling 1	€ 15,39 p/h	90% sig		

Table 36 ML model estimation results using income segmentation

The hypothesis is tested that a positive attitude towards the health benefits of cycling decreases the VoT. Table 37 presents the results of a ML model estimations that splits the sample into two groups based on median factor score 'enjoyability of cycling'. The positive group chooses more often to cycle because of the health benefits, the relaxation of cycling and the enjoyability of cycling. The negative group does not cycle for these reasons or at least in lesser extent.

The scale parameter estimated a value of 1.20 (commute) and 0.949 (other recreational) for cyclists with an above average positive attitude towards the enjoyability of cycling. This finding indicates that the commuting cyclists' VoT for this group is 20% higher and the other recreational cyclists' VoT is 5% lower in comparison to cyclists with less positive cycling attitude. For other recreational travel, this finding is in accordance with previous studies. Internalizing health benefits reduce the individual's VoT (Börjesson & Eliasson, 2012). The lower VoT is related to the higher direct utility of cycling travel time cyclists have with a positive attitude towards the enjoyability of cycling. For commuting travel, no VoT can be estimated. The scale does indicate a higher VoT for commuters with an above average positive attitude towards cycling, which is an unexpected result. The descriptive statistics for the commuting sample shows a significant positive correlation (0.251) between income and the attitude towards the 'enjoyability of cycling', which is not found in the other recreational sample. This correlation supports the assumption that the group with an above average attitude has both a higher direct utility of travel time and a lower marginal utility of costs, which eventually leads to a higher VoT.

	Trip Purpose	Commute		Other Recreational	
	Model Type	ML Extended		ML Extended	
	Group 1	Last 50% pos. attitude		Last 50% pos. attitude	
	Group 2	First 50% pos. attitude		First 50% pos. attitude	
Parameter	Affected Utility	value	t-test	value	t-test
ASC Cycling 1	Cycling 1	7,43	12,74	16,8	7,74
ASC Cycling 2	Cycling 2	6,56	12,06	15,9	7,96
ASC Car	Car	4,4	7,04	12,3	7,68
ASC Other	Other	0			
ASC PT	PT	2,13	1,54	12	6,75
βCost Car	Car	-0,202	-0,61	-0,152	-0,7
βCost PT	PT	-0,456	-1,39	-0,689	-1,57
βCostdif. PT-C1	Cycling 1	0,0745	0,34	0,447	2,4
βCostdif. PT-C2	Cycling 2	0,0392	0,17	0,401	1,91
βTime Car	Car	-0,0988	-4,4	-0,101	-3,18
βTime HQ Cycling	Cycling 1	-0,0401	-6,72	-0,0455	-4,35
βTime MQ Cycling	Cycling 1	-0,0524	-7,4	-0,0616	-4,74
βTime LQ Cycling	Cycling 2	-0,0259	-9,29	-0,0412	-5,91
βTime PT	PT	-0,107	-4,6	-0,0756	-1,32
δAge>50	Cycling 1	0,436	3,06		
δHousehold<=2	Cycling 1			1,94	3,66
βAtt D (Cycling dest. facilities)	Cycling 1	0,232	3,25		
βAtt E (The Weather)	Car	1,05	5,48		
ε Car	Car	-2,6	-4,43	3,57	5,7
ε PT	PT	3,85	7,49	1,4	4,77
ε Cycling	Cycling 1 & 2	-1,34	-7,16	2,52	5,79
Scale parameter for Group 2		1,20	8,85	0,949	4,5
Number of observations		4455		2010	
Number of respondents		297		134	
Log-Likelihood		-3.467		-1.591	
Likelihood ratio test		7.044		3.180	
Rho-square		0,504		0,5	
Adjusted rho-square		0,501		0,494	
VoT Cycling HQ Group 1	Cycling 1			€ -6,11 p/h	
VoT Cycling MQ Group 1	Cycling 1			€ -8,27 p/h	
VoT Cycling HQ Group 2	Cycling 1			€ -5,80 p/h	
VoT Cycling MQ Group 2	Cycling 1			€ -7,85 p/h	

Table 37 ML model estimation results using attitude segmentation

6.3.5 Trip distance

One may expect that the cyclists' VoT tend to decrease with travel distance, since the relative speed advantage of motorized modes will be larger for long trips. The longer the distances, the larger the time advantage of motorized modes will be, and consequently the lower the resource value of time of a traveler has to be if he or she is to choose to travel by bicycle. Self-selection of travelers with a low resource value of time takes place on long distance cycling trips (Börjesson & Eliasson, 2012).

The effect of trip distance is tested in the final ML model, where respondents are differentiated between RP cycling travel times above and below 30 minutes. The results are shown in Table 36.

	Trip Purpose	Commute		Other Recreational	
	Model Type	ML Extended		ML Extended	
	Group 1	Travel Time < 30 min		Travel Time < 30 min	
	Group 2	Travel Time > 30 min		Travel Time > 30 min	
Parameter	Affected Utility	value	t-test	value	t-test
ASC Cycling 1	Cycling 1	9.83	7.26	34,1	4,57
ASC Cycling 2	Cycling 2	8.77	6.55	33	4,5
ASC Car	Car	6.19	5.26	29,2	4,39
ASC Other	Other	0		0	
ASC PT	PT	4.85	2.53	28,4	4,34
βCost Car	Car	-0.0431	-0.16	-0,329	-0,68
βCost PT	PT	-0.463	-1.41	-0,578	-1,12
βCostdif. PT-C1	Cycling 1	0.261	1.37	0,619	1,7
βCostdif. PT-C2	Cycling 2	0.173	1.07	0,69	1,85
βTime Car	Car	-0.137	-4.74	-0,0826	-1,12
βTime HQ Cycling	Cycling 1	-0.0524	-7.30	-0,0665	-4,57
βTime MQ Cycling	Cycling 1	-0.0697	-7.98	-0,0839	-5,53
βTime LQ Cycling	Cycling 2	-0.0359	-8.62	-0,0617	-8,17
βTime PT	PT	-0.125	-2.63	-0,234	-3,08
δAge>50	Cycling 1	0.582	3.06		
δHousehold<=2	Cycling 1			1,46	0,78
βAtt A (Enjoyability of cycling)	Cycling 1 & 2	0.955	5.01		
βAtt D (Cycling dest. facilities)	Cycling 1	0.295	3.22		
βAtt E (The Weather)	Car	1.09	4.19		
ε Car	Car	3.05	6.58	4,7	4,74
ε PT	PT	2.60	3.83	2,14	4,7
ε Cycling	Cycling 1 & 2	1.39	5.23	3,89	4,92
Scale parameter for Group 2		0.739	7.22	0,426	3,96
Number of observations		4455		2010	
Number of respondents		297		134	
Log-Likelihood		-3.453		-1.580	
Likelihood ratio test		7.072		3.202	
Rho-square		0,506		0,503	
Adjusted rho-square		0,503		0,498	
VoT Cycling HQ Group 1	Cycling 1			€ -6,45 p/h	90% sig
VoT Cycling MQ Group 1	Cycling 1			€ -8,13 p/h	90% sig
VoT Cycling HQ Group 2	Cycling 1			€ -2,75 p/h	90% sig
VoT Cycling MQ Group 2	Cycling 1			€ -3,46 p/h	90% sig

Table 38 ML model estimation results using RP cycling travel time segmentation

The scale parameter estimated a value of 0.739 (commute) and 0.426 (other recreational) for cyclists with travel times above 30 minutes. The scale parameter indicates that the VoT for cyclists with travel times above 30 minutes is 26% lower for commuting and 57% lower for other recreational travel in comparison to cyclists with shorter travel times. This finding is in accordance with previous studies, see for example Börjesson and Eliasson (2012). The lower VoT is a result of the lower resource value of time for the long distance cyclists. For long distance trips, the time advantage for motorized alternatives is higher. When an individual's resource value of time is high, he or she will not travel per bicycle (self-selection). On top of the lower resource value of time, the time spent cycling during long distance other recreational trips will probably have a higher direct utility of travel time due to its recreational context.

6.3.6 Trip Frequency

The final exploration assesses the influence of trip frequency on the VoT. The differentiation between trip frequencies is one of the approaches to differentiate between the considering car driver / inquisitive cyclists and the carefree cyclist (paragraph 3.1.2). The hypothesis is that respondents who travel less frequent use a different set of decision-making rules than frequent cyclists, resulting in a higher VoT. For example, frequent cyclists could have less money available to travel by car / PT, have a more positive attitude towards cycling or less time pressure, which result in a VoT difference between frequent and non-frequent cyclists.

Trip frequencies will only be assessed for commuting. Other recreational trips are characterized by a lower trip frequency, which makes it hard to differentiate between frequent and non-frequent 'other recreational' cyclists. The influence of trip frequency is tested in the final ML models, where commuters are differentiated between cycling 4-5 days per week (frequent) and less than 4 days per week (non-frequent). The results are shown in Table 37.

	Trip Purpose	Commute	
	Model Type	ML Extended	
	Group 1	Cycles 4-5 days per week	
	Group 2	Cycles 0-3 days per week	
Parameter	Affected Utility	value	t-test
ASC Cycling 1	Cycling 1	7.87	12.57
ASC Cycling 2	Cycling 2	6.95	11.48
ASC Car	Car	4.49	7.55
ASC Other	Other	0	
ASC PT	PT	3.65	3.47
βCost Car	Car	0.0163	0.08
βCost PT	PT	-0.295	-1.36
βCostdif. PT-C1	Cycling 1	0.190	1.53
βCostdif. PT-C2	Cycling 2	0.148	1.14
βTime Car	Car	-0.102	-5.31
βTime HQ Cycling	Cycling 1	-0.0431	-7.73
βTime MQ Cycling	Cycling 1	-0.0563	-8.79
βTime LQ Cycling	Cycling 2	-0.0273	-10.66
βTime PT	PT	-0.0946	-2.98
δAge>50	Cycling 1	0.477	3.24
βAtt A (Enjoyability of cycling)	Cycling 1 & 2	0.751	5.87
βAtt D (Cycling dest. facilities)	Cycling 1	0.257	3.40
βAtt E (The Weather)	Car	0.876	6.16
ε Car	Car	2.56	8.60
ε PT	PT	2.05	5.37
ε Cycling	Cycling 1 & 2	1.15	6.26
Scale parameter for Group 2		1.14	8.03
Number of observations		4455	
Number of respondents		297	
Log-Likelihood		-3.459	
Likelihood ratio test		7.061	
Rho-square		0.505	
Adjusted rho-square		0.502	
VoT Cycling HQ Group 1	Cycling 1		
VoT Cycling MQ Group 1	Cycling 1		
VoT Cycling HQ Group 2	Cycling 1		
VoT Cycling MQ Group 2	Cycling 1		

Table 39 ML model estimation results using cycling trip frequency segmentation

The scale parameter estimated a value of 1.14 for commuting cyclists who travel less than four days per week, which indicates that the VoT for this group is 14% higher in comparison to commuting cyclists who cycle 4-5 days per week. A VoT cannot be estimated due to insignificant cost parameters in this exploration. This finding coincides with the hypothesis that the VoT for non-frequent cyclists is higher than for frequent cyclists. Possible causes could be that non-frequent cyclists have a higher time pressure, a lower direct utility of cycling (i.e. perceiving cycling as dangerous), or a lower marginal utility of costs. The descriptive statistics show that the weather conditions, as an influencing factor on mode choice, are more important for non-frequent cyclists in comparison to frequent cyclists (t-test: 4.8).

6.4 Additional analyses

This paragraph performs additional analyzes which cannot be performed with the final ML model, but are of interest for this study. First, a 'RP data only' model is estimated to compare the stated and revealed choice behavior to validate the findings from the SP models. Secondly, an exploratory analysis is performed to give insight into the VoT for the educational trip purpose.

6.4.1 RP model analysis

One of the tools to validate the SP model outcomes is to estimate the SP model with RP data only. The RP model estimation will be discussed in this paragraph.

To perform the analysis, the model specification from paragraph 6.1 requires some alternations to fit the RP situations and data. For example, the 'other' option is not available and the RP data has only information on one cycle route available, which could be any comfort level.

The model in this analysis is specified according to the procedure for the SP model specification, the specification of the basic model that only contains the ASC and the LOS variables and extending the basic model with socio-economic characteristics and attitudes that significantly influence choice behavior.

Several basic MNL model specifications were tested. However, all set-ups resulted in insignificant time and cost parameters. An analysis of the descriptive statistics found that the small sample size, the imputation of the cost variable and the ecological fallacy effect all contribute to the insignificance of the results.

The small sample size introduces large variances. Only 297 observations are available for a commuting RP model estimation. Furthermore, the RP choice is derived from the car, public transport and cycling travel frequencies of the respondent. As most respondents are frequent cyclists, cycling is overrepresented as RP choice (254x cycling, 38x car, 5x public transport). The small amount of public transport choices makes it very difficult for BIOGEME to correctly estimate the influence of travel time and travel costs on the choice probability. Also, car and PT are not always available in the RP situation, which also affects the availability of the cost difference variable.

The cost variables are imputed from the travel distance. Based on the distance between origin and destination, the travel costs are calculated using the average gasoline costs per kilometer and the average PT costs per kilometer. Therefore, the cost variable is positively correlated to the trip distance. Together with a negative correlation between trip distance and the probability to cycle, the result indicates a higher probability to travel by car or PT when costs are higher.

A similar effect is found for car and PT travel times. The travel times of all modes are positively correlated to each other, where the cycling travel time has the strongest influence. This results in higher probabilities to travel by car and PT when travel times increase. This effect is called ecological fallacy and an illustration of this issue is shown in Figure 6 (Ortúzar & Willumsen, 2002).

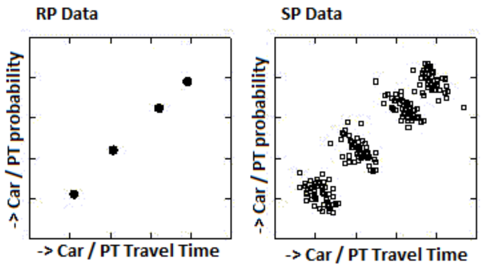

Figure 6 Exaggeration of the ecological fallacy effect

In the RP model analysis (left figure); only one observation per respondent is available. Therefore, the data shows a positive relation between cost / travel time and the probability to travel by car and PT. In the SP model analysis (right figure); multiple observations per respondent are available. Therefore, the data shows a negative relation between cost / travel time and the probability to travel by car and PT.

To cope with the ecological fallacy, model specifications are tested that include car and PT travel times that are relative to the cycling travel time instead of the absolute values. The hypothesis is that car and PT are relatively more attractive when these travel times are shorter than cycling and vice versa. Unfortunately, negative correlations are found between, for example, the ratio 'car / cycling travel time' and trip distance, which distort the model estimation process. In other words, the negative correlation shows that cycling is a relative fast alternative for short distance trips and relative slow alternative for long distance trips, which again introduces the ecological fallacy.

Table 40 shows the model estimation result for commuting, which had the highest model performance was found. It includes the ASC, LOS, significant SE and attitude variables. The time parameters for car and PT are derived from a relative travel time difference between car / PT and cycling:

$$\frac{Car/PT}{Cycling} ratio = \left(\frac{Time_{Car/PT} - Time_{Cycling}}{Time_{Cycling}}\right)$$

The model estimation result shows that individuals with a HBO or WO education have a higher probability to travel per car and individuals living in single or double person households have a higher probability to travel per bicycle. In the theory section (paragraph 2.3) no clear influence of education on choice behavior were found. However, considering the correlation between income and education, higher educated travelers should have a lower marginal utility of money and a higher VoT. Under these presumptions, higher educated individuals have a relatively higher probability to travel by car. This finding contrasts with previous cycling surveys performed alongfast cycle routes in the Netherlands. Higher educated cyclists are the largest group of cyclists (SOAB, 2013). Therefore, care is needed when interpreting these model findings. Higher educated cyclists are more commonly found in the cycling population, but they are more sensitive for the car alternative.

The theory section suggest that a larger household size decreases the spendable income available, increasing the marginal utility of costs. In the case of single or double person households, this would result in a lower marginal utility of costs, a higher VoT and a higher probability to travel not per bicycle. However, the collected data shows that there is a correlation between household size and car ownership. Single and double person households own fewer cars than larger households do. Although car ownership itself was not found to be significant in the model estimation, this would seem to be the underlying cause for single and double person households to have a higher probability to travel per bicycle.

The results do not allow the estimation of a VoT, but the valuation of cycling travel time is comparable to the cycling travel time valuations in the final SP model (Table 30). In the RP model, one minute cycling gives 0.0534 disutility, while one minute cycling in the SP model gives between 0.0239 and 0.0555 disutility. Furthermore, the ASC of cycling is 5.22 higher than PT in the RP model, while the ASC of cycling is between 5.08 and 4.83 higher than PT in the SP model. Further comparison between the RP and SP model estimation results are not possible due to the insignificance of the cost parameters and ecological fallacy in the car and PT parameters. Based on the ASC and the beta cycling, it can be said that the RP and SP models show similar results.

	Trip Purpose	Commute	
	Model Type	RP MNL Basic	
Parameter	Affected Utility	value	t-test
ASC Cycling	Cycling	5.22	3.77
ASC Car	Car	1.43	0.91
ASC PT	PT	0	0
βCost Car	Car	0.723	1.46
βCost PT	PT	-0.426	-0.93
βCostdif. PT-Cycling	Cycling	-0.150	-0.85
δEducation=HBO||WO	Car	2.01	3.03
δHousehold<=2	Cycling	1.45	2.55
βTime Cycling	Cycling	-0.0534	-2.17
βTime Car / Cycling Ratio	Car	2.60	2.44
βTime PT / Cycling Ratio	PT	1.44	2.16
Number of observations		297	
Number of respondents		297	
Log-Likelihood		-66.288	
Likelihood ratio test		365.457	
Rho-square		0.734	
Adjusted rho-square		0.694	
VoT Cycling		Not significant	

Table 40 RP MNL model estimation result

6.4.2 Educational trip purpose

The available data only includes 92 completed questionnaires with an educational trip purpose. This is not enough to estimate a separate model. Therefore, another approach is used to compare the travel behavior during educational trips to the commuting and other recreational trip purpose.

Using all available data, scale parameters are estimated to derive an indication of the cyclists' VoT for educational trips. The model for this analysis will be the basic model specification from paragraph 6.1.1. This model does not include the socio-economic characteristics and attitudes as they are derived per trip purpose and this model will include all trip purposes.

Furthermore, additional weight factors need to be calculated to represent the Dutch cycling population. The table below shows the share of the three trip purposes in the Netherlands, in this sample and the additional weight factor that needs to be incorporated.

Trip Purpose	Population	Sample	Weight Factor
Commute	21%	56%	0.375
Education	13%	17%	0.765
Other Recreational	60%	27%	2.22

Table 41 Additional weight factor

Table 42 presents the ML model estimation results. The scale parameters for both the educational and other recreational trip purpose are estimated to be higher than one, while the commuting scale parameter is fixed to one. This would mean that the commuting VoT is the lowest VoT among the three trip purposes, which is not in accordance with literature on activity patterns and income from paragraph 2.3 and the separate trip purpose estimations from paragraph 6.2. A comparison of the separate commuting and other recreational trip purpose models in Table 30 and Table 31 showed that the ASC are all much higher for the other recreational trip purpose. The high ASC might contribute to the high scale parameter for other recreational travel. It cannot be excluded that this same effect is present in the student sample.

	Model Type	ML Basic	
	Group 1	Commuting	
	Group 2	Education	
	Group 3	Other Recreational	
Parameter	Affected Utility	value	t-test
ASC Cycling 1	Cycling 1	7.07	12.57
ASC Cycling 2	Cycling 2	6.48	12.67
ASC Car	Car	3.96	6.14
ASC Other	Other	0	
ASC PT	PT	-1.50	1.75
βCost Car	Car	-0.205	-1.01
βCost PT	PT	-0.472	-1.92
βCostdif. PT-C1	Cycling 1	0.124	0.79
βCostdif. PT-C2	Cycling 2	0.0385	0.23
βTime Car	Car	-0.0965	-5.71
βTime HQ Cycling	Cycling 1	-0.0353	-7.72
βTime MQ Cycling	Cycling 1	-0.0500	-9.10
βTime LQ Cycling	Cycling 2	-0.0320	-15.53
βTime PT	PT	-0.0865	-3.41
ε Car	Car	3.32	10.63
ε PT	PT	3.31	7.47
ε Cycling	Cycling 1 & 2	0.381	1.32
Scale parameter for Group 2		1.09	7.33
Scale parameter for Group 3		1.24	8.50
Number of observations		7845	
Number of respondents		523	
Log-Likelihood		-6201.062	
Likelihood ratio test		12113.584	
Rho-square		0.494	
Adjusted rho-square		0.493	

Table 42 ML model estimation results using all data and scale parameters per trip purpose

Next to the scale parameter estimation, the student sample can also be assessed using the descriptive statistics. The descriptive statistics show that car ownership (t-test: 6.16) and income (t-test: 7.65) are significant lower for students. Less car ownership increases the amount of captives in the sample and therefore a higher resource value of time. The lower income increases the marginal utility of costs. Furthermore, in comparison to the commuting cycling travel times the educational cycling travel times are significant lower in the sample (t-test: 7.16). The shorter travel times decrease the self-selection among students, which increases the resource value of time. The choice considerations from Figure 5 showed that health is much less important for students in their mode and route choice, which decreases the direct utility of time spent cycling. However, travel time and travel costs are found to be more important for a student, which increases the resource value of time and is in accordance with a previous cyclists study in the Netherlands by Mobycon (2006) on the importance of several choice considerations.

In comparison to cycling commuters, students are expected to have higher resource value of time, a higher marginal utility of costs and a lower direct utility of travel. Altogether, this should lead to a lower cyclists' VoT for an educational trip purpose. Furthermore, the higher importance of travel time and lower importance of health is expected to lead to higher preference among students to cycle on uncomfortable cycle routes and a lower willingness to accept extra travel time for more cycling comfort.

6.5 Model application

This paragraph describes the application of the found valuations. Through the application of the found ML models, insight will be gain into the mode and route choice sensitivity of cyclists with respect to a change in the characteristics of alternatives.

6.5.1 Elasticities

Next to the estimation of the VoT and VoC, the found values in the model estimation are also used to derive the direct and cross-elasticities (paragraph 4.5.5). The interest of this paragraph is to assess how choice probabilities would change as an effect of a change in the attributes.

This paragraph uses the final ML models from the previous chapter (Table 30 and Table 31). These models are applicable to the commuting and other recreational sample. The student sample is excluded from this analysis, as there is no student model available. The generalized model from paragraph 6.4.2 provides scale parameters to calculate the student utilities. However, the estimated scale parameter for an educational trip does not lead to choice probabilities that coincide with the student's actual choice behavior.

Table 44 presents the direct and cross-elasticities for the mode share of the different modes / routes. It is important to keep the set-up of the choice experiment in mind, which included two differently interpreted types of cycle routes. These are cycling 1 (slow & comfortable) and cycling 2 (fast & uncomfortable). No elasticity for comfort can be derived, as this is an ordinal instead of a continuous variable and the comfort level is interacted with the cycling travel times. Instead, the elasticities will be derived for the three possible situations regarding the cycle routes presented in the stated choice experiment. The three different situations are shown in Table 43. Each situation results in a different distribution of travelers over the mode / route alternatives.

	Cycling 1	**Cycling 2**
Situation 1	Comfortable cycle route	Standard cycle route
Situation 2	Comfortable cycle route	Uncomfortable cycle route
Situation 3	Standard cycle route	Uncomfortable cycle route

Table 43 The three situations as presented in the stated choice experiment

The elasticities are easily interpreted; an increase in travel time reduces the choice probability of the corresponding alterative and increases the choice probabilities for the other alternatives. An increase in costs reduces the choice probability of the corresponding alternative and increases the choice probabilities of the other alternatives.

In situation 1, where the comfortable and standard cycle routes are contrasted, the elasticities for a change in travel time on the standard cycle route are excluded. In the model analysis, the coefficient for travel time on a standard cycle route as the fast and uncomfortable route alternative was insignificant and close to zero. When a coefficient is zero, the elasticities are zero. Therefore, this coefficient was left out of the model specification.

The three different situations show that the cross-elasticities for cycling are equal to each other. A change in PT and car characteristics lead to a proportional change over the different cycle route alternatives, which is in accordance with the nested structure of route and mode choices.

Situation 1: Car, PT, Comfortable cycle route, Standard Cycle route.

Commute

Affected Mode/Route	A +1% increase in:	Car	PT	Cycling 1 Comfortable	Cycling 2 Standard	Other
Cycling 1, 2 and PT	PT Cost	-0.432	-1.02	0.093	-0.040	-0.542
Car	Car Cost	0.015	-0.002	-0.001	-0.001	-0.003
Cycling 1	Cycling 1Travel Time	0.386	0.437	-0.880	0.580	0.502
Car	Car Travel Time	-1.60	0.220	0.069	0.069	0.353
PT	PT Travel Time	0.036	-3.36	0.012	0.012	0.067

Other Recreational

Affected Mode/Route	A +1% increase in:	Car	PT	Cycling 1 Comfortable	Cycling 2 Standard	Other
Cycling 1, 2 and PT	PT Cost	-0.480	-2.57	0.115	-0.023	-0.831
Car	Car Cost	-0.390	0.065	0.022	0.022	0.076
Cycling 1	Cycling 1Travel Time	0.233	0.394	-1.12	0.460	0.426
Car	Car Travel Time	-0.736	0.123	0.043	0.043	0.146
PT	PT Travel Time	0.007	-3.69	0.005	0.005	0.034

Situation 2: Car, PT, Comfortable cycle route, Uncomfortable Cycle route.

Commute

Affected Mode/Route	A +1% increase in:	Car	PT	Cycling 1 Comfortable	Cycling 2 Uncomfortable	Other
Cycling 1, 2 and PT	PT Cost	-0.348	-0.808	0.068	-0.044	-0.451
Car	Car Cost	0.011	-0.002	-0.001	-0.001	-0.003
Cycling 1	Cycling 1Travel Time	0.497	0.555	-0.563	0.809	0.675
Cycling 2	Cycling 2Travel Time	0.149	0.167	0.245	-0.448	0.202
Car	Car Travel Time	-1.31	0.227	0.082	0.082	0.373
PT	PT Travel Time	0.043	-2.63	0.017	0.017	0.085

Other Recreational

Affected Mode/Route	A +1% increase in:	Car	PT	Cycling 1 Comfortable	Cycling 2 Uncomfortable	Other
Cycling 1, 2 and PT	PT Cost	-0.372	-2.07	0.080	-0.038	-0.695
Car	Car Cost	-0.276	0.064	0.026	0.026	-0.276
Cycling 1	Cycling 1Travel Time	0.391	0.690	-0.606	0.882	0.797
Cycling 2	Cycling 2Travel Time	0.176	0.318	0.403	-0.753	0.365
Car	Car Travel Time	-0.570	0.137	0.056	0.056	0.170
PT	PT Travel Time	0.012	-2.91	0.009	0.009	0.056

Situation 3: Car, PT, Standard cycle route, Uncomfortable Cycle route.

Commute

Affected Mode/Route	A +1% increase in:	Car	PT	Cycling 1 Standard	Cycling 2 Uncomfortable	Other
Cycling 1, 2 and PT	PT Cost	-0.535	-1.01	0.103	-0.036	-0.547
Car	Car Cost	0.014	-0.003	-0.001	-0.001	-0.004
Cycling 1	Cycling 1Travel Time	0.506	0.570	-1.09	0.812	0.681
Cycling 2	Cycling 2Travel Time	0.165	0.191	0.267	-0.287	0.223
Car	Car Travel Time	-1.407	0.248	0.085	0.085	0.396
PT	PT Travel Time	0.041	-2.929	0.016	0.016	0.081

Other Recreational

Affected Mode/Route	A +1% increase in:	Car	PT	Cycling 1 Standard	Cycling 2 Uncomfortable	Other
Cycling 1, 2 and PT	PT Cost	-0.467	-2.64	0.117	-0.029	-0.864
Car	Car Cost	-0.374	0.082	0.031	0.031	0.099
Cycling 1	Cycling 1Travel Time	0.375	0.661	-1.24	0.804	0.735
Cycling 2	Cycling 2Travel Time	0.214	0.391	0.469	-0.456	0.431
Car	Car Travel Time	-0.630	0.141	0.053	0.053	0.170
PT	PT Travel Time	0.010	-3.280	0.007	0.007	0.043

Table 44 Direct- and cross-elasticities for the mode share of the different modes

Furthermore, the results indicate that the influence of a change in travel costs on cycling is very low in comparison to the influence of a change in travel time. This finding is in accordance with earlier findings from the stated preference experiment that travel costs are not very influential. For example, less than 10% stated that costs were the most dominant choice consideration (paragraph 6.2.2).

The elasticities show that the cross-elasticities for cycling due to changes in car and PT alternatives are zero or close to zero, which is an effect of the small car and PT probabilities. A change in the car and PT alternatives only has a marginal effect on the choice behavior of cyclists.

The results indicate that cyclists are more sensitive for travel time while traveling for an other recreational trip in comparison to a commuting trip. Furthermore, the elasticities of public transport are higher and the elasticities of car are lower for an other recreational trip in comparison to a commuting trip.

Regarding the differences between types of cycle routes, differences are found depending on the amount of comfort difference. When the comfort difference is large (comfortable vs. uncomfortable) a low direct elasticity is found for cycling on the comfortable route, while a high direct elasticity is found for cycling on the uncomfortable route. An interpretation of this finding is that cyclists on a comfortable route, in case of travel time increase, are relatively less willing to travel on the faster and uncomfortable route in comparison to cyclists on the uncomfortable cycle rout, who are more willing to travel on a slower and comfortable route. The opposite effect is found when the comfort difference is low (standard vs. uncomfortable). A low direct utility is found for cycling on an uncomfortable route, while a high direct utility is found for cycling on a standard cycle route. To resume, the comfortable cycle route is more able to attract and keep cyclists cycling on this route despite changes in travel characteristics in comparison to a standard cycle route.

6.5.2 **Choice probabilities**

Market shares are calculated with the developed model, estimating the probabilities of choosing each transport mode and routes. Market shares are calculated for the three situations, similar to the elasticity calculation.

Figure 7 and Figure 8 show the estimated market shares for commuting and other recreational travel controlled by travel time on a comfortable cycle route and calculated with the stated choice experiment. Other market share graphs can be found in appendix F. There is a travel time decay effect for cycling on a comfortable (and slow) cycle route, which is different for each situation and transport mode. The opposite effect is found for cycling on the lower quality cycle route, which is the faster cycle route option. Here, probabilities increase with travel time. Furthermore, the overall cycling probability hardly declines with travel time. Therefore, it can be concluded that respondents from this sample are overrepresented by cyclists who prefer to cycle despite the travel time (the carefree cyclist). The trip frequency exploration in paragraph 6.3.6 found lower VoTs for the frequent cyclists, which could mean that the VoT is biased downwards due to the overrepresentation of frequent cyclists in the sample. However, route choice is affected by travel time as the probability to cycle on the slower and more comfortable route declines with travel time. The stated choice experiment controlled the cycle route travel times, where the comfortable cycle route is slower than the uncomfortable cycle route.

