SUSTAINABLE
URBAN AREAS
43

Bicycle commuting

Eva Heinen

TU Delft

Delft Centre for Sustainable Urban Areas

Delft University of Technology

Bicycle commuting

PROEFSCHRIFT

ter verkrijging van de graad van doctor
aan de Technische Universiteit Delft,
op gezag van de Rector Magnificus prof. ir. K.Ch.A.M. Luyben,
voorzitter van het College voor Promoties,
in het openbaar te verdedigen op woensdag 15 juni 2011 om 15.00 uur

door

Eva HEINEN

doctorandus in de Planologie
geboren te Voorburg.

Dit proefschrift is goedgekeurd door de promotor:
Prof. dr. G.P. van Wee

Copromotor: dr. C. Maat

Samenstelling promotiecommissie:
Rector Magnificus, voorzitter
Prof. dr. G.P. van Wee, Technische Universiteit Delft, promotor
Dr. C. Maat, Technische Universiteit Delft, copromotor
Prof. ir. L.H. Immers, Technische Universiteit Delft
Prof. dr. E.M. Steg, Rijksuniversiteit Groningen
Prof. dr. ir. L. Bertolini, Universiteit van Amsterdam
Prof. dr. P. Rietveld, Vrije Universiteit Amsterdam
Dr. I.J.M. Hendriksen, TNO
Prof. dr. ir. H. Priemus, Technische Universiteit Delft, reservelid

Bicycle commuting

Eva Heinen

The series **Sustainable Urban Areas**
is published by IOS Press under the imprint Delft University Press

IOS Press BV
Nieuwe Hemweg 6b
1013 BG Amsterdam
The Netherlands
Fax +31 20 6870019
E-mail: info@iospress.nl

Sustainable Urban Areas is edited by
Delft Centre for Sustainable Urban Areas
C/o OTB Research Institute for the Built Environment
Delft University of Technology
Jaffalaan 9
2628 BX Delft
The Netherlands
Phone +31 15 2783005
Fax +31 15 2784422
E-mail mailbox@otb.tudelft.nl
http://www.otb.tudelft.nl

Design and dtp: Cyril Strijdonk Ontwerpburo, Gaanderen
Printed in the Netherlands by Haveka, Alblasserdam

ISSN 1574-6410; 43 (print) ISBN 978-1-60750-771-0 (print)
ISSN 1879-8330; 43 (online) ISBN 978-1-60750-772-7 (online)
NUR 755

Contents

Preface

Doing a PhD on cycling was by no means a logical consequence of my own travel behavior or existing pro-cycling beliefs. For a Dutch person I was rather late learning the advantages of cycling. Growing up in Rotterdam, I experienced the advantages of public transport and the car from early childhood. I learned to cycle as a child but it was only at around the age of sixteen that I started to use the bicycle for everyday trips. I relied on public transport during the first part of my student life but moving to Delft resulted in a shift in my travel behavior. My bicycle use steadily increased over time and my trips abroad made me realize how dependent I had become on the 'Dutch' transportation mode. Be that as it may, I continue to rely on the car and public transport for many journeys.

Although my behavior did not change so much the last four years, doing a PhD on bicycle commuting made me frequently question my mode choice and I became more aware of my own travel behavior. My PhD journey showed me the advantages of cycling and I hope that the outcomes of this research can and will be used to encourage more cycling.

Of the people who supported me during the writing of this thesis, I would particularly like to thank both of my supervisors: Bert van Wee and Kees Maat. They provided me with advice and feedback on my work during the last four years. I am also grateful to my colleagues, Wendy Bohte, Evert Meijers and Jan Jacob Trip, for discussions on my work and for providing feedback on draft chapters of my thesis. For statistical and graphical advice, I would like to thank Sylvia Jansen, Itziar Lasa Epelde and Eric Molin. I would also like to thank all my other colleagues who spent time discussing my work.

My research stay at University of California in Davis was both personally and professionally rewarding for my PhD research. I wish to thank everyone who made this visit possible: my employer, OTB Research Institute for the Built Environment, the Van Eesteren-Fluck & Van Lohuizen Foundation, and especially Susan Handy from the University of California Davis for her hospitality, discussions and opportunities offered to me during my stay. My visit to Davis resulted in a journal paper, which is part of this thesis, as well as contributions to Dutch journals.

Also indispensable are the many respondents of my surveys and the interviewees I questioned. I am extremely grateful for all their time and the information. I would also like to thank the employers and the municipalities of Delft, Zwolle, Midden-Delfland and Pijnacker-Nootdorp for providing me with access to some of their data to be able to identify possible survey respondents.

I could not have finished this thesis without social support and distractions. First, my colleagues who created a pleasant working environment, including my current and former colleagues in the section of Urban and Regional Development (SRO) as well as colleagues from other parts of the institute, espe-

cially Nam Seok, Merve, Hugo, Janneke, Evelien and Christian. I would also like to thank my friends Wouter, Machteld, Peter Jan, Bart, Jolanda, Sabine and Raquel for their moral support and their time and patience to discuss my work. I also wish to express my gratitude of all other friends, family and acquaintances for their friendship, pleasant times, sporting challenges and all the things that life is really about.

Eva Heinen
Delft, 2011

1 Introduction

This thesis focuses on bicycle commuting. Despite the increased policy attention on cycling to work and given that many individuals live at cycling distance from work, only 20% of Dutch commuters cycle to work. Moreover, not all these commuters cycle to work every working day: many alternate their commuting transportation modes. This thesis aims to explain the decision to cycle to work and the day-to-day variation of this commute decision. It is anticipated that different factors affect the decision of different commuters. The introduction first explores successively the background to commuting, bicycle use and cycling policies and numbers over the world. It then briefly reviews the current literature and identifies several knowledge gaps. Section 1.5 follows with a description of the research aim and research questions, after which the research methods and areas are discussed.

1.1 Background

1.1.1 Commuting

Commuting enables an individual to work at a location spatially separated from the residential location and offers the individual and country benefits in terms of economic propensity. This results in the possibility that individual living preferences can be met without being restricted by the spatial proximity of the working location. Commuting is in a way a substitute for migration. It provides individuals with the option to change jobs whilst remaining in the same residence, or the opposite, to remain in the current professional position and change residence.

Commuting is one of the main purposes of travelling. One fifth of all trips made in the Netherlands are commuting trips (Statline, based on 2007). An important characteristic of commuting is its concentration in time and place. Workers generally start working early in the morning and stop at the end of the afternoon/beginning of the evening. There is also spatial and temporal concentration of commuting within a country, region or city, and the resulting concentration of trips leads to various problems, including traffic-related problems such as congestion, and environmental problems such as peak levels of air pollution.

Recently, commuting has often been addressed both in policies and scientific research. There are three reasons for this focus. The first reason lies

in the fact that commuting covers a large amount of all trips made. Second, commuting is relatively easy to address in research since it is less spatially diffuse than other travel behavior, as the working locations are concentrated and for many individuals are identical every day. Finally, commuting negatively impacts society: (car) commuting pollutes, car and public transport commuting requires expensive infrastructure – which is often even more expensive as space is required in urban settings where it is scarce and expensive – and commuting results in negative transportation outcomes such as congestion, again especially in urban areas.

1.1.2 Bicycle use and commuting

Cycling presents a number of advantages over other modes of transport, given the pros and cons of commuting. Compared to car commuting, cycling is environmentally sustainable, it requires limited space, bicycle infrastructure is relatively inexpensive, it results in a limited noise production and improves public health (Olde Kalter, 2007). In addition, cycling offers individual benefits: Cycling is a cheap form of transportation, it improves the health of the individual, cycling can sometimes prove to be faster than other transport modes – especially in urban areas – and enables individuals to avoid traffic jams.

Nevertheless, even at short distances many individuals do not cycle. For distances up to 7.5 kilometer, 36% of all trips are still made by car, and 'only' 35% are made by bicycle (Ministry of Transport, Public Works and Water Management and Bicycle Council, 2009). The proportion of bicycle use decreases (to 15%) and proportion of car use increases for distances between 7.5 and 15 kilometers. This means that a larger amount of journeys could be made by bicycle. In other words: despite the fact that cycling is an option for many, a considerable amount of people choose to use other means of transportation. For commuting, the Dutch National Travel Survey 2007 (NTS) shows a similar proportion. So, even in the Netherlands, which has a bicycle-friendly infrastructure and where cycling has a positive image, many people choose not to cycle in situations where cycling could be a highly appropriate transport mode. In addition, not all cyclists commute on a daily basis, due to a variety of reasons, such as the weather.

1.2 Cycling in the Netherlands and around the world

1.2.1 Numbers on cycling

In the Netherlands the bicycle is primarily considered a daily transportation mode, rather than a sport or leisure vehicle. In other countries such as the

United States (US) those forms of bicycle use are more prevalent (Xing *et al.*, 2010).

The Netherlands has a much higher cycling rate than other countries. More than one quarter of all journeys are made by bicycle (Ministry of Transport, Public Works and Water Management and Bicycle Council, 2009). Other countries, such as Denmark (19%) and Germany (10%), follow at a significant distance. The Dutch not only cycle more, but also over longer distances. The mean Dutch daily cycling distance per person is 2.5 kilometer, compared to 1.6 kilometer in Denmark, 0.5 kilometer in the European Union (EU), and 0.1 kilometer in the US (Pucher and Buehler, 2008a).

Dedicated bicycle infrastructure prevails in Dutch streets, making the Netherlands a relatively safe country in which to cycle. With only 1.1 fatalities per 100 million kilometers cycled, the chance of getting killed in a bicycle accident is lower than in many other countries. In Denmark and Sweden, for example, the fatality rate is 1.5 per 100 million kilometers cycled, while the rate is 3.0 in UK and 5.8 in the US (Pucher and Buehler, 2008b).

Cycling seems to have an unassailable position in the Netherlands. This position is by no means evident, however, looking at historical trends. Bruhéze and Veraart (1999) investigated the bicycle share over time in several Western-European cities. In the first part of the last century cycling was more popular in this region. After the car became an option for many (between 1940 and 1970), a steep decline is visible. The cycling share stabilized in the 1970s, but in many Dutch cities (Amsterdam, Enschede, Eindhoven) the decline was smaller and a revival occurred. Foreign cities such as Antwerp and Manchester do not show this revival. Bruhéze and Veraart (1999) use three factors to explain the current popularity of the bicycle in most of the Dutch cities: the relatively positive image of the bicycle in the past, the high use of the moped, and the compact spatial structure of Dutch cities. In addition, they express their belief that the policies between 1970 and 1980 contributed to the high bicycle use in the 1990s, emphasizing that an increase in cycling rates can be obtained by policies.

1.2.2 Policies on cycling

Governments encourage bicycle use both nationally and internationally. Recently cycling has merited particular attention by policy makers internationally. One example is the bicycle loan or rental schemes that have emerged in the past ten years. Most known is the Vélib in Paris, France, but comparable constructions exist in Copenhagen, Washington D.C. and London. Other initiatives include the construction of dedicated bicycle infrastructure. In the US, 25 million dollar was awarded to four communities to construct a network of non-motorized transportation infrastructure (FHWA, 2005; SAFETEA-LU, SEC 1807). Another well-known example from the US is New York. In this city bi-

cycle infrastructure has been rapidly added, which has resulted in an increase in commuter cycling by 26% between 2008 and 2009. The number of cyclists has more than doubled since 2005 (New York City, http://home2.nyc.gov/html/dot/html/bicyclists/bikemain.shtml). In Denmark, money was allocated by law to bicycle infrastructure from 1982 to 2001 in every Danish municipality. Bicycle use is not only encouraged by the construction of infrastructure, but also by other options, including legislation. An example of this can be found in the UK, where a Finance Act from 1999 allowed employers to lend bicycle and safety equipment to their employers as a tax-free benefit.

Cycling is taken for granted in the Netherlands and has been an integral part of transportation planning for a long time. An important difference with other countries is the liability in case of an accident. In the Netherlands, the car driver is liable for at least 50% of the costs, independent of who is to blame, in the case of an accident between a cyclist (or pedestrian) and a motorized vehicle, such as a car (artikel 185 Road Traffic Act (Wegenverkeerswet)).

For commuting, policies in favor of the bicycle have been adopted in the past, such as the possibility for employees to buy a bicycle up to € 750 from your wages before taxation via your employer (Ministry of Finance, 2004; 2009). The current aim of the Dutch central government is to increase the total amount of bicycle kilometers and specifically to increase bicycle commuting for distances over 7.5 kilometers (Ministry of Transport, Public Works and Water Management, 2009).

1.3 Research into bicycle commuting

This section provides a short literature overview to be able to reveal the research gaps on bicycle commuting. Chapter 2 provides a more comprehensive overview of the scientific literature.

Remarkably, in scientific research relatively little attention has been paid specifically to cycling compared with other modes of transportation. Bicycle mode choice has occasionally been investigated in general mode choice research, sometimes combined with walking. Traditionally, micro-economic theories have been used in this research to explain mode choice, such as utility-theory (Domarchi *et al.*, 2008). Recently, however, a shift in attention occurred and more consideration was given to psychological determinants. Lifestyles, attitudes, symbolic and affective motives, and positive emotions explain why individuals travel by a certain mode (Domarchi *et al.*, 2008; Schneider and Holz-Rau, 2007; Steg, 2005). An ongoing debate has also emerged on self-selection. The most important issue in this debate is whether individuals use a certain transport mode as a result of their living location or whether they choose their living location based on their transport preferences (e.g. Mokhtarian and Cao, 2008; Cao *et al.*, 2009; Bohte, 2010).

Nevertheless, mode choice research does not take into account all the relevant factors involved in bicycle commuting. It is expected that cyclists are affected by different factors than other commuters. To give some examples: cyclists are at the mercy of the weather, and thus weather conditions are more likely to affect the bicycle commute choice than other transport mode choices. Distance may also be more important to cyclists as it is a human powered vehicle.

The existing research that focuses on cycling addresses this issue at three levels: countries, cities/regions and individuals. The first research level mainly parallels one country with another. International comparative research has predominantly focused on policies, best practices, and analyses of national data (e.g. Pucher and Buehler, 2008, 2006). This research shows mainly the differences between countries, as a basis for identifying ways for one country, mainly the US, to stimulate cycling. Recently, other international comparative literature links national health situations with cycling (Pucher and Dijkstra, 2003; Pucher *et al*., forthcoming; Bassett *et al*., 2008). On the second level, various studies have focused on the effect of the built environment on bicycle use. On the level of a city factors have been found to increase the bicycle mode share and frequency such as a higher density, the presence of bicycle infrastructure and a larger mixture of functions (e.g. Cervero, 1996; Moudon *et al*., 2005). In addition, by comparing city characteristics, such as age and religion, with the city's cycling level, conclusions can be drawn of the effect of socio-demographics on cycling (e.g. Handy *et al*., forthcoming; Xing *et al*., 2010; Dill and Carr, 2003). Although results on these two research levels offer interesting findings, they cannot explain why individuals from the same country or city travel with different transportation modes.

Research that takes the individual as the point of departure enables different research questions to be investigated, such as why individuals commute by bicycle, in which situations they cycle and who is more likely to cycle in terms of socio-demographical characteristics. This type of research has focused on preferences and mode choice. The literature reports connections between cycling and socio-demographics, attitudes, the built environment, the natural environment, and to a lesser extent weather conditions (e.g. Gatersleben and Uzzell, 2007; Gatersleben and Appleton, 2007; De Geus, 2007; Aultmann-Hall *et al*., 1997; Bergström and Magnussen, 2003; Stinson and Bhat, 2004; Plaut, 2005). Limited attention has been given to individual cycling frequency.

1.4 Research gaps

In order to be able to develop sound policies that encourage bicycle commuting, it is essential that we understand what determines bicycle use among different groups. Despite the increased attention on cycling in the scientif-

ic literature, several gaps can be identified in the existing knowledge. First, no comprehensive framework of the individual choice to commute by bicycle exists. To explain the mode choice of potential cyclists, it is without any doubt that non-customary factors in mode choice research need to be included in any explanation of this variation, such as the weather conditions and bicycle facilities (parking, infrastructure). The effect of these and other bicycle-specific factors have not been tested sufficiently so far.

Most research in the field of commuting and other travel behavior, including cycling studies, suggest that individuals just make one travel mode choice to reach a certain activity. However, this ignores the fact that many commuters alternate transportation modes. As bicycle commuters are more dependent on characteristics that vary per day than other modes, such as weather conditions, it is assumed that that there is a considerable group of bicycle commuters who cycle part-time rather than on a daily basis. Interesting issues which are still unclear, are (1) why some people always commute by bicycle and others alternate the bicycle with other modes, and (2) which factors influence the day-to-day choice and to what extent.

When it comes to commuting, it can be hypothesized that work characteristics may also play a role. Office norms, for example, might dictate that (for specific occasions) employees wear suits and drive company cars when visiting clients. If an individual uses a car for business trips, he/she may be expected to use it for commuting as well and is likely to do so. A workplace's commuting culture and mentality will also be revealed by whether it provides financial support for transport costs or facilities at work (bicycle storage, showers); or conversely, a car-friendly policy that reduces the relative attractiveness of cycling to work. A negative impact on commuter cycling is expected by the provision of non-cycling facilities (such as car parking), financial support for other modes of transportation, working in a sector or function which is not particularly bicycle-friendly (such as finance), the need to carry goods during office hours, or the need to travel for work.

Another set of factors that are rarely taken into account, are the attitudes of commuters and the norms of people in their social and work environment. 'Hard factors' can only explain the decision to cycle to a limited extent, and cannot explain why individuals in identical situations and with similar socio-demographical characteristics differ in their mode choice decision(s). Research in other fields leaves the impression that attitudes play a role here. With the inclusion of attitudes the explaining power is likely to increase of models describing bicycle mode choice. An attitude is the sum of products of the expected outcome of a behavior and the attached importance (Ajzen, 1991). An example of this expectation is 'cycling to work is relaxing' and an example of the importance is 'For me it is important that my commute mode choice is relaxing'. Another example is whether an individual finds it important that his/her commute mode is environmentally friendly, multiplied by

the extent to which he/she considers cycling environmentally friendly. It is anticipated that the more positive one's attitude is on cycling, the more likely this person is to cycle.

Finally, within in the Netherlands limited scientific attention has been devoted to bicycle commuting. Since this country has widespread experience with cycling in general and bicycle commuting in particular, a thorough understanding of choice behavior would be useful not only for the Netherlands, but also for other countries. Moreover, knowledge cannot easily be unconditionally transferred from other countries. Therefore, research on bicycle use needs to be conducted in multiple countries, including the Netherlands. This thesis addresses these four gaps specifically.

1.5 Research aims, research questions and scope

Current policies often assume that non-cyclists and cyclists are encouraged by the same incentives. In addition, current policies pay too little attention to the mode alternation of cyclists and neglect that different factors may affect this decision. Evidence for the assumption that different groups exist which differ from each other in the factors affecting their mode choice is provided by Hendriksen *et al*. (2010), who found that non-cyclists mention different reasons not to cycle than cyclists.

This thesis aims to contribute to the knowledge of the factors which affect bicycle commuting, and specifically on the day-to-day choice to cycle and the cycling frequency. Knowledge of the determinants of bicycle commuting will enable policies to be formulated that encourage commuting by bicycle – non-cyclists to start cycling and cyclists to cycle more frequently – and thus create a more sustainable and healthy society.

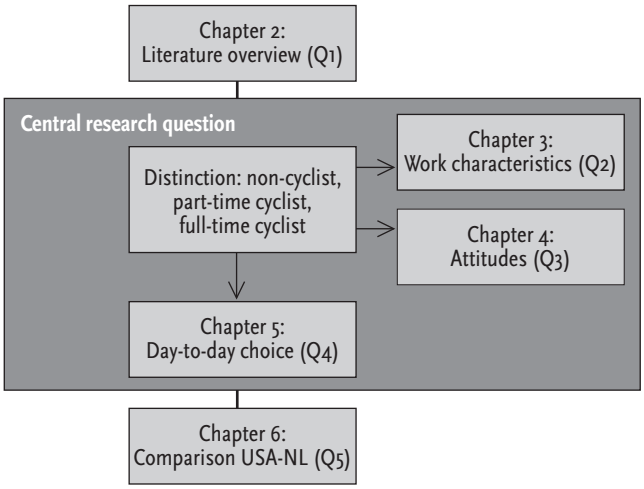
This aim leads to the following central research question:

> *To what extent is the individual day-to-day choice to commute by bicycle affected by personal attitudes towards cycling to work, social norms, work situation, weather conditions and trip characteristics?*

The research question is divided into five sub-questions, successively addressed in Chapters 2 to 6 (see Figure 1.1). Questions 2 to 4 explicitly aim to fill the indicated gaps. Question 1 leads to an exploration of the scientific literature for the purpose of putting together the existing knowledge. Question 5 focuses on the differences between countries and touches the issue of transferability of bicycle knowledge by comparing bicycle attitudinal components in two cities.

1. *Which factors of bicycle commuting are reported in the scientific literature?*

Figure 1.1 Connection between central research question, sub-questions and chapters



The existing empirical knowledge on bicycle use is dispersed on commuting. Chapter 2 addresses this question and aims to provide a comprehensive overview of the identified factors of commuting by bicycle, and for bicycle commuting frequency. The successive research questions and papers take this overview as a point of departure.

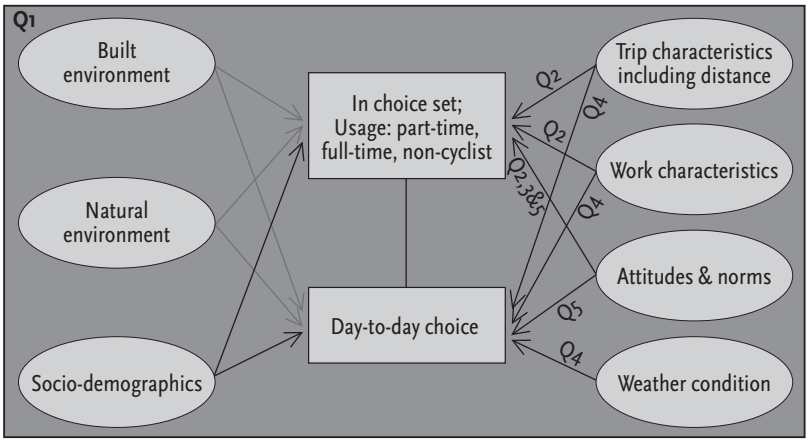
2. *To what extent does the work situation – such as working time, clothing style, working location, opinions of colleagues and need to transport oneself or equipment – affect the decision to commute by bicycle?*

In studying cycling to work, only a limited amount of academic research has been undertaken on the influence of work-related factors. This is remarkable, as it goes without saying that work-related factors may influence the choice of transportation mode for commuting made by an individual. The culture of the employer is expected to impact on the provision of cycling facilities and financial compensation schemes in the workplace. Chapter 3 addresses this question and analyzes the effect of cycling facilities and financial compensation schemes, individual attitudes and the norm of one's colleagues on a decision to cycle as well as the cycling frequency.

3. *To what extent is the decision to cycle to work affected by attitudes, the subjective norm, bicycle habit and the perceived possibility to commute by bicycle?*

Individuals in identical situations and with similar socio-demographic characteristics still decide to commute by different transportation modes. Since previous research has indicated a connection between attitudes and bicycle use, it is expected that the bicycle commute mode choice decisions will also be influenced by internal and social considerations, such as attitudes, norms and habits. The Theory of Planned Behavior (Ajzen, 1991) provides the basis

Figure 1.2 Factors on bicycle commuting and research questions



for the theoretical framework in this study. It is anticipated that people with a more positive attitude to cycling would cycle longer distances and with a higher frequency than individuals with a moderate or a negative attitude.

4. *Which day-to-day variable factors affect bicycle commuters in such way that commuters cycle on some days and not on others?*

The fourth paper addresses the day-to-day mode choice of cyclists. It is assumed that cyclists are particularly likely to alternate mode choices (sometimes commuting by car or public transport), as they are more affected by conditions that change from day to day. This question provides insights into the effect of short term conditions, which can change day to day, on cycling, such as weather conditions, work characteristics (e.g. clothing, working hours) and trip characteristics (e.g. trip chaining).

5. *In what way does the decision to cycle to work differ between countries? More specifically: To what extent do the beliefs about bicycle commuting, and the importance attached to those beliefs, correspond, comparing two bicycle-friendly cities, Delft and Davis?*

This fifth question explores the similarities and differences in beliefs and the importance attached to those beliefs about commuting to work by bicycle. So far, international comparative research has mainly focused on policies, best practices, and analyses of national data (e.g. Pucher and Buehler, 2008, 2006). Chapter 6 investigates the broadness in attitudes on cycling to work, paying attention to the similarities and differences. Answering this question contributes to the main question as it broadens the insights on how attitudes and social norms on cycling affect cycling behavior. Moreover, it explores the analogies in different settings. This facilitates the interpretation of the other results and thereby enlarges the scope of the whole research.

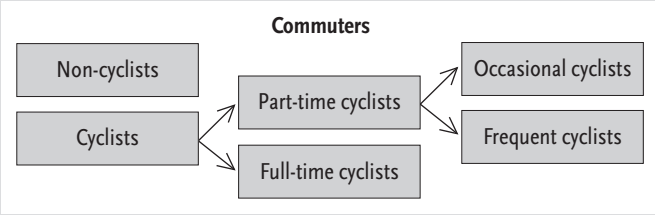
1.6 Definitions, conceptualization and categories of cyclists

Figure 1.2 shows the factors affecting bicycle mode choice and the position of the research questions within this conceptual mode. The oval-shaped boxes contain the dependent variables of bicycle commuting. Please note that only the direct influences is included in the figure and that additional interaction effects are present. The independent factors affect bicycle commuting on two levels. First, they influence whether the bicycle is in the choice set of an individual, meaning whether the bicycle is a commuting option (in the top square). Second, they affect the day-to-day choice to cycle. The day-to-day choice to cycle can only be made if the bicycle is in the real choice set, so actually used. Question one aims to provide a comprehensive overview of the identified factors involved in commuting by bicycle and the cycling frequency and this question focuses on the total framework. Questions two and three focus on the influence of two specific determinants of bicycle use – work characteristics, and attitude and norms. Question four focuses entirely on the daily choice to cycle, whereas question five compares Davis and Delft and addresses the attitude and norms of the choice set and the day-to-day choice.

An attitude towards a certain type of behavior is the sum of the various beliefs about the behavior multiplied by the importance that an individual assigns to each belief. A behavioral belief is the subjective assessment that the behavior will produce a given outcome. In this thesis the terms 'attitudes toward the various characteristics of bicycle commuting', 'attitudinal characteristic' and 'attitudinal components' are used for the sum of each individual belief multiplied by the importance attached to it. For readability reasons the term 'attitude' is sometimes used, while it is actually the product of the belief and its importance that is meant, rather than the sum of all beliefs and the importance assigned to those beliefs.

Figure 1.3 shows the division of the assumed groups of different commuters. The first distinction for all commuters is between cyclists and non-cyclists. *In this research bicycle commuters are defined as commuters who cycle the entire distance from home to work*. Thus the term does not include commuters who use the bicycle for part of a journey, such as for travelling to the railway station. Of these commuter-cyclists, a certain portion uses other travel modes as well, while another portion uses the bicycle for all their commuting journeys. *A full-time bicycle commuter is defined as someone who cycles to work every working day, while a part-time bicycle commuter cycles to work at least once a year*. Finally, the individual commuters in the groups of part-time cyclists can be placed on a continuum of cycling frequency. Different groups of cyclists are expected within this group. One category consists of people for whom the bicycle is the preferred mode. These commuters aim to cycle as long as certain conditions are met (or unless certain conditions are not met). Their reasoning is expect-

Figure 1.3 Categories of commuter cyclists



ed to follow the form of, *"I cycle, except when ...."*. Another group consists of commuters who prefer other modes of transportation, unless conditions are very favorable for cycle. Their reasoning might follow the form of, *"I only cycle if...."*. It is assumed that different groups of cyclists exist in terms of cycling frequency and that individual cyclists in those groups are affected by different factors. More specifically, it is expected that (1) the factors which explain why individuals cycle or do not cycle differ from the factors which explain the cycling frequency, (2) that full-time cyclists and part-time cyclists are two different kinds of cyclists, affected by different factors and that (3) the day-to-day decision to commute by bicycle is influenced by factors other than those affecting the general decision to commute by bicycle.

1.7 Research design

This section discusses the data collection methods applied and the link between the methods and the research questions. Each paper (chapter) addresses the data collection as well. This section therefore overlaps somewhat with parts of Chapters 3 to 6. The added value of this section is that it provides an overview of all the methods used and links the methods with the research aim and questions. This section starts with a discussion of the research methods, followed by a description of the research area, the selection of the respondents and the survey for the quantitative part of the research. It ends with a description of the research area and the selection of the respondents for the qualitative part of this thesis.

To answer the main research question, data are needed on the individual mode choice decisions and on personal, attitudinal, work and household characteristics, as well as on the characteristics of their commute travel pattern. This study employs both quantitative and qualitative research.

A quantitative approach is used to investigate sub-questions 2 to 4, because these require the relationships between the expected factors and cycling to be tested. These questions fill the main research gaps and require the relationships between the expected factors and cycling to be tested empirically. Existing data sources (e.g. the Dutch National Travel Survey (NTS)) do not provide the required data. In order to generate the necessary data, two web-based surveys were designed. A web-survey enables data to be collected in an efficient manner: it is fast and cheap, input errors can be avoided, and the use of routing eliminates asking non-applicable questions, thus reducing the burden for the respondent (Berrens *et al.*, 2003; Evans and Mathur, 2005). Since questions on travel behavior as well as attitudes towards this behavior are being asked in

one questionnaire, interference has to be minimized to prevent bias. A certain degree of under- or overrepresentation may be expected in web-surveys as not everybody has an Internet connection. Nevertheless, over 94% of the inhabitants in the Netherlands have Internet excess at home (Statline, 2010). Moreover, one can assume that many working people, in particular, are internet-oriented rather than paper-oriented, making this type of survey suited for working people. Thus an Internet survey is likely to fit a survey on commuting. In line with many other recent studies in the area of travel behavior, and due to the necessary routing in the questionnaire and the focus on commuting, the pros are considered to outweigh the cons (including the risk of bias).

Qualitative research methods are used for sub-questions 1 and 5, largely because of their exploratory character. Sub-question 1 aims to provide insight into the factors related to bicycle commuting, as reported in the scientific literature. To answer this question a literature study was conducted. Sub-question 5 deals with the transferability between countries. It aims to understand the underlying beliefs and the connection between attitudes, social norms, and behavior. In-depth interviews are selected as the data collection method, as they are more focused on the individual, while another not-applied method, focus groups, is more focused on the questions and variation in answers to the questions. In-depth interviews are a way of "discovering the subjective meanings and interpretation of people" (Liamputtong and Ezzy, 2005, p. 71), and with interviews we were able to glean each person's story as a whole, rather than the pieces we would get in focus groups. Responses are also less influenced by the presence of peers (Liamputtong and Ezzy, 2005). Therefore, participants may feel more comfortable sharing their thoughts about transportation modes and their opinions and expectations of others.

1.7.1 Quantitative study

Research area

This research was conducted in the Netherlands. From a cycling perspective, the Netherlands is an international frontrunner and is therefore an ideal location for bicycle research. In the Netherlands a high percentage of all trips are made by bicycle and for many the bicycle is a real alternative: most Dutch people possess a bicycle, cycling is accepted, there is a good bicycle infrastructure and most areas within the Netherland are flat. This situation enables research to be carried out into the effect of attitudes and work situation on the (day-to-day) decision to cycle.

The study was carried out in four Dutch municipalities: the medium-sized towns of Delft (approximately 100,000 inhabitants) and Zwolle (approximately 115,000 inhabitants); and two municipalities adjacent to Delft, Midden-Delfland (17,000 inhabitants) and Pijnacker-Nootdorp (38,000 inhabitants) (Figure 1.4). The selection of the cities was based on the relatively high likelihood

Figure 1.4 Research area quantitative research

that commuter cyclists would participate and the presence of employers with many employees. Additionally, personal knowledge of the cities and familiarity with the name and reputation of Delft University of Technology was taken into account. Both cities have a higher cycling percentage than the national average: Delft 26%, Zwolle 29% (Fietsberaad, 2010). Disregarding the highest and lowest 10% of municipalities in terms of bicycle share, municipalities fluctuate between 17% and 29% bicycle share. Dutch cities are relatively uniform in their infrastructure facilities due to the national infrastructure guidelines formulated by CROW (Dutch Center of expertise on infrastructure, traffic, transport and public space).

Selection of respondents

This thesis takes the individual commuter as the study unit due to the focus on the individual commute mode choice decision. The commuter could be approached in several ways. Two possible methods are interception of cyclists and advertisements or leaving leaflets close to bicycle shops, but these are la-

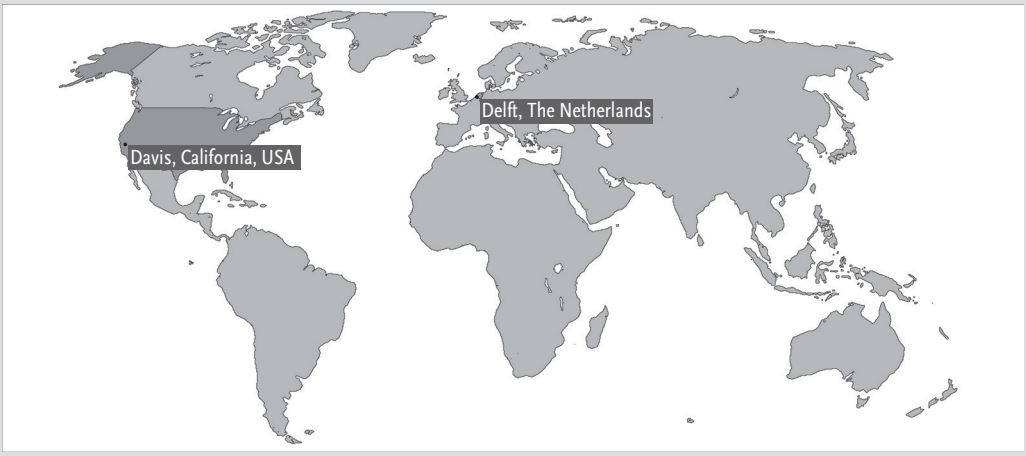
bor intensive and result in a bias: They result in more cycling-minded people (Madera and Smith, 2009). Two less intensive methods is approaching individuals at their home or work address. The advantage of approaching individuals at work is that it is relatively easy to reach large groups, it is possible to approach the respondents shortly after their commuting journey (useful for the follow-up survey), response is not dependent on having a computer at home, and that only workers are contacted. The last reason is an advantage for a study on commuting as everyone that is approached at their working address has to commute and is theoretically able to participate. On the negative side, both the environment and the participants are more likely to be homogeneous. This disadvantage can be overcome or reduced by approaching respondents at multiple employers. In conclusion, it is easier to approach respondents by asking their employer for permission to do so. Therefore, multiple employers were contacted in the field of education, public services, industry and business. However, not all employers granted permission for us to approach their employees. To obtain more and representative data, residents were also approached. The addressees were randomly selected from municipality data.

Survey

In April and May 2008, an Internet survey was conducted among: (1) the employees of several large organizations in Delft and Zwolle, including TU Delft, Delft's main hospital, housing authorities and a receivables management company; and (2) the inhabitants of the municipalities mentioned above. The questionnaire was presented as a survey of the commute mode choice. The specific focus on bicycle use was kept from the respondents in order to avoid a bias toward cyclists or people with a favorable opinion about cycling. All of the respondents were asked to fill out an online questionnaire, with 40 12-euro lottery tickets being offered as incentives. In total, 2,929 out of 22,000 residents responded (a rate of 13.3%). Of the employees, 1,370 responded from a total of approximately 3,500 e-mail requests (a response rate of 39%). Our overall response rate was thus 16.9%.

A follow-up survey was conducted to collect data on the day-to-day mode choice. Only commuters who had indicated that they commuted by bicycle at least occasionally or partly were included. Every participant was approached by e-mail randomly once every two weeks, in order to reduce the likelihood that respondents would change transportation modes in anticipation of the survey. Participants were therefore approached multiple times on each day of the working week (Monday-Friday), with the days alternating at random. Respondents were asked to answer a short questionnaire (lasting one to two minutes) regarding their commute mode choices on that specific day. Options were provided to indicate working at home or not having worked that day. The chance to win one of forty small prizes worth € 12 was offered as an incentive.

Figure 1.5 Research area qualitative research



1.7.2 Interviews

Research area
Two research locations were selected to conduct the interviews: Davis in California, USA, and Delft in the Netherlands (Figure 1.5). The Dutch city is selected for the connection between the quantitative and qualitative part of this thesis. Davis was selected based on its similarities with Delft. Both are medium-sized cities, with large student populations, close to important urban areas, and the cities are comparable in area size. In Davis, unlike most other American cities, the bicycle is a common form of transportation. Davis is known in the US for its extensive bicycle infrastructure and its high bicycle share. Similar to Delft, Davis is flat and is, by US standards, a compact city.

Selection of respondents
The participants in Delft were recruited from the participants of the previously mentioned survey in Delft. In our selection gender, distance and mode choice were taken into account in order to obtain a broad spectrum of commuters. Randomly selected individuals were approached by e-mail and were asked to participate in an in-depth interview. In Davis, participants were recruited via a well-read local newspaper. A notice was published asking residents to participate in a commute mode choice study, involving an interview of 60 minutes. The interviews in Delft were conducted in August 2009 and December 2009 and January 2010. In Davis the interviews took place between September 2009 and November 2009.

1.8 Outline of the thesis

The present thesis is a collection of five papers: one literature review, three empirical papers and one comparison of two cities. Each chapter is based on a paper either published in, accepted, or submitted to peer-reviewed journals.

As a result there is some overlap between the chapters. Each of these papers addresses one specific research question.

Chapter 2 provides an overview of the scientific literature on bicycle commuting, and other relevant bicycle literature. Chapter 3 then focuses on the effect of the working environment on the decision to cycle to work. Chapter 4 investigates the relationship between attitudes towards cycling and the activity of cycling to work. Chapter 5 addresses the question of what causes people to cycle on one day, but not on another day. This day-to-day decision to cycle is investigated among cyclists and takes bicycle-specific and variables that differ daily into account. Chapter 6 presents the comparison of Delft and Davis on bicycle attitudes and its effect on bicycle commuting behavior. This paper helps to give the outcomes of the survey an international perspective. Finally, the conclusion of this thesis, Chapter 7, summarizes the chapters and highlights the most important findings. Section 7.2 provides a discussion of the results and this research. This thesis ends with a reflection on the implications for policy and recommendations for further research.

References

Ajzen, I. (1991), The theory of planned behavior, *Organizational Behavior and Human Decision Processes, 50* (2), pp. 179-211.

Aultman-Hall, L., F.L. Hall and B.B. Baetz (1997), Analysis of bicycle commuter routes using geographic information systems: implications for bicycle planning, *Transportation Research Record, Washington, D.C. 1576*, pp. 102-110.

Bassett, D.R., J. Pucher, R. Buehler, D.L. Thompson, and S.E. Crouter (2008), Walking, Cycling, and Obesity Rates in Europe, North America, and Australia, *Journal of Physical Activity and Health, 5* (6), pp. 795-814.

Bergström, A. and R. Magnussen (2003), Potential of transferring car trips to bicycle during winter, *Transportation Research Part A, 37* (8), pp. 649-666.

Berrens, R.P., A.K. Bohara, H. Jenkins-Smith, C. Silva, and D.L. Weimer (2003), The advent of Internet surveys for political research: A comparison of telephone and Internet samples, *Political Analysis, 11* (1), pp. 1-21.

Bohte, W. (2010), *Residential self-selection and travel. The relationship between travel-related attitudes, built environment characteristics and travel behavior*. PhD Thesis Delft University of Technology, Delft (IOS Press).