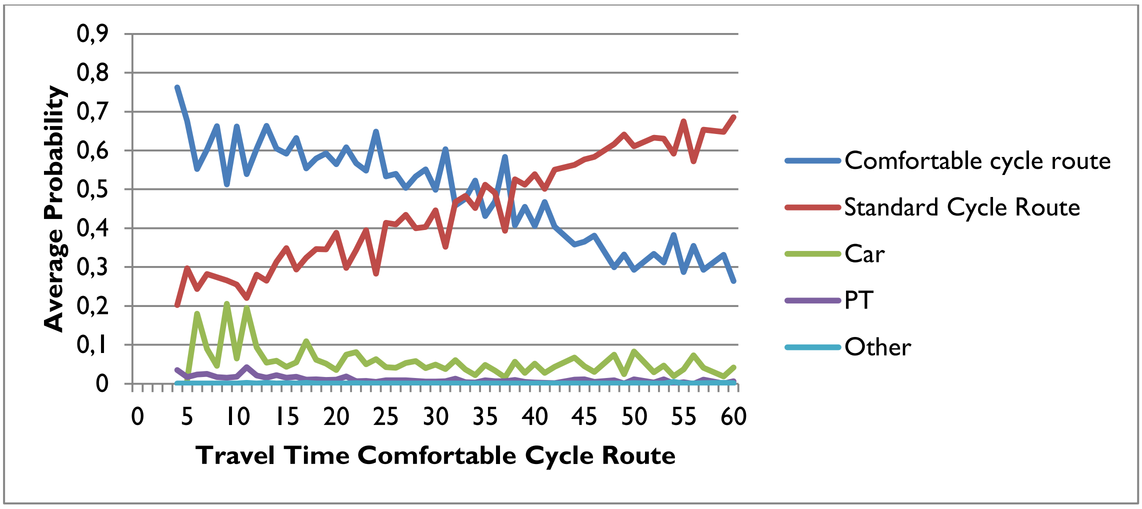

Figure 7 Situation 1 Commute: Market shares and comfortable cycle route travel time

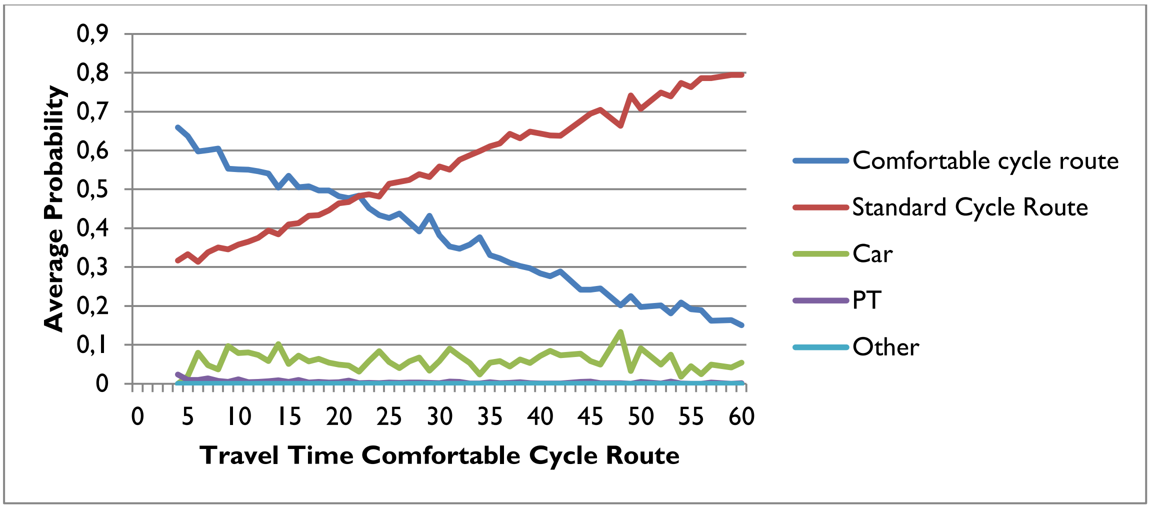

Figure 8 Situation 1 Other Recreational: Market shares and comfortable cycle route travel time

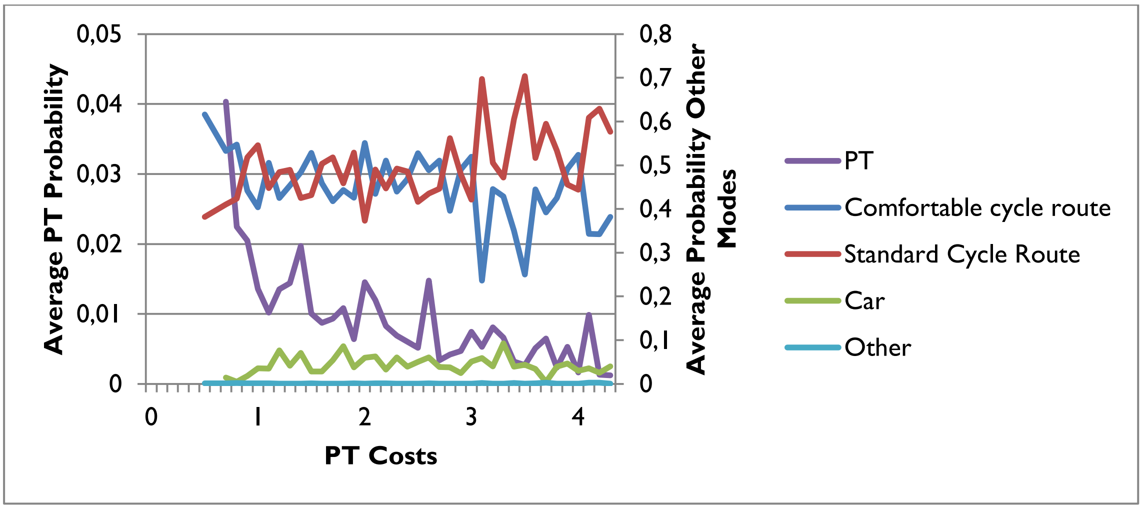

Figure 9 Situation 1 Commute: Market shares and PT costs

The market share figures further indicate that:

- There is a cost decay effect, which is different for each transport mode. Figure 9 shows the market shares controlled by travel costs. Although PT probabilities are not high, the figure does indicate that the probability to travel by PT declines with an increase in PT cost;
- The change in route choice probabilities is high when the quality difference between the route options is small. For example, equal probabilities are found when the comfortable cycle route takes 35 minutes in the case of commuting on a comfortable and standard cycle routes, while equal probabilities between a comfortable and uncomfortable route are found when the comfortable cycle route takes over an hour;
- Car and public transport probabilities are very small. This emphasizes that the respondents were mainly frequent and non-frequent cyclists, following the findings from paragraph 5.3.1. Non-cyclists are not present in the data;
- Other recreational cyclists have a higher probability to travel over the fast and uncomfortable route in comparison to commuters when experiencing equal travel situations. Figure 7 and Figure 8 show for commuting equal probabilities between both cycle routes at 35 minutes cycling on a comfortable route, while this is in only 22 minutes when traveling with an other recreational trip purpose.

6.5.3 **Scenario analysis**

To provide a further insight into the effects of travel time reductions and quality improvements on the propensity to cycle, a scenario analysis will be introduced. In the scenario analysis, a case will be introduced where a new fast cycle route replaces an existing standard cycle route.

The context of the scenario analysis will be the planned construction of a fast cycle route between Cuijk and Nijmegen. This corridor is one of the areas where respondents were recruited for this research and is the corridor associated with a lowest bicycle usage (paragraph 3.1.2).

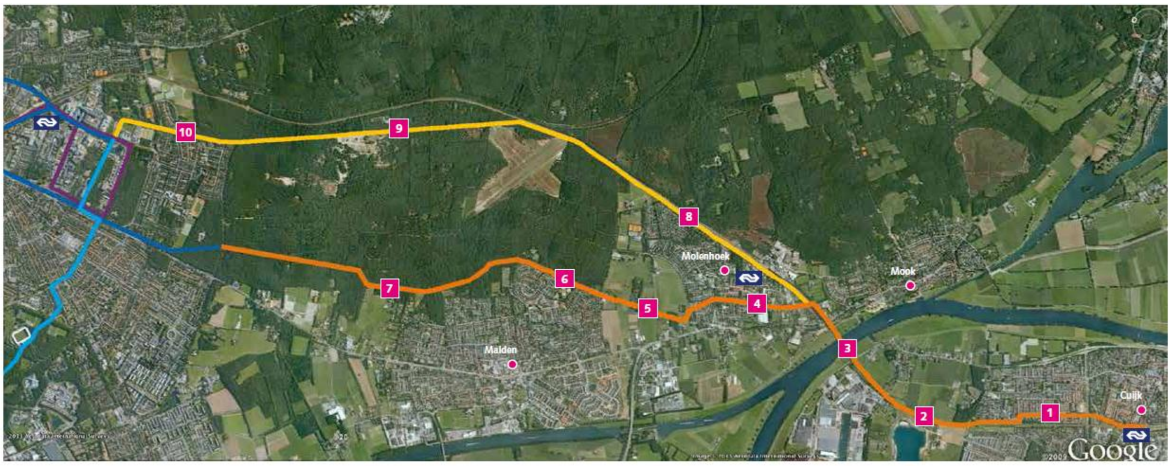

Figure 10 Planned cycle route between Cuijk and Nijmegen, including a new bridge (nr. 3). The orange route is the main fast cycle route, the yellow line is an alternative route (Stadsregio Arnhem Nijmegen, 2014).

The cities of Nijmegen and Cuijk have good rail and road connections, two bus services connect the villages of Malden, Molenhoek and Mook with Nijmegen. A direct cycle route is not available from Cuijk to Nijmegen due to the river Maas. Cyclists' from Cuijk have two indirect cycle routes available, a 14,5 km route along a freeway and a 15,8 km route with a ferry in-between.

The new cycle route includes a quality improvement and a new bridge over the river Maas, reducing the distance by approximately 25% to 11,2 km (Figure 10) (Stadsregio Arnhem Nijmegen, 2014).

In the analysis, separate and combined scenarios are composed to assess the effect of travel time reductions and cycle route quality improvements. Goudappel Coffeng used a transport model to calculate the average cycling travel time between Nijmegen and Cuijk before and after the construction of the fast cycle route. Depending on the average cycling speed that can be achieved on the fast cycle route, travel time reductions between 13% and 30% were found (Decisio, 2013). The 30% reduction assumes an average cycling speed of 25 km/h on the fast cycle routes, which can be achieved with a pedelec for example. The scenarios will use the same percentages. Table 45 presents an overview of the scenarios that will be analyzed.

Case	Choice set	Percentage change in travel time
Reference	Car, PT, Standard cycle route	No travel time reduction
1	Car, PT, Comfortable cycle route	No travel time reduction
2	Car, PT, Standard cycle route	-13% (Average cycling speed 18 km/h)
3	Car, PT, Standard cycle route	-20% (Average cycling speed 20 km/h)
4	Car, PT, Standard cycle route	-30% (Average cycling speed 25 km/h)
1 + 2	Car, PT, Comfortable cycle route	-13% (Average cycling speed 18 km/h)
1 + 3	Car, PT, Comfortable cycle route	-20% (Average cycling speed 20 km/h)
1 + 4	Car, PT, Comfortable cycle route	-30% (Average cycling speed 25 km/h)

Table 45 Overview of the scenarios

The scenario analysis will use the same dataset as the model analysis. However, the sample does not represent the actual modal split since cyclists are overrepresented in the sample. Therefore, an additional weighting is required to account for the modal split on the route Nijmegen – Cuijk. No data is available on the actual modal split on the route Nijmegen – Cuijk. An estimated guess, derived from the modal split for 10 km trips, shows a 70% car, 20% bicycle and 10% public transport distribution (Centraal Bureau voor de Statistiek, 2014). Table 46 shows the assumed modal split for Nijmegen – Cuijk and the RP mode choice from the sample. The choice probabilities for the reference scenario will be calibrated to fit the 70-20-10 modal split. Ather the calibration, the choice probabilities for each scenario will be related to the assumed modal split between Nijmegen and Cuijk, providing figures that are more reasonable. Table 47 shows the choice probabilities for commuting and other recreational travel for the different scenarios. No information is available on the modal split per trip purpose. Therefore, equal modal splits are assumed for commuting and other recreational trips.

	Car	PT	Bicycle
Nijmegen – Cuijk	70%	10%	20%
Sample (Commute)	12.8%	1.7%	85.5%
Sample (Other Recreational)	24.6%	4.5%	70.9%

Table 46 RP mode choice in the sample and

	Commute			Other Recreational		
	Car	PT	Cycling	Car	PT	Cycling
Reference	70,0%	10,0%	20,0%	70,0%	10,0%	20,0%
Case 1 (Comfortable)	65,9%	9,4%	24,7%	68,1%	9,8%	22,1%
Case 2 (-13% travel time)	68,1%	9,7%	22,2%	69,1%	9,9%	21,0%
Case 3 (-20% travel time)	67,0%	9,6%	23,4%	68,6%	9,8%	21,6%
Case 4 (-30% travel time)	65,4%	9,4%	25,3%	67,8%	9,8%	22,4%
Case 1+2 (Comfortable / -13% travel time)	64,2%	9,2%	26,5%	67,4%	9,7%	22,9%
Case 1+3 (Comfortable / -20% travel time)	63,3%	9,1%	27,6%	67,0%	9,7%	23,3%
Case 1+4 (Comfortable / -30% travel time)	62,0%	8,9%	29,1%	66,4%	9,7%	24,0%

Table 47 Choice probabilities for different scenarios

The results in Table 47 indicate, among others, that:

- A quality improvement itself influences the modal split even though cycling travel times are not reduced. The construction of a comfortable cycle route leads to 20 – 25% more commuting cycling trips and 5% less car trip;
- The actual modal split due to the availability of a faster cycle depends on the average speed that can be achieved on the new route. The results indicate an increase of 10 – 25% commuting cycling trips depending on the average cycling speed;
- Changes in the modal split for other recreational travel are approximately half the change in modal split for commuting travel.

All scenarios lead to a higher share of cycling trips in the modal split. Is this change caused by cyclist who cycle more often or by car and public transport users who changes modes? To answer this question, the same scenario analysis will be performed. However, in this analysis the data will be split by RP mode choice. Two groups are defined, cyclists and non-cyclists (car/PT users). Although not realistic, all reference scenario modal splits are assumed to be equal to each other. For this analysis, the relative changes are more important to assess than the absolute values. Table 48 shows the choice probabilities for commuting and other recreational travel for the different scenarios, divided over cyclists and car/PT users.

Cyclists	**Commute**			**Other Recreational**		
	Car	**PT**	**Cycling**	**Car**	**PT**	**Cycling**
Reference	70,0%	10,0%	20,0%	70,0%	10,0%	20,0%
Case 1 (Comfortable)	66,9%	9,3%	23,8%	68,0%	9,7%	22,3%
Case 4 (-30% travel time)	66,2%	9,5%	24,3%	67,8%	9,7%	22,5%
Case 1+4 (Comfortable / -30% travel time)	63,9%	9,1%	27,0%	66,6%	9,0%	24,3%
Car and PT users	**Commute**			**Other Recreational**		
	Car	**PT**	**Cycling**	**Car**	**PT**	**Cycling**
Reference	70,0%	10,0%	20,0%	70,0%	10,0%	20,0%
Case 1 (Comfortable)	65,5%	9,2%	25,2%	68,1%	9,8%	22,1%
Case 4 (-30% travel time)	65,0%	9,3%	25,7%	67,7%	9,9%	22,4%
Case 1+4 (Comfortable / -30% travel time)	61,0%	9,4%	29,6%	66,5%	9,5%	24,0%

Table 48 Choice probabilities per scenario and per RP mode choice

The results in Table 48 indicate, among others, that Car and PT users are more sensitive to changes in the cycling route in comparison to cyclists. This finding indicates that both travel time reductions and quality improvements have a strong effect on car and PT users to start cycling (the considering car driver and inquisitive cyclist), while this effect is smaller for cyclists to cycle more often (carefree cyclist);

To resume, the improvement of the cycle route quality has a stronger influence than the reduction of travel times. Although, a combination of both (the fast cycle route) is most ideally. Stimulating pedelec ownership can reduce travel times even more. Especially on long distance routes, it seems viable to invest in a combination of measures that include infrastructure and pedelec ownership to stimulate behavioral change among car and public transport users.

Chapter 7 Conclusions and Discussion

This chapter summarizes the research and its results; it discusses the used methodology and the validity of the results and provides recommendations for future research. Paragraph 7.1 reflects on the research questions and the overall findings. 7.2 discusses the used methodology, the encountered challenges and opportunities for improvement. Paragraph 7.3 reflects on the validity of the results, keeping the discussion of the methodology in mind. Paragraph 0 names the voids and imperfections in the research performed, which could be of interest for future additional research. Paragraph 7.5 concludes this chapter.

7.1 Reflection on research objective

The aim of this research was to fill one of the gaps in bicycle appraisal by setting the following research objective:

"The objective of this research is to estimate the valuation of travel time savings and comfort improvements for cycling."

To achieve this objective, a literature review was provided on the cyclists' VoT. Secondly, an adaptive stated choice experiment was constructed. This experiment consisted of 15 combined mode/route choice questions in which the respondent was confronted with two cycle routes, a car and public transport alternative. Respondents were distributed over three different trip purposes: commuting, educational and other recreational (shopping, visiting friends, etc.). 523 cyclists from the region Arnhem Nijmegen and Breda Etten-Leur correctly filled in the experiment, which was made available online. Thereafter, a descriptive analysis and model analysis were conducted. Data was collected for the educational trip purpose proved to be insufficient to perform a valid model analysis and this trip purpose is therefore not further elaborated. The model analysis used a mixed logit model to estimate the coefficients that influence the choice behavior. The mixed logit model takes into account the panel effect of a stated preference experiment and the nested structure of a combined mode/route choice experiment. Finally, the resulting model was applied to calculate elasticities and choice probabilities. This led to following answers on the research questions.

What is the current practice in the Netherlands regarding the use of the cyclists' value of time in bicycle cost-benefit analyzes?

Paragraph 2.1 reflected on the current standings. No Dutch cyclists' VoT is available. A CBA tool is available for cycle investments, but important key figures such as the value of time are educated guesses instead of derived through a stated choice experiment. A margin of €6,74 - €14,03 is currently used, with an estimated mean of €10,85. The social cost-benefit analysis is a popular policy tool that creates insight into the effect of policy measures and enables better founding of policy decisions. Therefore, interest is growing among policy makers, consultants and scientists for a Dutch cyclists' VoT, derived using the same method as for the other transport modes VoTs. The need for these key figures is growing in the Netherlands.

What are the international experiences with respect to the determination of the cyclists' value of time and comfort?

Paragraph 2.4 reflects on previous cyclists' value of time studies. Only a handful of studies calculated a cyclists' VoT in other countries. Two studies from Sweden specifically focused on the cyclists' VoT. These previous studies found that the cyclists' VoT is higher than for other modes, which is caused by the comparatively onerous and unproductive characteristics of travel time spent cycling. Furthermore, results indicate that the VoT is lower on a bicycle path than for street cycling and the VoT is lower when cyclists take into account the health benefits of cycling. The VoC has not been examined as such in previous studies.

Regarding the set-up of the stated choice experiment, all studies encountered the challenge to cope with the monetizing method. 'How to include a cost coefficient when cycling itself does not cost anything?'. Most studies chose to use a mode choice experiment in which cycling is contrasted with a motorized and costly alternative (car or PT). In these experiments, the VoT and VoC is a willingness to accept a smaller cost difference between cycling and the alternative transport mode.

It was further found that the alternative to which cycling is contrasted influences the resulting VoTs and VoCs. Higher valuations are found when cycling is contrasted to car instead of PT. Therefore, it is important to consider the implication of different car and PT costs valuations.

How do personal- and trip characteristics influence the cyclists' value of time and comfort?

Characteristics that influence the cyclists' VoT and VoC according to previous studies have been inventoried in paragraph 2.3. The experimental design in paragraph 3.3 explained the incorporation of the personal- and trip characteristics in the questionnaire. Paragraph 5.3 gave a descriptive analysis of the collected data to inventory which of the examined characteristics actually influence choice behavior. The findings from the descriptive analysis were incorporated in the model analysis (chapter 6).

The findings from the descriptive analysis were explored in the model analysis. The following socio-economic characteristics and attitudes were found to be significant:

- SP Model - Commute:
  - Commuters with an age above 50 have a higher propensity to cycle on a slower and more comfortable cycle route;
  - Commuters who take the positive health effects into account and who enjoy cycling have a higher probability to cycle;
  - Commuters who consider the presence of bicycle facilities at the destination have a higher probability to travel on a slower and more comfortable cycle route;
  - Commuters who consider the weather have a higher probability to travel by car.
- SP Model -Other Recreational:
  - Other recreational travelers who own more than one car in their household have a higher propensity to travel by car.
- RP Model – Commute
  - Commuters with a HBO or WO education have a relatively higher probability to travel per car;
  - Commuters who live in a single or double person household have a higher probability to travel per bicycle.

Due to small sample sizes, unobserved variances in the data are relatively large; this caused many examined coefficients to show insignificant result.

Regarding the trip characteristics, it is found that costs are relatively unimportant. Less than 10% of the respondents state costs to be their most important choice consideration. The unimportance is also reflected in the estimated cost coefficients, which are small of size and in many model analyzes insignificant. Cross-elasticities close to zero are found due to changes in car and PT costs.

Travel time spent in car and PT was found to be valued more negatively in comparison to travel time spent cycling. Cycling travel times were interacted with three different cycling comfort levels and results show that one minute cycling on a comfortable cycle route is valued equally as cycling 1,36 minutes on a standard cycle route while commuting. A value of 1.37 is found for other recreational travel. These 'ratios' resembles the non-monetary indication of the VoC and they are smaller than the ratios found in Sweden and the United Kingdom. The culture and context of cycling in the Netherlands is different from Sweden and the United Kingdom and result in a lower comfort ratio in the Dutch case. First of all, there is a complete cycle network available in the Netherlands. Adding new links to the cycle network would have less effect in comparison to the Swedish and British case. In comparison to Sweden and the United Kingdom, low-income groups cycle more often in the Netherlands, increasing the marginal utility of costs and decreasing the valuations. 84% of the Dutch have a positive opinion of the bicycle and cycling is often associated with low costs, self-reliance and reliable travel times (it always gets you there on time). In comparison to other countries, cycling on a standard cycle route (bicycle lane) is more convenient in the Netherlands, which is caused by the higher bicycle usage and the recognition of cyclists by all road users.

Which monetized value place Dutch cyclists on the reduction of travel time and improvement of cycle route comfort?

Chapter 6 estimated several mixed logit models. These models include the coefficients for PT costs and cycling travel time (as discussed in the previous section), which is the input for the VoT and VoC calculation in paragraph 6.2.6.

Table 50 presents the VoTs and VoCs for commuting and other recreational travel. The VoTs are estimated per comfort level and the VoC is the difference between VoTs. The comfortable and standard cycle routes are defined as follow:

- Comfortable cycle route: A non-stop, comfortable and save route where cyclists have priority on crossings and experience a pleasant ride;
- Standard cycle route: A fairly direct and reasonable comfortable route where cyclists have priority on several crossings and sometimes need to stop.

A short example is used to illustrate the VoC. If, for example, a road section that takes 5 minutes is improved, the value of comfort that should be used in a cost-benefit analysis is €0,30 ($5/60 * € 3.63$) per commuting trip and €0,22 for an other recreational trip. It is important to consider the actual comfort improvement and adjust the VoC to this improvement.

Trip Purpose	Cycling		
Commute	Value of Time	Comfortable route	€ 9,80 p/h
		Standard route	€ 13,43 p/h
	Value of Comfort	Standard → Comfortable	€ 3,63 p/h
Other Recreational	Value of Time	Comfortable route	€ 7,57 p/h
		Standard route	€ 10,26 p/h
	Value of Comfort	Standard → Comfortable	€ 2,69 p/h

Table 49 Values of time and comfort per trip purpose for cycling.

The found valuations are in line with the previous cyclists' VoT studies from Sweden and the United Kingdom. Standard cycle route valuations are higher in comparison to the valuations for car and PT travel in the Netherlands, which is presumably caused by a higher income among cyclists' and travel time spent cycling is comparatively onerous and unproductive. An improved cycle route quality increases the direct utility of cycling travel time and decreases the VoT to be almost equal to the car VoT.

The cyclists' VoT for commuting can also be compared to previous cyclists' VoT studies. The best comparison is made with the Swedish studies due to the use of similar methodologies. The Dutch VoTs and VoCs are slightly lower, which is presumably an effect of the specific Dutch cycling culture and context (more convenient and complete cycle network, and a larger cycling population). It causes the direct utility of cycling travel time to be higher on equal route types (travel time discussion from the previous research question).

According to the theory on time pressure, activity patterns and previous VoT studies in the Netherlands, the VoT's for other recreational travel are systematically lower than the VoTs for commuting travel.

<u>What is the influence of income, travel context and the attitude towards cycling on the cyclists' value of time and comfort</u>?

As an elaboration of the general exploration on the influence of personal- and trip characteristics on the cyclists' VoT and VoC, the influences of income, travel context, and health attitude were explored in-depth. Paragraph 6.3 explored these influences through the estimation and comparison of scale parameters. The exploration findings are summed up below:

- Travel Context
  - Evidence is found that cyclists who assess their cycle route positively (in this case, rating it 7 out of 10 or higher) have a relatively low value of time. A better cycle route quality decreases the value of time and increases the bicycle usage;
  - Cyclists who travel more than 30 minutes have a lower VoT and VoC than cyclists who travel shorter distances. The VoT and VoC is 26% lower for commuting and 57% lower for other recreational travel. This is presumably caused by a self-selection of cyclists as with a higher resource value of time (higher time pressures) are more likely to travel by car or PT;
  - Cyclists who travel 4-5 days per week have a lower VoT and VoC than cyclists who travel less frequent. The VoT and VoC for the less frequent cyclists is 14% higher, presumably caused by a lower direct utility of cycling among less frequent cyclists.
- Income
  - Results indicate that cyclists with a net monthly household income above €2.500 have a higher VoT and VoC. The VoT and VoC are 7% higher for commuting and 13% higher for other recreational travel. This is an expected finding as a higher income decreases the marginal utility of costs and therefore increases the value of time;
- Health attitude
  - In the factor analysis, health, fun and convenience of cycling were found to be correlated to each other and are therefore combined into one coefficient in the analysis (paragraph 5.3.4). The results indicate, for commuting travel, a 20%

higher VoT and VoC when one has an above average attitude towards cycling. This is an unexpected finding. It is found that the attitude toward cycling is correlated to income, so it is presumed that the higher income among the positive cyclists causes the value of time to be higher. Expected results are found for other recreational travel, where the VoT and VoC is 5% lower. An above average attitude toward cycling increases the direct utility of cycling travel time and decreases the value of time.

Related to the travel context, the difference between the two interview regions, Arnhem – Nijmegen and Breda – Etten-Leur, has also been assessed. The results found a lower VoT and VoC for the region Arnhem – Nijmegen, in comparison to the overall VoT and VoC. The sample characteristics showed that cycle routes in the region Arnhem – Nijmegen are valued less positively and is of lesser quality than Breda – Etten-Leur according to the road users. The cycle route Breda – Etten-Leur presumably attracts more 'new' cyclists who have a higher resource value of time. Therefore, it can be said that the level of self-selection depends on the quality of the cycle route and affects the VoT on regional level.

What are the elasticities of cyclists for changes in characteristics of alternatives?

Paragraph 6.5 elaborated on the model analysis through the estimation of elasticities and choice probabilities due to changes in the characteristics of the choice alternatives. Thereafter a scenario analysis is performed to assess how the modal split between the cities of Nijmegen and Cuijk would change due to the introduction of a fast cycle route. The results confirm that cyclists have low sensitivity to changes in car and PT alternatives, such as the costs of travel. Furthermore, it is found that:

- A quality improvement itself influences the choice probabilities even though cycling travel times are not reduced;
- The elasticities and probabilities show that the change in cycle route probabilities is high when the quality difference is small. A comfortable cycle route is more able to attract and keep cyclists cycling on its route despite changes in travel characteristics in comparison to a standard cycle route;
- The probabilities of car and PT are very small, emphasizing that the sample primarily consists out of cyclists. There is no travel time decay effect on the whole cycling market share, although the propensity to cycle on the slower and more comfortable route does decline with distance;
- Car and public transport users are found to be more sensitive to changes in the cycling alternative in comparison to cyclists. When a cycle route investment results in more cycling trips, these new cycling trips are relatively more often a substitution of car and PT trips instead of extra trips made by cyclists;
- Other recreational cyclists have a higher probability to travel over the fast and uncomfortable route, in comparison to commuters under equal circumstances.

7.2 Discussion on the used methodology

The VoT and VoC were not estimated in the Netherlands before. Only a few studies conducted the same research in other countries. Based on these experiences and expert judgments, a VoT for cycling was used in the Netherlands. This research is a novelty in the Netherlands, which means that there were no standard conventions available for the performance of this type of research. The construction of the questionnaire required many choices to be made, which affects the outcome of this research and its validity. Throughout the report, arguments were provided for the methods chosen to cope with the challenges in the research. This section reflects these choices and their influence on the outcome in two broad categories; the sample and the set-up of the experiment.

Issues regarding the used sample

Due to limitations in time and means, this research recruited a large share of respondent from a mail database. These respondents were originally recruited as cyclists for a fast cycle route questionnaire. Cyclists who cycle along fast cycle routes are generally associated with a longer trip distance and a more positive cycling attitude. The weighting of the data cannot account for these aspects (paragraph 5.4). Thus it is important to realize that the average Dutch cyclist probably has a shorter trip distance (lower VoC) and a less positive cycling attitude (higher VoT). Furthermore, the composition of the sample over represents the carefree cyclist who always cycles and who choose to cycle in all choice experiment questions (lower VoT and VoC). Most people in the Netherlands possess a bicycle also uses its bicycle. However, not everyone uses the bicycle to commute and there are different types of cyclists who all have other choice considerations.

Important to consider is that most data is collected from the region Arnhem – Nijmegen and a bit from Breda – Etten-Leur (paragraph 3.1). Both areas are characterized by strong urbanized inner cities surrounded by rural areas and villages. The results from the model estimation suggest that the valuations are slightly lower for the cyclists in the region Arnhem Nijmegen in comparison to Breda – Etten-Leur. The found valuations should therefore not just simply be applied on other regions, but regional differences that might influence the VoT should be considered.

The samples are weighted according to the Dutch and regional cycling populations. However, as most cyclists are recruited from fast cycle routes, a fast cycle route weighting might have provided a better weighting of the respondents. Especially since the weighting does not account for the distribution of trip distances. Furthermore, the weighting does not account for the respondent's attitude toward cycling, while this is an influential factor on the value of time.

Several respondents were incorrectly assigned to the educational trip purpose. The feedback on the questionnaire showed that some respondents interpreted the educational trip not as trip to school/university, but as a trip to yoga class. These respondents are generally characterized by a higher age, education, income, car ownership, etcetera in comparison to the college student. The influence of the yoga practitioners is minimized through the application of weights, but it cannot be assured that they are all removed through the weighting. In combination with a relative low sample size (n = 92), it is not possible to find accurate figures for the cyclists' value of time and comfort (paragraph 6.4.2).

Issues regarding the set-up of the experiment

The questionnaire collected information on the revealed and stated preference (RP & SP) regarding mode choice behavior. One of the purposes of the RP information is the validation of the SP model estimation through estimation of the same model with RP data only. However, the RP questions in the questionnaire were not sufficient to derive the same information as was included in the choice experiment. Through the imputation of new attributes, it was possible to derive RP data that is similar to the SP data, but it is no perfect fit. Due to this problem, the RP model estimations resulted in many insignificant coefficient values. The few significant coefficients that were found, ASC and time coefficient for cycling did show comparable effects (paragraph 6.4.1).

The average cycling distance in the sample is larger than the Dutch average. The fact that the cyclists from this sample are willing to cycle longer distances, which could mean they have less time pressure, have a positive attitude toward cycling or are bound to traveling per bicycle (the carefree cyclist). In the choice experiment, this resulted in many respondents who only chose the cycling alternatives. The used experimental set-up did not manage to get the respondents to consider all mode alternatives. The strong cycling preference resulted in insignificant car cost coefficients and, because of that, insignificant results for VoT and VoC were found when relating the VoT to car costs. Another choice card design should perhaps be considered in a future cyclists' VoT study. For example, the lowest PT and car costs in the choice experiment were 55% of the actual car and PT costs. Presenting a choice card where PT or car is free of costs, i.e. as one of the employer's facilities for their employees, can provide more insight into the mode choice behavior of carefree cyclists.

Another issue related to the insignificant cost coefficients is the ecologically fallacy (paragraph 6.2.2 and 6.4.1). The questionnaire did not ask the respondent for his car and PT costs, assuming that they are not all able to provide an accurate answer. Respondents might never travel by public transport or receive a travel cost reimbursement. Therefore, the choice experiment used an estimated guess for the travel costs based on trip distance. Unfortunately, an invalid correlation was introduced in the cost variable. As trip distances increase, the propensity to cycle declines. However, this also causes car and PT costs to increase, decreasing to propensity to travel by car and PT. For car costs, it was eventually not possible to find coefficients with the correct sign.

Regarding the set-up of the experiment, the average sampled trip distance lies around 10 kilometers. For the estimation of the value of time, one would also need data on the shorter trip distances. However, the current set-up of the experiment would result in many indifferent or dominant choice situations for short trips. Respondents in the survey would always choose to cycle if they had to choose between a 3-minute car ride and a 4-minute bicycle trip and the respondent is indifferent for an uncomfortable 3-minute ride or a comfortable 4-minute ride. A redesign of choice cards could improve the data collection for very short cycling trips.

7.3 Validity of the results

An important question for the practitioners is the validity of the results. For which cases can these values be used and what is the quality of the results?

Important to emphasize here is that much research is validated through a reflection on previous work. No previous cyclists' VoT studies are available in the Netherlands. In Sweden and a few other countries, cyclists' VoT studies are available. However, care is need when reflecting on these studies due to the unique Dutch cycling context/culture. The main difference between the Netherlands and other countries is the completeness of the cycling network and the cycling experience among the inhabitants. The results should be interpreted as a first exploration on the cyclists' VoT and VoC in the Netherlands. The results, interpretation and discussion provide a broader view on the cyclists' VoT and VoC and can serve as a benchmark for future research.

No surprises were found comparing the findings from this study to previous cyclists' VoT studies and the VoTs for car and public transport in the Netherlands. Compared to cycling VoTs from abroad, the Dutch values are lower. This can be related to cycling culture and context differences between nations. The cyclists' VoTs are higher with respect to other modes in the Netherlands, which is in accordance with findings from few previous studies (paragraph 6.2.3).

The VoC is valued highly. To assure a valid application of the VoC in cost-benefit analyses, it is important to consider that the VoC should only be applied on those road sections that are actually made more comfortable. When the cycle route quality is only improved slightly, only a fraction of the VoC should be used to represent the actual quality improvement. For example, one of the fast cycle route criteria is a 4m width two-way bicycle path. Widening a bicycle path from 3,5m to 4m, does not justify the use of the full VoC since a 3,5m two-way width bicycle path is also a good quality bicycle path. Expert judgments are required to decide which VoC to use as the comfort definitions are not specific.

To validate the SP model estimation results, a comparison has been made with a RP model estimation. As mentioned in the previous paragraph, there is no good fit between the RP and SP data to come to an accurate comparison. However, few significant coefficients were found and did show comparable results. These significant coefficients were the time coefficient for cycling and the ASC for cycling.

Most data is collected in the region Arnhem Nijmegen. An exploration of the interview location showed that there are difference between regions which are caused by a different composition of the population, but also by the quality of the cycling network. As most data is collected in the region Arnhem Nijmegen, the results would presumably be most fit for analyses in the Arnhem Nijmegen region.

Important to keep in mind, this research used a sample in which the average cycling distance is longer than the Dutch average. The application of the found values for fast cycle routes would therefore be encouraged, but applying these values for inner city infrastructure improvements where most of the benefitting cyclists are cycle short distances would be more questionable.

Regarding the three trip purposes, most data is collected for the commuters and this trip purpose showed the most accurate results. The student sample is unfortunately too small for the estimation of valuations.

7.4 Recommendations for future research

This study did not manage to estimate precise valuations for different (sub-) segments of the cycling population. Therefore, the following future research is recommended.

Combine the cyclists' value of time study with the current value of time studies

To ensure that the VoT for cyclists can be correctly compared to the VoT for car and public transport, it is advised that this study should be refined and combined with the next value of time study from the Ministry of Infrastructure and Environment.

Combine the cyclists' value of time study with the application in transport models

This study provides many quantitative figures on the choice behavior of cyclists. See for example its application in the scenario analysis. These figures might help in the development of cycling transport models. When starting a next VoT study for cycling, it would be advised to consider explicitly the applicability of the results in the bicycle modelling tools.

Investigate the elasticities for considering car drivers and inquisitive cyclists

Related to the transport modelling is the derivation of the cycling choice behavior for different types of travelers. To assess the modal shift due to the construction of a shorter or more comfortable cycle route, information on the elasticity of the most influential target population is required (considering car drivers and inquisitive cyclists).

In this research, the collected data primarily consisted out of carefree cyclists who state to always cycle (paragraph 5.3.1). Considering car drivers and inquisitive cyclists use different decision-making rules due to a higher time pressure, lower marginal utility of money or a lower direct utility of cycling. The exploration of the final model found evidence that the VoT and VoC for the considering car drivers and inquisitive cyclists are higher in comparison to carefree cyclists (paragraph 6.3.6). Furthermore, the scenario analysis in paragraph 6.5.3 showed that considering car drivers and inquisitive cyclists are more sensitive to changes in the cycle route alternative in comparison to carefree cyclists.

Quantitative research on the reasons why people do not cycle is not broadly available. Recruiting more considering car drivers and inquisitive cyclists for the cyclists' VoT study could provide important insights into the elasticities, creating better opportunities to design cycling infrastructure and behavioral measures to persuade considering car drivers and inquisitive cyclists to start cycling (more often).

Estimate the value of time and value of comfort for short distance cyclist

One of the reasons why this study focused on long distance cyclists is the problem that occurres when respondents with very short travel times fill in the questionnaire. Respondents in this study would always choose to cycle if they had to choose between a 3-minute car ride and a 4-minute bicycle trip. Another similar issue is respondents' indifference between an uncomfortable 3-minute ride and a comfortable 4-minute ride.

This research did not found a solution to cope with this issue, but deriving the value of time for very short cycling trips is important as three quarters of our cycle trips are less than four kilometers long.

7.5 Conclusions

The cyclists' value of time and comfort were not yet estimated before in the Netherlands. Only a few studies did the same research in other countries. Based on these experiences and expert judgments, a cyclists' value of time was used in the Netherlands. This research pioneers in the Netherlands with its estimation of the value of time and value of comfort.

Values of time and comfort are found for commuting travel and other recreational travel (i.e. shopping or visiting family). For commuting, the cyclists' value of time is estimated at €13,43 per hour on a standard cycle route and €9,80 per hour at a comfortable cycle route. Different values of time are found since cycling on a comfortable cycle route is more convenient in comparison to a standard cycle route. The difference between both values of time resembles the value of comfort for a route quality improvement from standard to comfortable. The value of comfort, cycling on a comfortable cycle route instead of a standard cycle route, is valued at €3,63 per hour. For other recreational travel, the cyclists' value of time at €10,26 per hour on a standard cycle route and €7,57 per hour at a comfortable cycle route. The value of comfort, cycling on a comfortable cycle route instead of a standard cycle route, is valued at €2,69 per hour.

A new finding that can be applied in cost-benefit analyzes is the value of comfort. Comfort is valued strongly and indicates that cyclists also value a quality improvement even though travel times remain unchanged. When applying the value of comfort it is important to consider the actual quality improvement of a route and adjust the value of comfort to this improvement.

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Appendix A: Questionnaire (English)

This appendix presents the questionnaire in English, including the underlying calculations and dependencies. The Dutch version, which is presented to the respondent is included in appendix B.

Current Travel Behavior

An adaptive choice experiment will be used. This set-up makes use of the actual travel situation of the respondent and makes relative changes to their choice alternatives. This allows for the presentation of choices that the individual can actually consider while removing alternatives that the respondent will surely not consider (Tilahun et al., 2007). The RP questions are presented in three groups. The first series of questions are used to control the distribution of the respondent over the segments. The other series are used to collect RP data for the different modes of transportation. Please note that in the following section the italic text refer to actions to be taken when an answer is chosen and to prerequisites for the question to be shown.

Screening & trip purpose assignment

1. For which purpose have you used the bicycle in the last three months?
    - Commuting
    - Shopping / Groceries
    - Education / Course
    - Visit family or friends
    - Recreation (i.e. cinema visit)
    - I do use the bicycle, but not for the above reasons
        - *Screen out*
    - I never use the bicycle
        - *Screen out*
2. How often do you make use of your bicycle for the selected trip purposes?
    - 4-5 days per week
    - 1-3 days per week
    - 1-3 days per month
    - Less than 1 day per month
3. *If trip purpose is 'Commuting'*
   Which situation applies to your commuting cycling trip?
    - I use the bicycle for my whole trip.
        - *25% chance to be assigned to shopping, 75% chance to be assigned to commuting.*
    - I use the bicycle to cycle from/to the train- or bus station.
        - *Respondent is assigned to the shopping trip purpose.*

To increase the quality of the choice experiment, the reference trip should be as specific as possible. Respondents are assigned to one specific trip purpose and the questions are attuned for this trip purpose. To assign all respondents to a trip purpose, the respondent is asked to state how often they use the bicycle for different trip purpose. These trip purposes are shown in question one. Note that in the model analysis the trip purposes shopping / groceries, visit family or friends and recreation are combined in the 'other recreational' trip purpose.

25% of the commuters are randomly assigned to the shopping motive. It prevents that all respondents in the other recreational trip purposes are unemployed. The procedure of assigning trip purposes to respondents goes as follow:

a) *If 'Education / Course' ≠ never, then trip purpose = 'Education / Course'*
b) *If 'Commuting' ≠ never, then 75% chance of trip purpose = 'Commuting' and 25% chance to be assigned to another trip purpose = next step.*
c) *If 'Shopping / groceries' ≠ never, then trip purpose = 'Shopping / groceries'*
d) *If 'Visit family or friends' ≠ never, then trip purpose = 'Visit family or friends'*
e) *If 'Recreation' ≠ never, then trip purpose = 'Recreation'*
f) *Else, screen out respondent.*

RP questions for the cycling alternative

In the following questions where [trip purpose] is used, the destination of the assigned trip purpose is meant.

4. What was the departure time with your bicycle to your [trip purpose]?
5. What type of bicycle have you used for your trip to your [trip purpose]?
    - City Bike, Hybrid, Pedelec, Race Bike, MTB or Other
6. What was your travel time for your bicycle trip between your home and your [trip purpose]?
    - *= RP Base level for cycling travel time*
7. How many kilometers was your bicycle trip between your home and your [trip purpose?]
    - *Input for RP base level Car/PT Costs:*

      $$Cost_{Car} = (km/15) * 1{,}70 + 0{,}65_{(if\ trip\ pupose=work\ or\ study)} + 2{,}50_{(if\ trip\ pupose=shopping)}$$

      $$Cost_{PT} = \left(0{,}87 + km * 0{,}1768_{(if\ RP\ PT=Train)} + km * 0{,}127_{(if\ RP\ PT=Bus)}\right) * 0{,}6_{(if\ traveled\ with\ discount)}$$

    - *Input for RP base level PT travel time if PT is not available (assume average speed of 20 km/h for public transport):*

      $$TT_{PT} = (km/20) *\times 60$$
8. What is your home postal code (6 digits)?
9. What is your destination postal code (6 digits)?
10. Are you familiar with the concept of fast cycle routes?
11. How much have you cycled on the following three quality levels? Choose between: 100%, 75%, 50%, 25%, 0%
    - Fast cycle route
    - Standard cycle path
    - Public road
        - *Quality level with highest share = RP base level cycle route quality*
12. Have you paid for parking your bicycle at your [trip purpose]?
13. *If previous question = yes.* How much have you paid for parking your bicycle?
14. What grade would you give to the following aspects of your cycle route? (0 – 10)
    - Directness
    - Quality of the road surface
    - Drainage
    - Setting of the traffic lights
    - Crossing speed of not signalized intersections
    - Lighting
    - Traffic safety
    - Social safety
    - Signage
    - Attractiveness of the route

Stinson and Bhat (2004) found that the direct utility of cycling travel time is higher for travelers with a positive attitude towards cycling. (Börjesson and Eliasson (2012)) found evidence that the direct utility of cycling travel time is higher for travelers who internalize the health benefits in their choice consideration. The attitude of the traveler towards the benefits of cycling affects the choice behavior. Therefore, the questionnaire also includes thirteen attitude questions in which the respondent is asked how important different route and mode aspects influence their propensity to cycle on 5-point scale. Five being very influential and one being not influential on the propensity to choose the bicycle. Next to the influence of health benefits, the respondent is also asked to state their attitude towards other aspects. The attitude question assesses the following factors:

15. Cycling is good for my health;
16. I enjoy cycling;
17. I can take a shower at my destination;
18. I can easily park my bicycle;
19. I can access a secured bicycle parking at my destination;
20. Cycling the fastest way of transportation;
21. I'm not bound to fixed departure times;
22. Cycling is good for the environment;
23. I avoid congestion;
24. I have to pay for parking my car;
25. Public transport is too expensive;
26. Public transport is too full;
27. The weather.

RP questions for car and public transport

28. How often do you make use of the following modes of transport for your [trip purposes]? Choose between: 4-5 days per week, 1-3 days per week, 1-3 days per month, 6-11 days per year, 1-5 days per year, never.
    - Car
    - Train
    - Bus/Tram/Metro
29. *If car it taken at least once a year*
    What was your travel time for your last car trip between your home and your [trip purpose]?
        - *= RP Base level for car travel time*
30. *If train or bus/tram/metro is taken at least once a year*
    What was your travel time for your last public transport trip between your home and your [trip purpose]?
        - *= RP Base level for PT travel time*
31. *If train or bus/tram/metro is taken at least once a year*
    Which type of ticket have you used for your last PT trip between your home and your [trip purpose]?
    - Single Ticket
    - OV-Chipcard – No discount
    - OV-Chipcard - With discount
    - PT abonnement
    - PT free travel for students
        - *If PT Ticket = OV-Chipcard with discount or PT abonnement, then the RP base level for PT costs in the choice experiment is reduced by 40%.*

Stated choice experiment

Questions 32 – 46 are the 15 choice cards from the choice experiment.

	Cycling	If RP cycling comfort is high		If RP cycling comfort is low		Car		Public Transport	
#	Comfort Level (1 vs 2)	Time Cycling 1	Time Cycling 2	Time Cycling 1	Time Cycling 2	Time	€	Time	€
32	High vs. Low	-25%	-10%	+10%	-25%	-15%	-30%	-20%	-30%
33	High vs. Low	+25%	-10%	+30%	-25%	+15%	RP	+20%	RP
34	High vs. Low	-25%	-20%	+10%	RP	-15%	+30%	-20%	+30%
35	High vs. Low	RP	-30%	+20%	+25%	RP	-30%	RP	-30%
36	High vs. Low	+25%	RP	-45%	-35%	-40%	-45%	-40%	-45%
37	High vs. Mid	-25%	-10%	+10%	-25%	RP	RP	RP	RP
38	High vs. Mid	RP	-20%	+20%	RP	+15%	+30%	+20%	+30%
39	High vs. Mid	+25%	-30%	+30%	+25%	-15%	-30%	-20%	-30%
40	High vs. Mid	RP	-10%	+20%	-25%	+15%	-30%	+20%	-30%
41	High vs. Mid	-25%	-30%	+10%	+25%	RP	+30%	RP	+30%
42	Mid vs. Low	RP	-10%	+20%	-25%	-15%	+30%	-20%	+30%
43	Mid vs. Low	+25%	-20%	+30%	RP	RP	-30%	RP	-30%
44	Mid vs. Low	-25%	-30%	+10%	+25%	+15%	RP	+20%	RP
45	Mid vs. Low	+25%	-10%	+30%	-25%	RP	+30%	RP	+30%
46	Mid vs. Low	RP	-30%	+20%	+25%	-15%	RP	-20%	RP

Table 50 The choice cards, attributes and levels

47. What was your most important consideration while answering the choice experiment questions?
    - Travel Time;
    - Comfort;
    - Costs;
    - Health;
    - Other:_____

Socio-economic characteristics

The last section collects information on the respondent's socio-economic characteristics to assess representativeness and assess the influence of specific characteristics on choice behavior.

48. Are you male or female?
49. What is your age?
50. Please indicate the composition of your household. For students living in student housing, only indicate yourself.
    a. Working persons above the age of 15;
    b. Non-working persons above the age of 15;
    c. Persons between the ages 5 and 15;
    d. Persons under the age of 5.
51. Do you have a valid driver's license?
52. How many other people in your household possess a driver's license?
53. How many motor vehicles are usually available for your household?
54. What is your highest level of education?
55. What is the net income per month of all your households members combined?

Appendix B: Questionnaire (Dutch)

De Universiteit Twente voert samen met uw gemeente/regio onderzoek uit om de kennis over reisgedrag en routekeuze van fietsers te vergroten. In de enquête krijgt u een reeks reismogelijkheden voorgelegd waarbij wij graag uw voorkeur willen weten. Door het invullen van deze vragenlijst kunt u ons helpen bij deze inspanning en we hopen dat u het interessant vindt om deel te nemen!

Alle reacties worden vertrouwelijk behandeld. De resultaten zullen alleen worden gerapporteerd als statistische gegevens en u, als individu, bent natuurlijk volledig anoniem. De uitkomsten zullen worden gebruikt om nog betere fietspaden te ontwikkelen.

Het invullen van de vragenlijst kost ongeveer 15 minuten. Deelnemers maken kans op één van de **bol.com cadeaubonnen t.w.v. €25,-!**

Als u vragen heeft over het onderzoek, kunt u contact opnemen met projectleider Jeroen van Ginkel, Stadsregio Arnhem Nijmegen, 024-329 79 79, jvginkel@destadsregio.nl

Laad onvoltooide enquête | Volgende

INLEIDENDE VRAGEN (ONDERDEEL 1 VAN 6)

Voor welke van de volgende doeleinden heeft u de afgelopen 3 maanden de fiets gebruikt?

Meerdere antwoorden mogelijk

- ☐ Van en naar het werk
- ☐ Winkelen / Boodschappen doen
- ☐ Onderwijs / Cursus volgen
- ☐ Visite / Logeren
- ☐ Ontspanning (bv. bezoek sportclub / bioscoop)
- ☐ Ik gebruik de fiets wel, maar niet voor de bovenstaande redenen
- ☐ Ik gebruik nooit de fiets

Hoe vaak maakt u gebruik van de fiets voor de volgende motieven?

	4 - 5 dagen per week	1 - 3 dagen per week	1 - 3 dagen per maand	Minder dan 1 dag per maand
Van en naar het werk	○	○	○	○
Winkelen / Boodschappen doen	○	○	○	○
Onderwijs / Cursus volgen	○	○	○	○
Visite / Logeren	○	○	○	○
Ontspanning (bv. bezoek sportclub / bioscoop)	○	○	○	○

Welke situatie is van toepassing voor uw woon-werk rit?
Kies één van de volgende antwoorden

- ◯ Ik maak de gehele reis gebruik van mijn fiets.
- ◯ Ik gebruik de fiets om van/naar het station het trein- of busstation te fietsen.

FIETS (ONDERDEEL 2 VAN 6)
De volgende vragen gaan over uw laatste reis met de fiets tussen uw huis en uw school en/of universiteit.

De volgende vragen gaan over uw laatste reis op de fiets tussen:

uw huis en uw school en/of universiteit.

Hoe laat was u met de fiets van huis vertrokken naar uw school en/of universiteit?

Uur : Minuut

Met welke fiets heeft u uw reis tussen uw huis en uw school en/of universiteit gemaakt?
Kies één van de volgende antwoorden

- ◯ Stadsfiets
- ◯ Hybride fiets
- ◯ Elektrische fiets
- ◯ Racefiets
- ◯ MTB
- ◯ Anders

Wat was de reistijd van uw laatst gemaakte reis per fiets tussen uw huis en uw school en/of universiteit?

minuten

In dit veld mogen alleen cijfers ingevoerd worden.

Hoeveel kilometer heeft u gefietst tijdens uw laatste rit naar uw school en/of universiteit? Als het niet exact weet, geeft u dan alstublieft een schatting.

kilometer

In dit veld mogen alleen cijfers ingevoerd worden.

? *Hele kilometers*

Wat is de postcode van uw woonadres? (bv. 6541NN)

Wat was de postcode van uw bestemming? (uw school en/of universiteit). (bv. 3511CE).
Als u de postcode niet weet, mag u een omschrijving geven (bv. 'Biltstraat te Utrecht' of 'station Arnhem').

Bent u bekend met het concept 'snelfietsroute?'

◯ Ja ◯ Nee

<u>Om onduidelijkheid te voorkomen leggen wij hier uit wat wij bedoelen met een snelfietsroute:</u>

Snelfietsroutes verbinden woon-, werk- en winkellocaties met elkaar. Het zijn non-stop, directe, comfortabele en veilige routes, waarbij fietsers zoveel mogelijk voorrang krijgen. Voor de herkenbaarheid worden de snelfietsroutes uitgevoerd in vier meter breed rood asfalt. Met het realiseren van snelfietsroutes wordt men verleid om vaker te fietsen. Meer fietsers betekent betekent minder verkeer-/autodruk, minder files, minder lawaai en lucht verontreiniging. De snelfietsroutes zorgen voor een betere bereikbaarheid van de regio in een gezondere omgeving.

Wij onderscheiden drie verschillende soorten fietsroutes. De snelfietsroute, het standaard fietspad en het fietsen op de openbare weg.

Kunt u voor uw laatste fietsrit tussen uw huis en uw school en/of universiteit aangeven hoeveel u op elk van de drie soorten fietsroutes heeft gefietst?

Snelfietsroute:
Een non-stop, directe, comfortabele en veilige route, waarbij fietsers zoveel mogelijk voorrang krijgen

Selecteer...

Standaard fietspad:
Een vrij directe en redelijk comfortabele route, waarbij fietsers af en toe voorrang krijgen en af en toe moeten stoppen

Selecteer...

Openbare weg:
Een indirecte, oncomfortabele en onveilige route, waarbij fietsers weinig voorrang krijgen en vaak gestopt moet worden.

Selecteer...

Heeft u bij uw laatste reis op de fiets van uw huis naar uw school en/of universiteit ook betaald voor het parkeren van uw fiets?

○ Ja ○ Nee

Hoeveel heeft u betaald voor het parkeren van uw fiets?

€ 0,00

In dit veld mogen alleen cijfers ingevoerd worden.

? *Gebruik de komma (,) als decimaal schijdingsteken*

REDENEN OM MEER OF MINDER TE GAAN FIETSEN (ONDERDEEL 3 VAN 6)

Hoe belangrijk zijn de volgende facoren voor u, in het algemeen, bij het kiezen van de fiets?
1 = zeer onbelangrijk, 5 = zeer belangrijk
Indien niet van toepassing, kies 'geen antwoord'.

	1	2	3	4	5	Geen antwoord
De fiets is het snelste vervoersmiddel	○	○	○	○	○	◉
Fietsen is goed voor het milieu	○	○	○	○	○	◉
Fietsen is goed voor mijn gezondheid	○	○	○	○	○	◉
Ik kan de fiets makkelijk parkeren	○	○	○	○	○	◉
Het weer	○	○	○	○	○	◉
Bewaakte fietsenstalling op de bestemming	○	○	○	○	○	◉
Ik vermijd de files	○	○	○	○	○	◉
Openbaar vervoer is te vol	○	○	○	○	○	◉
Ik vind het prettig om te fietsen	○	○	○	○	○	◉
Ik kan douchen op de bestemming	○	○	○	○	○	◉
Openbaar vervoer is te duur	○	○	○	○	○	◉
Ik moet betalen voor het parkeren van mijn auto	○	○	○	○	○	◉
Ik ben niet afhankelijk van vaste vertrektijden	○	○	○	○	○	◉

Welk rapportcijfer geeft u aan de volgende kenmerken van uw laatst gebruikte fietsroute naar uw school en/of universiteit?
1 = zeer slecht; 10 = uiterst goed;
Indien niet van toepassing, kies 'geen antwoord'.

	1	2	3	4	5	6	7	8	9	10	Geen antwoord
Directe/rechtreekse route	○	○	○	○	○	○	○	○	○	○	◉
Kwaliteit van het wegdek	○	○	○	○	○	○	○	○	○	○	◉
Afwatering van het wegdek (vorming plassen)	○	○	○	○	○	○	○	○	○	○	◉
Afstelling verkeerslichten voor fietsers	○	○	○	○	○	○	○	○	○	○	◉
Oversteeksnelheid bij kruispunten zonder verkeerslichten	○	○	○	○	○	○	○	○	○	○	◉
Verlichting van de route	○	○	○	○	○	○	○	○	○	○	◉
Verkeersveiligheid van de route	○	○	○	○	○	○	○	○	○	○	◉
Sociale veiligheid op de route	○	○	○	○	○	○	○	○	○	○	◉
Bewegwijzering van/op de route	○	○	○	○	○	○	○	○	○	○	◉
Aantrekkelijkheid van de omgeving	○	○	○	○	○	○	○	○	○	○	◉

GEBRUIK VAN ANDERE VERVOER (ONDERDEEL 4 VAN 6)

Kunt u aangeven hoe vaak u de volgende vervoerswijzen gebruikt om naar uw school en/of universiteit te komen?

	4 - 5 dagen per week	1 - 3 dagen per week	1 - 3 dagen per maand	6 - 11 dagen per jaar	1 - 5 dagen per jaar	Geen antwoord
Auto	○	○	○	○	○	◉
Trein	○	○	○	○	○	◉
Bus/Tram/Metro	○	○	○	○	○	◉

AUTO (ONDERDEEL 4 VAN 6)

Wat was de reistijd van uw laatste gemaakte reis met de auto tussen uw huis en uw school en/of universiteit?

[ ] minuten

In dit veld mogen alleen cijfers ingevoerd worden.

OPENBAAR VERVOER (ONDERDEEL 4 VAN 6)

Wat was de reistijd van uw laatste gemaakte reis met het openbaar vervoer (van deur tot deur) tussen uw huis en uw school en/of universiteit?

[ ] minuten

In dit veld mogen alleen cijfers ingevoerd worden.

Welk vervoerbewijs heeft u voor uw laatste met het openbaar vervoer reis naar uw school en/of universiteit gebruikt?

Kies één van de volgende antwoorden

- ◯ Los kaartje
- ◯ OV-Chipkaart op saldo (zonder korting)
- ◯ OV-Chipkaart op saldo (met korting, inc. studentreisproduct)
- ◯ OV-Abonnement
- ◯ OV-Studentenabonnement Vrij Reizen

KEUZE EXPERIMENT (ONDERDEEL 5 VAN 6)

We gaan u zodadelijk drie reeksen van vijf keuzes voorleggen. U kunt hierbij uit verschillende vervoerswijzes kiezen.

De vragen en antwoordmogelijkheden verschillen telkens in **reistijd**, **kosten** en **kwaliteit fietspad**. Hierbij zijn de vragen er op gericht om uw afweging tussen tijd en comfort én tussen tijd en kosten te achterhalen.

Bij alle keuzes wordt u gevraagd zich de volgende zaken voor te stellen:
- De reistijd geldt van deur-tot-deur;
- De kosten van het openbaar vervoer zijn de kosten na verrekening van uw korting;
- In het openbaar vervoer heeft u een zitplaats en u hoeft niet over te stappen;
- Dat alle opties mogelijk zijn (ook als ze onrealistisch lijken);
- Dat alle kosten voor uw eigen rekening komen;
- Dat er sprake is van goed fietsweer (15 - 25 graden, droog, windkracht 3).

Steeds vragen we u welke reis u het meeste aanspreekt.

We starten met vijf keuzes waarbij u kunt kiezen tussen de **auto, openbaar vervoer** en **twee typen fietsroutes**:

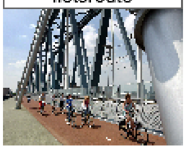
Een lange, maar comfortabele route: Een non-stop, comfortabele en veilige route, waarbij fietsers zoveel mogelijk voorrang krijgen en prettig doorgefietst kan worden.

Een korte, maar oncomfortabele route: Een oncomfortabele en onveilige route, waarbij fietsers weinig voorrang krijgen, vaak gestopt moet worden en waar vaker ongelukken gebeuren.

(01/15)
Stel dat u voor uw laatste reis tussen uw huis en uw school en/of universiteit kon kiezen uit de onderstaande opties.
Welke rit heeft uw voorkeur?

Kies één van de volgende antwoorden

Voorkeur voor:	Voorkeur voor:	Voorkeur voor:	Voorkeur voor:	Ik zou ander vervoer kiezen
(auto)	(trein / bus)	(fiets)	(fiets)	
9 minuten	14 minuten	15 minuten	12 minuten	
€ 0.90	€ 0.70	€ 0,00	€ 0,00	
		Comfortabele fietsroute	Oncomfortabele fietsroute	



- *Comfortabele route: Een non-stop, comfortabele en veilige route, waarbij fietsers zoveel mogelijk voorrang krijgen en prettig doorgefietst kan worden.*
- *Standaard fietsroute: Een vrij directe en redelijk comfortabele route, waarbij fietsers af en toe voorrang krijgen en af en toe moeten stoppen.*
- *Oncomfortabele route: Een oncomfortabele en onveilige route, waarbij fietsers weinig voorrang krijgen, vaak gestopt moet worden en waar vaker ongelukken gebeuren.*

(02/15)
Stel dat u voor uw laatste reis tussen uw huis en uw school en/of universiteit kon kiezen uit de onderstaande opties.
Welke rit heeft uw voorkeur?

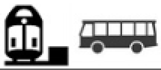
Kies één van de volgende antwoorden

○ Voorkeur voor:	○ Voorkeur voor:	○ Voorkeur voor:	○ Voorkeur voor:	○ Ik zou ander vervoer kiezen
				
22 minuten	12 minuten	17 minuten	12 minuten	
€ 1,00	€ 0,00	€ 0,00	€ 1.20	
	Oncomfortabele fietsroute	Comfortabele fietsroute		
				

? • *Comfortabele route: Een non-stop, comfortabele en veilige route, waarbij fietsers zoveel mogelijk voorrang krijgen en prettig doorgefietst kan worden.*
• *Standaard fietsroute: Een vrij directe en redelijk comfortabele route, waarbij fietsers af en toe voorrang krijgen en af en toe moeten stoppen.*
• *Oncomfortabele route: Een oncomfortabele en onveilige route, waarbij fietsers weinig voorrang krijgen, vaak gestopt moet worden en waar vaker ongelukken gebeuren.*

(03/15)
Stel dat u voor uw laatste reis tussen uw huis en uw school en/of universiteit kon kiezen uit de onderstaande opties.
Welke rit heeft uw voorkeur?

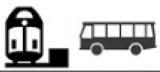
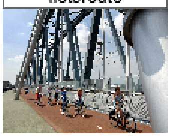
Kies één van de volgende antwoorden

○ Voorkeur voor:	○ Voorkeur voor:	○ Voorkeur voor:	○ Voorkeur voor:	○ Ik zou ander vervoer kiezen
				
14 minuten	9 minuten	15 minuten	18 minuten	
€ 1.30	€ 1.60	€ 0,00	€ 0,00	
		Oncomfortabele fietsroute	Comfortabele fietsroute	
				

? • *Comfortabele route: Een non-stop, comfortabele en veilige route, waarbij fietsers zoveel mogelijk voorrang krijgen en prettig doorgefietst kan worden.*
• *Standaard fietsroute: Een vrij directe en redelijk comfortabele route, waarbij fietsers af en toe voorrang krijgen en af en toe moeten stoppen.*
• *Oncomfortabele route: Een oncomfortabele en onveilige route, waarbij fietsers weinig voorrang krijgen, vaak gestopt moet worden en waar vaker ongelukken gebeuren.*

(04/15)
Stel dat u voor uw laatste reis tussen uw huis en uw school en/of universiteit kon kiezen uit de onderstaande opties.
Welke rit heeft uw voorkeur?