Bruhéze, A.A. de la, and F. Veraart (1999), *Fietsverkeer in praktijk en beleid in de twintigste eeuw*. Rijkswaterstaatserie 63. Den Haag (Ministerie voor Verkeer en Waterstaat).

Cao, X., P.L. Mokhtarian and S.L. Handy (2009), *Transport Reviews, 29* (3), pp. 359-395.

Cervero, R. (1996), Mixed land-uses and commuting: evidence from the American housing survey, *Transportation Research Part A, 30* (5), pp. 361-377.

Cervero, R. and M. Duncan (2003), Walking, bicycling, and urban landscapes: evidence from the San Francisco Bay Area, *American Journal of Public Health, 93* (9), pp. 1478-1483.

De Geus, B. (2007), *Cycling to work. Psychosocial and environmental factors associated with cycling and the effect of cycling on fitness and health indexes in an untrained working population*, doctoral dissertation, Brussel (Vrije Universiteit Brussel, Department of Human Physiology and Sports Medicine), pp. 1-209.

Dill, J. and T. Carr (2003), Bicycle Commuting and Facilities in Major U.S. Cities: If You Build Them, Commuters Will Use Them – Another Look, *Transportation Research Record, 1828*, pp. 116-123.

Domarchi, C., A. Tudela and A. Gonzalez (2008), Effect of attitudes, habit and affective appraisal on mode choice: an application to university workers, *Transportation, 35* (5), pp. 585-599.

Evans J.R. and A. Mathur (2005), The value of online surveys, *Internet Research, 15* (2), pp. 195-219.

Federal Highway Administration (FHWA) (2005), Bicycle and Pedestrian Provisions, in: *(SAFETEA-LU), SEC. 1807*. Nonmotorized transportation pilot program, via http://www.fhwa.dot.gov/environment/bikeped/legtealu.htm#sec1807.

Fietsberaad (Center of expertise on bicycle policy) (2010), cycling percentages in Dutch municipalities (data from 2004-2008). (http://www.fietsberaad.nl/library/repository/bestanden/Kenniscentrum_Fietsberaad_fietsgebruik_per_gemeente_download.xls).

Gatersleben, B. and K.M. Appleton (2007), Contemplating cycling to work: attitudes and perceptions in different stages of change, *Transportation Research Part A, 41* (4), pp. 302-312.

Gatersleben, B. and D. Uzzell (2007), Affective appraisals of the daily commute. Comparing perceptions of drivers, cyclist, and users of public transport, *Environment and Behavior, 39* (5), pp. 416-431.

Handy, S.L., Y. Xing, T.J. Buehler (2010), Factors associated with bicycle ownership and use: a study of six small U.S. cities, *Transportation, 37 (*6), pp. 967-985.

Hendriksen, I.J.M., M. Fekkes, M. Butter and V.H. Hildebrandt (2010), *Beleidsadvies Stimuleren van fietsen naar het werk* [Policy recommendation, encouraging bicycle commuting], 1-92, Leiden (TNO kwaliteit van leven). http://home2.nyc.gov/html/dot/html/bicyclists/bikemain.shtml.

Liamputtong, P. and D. Ezzy (2005), *Qualitative research methods*, Victoria, Australia (Oxford University Press), 2nd edition.

Madera, J.A. and C. Smith (2009), *Surveys of Bicyclists and the General Population in Three Cities: Comparison of Methods and Results*. Paper presented at Transportation Research Board Annual Meeting 2009, Washington D.C., pp. 1-15.

Ministry of Finance (2009), *State decision 9 February 2009*, nr. CPP2009/109M, Stcrt. nr. 29, via http://www.minfin.nl/Actueel/Besluiten_beleidsregels/2009/02/Omzetbelasting_Aftrek_omzetbelasting_met_betrekking_tot_auto_s_e_d.

Ministry of Finance (2004), *State decision on 22 June 2004*, nr. CPP2004/1454M. via: http://www.loonheffing.nl/besluiten/CPP2004-1454M.htm.

Ministry of Transport, Public Works and Water Management (2009), Letter to the House of Representatives, *Rijksinzet op het stimuleren van fietsgebruik* [National government efforts to stimulate bicycle use], August 29th 2009, The Hague, The Netherlands.

Ministry for Transportation, Public Works and Water Management (2005), *Nota Mobiliteit*, Den Haag (Ministry for Transportation, Public Works and Water management).

Ministry of Transport, Public Works and Water Management and Fietsberaad [Centre of Expertise on Bicycle Policy] (2009), *Cycling in the Netherlands*. Den Haag, The Netherlands.

Mokhtarian, P.L. and X. Cao (2008), Examining the Impacts of Residential Self-Selection on Travel Behavior: A Focus on Empirical Findings. *Transportation Research Part B, 42* (3), pp. 204-228.

Moudon, A.V., C. Lee, A.D. Cheadle, C.W. Collier, D. Johnson, T.L. Schmid and R.D. Weather (2005), Cycling and the built environment, a US perspective, *Transportation Research Part D, 10* (3), pp. 245-261.

Olde Kalter, M.-J. (2007), *Vaker op de fiets? Effecten van overheidsmaatregelen* [More often by bike? Effects of governments measures]. Den Haag (Kennisinstituut voor Mobiliteitsbeleid (KiM)).

Parkin, J., T. Ryley and T. Jones (2007), On barriers to cycling: an exploration of quantitative analyses, in: Horton, Rosen and Cox (Eds), *Cycling and society* (Ashgate Publishing).

Plaut, P.O. (2005), Non-motorized commuting in the US, *Transportation Research Part D, 10* (5), pp. 347-356.

Pucher, J. and R. Buehler (2008a), Making cycling irresistible: lessons from the Netherlands, Denmark and Germany, *Transport Reviews, 28* (4), pp. 495-528.

Pucher, J. and R. Buehler (2008b), Cycling for Everyone: Lessons from Northern Europe, *Transportation Research Record, 2074*, pp. 58-65.

Pucher, J. and L. Dijkstra (2003), Promoting Safe Walking and Cycling to Improve Public Health: Lessons From The Netherlands and Germany, *American Journal of Public Health, 93* (9), pp. 1509-1516.

Pucher, J., R. Buehler, D.R. Bassett and A.L. Dannenberg (2010), Walking and Cycling to Health: A Comparative Analysis of City, State, and International Data, *American Journal of Public Health, 100* (10), pp. 1986-1992.

Road Traffic Act (Wegenverkeerswet), artikel 185.

Saelens, B., J. Sallis and L.D. Frank (2003), Environmental correlates of walking and cycling: findings from the transportation, urban design, and planning literatures, *Annals of Behavioral Medicine, 25* (2), pp. 80-91.

Schneider, J. and C. Holz-Rau (2007), Travel mode choice: affected by objective or subjective determinants?, *Transportation, 34* (4), pp. 487-511.

Steg, L. (2005), Car use: lust and must. Instrumental, symbolic and affective motives for car use, *Transportation Research Part A: Policy and Practice, 39* (2-3), pp. 147-162.

Stinson, M.A. and C.R. Bhat (2004), Frequency of bicycle commuting: internet-based survey analysis, *Transportation Research Record, 1878*, pp. 122-130.

Statline (2010), http://statline.cbs.nl/StatWeb/publication/?DM=SLNL&PA=37727&D1=0&D2=l&D3=0&D4=0-1&D5=0&D6=l&VW=T, and http://statline.cbs.nl/StatWeb/publication/?DM=SLNL&PA=71098ned&D1=33-40&D2=0-6&D3=a&HDR=G1&STB=T,G2&VW=T.

Xing, Y., S.L. Handy, P.L. Mokhtarian (2010), Factors associated with proportions and miles of bicycling for transportation and recreation in six small US cities, *Transportation Research Part D, 15* (2), pp. 73-81.

2 Commuting by bicycle: An overview of the literature

Heinen, E., G.P. van Wee and K. Maat (2010), Bicycle Use for Commuting: a Literature Overview, *Transport reviews, 30* (1), pp. 59-96. Published by Routledge (Taylor and Francis group, http://www.tandf.co.uk/journals/titles/01441647.asp). Article via http://dx.doi.org/10.1080/01441640903187001.

Abstract
Commuting by bicycle has advantages over other modes of transport, both for the commuter and for society. Although cycling is an option for many commuters, a considerable number of them choose to use other forms of transport. In order to underpin policies that promote commuting by bicycle, this paper investigates the determinants for commuting to work. As many bicycle commuters do not cycle every day, we also examine people's daily choices, in terms of frequency. We conducted a survey of the current literature in order to identify the determinants for commuting by bicycle. We found many determinants, not all of which are addressed by conventional mode choice studies and models. This suggests that predicting and influencing bicycle use needs to be grounded in other kinds of knowledge than those currently available for motorized forms of transport.

2.1 Introduction

For society and for the individual, cycling presents a number of interesting advantages over other modes of transport. Individuals benefit from the fact that cycling is a healthy and cheap form of transport. Moreover, in urban areas, cycling can sometimes prove to be faster than other transport modes and also allows cyclists to avoid traffic jams (Olde Kalter, 2007). For society, meanwhile, the advantages of cycling include environmental sustainability (no direct emissions of pollutants, CO_2 or noise), cheap infrastructure requirements and improvements in public health (Olde Kalter, 2007). Cycling also has a number of disadvantages, however, including a greater physical effort, the difficulty of carrying loads while cycling, being at the mercy of the weather, and, outside urban areas, travelling more slowly than motorized transport. Factors such as physical effort and speed also limit the distance that a cyclist can travel.

Despite the fact that cycling is an option for many commuters (e.g. those who only have to travel short distances) and also brings a number of benefits, a considerable proportion of commuters choose to use other means of trans-

port. Even in the Netherlands, which has a bicycle-friendly infrastructure and where cycling has a positive image, many people choose not to cycle in situations when cycling would be a highly appropriate transport mode (Ministerie van Verkeer en Waterstaat, 2007).

Due to the social gain to be realized from increasing the share of bicycle commuters and the potential share of bicycle commuters, policy-makers in a number of countries, including the Netherlands, are showing increasing interest in encouraging cycling. Cities such as Paris and Washington, D.C., also recognize the value of cycling, and have recently introduced systems that provide cheap rental bikes (Enserink, 2007). As we will show in this paper, like policy-makers, academic researchers are also becoming increasingly interested in cycling.

It is nevertheless striking that, despite the increasing policy and academic interest in cycling, little attention has been paid to cycling when compared with other modes of transport. In order to be able to develop sound policies that encourage cycling, it is essential that we understand what determines bicycle use. We assume that conventional knowledge on mode choice (models) is not sufficient for developing bicycle policies. The characteristics of bicycle use are very different from the characteristics of car and public transport use, with the former being influenced by factors such as the weather and the physical effort needed (Wardman *et al*., 1997).

To the authors' knowledge, no comprehensive overview of all the dominant factors influencing bicycle commuting is available (although some partial overviews have been undertaken; see, e.g. Saelens *et al*., 2003; Parkin *et al*., 2007). This paper aims to offer an overview of the academic literature on bicycle commuting. We mainly focus our study to the academic literature for two reasons: first, on the grounds of quality; and second, because including the 'grey literature' in our overview would result in too lengthy a paper. We pay particular attention to empirical results from the areas of travel behavior, transportation planning, psychology and health science. Our primary aim is to present an overview of the literature rather than a thorough review of the literature. This is mainly due to the fact that the incidence of contradictory results makes it difficult to determine which analyses are correct.

Cycling for utilitarian purposes, including commuting, is likely to be influenced by different determinants than those that influence other forms of cycling, such as cycling for leisure or for sporting purposes. In this paper, we have chosen to focus on commuting for two reasons. First, commuting is an important aspect of travel behavior for the society because it contributes to economic prosperity. In the Netherlands, it covers about 20% of the number of trips, which is fairly comparable with other western countries. As commuting is non-discretionary and fixed in time and place for most people, it contributes disproportionately to traffic congestion and environmental pollution. Commuting by bicycle can therefore make a greater contribution to reducing

congestion than cycling for other purposes. In addition, a modal shift towards cycling to work will have the great impact on improving public health and reducing the proportion of overweight people. Experts argue that the health benefits of exercise are greatest in the case of daily repetitive and necessary activities, such as commuting, as these are more successful and durable over longer periods (Lawlor *et al.*, 2003). Although our focus is on commuting by bicycle, we also include some general commuting studies, as well as studies on general bicycle use (including leisure and all trips made), on the grounds that both provide insights into cycling to work. As most cycling studies do not focus on commuting, we identify those that explicitly address cycling to work. Furthermore, it is of interest to distinguish between (1) mode choice in general, that is to say, the bicycle is at least one of the modes used; and (2) daily choice, in terms of frequency. The latter is useful because many bicycle commuters choose not to cycle every day.

In this paper, we subdivide the determinants into five groups. As travel is a matter of bridging a gap between locations, we start with the spatial context: the built environment. Second, we focus on the natural environment, including landscape, weather conditions and climate, which are particularly important for non-motorized transport modes. The third group of determinants is composed of socio-economic variables, a well-known category of determinants in travel behavior research. The fourth group focuses on psychological factors, including attitudinal aspects. Fifth, we discuss a number of further aspects related to cost, time, effort and safety.

2.2 Built environment

A large number of studies have examined the relationship between the environment and the travel behavior. These studies, in turn, have been reviewed in a number of papers (e.g. Crane, 2000; Ewing and Cervero, 2001). Although we know a lot about the effects of the environment on cycling, certain landscape related aspects, such as hilliness, which would seem particularly important for cycling, are under-researched in mode choice studies (for an overview, see Saelens *et al.*, 2003). This section describes the results for three categories: urban form, infrastructure and facilities at work.

Urban form

Distance, either commuting distance or the distance between activities, is almost always taken into consideration when investigating an individual's choice to cycle or to use other transport modes (e.g. Rietveld, 2000a). An increase in the travel distance results in an increase in the time and effort needed for travelling. We would therefore expect a decrease in the cycling share of commuter trips and the frequency of bicycle commuting.

In general, an increase in *trip distance* results in cycling having a much lower share in mode choice (Moritz, 1998; Zacharias, 2005; Pucher and Buehler, 2006) and for commuting (Cervero, 1996; Dickinson *et al.*, 2003; Timperio *et al.*, 2006; Parkin *et al.*, 2008). Non-cyclists often mention having to travel long distances as an excuse for not travelling or commuting by bicycle (said to be 27% of non-cyclists compared to 3% of cyclists) (Dickinson *et al.*, 2003; Stinson and Bhat, 2004).

Most research into bicycle use identifies distance as a significant factor; indeed, for a great many bicycle research studies, respondents are even selected according to the travel distance. Bike commuters tend to live closer to their work than other types of commuters (Cervero, 1996).[1] One should note that, for cyclists, resistance to travel probably increases disproportionately with distance due to the physical effort required (Van Wee *et al.*, 2006). Moreover, there might be an 'acceptable' maximum travel distance that differs between individuals and also genders. Studies suggest that women cycle shorter distances to work than men (Garrard *et al.*, 2008), with Howard McDonald and Burns (2001) suggesting 6.6 km for women compared to 11.6 km for men. This might be related to location and activity choices that differ between the sexes.

The importance of distance is further reflected in the relationship between town and city size and the mode share. In the Netherlands, small- and medium-sized cities have the highest bicycle share (Martens, 2004; Rietveld and Daniel, 2004), probably as a result of the proximity of the destinations involved.

The bicycle does not merely serve as a main (or sole) mode of transport, but is also used by some commuters to get to a (train) station. Again, research has identified a relationship between distance and the chosen means of transport. For distances between 0.5 and 3.5 km the bicycle is most often used (Keijer and Rietveld, 2000; Rietveld, 2000a; Martens, 2004). We have not found a study that draws conclusions on how access and egress distance affect cycling frequency. However, we would assume that the frequency of cycling declines with increases in distance.

The *network layout* could also influence cycling, because it affects distance. According to Southworth (2005), a denser road structure is more suitable for non-motorized transportation, because distances are generally smaller: the more fine-grained the network, the less difference there is between the network distance and the distance as the crow flies. However, neither Moudon *et al.* (2005) nor Zacharias (2005) find significant empirical evidence that can confirm the influence of the density of roadways and block size on cycling. Land-use concepts, such as new urban designs and the notion of the com-

1 Of course, this is a statistical outcome that does not indicate the causality of the relationship: given that people living closer to their work cycle more often, the causality is not (or is hardly) from mode choice to distance.

pact city, link higher density levels with higher shares of non-motorized travel. The argument is that in *denser urban areas*, distances between locations are shorter, and consequently can be bridged more easily on foot or by bicycle. Although Rodríguez and Joo (2004) conclude that residential densities do not have a large influence on mode choice, we did find a number of studies that supported this argument: namely, Parkin *et al.* (2008), Pucher and Buehler (2006), Zahran *et al.* (2008) and Guo *et al.* (2007). These studies find that higher densities lead to a higher cycling share. Moreover, higher densities are related to lower levels of car ownership and car use (Litman, 2007), which has a positive effect on cycling (see Socio-economic and household characteristics in Section 2.4). Following on from this, Witlox and Tindemans (2004) find that inhabitants of city centers choose the bicycle as a mode of transport more often than residents in the suburbs. The only reference that we have found to the impact of density on cycling frequency is that made by Dill and Voros (2007), who conclude that people living closer to city centers cycle more frequently when making utilitarian trips (a 10% decrease in non-cyclists).

Just like higher densities, having a *mixture of functions* in a neighborhood reduces travel distances, increasing cycling's share in the transport mode choice (Cervero and Duncan, 2003; Pikora *et al.*, 2003; Pucher and Buehler, 2006; Litman, 2007). The presence of convenience stores, offices, fast-food restaurants, hospitals and multifamily housing in a neighborhood has a positive effect on cycling (Cervero, 1996; Cervero and Duncan, 2003; Moudon *et al.*, 2005).

To conclude, distance can be a daunting factor for cyclists, and has a negative influence on whether individuals choose to commute by bike. Little is known about the effect of distance on cycling frequency, however. Factors contributing to shorter travel distances, such as having a denser network layout, higher density and mixed land-use, affect cycling positively.

Infrastructure

Bicycle infrastructure comes in a number of forms: bicycle paths, bicycle lanes and 'normal' streets (with or without markings). In some cases, car-parking facilities may be adjacent to such facilities, resulting in potential interactions between cyclists and drivers. In practice, it is often assumed that it is safer to separate cyclists from the rest of the traffic, therefore tend to prefer bicycle paths to bicycle lanes or cycling on roads that do not have bicycle facilities.

Research confirms that the *type of bicycle infrastructure* matters. Potential users prefer bicycle paths to curb lanes (Taylor and Mahmassani, 1996), and prefer bicycle paths to both bicycle lanes and roads without bicycle facilities (Wardman *et al.*, 1997; Abraham *et al.*, 2002; Stinson and Bhat, 2005; Hunt and Abraham, 2007). Comparative analyses by Pucher (2001) suggest that those countries with more cycling facilities have a higher modal split share of cycling and higher levels of bicycle safety. Preferences for particular cycling

facilities differ across socio-economic groups, and across experienced and non-experienced cyclists. Inexperienced cyclists, women and younger cyclists tend to consider bicycle facilities to be more important (Stinson and Bhat, 2003; Krizek *et al.*, 2004; Stinson and Bhat, 2005; Garrard *et al.*, 2008). For experienced cyclists, bicycle lanes are not considered to be more desirable than wide curb lanes (Taylor and Mahmassani, 1996).

The question of bicycle infrastructure is very much related to safety. We can identify two types of safety: objective and subjective safety. Objective safety is 'real' safety for cyclists, measured in terms of the number of bicycle-related incidents per million inhabitants. Subjective safety refers to how individuals perceive safety, and is mostly measured in terms of the stated safety experience of users or other respondents. These two types of safety can both correspond with and differ from one another. Klobucar and Fricker (2007) argue that the effect of bicycle infrastructure on objective safety remains unclear, but that subjective safety levels are higher when dedicated bicycle facilities are present. Petritsch *et al.* (2006) conducted research into objective cycling safety. They suggest that close to road intersections, bicycle side paths should either be close to roadways, or the speed of travel should be reduced in order to increase the likelihood of car drivers detecting the cyclist. They also suggest that side paths should be constructed for roads with speeds over 40 mph, rather than adjacent roadways, because this results in lower crash rates.

Car parking facilities can lead to more dangerous situations for cyclists, because car drivers need to cross bicycle facilities in order to park. Travelers rate roads without parking as safer than roads with adjacent parking (Stinson and Bhat, 2003, 2005). More specifically, Stinson and Bhat (2003) suggest that parking adjacent to roads is considered to be less problematic in urban or suburban areas than in rural areas, possibly because cyclists are more used to parked cars in urban or suburban areas. Not all space or infrastructure adjacent to the road, such as parking facilities, is perceived to have a negative effect on safety, however. Commuting cyclists consider the presence of a hard shoulder to be safer (Noland and Kunreuther, 1995), while Rodríguez and Joo (2004) did not find a similar effect for the absence of pavements.

Cyclists tend to prefer roads with two *lanes for motorized traffic* to four-lane roads (Petritsch *et al.*, 2006; Shankwiler, 2006). The explanation for this may be that on four-lane roads, car drivers are forced to pay greater attention to other car drivers as well as cyclists, resulting in their attention being distracted from cyclists. This could be the reason why Dill and Voros (2007) found that cyclists have a negative perception of roads with high-traffic intensities.

The second infrastructure aspect, *continuity of bicycle infrastructure* (either separate lanes or marked sections on roads where a bicycle facility is present throughout the route), is also important, because the existence of a route segment with no cycling facilities could deter some people from cycling. Stinson and Bhat (2003) expect cyclists to prefer routes with more continuous facili-

ties, and indeed find that cyclists have a negative perception of the sudden ending of a facility (Stinson and Bhat, 2005). This seems to be more important for inexperienced than for experienced cyclists, and for transportation trips as opposed to recreational trips. This latter finding might be due to the fact that recreational cyclists have greater freedom to choose their routes. Moreover, travel time is less important for recreational trips, when cycling can function as an activity in itself, rather than as a necessity. In some countries, cycling facilities can end at different locations on a road. In countries where vehicles drive on the right-hand side of the road, the ending of a facility is considered to be most acceptable if it is on the right-hand side of the road, and least acceptable if it is located on the left-hand side of the road (followed by an ending at an intersection) (Krizek and Roland, 2005). This finding is probably related to safety: if a facility ends on the left-hand side of the road, cyclists have to cross the road, which might be perceived as being dangerous. Meanwhile, inexperienced cyclists consider *cycling infrastructure facilities on bridges* to be important (Stinson and Bhat, 2005). Although Aultman-Hall *et al.* (1997) conclude that cyclists do not prefer pedestrian bridges to road bridges when selecting their routes, Stinson and Bhat (2003) suggest that cyclists do indeed prefer pedestrian bridges. Therefore, it would seem that while cyclists do have a preference for bicycle infrastructure on bridges, this does not cause them to make detours or change routes in order to use these facilities.

Third, having more *bicycle paths* has been found to result in a higher share of cycling (Barnes and Thompson, 2006; Pucher and Buehler, 2006). Constructing bicycle paths increased the bicycle share on some locations by 1–2%, compared to little increase elsewhere (Barnes and Thompson, 2006). According to Dill and Voros (2007), people tend to say that they would cycle more often if they had bicycle paths, and if these were easy to reach and well connected to useful destinations. Dickinson *et al.* (2003) also conclude that the provision of cycle paths would be popular among employees. However, Moudon *et al.* (2005) report that the presence of more bicycle infrastructure does not have a significant effect on cycling levels. This particular research was conducted in the USA, which might have influenced the results. In a number of other countries, where cycling facilities are more common, additional infrastructure might make little difference and therefore have little effect on cycling levels. Indeed, there might be a two-way relationship between the presence of bicycle infrastructure and cycling rates: the presence of infrastructure might not only result in more cycling, but a higher cycling frequency could also stimulate the construction of bicycle infrastructure.

Fourth, *stop signs, traffic lights and other traffic-controlling systems* are necessary for regulating traffic, but can also cause irritation due to delays. Stopping and accelerating cost cyclists a disproportionate amount of effort (Fajans and Curry, 2001). We can therefore expect cyclists to avoid traffic lights and stop signs (Stinson and Bhat, 2003). Rietveld and Daniel (2004) conclude that few-

er people cycle in cities that have large numbers of stops. More specifically, Stinson and Bhat (2003) find that cyclists generally avoid traffic lights when choosing a route, although according to Aultman-Hall *et al.* (1997), more traffic lights are present on the actual route than the shortest. These findings do not correspond, suggesting that cyclists dislike traffic lights, but that they might prefer to avoid route segments that are perceived in a more negative way. Another reason for the discrepancy could be a difference in research methods, namely, between stated preference and revealed preference.

Traffic control mechanisms do not always deter cyclists. Aultman-Hall *et al.* found that traffic lights are mainly used to cross major roads. Moreover, not all cyclists accord the same value to traffic control systems. Stinson and Bhat (2003) found that there is a higher tendency for cyclists in urban areas (as opposed to non-urban areas) to avoid traffic lights, and experienced cyclists tend to have a more negative perception of stop signs than inexperienced cyclists. They argue the reason is that experienced cyclists feel more confident and safer in traffic, and consider travel time to be more important. Stinson and Bhat (2003) conclude that commuters find street crossings less bothersome than other cyclists, but that crossings still have a negative effect on bicycle use. In some cases, people even prefer traffic lights or stop signs (Stinson and Bhat, 2003). When it comes to explaining such behavior, safety might play a key role. In the USA, half of all bicycle accidents between bicycles and cars occur on crossings (Hunter and William, 1995). In particular, drivers do not always notice cyclists who are travelling straight ahead at high speed. Since the presence of other road users can make cycling trips more onerous and dangerous, most studies assume that *lower speeds* and lower levels of traffic have positive effects on bicycle mode share (Pucher, 1998; Porter *et al.*, 1999; Shankwiler, 2006).

Little research has been conducted into the effect of *surface quality*. The literature that does exist suggests that older people, women and experienced cyclists attach more importance to a smooth surface (Bergström and Magnussen, 2003; Stinson and Bhat, 2003, 2005).

To conclude, in general, the results indicate that cyclists have a preference for dedicated bicycle infrastructure. Cyclists' preferences are based on subjective notions of safety. They also prefer to have access to continuous bicycle infrastructure and roads without parking. Cyclists think that stop signs and traffic lights are inconvenient. It remains unclear whether the presence and continuity of bicycle infrastructure increases bicycle mode share or cycling frequency.

Facilities at work

Since we have chosen to focus on commuting, we need to consider whether a person's decision to cycle to work might be affected by the facilities at their place of work. This section discusses bicycle and car parking, storage facilities

for clothes and the availability of showers.

Noland and Kunreuther (1995), Pucher (1998), Abraham *et al.* (2002), Dickinson *et al.* (2003), Stinson and Bhat (2004), Hunt and Abraham (2007) and Martens (2007) all find that (commuting) cyclists consider safe *bicycle parking* to be important. The strongest preference is for bike lockers, followed by bike enclosures and bike racks (Abraham *et al.*, 2002). Taylor and Mahmassani (1996) report that cyclists show similar preferences for bicycle lockers when travelling to public transport services. Not all cyclists attach the same value to parking facilities, however. Men, younger people and individuals with more expensive bicycles consider secure parking facilities to be more important (Dickinson *et al.*, 2003; Hunt and Abraham, 2007). Hunt and Abraham (2007) suggest that for people with expensive bicycles and younger people, this perception of importance is related to the relative value of their bikes.

Next to parking facilities, commuters consider the *presence of showers, changing facilities and lockers* to be important. The research findings in this area are ambiguous, however. Abraham *et al.* (2002) conclude that showers, lockers and changing facilities are important. De Geus (2007) and Hunt and Abraham (2007) also find this for showers. According to Taylor and Mahmassani (1996), however, showers do not have a significant effect, and the presence of shower facilities does not seem to result in higher frequencies of cycling to work (Stinson and Bhat, 2004). Men seem to value employers' attempts to stimulate cycling by providing facilities more highly than women (Dickinson *et al.*, 2003).

To conclude, having no facilities at work has been cited as a reason not to cycle (Moritz, 1998). When facilities are provided, people prefer safe parking over showers and lockers (Dickinson *et al.*, 2003; Hunt and Abraham, 2007). Of all parking facilities, cyclists most prefer bicycle lockers. Although cyclists apparently value having access to showers and parking facilities, the presence of such facilities does not appear to affect bicycle mode share and cycling frequency (although one should note that very little research has been undertaken in this area).

Conclusion

Similar to findings of general mode choice studies, the environment has been found to influence bicycle use. Uncertainty continues to surround the effects of many factors, however. Shorter distances, a greater mix of functions and access to good storage facilities are all factors that increase cycling share. Having a denser network layout and higher densities would seem to have a similar effect, but this remains unclear. Cyclists have a negative perception of traffic lights and stop signs, but it is unclear whether this affects frequency or mode choice. The effect of the presence of more cycling infrastructure and the extent to which this infrastructure is continuous remains an open question. Most research shows that cyclists and non-cyclists prefer to have access to cycling facilities. It remains unclear whether having separate bicycle facili-

ties actually increases objective safety, compared with non-separate forms of bicycle infrastructure.

Based on these findings, we conclude that extra research is needed into the relationship between cycling and the environment. A great deal of research into the relationship between cycling and the environment has examined cyclists' preferences. To date, however, few research studies have focused on the extent to which the built environment influences a person's decision to cycle, and even fewer studies have looked at cycling frequency. Additional research is therefore needed, preferably in the form of revealed preference research and longitudinal research. Moreover, one should note that due to low regional cycling rates only a limited number of cyclists participated some of the research studies that we surveyed. The results may well differ for regions with higher cycling rates and more participants.

2.3 Natural environment

In contrast to motorized transport, whether a person chooses to cycle is strongly determined by landscape, hilliness, weather and climate. By weather we refer to the daily weather conditions, whereas the term climate describes the weather over a 30-year period. One would expect some regions not to have attractive natural environments for cycling, while in other regions, cycling during particular seasons becomes less attractive. This section describes how landscape and weather conditions affect bicycle mode share.

Hilliness and landscape

Mode choice studies rarely consider landscape. For car users, landscape and changes in altitude change would not appear to be very important factors. We would expect to see an effect as far as cyclists are concerned, however, because the presence of slopes increases the amount of effort that cyclists need to make.

Rietveld and Daniel (2004), Rodríguez and Joo (2004), Timperio *et al.* (2006) and Parkin *et al.* (2008) all find that slopes have a negative effect on bicycle use. For example, the City of York (UK), with slopes of more than 3% on only 5% of its surface area, has a cycling share of 13.1%. The City of Bradford, meanwhile, which is characterized by steep slopes throughout its surface area, only has a cycling share of 0.8%. Moudon *et al.* (2005), however, find that slopes have no significant effect on bicycle share for all trips. This finding contradicts both what we would expect to be the case and other research findings. To explain this, Moudon *et al.* (2005) point to the fact that the personal factors covered in the study play a larger role than the environmental factors. Furthermore, most of the cyclists in Moudon *et al.*'s (2005) study were recreational cyclists, who might actually prefer cycling on hilly terrain. Anoth-

er explanation is offered by Stinson and Bhat (2005), who argue that cycling downwards might compensate for the extra effort required to cycle upwards. Stinson and Bhat (2005) also distinguish between experienced and inexperienced cyclists: the latter tend to prefer flat or hilly environments to mountainous ones, whereas the former prefer hilly environments to flat or mountainous terrains for commuting. They suggest that in addition to the above-mentioned reason, the feeling of success when reaching a summit, and having attractive surroundings could play a role. However, this preference for hilliness is probably not representative as far as the average cyclist is concerned. The importance of this last aspect, cycling in an *attractive built environment*, is also mentioned in the theoretical academic literature (Southworth, 2005), and experts acknowledge its importance in stimulating walking and cycling (Pikora *et al.*, 2003). Gatersleben and Uzzell (2007) report that being in an attractive environment is mentioned as one of the most positive aspects of cycling, although this is not statistically confirmed: Moudon *et al.* (2005), for instance, find that the presence of a park has a non-significant effect on cycling share. As suggested above, they find personal factors to be more important than environmental ones.

To conclude, the presence of slopes has a negative impact on cycling. In one study, however, experienced cyclists showed an unexpected preference for hilly environments over flat and mountainous terrains. It is unclear whether experience is the explanatory variable, or whether other related factors are also involved. It could be that the preferences of experienced American cyclists are more 'hard core' than those of the average cyclist, or of cyclists in other countries. Although policy cannot influence the number of slopes, it is interesting that an area's topography can be interpreted differently, depending on a cyclist's level of experience.

Seasons and climate

Stinson and Bhat (2004) and Guo *et al.* (2007) report that in the USA, cycling in the summer is more common than in other *seasons*. In Australia, Nankervis (1999) finds that more people cycle in summer (over 20% of all travelers) and autumn, compared with winter (less than 10% of all travelers) and spring. The exact decline in cycling during the winter differs across regions (Stinson and Bhat, 2004). Regions with low winter temperatures, such as Canada and the American North-East and Midwest, have sharper decreases in winter cycling rates than regions with milder winters. Not only do people cycle less in winter, but according to Bergström and Magnussen (2003), in Sweden, the maximum distance cycled decreases from 20 km in summer to 10 km in winter. The same study identified a similar effect for shorter distances: in summer, only 25% of people travel by car for journeys up to 3 km, whereas in winter, almost 40% (Bergström and Magnussen, 2003). One should note that seasons are not only related to weather conditions, but also to hours of *daylight*. Stin-

son and Bhat (2004) and Gatersleben and Appleton (2007) find that *darkness* has a negative effect on commuting by bicycle. In particular, women cyclists care more about the presence of daylight than men (Bergström and Magnussen, 2003; Cervero and Duncan, 2003).

Very little research has been undertaken into the impact of *climate* on cycling. Dill and Carr (2003) find that the six American cities with the lowest bicycle mode share experience, on average, over 100 days of rain a year. Three of the top six cities for cycling also have over 100 days of rain, however. With regard to another climate-related factor, temperature, Pucher and Buehler (2006) suggest that other factors play a more important role. They base this assertion on the fact that Canadians cycle more than Americans, despite the colder climate.

Weather

While climate is about conditions in the long term, weather varies from day to day, and can affect cyclists' daily decisions as a result. Precipitation – or *the chance of rain* – is often mentioned as the most negative weather aspect (Nankervis, 1999; Brandenburg *et al*., 2004 (Austria)) and as a reason of not to cycle. Women, recreational cyclists and commuters who also cycle in winter have a greater aversion to rain (Bergström and Magnussen, 2003; Brandenburg *et al*., 2004). A contrary result is presented by Cervero and Duncan (2003) (USA), who found rainfall (measured as the number of inches on the day of the trip) to have an insignificant effect on cycling. This is surprising, and in our opinion, it could be explained by the fact that rainfall can be measured in several ways: the number of rainy days, the number of inches per day, the chance of rain and so forth. As these different measurements could have different effects on cycling, it is plausible that contradictory patterns could emerge.

While cyclists consider rain to be the most negative weather aspect, a number of other weather-related factors also affect bicycle use, including *temperature*. More specifically, an increase in temperature results in higher cycling percentages (for temperatures between 8.6°C and 10.3°C) (Parkin *et al*., 2008 [UK]). Nankervis (1999) finds that cyclists perceive cold temperatures (<17°C) to be more unpleasant than hot temperatures (>30°C). Indeed, it is remarkable that temperature does influence commuters less than other cyclists (Bergström and Magnussen, 2003; Brandenburg *et al*., 2004). One reason for this could be that some commuters have little choice but to cycle; if they are dependent on travelling by bicycle, they cycle regardless of the weather conditions.

Conclusion

The natural environment has a large influence on both the decision to cycle and the frequency. Hilliness has been found to have a negative effect on cycling. Experienced cyclists actually prefer hilly environments, however, perhaps because they enjoy being challenged. Weather has a large influence on

the cycling frequency. (The chance of) rain, low temperatures and darkness result in people choosing to cycle less. Commuters are less influenced by temperature than other cyclists, implying that many people only choose to cycle for leisure purposes when the weather is pleasant. Surprisingly little is known about the effect of wind, despite that wind clearly influences the amount of effort made by the cyclist (Parkin *et al.*, 2007). Future research should focus not only on climate and weather conditions, which cannot be changed, but also on measures and facilities that might lessen the weather's negative effects.

2.4 Socio-economic factors

Commuting behavior is obviously strongly linked to personal and household characteristics. Mode choice studies have shown that there is a strong relationship between mode choice behavior and gender, income and age (see, e.g. Cervero, 2002). This section discusses the relationship between cycling and gender, age, income, vehicle ownership (both car and bicycle), a person's employment situation, household structure and several other socio-economic factors.

Socio-economic and household characteristics

Most research concludes that *men* cycle more than women (Räsänen and Summala, 1998; Banister and Gallant, 1999; Pucher *et al.*, 1999; Howard McDonald and Burns, 2001; Dickinson *et al.*, 2003; Krizek *et al.*, 2004; Rietveld and Daniel, 2004; Rodríguez and Joo, 2004; Moudon *et al.*, 2005; Plaut, 2005; Stinson and Bhat, 2005; Ryley, 2006; Dill and Voros, 2007). The reason for this does not lie in the distance travelled to work, because women tend to live closer to their places of work than men (Dickinson *et al.*, 2003). Only a few researchers did not find that men cycled more than women (namely, Witlox and Tindemans, 2004; De Geus, 2007; Wardman *et al.*, 2007). Witlox and Tindemans (2004) even found that in the active working population women cycled more than men for all trips, whereas for other, non-working age groups, they found that men cycled more. It appears that the impact of gender on cycling is country specific. In countries with low cycling rates, men tend to cycle more; while in countries with high cycling rates, such as the Netherlands and Belgium, cycling is also popular among women (Garrard *et al.*, 2008).

The relationship between cycling and *age* is also ambiguous. Pucher *et al.* (1999), Moudon *et al.* (2005), Zacharias (2005) and Dill and Voros (2007) all conclude that cycling levels decline with age. According to De Geus (2007), Wardman *et al.* (2007), Zacharias (2005) and Kitamura *et al.* (1997), however, age is not a significant factor. Elderly people are sometimes physically incapable of cycling, and they mention age as a reason not to cycle (Lohmann and Rölle, 2005). While a relationship between age and cycling evidently exists, it is unclear whether it is a universal one.

The relationship between cycling and *income* is even less clear. One would expect having a high income to have a negative impact on cycling, because at an aggregate level, having a high income results in less cycling (Pucher *et al.*, 1999; Pucher and Buehler, 2006). However, Parkin *et al.* (2008) conclude that in England and Wales, there is a link between lower incomes and a lower bicycle share for commuting. They suggest that economic deprivation may function as a proxy for crime, safe storage, bicycle availability and image issues. Pucher *et al.* (1999), Stinson and Bhat (2005) and Dill and Voros (2007) find a positive connection between income and commuting by bicycle, suggesting that people who earn more tend to cycle more often. However, Witlox and Tindemans (2004), Plaut (2005), Schwanen and Mokhtarian (2005) and Guo *et al.* (2007) report a negative relationship between cycling and income; while according to Dill and Carr (2003) and Zacharias (2005), income has no significant effect.

The relationship between a person's income and cycling thus remains unclear. This unclear relationship may stem from two potential consequences of having a higher income. In our view, on the one hand, having a higher income enables a person to spend money on a bicycle, which in turn increases bicycle use. This particularly applies to those countries in which people do not, as a rule, tend to own bicycles; Pucher and Buehler (2008) point out that the USA falls into this category. Moreover, wealthy people may also pay greater attention to their health, and therefore cycle more. On the other hand, having a high income implies that one is able to spend more money on transport in general, including buying a car (Witlox and Tindemans, 2004). *Car ownership* has a strong negative effect on cycling mode share (Cervero, 1996; Kitamura *et al.*, 1997; Banister and Gallant, 1999; Stinson and Bhat, 2004, 2005; Plaut, 2005; Pucher and Buehler, 2006; Dill and Voros, 2007; Guo *et al.*, 2007; Parkin *et al.*, 2008). Stinson and Bhat (2004) conclude that having fewer cars increases cycling frequency. Some cite needing a car for their work as a reason for not commuting by bicycle (Moritz, 1998). As car ownership results in less cycling, *bicycle ownership* logically increases the probability of individuals cycling.

A person's *employment status* affects bicycle use. Among employed individuals, part-time workers commute more frequently to work by bicycle than full-time workers (Boumans and Harms, 2004), perhaps because they tend to live closer to their work. *Household structure* also influences the chance that an individual cycles. Compared with an average of 6.4%, Ryley (2006) found that individuals without children (16%), students (17.9%), those in-between jobs (11%) and part-time workers without children (8.1%) are more likely to cycle, as are people who work fewer than 40 hours a week, or who are divorced or widowed (Moudon *et al.*, 2005). Having a high social status and having a young family reduces the probability of cycling (Moudon *et al.*, 2005; Ryley, 2006).

A number of additional personal characteristics increase the probability of cycling; *being physically active*, for example, increases the chance that an individual cycles. In the Netherlands, meanwhile, *native Dutch* people cycle more.

On the whole, highly educated people cycle less (Rietveld and Daniel, 2004; Moudon *et al*., 2005; Plaut, 2005; De Geus, 2007; Parkin *et al*., 2008).

Conclusion

There is a relationship between socio-economic factors and cycling, but we lack clarity on both the direction of this relationship, and its causality. The evidence for the relationship between cycling, age and income is mixed.

Most of the research discussed above simply uses survey results to draw links between socio-economic factors and cycling. The research tends not to examine whether these are causal relationships, meaning that we are unable to draw any conclusions in this respect. Moreover, large differences exist between different countries, perhaps due to the impact of differences in countries' social and built environments, and economic circumstances. Based on these findings, we think that future research should avoid focusing too heavily on socio-economic factors, because in our opinion, the relationship between certain socio-economic factors and cycling mainly results from other non-tested factors. This is indicated, for example, by the significant differences between countries. Social values and attitudes may play a key role in this respect, and it is to these that we turn in the next section.

2.5 Psychological factors: attitudes, social norms and habits

Recent research has focused on the effect of attitudes and other psychological factors on travel behavior and mode choice. This section examines what is currently known about the impact of psychological factors on cycling. We consider attitudes, norms, perceived behavioral control and habits. The second part of this section discusses people's perceptions of what makes it possible to, and prevents them from, cycling to work. This section is structured differently from the previous sections, on the grounds that research into psychological constructs tends to be more theoretical. We thus discuss the research findings in relation to theory.

Attitudes and social norms

Attitudes play a key role in two theories that have been applied in mode choice research studies: namely, the theory of planned behavior (TPB) (Ajzen, 1991) and the theory of interpersonal behavior (TIB) (Triandis, 1980, 1997). An attitude can be defined as the expectation of all the outcomes of an activity, and the personal value of these outcomes. People's attitudes towards car use are generally more positive than people's attitudes towards cycling (Dill and Voros, 2007). Moreover, Dill and Voros show that having a positive attitude towards cycling increases the likelihood of commuting by bicycle. It is not only

cyclists who tend to be more positive about cycling; Gatersleben and Appleton (2007) find that people who are considering cycling to work are also more positive about cycling than others, with 56% saying that they liked cycling compared to 34%. The importance that individuals attach to aspects such as the health-related benefits of cycling also has an impact on cycling for commuting purposes (Gatersleben and Appleton, 2007). Having a negative perception of the consequences of car use also stimulates cycling (Stinson and Bhat, 2005).

According to the TPB, not only personal attitudes, but also perceived social norms are key factors affecting decision-making. Social norms can be defined as norms held by a society, or by smaller groups, which influence and regulate behavior by functioning as informal social controls. People may also adapt their behavior in line with a norm, so as to fit in with a certain group. When applying the TPB to the case of people cycling to a university, Bamberg and Schmidt (1994) found that social norms had no significant impact. However, De Bruijn *et al*. (2005) found that cyclists experience a more positive social norm than non-cyclists (a correlation between subjective norm and intention of 0.33). De Geus (2007), meanwhile, concludes that cyclists perceive more support for cycling, and more often have a cycling partner. These findings indicate that social norms do indeed play an important role. It is assumed that there is a relationship between other social aspects, such as cycling's public image and the general attitude to cycling within a particular country or region's culture and bicycle use (Pucher *et al*., 1999). Indeed, Dill and Voros (2007) provide evidence for this relationship: if an individual's coworkers cycle to work, then it is more likely that the individual will cycle as well. Furthermore, according to De Geus (2007), if employers offer financial support for cycling, which can be seen as evidence of a positive attitude towards cycling, then there is a higher chance that the recipient will be a cyclist.

Altruistic and ecological beliefs also influence mode choice. Individuals with more deeply held environmental beliefs make more frequent use of public transport, and the same is probably true for non-motorized forms of transport (Hunecke *et al*., 2001). In general, users of public transport, physically active people, people who have strong preferences for out-of-home self-realization, those with good access to public transport, retail and services and those living in urban environments are more likely to use non-motorized transport (Moudon *et al*., 2005; Scheiner and Holz-Rau, 2007).

Perceived behavioral control

A third aspect of the TPB is perceived behavioral control; that is, a person's evaluation of the possibility of performing certain behavior. Gatersleben and Appleton (2007) and De Geus (2007) show that individuals who do not commute by bicycle perceive more barriers to commuting by bicycle than bicycle commuters. Bamberg and Schmidt (1994), meanwhile, show that compared to non-cyclists, cyclists perceive more possibilities for cycling.

Habits

Both the TPB and the TIB and, indeed, most of the studies reviewed are at least partly based on the assumption that decisions are made on the basis of rational evaluation. The existence of habits, however, puts the validity of this assumption into question. Looking at repetitive behavior, Bamberg and Schmidt (2003) found that respondents do not take every factor into consideration when making a decision. Meanwhile, Verplanken *et al.* (1997) show that people investigate less information about their choice, in case a habit exists.

The process of breaking a habit might result in mode reconsideration and possibly mode change. For example, simply experiencing what it is like to commute by bicycle to work may persuade some people to change commuting modes (Rose and Marfurt, 2007). Also cycling more in one's free time results in a higher frequency of bicycle use for commuting (Stinson and Bhat, 2004). Stinson and Bhat also conclude that cycling to work over a long period of time results in higher frequencies. Moreover, bicycle use during childhood can affect adult cycling behavior. Cycling as a child increases the likelihood of cycling as an adult (Dill and Voros, 2007). Surprisingly, however, there is no evidence of a relationship between adult bicycle use and having cycled to school as a child. Not only do individuals' cycling habits affect their cycling behavior, but Verplanken *et al.* (1997) and Ministry of Transport, Public Works and Water Management (2004) also suggest that being in the habit of using other modes of transport has a negative impact on bicycle use.

Reasons for (not) cycling

Respondents cite many reasons for (not) cycling. The reasons given for cycling include: health reasons, exercise/fitness, fun, flexible, convenient and enjoyment of attractive scenery (Bergström and Magnussen, 2003; Stinson and Bhat, 2004; Ryley, 2006; Gatersleben and Appleton, 2007; Gatersleben and Uzzell, 2007). As Gatersleben and Appleton (2007) found when they questioned novice cyclists, some of these reasons (namely, fitness, fun and being outside) were cited before the individuals in question had tried their commutes. These individuals were later a little disappointed by the experience. On the other hand, novice cyclists found that some of the factors that they had expected to be negative, such as traffic safety, proved to be more positive in practice. Overall, compared to car drivers, walkers and public transport users, cyclists evaluate their journeys to work as more relaxing and exciting (Gatersleben and Uzzell, 2007).

Questionnaire respondents and experts identify a number of cycling's more negative aspects as reasons not to cycle. These include: too dangerous, too much traffic, bad weather, personal factors (too busy), lack of daylight, inconvenience, lacking sufficient fitness, uncomfortable, lack of time, being tired, too much effort, the bicycle being an uncharacteristic transportation mode and difficulties with trip-chaining (Noland and Kunreuther, 1995; Dickinson *et al.*, 2003; Stinson and Bhat, 2004; Gatersleben and Appleton, 2007; Gatersle-

ben and Uzzell, 2007; Wardman *et al*., 2007). Not being able to cycle obviously decreases the likelihood of cycling (Wardman *et al*., 2007). As Dickinson *et al*. (2003) have found, some factors are more important for specific groups. Women, in particular, cite the difficulty of combining a journey with picking up children or shopping as a reason for not cycling.

Remarkably, some factors are mentioned as both advantages and disadvantages: 'convenience', for example, occurs on both lists. In our opinion, this might be a reflection of either of the breadth of the term, or the fact that when it comes to cycling, cyclists and non-cyclists have different notions of 'convenience'.

Conclusion

Attitudes, social norms and habits influence a person's decision to cycle to work. If a person has a more positive attitude towards cycling, there is a higher probability that they will cycle. The existence of habits, however, means that people do not always select modes of transport once they have rationally evaluated all of the potential outcomes. Habits can affect mode choice and frequency: if a person is used to using a certain form of transport, they are unlikely to search for new options. As a result, some modes of transport, such as the bicycle, are not taken into consideration. When it comes to commuting, one would expect the same factors to be significant as for cycling in general, with the additional influence of being in the habit of cycling in one's free time affecting mode choice for commuting.

Many questionnaires probe why people decide to (not) travel by bike. It is unclear, however, whether these attitudes are a result of (not) cycling, or whether (not) cycling is a result of holding such attitudes.

Current research suggests that attitudes and norms are very influential when it comes to cycling to work. Only a limited amount of research has so far been conducted into the relationship between attitudes, norms and cycling, however. Given that the existing research adds a great deal to the explanatory power of the models used, it would seem to be the case that attitudes play a more significant role than has been assumed in most research to date. We therefore recommend that more specific research should be undertaken into bicycle commuting, using psychological theories.

2.6 Cost, travel time, effort and safety

Cost, time and effort are aspects that can be derived from utility theory. Utility theory assumes that each individual acts to maximize his or her utility. When applied to mode choice, utility theory assumes that an increase in the time, cost and effort of a travel option will result in a decrease in the probability that this option will be chosen. In this section, we focus on how cost, travel time, effort and safety affect cycling mode choice and frequency.

Safety

Safety is often mentioned as a reason not to cycle. If there is a heightened risk of having an accident, the assumption is that people will cycle less (Pucher *et al.*, 1999; Rietveld and Daniel, 2004; Lohmann and Rölle, 2005; Southworth, 2005; Pucher and Buehler, 2006). Not only is objective safety an important factor, but subjective safety may also play a critical role (see Infrastructure in Section 2.2). It appears that people remember what they perceive to be dangerous route segments better than 'normal' route segments (Shankwiler, 2006). Not all people have similar perceptions of what it means to be safe. For example, safety seems to be less important for people with high incomes (Johansson *et al.*, 2005), and for men than for women (15.9% and 10% (depending on the city) for men, compared to 4.6% and 3.9% for women) (Lohmann and Rölle, 2005). Importantly, all respondents thought that cycling was less safe than walking, driving a car or using public transport, but cyclists gave the highest rating for bicycle safety.

Transportation costs

Transportation costs affect mode choice. Cycling is relatively cheap, and according to Bergström and Magnussen (2003), this is one reason why commuters choose to cycle. Not only is the cost of cycling important, but the cost of other forms of transport also plays role (Noland and Kunreuther, 1995; Rietveld and Daniel, 2004; Rodríguez and Joo, 2004; Pucher and Buehler, 2006). Pucher and Buehler (2006) discovered a relationship between bicycle use, petrol prices, income and car use when comparing data from the USA and Canada. One should note, though, that Dill and Carr (2003) did not find a similar pattern for petrol prices within the USA. In our opinion, petrol prices do probably affect people's choices, but the relatively minor differences between different states do not show this effect. Bamberg *et al.* (2003) has identified another cost-related effect: namely, providing free public transport reduces bicycle use. Paying people to cycle, however, would have a positive effect on cycling levels: research suggests that if people in Britain were to receive two pounds each day they cycled to work, the level of cycling would almost double (Wardman *et al.*, 2007). Offering people loans to buy bicycles would not be a popular option; however, only 7% of respondents indicated that this would encourage them to cycle (Dickinson *et al.*, 2003).

Travel time and effort

Travel time and effort also influence bicycle use. In particular, experienced cyclists prefer short travel times (Stinson and Bhat, 2005; Hunt and Abraham, 2007). Travel time by bicycle is even considered to be three times more unpleasant than travel time for other modes (Wardman *et al.*, 2007). The perceived convenience of a trip declines with an increase in the travel time, which is not the case for other modes of transport (Noland and Kunreuther, 1995). More-

over, an increase in the travel time may result in having to expend more effort. Since having to make a greater effort generally results in having a less positive attitude to cycling (Gatersleben and Uzzell, 2007), longer travel times and having to expend more effort would logically lead to less cycling. One should note that some cyclists choose to cycle precisely because of the effort needed (e.g. those interested in sports or maintaining their health), and they may even prefer slightly longer commuting distances. As with safety, cyclists attach the highest value to cycling's comfort level (Noland and Kunreuther, 1995), although the relationship between cause and effect here is unclear.

Conclusion

The cost, travel time, effort needed and safety of a trip are important for cyclists. All four aspects appear to affect mode choice. These four aspects should always be considered in relation to other transport modes, as the example of cost makes clear: if another mode of transport becomes more expensive, then levels of cycling increase. Little is known about the effect on cycling frequency, however.

Not only the real value, but also the perceived value of cost, time and effort is important for people's decisions with regard to mode choice. Safety is a good example in this respect. Cyclists give cycling a higher safety value than non-cyclists, which could in turn reflect the different ratings used by different transportation users, or could result from different experiences. Based on these findings, we suggest that future research should thus focus on both subjective and objective values.

2.7 Conclusion

Summary of the results

From the perspective of society, cycling offers a number of interesting advantages over other forms of transport. There are thus many reasons to encourage cycling, and in recent years, governments and academic researchers have renewed their interest in the topic. In order to develop policies that encourage cycling, we need a better understanding of the factors that influence cycling behavior. Empirical knowledge on bicycle use is dispersed, however, and it was for this reason that we conducted this literature study. Our aim was to identify the determinants for commuting by bicycle, and for bicycle commuting frequency. We think that our findings enhance not only our understanding of commuting, but also other forms of 'functional' travel. They are not necessarily relevant to recreational cycling, however.

We set out our most important findings in Table 2.1 (page 42-45, see also Appendices 2.1 and 2.2 of this chapter). As detailed in the table, the key evidence to emerge from the literature is as follows:

- The built environment affects a person's choice to commute by bicycle. Cycling share is influenced by the following factors: distance, function mixture, storage facilities, block size and density, the presence of bicycle infrastructure and its continuity, traffic lights and stop signs, land use, parking facilities and showers at work. Of these, distance is probably the most important factor.
- A climate with moderate temperatures and little rain increases the share of bicycle commuting. Bad and uncertain weather negatively affects a person's decision to cycle.
- The relationship between socio-economic factors and cycling is unclear. Certain socio-economic aspects differ between countries. In most countries, men cycle more than women. In those countries in which cycling is very common, such as Belgium and the Netherlands, women cycle more.
- Car ownership has a negative effect on cycling; logically, bicycle ownership has a positive effect.
- Most research merely mentions or examines the relationship between socio-economic factors and cycling, but does not allow us to make any inferences about the causality of this relationship.
- There is a relationship between commuting by bicycle and people's attitudes and perceived values. More cycling may result from positive perceptions of cycling or negative perceptions of car use. If the individual's social surroundings have a positive opinion of cycling, then there is a higher chance that the individual in question will cycle.
- It is thought that individuals sometimes decide whether or not to commute by bicycle by comparing cycling with other transport options, in terms of cost, travel time and safety. Negative factors relating to car use or public transport could lead individuals to develop a more favorable view of cycling.
- Travel time and safety seem to be more important for cycling than for other modes of transport.

Since most research only considers a few of the factors listed above, it is not yet clear which factors most strongly influence bicycle use. When it comes to mode choice, however, 'attitude' appears to be one factor that has particular explanatory power. This is clear from the fact that all of the research studies on attitude that we surveyed identified a connection between cycling and psychological factors. Moreover, every one of the few studies that considered multiple factors identified attitude as being very influential. Other important factors include distance, costs and travel time of the journey. Weather conditions affect mainly the frequency of commuting. Policy-makers will be able to use the insights obtained from this overview to determine which actions and policies will be most appropriate for their policy contexts, and use the arguments presented to underpin them. On the whole, this overview should enable policy-makers to put a better case for taking particular courses of action.

Table 2.1 Main findings

Determinants	Influence	
	Mode choice	**Frequency**
trip distance	increase results in less cycling (according to 27% of non-cyclists, compared with 2% of cyclists)	
network layout	no significant effect on cycling	
density	higher density corresponds with more cycling	people living closer to the city/town centre cycle more (decrease from 56% to 46% of non-cyclists closer to the centre)
	residential densities have no effect	
function mixture	higher density increases bicycle share	people living close to the city/town centre cycle more
cycling infrastructure		
adjacent car parking		
continuity of cycling facilities		
number of bicycle paths	more cycling infrastructure results in more cycling (increase of 1-2%, but probably depending on location)	
		no effect
traffic lights	more traffic lights in a city corresponds with lower cycling levels	
hilliness	less cycling with hills	
	no significant effect on cycling	
bicycle parking		
shower at work	if present more cyclists	
	no effect	no effect
locker at work		
season	more cycling in summer and autumn (20% to 10%; 40% to 25%; differs between locations)	
temperature	unpleasant temperature corresponds with less cycling;	unpleasant temperature corresponds with less cycling
	cold more unpleasant than heat	
rain	negative effect on cycling	
	no effect	
gender	men cycle more than women	men cycle more than women
	no effect	
	women cycle more than men	

Preference	Reference(s)
	Parkin *et al.* (2007); Timperio *et al.* (2006); Stinson and Bhat (2004); Dickenson *et al.* (2003)
	Moudon *et al.* (2005); Zacharias (2005)
	Parkin *et al.* (2008); Guo *et al.* (2007); Dill and Voros (2007); Zahran *et al.* (2008)
	Rodríguez and Joo (2004)
	Litman (2007); Pikora *et al.* (2003); Pucher and Buehler (2006); Dill and Voros (2007)
preference for separate facilities (safety-related)	Hunt and Abraham (2007); Stinson and Bhat (2005); Abraham *et al.* (2002); Taylor and Mahmassani (1996); Garrard *et al.* (2008)
experienced cyclists express no preferences for bicycle lanes and wide curb lanes	
females have greater preference for cycling facilities	
roads with no parking perceived to be safer	Stinson and Bhat (2003; 2005)
preference for continuous facilities	Stinson and Bhat (2003; 2005)
	Barnes and Thompson (2006); Pucher and Buehler (2006)
	Moudon *et al.* (2005)
experienced cyclists perceive them more negatively	Rietveld and Daniel (2004); Stinson and Bhat (2003)
	Stinson and Bhat (2003); Rietveld and Daniel (2004); Rodríguez and Joo (2004); Parkin *et al.* (2008); Hunt and Abraham (2007)
	Moudon *et al.* (2005)
is important to cyclists	Noland and Kunreuther (1995); Abraham *et al.* (2002); Dickenson *et al.* (2003); Stinson and Bhat (2004); Martens (2007); Wardman *et al.* 1997)
bicycle locker mostly preferred	Abraham *et al.* (2002); Taylor and Mahmassani (1996)
important to cyclists	De Geus (2007); Hunt and Abraham (2007); Abraham *et al.* (2002)
	Taylor and Mahmassani (1996); Stinson and Bhat (2004)
important to cyclists	Abraham *et al.* (2002)
	Stinson and Bhat (2004); Guo and Bhat (2007)
less influential for commuting; more influence on women	Bergström and Magnussen (2003); Brandenburg *et al.* (2004);
	Nankervis (1999)
mentioned by cyclists as most negative weather aspect	Nankervis (1999); Brandenburg *et al.* (2004)
	Cervero and Duncan (2003)
	Räsänen and Summala (1998); Banister and Gallant (1999); Pucher *et al.* (1999); Howard McDonald and Burns (2001); Dickinson *et al.* (2003); Krizek *et al.* (2004); Rietveld and Daniel (2004); Rodríguez and Joo (2004); Moudon *et al.* (2005); Plaut (2005); Ryley (2006); Dill and Voros, (2007)
	De Geus (2007); Wardman *et al.* (2007)
	Witlox and Tindemans (2004) >>

Table 2.1 Main findings (continuation)

Determinants	Influence	
	Mode choice	**Frequency**
age	cycling declines with increase	
	age is not significant	
income	positive connection between income and cycling	
	negative connection	
	no significant connection	
employment status		part-time workers commute more frequently by bicycle
car ownership	car ownership decreases cycling	car ownership decreases cycling
	car ownership has no effect	
attitude	cyclists have a more positive attitude towards cycling	
perceived social norm	cyclists have a higher perceived social norm	
	no effect on being a cyclist	
habit	a cycling habit increases the cycling share	a cycling habit increase the cycling frequency
safety	a reason not to cycle	
cost of other means of transportation	if higher, more cycling	
travel time		

Finally, it is remarkable that to date, few studies have focused specifically on commuting by bicycle. Much of the research surveyed focuses either on bicycle use in general, or on commuting in general, and pays only limited attention to the bicycle as a means of transporting individuals to work. A few of the studies surveyed are also based on original data; and in this regard, it is also notable that in what can be very large mode choice studies, factors relating specifically to bicycle use are frequently not included.

Discussion

In this section, we discuss the following three issues: (1) transferability, (2) the need to differentiate between mode choice in general and daily choice (frequency), and (3) the issue of self-selection.

We should exercise particular care when transferring research findings on bicycle use to different contexts. There are four key reasons for this. First, as suggested above, general mode choice studies and models often neglect bicycle-specific factors, such as weather or cycling facilities. Second, the number of cyclists participating in even the largest mode choice studies can be negli-

Preference	Reference(s)
	Pucher *et al.* (1999); Moudon *et al.* (2005); Zacharias (2005); Dill and Voros (2007)
	Zacharias (2005); De Geus (2007); Wardman *et al.* (2007); Kitamura *et al.* (1997)
	Pucher *et al.* (1999); Stinson and Bhat (2005); Dill and Voros (2007)
	Witlox and Tindemans (2004); Plaut (2005); Schwanen and Mokhtarian (2005); Guo *et al.* (2007)
	Dill and Carr (2003); Zacharias (2005)
	Boumans and Harms (2004)
	Cervero (1996); Kitamura *et al.* (1997); Banister and Gallant (1999); Stinson and Bhat (2004; 2005); Plaut (2005); Pucher and Buehler (2006); Dill and Voros (2007); Guo *et al.* (2007); Parkin *et al.* (2008); Stinson and Bhat (2004)
	Moudon *et al.* (2005)
	Dill and Voros (2007); Gatersleben and Appleton (2007)
	De Bruijn *et al.* (2005)
	Bamberg and Schmidt (1994)
	Verplanken *et al.* (1997); Ministerie van Verkeer en Waterstaat (2004); Stinson and Bhat (2004)
subjective safety does not always correspond with objective safety	Pucher *et al.* (1999); Rietveld and Daniel (2004); Lohmann and Rölle (2005); Southworth (2005)
	Noland and Kunreuther (1995); Rietveld and Daniel (2004); Pucher and Buehler (2006)
experienced cyclists prefer short travel time	Stinson and Bhat (2005); Hunt and Abraham (2007)

gible, due to low cycling rates. Third, there are significant variations in bicycle use and attitudes towards cycling. In many European countries, the bicycle is used for daily transportation, including commuting, shopping and carrying children. In the USA, by contrast, the bicycle is mainly used for leisure purposes. Furthermore, we encounter differences in economic status: in some social contexts, it is seen as inappropriate to use a bicycle for business and commuting purposes, whereas in other settings, using the bicycle for all purposes is much more acceptable. Another factor relates to the enormous contextual differences in topography, the built environment and infrastructure (i.e. the availability of bicycle paths and facilities). There are also (cultural) differences when it comes to subjective perceptions of safety, and the degree to which other road users accept sharing the road with cyclists. Fourth, when transferring research results, it is necessary to pay close attention to differences in research methods. For example, research studies that are grounded in utility theory tend to assess the economic effects of certain factors, and assume that individuals make rational decisions. Factors that cannot be expressed in economic terms are often neglected as a result, while it is difficult to include

beliefs and attitudes. The overall picture that emerges is thus different from the outcomes of studies that take 'softer' factors into account.

Second, in this discussion we draw attention to the relationship between frequency and mode choice. Relatively few research studies into daily mode choice have taken into account the fact that individuals may vary their modes (represented by various frequencies). However, this paper has shown that daily choice is (more) influenced by other factors (e.g. the weather) than the inclusion of cycling in the choice set. Future research should therefore distinguish clearly between daily mode choice and the main mode of travel.

Finally, we need to take self-selection into account: namely, both residential self-selection and self-selection for research. By 'residential self-selection', we mean the notion that bicycle travel is not only influenced by residential location (people cycle more in bicycle-friendly environments), but that households also choose their particular locations because they intend to cycle, and therefore they choose a bicycle-friendly environment. 'Self-selection for research', meanwhile, refers to the fact that individuals who are more pro-bicycle tend to be more willing than the average person to take part in a bicycle survey.

Research gaps

As suggested above, many bicycle research studies only examine a limited number of factors. We need a more comprehensive approach to bicycle research in order to obtain better insights into the effects of the many determinants of bicycle mode choice and frequency, thereby better equipping policy-makers to encourage cycling. Contrary to conventional mode choice studies, this research should include bicycle-specific factors, such as slope, weather conditions and bicycle-specific infrastructure.

We still do not know how some factors influence bicycle use. The effect of certain aspects of the built environment, such as bicycle infrastructure facilities, or weather aspects such as wind, on bicycle mode choice remains unclear. In addition, either no or very little research has been carried out into certain factors that one would assume to have an effect, such as the presence of traffic lights and stop signs, and pavement quality.

We know relatively little when it comes to specific determinants for cycling frequency. We also need to know more about the presence and the extent of the effect of the built environment, psychological factors and the weather on cycling frequency. To obtain more insights into the relationship between cycling frequency and such factors, data on mode choice need to be gathered over a long period of time. We also need to examine the reasons for mode choice, as this will provide us with insights into daily mode choice decisions. Undertaking longitudinal research would allow one to investigate this causal relationship, and such research is clearly needed, on the grounds that people find it difficult to state their daily choices over long time periods. Moreover, conducting longitudinal research would allow one to detect the most

important factors at the level of the individual. Longitudinal research is therefore needed in order to examine determinants for daily choices and therefore cycling frequency.

While research has been conducted into bicycle mode choice in some countries (such as the UK), and these studies have looked at a relatively large number of possible factors influencing mode choice, such studies are lacking for other countries. In order to gain better insights into the transferability of knowledge (see Discussion in Section 2.7), bicycle research should be conducted across a wider range of countries. Bicycle infrastructure is an example of one factor that could be studied in this way. Since most studies surveyed in this paper originate from the USA, studying other countries' infrastructure may offer a more nuanced picture of the effect of infrastructure on bicycle use.

Current bicycle research focuses heavily on the preferences of cyclists and of other respondents. Indeed, it would be logical to assume that cycling preferences correspond with the determinants of bicycle mode share and frequency. However, this assumption has not always been shown to be true. The process of feeding our knowledge about people's cycling preferences into planning decisions would undoubtedly be more effective if we were to have better insights into how these preferences can influence mode choice and bicycle frequency, and this should thus be included in any comprehensive research study.

Finally, we suggest that attitudes play a more significant role in mode choice than has so far been assumed. From current research, it would appear that individuals in identical situations and in the same socio-economic groups choose to commute using different transport modes. This implies that an individual will base his or her choice not on an objective situation, but on their perception of that situation; their eventual decision is thus also grounded in internal factors. Factors such as attitudes and social opinions should thus be considered as main contributors to this decision-making process. In future, comprehensive research into commuting by bicycle should thus focus on attitudes and people's social environments.

Acknowledgements
We would like to thank three anonymous reviewers for their comments on a draft version of this paper.

References

Abraham, J.E., McMillan, S., Brownlee, A.T. and Hunt, J.D. (2002), *Investigation of Cycling Sensitivities*, Washington, D.C. (Transportation Research Board).

Ajzen, I. (1991), The theory of planned behavior, *Organizational Behavior and Human Decision Processes,*50 (2), pp. 179-211.

Aultman-Hall, L., Hall, F.L. and Baetz, B.B. (1997), Analysis of bicycle commuter routes using geographic information systems: implications for bicycle planning, *Transportation Research Record, 1578*, pp. 102-110.

Bamberg, S. (2006), Is a residential relocation a good opportunity to change people's behavior? Results from a theory-driven intervention study, *Environment and Behavior, 38* (6), pp. 820-840.

Bamberg, S., Ajzen, I. and Schmidt, P. (2003), Choice of travel mode in the theory of planned behavior: the roles of past behavior, habit, and reasoned action, *Basic and Applied Social Psychology, 25* (3), pp. 175-187.

Bamberg, S. and Schmidt, P. (1994), Auto oder Fahrrad? Empirischer Test einer Handlungstheorie zur Erklärung der Verkehrsmittelwahl [Car or bike? Empirical test of a theory of action to explain the modal choice], *Kölner Zeitschrift für Soziologie und Sozialpsychologie, 46* (1), pp. 80-102.

Bamberg, S. and Schmidt, P. (2003), Incentives, morality, or habit? Predicting students' car use for university routes with the models of Ajzen, Schwartz and Triandis, *Environment and Behavior, 35* (2), pp. 264-285.

Banister, C. and Gallant, N. (1999), Sustainable commuting: a contradiction in terms? *Regional Studies: Journal of the Regional Studies Association, 33* (3), pp. 274-280.

Barnes, G. and Thompson, K. (2006), *A Longitudinal Analysis of the Effect of Bicycle Facilities on Commute Mode Share*, Washington, D.C. (Transportation Research Board).

Bergström, A. and Magnussen, R. (2003), Potential of transferring car trips to bicycle during winter, *Transportation Research Part A, 37*, pp. 649-666.

Bernhoft, I. M. and Carstensen, G. (2008), Preferences and behavior of pedestrians and cyclists by age and gender, *Transportation Research Part F, 11* (2), pp. 83-95.

Boumans, A. and Harms, L. (2004), *Part-time employment and travel patterns of women in the Netherlands*. Paper presented at Conference on Research on Women's Issues in Transportation, Chicago, IL, 18-20 November.

Brandenburg, C., Matzarakis, A. and Arnberger, A. (2004), The effects of weather on frequencies of use by commuting and recreation bicyclists, in: A. Matzarakis, C.R. De Freitas and D. Scott (Eds), *Advances in Tourism Climatology, Vol. 12*, pp. 189-197, Freiburg (Berichte des Meteorologischen Instituts der Universität Freiburg).

Cervero, R. (1996), Mixed land-uses and commuting: evidence from the American housing survey, *Transportation Research Part A, 30* (5), pp. 361-377.

Cervero, R. (2002), Built environments and mode choice: toward a normative framework, *Transportation Research Part D: Transport and Environment, 7* (4), pp. 265-284.

Cervero, R. and Duncan, M. (2003), Walking, bicycling, and urban landscapes: evidence from the San Francisco Bay Area, *American Journal of Public Health, 93* (9), pp. 1478-1483.

Cervero, R. and Radisch, C. (1996), Travel choices in pedestrian versus automobile oriented neighborhoods, *Transport Policy, 3* (3), pp. 127-141.

Chen, C. and McKnight, C.E. (2007), Does the built environment make a difference? Additional evidence from the daily activity and travel behavior of homemakers living in New York City and suburbs, *Journal of Transport Geography, 15* (5), pp. 380-395.

Crane, R. (2000), The influence of urban form on travel: an interpretive review, *Journal of Planning Literature, 15* (1), pp. 3-23.

De Bruijn, G.-J., Kremers, S.P.J., Schaalma, H., van Mechelen, W. and Brug, J. (2005), Determinants of adolescent bicycle use for transportation and snacking behavior, *Preventive Medicine, 40* (6), pp. 658-667.

De Geus, B. (2007), *Cycling to work: psychosocial and environmental factors associated with cycling and the effect of cycling on fitness and health indexes in an untrained working population*. Doctoral dissertation, Brussel (Vrije Universiteit Brussel, Department of Human Physiology and Sports Medicine).

Dickinson, J.E., Kingham, S., Copsey, S. and Hougie, D.J.P. (2003), Employer travel plans, cycling and gender: will travel plan measures improve the outlook for cycling to work in the UK?, *Transportation Research Part D, 8* (1), pp. 53-67.

Dill, J. and Carr, T. (2003), *Bicycle Commuting and Facilities in Major US Cities: If You Build Them, Commuters will Use Them—Another Look*, Washington, D.C. (Transportation Research Board).

Dill, J. and Voros, K. (2007), *Factors Affecting Bicycling Demand: Initial Survey Findings from the Portland Region,* Washington, D.C. (Transportation Research Board).

El-Geneidy, A., Krizek, K.J. and Iacono, M. (2007), *Predicting Bicycle Travel Speeds Along Different Facilities Using GPS Data: A Proof of Concept Model*, Washington, D.C. (Transportation Research Board).

Emmerson, P., Ryley, T.J. and Davies, D.G. (1998), The impact of weather on cycle flows, *Traffic Engineering and Control, 39* (4), pp. 238-243.

Enserink, M. (2007), Vélib: de zomerhit van 2007 [Velib: the summer hit of 2007], *Fietsverkeer, 17*, pp. 16-19.

Ewing, R. and Cervero, R. (2001), Travel and the built environment: a synthesis, *Transportation Research Record, 1780*, pp. 87-114.

Fajans, J. and Curry, M. (2001), Why bicyclists hate stop signs, *Access, 9* (18), pp. 28-31.

Frank, L., Bradley, M., Kavage, S., Chapman, J. and Lawton, T.K. (2008), Urban form, travel time and cost relationships with tour complexity and mode choice, *Transportation, 35* (1), pp. 37-54.

Garrard, J., Rose, G. and Lo, S.K. (2008), Promoting transportation cycling for women: the role of bicycle infrastructure, *Preventive Medicine, 46* (1), pp. 55-59.

Gatersleben, B. and Appleton, K.M. (2007), Contemplating cycling to work: attitudes and perceptions in different stages of change, *Transportation Research Part A, 41* (4), pp. 302-312.

Gatersleben, B. and Uzzell, D. (2007), Affective appraisals of the daily commute: comparing perceptions of drivers, cyclist, and users of public transport, *Environment and Behavior, 39* (5), pp. 416-431.

Guo, J.Y., Bhat, C.R. and Copperman, R.B. (2007), *Effect of the Built Environment on Motorized and Non-Motorized Trip Making: Substitutive, Complementary, or Synergistic?*, Washington, D.C. (Transportation Research Board).

Hossain, Q.S., Botma, H., Vandebona, U. and Kiyota, M. (2003), *Acceptable Access Distance to Bicycle Parking Facilities*, Washington, D.C. (Transportation Research Board).

Howard McDonald, C. and E.K. Burns (2001), *Cycling to Work in Phoenix: Route Choice, Travel Behavior, and Commuter Characteristics*, Washington, D.C. (Transportation Research Board).

Hunecke, M., Blöbaum, A., Matthies, E. and Höger, R. (2001), Responsibility and environment: ecological norm orientation and external factors in the domain of travel mode choice behavior, *Environment and Behavior, 33* (6), pp. 830-852.

Hunt, J.D. and Abraham, J.E. (2007), Influences on bicycle use, *Transportation, 34*, pp. 453-470.

Hunter, W. and William, W. (1995), *Bicycle–Motor Vehicle Crash Types: The Early 1990s, Washington, D.C.* (Transportation Research Record).

Iacono, M., Krizek, K. and El-Geneidy, A. (2008), *How Close is Close Enough? Estimating Accurate Distance Decay Functions by Purpose and Modes*, St. Paul, MN (Minnesota Department of Transportation).

Johansson, M.V., Heldt, T. and Johansson, P. (2005), *Latent variables in a travel mode choice model: attitudinal and behavioral indicator variables*. Working paper, Uppsala University.

Keijer, M.J.N. and Rietveld, P. (2000), How do people get to the railway station? The Dutch experience, *Transportation Planning and Technology, 23* (3), pp. 215-235.

Kitamura, R., Mokhtarian, P.L. and Laidet, L. (1997), A micro-analysis of land use and travel in five neighborhoods in de San Francisco Bay Area, *Transportation Planning and Technology, 24* (2), pp. 125-158.

Klobucar, M.S. and Fricker, J.D. (2007), *A Network Evaluation Tool to Improve Real and Perceived Bicycle Safety*, Washington, D.C. (Transportation Research Board).

Koike, H., Morimoto, A. and Kitazawa, A. (2003), *Research on the Unevenness of Intersection Pavement on Bicycle Safety*, Washington, D.C. (Transportation Research Board).

Krizek, K.J. (2006), Two approaches to valuing some of bicycle facilities' presumed benefits, *Journal of the American Planning Association, 72* (3), pp. 309-320.

Krizek, K.J., Johnson, P.J. and Tilahun, N. (2004), *Gender differences in bicycling behavior and facility preferences*. Paper presented at Conference on Research on Women's Issues in Transportation, Chicago, IL, 18-20 November.

Krizek, K. J., Poindexter, G., Barnes, G. and Mogush, D. (2007), Analysing the

benefits and costs of bicycle facilities via online guidelines, *Planning Practice and Research, 22* (2), pp. 197-213.
Krizek, K.J. and Roland, R.W. (2005), What is at the end of the road? Understanding discontinuities of on-street bicycle lanes in urban settings, *Transportation Research Part D, 10*, pp. 55-68.
Lawlor, D.A., Ness, A.R., Cope, A.M., Insall, P. and Riddoch, C. (2003), The challenges of evaluating environmental interventions to increase population levels of physical activity: the case of the UK National Cycle Network, *Journal of Epidemiology and Community Health, 57* (2), pp. 96-101.
Litman, T. (2007), *Land Use Impacts on Transport: How Land Use Factors Affect Travel Behavior*, (Victoria (Victoria Transport Institute).
Lohmann, G. and Rölle, D. (2005), "Ich würde ja Rad fahren aber…!", Veränderungen der Verkehrsmittelnutzung von dem Hintergrund der ipsativen Handlungstheorie ["I'd ride a bike but…!", changes in transport use from the background of the ipsative theory of behavior], *Umweltpsychologie, 9* (1), pp. 46-61.
Martens, K. (2004), The bicycle as a feedering mode: experiences from three European countries, *Transportation Research Part D, 9*, pp. 281-294.
Martens, K. (2007), Promoting bike-and-ride: the Dutch experience, *Transportation Research Part A, 41*, pp. 326-338.
Matthies, E., Kuhn, S. and Klöckner, C.A. (2002), Travel mode choice of women: the result of limitation, ecological norm, or weak habit, *Environment and Behavior, 34* (2), pp. 163-177.
Ministerie van Verkeer en Waterstaat (2004), *Mobiliteitseffecten Lokale Fietsmaatregelen* [Mobility effects of local bike actions], Rotterdam (Ministerie van Verkeer en Waterstaat [MinVenW]).
Ministerie van Verkeer en Waterstaat (2007), *Cycling in the Netherlands*, Den Haag (Ministerie van Verkeer en Waterstaat [MinVenW]).
Moritz, W.E. (1998), *Adult Bicyclists in the United States: Characteristics and Riding Experience in 1996*, Washington, D.C. (Transportation Research Board).
Moudon, A.V., Lee, C., Cheadle, A.D., Collier, C.W., Johnson, D., Schmid, T.L. and Weather, R.D. (2005), Cycling and the built environment: a US perspective, *Transportation Research Part D, 10*, pp. 245-261.
Nankervis, M. (1999), The effect of weather and climate on bicycle commuting, *Transportation Research Part A, 33*, pp. 417-431.
Nelson, A.C. and Allen, D. (1997), If you build them, commuters will use them: association between bicycle facilities and bicycle commuting, *Transportation Research Record, 1578* (paper no. 970132), pp. 79-83.
Noland, R.B. and Kunreuther, H. (1995), Short-run and long-run policies for increasing bicycle transportation for daily commuter trips, *Transport Policy, 2* (1), pp. 67-79.
Olde Kalter, M.-J. (2007), *Vaker op de fiets? Effecten van overheidsmaatregelen* [More often the bicycle? Effects of government measures], Den Haag (Kennisinstituut voor Mobiliteitsbeleid [KiM]).