Kies één van de volgende antwoorden

○ Voorkeur voor:	○ Voorkeur voor:	○ Voorkeur voor:	○ Voorkeur voor:	○ Ik zou ander vervoer kiezen
				
19 minuten	25 minuten	18 minuten	10 minuten	
€ 0,00	€ 0,00	€ 0.70	€ 0.90	
Oncomfortabele fietsroute	Comfortabele fietsroute			
				

? • *Comfortabele route: Een non-stop, comfortabele en veilige route, waarbij fietsers zoveel mogelijk voorrang krijgen en prettig doorgefietst kan worden.*
• *Standaard fietsroute: Een vrij directe en redelijk comfortabele route, waarbij fietsers af en toe voorrang krijgen en af en toe moeten stoppen.*
• *Oncomfortabele route: Een oncomfortabele en onveilige route, waarbij fietsers weinig voorrang krijgen, vaak gestopt moet worden en waar vaker ongelukken gebeuren.*

(05/15)
Stel dat u voor uw laatste reis tussen uw huis en uw school en/of universiteit kon kiezen uit de onderstaande opties.
Welke rit heeft uw voorkeur?

Kies één van de volgende antwoorden

Voorkeur voor:	Voorkeur voor:	Voorkeur voor:	Voorkeur voor:	Ik zou ander vervoer kiezen
7 minuten	15 minuten	19 minuten	12 minuten	
€ 0.70	€ 0,00	€ 0,00	€ 0.60	
	Comfortabele fietsroute	Oncomfortabele fietsroute		


- *Comfortabele route: Een non-stop, comfortabele en veilige route, waarbij fietsers zoveel mogelijk voorrang krijgen en prettig doorgefietst kan worden.*
- *Standaard fietsroute: Een vrij directe en redelijk comfortabele route, waarbij fietsers af en toe voorrang krijgen en af en toe moeten stoppen.*
- *Oncomfortabele route: Een oncomfortabele en onveilige route, waarbij fietsers weinig voorrang krijgen, vaak gestopt moet worden en waar vaker ongelukken gebeuren.*

U krijgt nu vijf keuzes waarbij u kunt kiezen tussen de **auto, openbaar vervoer** en **twee typen fietsroutes**:

Een lange, maar comfortabele route: Een non-stop, comfortabele en veilige route, waarbij fietsers zoveel mogelijk voorrang krijgen en prettig doorgefietst kan worden.

Een standaard fietsroute: Een vrij directe en redelijk comfortabele route, waarbij fietsers af en toe voorrang krijgen en af en toe moeten stoppen

(06/15)
Stel dat u voor uw laatste reis tussen uw huis en uw school en/of universiteit kon kiezen uit de onderstaande opties.
Welke rit heeft uw voorkeur?

Kies één van de volgende antwoorden

Voorkeur voor:	Voorkeur voor:	Voorkeur voor:	Voorkeur voor:	Ik zou ander vervoer kiezen
				
10 minuten	18 minuten	15 minuten	12 minuten	
€ 1.20	€ 1,00	€ 0,00	€ 0,00	
		Comfortabele fietsroute	Standaard fietsroute	
				

- Comfortabele route: *Een non-stop, comfortabele en veilige route, waarbij fietsers zoveel mogelijk voorrang krijgen en prettig doorgefietst kan worden.*
- *Standaard fietsroute: Een vrij directe en redelijk comfortabele route, waarbij fietsers af en toe voorrang krijgen en af en toe moeten stoppen.*
- *Oncomfortabele route: Een oncomfortabele en onveilige route, waarbij fietsers weinig voorrang krijgen, vaak gestopt moet worden en waar vaker ongelukken gebeuren.*

(07/15)
Stel dat u voor uw laatste reis tussen uw huis en uw school en/of universiteit kon kiezen uit de onderstaande opties.
Welke rit heeft uw voorkeur?

Kies één van de volgende antwoorden

Voorkeur voor:	Voorkeur voor:	Voorkeur voor:	Voorkeur voor:	Ik zou ander vervoer kiezen
				
20 minuten	15 minuten	12 minuten	22 minuten	
€ 0,00	€ 0,00	€ 1.60	€ 1.30	
Comfortabele fietsroute	Standaard fietsroute			
				

- *Comfortabele route: Een non-stop, comfortabele en veilige route, waarbij fietsers zoveel mogelijk voorrang krijgen en prettig doorgefietst kan worden.*
- *Standaard fietsroute: Een vrij directe en redelijk comfortabele route, waarbij fietsers af en toe voorrang krijgen en af en toe moeten stoppen.*
- *Oncomfortabele route: Een oncomfortabele en onveilige route, waarbij fietsers weinig voorrang krijgen, vaak gestopt moet worden en waar vaker ongelukken gebeuren.*

(08/15)
Stel dat u voor uw laatste reis tussen uw huis en uw school en/of universiteit kon kiezen uit de onderstaande opties.
Welke rit heeft uw voorkeur?

Kies één van de volgende antwoorden

Voorkeur voor:	Voorkeur voor:	Voorkeur voor:	Voorkeur voor:	Ik zou ander vervoer kiezen
				
9 minuten	27 minuten	19 minuten	14 minuten	
€ 0.90	€ 0,00	€ 0,00	€ 0.70	
	Comfortabele fietsroute	Standaard fietsroute		
				

- *Comfortabele route: Een non-stop, comfortabele en veilige route, waarbij fietsers zoveel mogelijk voorrang krijgen en prettig doorgefietst kan worden.*
- *Standaard fietsroute: Een vrij directe en redelijk comfortabele route, waarbij fietsers af en toe voorrang krijgen en af en toe moeten stoppen.*
- *Oncomfortabele route: Een oncomfortabele en onveilige route, waarbij fietsers weinig voorrang krijgen, vaak gestopt moet worden en waar vaker ongelukken gebeuren.*

(09/15)
Stel dat u voor uw laatste reis tussen uw huis en uw school en/of universiteit kon kiezen uit de onderstaande opties.
Welke rit heeft uw voorkeur?

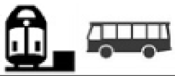
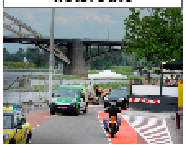
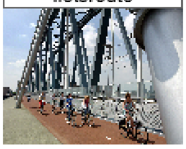
Kies één van de volgende antwoorden

Voorkeur voor:	Voorkeur voor:	Voorkeur voor:	Voorkeur voor:	○ Ik zou ander vervoer kiezen
				
22 minuten	12 minuten	16 minuten	12 minuten	
€ 0.70	€ 0,00	€ 0,00	€ 0.90	
○	○ Standaard fietsroute	○ Comfortabele fietsroute	○	
				

? • *Comfortabele route: Een non-stop, comfortabele en veilige route, waarbij fietsers zoveel mogelijk voorrang krijgen en prettig doorgefietst kan worden.*
• *Standaard fietsroute: Een vrij directe en redelijk comfortabele route, waarbij fietsers af en toe voorrang krijgen en af en toe moeten stoppen.*
• *Oncomfortabele route: Een oncomfortabele en onveilige route, waarbij fietsers weinig voorrang krijgen, vaak gestopt moet worden en waar vaker ongelukken gebeuren.*

(10/15)
Stel dat u voor uw laatste reis tussen uw huis en uw school en/of universiteit kon kiezen uit de onderstaande opties.
Welke rit heeft uw voorkeur?

Kies één van de volgende antwoorden

Voorkeur voor:	Voorkeur voor:	Voorkeur voor:	Voorkeur voor:	○ Ik zou ander vervoer kiezen
				
19 minuten	23 minuten	18 minuten	10 minuten	
€ 0,00	€ 0,00	€ 1.30	€ 1.60	
○ Standaard fietsroute	○ Comfortabele fietsroute	○	○	
				

? • *Comfortabele route: Een non-stop, comfortabele en veilige route, waarbij fietsers zoveel mogelijk voorrang krijgen en prettig doorgefietst kan worden.*
• *Standaard fietsroute: Een vrij directe en redelijk comfortabele route, waarbij fietsers af en toe voorrang krijgen en af en toe moeten stoppen.*
• *Oncomfortabele route: Een oncomfortabele en onveilige route, waarbij fietsers weinig voorrang krijgen, vaak gestopt moet worden en waar vaker ongelukken gebeuren.*

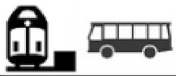
Voor de laatste vijf keuzes kunt u kiezen tussen de **auto, openbaar vervoer** en **twee typen fietsroutes**:

Een standaard fietsroute: Een vrij directe en redelijk comfortabele route, waarbij fietsers af en toe voorrang krijgen en af en toe moeten stoppen

Een korte, maar oncomfortabele route: Een oncomfortabele en onveilige route, waarbij fietsers weinig voorrang krijgen, vaak gestopt moet worden en waar vaker ongelukken gebeuren.

(11/15)
Stel dat u voor uw laatste reis tussen uw huis en uw school en/of universiteit kon kiezen uit de onderstaande opties.
Welke rit heeft uw voorkeur?

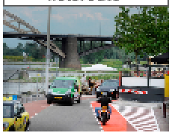
Kies één van de volgende antwoorden

Voorkeur voor:	Voorkeur voor:	Voorkeur voor:	Voorkeur voor:	Ik zou ander vervoer kiezen
				
9 minuten	14 minuten	16 minuten	12 minuten	
€ 1.60	€ 1.30	€ 0,00	€ 0,00	
		Standaard fietsroute	Oncomfortabele fietsroute	
				

? • *Comfortabele route: Een non-stop, comfortabele en veilige route, waarbij fietsers zoveel mogelijk voorrang krijgen en prettig doorgefietst kan worden.*
• *Standaard fietsroute: Een vrij directe en redelijk comfortabele route, waarbij fietsers af en toe voorrang krijgen en af en toe moeten stoppen.*
• *Oncomfortabele route: Een oncomfortabele en onveilige route, waarbij fietsers weinig voorrang krijgen, vaak gestopt moet worden en waar vaker ongelukken gebeuren.*

(12/15)
Stel dat u voor uw laatste reis tussen uw huis en uw school en/of universiteit kon kiezen uit de onderstaande opties.
Welke rit heeft uw voorkeur?

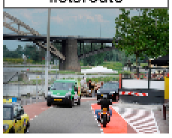
Kies één van de volgende antwoorden

Voorkeur voor:	**Voorkeur voor:**	**Voorkeur voor:**	**Voorkeur voor:**	**Ik zou ander vervoer kiezen**
				
21 minuten	15 minuten	10 minuten	18 minuten	
€ 0,00	€ 0,00	€ 0.90	€ 0.70	
Standaard fietsroute	Oncomfortabele fietsroute			
				

? • *Comfortabele route: Een non-stop, comfortabele en veilige route, waarbij fietsers zoveel mogelijk voorrang krijgen en prettig doorgefietst kan worden.*
• *Standaard fietsroute: Een vrij directe en redelijk comfortabele route, waarbij fietsers af en toe voorrang krijgen en af en toe moeten stoppen.*
• *Oncomfortabele route: Een oncomfortabele en onveilige route, waarbij fietsers weinig voorrang krijgen, vaak gestopt moet worden en waar vaker ongelukken gebeuren.*

(13/15)
Stel dat u voor uw laatste reis tussen uw huis en uw school en/of universiteit kon kiezen uit de onderstaande opties.
Welke rit heeft uw voorkeur?

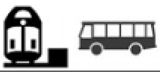
Kies één van de volgende antwoorden

Voorkeur voor:	**Voorkeur voor:**	**Voorkeur voor:**	**Voorkeur voor:**	**Ik zou ander vervoer kiezen**
				
12 minuten	23 minuten	19 minuten	22 minuten	
€ 1.20	€ 0,00	€ 0,00	€ 1,00	
	Standaard fietsroute	Oncomfortabele fietsroute		
				

? • *Comfortabele route: Een non-stop, comfortabele en veilige route, waarbij fietsers zoveel mogelijk voorrang krijgen en prettig doorgefietst kan worden.*
• *Standaard fietsroute: Een vrij directe en redelijk comfortabele route, waarbij fietsers af en toe voorrang krijgen en af en toe moeten stoppen.*
• *Oncomfortabele route: Een oncomfortabele en onveilige route, waarbij fietsers weinig voorrang krijgen, vaak gestopt moet worden en waar vaker ongelukken gebeuren.*

(14/15)
Stel dat u voor uw laatste reis tussen uw huis en uw school en/of universiteit kon kiezen uit de onderstaande opties.
Welke rit heeft uw voorkeur?

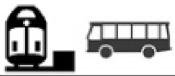
Kies één van de volgende antwoorden

Voorkeur voor:	**Voorkeur voor:**	**Voorkeur voor:**	**Voorkeur voor:**	**Ik zou ander vervoer kiezen**
				
18 minuten	12 minuten	17 minuten	10 minuten	
€ 1.30	€ 0,00	€ 0,00	€ 1.60	
	Oncomfortabele fietsroute	Standaard fietsroute		
				

? • *Comfortabele route: Een non-stop, comfortabele en veilige route, waarbij fietsers zoveel mogelijk voorrang krijgen en prettig doorgefietst kan worden.*
• *Standaard fietsroute: Een vrij directe en redelijk comfortabele route, waarbij fietsers af en toe voorrang krijgen en af en toe moeten stoppen.*
• *Oncomfortabele route: Een oncomfortabele en onveilige route, waarbij fietsers weinig voorrang krijgen, vaak gestopt moet worden en waar vaker ongelukken gebeuren.*

(15/15)
Stel dat u voor uw laatste reis tussen uw huis en uw school en/of universiteit kon kiezen uit de onderstaande opties.
Welke rit heeft uw voorkeur?

Kies één van de volgende antwoorden

Voorkeur voor:	Voorkeur voor:	Voorkeur voor:	Voorkeur voor:	○ Ik zou ander vervoer kiezen
				
19 minuten	25 minuten	14 minuten	9 minuten	
€ 0,00	€ 0,00	€ 1,00	€ 1.20	
○ Oncomfortabele fietsroute	○ Standaard fietsroute	○	○	
				

? • *Comfortabele route: Een non-stop, comfortabele en veilige route, waarbij fietsers zoveel mogelijk voorrang krijgen en prettig doorgefietst kan worden.*
• *Standaard fietsroute: Een vrij directe en redelijk comfortabele route, waarbij fietsers af en toe voorrang krijgen en af en toe moeten stoppen.*
• *Oncomfortabele route: Een oncomfortabele en onveilige route, waarbij fietsers weinig voorrang krijgen, vaak gestopt moet worden en waar vaker ongelukken gebeuren.*

Wat was voor u de belangrijkste overweging in uw keuzes?
Kies één van de volgende antwoorden

- ○ Reistijd
- ○ Comfort
- ○ Geld
- ○ Gezondheid
- ○ Ander overweging, namelijk:

PERSOONLIJKE SITUATIE (ONDERDEEL 6 VAN 6)

Er volgen nu nog een paar afsluitende vragen over uzelf. Deze gegevens zijn onder andere nodig om de representativiteit van het onderzoek te kunnen vaststellen

Bent u man of vrouw?

○ Vrouw ○ Man

Wat is uw leeftijd?
Kies één van de volgende antwoorden

- ○ Jonger dan 16 jaar
- ○ 16 t/m 20 jaar
- ○ 21 t/m 35 jaar
- ○ 36 t/m 50 jaar
- ○ 51 t/m 64 jaar
- ○ 65 jaar of ouder

Hoeveel personen telt uw huishouden (uzelf meegerekend)? In geval van een studentenwoning, geef enkel uzelf aan.
Vul hier het aantal personen in per categorie.

De som moet minimaal 1 zijn

Werkende personen van 16 jaar of ouder	0
Niet-werkende personen van 16 jaar of ouder	0
personen van 5 t/m 15 jaar	0
personen jonger dan 5 jaar	0
Totaal:	***0***

Heeft u een geldig autorijbewijs?

◯ Ja ◯ Nee

Hoeveel andere personen in uw huishouden hebben een geldig autorijbewijs?

[ ] personen

In dit veld mogen alleen cijfers ingevoerd worden.

Hoeveel motorvoertuigen heeft u/uw huishouden gewoonlijk ter beschikking

[ ] auto('s)

In dit veld mogen alleen cijfers ingevoerd worden.

? *Bromfietsen niet meerekenen*

Wat is uw hoogst voltooide opleiding?
Kies één van de volgende antwoorden

◯ Basisonderwijs / Lager onderwijs

◯ Lager beroepsonderwijs/VGLO/LAVO/MAVO/MULO

◯ Middelbaar beroepsonderwijs/HAVO/VWO/MMS/HBS

◯ Hoger beroepsonderwijs/Universiteit

◯ Anders, nl

[ ]

Wat is ongeveer het netto inkomen van alle leden van uw huishouden gezamelijk per maand? (Hier wordt het bedrag bedoeld dat u maandelijks op uw rekening gestort krijgt)

Kies één van de volgende antwoorden

- ◯ Minder dan € 625
- ◯ € 625 to € 1250
- ◯ € 1250 tot € 1875
- ◯ € 1875 tot € 2500
- ◯ € 2500 tot € 3125
- ◯ € 3125 tot € 3750
- ◯ € 3750 tot € 4325
- ◯ Meer dan € 4325
- ◯ Weet ik niet / Wil ik niet zeggen

? *Deze vraag is van belang voor het onderzoek aangezien bekend is dat mensen uit verschillende inkomensgroepen, andere reisgewoontes hebben. Mocht u echt bezwaar hebben tegen beantwoording van deze vraag, dan kunt u weet ik niet / wil ik niet zeggen aanklikken.*

HARTELIJK DANK VOOR UW MEDEWERKING

Indien u wilt meedoen aan de verloting van de **bol.com cadeaubonnen t.w.v. €25**, vul dan hier uw e-mailadres in. Dit e-mailadres wordt apart opgeslagen.

Heeft u nog op- of aanmerkingen die van belang kunnen zijn voor het onderzoek?

Hartelijk bedankt voor het invullen van de enquête!
Binnenkort wordt contact opgenomen met de winnaars van de **bol.com cadeaubonnen.**
U kunt het scherm sluiten.

Appendix C: Descriptive statistics

Level-of-service characteristics

Commute

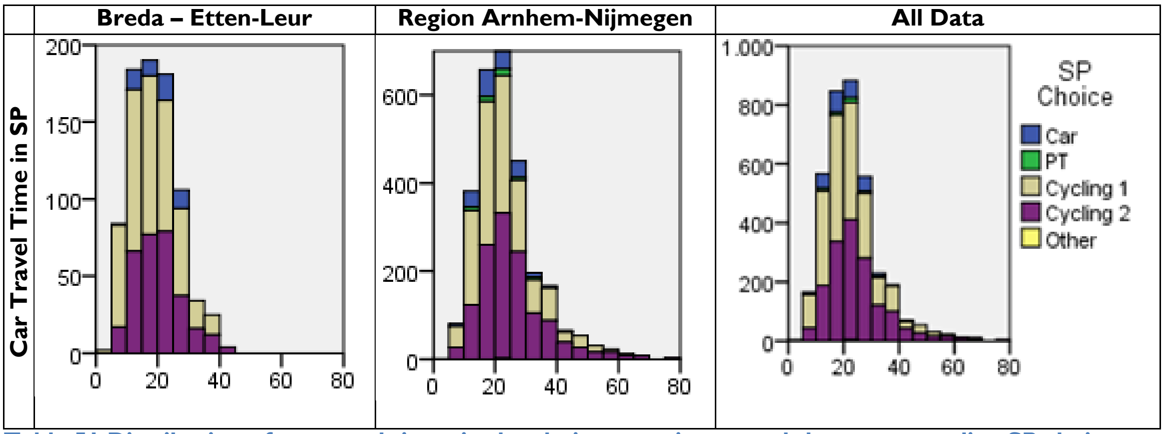


Table 51 Distribution of car travel times in the choice experiment and the corresponding SP choices

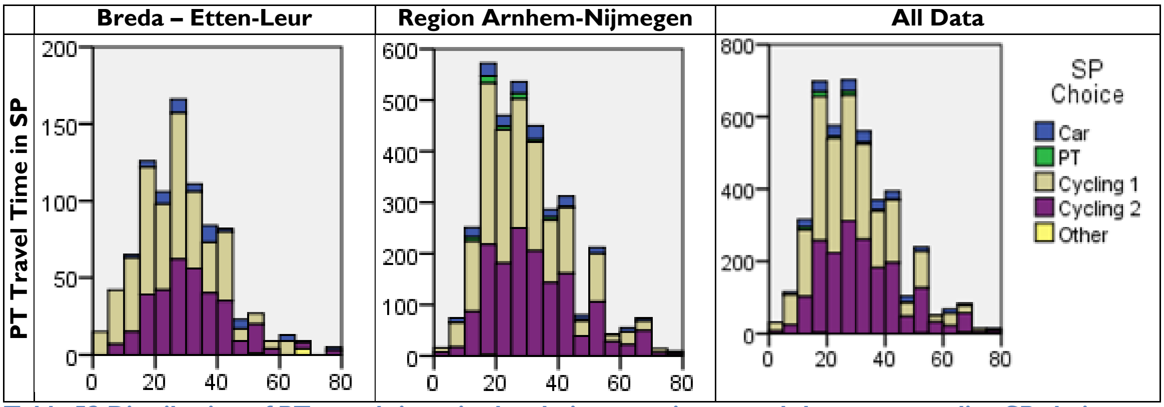


Table 52 Distribution of PT travel times in the choice experiment and the corresponding SP choices

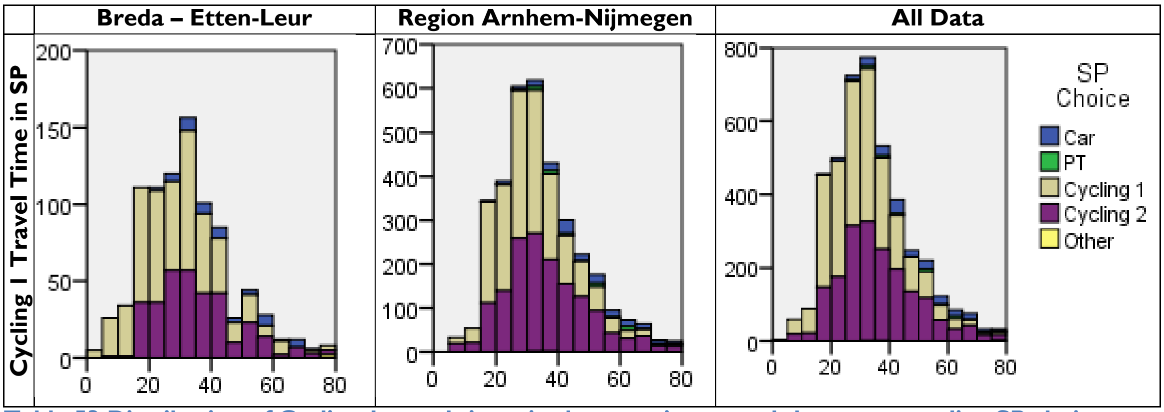


Table 53 Distribution of Cycling 1 travel times in the experiment and the corresponding SP choices

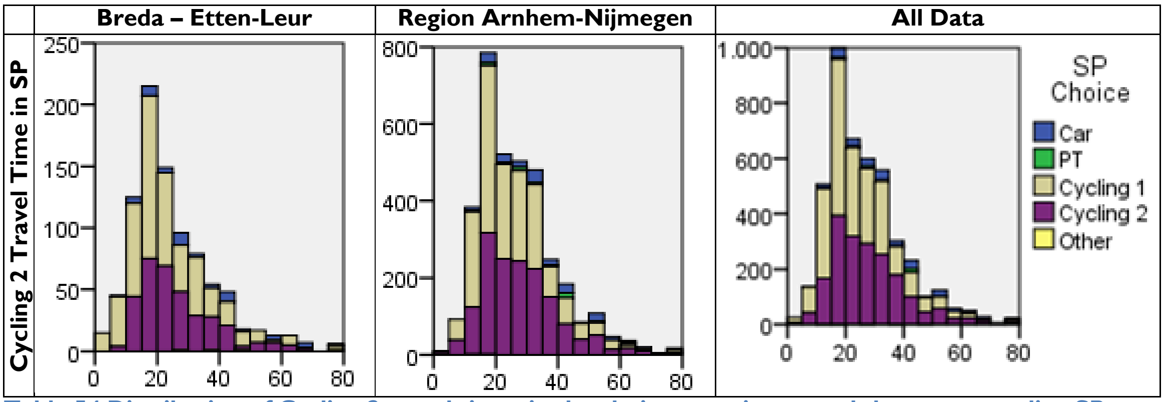


Table 54 Distribution of Cycling 2 travel times in the choice experiment and the corresponding SP choices

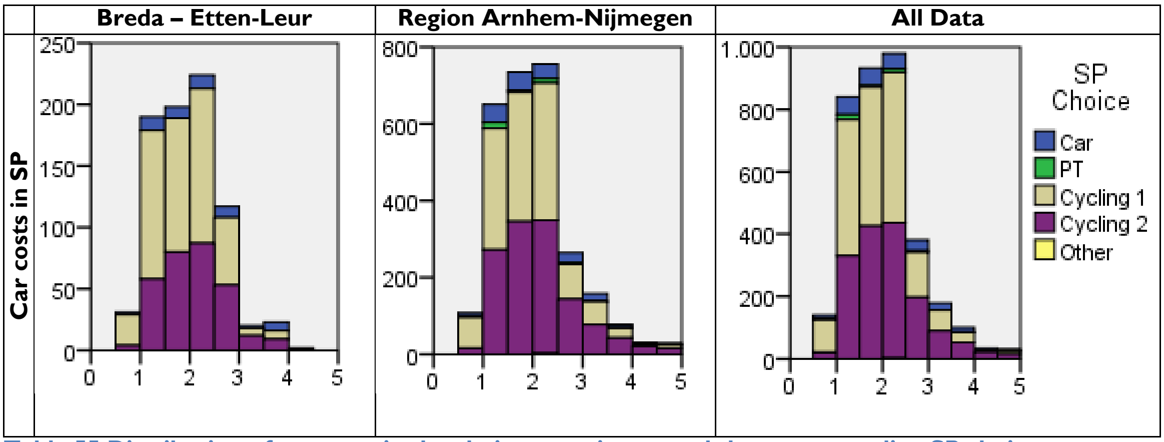


Table 55 Distribution of car costs in the choice experiment and the corresponding SP choices

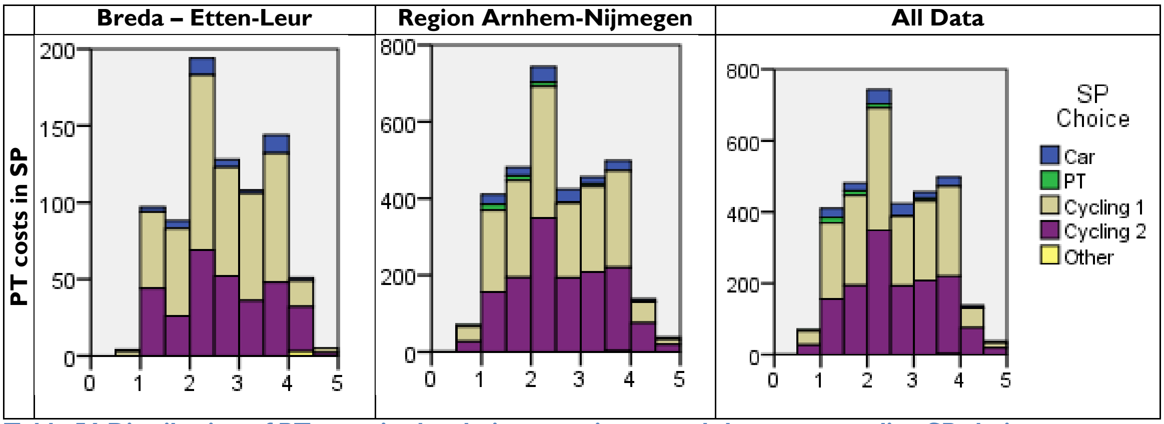


Table 56 Distribution of PT costs in the choice experiment and the corresponding SP choices

Educational

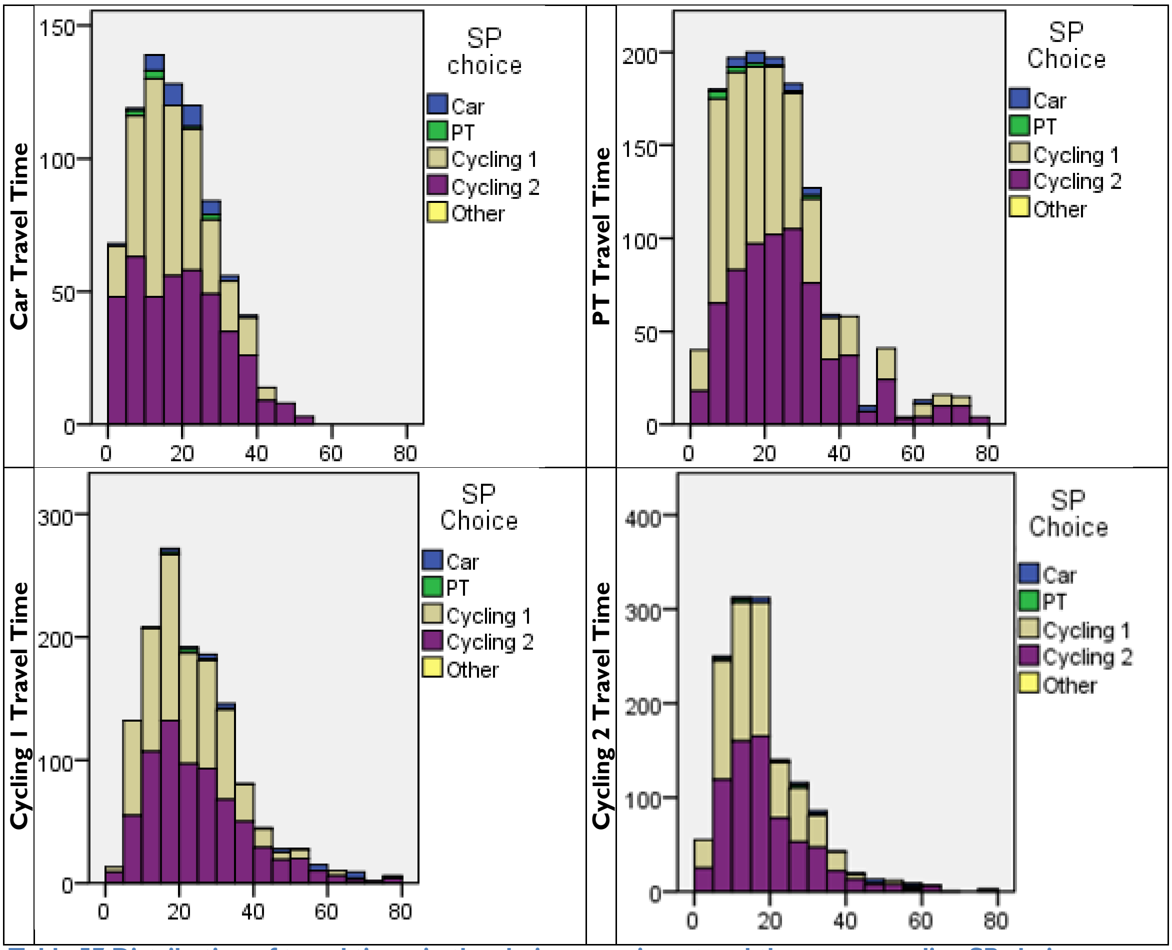


Table 57 Distribution of travel times in the choice experiment and the corresponding SP choices per choice alternative