Parker, A.A. (2002), *The Dutch model for making walking and cycling safer*. Paper presented at the Road Safety Research, Policing & Education Conference, Brisbane, Australia, November.

Parkin, J., Ryley, T. and Jones, T. (2007), On barriers to cycling: an exploration of quantitative analyses, in: D. Horton, P. Rosen and P. Cox (Eds), *Cycling and Society*, pp. 83-96, London (Ashgate).

Parkin, J., Wardman, M. and Page, M. (2008), Estimation of the determinants of bicycle mode share for the journey to work using census data, *Transportation, 35* (1), pp. 93-109.

Petritsch, T.A., Landis, B.W., Huang, H.F. and Challa, S. (2006), *Sidepath Safety Model: Bicycle Sidepath Design Factors Affecting Crash Rates*, Washington, D.C. (Transportation Research Board).

Pikora, T., Giles-Corti, B., Bull, F., Jamrozik, K. and Donovan, R. (2003), Developing a framework for assessment of the environmental determinants of walking and cycling, *Social science and Medicine, 56* (8), pp. 1693-1703.

Plaut, P.O. (2005), Non-motorized commuting in the US, *Transportation Research Part D, 10*, pp. 347-356.

Porter, C., Suhrbier, J. and Schwartz, J.L. (1999), Forecasting bicycle and pedestrian travel: state of the practice and research needs, *Transportation Research Record, 1674* (paper no. 99-0750), pp. 94-101.

Pucher, J. (1998), Urban transport in Germany: providing feasible alternatives to the car, *Transport Reviews, 18* (4), pp. 285-310.

Pucher, J. (2001), Cycling safety on bikeways vs. roads, *Transportation Quarterly,* 55 (4), pp. 9-11.

Pucher, J. and Buehler, R. (2006), Why Canadians cycle more than Americans: a comparative analysis of bicycling trends and policies, *Transport Policy, 13* (3), pp. 265-279.

Pucher, J. and Buehler, R. (2008), Making cycling irresistible: lessons from the Netherlands, Denmark and Germany, *Transport Reviews, 28* (4), pp. 495-528.

Pucher, J., Komanoff, C. and Schimek, P. (1999), Bicycling renaissance in North America? Recent trends and alternative policies to promote bicycling, *Transportation Research Part A, 33* (7/8), pp. 625-654.

Raford, N., Chiaradia, A., Gil, J. (2007), *Space Syntax: The Role of Urban Form in Cyclist Route Choice in Central London*, Washington, D.C. (Transportation Research Board).

Räsänen, M. and Summala, H. (1998), Attention and expectation problems in bicycle-car collisions: an in-depth study, *Accident Analysis and Prevention, 30* (5), pp. 657-666.

Rietveld, P. (2000a), The accessibility of railway stations: the role of the bicycle in the Netherlands, *Transportation Research Part D,* 5, pp. 71-75.

Rietveld, P. (2000b), Non-motorised modes in transport systems: a multimodal chain perspective for The Netherlands, *Transportation Research Part D: Transport and Environment,* 5 (1), pp. 31-36.

Rietveld, P. and Daniel, V. (2004), Determinants of bicycle use: do municipal policies matter?, *Transportation Research Part A, 38*, pp. 531-550.
Rodríguez, D.A. and Joo, J. (2004), The relationship between non-motorized mode choice and the local physical environment, *Transportation Research Part D,* 9 (2), pp. 151-173.
Rose, G. (2007), *Combining Intercept Surveys and a Self-Completion Questionnaire to Understand Cyclist Use of Off-Road Paths*, Washington, D.C. (Transportation Research Board).
Rose, G. and Marfurt, H. (2007), Travel behavior change impacts of a major ride to work day event, *Transportation Research Part A, 41*, pp. 351-364.
Ryley, T. (2001),. Translating cycling policy into cycling practice, *World Transport Policy and Practice, 7* (3), pp. 38-43.
Ryley, T. (2006), Use of non-motorised modes and life stage in Edinburgh, *Journal of Transportation Geography, 14* (5), pp. 367-375.
Saelens, B., Sallis, J. and Frank, L.D. (2003), Environmental correlates of walking and cycling: findings from the transportation, urban design, and planning literatures, *Annals of Behavioral Medicine, 25* (2), pp. 80-91.
Scheiner, J. and Holz-Rau, C. (2007), Travel mode choice: affected by objective or subjective determinants?, *Transportation* (34), pp. 487-511.
Schneider, R.J., Dunbar, L.C., Toole, J.L. and Flink, C. (2006), *Avoiding Biased Interpretation of Bicycle surveys: Comparing Results from Four Distribution Methods in Winston-Salem*, NC, Washington, D.C. (Transportation Research Board).
Schwanen, T. and Mokhtarian, P.L. (2005), What affects commute mode choice: neighborhood physical structure or preferences toward neighborhoods, *Journal of Transport Geography, 13*, pp. 83-99.
Shafizadeh, K. and Niemeier, D. (1997), Bicycle journey-to-work: travel behavior characteristics and spatial attributes, *Transportation Research Board, 1578*, pp. 84-90.
Shankwiler, K.D. (2006), *Developing a framework for behavior assessment of bicycling commuters: a cyclist-centric approach*, School of Industrial Design, p. 87, Atlanta (Georgia Institute of Technology).
Southworth, M. (2005), Designing the walkable city, *Journal of Urban Planning and Development, 131* (4), pp. 246-257.
Stinson, M.A. and Bhat, C.R. (2003), *An Analysis of Commuter Bicyclist Route Choice Using Stated Preference Survey*, Washington, D.C. (Transportation Research Board).
Stinson, M.A. and Bhat, C.R. (2004), Frequency of bicycle commuting: internet-based survey analysis, *Transportation Research Record, 1878*, pp. 122-130.
Stinson, M.A. and Bhat, C.R. (2005), *A Comparison of the Route Preferences of Experienced and Inexperienced Bicycle Commuters*, Washington, D.C. (Transportation Research Board).
Taylor, D. and Mahmassani, H. (1996), Analysis of stated preferences for intermodal bicycle-transit interfaces, *Transportation Research Record, 1556*, pp. 86-95.

Thøgersen, J. and Ölander, F. (2006), To what degree are environmentally beneficial choices reflective of a general conservation stance?, *Environment and Behavior, 38* (4), pp. 550-569.

Tilahun, N.Y., Levinson, D.M. and Krizek, K.J. (2007), Trails, lanes, or traffic: valuing bicycle facilities with an adaptive stated preference survey, *Transportation Research Part A, 41*, pp. 287-301.

Timperio, A., Ball, K., Salmon, J., Roberts, R., Giles-Corti, B., Baur, C.A. and Crawford, D. (2006), Personal, family, social, and environmental correlates of active commuting to school, *American Journal of Preventive Medicine, 30* (1), pp. 45-51.

Triandis, H.C. (1980), Values, attitudes and interpersonal behavior, in: H.E. Howe and M.M. Page (Eds), *Nebraska Symposium on Motivation*, Lincoln, NE (University of Nebraska Press).

Triandis, H.C. (1997), *Interpersonal Behavior*, Monterey, CA (Brooks/Cole).

Van Wee, B., Rietveld, P. and Meurs, H. (2006), Is average daily travel time expenditure constant? In search of explanations for an increase in average travel time, *Journal of Transport Geography, 14* (2), pp. 109-122.

Verplanken, B., Aarts, H. and van Knippenberg, A. (1997), Habit, information acquisition, and the process of making travel mode choices, *European Journal of Social Psychology, 27* (5), pp. 539-560.

Ververs, R. and Ziegelaar, A. (2006), *Verklaringsmodel voor fietsgebruik gemeenten* [Model for explaining cycling use of municipalities], pp. 1-41, Leiden (Research voor Beleid).

Wardman, M., Hatfield, R. and Page, M. (1997), The UK national cycling strategy: can improved facilities meet the targets?, *Transport Policy, 4* (2), pp. 123-133.

Wardman, M., Tight, M. and Page, M. (2007), Factors influencing the propensity to cycle to work, *Transportation Research Part A, 41* (4), pp. 339-350.

Witlox, F. and Tindemans, H. (2004), Evaluating bicycle-car transport mode competitiveness in an urban environment: an activity-based approach, *World Transport Policy and Practice, 10* (4), pp. 32-42.

Xing, Y., Handy, S.L. and Buehler, T.J. (2008), *Factors Associated with Bicycle Ownership and Use: A Study of 6 Small U.S. Cities*, Washington, D.C. (Transportation Research Board).

Zacharias, J. (2005), Non-motorized transportation in four Shanghai districts, *International Planning Studies, 10* (3-4), pp. 323-340.

Zahran, S., Brody, S.D., Maghelal, P., Prelog, A. and Lacy, M. (2008), Cycling and walking: explaining the spatial distribution of healthy modes of transportation in the United States, *Transportation Research Part D, 13* (7), pp. 462-470.

Appendix 2.1

Overview of selected characteristics of the studies

Overview of selected characteristics of the studies

Author(s)	Year	Country	Dependent variable	Travel to work	Only bicycle
Abraham *et al.*	2002	Canada	preferences of cycling attributes	no	yes
Aultmann-Hall *et al.*	1997	Canada	route preferences	yes	yes
Bamberg	2006	Germany	mode choice	no	no
Bamberg and Schmidt	2003	Germany	car use	no	no
Bamberg and Schmidt	1994	Germany	use of car; use of bicycle	no	no
Bamberg *et al.*	2003	Germany	mode choice	no	no
Banister and Gallant	1999	UK		yes	no
Barnes *et al.*	2006	USA	mode share	yes	yes
Bergström and Magnussen	2003	Sweden	mode choice	yes	yes
Bernhoft and Carstensen	2008	Denmark	preferences	no	no
Boumans and Harms	2004	Netherlands	frequency	yes	no
Brandenburg *et al.*	2004	Austria	daily frequency of recreational and commuting cyclists	yes	yes
De Bruijn *et al.*	2005		bicycle use behaviour	no	no
Cervero	1996	USA	probability of commuting by foot or cycling	yes	no
Cervero	2002	USA	mode choice	no	no
Cervero and Duncan	2003	USA	probability person choosing mode	no	no
Cervero and Radish	1996	USA	mode choice	yes	no
Chen and Mcknight	2007	USA	time allocation to out-of-home maintenance/ discretionary activities	no	no
De Geus	2007	Belgium	cyclist; non-cyclist	no	yes
Dickinson *et al.*	2003	UK	mode choice; cycling patterns; cycling to work; etc.	yes	yes
Dill and Carr	2003	USA	cycling percentages in cities	yes	yes
Dill and Voros	2007	USA	being a cyclist	no	yes
El-Gneidy *et al.*	2007	USA	travel speed	no	yes
Emmerson *et al.*	1998	UK	bicycle flows	no	yes
Fajans and Curry	2001	USA	cyclists' attitudes to stop signs	no	yes
Frank *et al.*	2007	USA	mode choice; etc	no	no
Garrard *et al.*	2008	Australia	preferences	no	yes
Gatersleben and Appleton	2007	UK	cycling percentage of respondents willing to cycle	yes	yes
Gatersleben and Uzzell	2007	UK		yes	no
Guo *et al.*	2007	USA	frequency of motorised and non-motorised mode use	no	no
Hossein *et al.*	2003	Japan	choice of parking lot; acceptable distance	no	yes
Howard McDonald and Burns	2001	USA	route choice	yes	yes
Hunecke *et al.*	2001	Germany	travel mode choice	no	no
Hunt and Abraham	2007	Canada	bicycle utility	no	yes

>>

Overview of selected characteristics of the studies (continuation)

Author(s)	Year	Country	Dependent variable	Travel to work	Only bicycle
Hunter and William	1995	USA	number of crashes	no	yes
Iacono *et al.*	2008	USA	distance	no	no
Johansson *et al.*	2005	Sweden	mode choice for commuting	yes	no
Keijer and Rietveld	2000	Netherlands	mode choice to the station	no	no
Kitamura *et al.*	1997	USA	vehicle use; number of trips per mode; fraction of trips per mode	no	no
Klobucar and Fricker	2007	USA	route choice	no	yes
Koike *et al.*	2003	Japan	safety/speed	no	yes
Krizek	2006	USA	preference facility characteristics; value proximity of bicycle facilities	yes	yes
Krizek and Roland	2005	USA	perception of comfort	no	yes
Krizek *et al.*	2004	USA	cycling behaviour and preferences	no	yes
Krizek *et al.*	2007	USA	distance; distance of route travelled; distance between chosen route and shortest route	no	yes
Krizek, Pointdexter *et al.*	2007	USA	benefit	no	yes
Lawlor *et al.*	2003	UK		no	yes
Litman	2004			no	no
Lohmann and Rölle	2005	Germany	mode choice; reasons not to cycle	no	yes
Martens	2004	Netherlands, Germany, UK	mode choice to station	no	no
Martens	2007	Netherlands	cycling to reach public transport	no	no
Matthies *et al.*	2002	Germany	willingness to reduce car use	no	no
Moritz	1998	USA	mode choice; bicycle facts	no	yes
Moudon *et al.*	2005	USA	how many times do you cycle per week?	no	yes
Nankervis	1999	Australia	number of parks cyclists	no	yes
Nelson and Allen	1997	USA	number of bicycle commuters	yes	yes
Noland	1995	USA	mode choice	yes	yes
Olde Kalter	2007	Netherlands	bicycle use mode choice, frequency	no	yes
Parker	2002	Netherlands	safety	no	yes
Parkin *et al.*	2007	UK	barriers to cycling	no	yes
Parkin *et al.*	2008	UK	proportion of individuals who cycle to work	yes	yes
Petrish *et al.*	2006	USA	bicycle crash rates	no	yes
Pikora *et al.*	2003	Australia	walking and cycling	no	no
Plaut	2005	USA	mode choice	yes	no
Porter *et al.*	1995		bicycle and pedestrian travel	no	no
Pucher	1998	Germany		no	no
Pucher	2001		cycling safety	no	yes
Pucher and Buehler	2006	USA, Canada	cycle share	no	yes
Pucher *et al.*	1999	USA, Canada	bicycle use	no	yes
Raford *et al.*	2007	UK	route choice	no	yes
Räsänen and Summala	1998	Finland	bicycle safety	no	yes
Rietveld (a)	2000	Netherlands	mode choice for transport to station	no	no
Rietveld (b)	2000	Netherlands	non-motorised modes in chains	no	no
Rietveld and Daniel	2004	Netherlands	bicycle use at municipality level	no	yes

>>

Overview of selected characteristics of the studies (continuation)

Author(s)	Year	Country	Dependent variable	Travel to work	Only bicycle
Rodriquez and Joo	2004	USA	mode choice	no	no
Rose	2007	Australia	use of cycling facilities	no	yes
Rose and Marfurt	2007	Australia	mode choice	yes	no
Ryley	2006	Scotland	types of trips; mode choice; etc	no	no
Ryley	2001	Scotland	bicycle ownership	no	yes
Saelens *et al.*	2003	USA	cycling rates	no	no
Scheiner and Holz-Rau	2007	Germany	share of modes	no	no
Schneider *et al.*	2006	USA	differences in distribution	no	yes
Schwanen and Mokhtarian	2005	USA	commute mode choice	yes	no
Shafizadeh and Niemeier	1997	USA	bicycle commuting	yes	yes
Shankwiler	2006	USA	perception-activity behavioural maps	yes	yes
Southworth	2005		walking	no	no
Stinson and Bhat	2005	USA	route preference	yes	yes
Stinson and Bhat	2003	USA	route choice	no	yes
Stinson and Bhat	2004	USA and Canada	bicycle frequency	yes	yes
Taylor and Mahmassani	1996	USA	utility of car, bike & ride and park & ride;	no	no
Thøgersen and Ölander	2006	Denmark	buying organic food; recycling; using alternative transport	no	no
Tilanhun *et al.*	2007	USA	willingness to pay	no	yes
Tiperio *et al.*	2006	Australia	active commuting to school	no	no
Verplanken *et al.*	1997	Netherlands	habit; mode choice	no	no
Ververs and Ziegelaar	2006	Netherlands	bicycle share in municipalities	no	yes
Wardman *et al.*	1997	UK	mode choice	no	yes
Wardman *et al.*	2007	UK	bicycle share	yes	no
Witlox and Tindemans	2004	Belgium	mode choice	no	no
Xing *et al.*	2008	USA	bicycle ownership; bicycle use	no	yes
Zacharias	2005	China	mode choice	no	no
Zahran *et al.*	2008	USA	cycling share	no	no

Appendix 2.2 Overview of methods used for data collection and analysis

Overview of methods used for data collection and analysis

Author(s)	Year	Data source	Method(s) of analysis	Unit of analysis (if not individuals)	*n* (valid response)	Year of data collection
Abraham *et al.*	2002	stated preference (cyclists only)	logit model		547	
Aultmann-Hall *et al.*	1997	authors' own survey	GIS	397 routes	338	1993
Bamberg	2006	mail surveys (longitudinal)	MANOVA; structural equations modelling		241; 169	
Bamberg and Schmidt	2003	authors' own survey	structural equations modelling		608; 321	1997
Bamberg *et al.*	2003	longitudinal study: two surveys	structural equations modelling		1874; 1036	1994; 1995
Banister and Gallant	1999	existing data (SAR)	descriptive			
Barnes *et al.*	2006	existing data (US census)	longitudinal analysis			1990 and 2000
Bergström and Magnussen	2003	authors' own survey	(cross tabs and bivariate analysis)		433	1998; 2000
Bernhoft and Carstensen	2008	authors' own survey	chi-square test		1905	2001
Brandenburg *et al.*	2004	video and interview	linear regression			
De Bruijn *et al.*	2005	authors' own cross-sectional survey	bivariate correlation, multiple linear and binary logistic regression		3859	1997
Cervero	1996	existing data (AHS)	binomial discrete logit model			1985
Cervero	2002	existing data (household travel survey, Washington)	binomial/multinomial logit model			1994
Cervero and Duncan	2003	existing data (BATS)	factor analyses discrete choice model			2000
Cervero and Radish	1996	authors' own paper surveys and existing data (BATS)	binomial logit model		620	1990-91; 1994
Chen and Mcknight	2007	existing data (HIS New York)	descriptive and structural equations modelling			1997-98
De Geus	2007	mail questionnaire; medical examination	ANOVA; independent t-test		343; 18; 101	2003-2004
Dickinson *et al.*	2003	authors' own survey (of companies)	descriptive		2065	1998-1999
Dill and Carr	2003	existing data (census, C2SS)	Regression; cross-sectional analysis	city	64	2000

>>

Overview of methods used for data collection and analysis (continuation)

Author(s)	Year	Data source	Method(s) of analysis	Unit of analysis (if not individuals)	*n* (valid response)	Year of data collection
Dill and Voros	2007	authors' own phone survey	GIS; chi-square test		566	2005
El-Gneidy *et al.*	2007	GPS		study segments	315	2005
Emmerson *et al.*	1998	existing data (counts, weather)	linear regression			1994-1996
Frank *et al.*	2007	existing data (puget travel survey)	discrete choice modelling; GIS		14487	1999
Garrard *et al.*	2008	bicycle observation	independent t-test; Duncan's multiple comparison		6589	2004
Gatersleben and Appleton	2007	authors' own e-mail survey	descriptive		389; 22	2000
Gatersleben and Uzzell	2007	authors' own survey	discriminant analysis; chi-square tests; regression analyses		389	2000
Guo *et al.*	2007	existing data (BATS, MTC, GIS, NCDC)	bivariate ordered probit modelling			2000
Hossein *et al.*	2003	field survey and questionnaire	bivariate analyses	wrong park bicycles	645; 330	2000
Howard McDonald and Burns	2001	revealed preference	GIS		150	latest in 1998
Hunecke *et al.*	2001	authors' own survey	multivariate analyses; two-factorial analysis		1206; 160	1998
Hunt and Abraham	2007	stated preference	logit choice model		1128	1994
Hunter and William	1995	existing data	descriptive	crashes	2990	
Iacono *et al.*	2008	existing data (TBI)	distance decay functions			2000-2001
Johansson *et al.*	2005	revealed preference survey	latent variable model (MIMIC)		1708	2001
Keijer and Rietveld	2000	existing data (CVS, Netherlands)	frequencies			1994
Kitamura *et al.*	1997	authors' own mail surveys	linear regression; factor analysis		1380	
Klobucar and Fricker	2007	compare chosen route with characteristics				
Koike *et al.*	2003	bicycle vibrating measures and GIS	GIS			
Krizek	2006	author's own survey; stated preference; revealed preference	logit regression; least square regression		167	

>>

Overview of methods used for data collection and analysis (continuation)

Author(s)	Year	Data source	Method(s) of analysis	Unit of analysis (if not individuals)	*n* (valid response)	Year of data collection
Krizek and Roland	2005	authors' own survey; stated preference based on real situation	multi-variate analysis		28	2003
Krizek *et al.*	2004	existing data (NHTS) and adaptive stated preference	descriptive and mixed-effect regression			2001
Krizek *et al.*	2007	authors' own human intercept survey	paired sample t-test; least square regression model		3121	2005
Krizek, Pointdexter *et al.*	2007	existing data	model development			
Litman	2004	theoretical/literature review				
Lohmann and Rölle	2005	authors' own phone survey	descriptive		2000	2001 or older
Martens	2004	existing data (multiple)	comparison countries			1992, 1993, 1996, 2001
Martens	2007		descriptive			
Matthies *et al.*	2002	authors' own survey	multiple regression; chi-square test		187	1998
Moritz	1998	author's own mail survey	descriptive; combination with crash rates		2400	1997
Moudon *et al.*	2005	existing data (WBG, GIS); disaggregate cross-sectional study	binary logit			2002
Nankervis	1999	author's own survey and counting	cross tabs	n of bikes		1980-1981, 1990-1991
Nelson and Allen	1997	existing data	cross-sectional; regression			1969-1990
Noland and Kunreuter	1995	authors' own mail survey	multi-nominal choice analyses		354	1991
Olde Kalter	2007	existing data (OVG, CVS)				1986-2006
Parker	2002	case study	descriptive			
Parkin *et al.*	2007	existing data	review			
Parkin *et al.*	2008	existing data (UK census)	logistic regression			2001
Petrish *et al.*	2006	geometric data, counting, crash data	Pearson correlation; stepwise regression			2004-2005
Pikora *et al.*	2003	expert interviews; Delphi-study	Delphi rounds		31	1999
Plaut	2005	existing data (AHS)	logit analysis and cross tabs		(247 bicycle commuters)	
Porter *et al.*	1995		theoretical			

>>

Overview of methods used for data collection and analysis (continuation)

Author(s)	Year	Data source	Method(s) of analysis	Unit of analysis (if not individuals)	*n* (valid response)	Year of data collection
Pucher	1998	case study	descriptive/theoretical			1950-1995
Pucher	2001	existing data	theoretical			1950-1996
Pucher and Buehler	2008	existing data (numerous international)	comparison of two countries			
Pucher and Buehler	2006	existing data (census, NPTS, NHTS)	comparison of two countries			2003
Pucher *et al.*	1999	existing data (NPTS; multiple)	case studies			1990 (mostly)
Raford *et al.*	2007		space syntax	routes	423 (46)	
Räsänen and Summala	1998	existing data	multidisciplinary in-depth analysis	accidents	234	1992-1993
Rietveld (b)	2000	existing data (CBS)	cross tabs			1998
Rietveld (a)	2000	existing data (NS and CBS)	descriptive			1975-1994
Rietveld and Daniel	2004	existing data (Dutch Cycling Union)	linear regression	city	103	2000-2002
Rodriquez and Joo	2004	authors' own survey	multinomial choice model, (nested) logit models		590	1997
Rose	2007	authors' own survey; interview and hand-out questionnaire to cyclists			4342 (474)	2006
Rose and Marfurt	2007	panel survey; two times	regression (stepwise, logistic)		1952	2002-2004
Ryley	2006	existing data (Scottish household data)	cluster analysis; chi-square analysis		2910	1999-2000
Ryley	2001	existing data (Scottish household data)	descriptive			1975-1999; 1999
Saelens *et al.*	2003	existing research	review			
Scheiner and Holz-Rau	2007	authors' own survey	structural equations modelling		2000	2002-2003
Schneider *et al.*	2006	authors' own survey: mail, elementary school, online and bicycle organisation	comparative statistics		591; 1062; 235; 132	2005
Schwanen and Mokhtarian	2005	existing data/survey in San Francisco	multinomial logit analysis; descriptive		1358	1998
Shafizadeh and Niemeier	1997	authors' own bicycle intercept survey	descriptive		579	1993
Shankwiler	2006	observation and audio-visual diaries	theoretical		10	2006
Southworth	2005		theoretical			

>>

Overview of methods used for data collection and analysis (continuation)

Author(s)	Year	Data source	Method(s) of analysis	Unit of analysis (if not individuals)	*n* (valid response)	Year of data collection
Stinson and Bhat	2005	authors' own survey; stated preference survey	discrete choice modelling		3126	2002
Stinson and Bhat	2003	authors' own survey; stated preference	binary logit model		3145	
Stinson and Bhat	2004	authors' own internet survey	mostly descriptive		2822; 2548; 2144	2002
Taylor and Mahmassani	1996	authors' own stated preference paper survey	nested logit model		814	1993
Thøgersen and Ölander	2006	authors' own telephone interview	partial correlation analysis; structural equations modelling		1071; 919; 817	2002-2003
Tilanhun *et al.*	2007	authors' own survey; adapted stated preference	mixed logit model/ linear model		167	
Tiperio *et al.*	2006	cross-sectional; authors' own self-administered questionnaires	correlation		912	2001
Verplanken *et al.*	1997	authors' own survey; computer controls survey(s)	ANOVA; MANOVA		80; 135	
Ververs and Ziegelaar	2006	existing data (Statline)	regression analyses			2003
Wardman *et al.*	1997	own household survey (SP)	logit model		221	1996
Wardman *et al.*	2007	existing data (NTS); authors' own stated preference survey	hierarchical logit model			1985-1997; 1998
Witlox and Tindemans	2004	existing data	descriptive			2000
Xing *et al.*	2008	authors' own online survey; cross-sectional analysis	nested dichotomous logistic analysis		965	2006
Zacharias	2005	authors' own survey on street	regression and ANOVA		1811	
Zahran *et al.*	2008	existing data (census)	negative binomial regression; GIS; zero-inflates negative binomial regression			2000

3 The effect of work-related factors on the bicycle commute mode choice in the Netherlands

Eva Heinen, Kees Maat and Bert van Wee. Submitted.

Abstract
Increasing the number of people cycling to work brings a number of benefits: it can lead to reductions in air pollution and traffic jams, and increases people's physical activity levels. We investigated the extent to which work-related factors influence (1) whether an individual decides to cycle to work, and (2) whether an individual cycles to work every day. It is anticipated that the office culture and colleagues' and employers' attitudes would significantly influence both decisions. These factors are expected to impact the provision of cycling facilities and financial compensation schemes in the workplace. We conducted an Internet survey in four Dutch municipalities, gathering data from over 4,000 respondents. The results suggest that the following factors increase the likelihood of being a commuter cyclist: having a positive attitude towards cycling; colleagues' expectations that an individual will cycle to work; the presence of bicycle storage inside; having access to clothes changing facilities; and needing a bicycle during office hours. The presence of facilities for other transport modes, an increase in the commute distance, and the need to transport goods, in turn, reduces the chance that an individual will cycle. Cycling frequency is negatively affected, meanwhile, by an increase in commute distance, a free public transport pass or car parking provided by the employer. These results indicate that an individual's working situation affects the commuting cycling behavior. The findings also indicate that (partly) different variables influence an individual's decision to cycle to work, and their decision to cycle every day.

3.1 Introduction

Commuting makes a key contribution to economic prosperity, and is an important aspect of travel behavior in modern societies. In the Netherlands, approximately 30% of journeys are commuter trips, a percentage that is comparable with that in other western countries. The fact that commuting is mandatory for most employees, and occurs between fixed points at fixed times, however, means that commuter trips are vulnerable to traffic congestion. In addition, motorized transport is a key producer of environmental pollution. Over short distances, the bicycle presents a good alternative to motor-

ized transport, can reduce these negative effects, and can even help to improve public health levels and combat obesity. With this in mind, many governments are encouraging bicycle commuting. For example, recent changes to US tax law (Bicycle Commuter Benefit Act, 2009 (US Department of the Treasury (2008)) allow employers to reimburse cycling commuters for bicycle-related expenses. In some cities, meanwhile, such as Davis and Portland, a system of cycle lanes has clearly changed the modal split for commuting in favor of the bicycle.

With a long cycling tradition, positive attitudes towards cycling, and good cycling facilities, the Netherlands has the highest rate of bicycle use in the world. The Dutch Government acknowledges the importance of cycling and bicycle-related policies, and encourages bicycle commuting by for example offering tax benefits over their employers that employees can buy a bicycle tax-free once every three years for up to a value of €749. Indeed, encouraging bicycle commuting is a key national policy objective. The Dutch Government has pledged to improve and extend bicycle facilities at railway stations, distributes information about cycling, and until 2010, is providing financial support for the realization of a national cycling network (Ministry of Transport, Public Works and Water Management, 2004). This policy of encouraging bicycle commuting has also resulted in local initiatives such as the 'trappers' program, which measures the number of kilometers cycled by commuters. These can then be exchanged for reward points (Ministry of Transport, Public Works and Water Management, 2009; www.trappers.net).

The Dutch Government requires municipal, regional and provincial authorities to provide proper bicycle facilities and cycling environments, such as bicycle storage facilities that are close to public transport stops, a well-designed bicycle infrastructure, and measures to reduce bicycle theft and improve social security (Ministry of Transport, Public Works and Water Management, 2004). Moreover, the Dutch Government has set regional targets for bicycle use in 2010 that, at a minimum, match the 2000 figures for actual use (Ministry of Transport, Public Works and Water Management, 2004). Although central government is positive about encouraging cycling, almost all cycling-related investments in the Netherlands are made at the local or regional levels. The country's decentralized planning system means that the municipal, regional and provincial authorities start from different points, and have different policies and outcomes. Central government provides local government with financing for all transport modes, which can be spent in accordance with local priorities.

Increasing knowledge about the effect of work-related factors on bicycle commuting can help employers and governments to develop policies that encourage bicycle commuting. Increased knowledge can help employers to adapt the incentives that they provide for specific modes of commuting and allow them to benefit from having healthier employees, less demand for park-

ing places, and lower commuting costs. Governments can use such information to develop targeted policies to help employers develop bicycle-friendly facilities, and formulate policies to encourage commuters to start cycling to work.

Much research has been conducted into commuting behavior, and particularly into the role of the car (see, for example: Cervero, 2002; Dargay and Hanly, 2007; Susilo and Maat, 2007). By contrast, bicycle commuting has received limited attention. To date, research have found that an individual's bicycle mode choice can be explained by factors such as weather conditions and climate, socio-economic factors, the distance travelled, and attitudes towards cycling (e.g. Gatersleben and Appleton, 2007; Parkin *et al.*, 2008; Pucher and Buehler, 2006; Rodriquez and Joo, 2004; Rietveld and Daniel, 2004; Bergström and Magnussen, 2003; Dickinson *et al.*, 2003; Stinson and Bhat, 2004; Nankervis, 1999; Noland and Kunreuther, 1995). In studying *cycling to work*, only a limited amount of academic research has been undertaken on the influence of work-related factors, however. This is remarkable, as it would seem self-evident that work-related factors have an influence on the individual decision of the commute transport mode.

To address this gap, this paper examines the extent to which work-related factors determine an individual's decision to cycle to work. In order to do so, we design a comprehensive model of bicycle commuting. We assume that bicycle commuting is not only determined by factors such as the built environment, available infrastructure, socio-demographics and the commute distance, but also that attitudes, expectations and mentalities – not only those of the cyclist, but also those within their social environment, such as the employer's – affect an individual's decision to cycle. On the one hand, certain experiences or perceptions may result in an employee having a negative attitude towards cycling to work, such as the perceived risk of having an accident, sweating, having to wear a particular type of clothing, being rained upon, or having to cycle through an unattractive built environment. Such perceptions may also be positive, such as relaxing after a long day at the office. In addition, an employee may not feel able to cycle, as a car might be needed during work hours, or goods need to be transported. On the other hand, an employee's decision will be influenced by the expectations and attitudes of their employer and co-workers. Office norms, for example, might dictate that employees wear suits and drive company cars when visiting clients. A workplace's commuting culture and mentality will also be revealed by whether it provides financial support for transport costs or facilities at work (bicycle storage, showers); or conversely, a car-friendly policy that reduces the relative attractiveness of cycling to work.

A further aspect in need of greater attention is the definition of bicycle commuting. Most travel studies define mode choice as the mode that is usually taken to work, the mode that is used for the main part of the journey, or

the mode that is taken on a particular day. This entails making the implicit assumption that commuters use the same mode of transport every day. While this is not true in general, it is even less true of cyclists, who are more dependent on a number of factors, such as the weather, the need to transport loads, and so on. We therefore analyze how work-related factors influence both full-time and part-time bicycle commuting. A full-time bicycle commuter is defined as someone who cycles to work every working day, while a part-time commuter cycles to work at least once a year. In addition, we limit our analysis to commuters who cycle the entire distance from home to work. We thus do not include commuters who use the bicycle for part of a journey, such as for travelling to the railway station.

The paper is structured as follows. In the next section, a short review of the literature is provided, followed by a conceptual model. Then the process of data collection and the research design are described. The last two sections present the research results and conclusions.

3.2 Literature review

This section identifies the factors that are assumed to influence bicycle use, according to the scientific literature. For a more detailed overview of the literature, see Heinen *et al.* (2010).

3.2.1 Facilities at work

Whether cycling facilities are available in a workplace reveals an employer's attitude towards modes of commuting. The presence of cycling facilities, such as secure storage, showers and changing rooms, makes cycling more attractive (Abraham *et al.*, 2002). Having access to facilities at the end of a trip is more important for commuters than for other types of cyclists. According to Abraham *et al.* (2002), secure bicycle parking is the most important facility. Of the different kinds of parking, individual bike lockers are most popular, followed by bicycle enclosures and standard bike racks. Not all cyclists consider secure parking to be equally important. Hunt and Abraham (2007) report that for young cyclists, particularly for under-16s, secure parking is more important than for other age groups. Likewise, people with expensive bicycles tend to value secure parking more highly. Hunt and Abraham (2007) suggest that this is due to the relative value of a bicycle is greater for these two groups. Cyclists also attach positive value to the provision of showers (Abraham *et al.*, 2002; Hunt and Abraham, 2007). Interestingly, Abraham *et al.* (2002) find that cyclists and non-cyclists value the provision of showers to the same extent.

Both Abraham *et al.* (2002) and Hunt and Abraham (2007) undertook stated preference experiments to achieve these research findings. Although we

might expect similar effects when researching actual decisions to cycle, the effects might well differ. The limited number of research studies that has been undertaken using revealed preferences has occasionally produced different results. Stinson and Bhat (2004), for example, who focus on commuting frequency, do not find that the availability of showers or clothing lockers has an effect on cycling frequency. However, De Geus (2007) does find that cyclists tend to have greater access to facilities at work than non-cyclists. Thus to conclude, the current picture is an ambiguous one, and it is unclear whether the research methods used, the country studied or the dependent variable chosen is the reason for this.

3.2.2 Attitudes and norms

It seems that there is a positive correlation between cycling, having a positive attitude towards cycling, and supportive social norms. Dill and Voros (2007), for example, demonstrate that being environmentally aware and having a positive attitude towards cycling increases the likelihood that an individual is a utilitarian cyclist. Moreover, cyclists tend to like cycling, and generally think that cycling is healthy and environmentally friendly (Gatersleben and Appleton, 2007). Gatersleben and Appleton (2007) contrast the attitudes held during five different stages of developing as a cyclist, ranging from not even considering being a cyclist, to cycling frequently. Their results show that individuals who have been cycling for a long time, who have just started cycling, or who would be prepared to cycle, have more positive attitudes towards cycling than individuals who would not consider cycling or have just started to consider cycling. Attitudes towards cycling change when people change their mode of transport and start cycling. Gatersleben and Appleton (2007) identified a negative shift in new cyclists' perceptions relating to fitness, fun, being outside, and convenience. However, these individuals developed a more positive perception of cycling's flexibility and traffic safety.

Changes in an individual's circumstances can also result in attitudinal change. A longitudinal study conducted by Bamberg *et al.* (2003) found that introducing free bus passes affected people's attitudes and social norms. Free public transport led to an increase in public transport use and a consequent fall in people's intentions to cycle, although the scheme did not have a significant effect on attitudes to cycling. A similar effect was found in the Netherlands, when cycling rates fell after students were given free access to public transport (Rietveld, 2000).

Aside from individual attitudes, people are more likely to cycle if their social environment is positive about cycling. De Geus (2007) found that cyclists tend to receive more frequent support for cycling from their social environments than non-cyclists. Moreover, cyclists are more likely to have a 'cycling buddy' and perceive a more positive social norm which implies that the key individ-

uals in their lives tend to be more positive about them cycling. Additionally, Dill and Voros (2007) found that seeing other cyclists on the street makes people want to cycle more.

3.2.3 Socio-demographic factors

The impact of socio-demographic factors varies between countries. With respect to gender, Gerrard *et al.* (2008) found that most cyclists tend to be male in countries with low rates of cycling. By contrast, in countries with high cycling rates, such as the Netherlands and Denmark, cycling is more evenly spread over the two genders.

The research findings with respect to the effects of income and age are ambiguous. For example, Witlox and Tindemans (2004), Plaut (2005) and Guo *et al.* (2007) find that an increase in income has a negative effect on cycling levels. Parkin *et al.* (2008), meanwhile, conclude that an absence of high incomes in England and Wales is connected with a lower bicycle share for commuting.

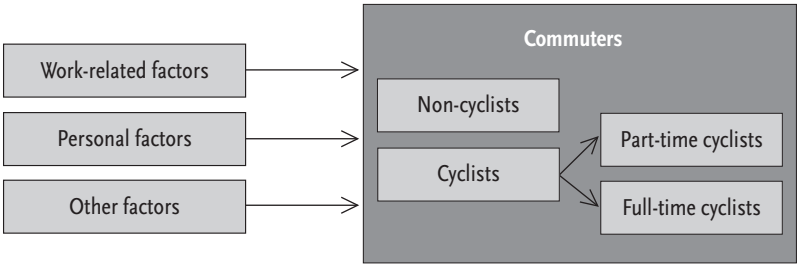
3.3 Research design

3.3.1 Conceptual model

To date, most bicycle research has looked at the effect of personal, spatial and infrastructural variables on cycling (such as distance, for example). However, only limited attention has been paid to (social) work-related factors in particular. Therefore this paper aims to identify the work-related factors of bicycle-commuting decisions. In order to control for personal variables, these are included. Based on the literature review (see Section 3.2) and analytical reasoning we assume that work-related, socio-economic and other factors influence an individual's decision to be a commuter cyclist (see Figure 3.1). Two examples illustrate the potential significance of work-related factors. First, having a positive, pro-cycling work culture may mean that an employer provides financial incentives for cycling, or bicycle facilities. Second, a work culture that does not provide such incentives, or only provides facilities for other modes of transport, might have a lower share of commuter cycling.

As explained in the introduction, in this study, we define bicycle commuting as cycling the entire distance between home and work. This definition excludes cycling to public transport stops. Our frequency for 'cycling' ranges from cycling to work once a year, to cycling to work every day. Our study therefore includes those commuters who cycle part-time. The category of cyclists is divided into two groups, full-time cyclists (FT) and part-time cyclists (PT), indicating whether the individual cycles daily, or alternates with other modes of transport. Part-time cyclists thus decide whether or not to

Figure 3.1 Conceptual model for bicycle commuting



cycle to work on a daily basis. So defined, we would expect to see a combination of work-related and socio-economic factors affecting both an individual's decision to commute by bicycle, and his or her daily choice to cycle to work, as reflected in the cycling frequency.

Work-related factors include: having bicycle facilities at the workplace; financial support for commuting; the office dress code; the number of hours worked; office hours; the need for transport during office hours; type of company and contract; and office social norms. Our hypothesis is that these factors correspond with the probability of being a commuter cyclist, and have a positive effect on cycling frequency. On the other hand, the provision of other non-cycling facilities (such as car parking), financial support for other modes of transport, working in a sector or function which is not particularly bicycle-friendly (such as finance), the need to carry goods during office hours, or the need to travel for work, will have a negative impact on commuter cycling.

'Personal factors' include factors as a person's age, gender, education level, vehicle possession, income, household structure, ethnicity, and personal attitudes towards commuting. Previous research suggests that there is a relationship between cycling and socio-economic variables. Based on this research, we would expect women to cycle as much as men do. In this study, we would expect individuals with higher incomes, non-native Dutch individuals and non-students to cycle less, while we would also expect individuals who have more positive attitudes towards cycling to cycle more. Our expectations with respect to household composition and age are more uncertain, as previous research is ambivalent regarding these factors.

Finally, the 'other factors' category consists of the main commuting distance, and the number of living and working locations. We would expect that with an increase in distance, and consequently with the amount of effort needed, both the probability that people cycle to work and the probability that they cycle every day would decrease. Moreover, we would expect to find fewer (full-time) cyclists among those people who have multiple living or working locations, since this group is more likely to have to make complex journeys. In addition, this group of individuals may have longer commuting distances (which is not controlled for in the analysis), because the distance studied consists of one single distance between the main living- and working locations (see Section 3.4).

3.3.2 Case study area

This study was carried out in four Dutch municipalities: the medium-sized towns of Delft (approximately 100,000 inhabitants) and Zwolle (approximately 115,000 inhabitants); and two municipalities adjacent to Delft, Midden-Delfland (17,000 inhabitants) and Pijnacker-Nootdorp (38,000 inhabitants). The first reason for selecting Delft and Zwolle was that they have high percentages of (commuting) cyclists, which increased the probability that a large number of cyclists would take part in the survey. These towns are clearly attractive for cycling, and we wanted to discover the apparently positive bicycle characteristics of the cities. This does not threaten the study's representativeness, as the selection criteria have been explicitly taken into account as explanatory variables in the analyses, allowing us to control for their effect. Both Delft and Zwolle have higher cycling rates than the Dutch average, with cyclists making 28.2% and 32.6% of all trips ending in Delft and Zwolle respectively, and 22.1% and 27.5% of commuting trips (MON (Dutch Census data), 2007). The second reason for selecting these particular towns was the potential availability of enough employers with over 100 employees in different branches. In Delft and Zwolle, one can find large educational organizations, local and non-local governmental institutions, public services, industries, and commercial business services. Finally, we expected to gain some advantage from the university's reputation in the City of Delft.

Separate bicycle infrastructure facilities are widely available in all of the selected municipalities. Car ownership rates are as follows: 39 inhabitants per 100 cars in Delft; 49 inhabitants per 100 cars in Zwolle; and 57-58 cars per 100 inhabitants in both Pijnacker-Nootdorp and Midden-Delfland.

3.3.3 The survey

In April and May 2008, an Internet survey was conducted among (1) the employees of several large organizations in Delft and Zwolle, including TU Delft, Delft's main hospital, housing authorities and a receivables management company; and (2) the inhabitants of the municipalities mentioned above. Using address data obtained from the local authorities, a total of 22,000 letters were randomly sent to residents of working age, inviting them to participate (10,000 in Delft, 6,000 in Zwolle, and 3,000 in Pijnacker-Nootdorp and Midden-Delfland). A reminder was sent one month later. To the employees, we sent just under 3,500 invitation e-mails. All of the respondents were asked to fill out an online questionnaire, with 40 12-euro lottery tickets being offered as incentives.

The questionnaire was presented as a survey of commuting mode choice. We did not reveal our specific interest in bicycle usage to the respondents, in order to avoid bias towards cyclists or people with positive attitudes toward cycling. In total, 2,929 out of 22,000 residents responded (a rate of 13.3%). Of the employees,

Table 3.1 Mode choice according to collected survey data

	Always same transport or combination of transport		Different transport or combination of transport on different days	
	Frequency	Valid percent	Frequency	Valid percent
Only car	1,294	50.2	1,031	61.7
Only bicycle	648	25.1	1,017	59.1
Only public transport	133	5.2	447	26.0
Only walking	61	2.4	113	6.6
Combination of public transport and bicycle	161	6.2	231	13.4
Combination of car and bicycle	145	5.6	248	14.4
Combination of car and public transport	42	1.6	93	5.4
Other	95	3.7	261	15.2
Total	**2,579**	**100.0**	**1,720**	
Missing	1,720		2,579	

1,370 responded from a total of approximately 3,500 e-mail requests (a response rate of 39%). Our overall response rate was thus 16.9%.

The mode data of the survey are fairly similar to the Dutch national census data. While there are some differences in respondents' mode choices, in general, similar patterns can be observed (see Table 3.1 and Table 3.2). The main difference can be found within the group of respondents stating that they do not use one particular mode of transport to commute, but make a daily choice from multiple forms of transport. This group contains a higher share of cyclists.

Table 3.2 Main mode of transport according to Dutch Census travel data of 2007

Main mode of transport	All trips
Only car	57%
Only bicycle	25%
Only public transport	6%
Only walking	10%
Combination of public transport and bicycle	
Combination of car and bicycle	
Combination of car and public transport	
Other	2%
Total	**100%**

Source: Ministry of Transport, Public Works and Water Management, 2010

Within our dataset, some differences can be observed between the two groups of respondents targeted (residents or employees). Compared to the residents, employees are more likely to have a middle income; be older; to have a lower level of education; to have one or more cars in their household; to work irregular hours; to have showers, changing facilities, and bicycle storage inside at work; and to work within one kilometer of a highway. However, respondents approached via their employers have a smaller change to have a permanent or temporary contract. As we used two different methods of data collection, we included a dummy variable for each method to reveal any possible influence on the results. We also included a dummy variable for the municipality, so as to see whether people's home or working municipalities were affecting the results.

3.3.4 Variables

In this section we describe the variables that are derived from the conceptual model. Table 3.3 provides an overview of the variables in the analyses.

Table 3.3 Variables

Description	Values	Mean	Standard deviation
being a cyclist	no	60.2 %	
	yes	39.8 %	
type of cyclist	part-time cyclist	57.5 %	
	full-time cyclist	42.5 %	
distance in kilometers	(0 - 270)	17.0	25.3
attitude towards cycling	(-140 - +140)	33.9	41.2
working hours 12:00-19:00	no	5.3 %	
	yes	94.7 %	
working hours 00:00-06:30	no	94.8 %	
	yes	5.2 %	
need to transport goods to work	always	6.2 %	
	sometimes	29.9 %	
	never	63.9 %	
needing vehicle during office hours	no	52.3 %	
	yes	47.7 %	
needing a bicycle during office hours	no	76.2 %	
	yes	23.8 %	
number of working locations	1 location	79.3 %	
	2 locations	12.2 %	
	3+ locations	8.6 %	
facility at work: bicycle storage inside	no	55.0 %	
	yes	45.0 %	
facility at work: changing facility	no	53.2 %	
	yes	46.8 %	
facility at work: free car parking	no	26.3 %	
	yes	73.7 %	
facility at work: public transport within 500 meters	no	42.5 %	
	yes	57.5 %	
bicycle contribution from work	no	48.4 %	
	yes	51.6 %	
free car from work	no	88.9 %	
	yes	11.1 %	
free public transport from work	no	87.8 %	
	yes	12.2 %	
type of organization	agriculture and construction	14.7 %	
	business	9.0 %	
	government, education	50.7 %	
	other services	14.3 %	
	other	11.4 %	
type of work	employed	92.1 %	
	own company	4.0 %	
	volunteer work	1.6 %	
	mix	2.2 %	

>>

Description	Values	Mean	Standard deviation
number of hours worked per week	0-28	25.6 %	
	28-40	58.6 %	
	>40	15.6 %	
expressed expected opinion of colleagues regarding how one should travel to work	car	24.4 %	
	bicycle	23.9 %	
	other	8.1 %	
	does not matter	43.5 %	
having a car available for commuting	always	66.2 %	
	never	17.6 %	
	sometimes	16.2 %	
gender	male	55.3 %	
	female	44.7 %	
education level	low	14.8 %	
	medium	31.3 %	
	high	53.9 %	
owning a bicycle	none	2.0 %	
	one bicycle	12.1 %	
	2 or more	85.9 %	
owning a car, motor, scooter	no	9.6 %	
	yes	90.4 %	
personal clothing style at work	sometimes or always a suit	12.7 %	
	never a suit	87.3 %	
age groups	<30	17.0 %	
	30-45	40.1 %	
	45-60	37.9 %	
	60+	5.0 %	
ethnicity	Dutch	94.5 %	
	Western European	0.7 %	
	other	4.8 %	
household composition	single	15.1 %	
	only with partner	31.7 %	
	with children or other family	50.7 %	
	student house	2.4 %	
respondents group	employees	31.9 %	
	inhabitants	68.1 %	
survey location	Delft	50.0 %	
	Zwolle	24.5 %	
	Pijnacker	6.0 %	
	Nootdorp	3.6 %	
	Delfgauw	3.2 %	
	Den Hoorn	5.6 %	
	Maasland	3.8 %	
	Schipluiden	3.4 %	

Attitudes towards bicycle commuting were measured using five-point Likert scales. Two scales were used: one measured the individual's expectations in terms of the results of the behavior (for example, statements such as 'for me, cycling the whole journey to work is mentally relaxing'), on a scale that ranged from 'completely disagree' (-2) to 'completely agree' (+2). The other scale measured the importance of this result for the individual concerned (for example, statements such as 'for me, it is important that my commuting transport mode is mentally relaxing'), on a scale ranging from 'not important at all' (1) to 'very important' (5). A person's attitude was calculated by summing all the products relating to expectations and importance, and had a Cronbach α of 0.897. We considered the following aspects: environmental friendliness, mentally relaxing, physically relaxing, comfortable, time-saving, flexible, cheap, pleasant, privacy-offering, status-giving, healthy, traffic safety, social safety, and matching with a person's lifestyle.

Social norms in the workplace were measured using the question 'With which transport mode do you think your colleagues expect you to travel to work?' Respondents could select from all transport modes (car, bicycle, public transport, on foot), and could also indicate if they thought that their colleagues' expectations did not matter. We included four categories in our analysis: by car, by bicycle, by another transport mode, and 'it does not matter'.

The commuting distances are calculated using postal codes for residential and (main) work locations. We used the shortest possible route, not the fastest route by car, on the assumption that the shortest route would be the fastest route for cyclists, and that cyclists usually choose the shortest route.

The following variables were not included in our analysis, although theoretically, one would expect them to have an effect: the number of residential locations; the presence of a train station within one kilometer of the workplace; a high way entrance within one kilometer of the workplace; the availability of bicycle storage outside; being provided with a free bicycle by one's employer; employment type; income; and being a student. We chose not to include these variables on the grounds that they have an insignificant effect. In particular, we had expected that having a free bicycle and income would have an effect. Univariate analyses indeed show that income affects both dependent variables, as being provided with a free bicycle has a small but significant relationship with being a commuter cyclist, although no effect has been found on frequency. One explanation for this may be that in our model, the influence of income is correlated with and therefore explained by other variables, such as age and the provision of a free car. The effect of being given a bicycle is small if not controlled for the effect of other variables. The absence of a contribution in the final models is probably due to the correlation between bicycle ownership and employer-related factors, such as the availability of bicycle storage.

The municipalities Pijnacker-Nootdorp and Midden-Delfland contain mul-

tiple towns: respectively Pijnacker, Nootdorp and Delfgauw, and Den Hoorn, Maasland and Schipluiden. We included all towns separately in our analyses.

The two dependent variables for the analysis are 'being a commuter cyclist' and 'being a full-time commuter cyclist'. Both dependent variables are dummy variables and dichotomous. Therefore, two binary logit models were estimated using Stata.

Missing data were estimated for the following variables – working hours, income, age, ethnicity, education and function – by applying the 'compute' command, multiple regression analyses, multi nominal logit-models and logical sense. Those cases that had incomplete data on distance were excluded from the analysis.

3.4 Results

3.4.1 Method

Two binary logit models were applied. According to Scott Long and Freese (2006), the McKelvey-Zavoina ρ^2 is the best approach for explaining the proportion of variation for binary logit models of the available measures of fit. The reported odds ratios can be interpreted as the chance that someone chooses to cycle after a one-unit change in a predicting variable. For example, an odds ratio of 1.1 for age indicates that with every increase in years, the chance of that person being a cyclist (as opposed to being a non-cyclist) increases by a factor of 1.1. Table 3.4 sets out the effect of work-related and socio-economic factors on being a commuter cyclist, as compared with being a non-cyclist. This analysis is based on 4,171 observations, and has a ρ^2 of 0.81. Table 3.5, in turn, shows the results of the model with respect to choosing to be a full-time or a part-time cyclist and has a ρ^2 of 0.50, and included 1,660 cases.

3.4.2 Cycling or not cycling to work

In this section, the impact of work-related and personal factors is examined on the individual decision to be a commuter cyclist compared to a non-cyclist.

Table 3.4 shows that the distance commuted and the commuter's attitude towards commuting by bicycle influence an individual's decision to cycle to work. With every additional kilometer, the odds of being a commuter cyclist decline by 0.905. We also analyzed the interaction-effect of gender and distance, which revealed that compared with men, women are less likely to cycle if the distance increases; so, women are more distance-sensitive. Attitudes towards cycling also play an important role in this regard. With every extra

Table 3.4 Being a commuter cyclist: logit model results

		Odds Ratio	Standard Error	z	p>|z|	Significance
distance in kilometers		0.905	0.01	-12.26	0.000	**
commuter's attitude		1.015	0.00	11.71	0.000	**
expressed expected opinion of colleagues regarding how one should travel to work	car	0.506	0.08	-4.43	0.000	**
	(bicycle)					
	other	0.234	0.04	-7.60	0.000	**
	does not matter	0.883	0.09	-1.17	0.242	
free car from work	(no)					
	yes	0.601	0.12	-2.54	0.011	*
free public transport from work	(no)					
	yes	0.568	0.09	-3.69	0.000	**
bicycle contribution from work	(no)					
	yes	1.369	0.12	3.45	0.001	**
needing a vehicle during office hours	(no)					
	yes	0.623	0.07	-4.52	0.000	**
needing a bicycle during office hours	(no)					
	yes	1.873	0.20	5.88	0.000	**
facility at work: bicycle storage inside	(no)					
	yes	1.310	0.12	2.93	0.003	**
facility at work: changing facility	(no)					
	yes	13.421	1.340	3.23	0.001	**
facility at work: public transport within 500 meters	(no)					
	yes	1.438	0.13	3.95	0.000	**
need to transport goods to work	(always)					
	sometimes	3.531	1.11	4.00	0.000	**
	never	3.641	1.14	4.14	0.000	**
having a car available for commuting	always	0.590	0.07	-4.2	0.000	**
	sometimes	1.202	0.18	1.24	0.214	
	(never)					

point in attitude towards bicycle commuting, the odds of being a commuter cyclist increase by 1.015.

The results indicate that many work-related factors play an important role in an individual's decision to commute by bicycle. Among these, we found that social norms, financial incentives such as the provision of a free car or public transport tickets, having access to facilities at work, the need to carry goods, and the need for transport during working hours, influence an individual's decision to cycle to work. The next five paragraphs discuss these findings in detail.

If an individual's colleagues expect a worker to commute by car or to use a mode of transport other than the car or the bicycle, this individual is less likely to be a cyclist than if the individual's colleagues expect him or her to cycle to work.

A financial incentive offered by the employer that is related to a particular mode of transport has a significant influence on employees' commuting

		Odds Ratio	Standard Error	z	p>|z|	Significance
owning a bicycle	(none)					
	one bicycle	22.465	23.18	3.02	0.003	**
	2 or more	34.876	35.80	3.46	0.001	**
owning a scooter	(no)					
	yes	0.538	0.07	-4.46	0.000	**
gender	(male)					
	female	0.964	0.13	-0.26	0.792	
age group	<30	1.637	0.36	2.25	0.024	*
	30-45	1.586	0.32	2.3	0.022	*
	45-60	1.325	0.26	1.41	0.158	
	(60+)					
ethnicity	Dutch	1.650	0.35	2.35	0.019	*
	Western European	1.221	0.67	0.37	0.714	
	(non-Western European)					
respondent group	employees	0.827	0.08	-1.87	0.062	
	(inhabitants)					
city where survey is conducted	(Delft)					
	Zwolle	1.056	0.12	0.46	0.645	
	Pijnacker	1.250	0.22	1.24	0.214	
	Nootdorp	1.103	0.24	0.44	0.657	
	Delfgauw	1.736	0.41	2.31	0.021	*
	Den Hoorn	1.020	0.20	0.10	0.917	
	Maasland	0.725	0.18	-1.32	0.187	
	Schipluiden	1.084	0.24	0.36	0.720	
interaction gender and distance	(male)					
	female	0.932	0.01	-4.58	0.000	**

Significance: * p<0.05; ** p<0.01.
Categories in brackets are reference.
N = 4171

mode choices. An employee who has access to a free car or free public transport is less likely to cycle to work. Contributing to the costs of cycling, however, increases bicycle use. These results are consistent with the findings of Rietveld (2000) and Bamberg *et al.* (2003), who studied bicycle use among students (see Section 3.2).

The findings indicate that needing a mode of transport during working hours has a negative effect on bicycle commuting mode choice. People who need a vehicle during working hours, such as a car, are less likely to cycle, while the probability of cycling to work is almost double for those people who need a bicycle. In the Netherlands some employers offer bicycles for use for work purposes. That in spite that people are still more likely to cycle, is probably related to convenience and the possibility of travelling directly from home to the working location, rather than first having to go to one's main work location.

Having access to certain facilities at work increases the likelihood of being

a cyclist, namely: bicycle storage inside a building; clothes changing facilities; and having a public transport stop within 500 meters of the workplace. The findings with respect to the first two facility types – storage and changing rooms – are consistent with the literature (Hunt and Abraham, 2007; De Geus, 2007; see Section 3.2). The effect of the public transport stop was more unexpected, but this finding might be explained by the fact that combining cycling with public transport on alternate days is more common than combining travelling by car and bicycle. Another explanation could be linked to the employer's attitude towards sustainable transport. If an employer stimulates cycling or public transport use, whether financially or verbally, an employee is more likely to have a positive attitude towards sustainable transport.

The need to carry goods as part of one's work has a negative effect on being a cyclist. People who always or sometimes need to transport goods are much less likely to cycle than people who do not need to transport goods. The Dutch bicycle-promoting literature acknowledges this problem, and suggests as a solution that employers should stimulate employees to limit the need to transport goods to certain days (Fietsberaad, 2005).

The results indicate that personal factors also have an effect. Having a bicycle increases the likelihood of cycling to work, while having access to other forms of transport makes it less likely. In particular, possessing a scooter, which competes directly with the bicycle due to its similar distance range, reduces the probability of cycling to work; although so does having every day access to a car. However, people who only sometimes have access to a car are more likely to be commuter cyclists. Moreover, the results suggest that some socio-economic factors have an impact. Native Dutch people are more likely to be cyclists, for example, than people from non-western European countries. Finally, people under 45 are more likely to be cyclists than those over 60.

The variable that we added to test the different methods of data collection (employees versus residents) proved to be insignificant. Employees are as likely as residents to commute by bicycle. The dummy variable that we included to control for possible differences between cities proved to have a significant effect. People living in Delfgauw have a higher probability of being commuter cyclists than residents of Delft, a difference that might be due to land-use factors. One specific reason for this may be that Delfgauw is in cycling distance of many locations, but lacks good public transport.

3.4.3 Full-time or part-time commuter cycling

This section focuses on the impact of work-related and personal factors on an individual's decision to commute full-time by bicycle, as opposed to part-time. Table 3.5 presents the results of the logit model.

Table 3.5 shows that the commute distance has a negative effect on the probability of being a full-time cyclist. The probability of being a full-time

commuter cyclist decreases by 0.887 with every additional kilometer commuted. Testing the interaction effect between gender and distance indicates that with an increase in distance, women are less likely to be full-time cyclists than men. We can thus conclude that women are more distance-sensitive when it comes to choosing whether to cycle full-time or part-time. Having a more positive attitude towards bicycle commuting increases the probability that an individual cycles to work every day. The odds of cycling increase by 1.017 with every point of increase in attitude.

An individual's social and work situation certainly has an effect on the frequency with which they cycle to work. This suggests that employers and coworkers can significantly influence an individual's commuting mode choice.

Of the financial contributions that an employer can offer, only the provision of a free public transport pass has an effect, namely, having free public transport discourages full-time cycling. This is an interesting finding, as many employers try to be environmentally friendly by offering their employees both a free public transport pass and bicycle-related benefits. Our findings, however, suggest that combining these two fringe benefits is in fact counterproductive as far as cycling is concerned.

In terms of the role played by workplace facilities, among the variables studied, only the presence of free car parking was found to influence an individual's decision to cycle every day. Not having to pay for car parking reduces the likelihood of being a full-time cyclist, a finding that agrees with claims made in the Dutch bicycle-promoting literature (Fietsberaad, 2005).

The results also show that people who always or sometimes need to transport goods are less likely to cycle to work every day than people who do not need to carry goods. Moreover, people who use a vehicle during working hours are less likely to be full-time commuter cyclists.

In contrast to the first analysis outlined in Section 3.4.2, a person's working hours do have an impact on whether they choose to cycle every day. Working between 12:00 and 19:00 and between 00:00 and 06:30 lessens the likelihood of being a full-time cyclist. It is unclear why working between 12:00 and 19:00 would have this effect. The second finding can be explained, however, by the fact that a person working during these hours will need to cycle in the dark, and this is known to have a negative impact on cycling (Stinson and Bhat, 2004; Gatersleben and Appleton, 2007; see Section 3.2). The number of hours worked also affects the likelihood of being a full-time cyclist. People who work over 40 hours a week, or between 28 and 40 hours, are less likely to be full-time bicycle commuters than people who work between 0 and 28 hours. Note that neither commuting distance, nor personal attitudes, nor gender account for this difference. One might have expected to find a link between such factors, as many Dutch part-time workers are women who commute over small distances. Neither is personal income (which was not included in the model) the explanatory variable.

Table 3.5 Bicycle commuting full-time or part-time: logit model results

		Odds Ratio	Standard Error	z	p>|z|	Significance
distance in kilometers		0.887	0.02	-5.53	0.000	**
commuter's attitude		1.017	0.00	8.50	0.000	**
free public transport from work	(no)					
	yes	0.531	0.15	-2.20	0.028	*
facility at work: free car parking	(no)					
	yes	0.590	0.08	-3.86	0.000	**
need to transport goods to work	always	0.133	0.11	-2.54	0.011	*
	sometimes	0.474	0.07	-4.75	0.000	**
	(never)					
need vehicle during office hours	(no)					
	yes	0.515	0.08	-4.55	0.000	**
working hours 12:00-19:00	(no)					
	yes	0.499	0.14	-2.46	0.014	*
working hours 00:00-06:30	(no)					
	yes	0.453	0.13	-2.92	0.006	**
number of hours worked per week	(0-28)					
	28-40	0.637	0.11	-2.72	0.006	**
	>40	0.455	0.12	-3.03	0.002	**
personal clothing style at work	sometimes or always a suit	0.447	0.13	-2.71	0.007	**
	(never a suit)					
type of work	(employed)					
	own company	2.570	0.98	2.47	0.014	*
	volunteer work	3.050	1.71	1.99	0.047	*
	mix	1.097	0.43	0.24	0.812	

Individuals who always or sometimes wear suits are less likely to be full-time cyclists than people who never wear suits. In addition, a worker's sector and employment status affect their commuting choices. Individuals working in the educational and governmental sectors are more likely to cycle full-time than individuals working in other service sectors. Moreover, compared to employees, people with their own companies or who do voluntary work are more likely to cycle to work every day. Finally, people who have two working locations are less likely to commute by bicycle every day than people who only have one working location.

Three personal factors were found to influence whether an individual chooses to commute full- or part-time. First, having full-time or part-time access to a car lessens the likelihood of being a full-time cyclist, a finding that could reflect the convenient aspects of car ownership. Having a car allows one to avoid cycling in bad weather, for example. The results also show that owning a motorized vehicle of any kind (car, motorbike or scooter) lowers the probability that an individual cycles to work every day. Household composition is the only socio-economic factor that affects whether individuals are full-time cyclists. People who live with partners or family members are more likely to be full-time cyclists, compared to people living in a student house

		Odds Ratio	Standard Error	z	p>|z|	Significance
type of organization	agriculture and construction	1.103	0.22	0.48	0.628	
	business	0.695	0.16	-1.61	0.106	
	(government, education)					
	other services	0.652	0.14	-2.05	0.040	*
	other	0.944	0.21	-0.26	0.794	
number of working locations	(1 location)					
	2 locations	0.632	0.13	-2.25	0.024	*
	3+ locations	0.928	0.26	-0.27	0.791	
having a car available for commuting	always	0.265	0.05	-7.08	0.000	**
	sometimes	0.363	0.07	-5.09	0.000	**
	(never)					
owning a car, motorbike or scooter	(no)					
	yes	0.546	0.13	-2.45	0.014	*
household composition	single	1.825	0.74	1.47	0.140	
	only with partner	2.372	0.97	2.12	0.034	*
	with children or other family	2.380	0.95	2.18	0.029	*
	(student house)					
gender	(male)					
	female	0.924	0.21	-0.35	0.726	
interaction gender and distance	(male)					
	female	0.874	0.03	-3.41	0.001	**

Significance: * p<0,05; ** p<0,01.
Categories in brackets are reference.
N = 1660

or a similar household structure. One possible reason for this might be that these individuals have more highly structured, less flexible lives than students or singles, meaning that they perceive travelling by car (instead of by bicycle) to be a better mode of transport that enables them to travel between multiple commitments.

No effect was found for the dummy variable for the data-collection method. This indicates that there is no link between the data-collection method and whether an individual decides to cycle to work every day. In addition, the city in which the survey was conducted was found to have no significant impact on this decision.

3.5 Conclusion and implications

This paper has investigated the extent to which work-related factors affect an individual's decision to become a commuter cyclist, and the frequency with which commuter-cyclists cycle to work. Data was collected by means of an Internet survey of employees and residents based in four Dutch municipalities, Delft and Zwolle, Midden-Delfland and Pijnacker-Nootdorp. Our expectation

was that cycling would not only be determined by 'hard' factors, such as the built environment, available infrastructure and socio-demographic factors, but also that attitudes and expectations – not only of the cyclists themselves, but also those of the people around them – would affect commuting decisions. These latter expectations and attitudes are reflected in the provision of bicycle-(un)friendly facilities and employer-provided incentive schemes, such as bicycle storage facilities and bicycle contributions. Two binary logit models, the first for being a cyclist and the second for being a full-time or part-time cyclist, offered insights into which work-related factors influence an individual's decision to cycle to work.

This research shows that the bicycle facilities provided by an employer and attitudes in the workplace – whether of the employer, co-workers, or employees – play a key role in determining bicycle commuting mode choice and frequency. This conclusion is based on the following findings. First, an employee who is more positive about bicycle commuting is more likely to be a cyclist and to cycle more frequently. In addition, employees who are expected by their colleagues to commute by car are less likely to cycle to work. These results suggest that by actively promoting cycling among employees and thereby improving employees' attitudes towards bicycle commuting; employers might encourage more people to cycle to work and to do that more frequently. Second, we also found that having bicycle storage inside, changing facilities and a public transport stop within 500 meters of the workplace all increase the chance of being a bicycle commuter. Employers could offer such facilities in order to encourage employees to cycle to work. This finding is in line with the schemes that have already been established by some Dutch companies, which provide bicycle facilities to stimulate cycling. Third, the presence of facilities for other transport modes has a negative effect on bicycle use. Results show that the presence of free car parking is connected with having a smaller number of full-time cyclists. This finding implies that if increasing cycling is a key policy aim, free car parking should be limited. Fourth, individuals who need to transport goods are less likely to cycle. When such transportation is unavoidable, it will be difficult to commute by bicycle. In this case, an employer could limit the need to transport goods to certain days, thus enabling an employee to cycle to work on other days. The same applies to those employees who need a vehicle during office hours. Our findings show that workers who need a vehicle for work are less likely to commute by bicycle. In order to encourage bicycle commuting, employers could limit necessary car, motorbike or scooter use to certain days. This would make it easier for workers to commute by bicycle. Finally, providing employees with a free car or public transport pass was found to have a negative impact on bicycle commuting rates. Employers who specifically wish to stimulate cycling should thus take a critical stance with respect to compensation schemes for public- and car transport. This is an important finding, as in the Netherlands,

cycling and use of public transport are often encouraged simultaneously, as both are considered to be sustainable modes of transport.

In addition, we found that as in previous research studies, commuting distance has an important impact on an individual's decision to cycle to work, and the frequency with which they cycle. This means that in order to facilitate bicycle commuting, the distance between an individual's working and living locations should ideally be relatively short. Although it is difficult for policymakers or employees to reduce this distance for current employees, compensation could be offered to those employees who move closer to their workplaces, recruitment could target local employees, and policymakers could offer financial incentives to those changing their residential or work locations.

This research suggests that different variables influence an individual's decision to cycle to work, and the frequency with which he or she cycles. The presence of bicycle storage, changing facilities and travel compensation schemes encourage an individual to cycle, but do not affect frequency. By contrast, the number of hours worked and an individual's working hours only affect whether an individual decides to cycle full-time or part-time. These findings strongly suggest that whether an individual cycles to work is composed of multiple decisions, each of which is made after considering (partially) dissimilar factors. Future research should make this distinction, which would allow policies to be better focused on either encouraging people to take up cycling to work, or to encourage people to cycle to work more often.

The facilities and benefits offered by employers were self-reported by the respondents. Bicycle commuters may be more aware of the bicycle facilities provided, and similarly car commuters may be more aware of car facilities. Nonetheless, we believe that any lack of information about facilities for other transport modes would mainly occur among individuals who do not consider a particular mode of transportation at all. Moreover, we believe that employees are aware of facilities such as free car parking, bicycle parking facilities and showers even if they do not use them. The possible effect of respondents not knowing about certain facilities is therefore assumed to be low.

People's daily choices are further influenced by additional factors, the most important of which is the weather. We were unable to include a weather variable in this research study, as we did not have longitudinal data. Moreover, given that the Netherlands is a small country, there were hardly any differences in climate between the locations surveyed. Additional longitudinal research should thus be conducted in order to test for the effect of weather and other daily determinants on daily bicycle mode choice, such as clothing requirements, or having an appointment on a specific day.

As suggested in the introduction, our findings are of potential significance to both policymakers and employers. Employers could benefit in a number of ways from encouraging more employees to cycle, including: reducing the

demand for parking, lower commuting costs, fewer company cars, and healthier employees. Employers could encourage cycling by providing car-commuters with bicycles for (short-distance) business trips; providing company cars for business trips during working hours, so that people do not have to commute by car simply because they need a car during working hours; develop an explicitly pro-cycling office culture; and use financial stimuli to encourage bicycle commuting. Policymakers, meanwhile, could use fiscal means to encourage bicycle commuting; develop employer-related policies (voluntary or compulsory); make business parks more bicycle-friendly; and act as role models for other employers, by encouraging cycling among their own employees.

References

Abraham, J.E., S. McMillan, A.T. Brownlee and J.D. Hunt (2002), *Investigation of Cycling Sensitivities*, Washington, D.C. (Transportation Research Board).

Bamberg, S., I. Ajzen and P. Schmidt (2003), Choice of travel mode in the theory of planned behavior: the roles of past behavior, habit, and reasoned action, *Basic and Applied Social Psychology, 25* (3), pp. 175-187.

Bergström, A. and R. Magnussen (2003), Potential of transferring car trips to bicycle during winter, *Transportation Research Part A 37*, pp. 649-666.

Cervero, R. (2002), Built environments and mode choice: toward a normative framework, *Transportation Research Part D, 7* (4), pp. 265-284.

Cervero, R. and M. Duncan (2003), Walking, bicycling, and urban landscapes: evidence from the San Francisco Bay Area, *American Journal of Public Health, 93* (9), pp. 1478-1483.

Dargay, J.M. and M. Hanly (2007), Volatility of car ownership, commuting mode and time in the UK, *Transportation Research. Part A: Policy & Practice, 41* (10), pp. 934-948.

Dickinson, J.E., S. Kingham, S. Copsey and D.J.P. Hougie (2003), Employer travel plans, cycling and gender: will travel plan measures improve the outlook for cycling to work in the UK?, *Transportation Research Part D, 8* (1), pp. 53-67.

Dill, J. and K. Voros (2007), *Factors Affecting Bicycling Demand: Initial Survey Findings from the Portland Region*, Washington, D.C. (Transportation Research Board).

Fietsberaad (2005), *Beleidswijzer Fietsverkeer. Kennis voor Fietsbeleid Gebundeld* [Policy Guide for Bicycle Transportation. Compilation of Knowledge for Bicycle Policies] 9, Ede, The Netherlands.

Garrard, J., G. Rose and S.K. Lo (2008), Promoting transportation cycling for women: the role of bicycle infrastructure, *Preventive Medicine, 46* (1), pp. 55-59.

Gatersleben, B. and K.M. Appleton (2007), Contemplating cycling to work: attitudes and perceptions in different stages of change, *Transportation Research Part A, 41* (4), pp. 302-312.

Geus, de B. (2007), *Cycling to work. Psychosocial and environmental factors associated with cycling and the effect of cycling on fitness and health indexes in an untrained working population*. Doctoral thesis, Belgium (Free University Brussels).

Guo, J.Y., C.R. Bhat and R.B. Copperman (2007), *Effect of the built environment on motorized and non-motorized trip making: substitutive, complementary, or synergistic?*, Washington, D.C. (Transportation Research Board).

Heinen, E., B. van Wee and K. Maat (2010), Commuting by bicycle: an overview of the literature, *Transport Reviews, 30* (1), pp. 59-96.

Hunt, J.D. and J.E. Abraham (2007), Influences on bicycle use, *Transportation, 34* (4), pp. 453-470.

Ministry of Transport, Public Works and Water Management (Kennisinstituut voor mobiliteit) (2010), *Mobiliteitsbalans 2010*, Den Haag, The Netherlands.

Ministry of Transport, Public Works and Water Management and Fietsberaad [Centre of Expertise on Bicycle Policy] (2009), *Cycling in the Netherlands*. Den Haag, The Netherlands.

Ministry of Transport, Public Works and Water Management (2004), *Nota Mobiliteit*, Den Haag, The Netherlands.

Nankervis, M. (1999), The effect of weather and climate on bicycle commuting, *Transportation Research Part A, 33*, pp. 417-431.

Noland, R.B. and H. Kunreuther (1995), Short-run and long-run policies for increasing bicycle transportation for daily commuter trips, *Transport Policy, 2* (1), pp. 67-79.

Parkin, J., M. Wardman and M. Page (2008), Estimation of the determinants of bicycle mode share for the journey to work using census data, *Transportation, 35* (1), pp. 93-109.

Plaut, P.O. (2005), Non-motorized commuting in the US, *Transportation Research Part D, 10*, pp. 347-356.

Pucher, J. and R. Buehler (2006), Why Canadians cycle more than Americans: a comparative analysis of bicycling trends and policies, *Transport Policy, 13* (3), pp. 265-279.

Rietveld, P. (2000), Non-motorized modes in transport systems: a multimodal chain perspective for the Netherlands, *Transportation Research Part D: Transport and Environment,* 5 (1), pp. 31-36.

Rietveld, P. and V. Daniel (2004), Determinants of bicycle use: do municipal policies matter?, *Transportation Research Part A, 38*, pp. 531-550.

Rodríguez, D.A. and J. Joo (2004), The relationship between non-motorized mode choice and the local physical environment, *Transportation Research Part D,* 9 (2), pp. 151-173.

Scott Long, J. and J. Freese (2006), *Regression Models for Categorical Dependent Variables Using Stata*, College Station (Stata Press).

Stinson, M.A. and C.R. Bhat (2004), Frequency of bicycle commuting: internet-based survey analysis, *Transportation Research Record (1878)*, pp. 122-130.

Susilo, Y.O. and K. Maat (2007), The influence of built environment to the trends in commuting journeys in the Netherlands, *Transportation, 34* (5), pp. 589-609.

US Department of the Treasury (2008), *Publication 15-B Cat. No. 29744N*, for use in 2009, (US Tax law, Bicycle Commuter Benefit Act, effective January 1st 2009), pp.18-20.

Witlox, F. and H. Tindemans (2004), Evaluating bicycle-car transport mode competitiveness in an urban environment. An activity-based approach, *World Transport Policy & Practice, 10* (4), pp. 32-42.

www.trappers.net (accessed on 18 August 2009).

4 The role of attitudes toward characteristics of bicycle commuting on the choice to cycle to work over various distances

Heinen, E., K. Maat and G.P. van Wee (2011), The role of attitudes toward characteristics of bicycle commuting on the choice to cycle to work over various distances, *Transportation Research Part D: Transport and Environment, 16* (2), pp. 102-109. Published by Elsevier (http://www.elsevier.com/wps/find/journaldescription.cws_home/31153/description#description). Article via http://dx.doi.org/10.1016/j.trd.2010.08.010.

Abstract
This paper analyses the influence of commuters' attitudes toward the benefits of travel by bicycle (e.g. convenience, low cost, health benefits) on the mode choice decision for commutes to work. We assume that when the commute journey intensifies, either in terms of distance or frequency, attitudes toward cycling become more positive. Factor analysis reveals three underlying attitudinal factors toward cycling to work: awareness, direct trip-based benefits and safety. The decision to cycle is influenced by the factor "direct trip-based benefit" at all distances, whereas the "awareness" is influential only over long distances. The decision to cycle every day is again affected by the "direct benefit" factor. The factors "safety" and "awareness" are important over shorter distances. Having a cycling habit increases the likelihood of cycling and a higher frequency of cycling. The perceived opinion of others only affects the mode choice over short distances suggesting that mode choice on longer commutes is based on one's own attitudes. These findings indicate that attitudes and other psychological factors have a relatively strong impact on the choice to commute by bicycle.

4.1 Introduction

The bicycle has gained a more prominent role in transportation policy because of its environmental and health benefits, especially when compared to the car. Developing policies to increase levels of cycling requires knowledge of the determinants of bicycle commuting. Conventional analysis of bicycling is often based on utility theory, assuming people decide on the best available transport mode by considering costs, time and effort. These studies offer insight into the mode choice and its determinants, taking hard factors such as socio-economics into account. This, however, fails to explain why individuals in similar situations and with corresponding socio-economic characteristics

make different decisions about whether to cycle to work.

It may also be expected that the bicycle commute mode choice decisions will also be influenced by internal and social considerations, such as attitudes, norms and habits. The theory of planned behavior (Ajzen, 1991) provides the basis for the theoretical framework. This theory assumes that attitudes, the subjective norm, and the perception that one can perform a behavior affect the actual execution of a certain behavior. We also expect the influence of the beliefs on bicycle characteristics to be more important to the bicycle commute mode choice than the beliefs of other transport modes, because we expect that people's opinions about cycling are often stronger than opinions about other transport modes.