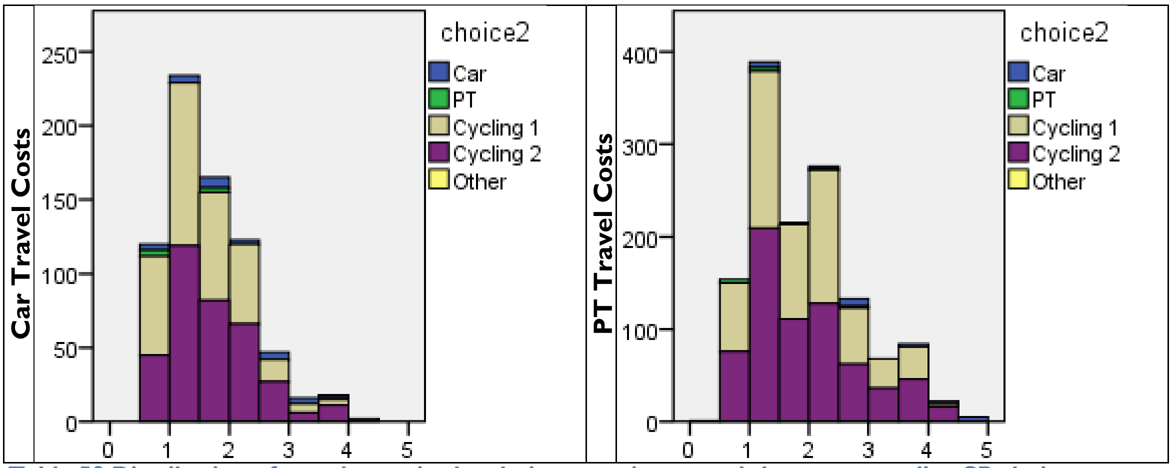


Table 58 Distribution of travel costs in the choice experiment and the corresponding SP choices per choice alternative

Other Recreational

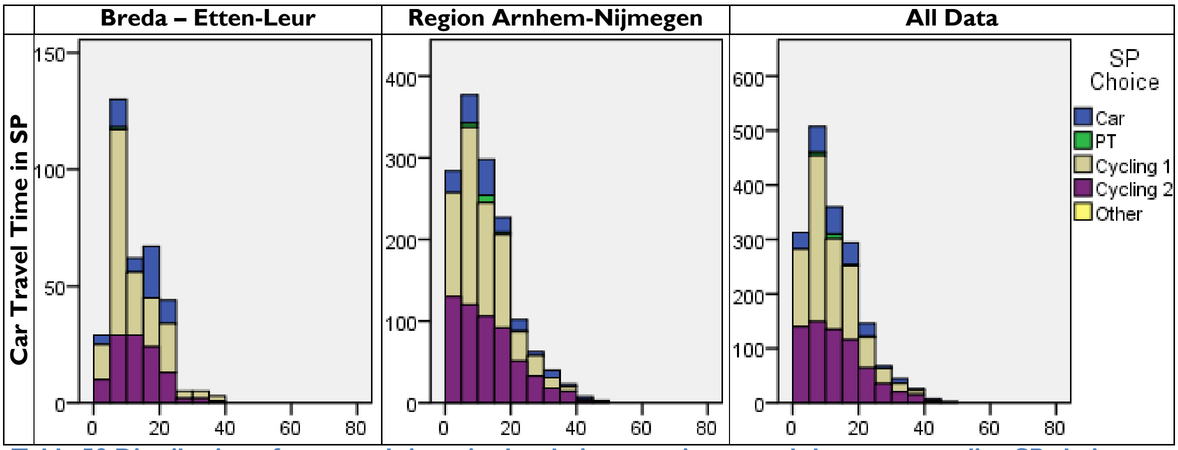


Table 59 Distribution of car travel times in the choice experiment and the corresponding SP choices

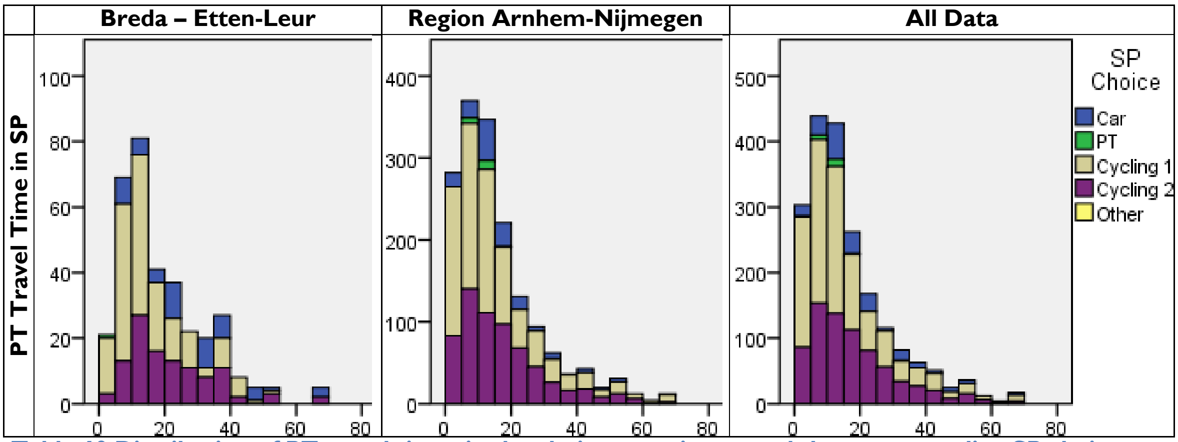


Table 60 Distribution of PT travel times in the choice experiment and the corresponding SP choices

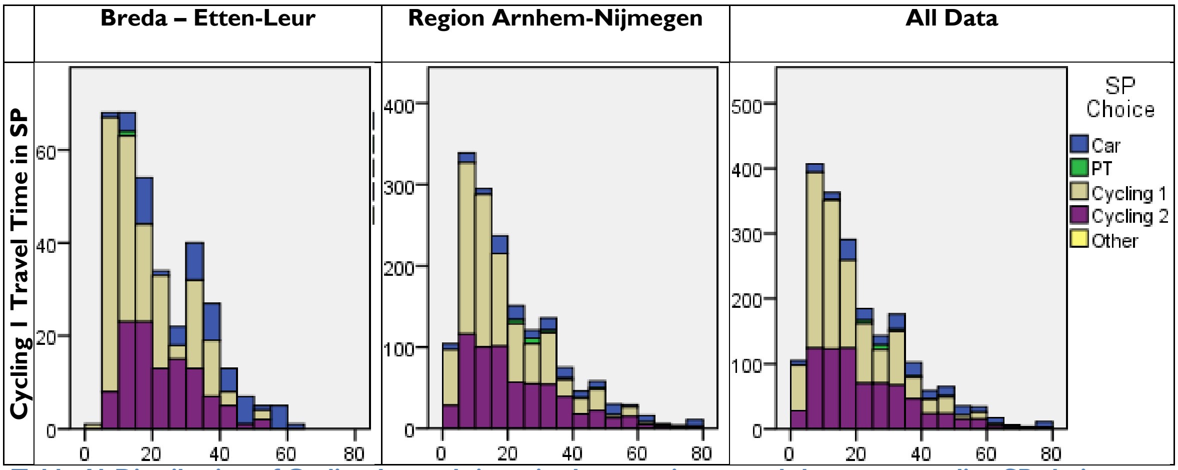


Table 61 Distribution of Cycling 1 travel times in the experiment and the corresponding SP choices

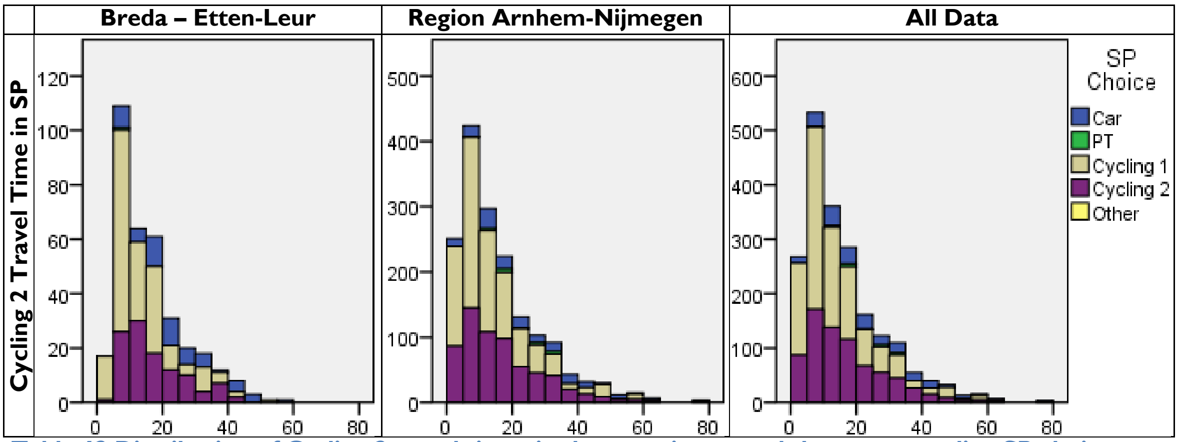


Table 62 Distribution of Cycling 2 travel times in the experiment and the corresponding SP choices

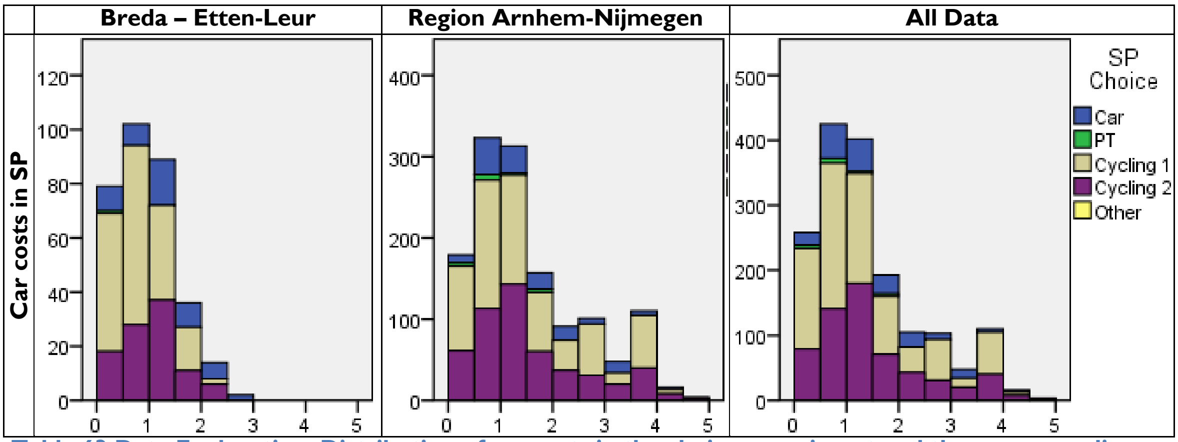


Table 63 Data Exploration: Distribution of car costs in the choice experiment and the corresponding SP choices

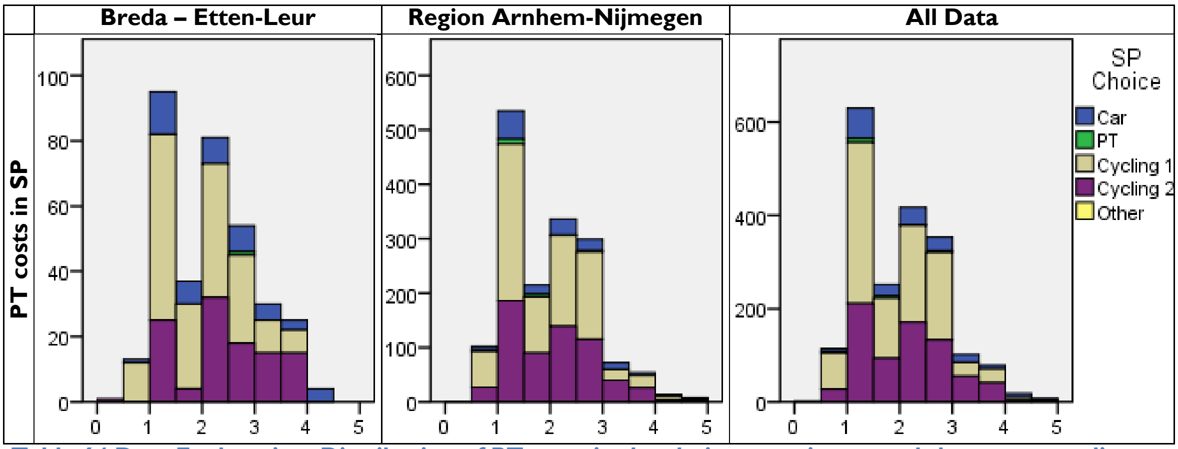


Table 64 Data Exploration: Distribution of PT costs in the choice experiment and the corresponding SP choices

Socio-economic characteristics

Commute

Gender

No significant differences are found between both samples regarding the distribution of gender (p-value 0,801). Table 65 indicates a relative higher share of females among the respondents who choose to travel by car.

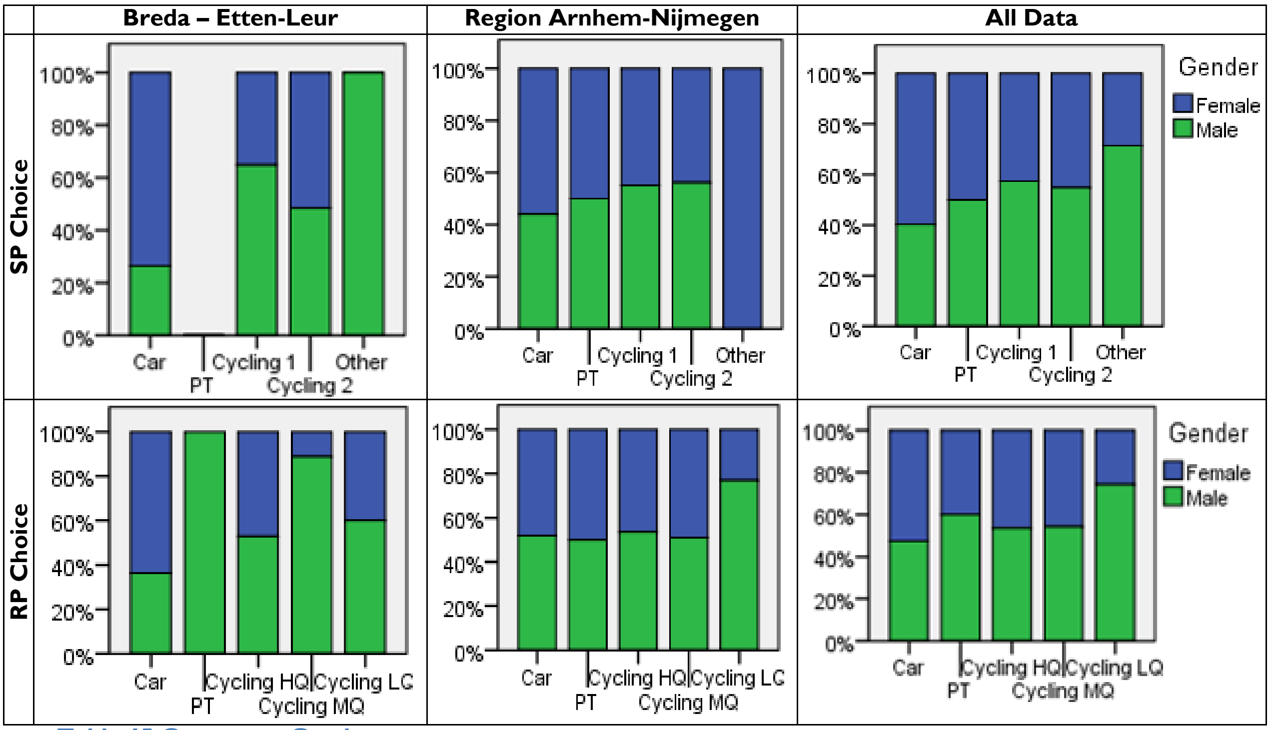


Table 65 Commute: Gender

Age

No significant differences are found between both samples regarding the distribution of age (p-value 0,641). Overall, more people of high age are present in the data. The data in Table 66 indicates a higher share of respondents below the age of 35 among the car and public transport travelers. The data also indicates that people above the age of 51 are more commonly found among the cyclists, which is in accordance with the finding from Börjesson and Eliasson (2012) who found a higher direct utility of cycling travel among higher ages and vice versa. However, the presumed cause (health attitude) is not found to be correlated to age in the dataset.

Education level

Significant differences are found between both samples regarding the distribution of education al level (p-value 0,002). Respondents from the region Arnhem Nijmegen sample are higher educated, probably due to the presence of the Radboud University. Table 67 shows that among respondents choosing car or public transport, the educational level is higher. As income correlates with education (0,288), the higher educated traveler has a lower marginal utility of money. Therefore, the higher educated traveler has a higher tendency to travel by car and public transport.

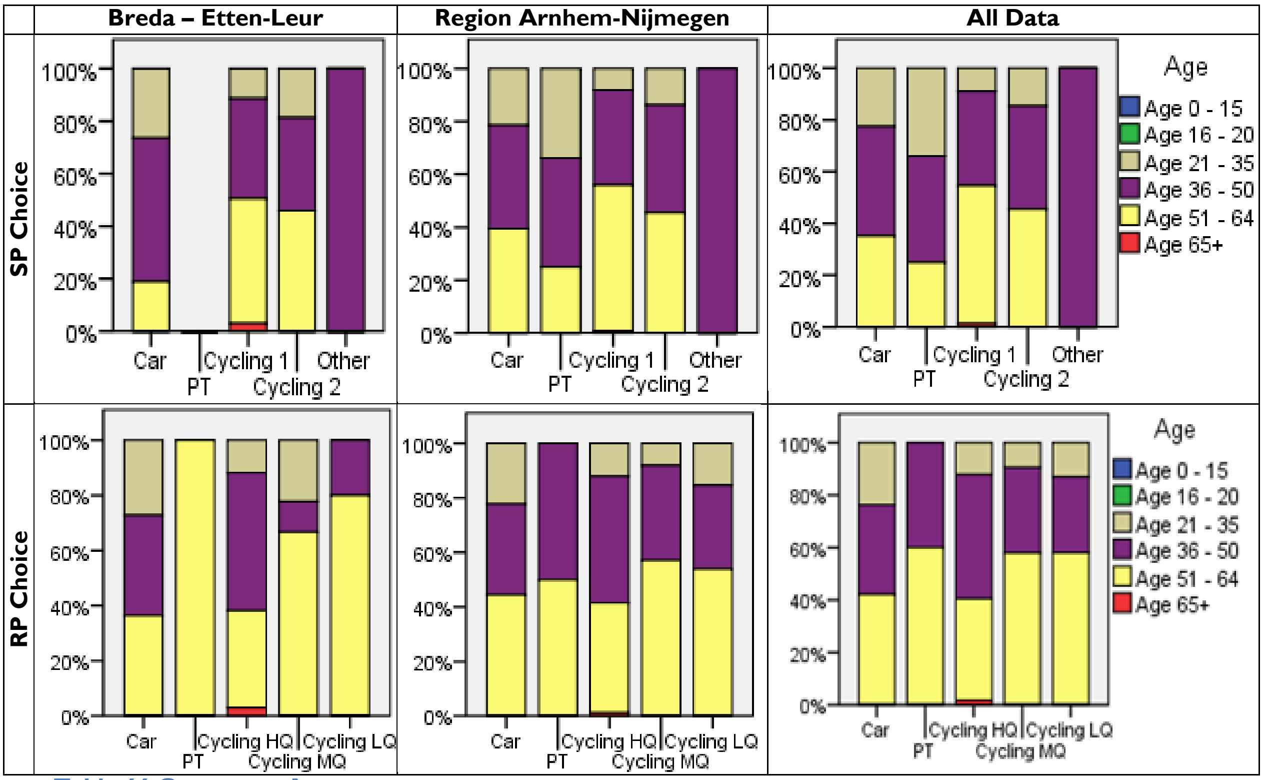


Table 66 Commute: Age

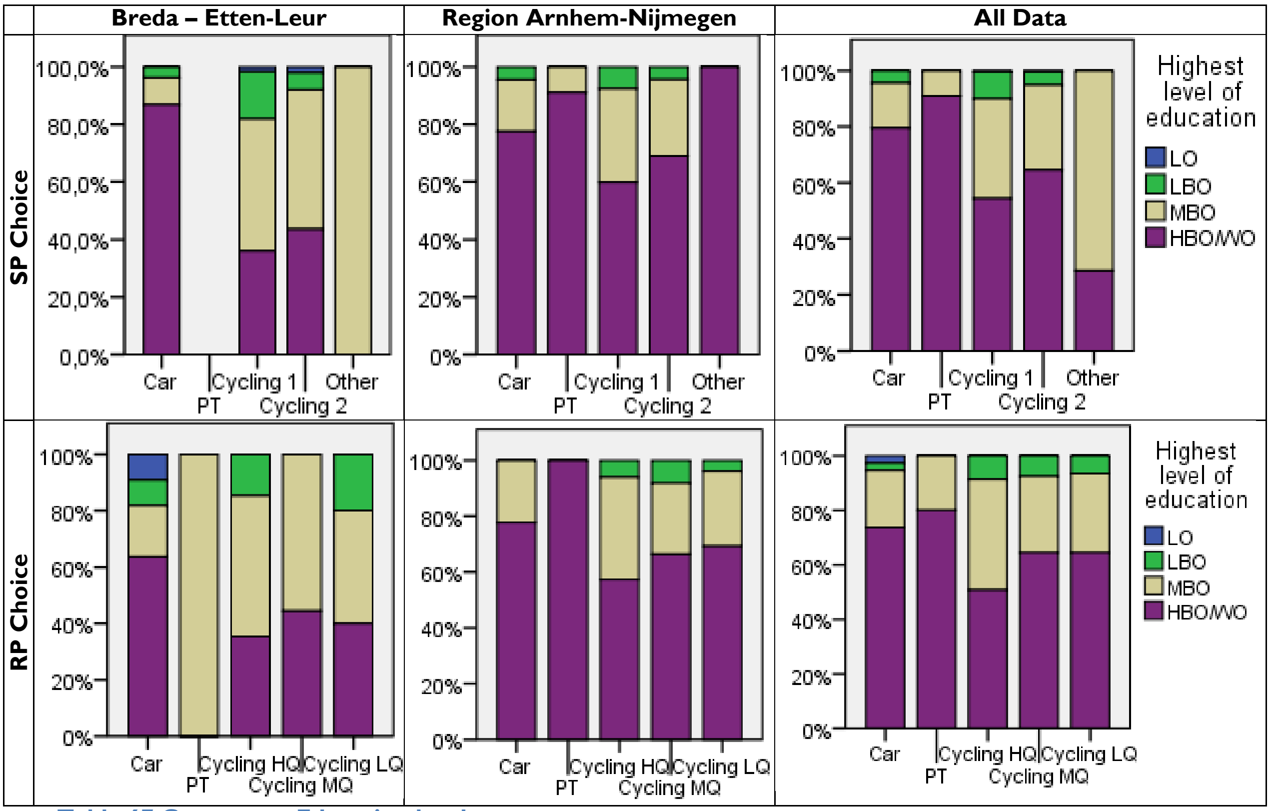


Table 67 Commute: Education level

Income

No significant differences are found between both samples regarding the distribution of income (p-value 0,525). Lower incomes are in both samples rarely found, due to an underrepresentation of unemployed and part-time travelers in the sampling frame. Table 68 indicates that among the public transport travelers, net household incomes below €2.500 per month are relatively more often found. With a confidence level of 95%, it is found that respondents with an income below €2.500 have significantly less often a car available than higher incomes (85% vs 70% of the respondents). There is a correlation between income and car ownership.

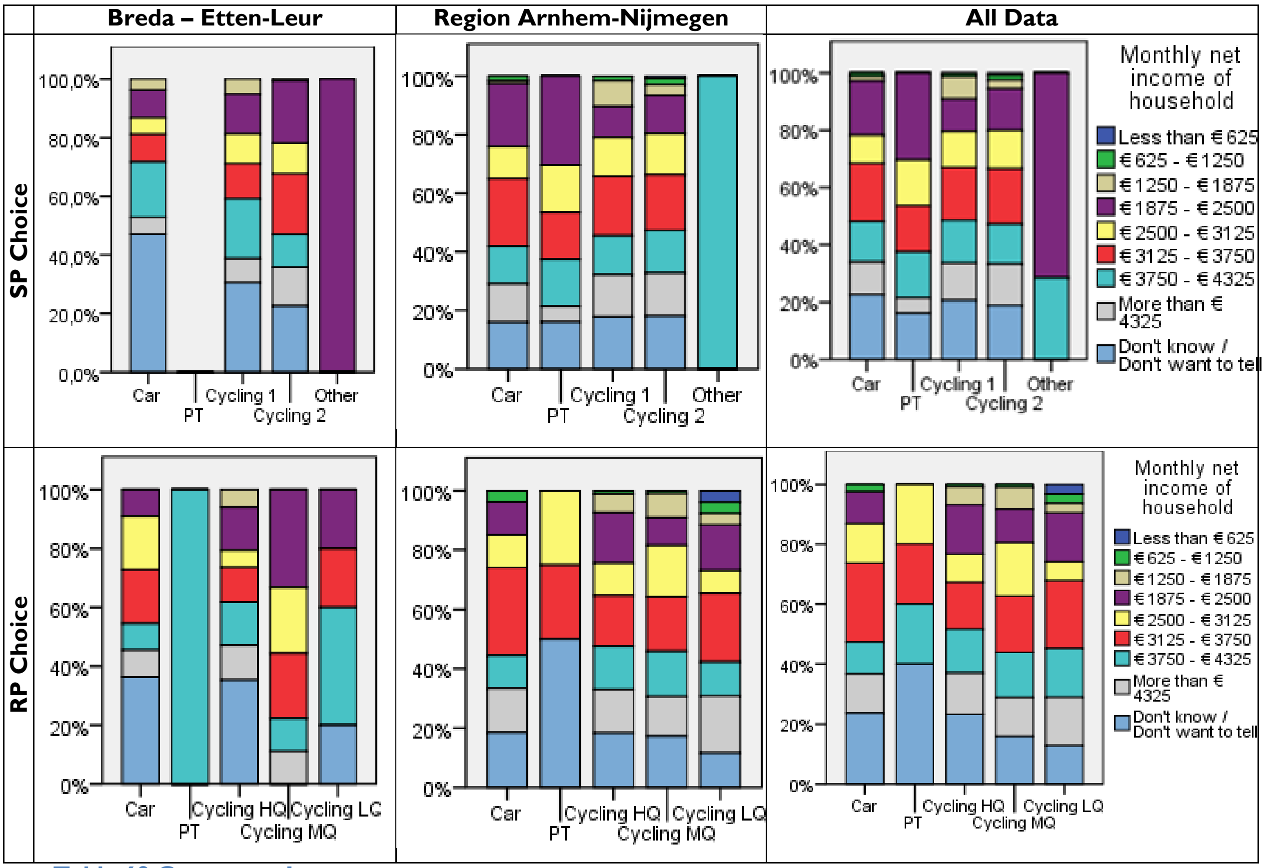


Table 68 Commute: Income

Household Size

No significant differences are found between both samples regarding the distribution of household sizes (p-value 0,129). Table 69 shows that households with three or less people are slightly more often found among car users.

Motor Vehicle Ownership

No significant differences are found between both samples regarding the distribution of number of motor vehicles owned (p-value 0,365). A large share of respondents possesses one car per household. Table 70 indicates a higher share of respondents with two or more cars in one household among the respondents who choose the car in the stated choice experiment.

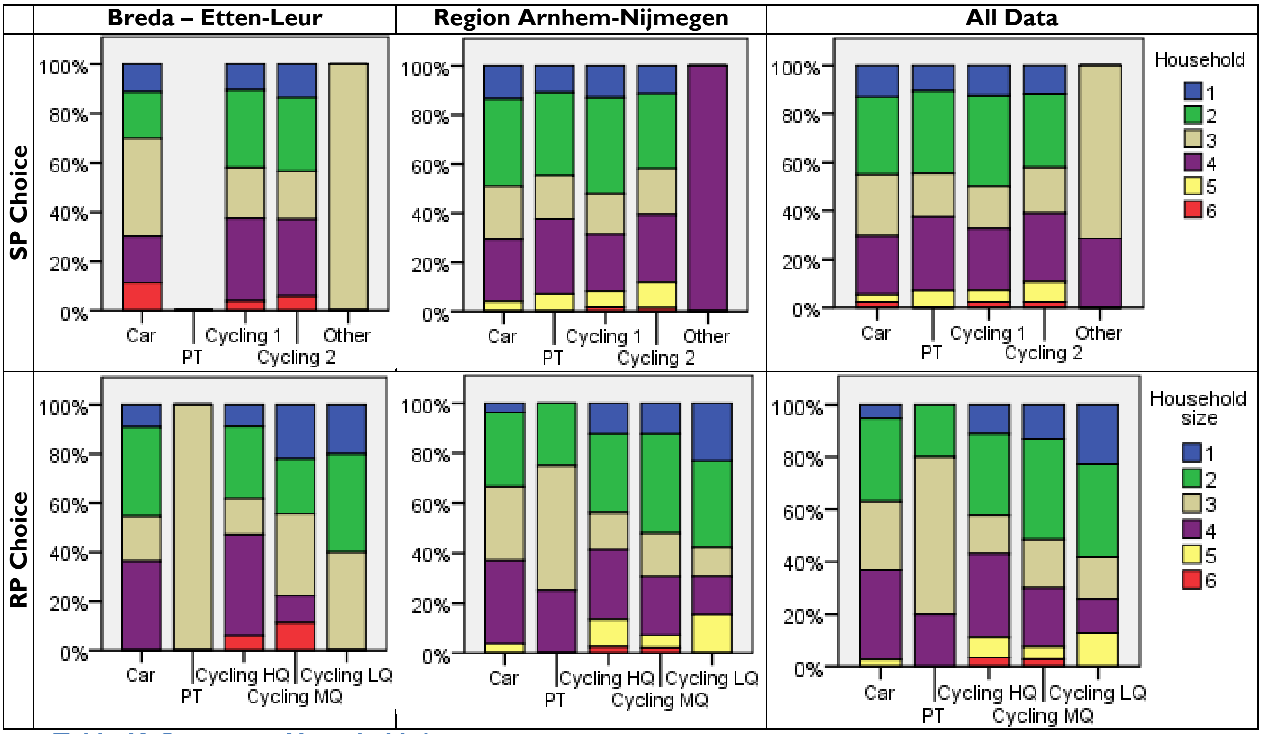


Table 69 Commute: Household size

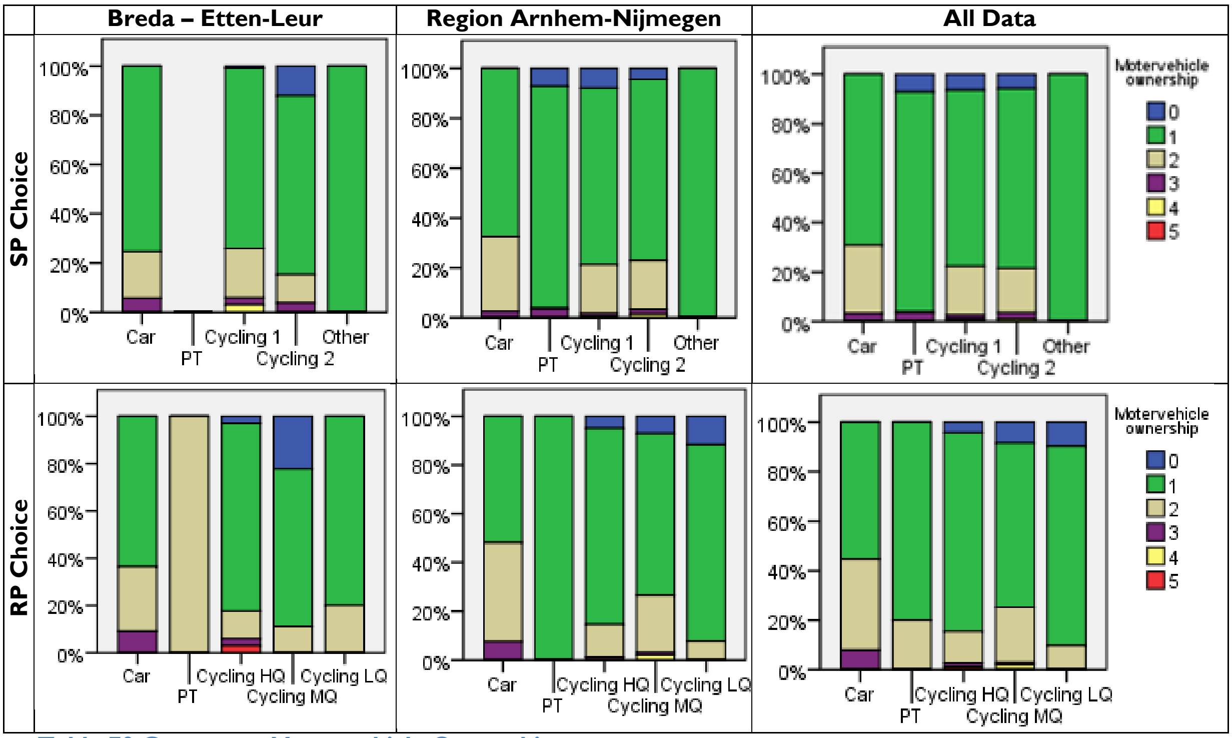


Table 70 Commute: Motor vehicle Ownership

Educational

Gender

Table 71 indicates a relative higher share of females among the respondents who choose to travel by car in both the SP and the RP data with respect to the other mode choices. Females are slightly overrepresented in the student sample.