Although there has been work on the impact of attitudes on travel behavior, there has been little cycling behavior. Also, research has tended to focus mainly on the general attitude, the sum of separate beliefs and associated importance, toward transport modes and not specify on the relation between the different attitudes and bicycle use. Moreover, there has been little work on the effect of attitudes towards transport mode on the on mode choice and frequency with respect to bicycling. One would expect, however, a relationship to exist and that people with a more positive attitude towards cycling make longer and more frequent cycle trips than those with moderate or negative attitudes.

We determine differences of attitudes between cyclists and non-cyclists, and between full-time and part-time cyclists. Second, we analyze the influence of attitudinal factors on bicycle commuting over different distances assuming that attitudes become more positive and play a more prominent role as the frequency or distance of cycling intensifies. We would expect that people with a more favorable attitude towards cycling, and who attach more value to some of its beneficial health and environmental effects, to cycle more often. Further, one may expect that a more positive attitude towards the various beneficial attributes of cycling would increase the probability of people to cycle over longer distances.

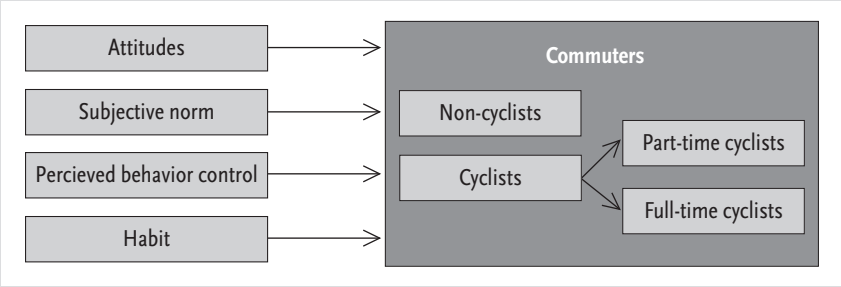
Bicycle commuting is defined as cycling the complete journey and commuters are divided into three groups. The first distinction is between cyclists and non-cyclists. Within bicycle commuters, those who cycle to work every working day are considered to be full-time cyclists, while those who alternate modes, and only occasionally use the bicycle, are considered to be part-time cyclists.

4.2. Conceptual model

4.2.1 Framework

Psychological attitudinal theories provide the conceptual basis for the analysis. Handy (2005) has stressed that, in the study of travel behavior attitudinal theories have been of minor importance compared to economic theories.

Figure 4.1 Research model



However, it has been found that attitudes, norms and habits significantly influence bicycle use (Gatersleben and Appleton, 2007; Gatersleben and Uzzell, 2007) and Heinen *et al.* (2010) have suggested that such factors influence bicycle use and should receive more attention.

It is anticipated that three factors of planned behavior theory – attitudes, subjective norm and perceived behavioral control – influence bicycle commuting (Figure 4.1) when adhering to Ajzen's definition of attitudes, as "the degree to which performance of the behavior is positively or negatively valued". The subjective norm is the perceived social expectation to follow a certain behavior. The perceived behavioral control is the individual's perception of the possibility of engaging or not engaging in a certain behavior. We have also included "habit" in this research. The inclusion of habit implies that we assume that not all decisions to commute by bicycle are made after a rational evaluation of alternatives, but that past behavior and behavior in other travel situations affects the bicycle commute mode choice.

Most travel studies define mode choice as the mode that is usually taken to work, the mode that is used for the main part of the journey, or the mode that is taken on a particular day. This entails making the implicit assumption that commuters use the same mode of transport every day. While this is not true in general, it is even less true of cyclists, who are more dependent on a number of changing daily factors, such as the weather, having to transport a load, and so on. We therefore analyze how attitudes influence both full-time and part-time bicycle commuting. A full-time bicycle commuter is defined as someone who cycles to work every working day, while a part-time commuter cycles to work at least once a year.

Non-attitudinal characteristics of individuals, such as gender and age, and the built environment are not explicitly included in the conceptual model, as it is assumed that attitudes are derived, at least in part, from these characteristics. For example, a woman needing to travel at night through isolated areas might not feel safe enough to cycle, or her social surrounding might discourage her. As a result of her circumstances – working at night, being female, and her built environment – her attitudes towards cycling to work are affected.

4.2.2 Distance

Distance is the main factor in the decision to cycle. In examining this, studies have generally focused on travelers whose journeys are shorter than some ar-

bitrarily chosen distance; a decision defensible because most cycling trips are up below 15 km. Other analysis has included distance as a continuous independent variable because this shows the effect of every unit increase in distance. van Wee *et al.* (2006), however, argued that an increase in distance disproportionately discourages travelers from cycling because the physical effort needed also increases disproportionately. Moreover, Keijer and Rietveld (2000) show that for trips up to 2 km, the bicycle is a less attractive mode of transport; Dutch data on journeys to and from train stations show that many people choose to walk these shorter distances. These findings indicate that the effect of distance on cycling is not linear. We assume that cycling shorter distances is affected by different attitudes than cycling over longer commutes. Commuters who cycle over longer distances are more likely to have favorable opinions towards cycling compared to short-distance bicycle commuters. These long-distance cyclists are assumed to attach more value to the beneficial effects of cycling such as on the environment and their physical health, compared to commuting by car, instead of to more practical reasons such as travel time. Therefore, we have analyzed the effect of attitudes on bicycle commuting for three distance groups: short distances of less than 5 km, medium distances between 5 and 10 km, and longer distances of 10 km and more.

4.3 Methodology

4.3.1 Data collection

In 2008, we collected data through an internet survey conducted among a sample of employees from several large companies in the Netherlands and residents of the cities of Delft (population 100,000) and Zwolle (population 115,000), and two municipalities adjacent to Delft, Midden-Delfland (17,000) and Pijnacker-Nootdorp (38,000). Delft is a university town in the western part of the Netherlands, positioned in the southwest section of the Randstad, a polycentric, highly urbanized area. Zwolle is a city outside this urban conurbation with a large population of students pursuing higher vocational education. Both cities (like many other Dutch cities) have many bicycle facilities, including a separate bicycle infrastructure.

The selection of the cities was based on the relatively high likelihood that commuter cyclists would participate, and the presence of employers with many employees. Both cities have a higher cycling percentage than the national average: Delft 26% and Zwolle 29% (Fietsberaad, 2010). If we disregard the top and lowest 10% of municipalities in terms of bicycle share, municipalities fluctuate between 17% and 29% bicycle share. Dutch cities are relatively uniform in infrastructure facilities because of the national guidelines formu-

lated by CROW (Dutch Center of expertise on infrastructure, traffic, transport and public space).

The respondents were approached in two ways. Nearly 3500 e-mail invitations were sent to employees, as well as a request to employers to urge their employees to participate via e-mail and intranet. The chance to win one of 40 lottery tickets worth €12 was offered as an incentive. Second, residents were approached by mail, using address data from the local authorities. The addressees were randomly selected from a pool of inhabitants aged between 18 and 65 years, because of the focus on commuting; people under 18 are not permitted to drive a car, and 65 is the retirement age in the Netherlands. Twentytwo thousand letters were sent out – 10,000 in Delft, 6000 in Zwolle, 3000 in Midden-Delfland, and 3000 in Pijnacker-Nootdorp. The response rate among residents was 13.3%, among employees, 39% response rate, and 16.9% overall. The questionnaire was presented as a survey of commute mode choice, without the specific focus on bicycle use being stated to avoid any bias or strategic responses.[1]

4.3.2 Variables

Table 4.1 provides an overview of the variables used. The focus is on attitudinal components, defining attitudes towards bicycle commuting as the sum of all beliefs about bicycle characteristics multiplied by the importance attached to these characteristics. The beliefs were measured using a 5-point Likert scale ranging from completely disagree (-2) to completely agree (+2), with questions such as "Cycling the entire journey to work is mentally relaxing for me." The beliefs examined are environmental benefits, mentally relaxing, physically relaxing, comfortable, time-saving, flexible, cheap, pleasant, offers privacy, provides status, healthy, traffic safety, socially safe and suits lifestyle. The importance individual attach to these beliefs are determined by statements such as, "It is important to me that my commute transport mode is mentally relaxing." Respondents could value these statements on a scale from not at all important (one) to very important (five).

The subjective norm is measured according to theory of planned behavior (Ajzen, 1991) and determined by the question "To what extent do important people in your surroundings think you should travel by bicycle to work?" Respondents chose answers ranging from "not at all" (one) to "completely" (five). The perceived behavioral control is a person's own evaluation of the possibility of cycling to work. Respondents answered the question "To what degree do you consider it possible to travel your entire commute by bicycle?",

1 Internet-based survey suffer from well-known issues of bias, but afford a large sample to be collected relatively easily.

Table 4.1 Overview of variables

		Mean	Standard deviation
opinion on cycling to work	provides status	-0.80	1.12
	environmental benefits	1.65	0.81
	mentally relaxing	1.24	0.99
	physically relaxing	0.95	1.17
	comfortable	-0.01	1.17
	time-saving	-0.28	1.37
	flexible	0.46	1.31
	cheap	1.45	0.96
	pleasant	0.82	1.19
	offers privacy	0.12	1.17
	health benefits	1.51	0.88
	traffic safety	0.30	1.11
	socially safe	0.25	1.05
	suits lifestyle	0.52	1.22
importance	provides status	1.76	0.96
	environmental benefits	3.62	0.89
	mentally relaxing	3.82	0.84
	physically relaxing	3.79	0.84
	comfortable	3.98	0.74
	time-saving	4.16	0.78
	flexible	4.20	0.75
	cheap	3.74	0.91
	pleasant	4.10	0.73
	offers privacy	3.38	1.03
	health benefits	3.80	0.85
	traffic safety	3.90	0.84
	socially safe	3.66	0.92
	suits lifestyle	3.38	1.10
attitude towards bicycle characteristic	provides status	-1.16	2.18
	environmental benefits	6.13	3.37
	mentally relaxing	4.93	4.10
	physically relaxing	3.83	4.74
	comfortable	-0.08	4.91
	time-saving	-1.30	6.01
	flexible	1.94	5.76
	cheap	5.57	3.95
	pleasant	3.48	5.15
	offers privacy	0.50	4.21
	health benefits	5.88	3.72
	traffic safety	1.26	4.61
	socially safe	0.95	4.22
	suits lifestyle	1.99	4.73
habit		4.39	2.71
subjective norm		3.11	1.34
perceived behavioral control		3.39	1.70

Table 4.2 Mean of attitudinal characteristics per type of cyclist

	Non-cyclists (2590)		Cyclists (1709)		Part-time cyclists (983)		Full-time cyclists (726)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
provides status	-1.37	2.29	-0.84	1.95 **	-0.95	1.83	-0.69	2.09 **
environmental benefits	5.66	3.43	6.84	3.15 **	6.52	2.96	7.28	3.34 **
mentally relaxing	4.14	4.27	6.13	3.51 **	5.76	3.39	6.63	3.62 **
physically relaxing	2.93	4.84	5.19	4.23 **	4.60	4.25	5.99	4.08 **
comfortable	-1.37	4.89	1.89	4.24 **	1.06	4.07	3.01	4.20 **
time-saving	-3.30	5.72	1.72	5.10 **	0.10	4.91	3.90	4.51 **
flexible	0.42	5.99	4.26	4.50 **	3.27	4.58	5.61	4.02 **
cheap	5.00	4.18	6.44	3.40 **	5.98	3.30	7.07	3.43 **
pleasant	1.99	5.37	5.73	3.81 **	5.23	3.70	6.41	3.86 **
offers privacy	0.15	4.41	1.05	3.81 **	0.76	3.59	1.43	4.07 **
health benefits	5.16	3.89	6.96	3.17 **	6.70	2.94	7.33	3.41 **
traffic safety	0.62	4.59	2.24	4.48 **	1.76	4.24	2.88	4.72 **
socially safe	0.35	4.22	1.84	4.05 **	1.30	3.71	2.58	4.36 **
lifestyle	0.43	4.56	4.35	3.93 **	3.50	3.68	5.51	3.96 **

Paired sample t-test shows a significant difference *(p<0.1) **(p<0.05), between cyclists and non-cyclists and between part-time and full-time cyclists.

again on a five point scale ranging from "not at all possible" (one) to "very possible" (five). Finally, the bicycle habit was constructed following Verplanken *et al.* (2007) when respondents were asked which transport mode would be most likely be used for 10 different purposes, such as visiting friends and daily shopping with the number of "by bicycle" responses counted.

On average, respondents hold positive beliefs on cycling to work, but are on average negative regarding it providing status, saving time, and comfort. Most of the factors included in the statements were considered important; however, most respondents do not put much importance on the status that their commute mode choice might provide. Most use their bicycles occasionally, on average stating they would use the bicycle for 43% of the 10 hypothetical occasions. Respondents reported slightly positive numbers on the subjective norm indicating that on average, they feel other people think positively about the respondent cycling to work. The above three scored on "perceived behavioral control" which indicates that most respondents see cycling to work to be possible, but there are significant individual differences on all of the items.

4.4 Results

4.4.1 Descriptive analyses

Table 4.2 provides an overview of the averages of the attitudinal bicycle commuting components showing that cyclists, compared to non-cyclists, score significantly higher on average on all characteristics, and that full-time cyclists have higher averages than part-time cyclists. Cyclists in general consider it important that their commute mode has environmental benefits, is mentally and

Table 4.3 Attitudinal characteristics for non-cyclists and cyclists by distance category

	Non-cyclists			Cyclists		
	<5 km	5-10 km	>10 km	<5 km	5-10 km	>10 km
	Mean	Mean	Mean	Mean	Mean	Mean
provides status	-1.18	-1.21 *	-1.45 **	-0.90	-0.94	-0.36
environmental benefits	5.88 **	5.90 **	5.58 **	6.86	6.81	6.87
mentally relaxing	4.54 **	4.24 **	4.01 **	5.90	6.45	6.69
physically relaxing	3.75 **	3.12 **	2.62 **	5.21	5.28	5.12
comfortable	0.20 **	-1.47 **	-1.88 **	2.28	1.49	0.94
time-saving	-0.23 **	-3.27 **	-4.38 **	3.09	0.22	-1.72
flexible	1.82 **	0.85 **	-0.18 **	4.82	3.87	2.51
cheap	5.47 **	5.05 **	4.85 **	6.74	6.18	5.62
pleasant	3.15 **	2.04 **	1.59 **	5.71	5.85	5.69
offers privacy	0.01 **	0.09 **	0.21 **	0.69	1.29	2.19
health benefits	5.53 **	5.55 **	4.96 **	6.88	7.13	7.11
traffic safety	1.18 **	0.88 **	0.37 **	2.46	2.14	1.51
socially safe	0.75 **	0.40 **	0.23 **	1.96	1.76	1.62
lifestyle	1.48 **	0.26 **	0.12 **	4.42	4.31	4.19

Paired sample t-test shows a significant difference *(p<0.1) **(p<0.05), between cyclists and non-cyclists at similar distances.

physically relaxing, cheap and healthy, but careless about comfort levels, time-saving benefits and the flexibility of their commute mode (Table 4.1).

An increase in distance corresponds with a decrease in the average value of attitudes toward the various characteristics of bicycle travel. Comfort, time-saving, flexible, cheap, pleasant and suits lifestyle show a significant decrease among the groups commuting less than 5 km, between 5 and 10 km and more than 10 km. Privacy, however, does not appear to be distance-sensitive. In looking at cycling intensity, Table 4.3 shows that non-cyclists also score on average significantly lower on attitudinal components than cyclists, when distance is taken into account, with a similar relationship between full-time and part-time cyclists, although several characteristics are significant only over some distances (Table 4.4).

4.4.2 Factor analysis on bicycle attitudinal characteristics

To identify the main attitudes about bicycling using exploratory factor analysis, the characteristic "provides status" is deleted based on low communality (<0.3), leaving 13 attitudinal characteristics to test for underlying constructs. We find three factors using the Oblimin method, with delta zero explaining nearly 66% of the variance (Table 4.5). This provided interpretable factors and has the advantage over orthogonal rotations such as the varimax method, that factors can correlate with each other (Hair *et al.*, 2006).[2]

2 The use of orthogonal results in a loss of information if the factors are correlated (Costello and Osborne, 2005) which likely expected among attitudes towards cycling.

Table 4.4 Attitudinal characteristics for full-time and part-time cyclists by distance category

	Part-time cyclists			Full-time cyclists		
	<5 km	5-10 km	>10 km	<5 km	5-10 km	>10 km
	Mean	Mean	Mean	Mean	Mean	Mean
provides status	-1.13 **	-1.03	-0.40	-0.70	-0.74	-0.13
environmental benefits	6.40 **	6.53 **	6.77	7.27	7.39	7.39
mentally relaxing	5.22 **	6.13 **	6.58	6.52	7.09	7.29
physically relaxing	4.32 **	4.92 **	4.92 *	6.02	6.02	6.21
comfortable	1.33 **	0.94 **	0.57 **	3.15	2.63	2.97
time-saving	1.65 **	-0.82 **	-2.46 **	4.40	2.34	2.32
flexible	3.80 **	3.11 **	2.19 **	5.75	5.41	4.29
cheap	6.23 **	5.93 **	5.38 **	7.21	6.69	6.89
pleasant	4.96 **	5.53 **	5.47 **	6.39	6.50	6.89
offers privacy	0.06 **	1.08	2.04	1.27	1.73	3.00
health benefits	6.41 **	7.00	6.98 *	7.30	7.40	7.82
traffic safety	1.80 **	2.04	1.26 *	3.07	2.34	2.84
socially safe	1.27 **	1.46 **	1.26 **	2.60	2.38	3.61
lifestyle	3.26 **	3.57 **	3.88 **	5.47	5.81	5.89

Paired sample t-test shows a significant difference *(p<0.1) **(p<0.05), between full-time and part-time cyclists at similar distances.

Table 4.5 Factor scores of the attitudes towards characteristics of bicycle commuting

	Direct benefit	Awareness	Safety
comfortable	0.712		
flexible	0.658		
mentally relaxing		-0.717	
health benefits		-0.774	
cheap		-0.559	
suits lifestyle	0.530		
physically relaxing	0.313	-0.527	
environmental benefits		-0.822	
pleasant/nice	0.554	-0.367	
offers privacy			0.315
socially safe			0.917
time-saving	0.815		
traffic safety			0.746

Values below 0.3 are not reported.

The first factor is labeled “direct trip-based benefit” as it is constructed mainly of the characteristics time-saving and comfort, and to a lesser extent, flexible and pleasant. The variables with high scores on the second factor are environmental benefit, health benefit and mentally relaxing. Therefore, the second factor is labeled “awareness.” The third factor, labeled “safety”, has high scores on social safety and traffic safety.

Table 4.6 Cycling to work

	<5 km		5-10 km		10>km	
	Odds Ratio	P>|z|	Odds Ratio	P>|z|	Odds Ratio	P>|z|
habit	1.154	0.000 **	1.077	0.038 **	1.106	0.005 **
subjective norm	1.102	0.058 *	1.115	0.142	1.119	0.169
pbc	2.293	0.000 **	2.497	0.000 **	2.925	0.000 **
factor direct benefit	1.747	0.000 **	1.984	0.000 **	1.681	0.000 **
factor awareness	0.970	0.661	0.834	0.047 **	0.563	0.000 **
factor safety	1.099	0.146	0.966	0.704	0.989	0.910
	n=1531		n=784		n=1863	
	r^2=0.35		r^2=0.47		r^2=0.56	

Significance: * p<0.1; ** p<0.05

The attitudes are calculated by the Anderson-Rubin scores of the factor analyses. The advantages of this method to construct factor scores are that factor scores have a reasonably high correlation with their estimated factor, and factor scores have a mean of zero and a standard deviation of one (Distefano *et al.*, 2009).

4.4.3 Factors influencing bicycle commuting

We turn to look at the effect of the attitudes, subjective norm, habit and perceived behavioral control on the decision to commute by bicycle using binary logit models, and at the decision to commute by bicycle instead of other modes. According to Scott Long and Freese (2006), the McKelvey-Zavoina ρ^2 is the best approach for explaining the proportion of variation for binary logit models, with the odds ratios being interpreted as the likelihood that someone chooses to cycle after a one-unit change in a predicting variable. For example, an odds ratio of 1.1 for a specific factor indicates that with every unit of increase in that factor, the likelihood of that person being a cyclist increases by multiples of 1.1.

Bicycle commuting

Table 4.6 shows the effects of habit, the subjective norm, perceived behavioral control and the constructed attitudes on the likelihood of commuting by bicycle by distance. The explanatory power of the models is high, with individuals who indicated that they bicycle for many other purposes also having a greater likelihood of cycling to work over all distances. A positive perception of the possibility of cycling to work also positively affects the choice to cycle to work. Over every distance class, people are more likely to cycle if they perceive the activity is possible, but the subjective norm only influences the decision to commute by bicycle over short distances. Over longer distances workers are not affected by their perception of what their social environment expects from them in terms of travel mode. This indicates that over longer distances, cycling is largely a decision based on individual considerations, not taking other opinions into account. The constructed attitude "direct benefit" influences the choice to cycle at every distance. The more beneficial individu-

Table 4.7 Full-time or part-time commuting by bicycle

	<5 km		5-10 km		10>km	
	Odds Ratio	P>|z|	Odds Ratio	P>|z|	Odds Ratio	P>|z|
habit	1.118	0.000 **	1.182	0.001 **	1.209	0.029 **
subjective norm	1.114	0.053 *	1.145	0.162	0.933	0.692
pbc	1.164	0.241	1.402	0.177	1.500	0.105
factor direct benefit	2.184	0.000 **	2.166	0.000 **	2.288	0.004 **
factor awareness	0.845	0.032 **	0.943	0.640	0.991	0.971
factor safety	1.256	0.001 **	0.974	0.829	1.432	0.057 *
	n=1027		n=391		n=248	
	r^2=0.16		r^2=0.19		r^2=0.26	

Significance: * p<0.1; ** p<0.05

als perceive cycling to be in terms of time savings, comfort and flexibility, the more importance they simultaneously attach to these benefits, the more often they are commuter cyclists. Regarding commute distances between 5 and 10 km and beyond 10 km, a higher score on the attitude "awareness" signifies a higher likelihood of cycling to work. This indicates that an awareness of the effect of their behavior on the environment and their health, stimulates cycling for a more intense commute in terms of distance.

Part-time and full-time cycling

Table 4.7 reports the outcome of the binary logit models analyzing the daily effect of cycling to work. The habit of cycling positively influences the likelihood of cycling full-time to work; cyclists are more inclined to cycle to work each day regardless of distance if they also cycle for other purposes. The subjective norm toward cycling only affects the cycling frequency of cyclists living within 5 km from their work, and the own expectation of the possibility of cycling does not influence the commute cycling frequency. This is unsurprising, because a person is likely to consider cycling to work possible if also cycling, either part-time or full-time, for other purposes. The attitude "direct benefits" strongly influences the decision to cycle on a daily basis; with each one-point increase the likelihood of cycling more than doubles. Moreover, for commute distances under 5 km but over 10 km, a high score on the safety attitude results in a greater probability of cycling to work every day implying that individuals who consider cycling not to be dangerous, and who do not attach importance to either traffic safety or social safety are more likely to cycle to work than individuals who consider cycling. It remains uncertain why safety concerns do not affect commute cycling on distances between 5 and 10 km. The attitude "awareness" is important in the decision on journeys up to 5 km and indicates that individuals who consider cycling environmentally friendly, healthy and mentally relaxing are more inclined to cycle to work. This perception of cycling, however, does not affect this choice over longer distances.

The explanatory power of the mode choice model is higher than that of models of the individual choice to cycle to work as opposed to full-time, indicating that attitudes do not have more impact if the cycling frequency increases by cycling full-time instead of part-time. Similarly regarding cycling

frequency, the explanatory power of the models increases with the longer the distance, suggesting that attitudes, habits and norms are more influential at these distances, and confirms the hypothesis that attitudes have a larger effect if the bicycle commute is longer.

Using bivariate analyses, to see if there is any influence on the results because the data combines two samples – from inhabitants and from employees – differences emerge only for cycling journey frequencies of less than 5 km. Among commuter cyclists, the inhabitants are more likely to cycle full-time compared to those recruited among employees with commute distances under 5 km. Including the sample origin in the full logit model has an insignificant effect; sampling the two does not have a significant effect on outcomes.

Attitudes and socio-demographics

Knowledge about the relationship between the constructed factors and socio-demographics is useful in targeting policies. Therefore, regression analysis is conducted to test the relation between the three factors and socio-demographic variables: age, gender, car ownership (yes/no), after-tax income per month (<€1500; €1500 to €3000; >€3000), having a partner (yes/no), and having children in the household (yes/no).

The explanatory power of the regressions is low: 2%, 7%, and 1% for factors 1, 2 and 3, indicating that most factors can be explained to a limited extent by socio-demographics. Moreover, the increase in explaining power of the logit models is limited with the inclusion of socio-demographics. These findings indicate that the attitudinal factors provide additional explanation for why people bicycle to work and cycling frequency.

4.5 Conclusion

This paper looked at the effect of attitudes on bicycle commuting. First, it examines three attitudes relating to bicycle commuting: direct benefit, long-term awareness and safety. Second, the effect of attitudes and norm is tested both on whether individuals cycle to work, but as well on the frequency with which is cycled. Finally, it takes into account that the decision to cycle to work differs for different distance categories.

The analysis indicates that attitudes are influential decisions regarding commuter cyclist, showing that to a large extent, individuals base their mode choice decision on the direct benefits in terms of time, comfort and flexibility. Individuals who commute over longer distances have, on average, a more positive attitude towards cycling than those who cycle shorter distances, support the idea that individuals have a more positive attitude as the bicycle commute lengthens.

Because cycling in the Netherlands is relatively safe, the importance of safety may be higher in countries where cycling is less common, e.g. due to a lacking bicycle infrastructure or a less cycling facilitating attitude of car and truck drivers; similarly the influence of other factors may be different. Nevertheless, in the Netherlands "direct benefit" attitude influences the commute mode choice the most, but awareness of long-term effects and safety also affect bicycle commuting and this may also be true for other countries where cycling is common such as Denmark, and also elsewhere where cycling is perceived as a mode of transport rather than a form of recreation.

References

Ajzen, I. (1991), The theory of planned behavior, *Organizational Behavior and Human Decision Processes, 50*, pp. 179-211.

Costello, A.B. and Osborne, J.W. (2005), Best practices in exploratory factor analysis: four recommendations for getting the most from your analysis, *Practical Assessment, Research and Evaluation, 10*, pp. 1-9.

Distefano, C., Zhu, M. and Mindrilã, D. (2009), Understanding and using factor scores: considerations for the applied researcher, *Practical Assessment, Research and Evaluation, 14*, pp. 1-11.

Fietsberaad [Center of expertise on bicycle policy] (2010), *Cycling Percentages in Dutch Municipalities (data from 2004-2008)*, http://www.fietsberaad.nl/library/repository/bestanden/Kenniscentrum_Fietsberaad_fietsgebruik_per_gemeente_download.xls.

Gatersleben, B. and Appleton, K.M. (2007), Contemplating cycling to work: attitudes and perceptions in different stages of change, *Transportation Research A 4*, pp. 302-312.

Gatersleben, B. and Uzzell, D. (2007), Affective appraisals of the daily commute. Comparing perceptions of drivers, cyclist, and users of public transport, *Environment and Behavior, 39*, pp. 416-431.

Hair, J.F., Black, W.C., Babin, B.J., Anderson, R.E. and Tatham, R.L. (2006), *Multivariate Data Analysis*, sixth ed., Upper Saddle River (Pearson Prentice Hall).

Handy, S. (2005), *Critical assessment of the literature on the relationships among transportation, land use, and physical activity*, Transportation Research, Board and the Institute of Medicine Committee on Physical Activity, Health, Transportation, and Land Use, Washington, D.C.

Heinen, E., van Wee, B. and Maat, K. (2010), Commuting by bicycle, an overview of literature, *Transport Reviews, 30*, pp. 59-96.

Keijer, M.J.N. and Rietveld, P. (2000), How do people get to the railway station? The Dutch experience, *Transportation Planning and Technology, 23*, pp. 215-235.

Scott Long, J. and Freese, J. (2006), *Regression Models for Categorical Dependent Variables Using Stata*, College Station (Stata Press).

van Wee, B., Rietveld, P. and Meurs, H. (2006), Is average daily travel time expenditure constant? In search of explanations for an increase in average travel time, *Journal of Transport Geography*, 14, pp. 109-122.

5 The day-to-day choice to commute or not commute by bicycle

Eva Heinen, Kees Maat and Bert van Wee. Accepted at *Transportation Research Record: Journal of the Transportation Research Board* (TRR Journal) (http://trb.metapress.com/home/main.mpx).

Abstract
This paper investigates day-to-day decisions to commute by bicycle using longitudinal data on 633 part-time bicycle commuters. Previous research has investigated mode choice, travel destination, and other travel choices for one day only. However, it cannot be assumed that travel choices do not vary from day to day and that most individuals travel with the same transportation modes every day. Day-to-day decisions to cycle are found to be affected by work characteristics, commute journey characteristics, and weather conditions. More specifically, workers wearing business attire, needing to transport goods, needing a car during office hours, having longer commute distances, commute in the dark and face higher wind speed, or a larger amount or longer duration of rain are less likely to commute by bicycle. Positive effects were found for temperature and the duration of sunshine. The results show that factors that can differ on a daily basis largely influence bicycle mode choice from day to day. The second conclusion is that two groups of part-time cyclists exist: occasional and frequent cyclists. Whereas the decisions of occasional cyclists to commute by bicycle are more affected by positive weather conditions, frequent cyclists are discouraged from cycling by more practical barriers, including wind speed and the need to be at multiple locations.

5.1 Introduction

This paper investigates day-to-day decisions to commute by bicycle. Commuting enables people to work at locations that are spatially separated from their living locations, however, commuting and mainly car commuting is also associated with transportation and spatial problems, such as congestion and parking difficulties, and negative impacts on the environment. Bicycle commuting offers an environmentally friendly, healthy alternative, and it requires less space for parking and for transportation infrastructure, which is now increasingly recognized by policymakers (Pucher *et al*., 2008). Cycling provides benefits to individuals as well, including time savings, especially for short distanc-

es and health advantages due to the regularity of the physical activity (Hardman, 1999; Pucher *et al.*, 2010). A recent study shows that the health advantages outweigh the risks of cycling (Hartog *et al.*, 2010).

Previous research has investigated travel choices for one day only, such as mode choice and travel destination. Recent research on bicycle commuting has found effects for the built environment, culture, socio-demographics, slope, weather, work-related factors and attitudes (for an overview, see Heinen *et al.*, 2010). Most of these studies analyze (commute) mode choice in general, but do not investigate day-to-day decisions. They therefore devote only limited consideration to the possibility that commuters alternate transportation modes.

However, we cannot assume that travel choices do not vary between days and that most individuals travel with the same transportation mode(s) every day. On the contrary, the Dutch Ministry of Transport, Public Works, and Water Management and the expertise center for cycling policy (Fietsberaad) have shown that individual commuters do alternate between transportation modes (2009). We assume that cyclists are particularly likely to alternate their mode choices (and commute by car or public transport), as they are more affected by conditions that change from day to day. Increasing the cycling frequency more effectively requires specific knowledge concerning the day-to-day determinants of bicycle commuting.

This paper aims to answer the question: Which factors determine the choice of part-time cyclists to cycle or not on a specific day? We define bicycle commuters as individuals who cycle the entire distance from home to work at least once a year. We assume that day-to-day decisions to commute by bicycle are affected by factors other than those affecting the general decision to commute by bicycle. Mode-alternating bicycle commuters differ from those who commute by bicycle all the time, and their decisions to cycle a specific day are at least partly based on different motives. We also assume that part-time cyclists can be divided in two groups, with different factors affecting their choices regarding bicycle commuting. One group (frequent cyclists) consists of bicycle commuters who choose not to cycle under specific circumstances, such as weather conditions or the need to transport goods. Another group (occasional cyclists) consists of car or public transport commuters who choose to cycle on certain days when conditions are favorable to cycling, such as pleasant weather or not wearing business attire.

To answer this question, we collected longitudinal data in two regions in the Netherlands. Respondents were approached once every two weeks during a period of one year. In contrast to cross-sectional data in which respondents are approached only once, this data-collection method allows us to model the day-to-day decisions of individuals, including factors that vary from day to day.

The paper begins with a review of the current literature (Section 5.2), followed by a conceptual model (Section 5.3) and the research design (Section

5.4). Section 5.5 presents the results of a Generalized Estimating Equations model of the day-to-day decision to cycle, followed by differences between frequent and occasional cyclists.

5.2 Background

This section consists primarily of a literature review concerning the day-to-day determinants of cycling. The amount of bicycle research focusing on day-to-day variations is limited. The scientific literature reports multiple factors that influence the choice to commute by bicycle (for an overview see Heinen *et al.*, 2010). Many of these factors (e.g. bicycle infrastructure, socio-demographic characteristics, distance, and employer) could at most change in the long term, but do not vary from day to day. The aspects that can vary by day are now discussed. To the best of our knowledge, no longitudinal research has been conducted on bicycle mode choice. Most studies that do include aspects that vary by day in their mode-choice models are based on cross-sectional data. The referenced literature also considers travel purposes other than commuting.

5.2.1 Weather conditions

Rain influences cycling negatively. Analyzing UK census data from 2001, Parkin *et al.* (2008) find that an increase in the annual rainfall in millimeters corresponds to a lower proportion of cycling to work. Similarly, research in Melbourne, Australia shows that bicycle ridership is lower on rainy days, as measured by the researcher's observations (using four categories ranging from no rain to heavy rain) (Nankervis, 1999). On the questionnaire, however, respondents indicated that weather conditions did not matter. The researchers explain this by stating that mode choice depends on early morning weather. The study focuses on students, however, and the effect could be different on workers, because students have fewer financial resources and therefore less likely to own cars, and they have less money to spend on transportation, thus increasing their dependency on the bicycle. In addition, students are more heading to class or blue collar employment and thus have to worry less about their appearance than a business man. Sabir *et al.* (2009) tested the effect of weather on travel demand in the Netherlands using national travel data matched with local and hourly weather data, including both the duration and the amount of precipitation. They report that the number of cycling trips decreases during extended periods of rain. In Vienna (Austria), Brandenburg *et al.* (2004) reveal that precipitation (yes/no) influences cycling frequency, using a linear regression model including only temperature and precipitation. One study found no effect of precipitation on the probability of cycling. Using the 2000 Bay Area Travel Survey, Cervero and Duncan (2003) reported

that the amount of rainfall during a 24-hour period had no effect on the probability that a trip shorter than five miles would be made by bicycle. The results of the studies above are hard to compare, as they measure rainfall in different ways (e.g. number of rainy days, number of inches per day, chance of rain). Because each of these measurements could have different effects on cycling, it is plausible that they would produce different results.

Temperature is the second weather condition that affects bicycle use negatively. According to Brandenburg *et al.* (2004), the influence of physiological equivalent temperature (PET) is greater than the effect of rain. This finding might be the result of the combination of a binary precipitation variable and ratio PET variable in this study. In the UK, Parkin *et al.* (2008) found that an increase in temperature results in a higher cycling percentage (for temperatures between 8.6°C and 10.3°C). Nankervis (1999) finds that cyclists perceive cold temperatures (<17°C) to be more unpleasant than hot temperatures (>30°C), although very high temperatures (as occur in some countries) could prevent commuters from cycling. Sabir *et al.* (2009) also report a negative effect of low temperature (<-8°C and between -8 and 0°C) and a positive effect of warm temperature (>+20°C) on the daily distance traveled by bicycle, although their study focuses on all trips. Studies by Bergström and Magnussen (2003) and by Brandenburg *et al.* (2004) indicate that, like temperature, precipitation is of less influence on bicycle commuters than it is on other cyclists. One explanation for this finding could be that some commuters have no alternative options, and the trip to work is necessary, regardless of weather conditions.

Remarkably, other weather conditions, such as wind, sunshine, and visibility have received little attention in the scientific literature. The analyses of Parkin *et al.* (2008) suggest that both wind and the hours of sunshine have an insignificant effect on the likelihood of cycling to work. They consider these as data in determining the propensity to cycle, but they do not include them in the presented model. Sabir *et al.* (2009) found no effect for visibility on distance traveled by bicycle, but they do report a negative effect for wind. Strong winds (higher than 6 on the Beaufort scale) decrease cycling distance. Two studies conclude that commuting is not affected by weather conditions as much as it is by other travel purposes (Sabir *et al.*, 2009; Brandenburg *et al.*, 2004).

The existing studies on the effect of weather conditions differ in terms of data and measurement. For example, some studies include temperature as a dummy variable indicating cold or heat, while others include it as a ratio-scale variable. In addition, only a few studies include multiple weather aspects, and even fewer include non-weather factors.

5.2.2 Work characteristics

Cycling trips to work are also affected by the working conditions. Using a binary logit model testing for bicycle commuting, based on data from more than

4000 respondents to an internet survey in the Netherlands, Heinen *et al.* (2009) find that needing a bicycle during office hours increases the likelihood of cycling to work. In contrast, needing a car decreases the chance of commuting by bicycle. They also find that individuals who need to transport goods are less likely to cycle to work. Further, working at night results in the need to travel in the dark, which discourages cycling (see e.g. Gatersleben and Appleton, 2007). Based on an internet survey of 3,500 individuals, Stinson and Bhat (2004) find that non-cyclists are more likely to identify darkness as a reason for not cycling than cyclists are. Female cyclists are particularly likely to care about the presence of daylight (Bergström and Magnussen, 2003; Cervero and Duncan, 2003). Cervero and Duncan (2003) list additional deterrents to bicycle commuting, including a number of work-related aspects, although no further analysis is reported: carrying cargo and avoiding sweat/dressing nicely. Heinen *et al.* (2009) confirm these factors and find that individuals who need to carry goods during their commuting trips are less likely to cycle to work, and their cycling frequency is lower Individuals who wear business attire to work are also less likely to cycle to work every day.

5.3 Conceptualization and hypotheses

Using the bicycle as a mode of traveling to work is an option for only a part of all commuters, and the likelihood is determined primarily by distance, but is influenced by a variety of socio-demographic and work characteristics as well. Of all commuters who consider the bicycle as an option, a certain portion still use other travel modes, while another portion use the bicycle on a daily basis. Other commuters who consider the bicycle an option alternate the bicycle with other modes; they belong to the category of part-time bicycle commuters. This paper aims to determine factors influencing day-to-day variations in bicycle mode choice among the latter category: when do part-time bicycle-commuters choose the bicycle? Are there distinctions between groups with regard to frequencies, and is it possible to identify factors that affect cycling for those groups?

We assume that part-time bicycle-commuters can be divided in at least two groups. One category consists of people for whom the bicycle is the preferred mode. These commuters aim to cycle as long as certain conditions are met (or unless certain conditions are not met). Their reasoning follows the form of, "I cycle, except when ….". Another group consists of commuters who prefer other modes, unless conditions are very favorable for cycle. Their reasoning might follow the form of, "I cycle only if….". Having assumed that the preferred mode is a point of departure for many commuters, we must acknowledge that we are dealing with a continuum. We also acknowledge the possibility of other categories of bicycle commuters. One example would be individ-

uals whose preferred mode is the bicycle two days a week (e.g. Monday and Tuesday) and the car the rest of the week. They deliberately choose to cycle on certain days and not on others.

Second, a number of factors are assumed to determinants. Weather is assumed to be a crucial factor for part-time cyclists for those who prefer to commute by bicycle, as well as for those who prefer other modes. Weather characteristics (e.g. temperature, sunshine, rain, wind) are assumed to have different effects on different commuters; while heavy rain may keep some from cycling, others may be more encouraged by sunshine. In addition to a linear relation between temperature and cycling (i.e. an increase in temperature encourages workers to cycle), low and high temperatures are expected to decrease the inclination to cycle. Related to weather, whether on needs to cycle in the dark or in daylight is believed to effect the decision to cycle.

Characteristics related to activity patterns are also assumed to be of influence. Work-related characteristics that could decrease the likelihood of cycling include the need to wear business attire, make business trips, or transport goods. In addition, the need to combine commuting with other destinations (e.g. taking children to school or shopping), which involves trip chaining, may also increase the likelihood of leaving the bicycle at home.

Previous research has related several socio-demographic variables to cycling levels (for an overview, see Heinen *et al*., 2009). For example, most research shows that men cycle more than women do (e.g. Plaut, 2005). In this research, we control for four socio-demographic variables: gender, age, education, and car ownership.

Although commuting distance does not differ from day to day for most workers, we still expect distance to have an influence. Cyclists who live further away from work are assumed to cycle less frequently, as the trip may be too exhausting to make every day. Conversely, long-distance bicycle commuters may be more dedicated to cycling and consequently be inclined to cycle more often.

In addition to the direct effects of these factors, we expect interactions between factors to affect the decision to cycle. Commuters who face longer commuting trips are assumed to be differently sensitive to the deterrents and the positive factors of their commutes on any given day. Long-distance cyclists are longer at the mercy of the weather and thus may be more affected by weather condition. On the other hand commuters who are already showing willingness to cycle long distances are less likely to care about externalities such as weather. So, it may also be that that part-time commuters who only bike a short distance would be more susceptible to changing their travel mode based on weather conditions. We also assume that female commuters are more inclined than their male counterparts are not to cycle if they would have to commute in the dark. Females are also assumed to be more sensitive to increases in commuting distance and thus to cycle on fewer days. A greater

sensitivity to distance is also expected for commuters who travel at night and for those who wear business attire, as they might fear sweating. Commuters who wear business attire are also expected to reconsider commuting by bicycle if it is raining.

5.4 Method

5.4.1 Data collection

Data were collected through an internet survey conducted among a sample of employees from several large companies and residents of two mid-sized cities in the Netherlands – Delft (population 100,000) and Zwolle (population 115,000) – and two municipalities adjacent to Delft – Midden-Delfland (population 17,000) and Pijnacker-Nootdorp (population 38,000) –. Respondents were followed from June 2008 until June 2009. Delft is a university town in the western part of the Netherlands, positioned in the southwest section of the Randstad, a polycentric, highly-urbanized area. Zwolle, a city outside this urban conurbation, has a large population of students pursuing higher vocational education. Like many other Dutch cities, Delft and Zwolle have many bicycle facilities, including a separate infrastructure for bicycles.

Respondents were selected from an earlier survey on bicycle commuting, in which participation in subsequent research was requested (see Heinen *et al.*, 2009). Only commuters who had indicated to be willing to participate in a follow-up survey and who commute at least partly by bicycle were included in the follow-up survey. Every participant was approached by e-mail randomly once every two weeks, in order to reduce the likelihood that respondents would change transportation modes in anticipation of the survey. Participants were therefore approached multiple times on each day of the working week (Monday-Friday), with the days alternating at random. Respondents were asked to answer a short questionnaire (lasting one to two minutes) regarding their commute mode choices on that specific day. Options were provided to indicate working at home or not having worked that day. The chance to win one of forty small prizes worth €12 was offered as an incentive. The specific focus on bicycle use was kept unknown to the respondents, in order to prevent individuals who almost never cycled from stopping their participation and to prevent respondents from cycling more frequently because of their participation in the survey. When approaching the respondents the research was presented as a survey on commuting.

We approached 834 part-time cyclists. In total, 20,016 invitations were distributed over the one-year period, and 12,928 questionnaires were completed, resulting in a 65% response rate. It is assumed that most of the non-response is the result of not working on that day. We excluded a number of respond-

ents for several reasons. First, individuals who moved or changed jobs during the survey were excluded (n=45), as they changed their commuting trips, whereas we are interested in variations in mode choice for given origins (residential locations) and destinations (work locations). The effect of the relocation of work or home could also affect the relative position of the bicycle positively or negatively as an option for transportation, thus generating either an increase or decrease in cycling. Second, cases in which respondents did not work or worked at home the whole day were excluded, as they could provide no relevant commute data. The analyses were thus conducted on 8,680 cases involving 633 participants.

We investigated the responses over time. Because many respondents worked part-time and had holidays, it was not expected that most respondents would participate each time they were approached. The minimum number of useful responses per respondent was 1, and the maximum was 24. Holidays are visible in the response rate: fewer respondents worked and participated in the survey during the summer and in the beginning of May, a period with many public holidays in the Netherlands. We did not survey the respondents in the two weeks around Christmas, as this is also a major holiday period. We also observed a slight reduction in the number of useful responses over time. Although we initially collected more than 400 useful responses per two weeks, the number decreased to around 350 in the second part of the survey period. One reason could be that increased familiarity with the survey could have led respondents to stop participating on non-working days (as they knew no further questions needed to be answered), despite our requests. A second reason could be that some participants did not want to participate for an entire year, despite indicating differently in the previous survey. Finally, some participants faced changes in their personal or working situations, such as the loss of a job, pregnancy, or illness.

To test the differences between the two groups of part-time cyclists (frequent and occasional), we calculated the cycling percentage using the days working out-of-home and the days of commuting by bicycle. We excluded respondents who had made fewer than 10 commuting trips, as their cycling percentage was easily affected by coincidence. There were no distinctive changes in this percentage; the only two real peaks are at 0% and 100%. In the first survey, these respondents had indicated that they commute by bicycle occasionally. Despite the fact that the data do not show their transportation-mode alternation, we have no reason to doubt their previous statements, as we did not approach them every day. Respondents with a cycling percentage of 0% or 100% are therefore included in the models. The part-time cyclists were divided into two groups. “Occasional cyclists” reported cycling 33.3% or less of the time, and “frequent cyclists” 66.6% or more of all their commuting trips. This categorization yielded 232 occasional cyclists and 237 frequent cyclists.

Our longitudinal data collection increases the possibility of investigating the relationship between factors that change from one day to the next and day-to-day decisions to cycle, and it enhances the validity of the outcomes, as compared to the collection of one-time (i.e. cross-sectional) measurements. The latter types of data reflect decisions made by different individuals. In our case, we could have approached 8,680 individuals once, but that would have yielded variations in many measured and hidden individual characteristics in addition to those changing from day to day. In the statistical model, however, we can control only for the measured factors. Longitudinal data allow us to distinguish between events and individuals. By repeatedly measuring the decisions of multiple individuals to cycle in response to factors that vary from day to day, we are able to explain the variance within individuals while simultaneously controlling for variations between individuals to a larger extent.

5.4.2 Variables

Table 5.1 provides an overview of the variables. We divided the factors that vary from day to day (upper part) including all valid cases from the factors related to the individual (below), listed for each respondent.

We used weather data from the Royal Netherlands Meteorological Institute (KNMI) from two weather stations close to the survey locations: Rotterdam for Delft, Midden-Delfland and Pijnacker-Nootdorp, and Marknesse for Zwolle. The data include information on precipitation (amount and duration), temperature (mean, lowest, highest), wind speed and direction, visibility, and sunshine. Three other weather variables are calculated: (1) rain, a dummy whether it rained that day, (2) freezing, a dummy for whether the temperature was below 0°C and (3) the average temperature of the previous week. We did not include a dummy for heat, as the data showed no decrease in cycling levels in response to increases in heat.

The variable for darkness was calculated using the working hours. For each month, the average sunrise and sunset was determined and rounded down (at the beginning of the working day) and up (at the end of working day) to a full hour. Individuals starting before or ending before sunrise and those starting or ending after sunset were coded as commuting in the dark. Density data (number of households per postal code) were derived at the level of four-digit postal codes. A four-digit postal code indicates the district of the city. The population of such a district fluctuates nationally from 0 to 27,030 inhabitants. Finally, we distinguished and controlled for whether respondents had been recruited according to their residence or through their employers.

Table 5.1 List of variables

Level	Category	Variable
all cases n=8731	mode choice	mode choice
	work characteristics	working at which location
		working at multiple locations
		commuting in the dark
		needing a car during office hours
		needing a bicycle during office hours
		needing other transport during office hours
		clothing style
	trip characteristics	transporting goods
		making stops/chaining trips
	weather	precipitation, daily amount (in .1 mm) (if 0, notation is -1)
		precipitation, length (in 0.1 hour)
		sunshine, duration (in 0.1 hour)
		average daily temperature (in 0.1°C)
		maximum temperature (in 0.1°C)
		minimum temperature (in 0.1°C)
		minimum visibility (0=less than 100 m, 1=100-200 m, 2=200-300 m,..., 49=4900-5000 m, 50=5-6 km, 56=6-7 km, 57=7-8 km,..., 79=29-30 km, 80=30-35 km, 81=35-40 km,..., 89=more than 70 km)
		maximum visibility
		daily average wind speed (in 0.1 m/s)
		daily strongest hourly wind speed (in 0.1 m/s)
		strongest wind of the day (in 0.1 m/s)
		rain that day
		below 0 that day
		season
		mean temperature, previous week (in 0.1°C)

	Amount	%	Mean	Standard variation	Minimum; maximum
bicycle	4,442	50.9%			
car	3,170	36.3%			
public transport	149	1.7%			
walking	458	1.8%			
combination of above/other	812	9.3%			
home	96	1.1%			
primary working location	7,899	90.5%			
other location	736	8.4%			
yes	1,414	16.2%			
no	6,665	76.3%			
yes	524	6.1%			
no	8,199	93.9%			
yes	706	8.1%			
no	8,025	91.9%			
yes	8,321	95.3%			
no	410	4.7%			
yes	122	1.4%			
no	8,609	98.6%			
suit	486	5.6%			
no suit	8,245	94.4%			
yes	837	9.6%			
no	7,894	90.4%			
yes	2,892	33.1%			
no	5,839	66.9%			
			26.3	51.1	(-1;449)
			20.9	30.2	(0;204)
			44.4	39.9	(0;152)
			100.9	59.4	(-57;240)
			135.6	66.0	(-17;311)
			63.2	57.0	(-89;189)
			36.3	22.9	(0;79)
			73.5	8.8	(23-83)
			43.6	17.8	(11;100)
			65.8	23.0	(20;160)
			113.1	39.3	(40;270)
yes	5,501	63.0%			
no	3,213	36.8%			
yes	114	1.3%			
no	8,600	98.5%			
spring	1,718	19.7%			
summer	2,413	27.6%			
fall	2,583	29.6%			
winter	2,017	23.1%			
			100.9	58.8	(-21;218)

>>

Table 5.1 List of variables (continuation)

Level	Category	Variable
individual	trip characteristics	distance (kilometers)
n=669	socio-demographics	age
		gender
		education
		car ownership
		sample source
		municipality
		density (of addresses)

5.4.3 Statistical method

The observations of any individual respondent are not independent of each other. Modeling the daily commuting choices thus requires a statistical method that can correct for dependency of observations within one individual and model for a binary dependent variable (bicycle/non-bicycle).

To model longitudinal data, both Generalized Estimating Equations (GEE) and Random Coefficient Analyses (RCA) are suitable methods, as both can correct for dependency of observations within one individual (Twisk, 2004). Also known as multilevel or mixed-effect analysis, RCA is a hierarchical statistic method that can model parameters varying at more than one level. It can be used for longitudinal studies by allowing the regression coefficients to differ between subjects. With GEE, relationships are analyzed at different time-points simultaneously (Twisk, 2007, p. 62). In this method, a correction for correlation within subjects is made using an a priori selected correlation structure for the repeated measurements of the outcome variable. "Like ran-

	Amount	%	Mean	Standard variation	Minimum; maximum
			6.7	5.1	(0;36.5)
<40	248	37.1%			
40-60	398	59.5%			
60+	23	3.4%			
male	366	54.7%			
female	303	45.3%			
lower education	73	10.9%			
medium education	202	30.2%			
high education	399	58.9%			
yes	628	93.9%			
no	41	6.1%			
inhabitants	466	69.7%			
employees	203	30.3%			
Delft	297	44.4%			
Zwolle	153	22.9%			
Pijnacker-Nootdorp	122	18.2%			
Midden-Delfland	97	14.5%			
very highly urban (≥ 2,500 addresses per km²)	43	6.4%			
highly urban (1,500-2,500 addresses per km²)	305	45.6%			
moderate urban (1,000-1,500 addresses per km²)	28	4.2%			
small urban (500-1,000 addresses per km²)	231	34.5%			
non-urban (<500 addresses per km²)	3	0.4%			

dom coefficient analysis, GEE enables to analysis longitudinal relationships using all available longitudinal data, without summarizing the longitudinal development of each subject into one value" (Twisk, 2007, p. 60).

For binary data, GEE is the more suitable method. Compared to RCA, the outcomes of GEE analyses are more conservative and thus more robust for binary dependent variables. With regard to outcomes, the regression coefficients and standard errors of a logistic longitudinal RCA are always higher than those of a GEE. Twisk (2007) advises using GEE analysis for dichotomous outcome variables from longitudinal research "if one is performing a population study and one is interested in the relationship between a dichotomous outcome variable and several other predictor variables", as in this case, as "GEE will probably provide the most 'valid' results" (p. 142). Another reason for not choosing RCA is that RCA models for dichotomous dependent variables are not fully developed. Even within one software package, there are multiple estimation options, which often lead to different outcomes (Twisk, 2004). We model daily choice using GEE and RCA in STATA.

Logistic GEE

GEE models are an extension of generalized linear models and are developed to test the influence of factors on binary and other non-normally distributed dependent variables collected within subjects over time. Models developed according to GEE measure population-averaged effects.

Twisk (2004) offers the following formula, in which *Yit* is the outcome variable, CORR is the working correlation matrix, *i* is the subject, *t* is time, *J* is the number of time-dependent predictor variables, and *m* is the number of time-dependent variables, β is the coefficient and ε is the error term:

$$\log(Y_{it}) = \beta_0 + \beta_{1t} + \beta_{2j}\sum_{j=1}^{J} X_{itj} + \beta_{3m}\sum_{m=1}^{M} X_{im} + \ldots + CORR_{it} + \varepsilon_{it}$$

To correct for within-subject correlation, GEE uses one of five a priori correlation structures: independent, exchangeable, autoregressive, stationary m-dependent, and unstructured (Twisk, 2007). We expect the sequence of measurements to have no effect; in other words, we assume similar correlations between the measurements. The correlation between the second and third measurements of a given respondent is thus expected to equal the correlation between the third and fourth and between the fourth and fifth measurements. We therefore used an exchangeable structure (see below), as it assumes that correlations between each subsequent measurement are similarly independent of the length of time between intervals. The estimated regression coefficients form a combined within-subjects and between-subjects relationship, resulting in one regression coefficient for each independent variable.

	t_1	t_2	t_3
t_1	1	ρ	ρ
t_2	ρ	1	ρ
t_3	ρ	ρ	1

Twisk (2004) indicates that analyses of an incomplete dataset due to missing data can produce results that differ from those obtained by analyzing a complete dataset. However, imputing data can also produce unpredictable results in longitudinal analysis with a dichotomous dependent variable. To assess the stability/validity of the obtained results, we also ran models for respondents who had at least 10 useful responses. In addition, we compared the results of the GEE model to those of a model based on RCA (random coefficient only, no random slope).

Logistic RCA

In longitudinal research, RCA models correct for dependency within subjects by allowing regression coefficients to differ between subjects (Twisk, 2007). The simplest form of RCA for analyzing longitudinal data is without random slope and intercept:

$$Y_{it} = \beta_{0i} + \beta_{1t} + \varepsilon_{it}$$

where Y_{it} represents the observation of subject i at time t. If both a random effect and random intercept are included in the RCA, the equation is as follows:

$$Y_{it} = \beta_{0i} + \beta_{1i}t + \varepsilon_{it}$$

where β_{0i} is the random intercept for subject i, and β_{1t} is the random regression coefficient at time t for subject i. Thus far, we have focused on the effect of time on a single outcome variable. The following formula represents the equation for longitudinal research with a dichotomous dependent variable and multiple independent variables.

$$\log(Y_{it}) = \beta_0 + \beta_{1t} + \beta_{2ij}\sum_{j=1}^{J} X_{itj} + \beta_{3m}\sum_{m=1}^{M} X_{im} + \ldots + \varepsilon_{it}$$

The estimated regression coefficients are a combined within-subjects and between-subjects relationship. Note the difference between RCA and GEE: GEE uses a correlation matrix, while RCA calculates a separate β (random regression coefficient) for the time-dependent variable j (β_{2ij}).

5.5 Results

We modeled the effect of work-related factors, trip-related factors, and weather conditions on the day-to-day choice to commute by bicycle, controlling for socio-demographic factors, two sample sources, and area of data collection. The dependent binary variable is whether the respondent cycled to work. Only significant variables in the GEE including all cases were included in the final model. All previously discussed variables not included were insignificant. This discussion is based on the outcomes of the GEE with all observations included (first column with results from the left of Table 5.2). The presented coefficients from the GEE analyses are a combined effect of within-subject and between-subject relationships (Twisk, 2004). The RCA was conducted with a random intercept only.

Table 5.2 The day-to-day decision to cycle to work

		All part-time cyclists				
		GEE	GEE, 10 or more valid cases	RCA (using GLLAMM)	Occasional cyclists	Frequent cyclists
		Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
gender	(male)					
	female	-0.248 *	-0.188	-0.565 ***	0.339	-0.060
age	(<40)					
	40-60	0.125	-0.008	0.214	0.077	0.083
	60+	-0.241	-0.105	-0.538	0.477	0.161
education	(high)					
	low	-0.407 **	-0.617 **	-0.512	-0.980 ***	0.266
	medium	-0.320 **	-0.459 **	-0.432 **	-0.620 ***	0.135
car ownership	(no)					
	yes	-1.277 ***	-1.372 ***	-1.779 ***	-0.028	-0.082
needing a car during office hours	(no)					
	yes	-1.72 ***	-1.702 ***	-2.499 ***	-1.566 ***	-2.283 ***
needing a bicycle during office hours	(no)					
	yes	1.267 ***	1.271 ***	2.025 ***	2.309 ***	1.805 ***
transporting goods	(no)					
	yes	1.465 ***	1.589 ***	2.354 ***	1.830 ***	2.430 ***
wearing business attire	(no)					
	yes	-0.437 **	-0.364 *	-0.860 ***	-1.010 **	-0.208
primary working location	(primary working location)					
	home	-0.146	-0.368	-0.180	1.051	-1.264 **
	other location	-1.355 ***	-1.465 ***	-2.035 ***	-0.441	-1.832 ***
working at multiple locations	(no)					
	yes	-0.188 **	-0.154	-0.317 **	-0.602	-0.513 ***

5.5.1 Cycling to work

Table 5.2 shows corresponding with our expectations, that work, trip, and weather characteristics affect the day-to-day decision to cycle (in the left part). Working somewhere else than the primary location and working at more than one location on a specific day decreases the probability of commuting by bicycle. This is probably a result of both the possible additional distance and the increased trip complexity. Commuters needing a car during working hours, needing to transport goods, or wearing business attire are more likely to leave their bicycles at home. Needing a bicycle during office hours increases the chance of cycling to work.

Increased home-to-work distance decreases the likelihood of commuting by bicycle. Individuals needing to make stops (trip chaining) during their commute trips are also less likely to cycle to work. An additional analysis (not reflected in the tables) reveals that combined trips made for childcare (picking up/dropping off), work, sport, social activities, cultural activities, and edu-

		All part-time cyclists			Occasional cyclists	Frequent cyclists
		GEE	GEE, 10 or more valid cases	RCA (using GLLAMM)		
		Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
precipitation, daily amount (in .1 mm)		-0.002 ***	-0.002 ***	-0.003 ***	-0.002	-0.002
precipitation, length (in 0.1 hour)		-0.002 *	-0.002	-0.003	-0.007	-0.002
maximum temperature		0.002 ***	0.003 ***	0.004 ***	0.005 ***	0.000
sunshine, duration (in 0.1 hour)		0.003 ***	0.002 ***	0.005 ***	0.007 ***	0.003
wind speed, daily average (in 0.1 m/s)		-0.005 ***	-0.005 ***	-0.008 ***	-0.009	-0.007 **
distance		-0.085 ***	-0.091 ***	-0.143 ***	-0.057 ***	0.033
darkness while commuting	(no)					
	yes	0.015	-0.006	-0.895 ***	-0.028	0.077
making stops/chaining trips	(no)					
	yes	-0.365 ***	-0.372 ***	-0.612 ***	-0.309	-0.29 **
interaction female-darkness		-0.249 **	-0.218		-0.800	-0.166
sample source	(inhabitants)					
	employees	0.120	0.244	0.087	-0.173	0.088
city	(Delft)					
	Zwolle	0.371 **	0.559 ***	0.524 **	-0.326	-0.145
	Pijnacker-Nootdorp	0.031	0.239	-0.115	0.233	-0.390
	Midden-Delfland	0.615 ***	0.777 ***	0.864 ***	0.599 **	-0.109
cons			0.492	0.764	-3.599 ***	0.047
		Wald $chi^2(26)$= 511.1	Wald $chi^2(26)$= 421.2	log likelihood= -3533	Wald $chi^2(26)$= 142.5	Wald $chi^2(26)$= 365.1

Significance: *p<0.1; ** p<0.05; *** p<0.01.
Categories in brackets are reference.

cation reduce the likelihood of commuting by bicycle. The combination of commuting with daily errands increases the chances of cycling to work. In contrast to other activities, doing daily errands is apparently easy to combine with commuting by bicycle.

Five weather conditions influence cycling behavior. Both the quantity and the duration of rain affect cycling negatively. In addition, the inclination to cycle decreases in proportion to increases in wind speed. Increases in the duration of sunshine or in temperature, however, increase the likelihood of commuters to cycle. Commuters thus base their mode choices partly on the weather conditions of a given day.

In contrast to our expectations, only one interaction effect is significant. Women are less likely to cycle to work in the dark, so women are more sensitive to the absence of daylight. No interactions between gender and distance were significant, indicating that male and female respondents are equally sensitive to distance. Moreover, wearing business attire is no stronger as a deterrent for commuters who cycle over longer distances, and cycling in the

rain wearing business attire is no more unpleasant than it is when wearing another type of attire. It is possible that commuters who are cycling longer distances may not be wearing business attire, but rather wear sport clothing and changing when they reach their destination. In contrast to the assumptions, several variables have insignificant effects (and therefore are not included in the model), including the following: density, season, temperature the previous week, extreme temperatures (below 0°C), and visibility. The insignificance of season and the previous week's temperature reveals that day-to-day weather conditions explain more of the variation in mode choice than do long-term conditions. Counter to the expectations, extreme temperatures have no added effects above those of the ratio variable for temperature. In addition, the outcome of the model shows no influence of the respondent's region, and no effect was found for the sample source.

We included all relevant respondents in the analysis, even those with few useful responses. We assumed that the low number of useful responses was caused by fewer working days or hours, illness, or dismissal and that the commuting styles of these respondents did not differ from those of other respondents. To check for an effect, we repeated the analysis with respondents who provided more than 10 useful responses. Corresponding to the assumptions, we obtained similar results (see Table 5.2). The choice to cycle was analyzed according to both GEE and RCA models (Table 5.2). The results are comparable (note that the interaction between darkness and gender is not included in the RCA model), and there are only a few differences in significance. We also ran a GEE for all cases, but excluding the respondents who reported cycling 100% or 0% of the time (not reported). Identical results were obtained in this case as well. These findings imply that the outcomes are robust.

5.5.2 Occasional and frequent cyclists

To test for the differences in factors affecting the daily choices of occasional and frequent cyclists, we estimated two GEE models using the same variables included in the model for all part-time cyclists. The outcome of the GEE supports our assumption that occasional and frequent cyclists base their decisions to commute by bicycle on different factors (Table 5.2, right part; only a significance level larger than 0.05 is marked). Frequent cyclists are mostly influenced by factors that make commuting by bicycle more difficult, whereas occasional cyclists are also affected by factors that make the bicycle trip more pleasant.

In detail, pleasant weather stimulates cycling among occasional cyclists. Both higher temperature and longer duration of sunshine increase the likelihood to cycle. This indicates that occasional cyclists are specifically encouraged by coincidental positive circumstances. Occasional cyclists do not cycle when wearing business attire, meaning that the clothing style can keep a

commuter from cycling. In general, occasional cyclists who live further away from work cycle less frequently.

Frequent cyclists are affected by their working locations. People who need to work at multiple locations on one day, or somewhere other than the primary location are less likely to cycle to work that day. When frequent cyclists combine their commuting trips with trips for other purposes, they cycle less often. These three factors increase trip complexity and possibly distance, which complicates cycling. This indicates that the mode choices of people who cycle frequently is more affected by changes in their trips, possibly because they decide not to cycle only if they truly cannot cycle. Finally, strong winds discourage frequent cyclists from commuting by bicycle.

For both groups, needing a car during office hours and needing to transport goods decrease the likelihood of cycling to work. Needing a bicycle also encourages both groups of part-time cyclists to commute by bicycle. These findings suggest that these factors have a similar influence on all part-time cyclists.

5.6 Conclusion

This paper provides insight into day-to-day decisions to cycle to work, using longitudinal data from two Dutch regions. The findings add to the existing knowledge in three ways. First, they provide evidence that the mode choices of many cyclists are affected by factors that change from day to day. The GEE results reveal that the day-to-day decision to cycle is largely influenced by short-term conditions, such as weather conditions, work characteristics and trip characteristics.

Second, the results show the existence of two groups of part-time cyclists. The decision of frequent cyclists (those who cycle more than 66.6% of their commuting trips) to choose an alternative mode of transportation is affected largely by factors that complicate cycling, such as strong wind and working at multiple locations. In contrast, occasional cyclists (those who cycle for less than 33.3%) are affected by factors that make cycling more pleasant, for example nice weather.

Third, the use of longitudinal data collection allowed us better insight into the decision to cycle than would have been possible with cross-sectional data. Longitudinal data make it possible to investigate a person's decision at multiple moments in time, in contrast to data that reflect only one observation per person (logically from only one day). By repeatedly measuring the decisions of multiple individuals to cycle in response to factors that vary from day to day, we are able to explain variance within individuals while controlling to a large extent for variation between individuals.

Many of the reported factors of the day-to-day bicycle mode choice are not easily subject to public policy, for example the effects of the weather. None-

theless, the amount of occurrence and the impact of these incidental day-to-day deterrents on cycling could be reduced. One example of the reduction of the impact is the placement of facilities to protect cyclists from wind or rain on highly-used bicycle routes. Influencing employers might have higher potential. An example of reducing the occurrence of incidental work-events that apparently prevent people from cycling, is clustering the occasions that employees are requested to wear a business attire.

Dutch commuters cycle more than commuters in other countries do. Differences in the built environment, cycling culture, attitudes, norms, and facilities at work could cause the findings of this study to differ from situations in other countries. First, if cycling is associated with stereotypes, individuals who do not fit this image, such as women, may be less inclined to cycle in certain circumstances. In other countries, therefore, we could expect to observe stronger effects of socio-demographics and interaction effects between socio-demographics and other factors. In addition, weather conditions may be more extreme in other countries. Commuters in countries with periods of colder weather, heat, or strong rainfall may face severe difficulties with cycling on those days. Nevertheless, the factors identified in this study are likely to have similar effects on the decision to commute by bicycle in other countries. Reducing the impact and frequency of these factors is thus likely to increase the probability of cycling in any country.

References

Bergström, A. and R. Magnussen (2003), Potential of transferring car trips to bicycle during winter, *Transportation Research Part A 37*, pp. 649-666.

Brandenburg, C., A. Matzarakis and A. Arnberger. (2007), Weather and cycling – a first approach to the effects of weather conditions on cycling, *Meteorological Applications, 14* (1), pp. 61-67.

Cervero, R. and M. Duncan (2003), Walking, bicycling, and urban landscapes: evidence from the San Francisco Bay Area, *American Journal of Public Health, 93* (9), pp. 1478-1483.

Gatersleben, B. and Appleton, K.M. (2007), Contemplating cycling to work: attitudes and perceptions in different stages of change, *Transportation Research Part A, 41* (4), pp. 302-312.

Hardman, A.E. (1999), Accumulation of physical activity for health gains: what is the evidence?, *British Journal Sports Medicine, 33* (2), pp. 87-92.

Hartog, J.J. de, H. Boogaard, H. Nijland and G. Hoek (2010), Do the Health Benefits of Cycling Outweigh the Risks?, *Environment Health perspectives, 118* (8), pp. 1109-1116.

Heinen, E., B. van Wee and K. Maat (2010), Commuting by bicycle, an overview of literature, *Transport Reviews, 30* (1), pp. 59-96.

Heinen, E., K. Maat and B. van Wee (2009), *The Effect of Work-related Factors on the Bicycle Commute Mode Choice in the Netherlands*, presented at IATBR, Jaipur.
KNMI (Koninklijk Nederlands Meteorologisch Instituut) [Royal Dutch Meteorological Institute] weather data the Netherlands, 2008-2009.
Ministry of Transport, Public Works and Water Management and Fietsberaad [Centre of Expertise on Bicycle Policy] (2009), *Cycling in the Netherlands*. Den Haag, The Netherlands.
Nankervis, M. (1999), The effect of weather and climate on bicycle commuting, *Transportation Research Part A, 33*, pp. 417-431.
Parkin, J., M. Wardman and M. Page (2008), Estimation of the determinants of bicycle mode share for the journey to work using census data, *Transportation, 35* (1), pp. 93-109.
Plaut, P.O. (2005), Non-motorized commuting in the US, *Transportation Research Part D, 10*, pp. 347-356.
Pucher, J., J. Dill and S. Handy (2010), Infrastructure, programs, and policies to increase bicycling: An international review, *Preventive Medicine, 50* (S1): S106-S125.
Pucher, J. and R. Buehler (2008), Cycling for everyone: Lessons from Europe. Transportation Research Record, *Journal of the Transportation Research Board*, pp. 58-65.
Sabir, M., J. van Ommeren, M.J. Koetse and P. Rietveld (2009), *Impact of weather on travel demand and mode choice: An Empirical Analysis*, presented at Transatlantic NECTAR Conference, Arlington.
Stinson, M.A. and C.R. Bhat (2004), Frequency of bicycle commuting: internet-based survey analysis, *Transportation Research Record, Journal of the Transportation Research Board (1878)*, pp. 122-130.
Twisk, J.W.R. (2007), *Applied longitudinal data analysis for epidemiology. A practical guide*, New York (Cambridge University Press).
Twisk, J.W.R. (2004), Longitudinal data analysis. A comparison between generalized estimating equations and random coefficient analysis, *European Journal of Epidemiology 19*, pp. 769-776.

6 Similarities in attitudes and norms and the effect on bicycle commuting: Evidence from the bicycle cities Davis and Delft

Eva Heinen and Susan Handy. Submitted.

Abstract
Owing to its beneficial effects, many governments encourage bicycle use for commuting. In search of effective strategies, they often study best practices from elsewhere. However, in order to assess the likely success of transferring measures from one city or country to another, an accurate comparison of the bicycling context is needed. This paper explores the similarities and differences in attitudes and beliefs about the decision to commute by bicycle to work in two bicycling-oriented cities: Delft, the Netherlands and Davis, California, US. Because bicycling conditions are good in both cities, it is possible to explore the role that attitudes play in the decision to cycle to work. Analyses indicate that beliefs about safety and the importance attached to environmental benefits differ between the cities. Social norms about cycling are important in both cities, but residents in Davis are more often confronted with negative reactions to cycling. Similarities are found in beliefs towards the health benefits of cycling. Strategies successful in one city in encouraging cycling by targeting or leveraging health therefore offer promise for the other city. This exploration provides an important starting point for large-sample comparative studies of attitudes towards bicycle commuting.

6.1 Introduction

Cycling offers benefits for both the individual and society. It is a non-polluting, healthy, cheap, and, in urban areas, relatively quick mode of transportation. Because of its societal benefits, many governments encourage cycling. The Dutch government provides safe bicycle routes and parking facilities, tries to increase total kilometers of bicycling, and specifically tries to increase bicycle commuting for distances over 7.5 kilometers (Ministry of Transport, Public Works and Water Management, 2009). In the United States (US), the non-motorized Transportation Pilot Program, administered by the Federal Highway Administration (FHWA), awarded $25 million to four communities to construct a network of non-motorized transportation infrastructure facilities in order to demonstrate that cycling and walking "can carry a significant part of the transportation load, and represent a major portion of the transportation solution" (FHWA, 2005; SAFETEA-LU, SEC 1807).

Governments often look to best practices elsewhere as a basis for developing their own policies to encourage bicycle commuting. Countries such as the Netherlands and Denmark are generally seen as models for creating bicycle-friendly environments. Both countries have a large network of separated cycling lanes that enable cyclists to travel more directly to their destinations, combined with policies that limit car use in urban areas (Pucher and Buehler, 2008). In the Netherlands, many policies in favor of the bicycle have been adopted, such as a tax reduction of up to €750 for employees to buy a bicycle (Ministry of Finance, 2004, 2009). In the US, cities such as Portland, Oregon, Boulder, Colarado and Davis, California are considered leaders in bicycling. Davis was recently reaffirmed as the most bicycle-friendly city of under 100,000 population and was the first city awarded with platinum status for bicycle friendliness by the League of American Bicyclists (2010). Bicycle commuting in these cities is many times higher than the US average of 0.5% of workers regularly cycling to work, as indicated in the 2008 American Community Survey (U.S. Census Bureau, 2010).

So far, international comparative research has predominantly focused on policies, best practices, and analyses of national data (e.g. Pucher and Buehler, 2008, 2006). This research shows mainly the differences between countries, as a basis for identifying ways for the US to stimulate cycling. However, to our knowledge, no international comparative research has focused on attitudes, beliefs, and social norms. This is a notable gap given that research has shown that attitudes are influential in the decision to cycle (e.g. Gatersleben and Uzzell, 2007; Gatersleben and Appleton, 2007). Also, research has shown that in bicycling-oriented cities attitudes are strongly related to the actual cycling behavior (Xing and Handy, 2010; Heinen *et al*., 2011). Such results are supported by psychological theories that posit that behavior is a result of a conscious evaluation of one's own attitudes and societal norms (e.g. the Theory of Planned Behavior (Ajzen, 1991) and the Theory of Interpersonal Behavior (Triandis, 1980)). The importance of attitudes and beliefs for bicycling behavior suggests that it is essential to take them into account when considering the transferability of strategies from one country (or even one city) to another.

This paper aims to fill this gap by exploring the similarities and differences in attitudes and beliefs about bicycling to work in two bicycle-friendly cities, Delft in the Netherlands and Davis, California in the US. The focus is not only on differences but explicitly also on similarities because the successful transference of strategies depends on an understanding of both. Delft and Davis have a bicycle-friendly infrastructure, and (perhaps therefore) bicycling is seen primarily as a mode of transportation rather than a form of recreation. This bicycling orientation enables an exploration of the decision to cycle to work in a context in which cycling is a real transport alternative and where attitudes are likely to play a more significant role. Through in-depth interviews with commuters, we collected individual stories on the decision (not)

to cycle to work, including the factors that influenced their mode choice, their beliefs about cycling and the importance attached to them. This exploration provides an important starting point for large-sample comparative studies of attitudes towards bicycle commuting.

6.2 Attitudes and cycling

6.2.1 Literature

Previous research has demonstrated that attitudes influence travel behavior. Some studies directly investigate attitudes towards the activity of cycling. Gatersleben and Uzzell (2007) found in a survey among university staff in the UK that cyclists find their commute journey more pleasant in comparison to users of other transportation modes. Additionally, based upon 389 completed questionnaires among university staff and students, Gatersleben and Appleton (2007) found that individuals who never consider cycling to work have the least favorable attitude towards cycling and seem unaware of the benefits. Seventy-seven respondents cycled to work and they had the most positive attitudes towards cycling, indicating that attitudes are strongly related to the actual cycling behavior. Xing and Handy (2010) found in a 2006 internet survey among inhabitants of Davis and other similar-sized US cities that agreement with the statement "I like riding a bike" explains the choice to cycle to a high extent. Similarly, Heinen *et al.* (2011) concluded that a positive attitude towards cycling to work resulted in more cycling, using data from an original survey conducted in 2007 in two cities in the Netherlands, Delft and Zwolle. The more positive the individual attitude towards cycling to work was, the higher the chance that that person cycled to work, and the higher the cycling frequency.

Other studies have investigated the effect on cycling of attitudes towards the potential outcomes of cycling, such as reduced environment impacts or improved health, which might provide a motivation for cycling. These studies examined whether individuals with a high awareness of, for example, the environment, are more likely to cycle or cycle more frequently. Bonham and Koth (2010) found that the main reasons to cycle are health, affordability, environmental concerns, time and pleasure. In focus groups on an Australian campus among both students and staff, both commuter cyclists and non-commuter cyclists indicated similar motivations for cycling, though the similarities may stem from the mixing of cyclists and non-cyclists in the same focus groups. One difference was that non-cyclists mentioned safety concerns as a reason not to cycle, whereas cyclists hardly mentioned this concern.

In addition to individual attitudes, perceptions of other cyclists – and of the cycling "culture" in a community – are also important. Bonham and Koth (2010) found that both non-cyclists and cyclists were in favor of creating a "vis-

ible cycling culture on campus, which generates its own momentum". The visibility of a cycling culture therefore might stimulate or prevent a person from bicycle commuting. In this vein, Gatersleben and Haddad (2010) showed that their 244 respondents held specific views about cyclists in Britain. They identified four types of cyclists, as perceived by respondents: commuter cyclists, hippy-go-lucky cyclists, responsible cyclists, and lifestyle cyclists. The intent of the respondents to cycle in the future was connected with their views of other cyclists. Individuals who perceived the typical cyclist to be a commuter cyclist (a young professional, assertive, good looking, well educated, and willing to commute always despite weather conditions) or a "hippy-go-lucky" cyclist (a kind person cycling for non-work day-to-day trips) had a higher intent to cycle.

6.2.2 Conceptualization and hypotheses

A large percentage of workers commute by bicycle in Davis and Delft, thanks in part to the supportive physical environment in both cities. However, the decision to cycle is fundamentally the decision of each individual and thus dependent on internal motivations, even or especially within the context of a supportive environment.

Several well-known theories emphasize the effect of individual beliefs and attitudes, in conjunction with the social environment, on one's behavior. The Theory of Planned Behavior (TPB), as developed by Ajzen (1991), has been tested extensively and has proved useful for understanding mode choice (e.g. Bamberg *et al.*, 2003). According to the TPB, behavior is a result of three considerations: (1) the personal attitude towards the behavior, (2) the expected norms of the social environment (subjective norm), and (3) the perception of the extent to which it is possible to perform the behavior (Ajzen, 1991). Previous research on cycling that examines the roles of individual constraints and bicycling infrastructure suggests an important role for the perception of the possibility of cycling. Here, we focus instead on the role of personal attitudes and subjective norms.

According to the TPB, an individual's attitude towards a behavior is the sum of an individual's various beliefs about the behavior multiplied by the importance that individual assigns to each belief. A behavioral belief is the subjective assessment that the behavior will produce a given outcome. The importance assigned to each belief contributes to the attitude towards the behavior and thus affects the propensity that this individual will engage in the behavior. A person could have many behavioral beliefs about cycling to work, but only those of importance will influence the decision to cycle. The second aspect of the TPB, the subjective norm, is the perceived social pressure to perform a behavior. The subjective norm is a result of normative beliefs – the expectations of "significant others" that you should engage in an activity – and the motivation to conform to these beliefs.