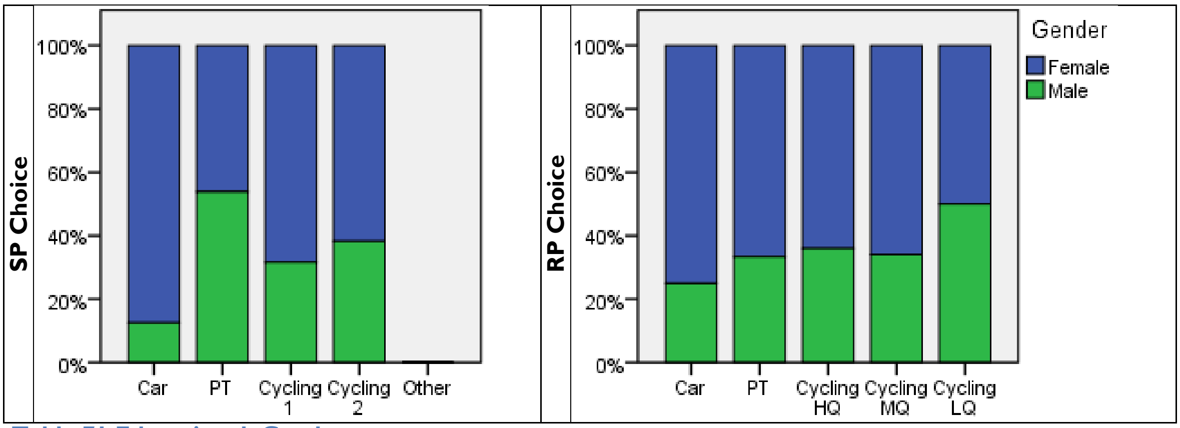


Table 71 Educational: Gender

Age

Table 72 shows that within the student data, many respondents are over the age of 36. This brings up the question who these respondents are. The commenting option in the questionnaire tells that some respondents filled in their weekly trip to yoga as educational trip. These trips should not be part of this data. Through weighting (paragraph 4.4), this group is suppressed in the model analysis, as they will be assigned to a very low weight (x0.01). Table 72 also indicates a high share of elderly among the car users; these will not be taken into account in the weighted model estimation. Student will have a strong preference for cycling.

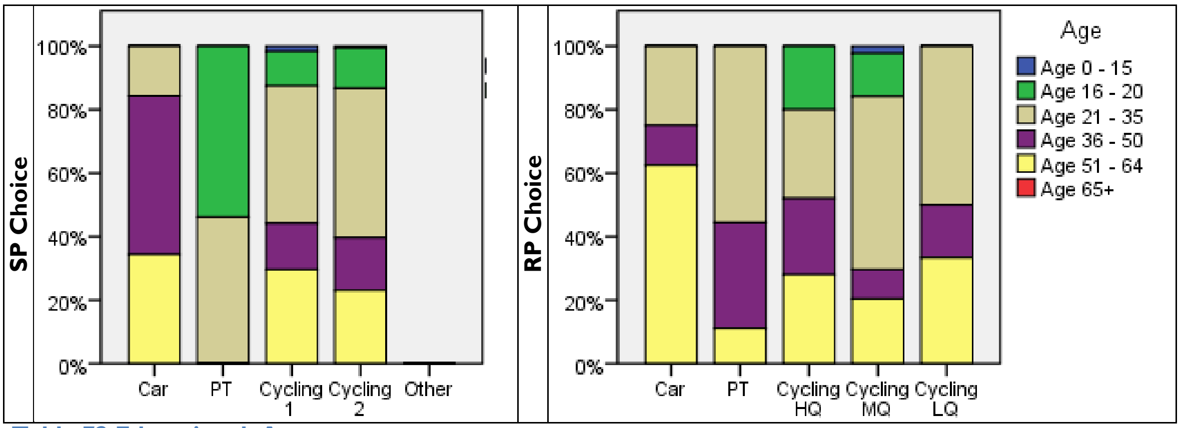


Table 72 Educational: Age

Education level

Table 73 indicates a high share of higher educated among all modes of transport. Since there is a correlation (0,303) between the elderly and higher educated, the share of higher educated will be much lower in the weighted model estimation. Not too much value should be added to these figures, but the results do indicate a relatively higher share of MBO and lower educated respondents among the cycle alternatives.

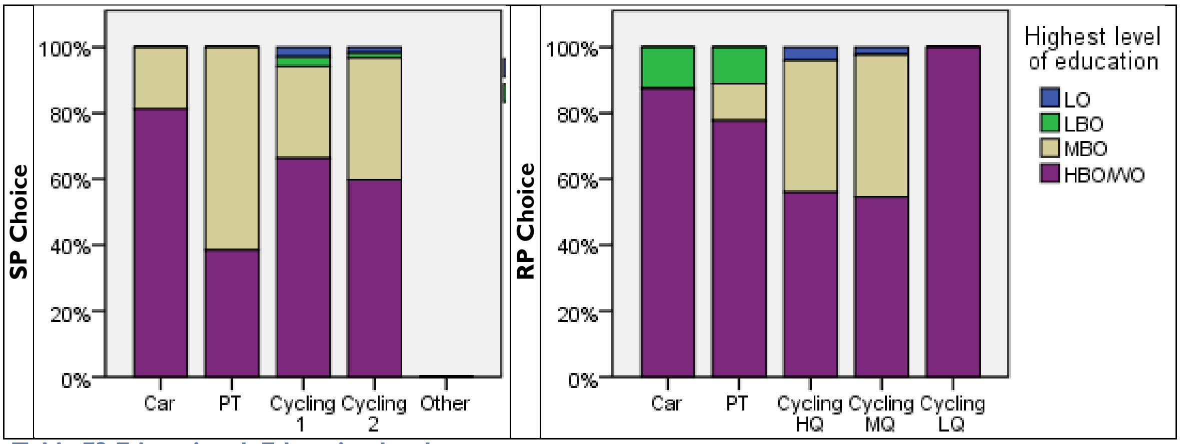


Table 73 Educational: Education level

Income

Table 74 shows a clear distinction between the share of low-income students and the yoga visiting elderly with an above average income. The results do indicate that students with a net income under € 625,- per month choose relatively less often to travel by car and public transport.

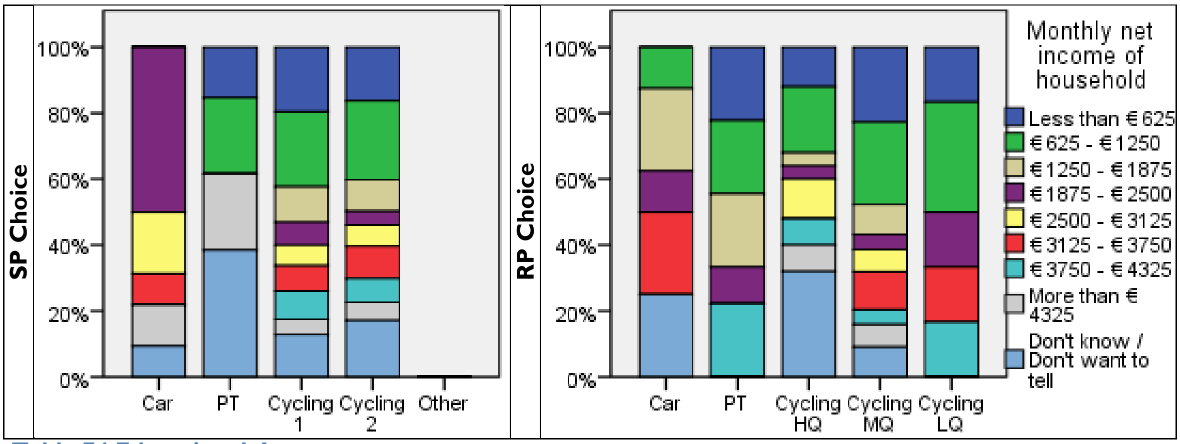


Table 74 Educational: Income

Household Size

Table 75 indicates a relatively high share of single person households choosing to travel by bicycle in the SP results.

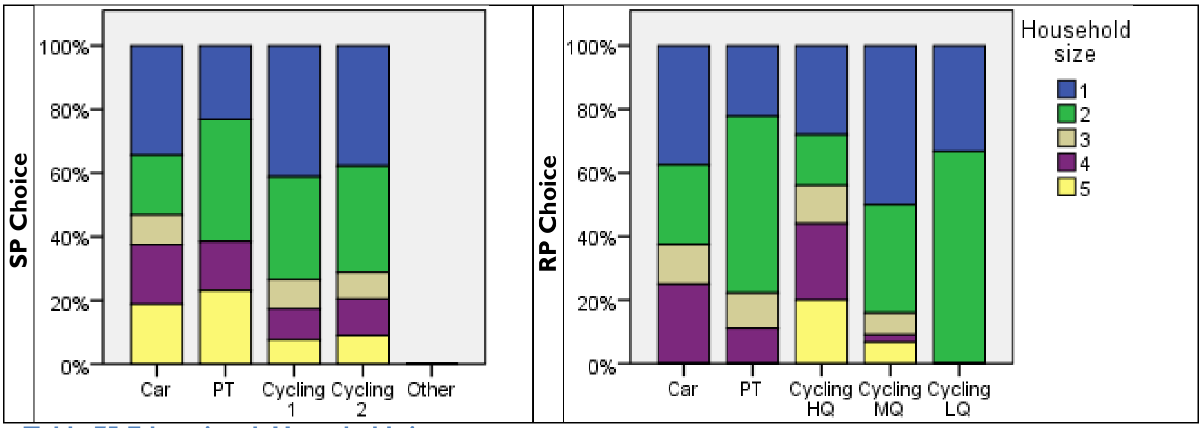


Table 75 Educational: Household size

Motor vehicle ownership

Table 76 shows that owners of more than one car do not choose to travel by public transport in both the RP as the SP questionnaire. The share of none and one car owners if equally distributed over the SP choices.

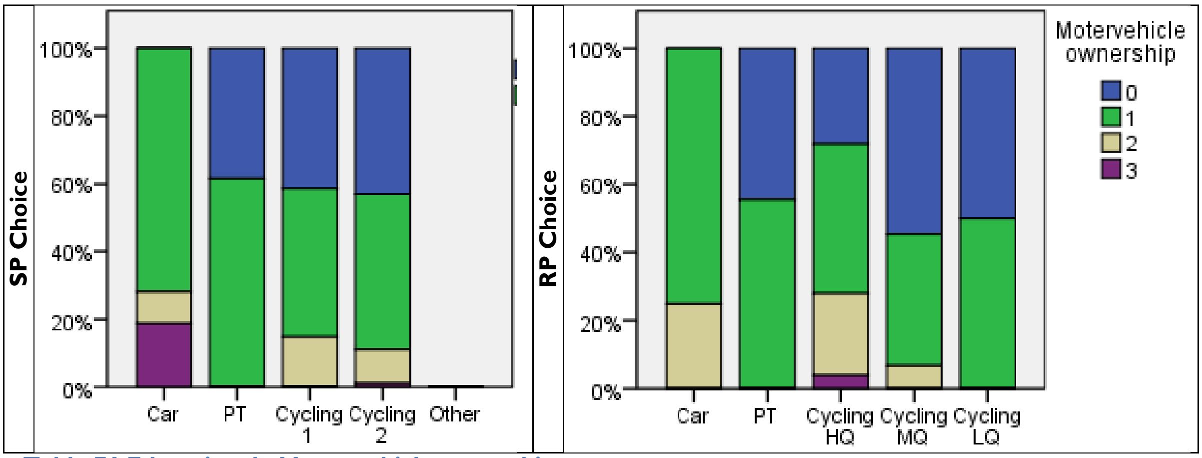


Table 76 Educational: Motor vehicle ownership

Other Recreational

Gender

Table 77 does not clearly indicate a higher propensity of traveling with a certain mode. The Breda – Etten-Leur sample does show some differences (i.e. fewer females in the motorized modes of transport). However, no significant differences are found between both samples regarding the distribution of gender (p-value 0,244).

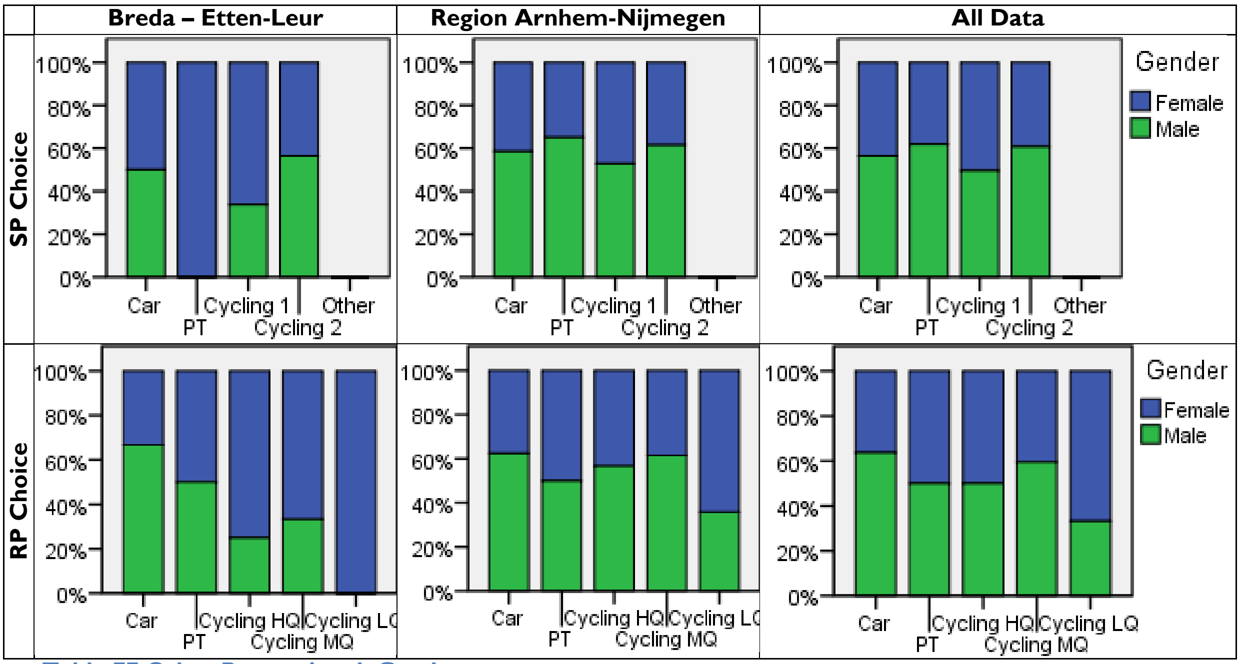


Table 77 Other Recreational: Gender

Age

No significant differences are found between both samples regarding the distribution of gender (p-value 0,801). The sample does not include information on respondents under the age of 20. Table 78indicates a higher propensity to travel by public transport when the age is under 35. Among the other mode/route choices, no notable differences are found. When interpreting the results for public transport, it is important to take into account that only a small number of respondents chose public transport. Overall, cycling is strongly preferred, but among the respondents who do choose public transport ages under 35 are more often found.

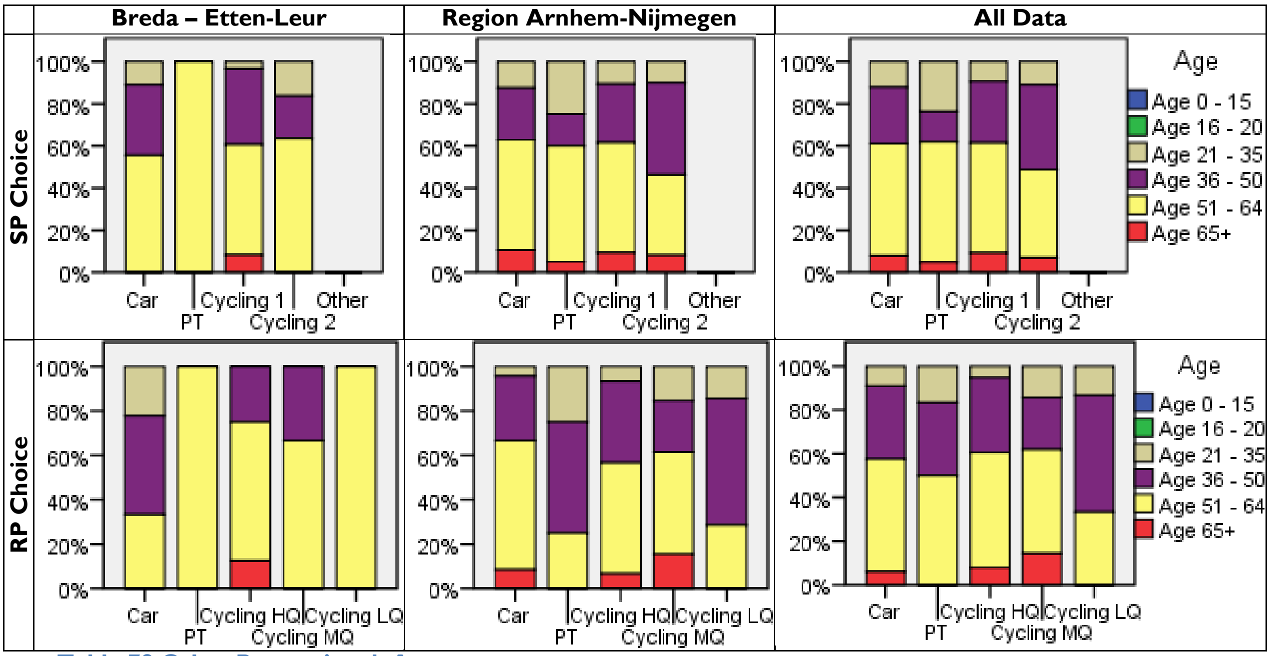


Table 78 Other Recreational: Age

Education level

No significant differences are found between both samples regarding the distribution of educational levels (p-value 0,887). A large share of the respondents has a high level of education. Table 79 indicates that the propensity to find a non-high educated traveler is higher among the respondents who choose to travel by car and by bicycle on a comfortable and slower cycle route.

Income

No significant differences are found between both samples regarding the distribution of income levels (p-value 0,909). Little low-income respondents are found in the sample. Table 80 indicates that among the respondents who choose to cycle a net household income between € 0, - and €3.125, - is more commonly found than among the respondents who choose to travel by car and public transport. Respondents who did not wanted to share their income are more commonly found among those who choose to drive.

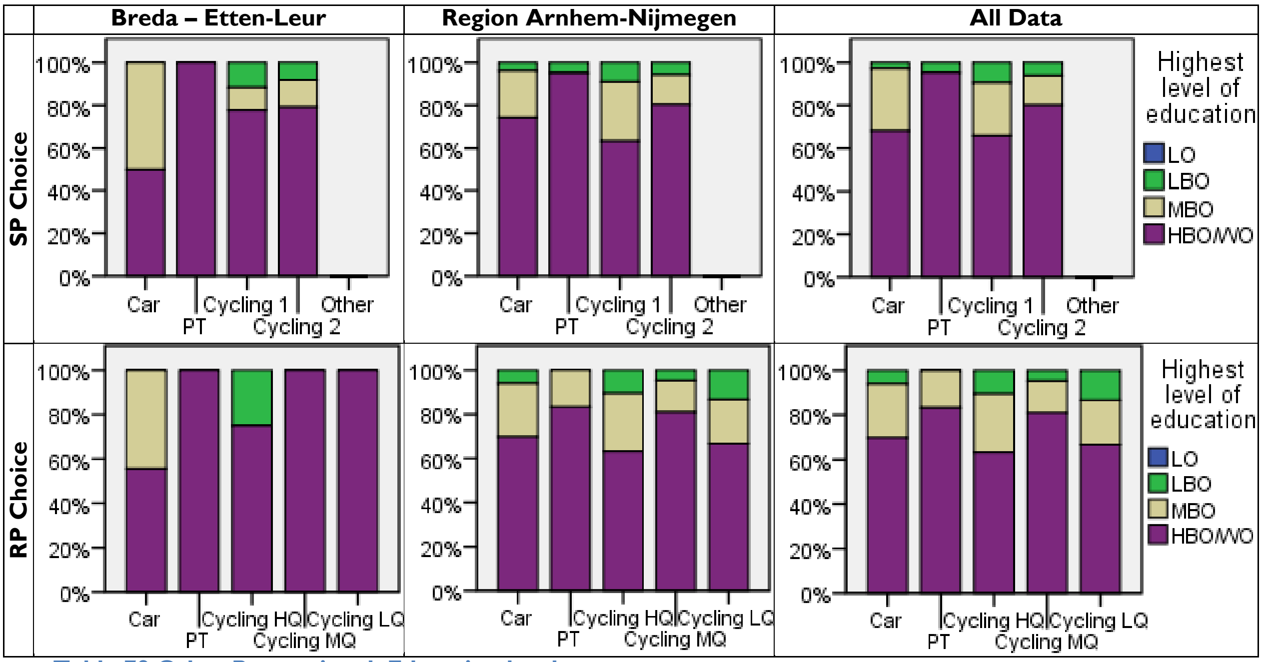


Table 79 Other Recreational: Education level

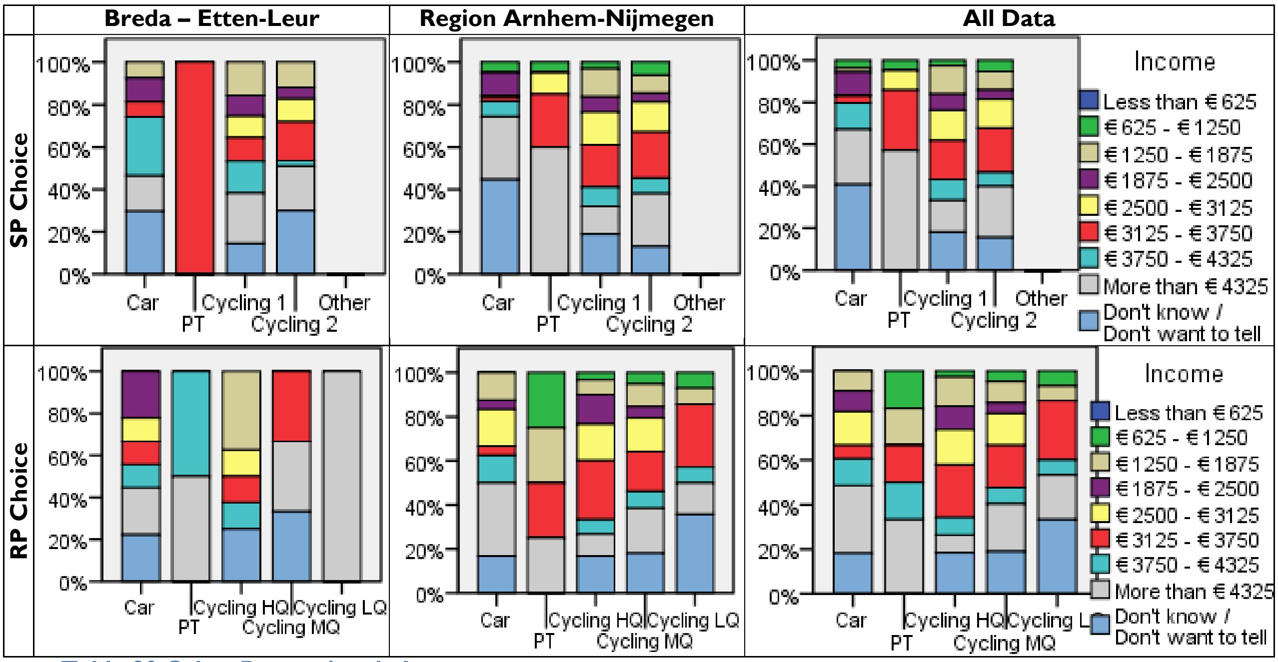


Table 80 Other Recreational: Income

Household Size

No significant differences are found between both samples regarding the distribution of household sizes (p-value 0,480). Table 81 indicates that among the respondents who choose to travel by bicycle on a comfortable and slow route, the single and double person households are more often found.

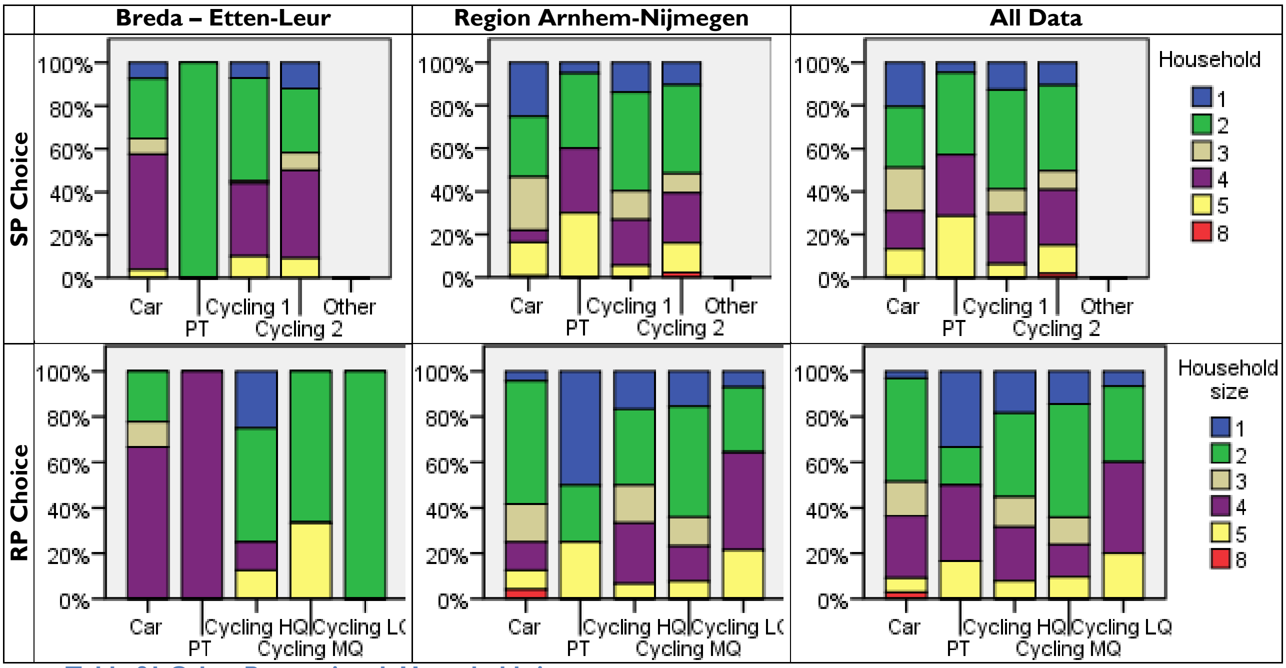


Table 81 Other Recreational: Household size.

Motor Vehicle Ownership

No significant differences are found between both samples regarding the distribution of household sizes (p-value 0,064). Table 82 shows in the SP choice results that respondents with more than one car are more commonly found among the motorized modes of transport and non-car owners are more commonly found among the cyclists. In the RP choice results, the non-car owners are more commonly found among the public transport users.

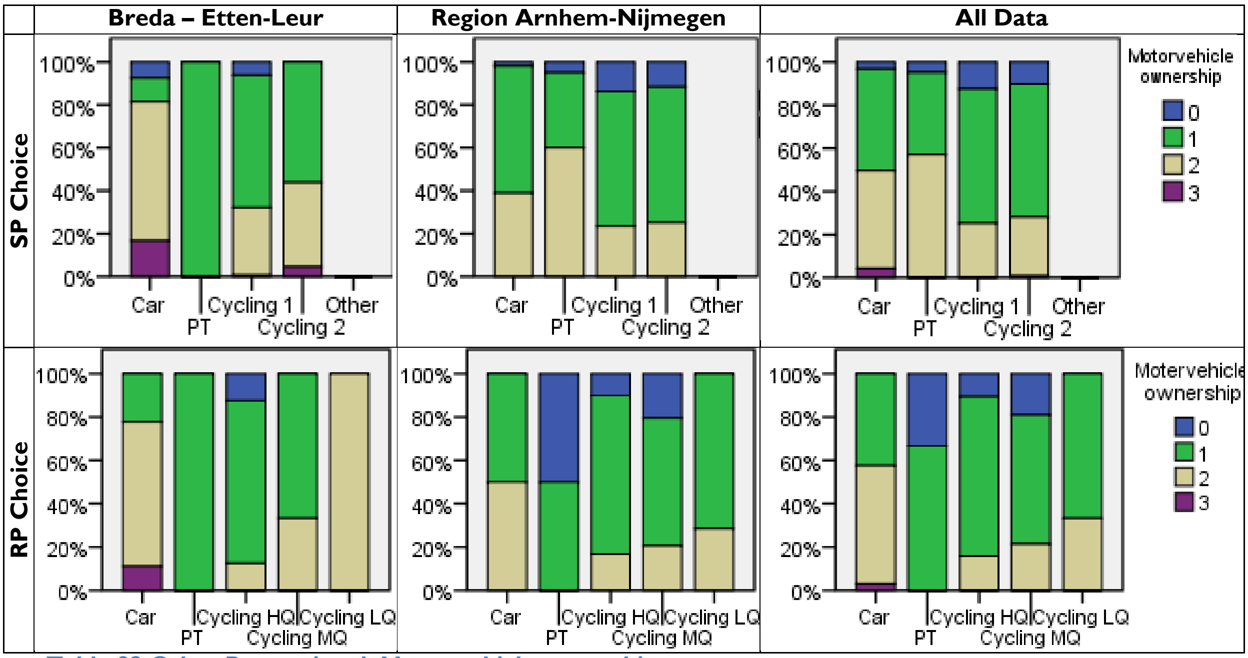


Table 82 Other Recreational: Motor vehicle ownership

Attitudes

Commute

Significant differences are found between both samples regarding the distribution of the third factor (p-value 0.02). Table 83 presents the average factor scores in box-plots per SP choice and RP choice. The following assumptions are derived from this table, which will be used as input for the model analysis:

- The enjoyability of cycling is associated with a higher propensity to cycle;
- Considering public transport is associated with a slightly higher propensity to travel by car or public transport. This factor possibly indicates if the respondent have mode alternatives available which in real life may be too unattractive, but are worth considering in the choice experiment;
- Travel time is associated with a higher propensity to cycle. Note that the attitudes for the Arnhem – Nijmegen sample are significantly higher than the Breda – Etten-Leur sample;
- Destination facilities is associated with a higher propensity to prefer comfort above speed in cycling;
- Weather is associated with a higher propensity to travel by car or public transport. Possibly because these respondents are able to choose not to cycle when the weather is bad.

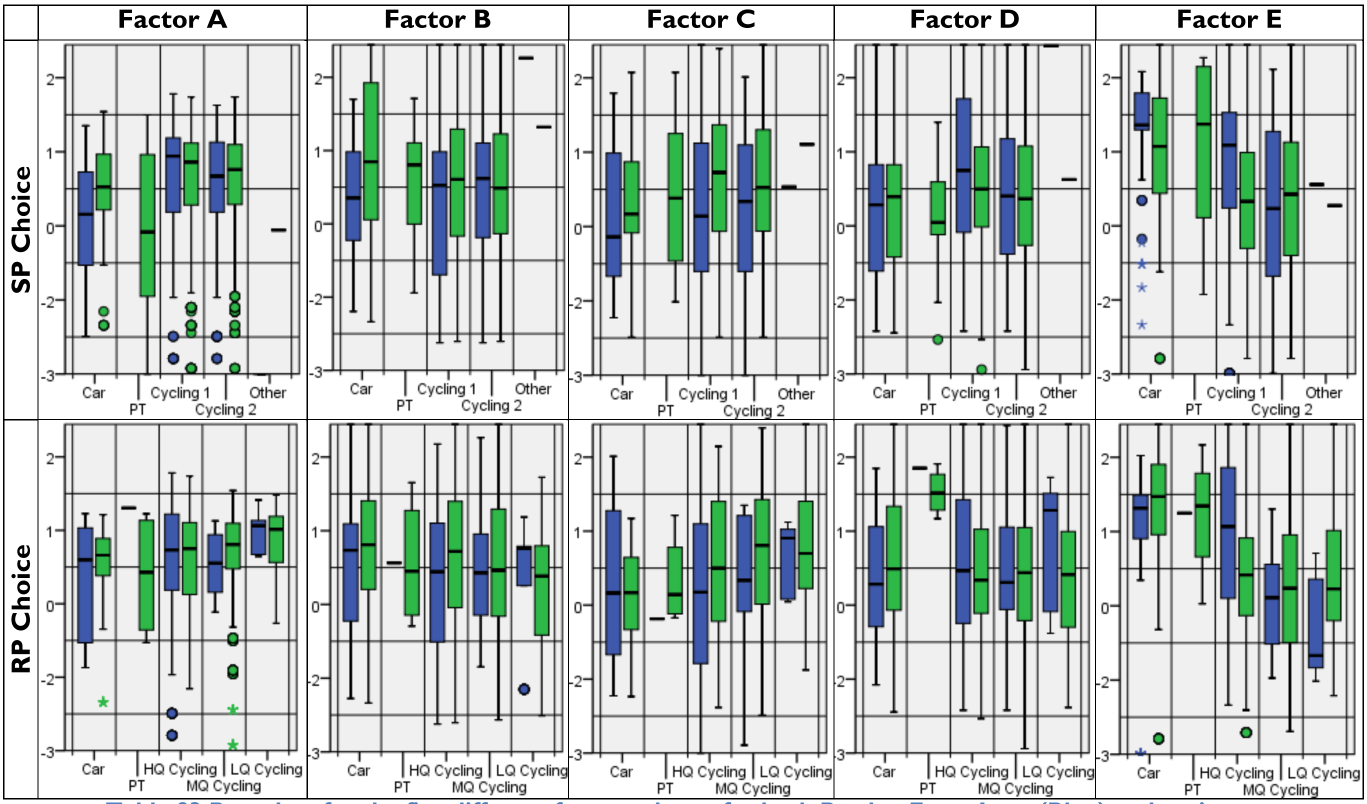


Table 83 Box-plots for the five different factors, shown for both Breda - Etten-Leur (Blue) and region Arnhem - Nijmegen (Green)

Educational

Table 84 presents the average factor scores in box-plots per SP choice and RP choice. The following assumptions are derived from this table, which will be used as input for the model analysis:

- The enjoyability of cycling is associated with a higher propensity to cycle;
- Respondents who consider all modes have a higher propensity to travel by car. This would mean that those respondents who consider the other modes also have the possibility not to cycle and therefore sometimes choose not to cycle;
- Respondents who consider the cycling travel times have a higher propensity to cycle;
- Respondents who consider the availability of secured parking at his destination have a higher probability to travel by car. A possible explanation is that the respondents who state to travel by car possess a more expensive bicycle. The risk of bicycle theft might be a consideration for not to travel by bicycle.

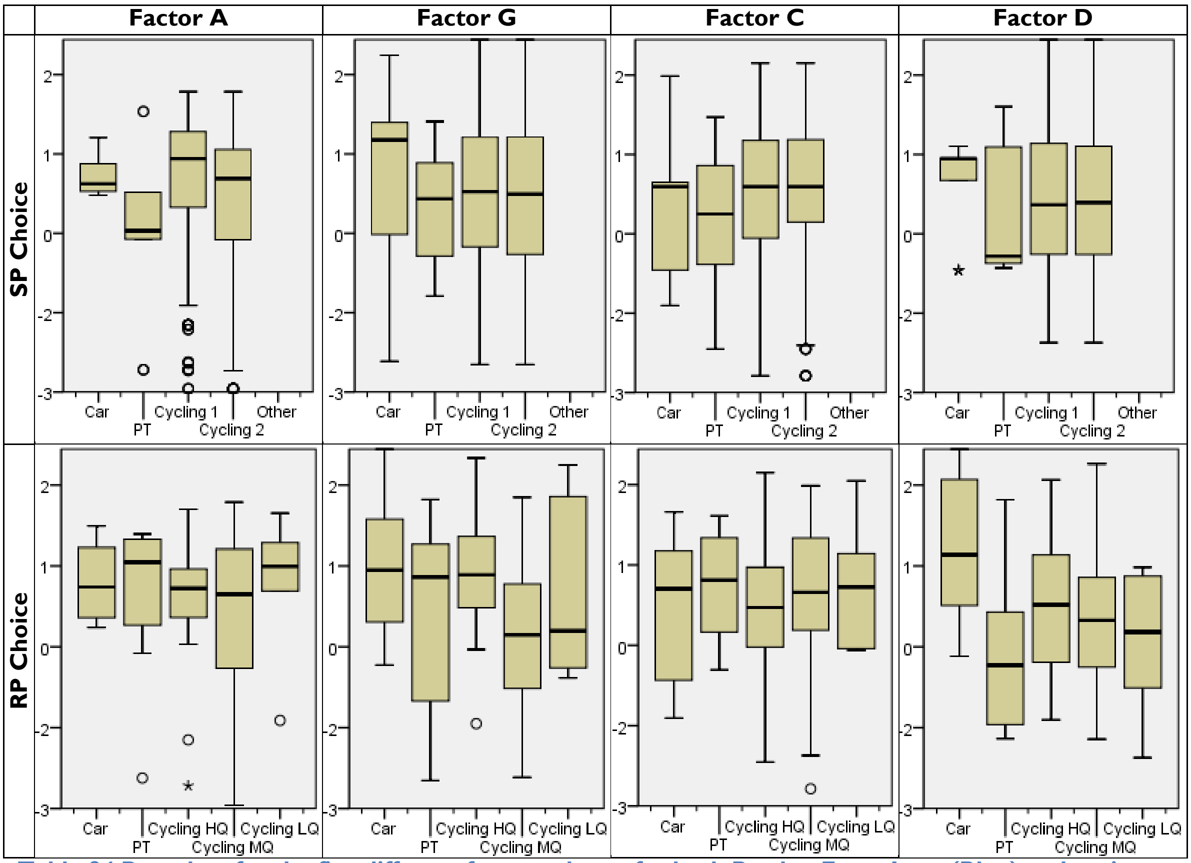


Table 84 Box-plots for the five different factors, shown for both Breda - Etten-Leur (Blue) and region Arnhem - Nijmegen (Green)

Other Recreational

Table 85 presents the average factor scores in box-plots per SP choice and RP choice. No significant differences are found between both sub-samples regarding the distribution of the five factors. The following assumptions are derived from this table, which will be used as input for the model analysis:

- The enjoyability of cycling is associated with a higher propensity travel per bicycle on the comfortable and slow route
- Considering the car is associated with a higher propensity to travel by car;
- Considering the shower facilities at the destination and the occupation of the public transport result in a slightly higher propensity to travel by car and public transport;
- Travel time is associated with a higher propensity to travel per bicycle on the uncomfortable and fast route;
- Considering destination facilities is associated with a lower propensity for car travel.

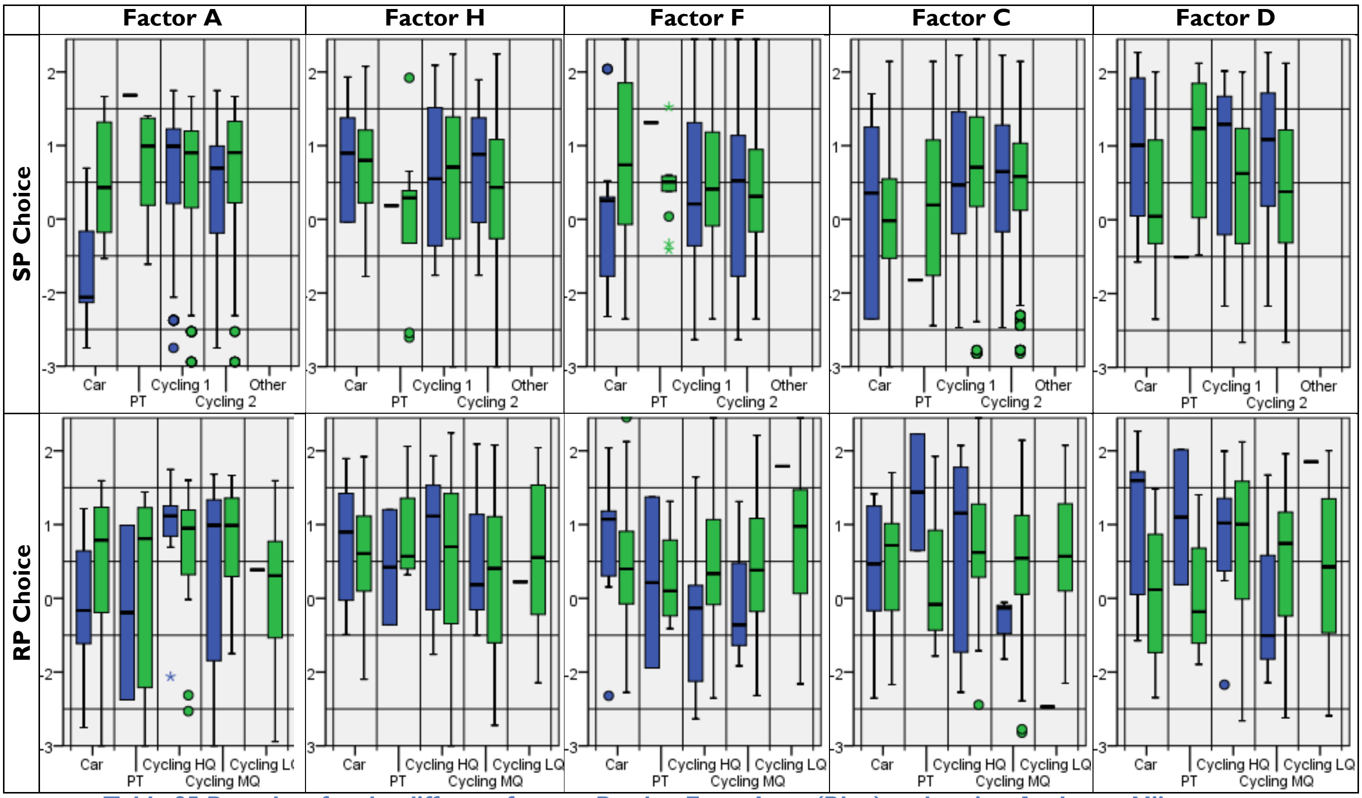


Table 85 Box-plots for the different factors, Breda - Etten-Leur (Blue) and region Arnhem - Nijmegen (Green).

Appendix D: Additional model explorations

Comparison of model specification set-ups

Parameter	Trip Purpose Model Type Weighting Sample Affected Utility	Commute MNL Basic Dutch cycling Population All locations value	t-test	Commute MNL Basic Dutch cycling Population All locations value	t-test	Commute MNL Basic Dutch cycling Population All locations value	t-test
ASC Cycling 1	Cycling 1	6,61	12,8	7,45	7,79	8,47	11,13
ASC Cycling 2	Cycling 2	6,32	12,44	7,11	7,38	7,57	9,89
ASC Car	Car	4,73	7,5	5,57	5,42	6,19	7,66
ASC Other	Other	0		0		0	
ASC PT	PT	5,02	6,9	5,93	6,4	6,72	8,32
βCost Car	Car	0,431	1,58	-0,106	-0,26	-0,441	-2,38
βCost PT	PT	-0,552	-1,76	-0,838	-2,47	-1,11	-3,85
βCostdif. PT-C1	Cycling 1	0,532	3,27	0,603	3,71		
βCostdif. PT-C2	Cycling 2	0,128	0,79	0,134	0,84		
βCostdif. Car-C1	Cycling 1			-0,673	-1,66	-0,412	-2,41
βCostdif. Car-C2	Cycling 2			-0,504	-1,24	-0,481	-2,71
βTime Car	Car	-0,0646	-5,93	-0,0644	-5,91	-0,0564	-5,32
βTime HQ Cycling	Cycling 1	-0,053	-9,18	-0,0527	-9,01	-0,0453	-7,71
βTime MQ Cycling	Cycling 1	-0,0663	-10,44	-0,0654	-10,22	-0,0528	-8,21
βTime MQ Cycling	Cycling 2	0,000557	0,07	0,000311	0,04	-0,00564	-0,73
βTime LQ Cycling	Cycling 2	-0,0398	-6,65	-0,0392	-6,49	-0,0406	-6,76
βTime PT	PT	-0,0461	-2,8	-0,0529	-3,34	-0,0506	-3,16
Number of observations		4455		4455		4455	
Number of respondents		4455		4455		4455	
Log-Likelihood		-4046		-4030		-4149	
Likelihood ratio test		6776		6809		6570	
Rho-square		0,456		0,458		0,442	
Adjusted rho-square		0,454		0,456		0,44	

Table 86 Comparison of model specification set-ups

Assessing the influence of the random component

The inclusions of the random components for the three attributes indicate that all means (betas) are significant higher than zero with differing deviations (sigma). Therefore, the positive influence of the attitudes on specific modes of transport applies to most commuters. More specifically, it is found that:

- Most respondents with a positive attitude towards the enjoyability of cycling have a relative higher probability to travel per bicycle (Applies to 50% - 84% of the cyclists).
- Just more than half of the respondents who consider the cycling destination facilities have a relative higher probability to travel on the comfortable and slow cycle route bicycle (Applies to 50% - 84% of the cyclists).
- Most respondents who take into account the weather conditions in their mode choice have a relative higher probability to travel by car (Applies to approximately 84% of the cyclists).

	Trip Purpose	Commute		Commute		Commute	
	Model Type	ML Extended		ML Extended		ML Extended	
	Weighting	Dutch cycling Population		Dutch cycling Population		Dutch cycling Population	
	Draws	125		125		125	
Parameter	Affected Utility	value	value	value	value	value	value
ASC Cycling 1	Cycling 1	7,98	10,77	10,3	12,7	8,63	11,26
ASC Cycling 2	Cycling 2	7,03	9,46	7,98	10,12	7,68	10
ASC Car	Car	5,26	6,93	5,84	7,42	5,67	6,8
ASC Other	Other	0		0		0	
ASC PT	PT	3,15	2,24	3,74	2,84	1,59	1,08
βCost Car	Car	0,122	0,55	-0,038	-0,14	0,102	0,46
βCost PT	PT	-0,34	-1,71	-0,394	-1,27	-0,0793	-0,23
βCostdif. PT-C1	Cycling 1	0,288	2,18	0,187	1,13	0,284	2,13
βCostdif. PT-C2	Cycling 2	0,246	1,81	0,109	0,66	0,242	1,74
βTime Car	Car	-0,112	-5,29	-0,109	-4,53	-0,116	-4,59
βTime HQ Cycling	Cycling 1	-0,044	-7,8	-0,0833	-13,31	-0,0443	-7,79
βTime MQ Cycling	Cycling 1	-0,0576	-9,03	-0,102	-14,18	-0,0579	-9
βTime LQ Cycling	Cycling 2	-0,0284	-12,43	-0,035	-10,83	-0,0286	-12,31
βTime PT	PT	-0,125	-4,68	-0,109	-3,45	-0,0975	-4,08
δAge>50	Cycling 1	0,474	3,08	0,384	1,51	0,489	3,17
βAtt A (Enjoyability of cycling)	Cycling 1 & 2	0,464	2,88	0,824	3,56	0,87	4,87
σAtt A		0,543	5,45				
βAtt D (Cycling dest. facilities)	Cycling 1	0,264	3,39	0,411	2,75	0,259	3,33
σAtt D				-3,23	-6,95		
βAtt E (The Weather)	Car	1,06	4,95	1	6,25	1,21	7,8
σAtt E						-1,21	-5,97
ε Car	Car	2,42	9,2	1,64	5,3	1,93	9,13
ε PT	PT	3,01	5,52	2,6	6,11	-4,76	-8,93
ε Cycling	Cycling 1 & 2	0,686	3,32	-2,24	-7,52	-1,55	-7,1
Number of observations		4455		4455		4455	
Number of respondents		297		297		297	
Log-Likelihood		-3.456		-3.054		-3.460	
Likelihood ratio test		7.066		7.871		7.059	
Rho-square		0,505		0,563		0,505	
Adjusted rho-square		0,502		0,56		0,502	
VoT Cycling HQ	Cycling 1	€ -9,17 p/h		n.a.		€ -9,36 p/h	
VoT Cycling MQ	Cycling 1	€ -12,00 p/h		n.a.		€ -12,23 p/h	

Table 87 Inclusion of random attitude components to final model

Comparison of the number of draws in mixed logit

Table 88 shows the ML model estimation results for the commuting sample, estimated with 125 and 250 draws. The results indicate, where only significant coefficients are found, that the coefficients are almost equal (time and SE coefficients). Where insignificant coefficients are found (ASC and cost coefficients), the absolute values of the parameters changed, while the differences between the significant coefficients remained almost unchanged. Furthermore, the rho-square and log-likelihood are not further improved when the number of draws are higher than 125.

In this case, the 125 draws is preferred since the rho-square and log-likelihood do not improve any further, the significant coefficients show comparable results and estimation times are much shorter.

	Trip Purpose	Commute		Commute	
	Model Type	ML Extended		ML Extended	
	Weighting	Dutch cycling Population		Dutch cycling Population	
	Draws	125		250	
Parameter	Affected Utility	value	value	value	t-test
ASC Cycling 1	Cycling 1	8,85	11,63	5.94	16.36
ASC Cycling 2	Cycling 2	7,88	10,34	5.01	14.17
ASC Car	Car	5,7	7,66	2.97	5.43
ASC Other	Other	0		0	
ASC PT	PT	3,05	2,42	-1.88	-0.84
βCost Car	Car	0,0103	0,05	0.547	2.44
βCost PT	PT	-0,213	-0,79	0.197	0.76
βCostdif. PT-C1	Cycling 1	0,248	2,03	0.601	4.11
βCostdif. PT-C2	Cycling 2	0,203	1,62	0.561	3.74
βTime Car	Car	-0,101	-5,77	-0.101	-4.7
βTime HQ Cycling	Cycling 1	-0,0405	-7,86	-0.0433	-7.76
βTime MQ Cycling	Cycling 1	-0,0555	-9,38	-0.0567	-8.98
βTime LQ Cycling	Cycling 2	-0,0239	-5,65	-0.0280	-12.52
βTime PT	PT	-0,113	-4,13	-0.116	-2.52
δAge>50	Cycling 1	0,480	3,13	0.486	3.15
βAtt A (Enjoyability of cycling)	Cycling 1 & 2	0,648	5,53	0.623	6.32
βAtt D (Cycling dest. facilities)	Cycling 1	0,262	3,38	0.260	3.35
βAtt E (The Weather)	Car	1,11	8,62	1.09	4.58
ε Car	Car	1,8	11,29	-2.21	-5.93
ε PT	PT	2,94	8,64	-4.9	-3.02
ε Cycling	Cycling 1 & 2	-2,15	-8,49	1.30	4.90
Number of observations		4455		4455	
Number of respondents		297		297	
Log-Likelihood		-3.451		-3.467	
Likelihood ratio test		7.076		7.045	
Rho-square		0,506		0.504	
Adjusted rho-square		0,503		0.501	

Table 88 Comparison of the number of draws in mixed logit

Comparison of the weighed and unweighted ML model estimation

Table 89 shows the ML model estimation results for the commuting sample, estimated with and without weights. The results show almost equal rho-squares and log-likelihoods. Furthermore, the weight factors lowers the VoT and increases the VoC.

According to the weight factors from paragraph 5.4, respondents with a HBO/WO education, age above 35 and owning a car are overrepresented in the sample. The largest overrepresentation is found among the HBO/WO educated cyclists. 61% of the sample has a HBO or WO education, while this is only 38% of the Dutch cycling population. The higher educational level is associated with a higher income. A higher income results in a lower marginal utility of money, which causes the VoT to be higher without weighting.

	Trip Purpose	Commute		Commute	
	Model Type	ML Extended		ML Extended	
	Weighting	Dutch cycling Population		No weighting	
	Draws	125		125	
Parameter	Affected Utility	value	value	value	t-test
ASC Cycling 1	Cycling 1	8,85	11,63	8.89	11.54
ASC Cycling 2	Cycling 2	7,88	10,34	7.94	10.30
ASC Car	Car	5,7	7,66	5.67	7.62
ASC Other	Other	0		0	
ASC PT	PT	3,05	2,42	3.13	2.53
βCost Car	Car	0,0103	0,05	0.0350	0.17
βCost PT	PT	-0,213	-0,79	-0.220	-0.82
βCostdif. PT-C1	Cycling 1	0,248	2,03	0.245	2.00
βCostdif. PT-C2	Cycling 2	0,203	1,62	0.202	1.60
βTime Car	Car	-0,101	-5,77	-0.103	-5.76
βTime HQ Cycling	Cycling 1	-0,0405	-7,86	-0.0441	-7.84
βTime MQ Cycling	Cycling 1	-0,0555	-9,38	-0.0577	-9.06
βTime LQ Cycling	Cycling 2	-0,0239	-5,65	-0.0286	-12.55
βTime PT	PT	-0,113	-4,13	-0.113	-4.09
δAge>50	Cycling 1	0,480	3,13	0.477	3.10
βAtt A (Enjoyability of cycling)	Cycling 1 & 2	0,648	5,53	0.631	5.44
βAtt D (Cycling dest. facilities)	Cycling 1	0,262	3,38	0.260	3.37
βAtt E (The Weather)	Car	1,11	8,62	1.10	8.62
ε Car	Car	1,8	11,29	1.77	11.60
ε PT	PT	2,94	8,64	2.90	8.79
ε Cycling	Cycling 1 & 2	-2,15	-8,49	-2.08	-8.77
Number of observations		4455		4455	
Number of respondents		297		297	
Log-Likelihood		-3.451		-3.452	
Likelihood ratio test		7.076		7.073	
Rho-square		0,506		0.506	
Adjusted rho-square		0,503		0.503	
VoT Cycling HQ	Cycling 1	€ -9,80 p/h		€ -10.80 p/h	
VoT Cycling MQ	Cycling 1	€ -13.43 p/h		€ -14.13 p/h	
VoC Cycling MQ - > HQ		€ 3.63 p/h		€ 3.33 p/h	

Table 89 Comparison of the weighed and unweighted ML model estimation

Appendix E: A note on...

Cyclists' Value of Time for alternative modes of transportation

Significance et al. (2013) made the last value of time estimation for car and public transport travel. How does the cyclists' value of time for car and public transport differ from the other values of time in the Netherlands? Important to understand is that three different aspects affect the VoT: resource value of time, direct utility of travel and the marginal utility of costs. The resource value of time and marginal utility of costs are bound to the individual, the direct utility of travel is bound to the mode alternative. The direct utility of travel is affected by factors such as the comfort of the mode and the productivity or enjoyability of the trip.

A recent example that relates to the direct utility of travel is the rise of the mobile telephones over the last decade. The mobile telephone increased the productivity of in-car travel time. The higher productivity increases the direct utility of travel and therefore decreases the value of time. In the latest car value of time actualization, the VoT had to be revised downwards to account for this effect (KiM, 2013).

Another issue to take into account is the self-selection among travelers. Börjesson and Eliasson (2012) argue that travelers with high resource value of time and low marginal utility of money tend to choose faster and more expensive modes. They expect that self-selection causes the average value of time to be higher on faster and more expensive modes. For trips where the bicycle is slower than other modes, one may expect that cyclists have a lower average resource value of time than people choosing other modes. If this is the case, the value of time a cyclist would have on an alternative mode is lower than the value of time of the travelers actually choosing the alternative mode. On top of that, actual cyclists may have a higher direct utility of cycling time than travelers choosing other modes, which would add to the difference in value of time between travelers on different modes induced by self-selection due to different resource values of time.

This study collected all data from existing cyclists. Following the findings and hypothesis in literature, it is expected that the VoT for car and public transport in this study is lower than the VoT for car and public transport estimated by Significance et al. (2013). Due to insignificant car and PT cost parameters, it is not possible to estimate the VoT for car and public transport. The only exception is the car VoT for other recreational travel weighted for the Arnhem – Nijmegen region. The car VoT in this situation is estimated at €4,64 per hour, which is lower than the €7,50 per hour estimated by Significance et al. (2013) for other recreational car travel. This single finding coincides with the hypothesis from Börjesson and Eliasson (2012), but further research is required to fully analyze the cyclists' value of time for car and public transport travel.

Appendix F: Market Shares

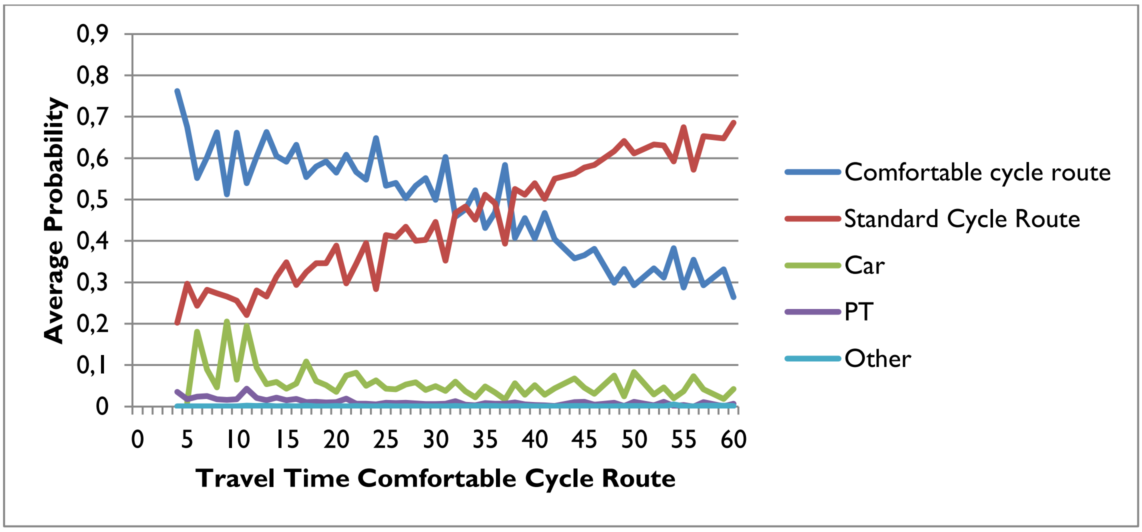


Figure 11 Situation 1 Commute: Market shares and comfortable cycle route travel time

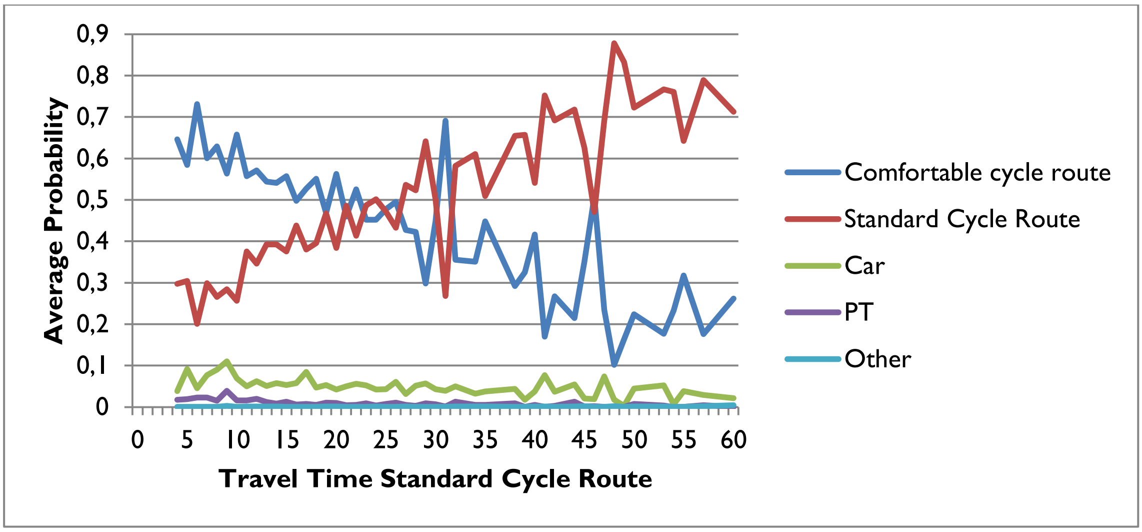


Figure 12 Situation 1 Commute: Market shares and standard cycle route travel time

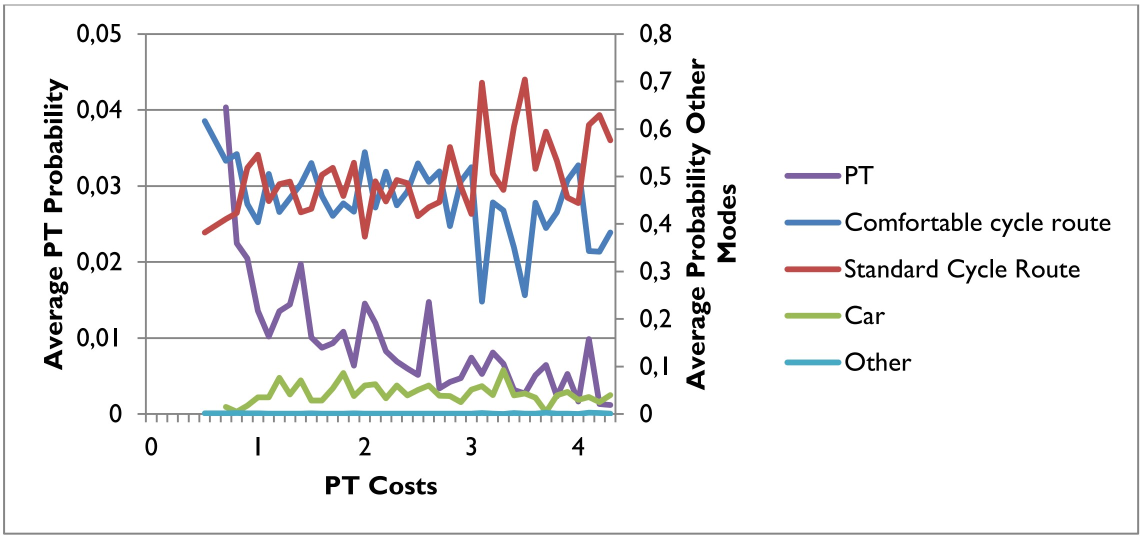


Figure 13 Situation 1 Commute: Market shares and PT costs

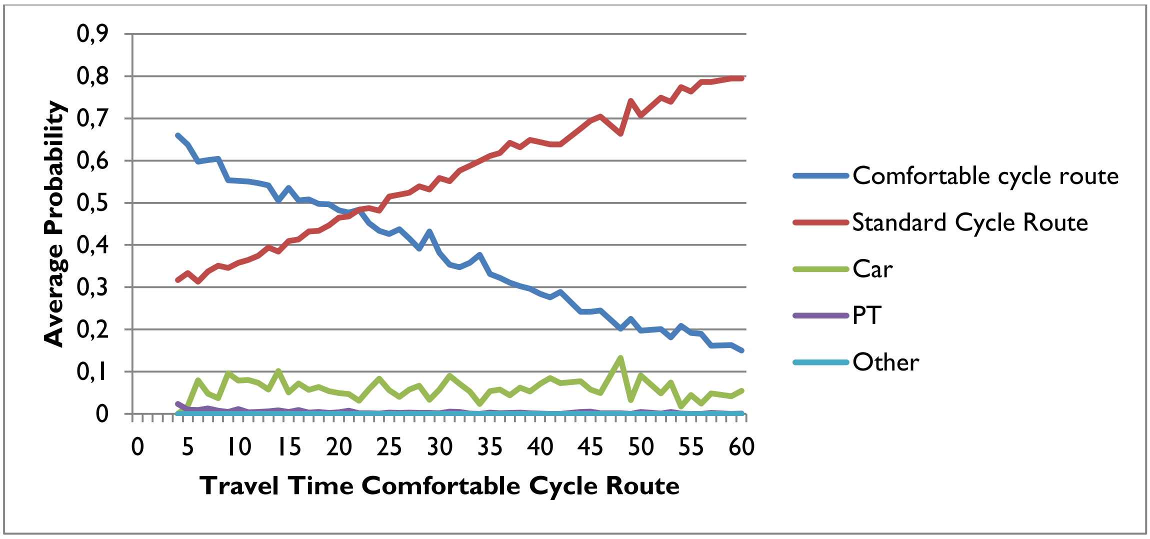


Figure 14 Situation 1 Other Recreational: Market shares and comfortable cycle route travel time

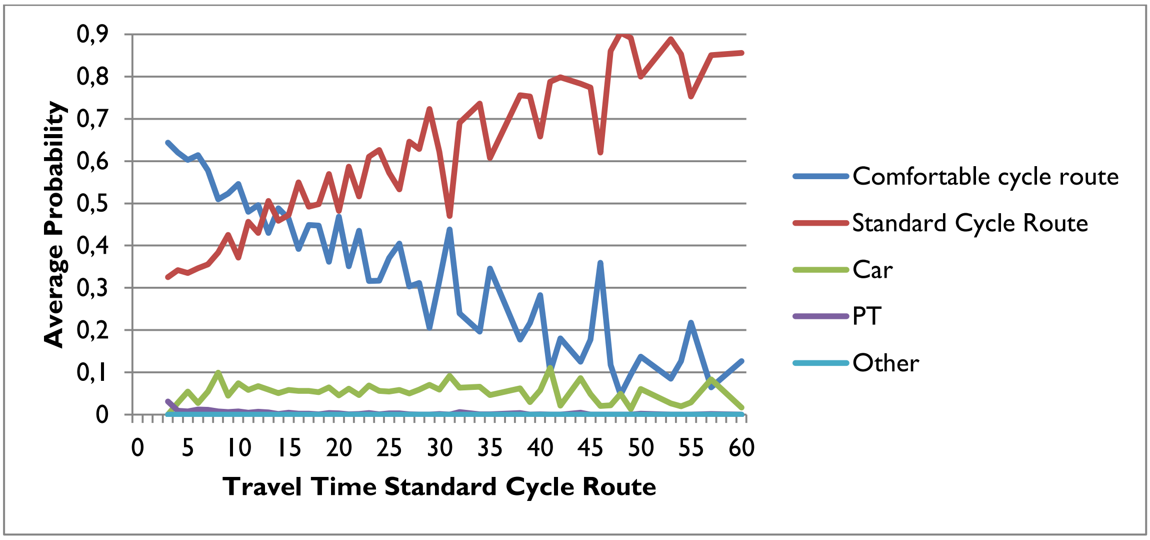


Figure 15 Situation 1 Other Recreational: Market shares and standard cycle route travel time

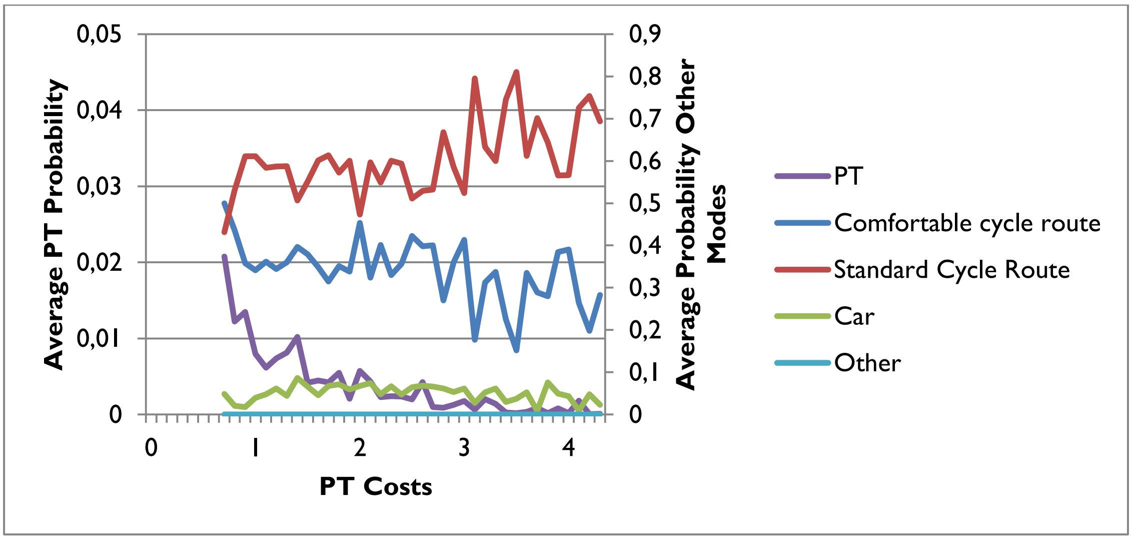


Figure 16 Situation 1 Other Recreational: Market shares and PT costs

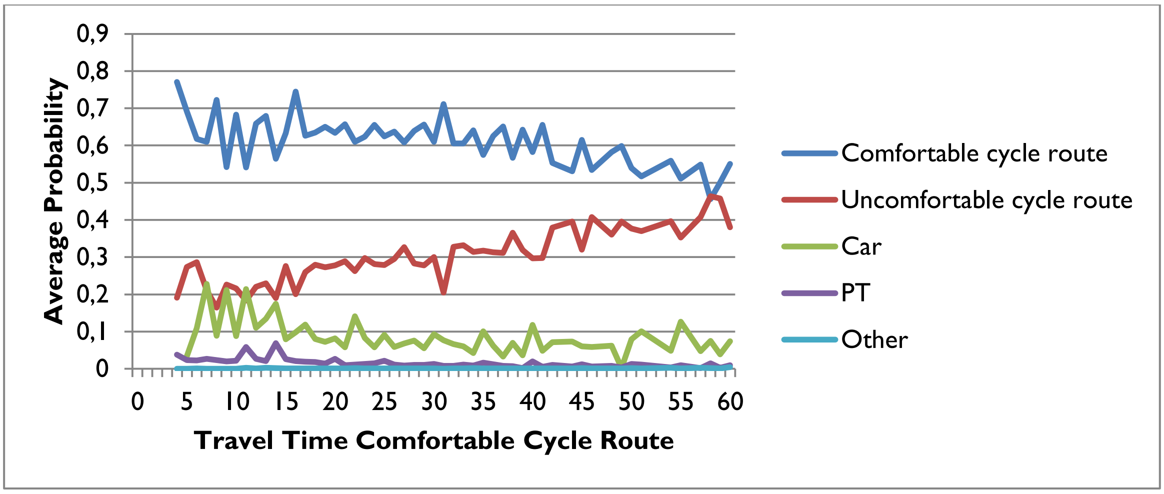


Figure 17 Situation 2 Commute: Market shares and comfortable cycle route travel time

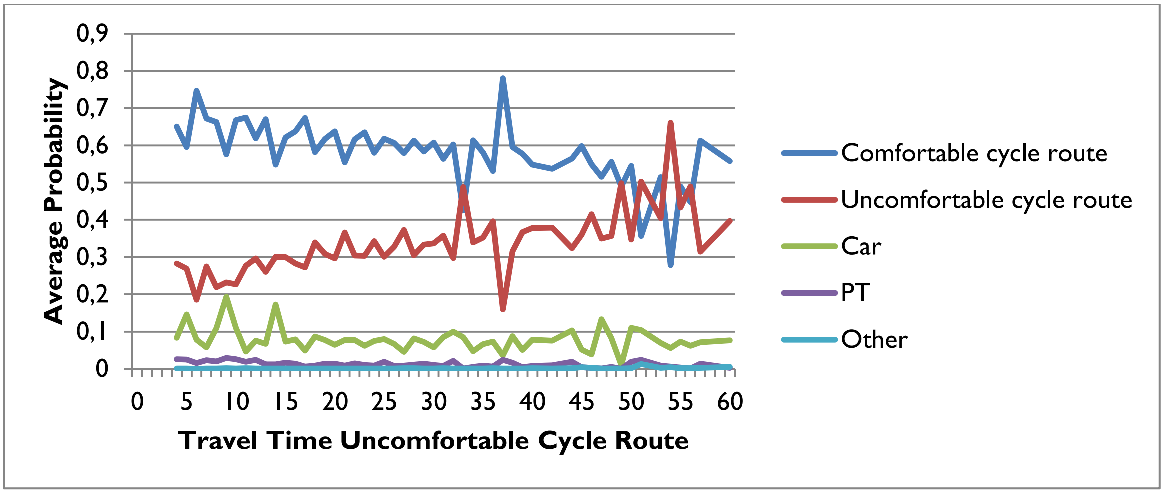


Figure 18 Situation 2 Commute: Market shares and uncomfortable cycle route travel time

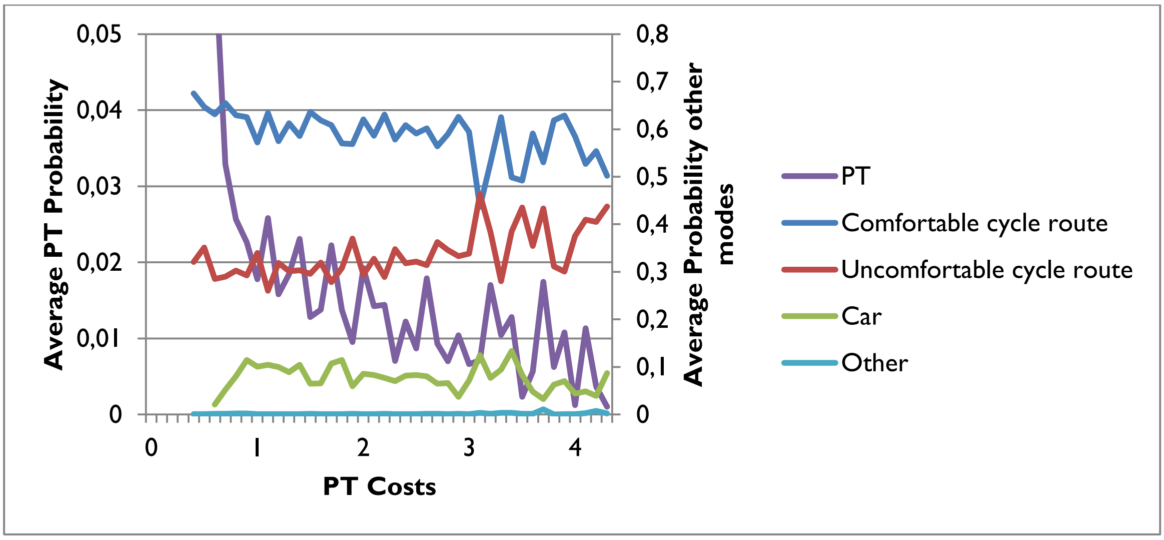


Figure 19 Situation 2 Commute: Market shares and PT costs

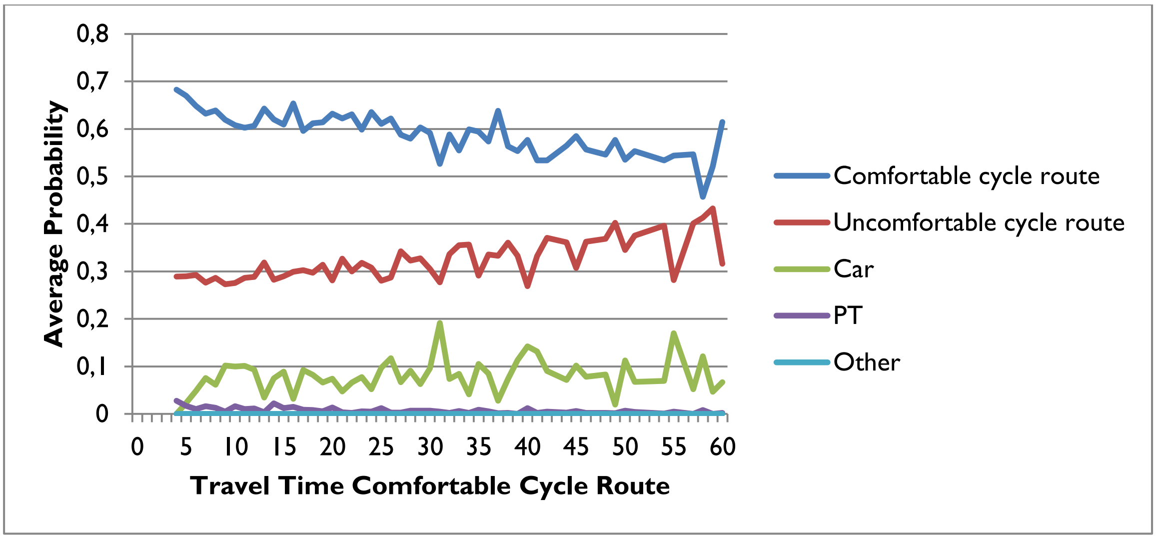


Figure 20 Situation 2 Other Recreational: Market shares and comfortable cycle route travel time

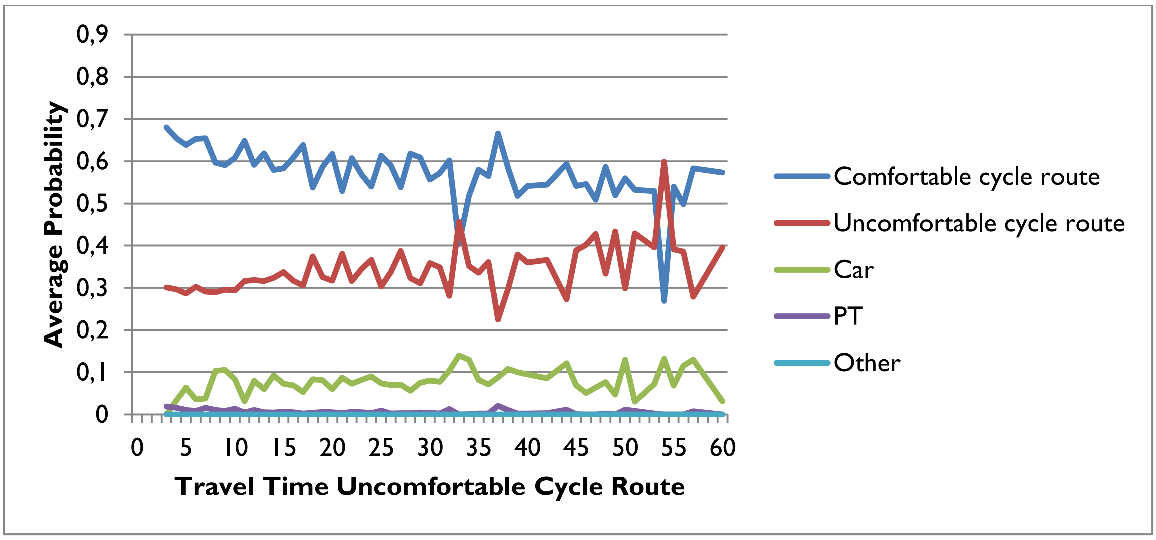


Figure 21 Situation 2 Other Recreational: Market shares and uncomfortable cycle route travel time

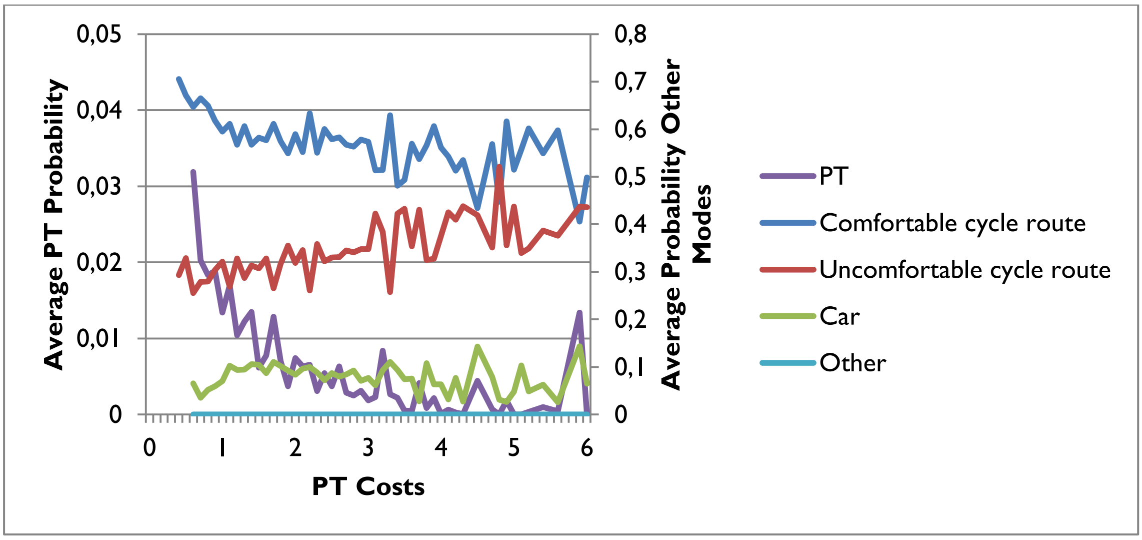


Figure 22 Situation 2 Other Recreational: Market shares and PT costs

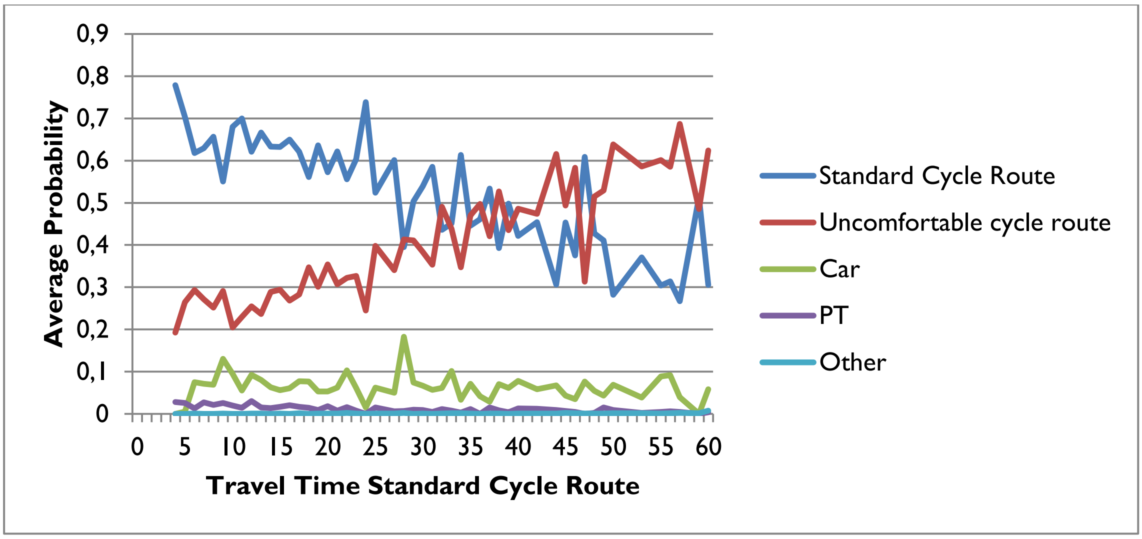


Figure 23 Situation 3 Commute: Market shares and standard cycle route travel time

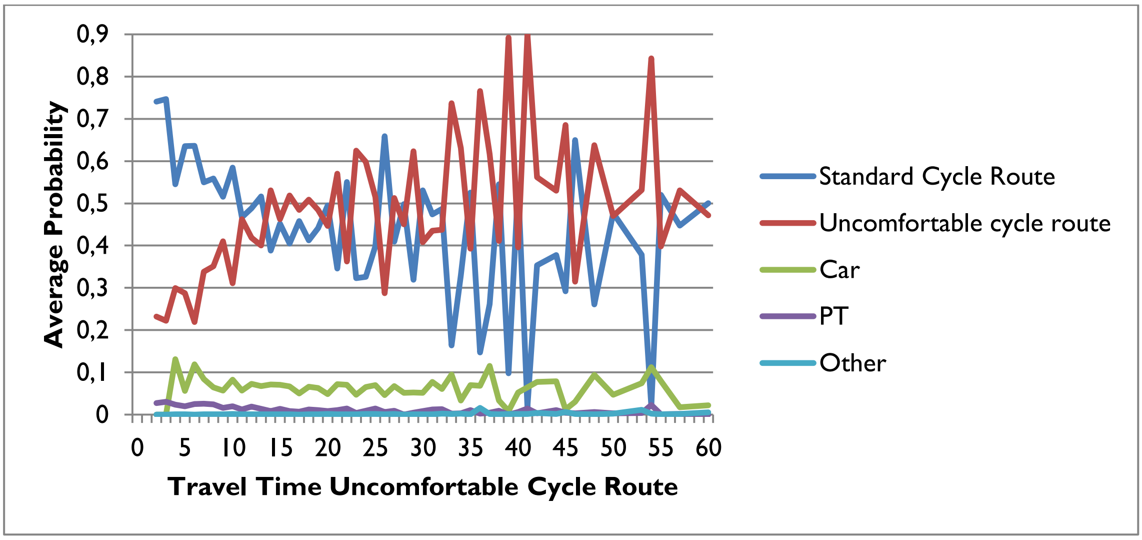


Figure 24 Situation 3 Commute: Market shares and uncomfortable cycle route travel time

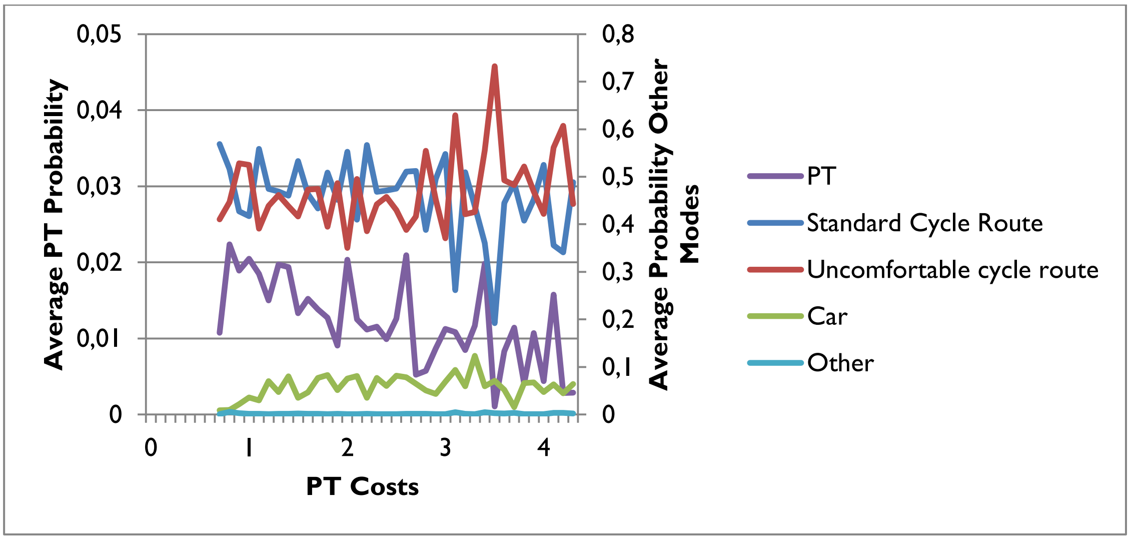


Figure 25 Situation 3 Commute: Market shares and PT costs

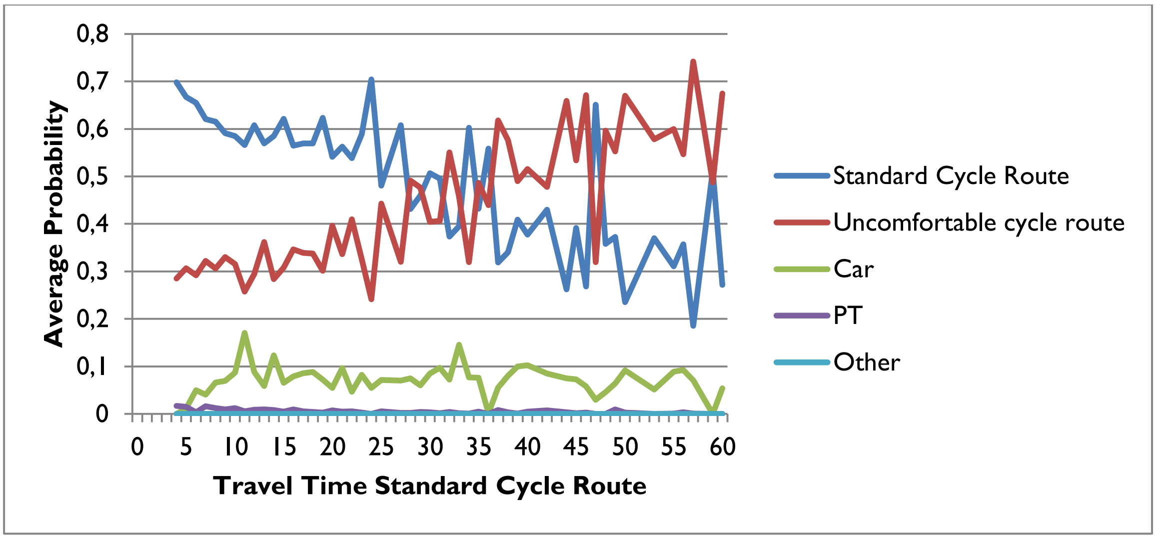


Figure 26 Situation 3 Other Recreational: Market shares and standard cycle route travel time

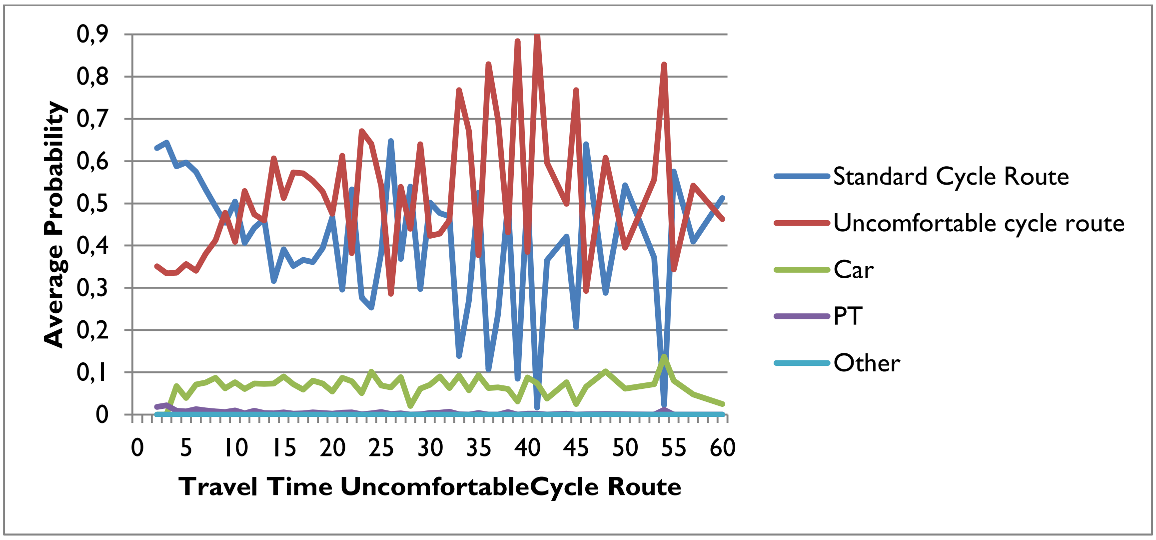


Figure 27 Situation 3 Other Recreational: Market shares and uncomfortable cycle route travel time

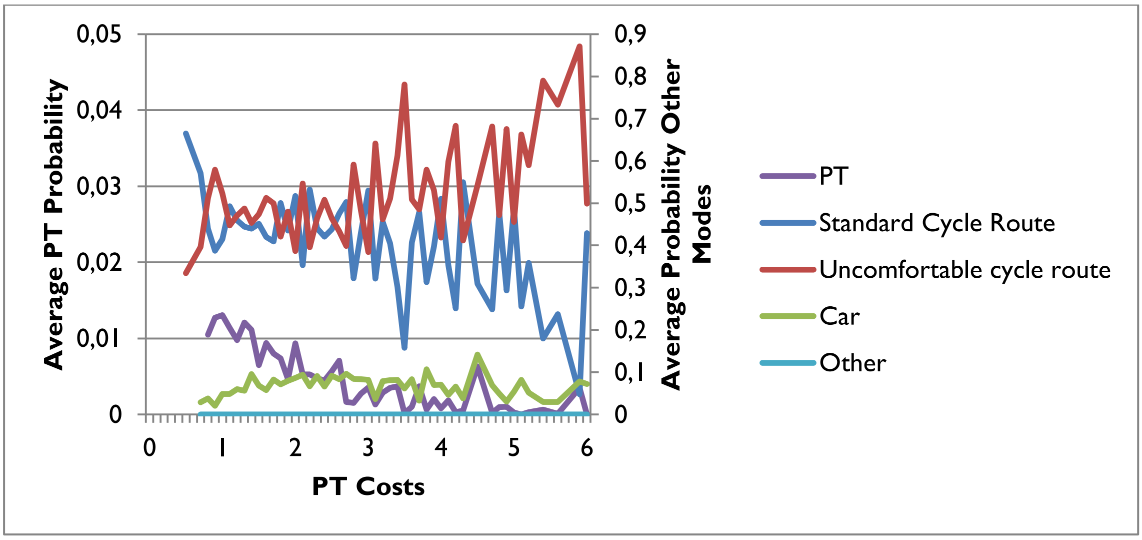


Figure 28 Situation 3 Other Recreational: Market shares and PT costs