This paper compares the attitudes and subjective norm of commuters in

Davis and Delft towards cycling and investigates the connection between these and the decision to cycle to work. If you have a belief about cycling and attach importance to it, it becomes a "reason" or motivation to bicycle. Of interest are both similarities and differences in the beliefs about cycling and the importance assigned to those beliefs, which together make up attitudes. We expect that differences in attitudes between residents of the two cities are larger than differences in attitudes among residents within each city. But we also expect that beliefs and the importance of these beliefs partly correspond between the two cities. As stated earlier, these similarities are of specific interest for identifying policies and best-practices that can successfully be transferred. Secondly, we expect that cyclists, regardless of city, share more similarities in their beliefs and the importance attached to those beliefs than differences, and that the same is true for non-cyclists. In this paper, the term "cyclist" is applied to individuals who (at least occasionally) cycle to work, while "non-cyclist" refers to those who do not currently cycle to work.

6.3 Research design

6.3.1 Location

Interviews were conducted in Davis and Delft. Both are medium-sized cities, with large student populations, close to important urban areas. The cities are comparable in area size, but Delft is more densely populated (Table 6.1). Both cities have major universities: UCDavis with over 30,000 students, Delft University of Technology with over 15,000.

Delft is located in the western part of the Netherlands (Figure 6.1). It is situated between the second and third largest cities of the Netherlands, Rotterdam and The Hague. The distance to The Hague is 10 kilometers, Rotterdam 15 kilometers and several other smaller municipalities are at cycling distance. Delft has an ancient city centre, but has also undergone several city expansions over the last century, comprising both high-rise and low-density developments. The city is well connected by rail and by car to Rotterdam, The Hague and the capital Amsterdam. The general mode share of the inhabitants of Delft is as follows: car 40%, bicycle 27%, public transport 6%, walking 25% (Municipality of Delft, 2005), fairly comparable to the Dutch national mode share. The city is flat and has an extensive bicycle path network. The Netherlands have a moderate maritime climate, characterized by cool summers (20-25 degrees) and cool winters (0 degrees). It rains year around.

Davis is situated about 70 miles northeast of San Francisco and 15 miles west of Sacramento in the Central Valley of California (Figure 6.2). Davis is connected to San Francisco and Sacramento by train service running every 1 to 2 hours, and to Sacramento by more frequent bus service. Davis is known

Figure 6.1 Delft and surroundings (including the highway network)

for its extensive bicycle infrastructure and its high bicycle share, with 15.5% of workers usually commuting to work by bicycle according to the 2006-2009 American Community Survey. Moreover, there is a bicycle facility to Sacramento parallel to the freeway and planning is underway for a separated bicycle path to a neighboring city, Woodland, as an alternative to the existing bike lane along a two-lane highway, but intra-city bicycle infrastructure is more limited than in Delft. Davis is flat and is, by US standards, a compact city. Davis has a Mediterranean climate, with mild winters (10°C) and hot, dry summers (30-35°C).

6.3.2 Method

This study is based on in-depth interviews. An interview is one of the appropriate data collection methods for research on attitudes, belief, opinions or knowledge (Baarda and Goede, 1997). As we are interested in exploring and understanding underlying beliefs and the connection between attitudes, so-

Figure 6.2 Davis and surroundings (including the highway network)

cial norms, and behavior, we chose this method over a quantitative approach. The behavior, cycling to work, can be relatively easily measured, either by surveying or observation, but the underlying attitudes affecting this behavior are more difficult to measure. Among qualitative methods, in-depth interviews have the advantage in that we were able to glean each person's story as a whole, rather than the pieces we would get in focus groups. In-depth interviews are a way of "discovering the subjective meanings and interpretation of people" (Liamputtong and Ezzy, 2005, p. 71). Moreover, "people's responses are less influenced by the presence of their peers and might be more prepared to discuss sensitive matters" than in focus groups (Liamputtong and Ezzy, 2005, p. 71). Participants may feel more comfortable sharing their thoughts about transportation modes and their opinions and expectations of others.

In total, 31 interviews were conducted, 15 in Delft, and 16 in Davis (see Table 6.1). The interviews in Delft were conducted in August 2009 and December/January 2009/2010. The participants were recruited from among the participants of another survey (for details see Heinen *et al.*, 2011). We selected possible par-

Table 6.1 Overview of research areas and characteristics of interviewees

Area	Delft	Davis
Located in	Netherlands (population 16 million)	California (population 36.5 million)
Population	96,000	65,000
Density	4,180 inh/km²	2,396 inh/km²
Area	24.08 km²	27.1 km²
Jobs	52,920	38,878
Distance to neighboring towns*	Rotterdam 14.5 km	San Francisco 119 km
	The Hague 8.8 km	Sacramento 24.6 km
	Schiedam 12.2 km	Woodland 15.1 km
	Rijswijk 4.8 km	Dixon 14.8 km
Interviewees		
Gender	8 male, 7 female	9 male, 7 female
Bicyclists	6 (almost always)	4 (almost always)
	4 (sometimes or partly)	4 (sometimes or partly)
	5 (never)	7 (never)
Mean age	42 (24-63)	49 (25-68)
Mean commute distance	16 km (1-70)	36.4 km (1.8-129)
Total participants	15	16

* Distance is measured by either the walking or driving distance, whichever was the shortest. The cycling distance might differ.

Sources: Davis: Municipality of Davis, 2008; Delft: Municipality of Delft, 2009

ticipants randomly by computer after first segmenting the sample by gender and cyclist or non-cyclist. The resulting list included individuals living at various distances from work for each of these subgroups. The selected individuals were approached via e-mail and were asked to participate in an in-depth interview. Approximately 50% of those asked agreed to participate. Slightly more men than women responded positively, but we did not find major gender differences. Also more cyclists than non-cyclists responded positively to our request. In Davis, participants were recruited via a well-read local newspaper. A notice was published asking residents to participate in a commute mode choice study, involving a 60-minute interview. The first publication of the notice attracted mostly public transport commuters. Subsequently, the notice was changed to ask for car- and bicycle-commuters specifically, resulting in an even balance between modes for the final sample of commuters.

The participants in both cities are relatively high-educated and with an above-average income. We are uncertain whether this has affected the outcome. The socio-economic status might have resulted in a lower influence of financial factors than for the general population. However, the effect is probably comparable in both cities. All participants are able to cycle and indicated having cycled in the past. In addition, all participants are able to drive, but a few (2 in Delft, 1 in Davis) do not possess a car. All bicycle commuters in Davis except one are employed in Davis. However, some participants in Delft cycle to other cities such as Den Haag, Rotterdam and Leiden. The gender distribution and mean age of the respondents correspond with the population in Delft, where 52% of the inhabitants are male and the mean age is 38.3 (Municipality of Delft, 2008). In Davis, the estimated mean age is 25.9, according to

the 2006-2008 American Community Survey. The focus of this study, commuting, may explain the higher mean age of the participants to some extent, as only workers can participate. In addition, many students live in both cities, which lowers the mean age of the inhabitants. Overall, the participants are generally representative of the populations in the two cities. For this small-sample, exploratory study, the more important aim was to ensure a balance between commuters and non-commuters and to include individuals with a diversity of experiences with bicycling.

The first questions in the semi-structured interviews were open-ended. We asked about commute mode choice(s), including the use of different modes on different occasions or at different times of year, and provided respondents the opportunity to explain the reasons behind their choice(s). We repeatedly prompted them to elaborate on their reasons and the beliefs attached to those choices. We also asked about the reasons for not choosing another mode of transportation. Based upon the literature (Heinen *et al*., 2010; Bonham and Koth, 2010), we asked about the influence of several factors on their mode choice, specifically health, safety, reliability, and the environment. The subsequent questions focused on their social surroundings, particularly the current reactions and expectations of friends, coworkers, and family, and their expected reactions if the participant were to change modes and travel by bike, car or public transportation. At the end of the interview, we collected information on socio-economic characteristics.

All the interviews were recorded and were transcribed afterwards, providing a greater level of detail than can be obtained by taking notes or from memory alone and allowing a greater amount of eye-contact during the interview (Liamputtong and Ezzy, 2005). The transcriptions were then coded through an iterative process. First, we put notes alongside statements in the transcripts of each interview. We then developed preliminary themes, reread the entire set of transcripts, and selected the final themes, based on their relevance to the research question, the similarities and differences within the statements, and the frequency with which that aspect was mentioned by the individuals before prompting. Final codes where then assigned. To better illuminate the patterns of responses, the statements of participants relating to attitudes (beliefs and importance) were coded, with the scale for beliefs ranging from disagree to agree (with the possibility neutral) and the scale for importance ranging from not at all important to very important.

Table 6.2 shows the results segmented between cities and between cyclists (those who currently cycle to work on at least some occasions) and non-cyclists (those who don't). This table provides quantitative support for the discussion. However, the statements of the participants provide far richer data for this exploration. We include representative quotations from the interview transcripts in Tables 6.3 through 6.7, with the gender, age, commute distance and commute mode choice(s) of the participant listed after the quotations in

Table 6.2 Overview of the distribution of beliefs and importance attached to beliefs

		Davis		Delft		
		Cyclist	Non-cyclist	Cyclist	Non-cyclist	
Health	belief positive	9	6	10	4	Agreeing that cycling is healthy (healthier than alternative transportation modes)
	belief neutral or negative	0	1	0	1	
	important	6	2	7	1	
	not important or indifferent	3	5	3	4	
Environment	belief positive	9	7	10	4	Agreeing that cycling is environmentally friendly (more than alternative transportation modes)
	belief neutral or negative	0	0	0	1	
	important	6	3	7	0	
	not important or indifferent	3	4	3	5	
Safety*	belief positive	4	0	2	0	Agreeing that cycling is safe (safer than alternative transportation modes)
	belief neutral	4	2	6	4	
	belief negative	1	5	2	1	
	important	2	3	4	1	
	not important or indifferent	7	4	6	4	
Enjoyment	belief positive	8	3	9	4	Agreeing that cycling is enjoying (more than alternative transportation modes)
	belief neutral or negative	1	3	1	1	
	important	7	2	7	2	
	not important or indifferent	2	4	3	3	

Davis: 9 cyclists, 6 non-cyclists
Delft: 10 cyclists, 5 non-cyclists
*Neutral beliefs are reported separately from negative beliefs because of the large number of neutral beliefs.

brackets. Text written in italic in the tables indicates phrases of the interviewer and is only added if needed for comprehension.

6.4 Results

Participants provided many explanations for why they do or do not cycle and if they do so, when. It goes beyond the scope of this paper to discuss them all. Many are practical, varying from one to several of the following: getting the kids to school, no proper connection by public transport, the need to transport papers or other goods, the need of a transport mode upon arrival, traveling to other locations after work, shopping, weather conditions, high parking costs, and/or distance.

This section discusses the results and focuses on topics on which responses were either largely consistent or widely divergent. It discusses both the beliefs about and importance attached to four aspects of attitude: health and exercise, environment, safety, and enjoyment. Within each of these aspects, we look first at beliefs and then importance. The final paragraph focuses on the social norms.

6.4.1 Health

The transcripts show almost identical reasoning and participants hold largely consistent beliefs about health and exercise. Health benefits of cycling are

Table 6.3 Health considerations of bicycle commuting in Delft and Davis

	Delft	Davis
Influenced	"I have the feeling that I stay healthy, because I am cycling. I am not a top athlete, however." (male, 48, 25 km, bicycle)	"It is good exercise. I have lost a lot of weight this year. Not just from biking, but it helps." (female, 50, 4 km, bicycle & public transport)
	"Exercise is important. I work in a hospital and see very often the consequences of inactivity. So that is the most important reason." (male, 48, 18 km, bicycle)	"The positive things about cycling are getting my heart rate up and exercising, I think that has a positive effect on the body. Plus for being sedentary." (male, 39, 129 km, public transport, bicycle to station)
	"I presume that if I had not cycled the previous 32 years, I would not be working at my computer. 10 kilometer is of course nothing, so why worry? You could simply take the car. But the fact that you remain fit is important." (male, 68, 10 km, bicycle)	"If I had the possibility to commute by bicycle it would be a significant factor to get some exercise." (female, 57, 45 km, car)
	"The exercise is important, although I exercise enough, so it is not really necessary." (male, 56, 4,5 km, bicycle)	"I would exercise anyway, but I like the exercise. It is not the biggest factor, because I would exercise anyway." (female, 48, 4.8 km, bicycle)
	"I prefer cycling over driving... especially because I sit in the office the whole day." (female, 46, 16 km, car & bicycle)	"I am motivated to maintain a certain level of fitness. And the bicycle allows me to do that." (male, 50, 22 km, bicycle & car)
		"I work the majority of the time and am sitting eight hours a day, so it feels really good to be able to move." (female, 24, 3 km, bicycle)
Did not influence	"I work in the health care sector, so health is important to me. But to let it influence my mode choice, no, I don't do that." (female, 25, 1 km, bicycle)	"Actually health is not important. Even if it would not be (healthy), I would still bike and use public transport." (male, 39, 129 km, public transport, bicycle to station)
	"Health is not important for my mode choice, otherwise I would have cycled the last 25 years. So no, I don't worry about my health. I just get in my car and drive to work." (male, 58, 11 km, car)	"Well, I recognize that I could probably be healthier. How important it probably is, I don't worry about it." (male, 39, 29 km and 122 km, public transport & car)

In brackets the characteristics of the respondents are reported in the following order: gender, age, commute distance and commute mode(s).

well known to most participants. Only two non-cyclists, one in each city, were not completely convinced of the health benefits of cycling (Table 6.2). Over half of the participants in both cities mention health or exercise as a very important reason to cycle. Thus, they hold both positive beliefs about the health benefits of cycling and attach importance to these benefits. Some indicate they have the feeling that they are healthy, became healthy, or stayed healthy because of cycling (Table 6.3). Others share the beliefs, but do not act on them. Six respondents cycle but indicate that health is not the main reason why they cycle or argue they get enough exercise through other means. Non-cyclists also indicate having chosen other modes of transportation because they

do not attach enough importance to being healthy. A Dutch woman of 25 explained that her health was very important to her, but adjusting her transportation mode for this reason would be too extreme.

Some participants connect the sedentary nature of their job with cycling to work. They spend much of their time sitting at their jobs and seem to mind the lack of movement. They attach more importance than others to being able to exercise and explicitly mention that this is a reason for them to commute by bicycle. Most other participants also have sedentary jobs but seem not to be bothered by the lack of movement to such an extent that it motivates them to cycle.

6.4.2 Environment

All participants except one (who was neutral on this subject) share the belief that cycling is environmentally friendly compared to car and public transport use (Table 6.4). However, participants in Davis attach more importance to the environmental friendliness of their commute mode and mention it more often as a main reason to cycle. Many participants from Davis, cyclists in particular, seem to like identifying themselves as environmentally conscious individuals, who take environmental impacts into consideration in their (mode choice) decisions and emphasized this repeatedly in the interviews. In contrast to research by Anable (2002), respondents in Davis mentioned the environment without prompting. Various participants in Delft also indicate that they cycle because of environmental benefits, but equally frequently the environmental benefits are mentioned as a pleasant side-effect, not as the main reason to cycle.

It is notable that non-cyclists in Davis also express their belief in the importance of the environment. This apparently does not affect their decision to cycle, however, though it does seem to influence the use of public transport or a hybrid car for commuting. Hunecke *et al*. (2001) reported similar results from a telephone survey, showing that public transport use was partly a result of monetary costs and partly one's personal ecological norm. It is also notable that not all cyclists consider the environment an important factor in their decision. Many indicate that the personal benefits, whether money, convenience, time, or the enjoyment of cycling, are far more influential, or that their decision is based on a combination of factors.

Whether the environment is really the most important factor, even in Davis, is not clear. Cyclists might like to identify themselves as environmentally friendly, and see this orientation confirmed by their cycling behavior. In this case, they might explain their behavior and decisions in terms of environmental friendliness, whereas the mode choice could in fact be based on other factors. Presumably, bicycle commuters who say they cycle for environmental reasons think of themselves as environmentally friendly because they bicycle.

Table 6.4 Environmental considerations of bicycle commuting in Delft and Davis

	Delft	Davis
Influenced	"Yes, I think the environment is important. I am not an environmental activist, but we try to live consciously." (male, 58, 15 km, bicycle) "For me the environmental impact plays a role. I do these things, but I am not an environmental activist." (male, 56, 4,5 km, bicycle)	"It is important for environmental reasons. I think that the driving part is one of the worse things we are doing to society. And for all kind of reasons." (female, 48, 4.8 km, bicycle) "I don't like eating up and leaving a bigger carbon footprint than I have to." (male, 26, 3 km, bicycle) "Since my wife already uses a car to commute and take care of my daughter, I try to drive a little as possible to reduce the carbon footprint I make." (male, 31, 27 km, public transport)
Did not influence	"I think that the way people cope with the environment has not convinced me that I as individual can contribute to that." (male, 58, 11 km, car) "It does not directly affect my choice; I do not consider it when deciding how to commute....that it is good for the environment is a nice side-effect." (female, 25, 1 km, bicycle) "It would play a role, if the travel time were similar. 5-10 minutes difference is okay. But if it differs more, too bad!" (female, 33, 20 km, car)	"That is not really a factor why I cycle." (male, 39, 129 km, public transport, bicycle to station) "For me I worry about fuel efficiency, because that comes right out of the pocket. But other than that I don't worry about it (the environment)." (male, 39, 29 km and 122 km, public transport & car)

In brackets the characteristics of the respondents are reported in the following order: gender, age, commute distance and commute mode(s).

Some of them may actually decide to cycle based on the benefits for the environment, some may not.

6.4.3 Safety

Almost all participants hold the belief that cycling is as safe as driving within Delft and Davis (Table 6.5). Most cyclists consider cycling safe, whereas non-cyclists more often stress the risks of cycling. This raises the question whether the actual act of cycling reduces the perception of the risk of cycling, or whether a low perception of risk contributes to the act of cycling. Cycling to nearby cities is also considered safe traffic-wise in Delft. In Davis, however, over half of the participants consider cycling to other cities unsafe. It seems that safety has greatest importance among the factors examined within Delft or Davis, but that safety concerns combined with the long distances between cities is probably a major deterrent for inter-city commutes in Davis.

Six participants reported having had bicycle accidents – four in Delft, two in Davis. After having an accident the behavior and beliefs of three of the participants changed. After her accident, an American woman considered cycling

Table 6.5 Safety considerations in Delft and Davis

	Delft	Davis
Traffic safety	"Safety is important for me, but not in relation to the choice of whether or not to use the bicycle. I think that cycling, or just simply being in traffic, either cycling or driving, is taking risks." (male, 48, 18 km, bicycle)	"There is a huge bike lane to campus here in Davis, which feels very safe for riding... And because traffic is not dangerous in Davis, I don't feel unsafe. I am not afraid of being hit by a car." (female, 24, 3 km, bicycle)
	"Safety is not the reason for driving instead of cycling." (female, 33, 20 km, car)	"Here are bike lanes, people are used to bicyclists. I feel safer here." (female, 51, 1.6 km, bicycle)
	"I believe that statistically the bicycle is less safe per kilometer. But I think it depends how you cycle. I am not afraid." (male, 54, 11 km, bicycle & public transport)	"But is the risk of driving greater or smaller than riding a bike? I don't know. I don't see why one is safer than the other." (male, 53, 110 km, public transport)
Traffic safety between cities		"It is actually very dangerous. The traffic. Really there is no way. Here (in Davis) we have bike paths and everything is safe. (To work) I would go basically through some pretty bad neighborhoods the whole time. I was told by a number of people that it was not safe." (female, 47, 40 km, car)
		"In other cities people are a lot more aggressive to cyclists; you are more likely to honked at or shouted at. You are being bugged." (male, 50, 22 km, bicycle & car)
		"Within Davis I would ride. But to Winters or Woodland, I might not. It is not safe." (female, 51, 1.6 km, bicycle)
		"The only way to get there is over farm road. To Woodland it is kind of narrow. It is safer here than there. A couple of people have been killed there." (female, 38, 21 km, car)
Accidents	"I don't think about that (safety). Once every 2-3 years I get hit." (male, 58, 15 km, bicycle) "Although I have had collisions on my bicycle, I still consider the bike safer than driving to work." (male, 48, 25 km, bicycle)	"I had a bike accident during that first year (in Washington State). I was not seriously hurt, but it scared me. So, I did not feel comfortable riding without bike lanes at that point." (female, 48, 4.8 km, bicycle)

in traffic unsafe, in sharp contrast with her previous behavior. Two Dutch persons reported changes in beliefs and behaviors in certain circumstances, one towards cycling as a sport activity and the other regarding cycling on slippery surfaces.

Concerns about personal safety and security also affect bicycle use negatively. In Delft, participants mostly mention concerns about riding in bad weather or in the dark. Women especially mention personal security as a reason for not cycling at night, although not all women believe it to be unsafe. Men in Delft indicate that personal security is not a factor for them, but believe that it may matter to women. Concerns over weather and personal security seem present in Davis as well, but were less frequently mentioned.

	Delft	Davis
Accidents	"If it is slippery, I choose the car. Once I had a very nasty fall." (female, 64, 4,5 km, bicycle & car) "Two years ago, I broke my collarbone when cycling. I fell riding a race bike...On my race bike I have become more cautious, because I was frightened. But cycling to work was not influenced by it. I started as soon as I could." (male, 56, 4,5 km, bicycle)	"I had a couple of accidents with cars and I had accidents with bikes." *Did these accidents influence your behavior?* "Well, you always wear a helmet, right. And I like to tell myself that I am a better rider, a more courteous rider that kind of comes and goes with near-death experiences." (male, 50, 22 km, bicycle & car)
Personal security	"Another problem in winter is that it gets dark early. In terms of my personal safety. At my previous working location I had a different route. This route was over rural roads and unlith bicycle paths. I just considered it too scary to cycle there in the dark. So I just commuted by car from November until January, always." (female, 46, 16 km, car & bicycle) "I would cycle at night, but not for commuting. At 11 at night from the city centre should not be a problem, but from Rotterdam, it is." (female, 64, 4,5 km, bicycle & car) "I do not really put attention to it"..."I am an older man. For a young woman, it would be different, I suppose." (male, 58, 15 km, bicycle) "I can cycle day and night, which I consider a huge benefit of Delft."... "I notice that some people don't cycle in the dark, but I will continue. I don't want to worry about it." (female, 48, 70 km, car)	*Are you only worried about traffic safety or also about personal security?* "A little bit of both actually. Traffic safety probably above and beyond. You know, there are also some personal safety issues, too. And the American [River] bike trail and so on, that are not places to be alone." (female, 47, 40 km, car) "The bike route is kind of going to some rough areas, especially in West-Sacramento. I have heard of people having had some problems. People have been mugged over there."..."People with young children. I wonder. It is unsafe. And you should want to get home safe for your family."... "Cycling is the least safe mode. I see an accident at least every two weeks. It is a reason not to cycle." (male, 31, 27 km, public transport & car) "Biking is safe...So, the bicycle offers you more freedom of movement. If you have to get away very quickly you ditch the bike and run to the other side of the street if you have to." (male, 37, 21 km, car & public transport)

In brackets the characteristics of the respondents are reported in the following order: gender, age, commute distance and commute mode(s).

These findings indicate different beliefs about cycling risks between the two cities. This could be a result of differences in bicycle infrastructure between the cities and their surrounding areas, consistent with Klobucar and Fricker's (2007) argument that perceived level of safety increases with the presence of dedicated bicycle infrastructure. In the Netherlands, separate bicycle facilities are available not only within city borders, but also on inter-city roads, so that Dutch participants might feel safer cycling traffic-wise. This difference could also be explained by differences in the cultures of the two countries.

Table 6.6 Enjoyment of cycling in Delft and Davis

	Delft	Davis
Positively influenced: Enjoying cycling	"I find cycling very pleasant. I am not a cyclist (sport). But I do cycle for fun and recreation, besides cycling to work. Just an extra round. I enjoy it." (female, 64, 4,5 km, bicycle & car) "Cycling is not quicker, but more enjoyable. That is also important to me. I love moving for one hour in the morning. Yes, I like cycling. I can't explain it in a better way." (male, 48, 25 km, bicycle)	"I probably just like it (cycling). It feels healthy, it feels energetic, it feels relaxing." (female, 48, 4.8 km, bicycle) "I enjoy going for a bike ride, for relaxation and so. If I am not working on a Saturday, I ride my bike to the market. But when I have to get to work, some days it is very pleasant, some days it is not." (female, 57, 45 km, car) "I rode my bike, because I enjoy riding a bike, first of all."..."I do enjoy driving, I listen to music, I can think, and you have that kind of solitude, time alone before you begin your work day. That said though, I have the same experience when I do bicycle to the train station."..."My ideal job would be that I could bicycle." (male, 53, 110 km, public transport) "I had a different car, and I used it until it broke down. I would ride my bike then, maybe for a month. I enjoyed it. But once I had the car fixed I stopped right away." (male, 26, 10 km and 40 km, car, public transport & bicycle)
Negatively or not influenced	"I should admit the moment I get into my car, I get in something of my own. It simply is my place, an extension of my home." (female, 48, 70 km, car)	"I don't think I'd like cycling for the sake of cycling. I like cycling for the sake of everything I was saying: being outside and a bit of exercise." (male, 26, 10 km and 40 km, car, public transport & bicycle) "I am so athletic, but my but hurts when I cycle and there is nothing that I can do about it." (female, 47, 40 km, car)

6.4.4 Enjoyment

The interviews show the importance of enjoyment of cycling as a predictor of cycling activity (Table 6.6). Participants explain their and others' cycling behavior as stemming from internal satisfaction. One participant illustrated this point in explaining that even if one could work out all the practical issues involved in commuting by bicycle, those who do not like cycling could find excuses to avoid cycling. More participants in Delft explicitly said that they like cycling while in Davis some participants admitted that they did not really enjoy cycling. Other participants stressed their dislike of car driving as an explanation of their mode choice. As expected, non-cyclists more often dislike cycling. The longer the commute, the more important an individual's enjoyment of cycling appears to be to the choice to cycle. This makes sense given the greater effort needed to commute over longer distances. Nevertheless, even a

	Delft	Davis
Liking cycling more specified	"It is relaxing and free. In a car you get very quickly occupied with other road users"..."Also that you sit on your bike and get some fresh air. Especially after a working day. You had a busy day, cycling 5 to 10 minutes, you can feel some wind and your head is empty again." (female, 25, 1 km, bicycle) "On a bike you empty your head, but you can reflect on things. Not that it is important, but you can concentrate better." ..."I consider it relaxing. It is an effort, but I think it is relaxing. I also consider it a break, a quiet moment during the day. It sounds silly, but the whole day I am talking and writing and people always want something from you. I have 45 minutes nothing." (male, 58, 15 km, bicycle) "I consider cycling a pleasant way of transport. It is relaxing and before you get home, many things disappear out of your mind." (male, 48, 18 km, bicycle)	"The car is definitely more stressful, where the bike relieves stress. It (car driving) increases stress in fact." (male, 26, 10 km and 40 km, car, public transport & bicycle) "I feel good because I get to relax, I can listen to my iPod in one ear. I like the wind and the breeze in the morning. Wave to people." (female, 50, 4 km, bicycle & public transport) "And if I don't feel well, I like having the choice of taking the bus, because I don't want to collapse or so. I do like enjoying the ride, not just doing the ride" (female, 50, 4 km, bicycle & public transport) "You got to enjoy it. Why else would you do it? You can find all kind of excuses to get in the car." (female, 51, 1.6 km, bicycle)

In brackets the characteristics of the respondents are reported in the following order: gender, age, commute distance and commute mode(s).

liking for cycling was not enough for people to continue cycling. For example, a man in Davis stopped cycling when a car became available and he no longer needed to cycle, but he still claims to enjoy cycling.

In the interviews, participants mentioned many different things that they like about cycling. First, some appreciate the freedom of cycling, not only in the functional way – being able to come and go when and where they want – but also in the sense of the experience itself. Second, many consider cycling relaxing, both mentally and physically; conversely, others express their dislike of car driving in terms of stress. Third, the break between work and home is appreciated, mainly by Dutch participants. The stories show that there is much variation in the positive experiences of cycling, but the findings indicate that, regardless of the location, the enjoyment of cycling matters greatly in the final decision to cycle.

Table 6.7 Cycling norms in Delft and Davis

	Delft	Davis
Negative social norm	"I am an external worker, companies rent me. And they expect a certain profile. I don't like stepping outside that profile."..."Where I work everyone is dressed nicely, and it does not feel right. But then I think whatever. But if there would be a problem, that is it." (male, 58, 15 km, bicycle)	"I used to cycle. People were not opposed to that, but they found it odd. They even said I was crazy for doing that. People thought it was dangerous. Or people had a pity on me. They where like: 'hey man, I can give you a ride home man, it's no problem for me'"..."And especially with bad weather. People would come up to me to pick me up for work. Especially in summer when it was hot they say: 'you can't bike'." (male, 26, 10 km and 40 km, car, public transport & bicycle) "My family and friends, there is that perception, you are a 24 year old woman, working full-time, and you don't have a car. Why don't you have a car? Can't you effort it? Everyone has a car! There is a little bit of judgment outside of this community." (female, 24, 3 km, bicycle) "In Davis, bicycling is more positive than cycling in Woodland or other surrounding towns. An adult riding in Woodland you just assume he lost his license, apposed to in Davis." (male, 53, 110 km, public transport)
Positive social norm	"I think most people think positively about cycling. In general also my colleagues, even if they aren't cyclists. They appreciate it if you cycle." (male, 56, 4,5 km, bicycle) "They consider it logical and good. I think that when I would travel by car, they would put question marks. You lazy person!" (female, 25, 1 km, bicycle) "Car use is being discouraged at my work." (male, 54, 11 km, bicycle & public transport	"Especially in this town, it is really positive, as I am not contributing to a large carbon footprint by cycling." (female, 24, 3 km, bicycle) "If I would ride my bike from Dixon and everybody knew I was doing it, I would get a lot of hags on the back and 'wow, that is amazing'." (male, 37, 21 km, car & public transport) "My coworkers are jealous that they can't get on their bike to go to work." ..."When I started a few years ago, I lost weight, I am more muscular, so everybody always thought that it was good for me. (female, 50, 4 km, bicycle & public transport)

	Delft	Davis
Transport culture	"For many people driving is the default. A default mentality of our society." *Do you experience it like this?* "I notice it, but it does not bother me. You see people taking the car for small distances." (male, 54, 11 km, bicycle & public transport) "For many colleagues a car is important. They enjoy it more. The bigger, the better. Mostly male colleagues. It is just considered important." (female, 33, 20 km, car) "I also think that some people, although not in my direct surroundings, don't think it is distinguished enough. They would say, I am a manager of a company, I can't do it." (male, 56, 4,5 km, bicycle)	"It is also part of a stigma sometimes. If you are an adult, especially in this area and in California, you are expected to have a car. That is just the way communities have been developed, it is just the way that people drive. They don't use public transport and bicycles. Maybe it is just the way they were raised. Just how things were designed and lied out for them to drive a car." (female, 24, 3 km, bicycle) "In California, however, people have seen their parents drive, so they drive as well. That's what they are used to. For them a car is more important. As a New Yorker I am not used to this. The car is part of the California lifestyle." (male, 31, 27 km, public transport & car) "... it is more an American culture, in terms of who drives. Most people assume you need to drive." (female, 47, 40 km, car) "If you would have asked me that question 10-15 years ago, I would have had probably very strong feelings one way or the other. I think over time, and living in Davis and what you read in the press, I think that it is just really an individual decision. And I admit I grew up in Los Angeles. The perception was, anyone would use public transport or bikes, is a loser." (male, 39, 29 km and 122 km, public transport & car) "I grew up in Holland. And that is what we did, we rode our bikes everywhere. My parents never ever chauffeured me."..."I rode my bike, rain, wind, it did not matter. It was just the way to get there. It was part of life." (female, 51, 1.6 km, bicycle) "Some people who could bike but drive instead may also worry about appearance. Because if you cycle, you hair gets mixed up and you don't want to bike in three pieces suit." (male, 39, 129 km, public transport, bicycle to station)

In brackets the characteristics of the respondents are reported in the following order: gender, age, commute distance and commute mode(s).

6.4.5 Norms/social environment

Participants in both countries indicate that they at least occasionally feel social pressure not to cycle (Table 6.7). They perceive a negative norm of cycling or do not consider it appropriate to cycle in certain situations. For example, one man indicated feeling uneasy walking into the office in cycling clothes. In Davis a few respondents faced a lack of understanding from co-workers and were subject to negative comments for cycling to work. Even the commuters who put low importance on this negative norm and cycle despite it feel uneasy and expressed an understanding of why others would choose not to cycle as a result. On the other hand, many cyclists also reported positive reactions from their social surroundings, which may encourage them to cycle. Most non-cyclists indicated that colleagues or friends would support them if they did cycle, for the same reasons that they themselves support cycling.

Cyclists also exert social pressure on other commuters. Several participants who cycle to work express their incomprehension of others who live close to work but do not cycle. For example, they seem not to be convinced that appearance at work, the need to wear smart clothing and not be sweaty, should be a reason not to cycle at all.

Both cities seem to have social pressure. But Davis respondents differ from those in Delft in perceiving the culture outside of their town as anti-bicycle. Many participants from Davis feel motivated to cycle within Davis, but outside seem to feel the need and expected use of a car; the subjective norm outside of Davis does not support cycling. Of course, distance is also a reason not to bicycle to neighboring towns, as is perceived safety, as noted earlier; a bicycling norm in other communities would probably not be enough to overcome these other deterrents. Participants in Delft do not identify a difference in the norms in and outside of Delft. The subjective norm is less local in Delft.

Some Davis participants say that American transportation culture does not support cycling. One admits that in the past he had ridiculed cycling and public transport users. Participants stress the car-dependent American and specifically Californian culture and cite that as the explanation for the travel behavior of others. Davis is considered an exception by participants with respect to bicycling norms. In contrast, no Dutch participants cite their culture as an influence on their travel behavior. One former Dutch woman, living in Davis but of Dutch origin, pointed at the Dutch culture as a reason and explains her current cycling behavior in terms of her Dutch background and norms. She continued this lifestyle in Davis. This example suggests the importance of early experiences in explaining bicycle commuting. Inhabitants of Delft do not seem to recognize this culture themselves.

6.5 Conclusions

6.5.1 Summary and discussion

This study explored the similarities and differences in attitudes, beliefs, and norms about bicycle commuting in Delft (Netherlands) and Davis (US) conducting thirty-one in-depth interviews with both bicycle commuters and non-bicycle commuters. It contributes to the existing knowledge by offering new insights on three points: (1) to what extent attitudes and social norms towards bicycling are similar in different settings, (2) to what extent they differ, (3) how they affect cycling behavior.

The narratives show similarities between participants in both countries. They share the belief that cycling is healthy and attach similar importance to health benefits. Most cyclists indicate that health benefits encourage them to cycle, whereas non-cyclists agree on these benefits but attach more importance to other factors. Secondly, cyclists in Delft and Davis share their beliefs that cycling is enjoyable. The fact that they like to cycle seems to play an important role in their decision to cycle.

The narratives also reveal differences. First, participants in Davis believe the bicycle to be an unsafe mode of transportation to a larger extent than the Dutch participants believe the bicycle to be unsafe. Although most feel safe cycling in Davis, they emphasize unsafe traffic conditions as well as concerns over personal security as reasons not to cycle to or within other cities. In Delft, traffic safety is hardly mentioned. Discussing safety, participants in Delft respond in terms of personal security. Especially for women, cycling at night was not always considered safe. Second, the importance of environmental concerns was more often mentioned in Davis. Some of the participants in Delft emphasize their belief that cycling is environmentally friendly, but attach less importance to it and refer more often to environment as a beneficial side-effect. Third, different norms clearly exist between the countries. Both cities seem to have a positive norm towards cycling. However, participants in Davis experience a negative norm in surrounding cities. Also family or friends sometimes respond negatively towards the participant cycling rather than driving. Some of the participants explain this in terms of the American and especially Californian culture in which the car plays a dominant role.

This paper reveals a clear influence of attitudes and norms on cycling behavior. In this study, cyclists hold generally positive beliefs about cycling and attach importance to these beliefs. Non-cyclists have more mixed attitudes. Many non-cyclists do not perceive the benefits of cycling or attach low importance to them, but some non-cyclists do attach importance to them. This results in a mismatch between their behavior and their attitudes and suggests that even if attitudes and beliefs are important, they are not enough to overcome constraints. This points to the importance of the third factors in

the Theory of Planned Behavior, "perceived behavioral control", defined as the expected possibility of performing a behavior. Low perceived behavioral control may deter even those with positive bicycle attitudes and positive subjective norms from cycling.

This study focused on individuals, both their attitudes (as determined by beliefs and the importance ascribed to those beliefs) and subjective norms, their perceptions of the social norms in their social surrounding community. Both attitudes and subjective norms, though held by the individual, are likely to be affected by national (or regional) culture. Moreover, attitudes and subjective norms can reinforce each other. As a result, we expected to see commonalities within each city but significant differences between cities. It is perhaps surprising that we found as many similarities as we did between the two cities, and the differences within each city, though not highlighted here, were also sometimes surprising.

The validity of this study could have been affected by a number of factors. Participants might have said what they believed the interviewer wanted to hear. We tried to overcome this problem by assuring the interviewees before the interview started that there were no right or wrong answers and that we were interested in their opinions. We also started with open-ended questions and put similar weight on questions about other modes. Although the questions focused on commute choices in general, over the course of the year, the responses may have been influenced by current weather conditions, as influenced by the variation in the timing of the interviews. The relatively high education and income levels of the participants compared to the national average may have affected the results, but in what way is unknown, given the lack of consistency in previous studies as to the reported influence of income levels on cycling (Heinen *et al*., 2010).

6.5.2 Policy and research recommendations

The fact that the inhabitants of the two cities share beliefs and attach equal importance to some of these beliefs about cycling suggests that policies and practices can be copied if related to the related attitudes and norms. First, the similarities in beliefs about and importance of health indicate that policies and campaigns emphasizing health benefits of cycling may have similar effects in the two cities. Secondly, similar attitudes suggest the possibility of transferring other kinds of strategies, such as bicycle infrastructure, reducing practical barriers for cyclists, or introducing barriers for other transportation modes (for examples see Pucher and Buehler, 2008). However, even if attitudes differ, this does not automatically mean that strategies cannot be transferred. Strategies may still work for a smaller share of the population, i.e. the people with the 'right' attitudes, though the effect is likely to be less predictable.

The insights from the exploration described in this paper provide an important starting point for large-sample comparative studies on attitudes towards bicycle commuting. This study found a wide variety of attitudes in these two cities, and future studies could examine the prevalence of these attitudes and the patterns in which they are found throughout each country. The results could also be taken as a point of departure for an international quantitative analysis to test the effects statistically. A better understanding of bicycling attitudes, their effect on cycling behavior, and how they compare in different cities is an important step towards the design of more effective strategies for increasing bicycle commuting.

Without doubt bicycle infrastructure plays a role in the consideration of whether or not to cycle to work. It can be reasoned that attitudes and norms toward cycling are connected with the presence and quality of bicycle infrastructure. Research on individual experience with bicycle facilities and the effect of this experience on individual attitudes could provide policy makers with important input for decisions about investments in bicycle infrastructure. Conversely, positive attitudes and norms toward bicycling in a community are likely to lead to greater investments in bicycle infrastructure. Studies on the mechanisms by which attitudes and norms influence the policy process could also provide insights useful to efforts to expand bicycle commuting.

To encourage cycling a bicycle-friendly atmosphere seems essential. We see several possibilities for achieving this. One approach is to make an exemplar out of a highly respected person, for example, by honoring a town leader who is a regular bicycle commuter. Exemplary behavior can result in copying, and it can also promote more positive attitudes and norms on cycling. A second option is to use a so-called super-promoter: an enthusiastic person who shares this enthusiasm with others and is taken seriously (Vogelaar, 2009). This enthusiasm can produce copying and lead others to follow recommendations. Ideally the super-promoter is someone who has switched from car to bicycle, so that car-drivers can identify themselves more easily with this person. Finally, in advertisements and public awareness campaigns a positive and emotionally appealing message should be sent to improve the public image of cycling. The interviews in Delft and Davis showed that enjoyment of cycling and appreciation of its health benefits are shared by almost every participant and that they act as motivators to cycle. These positive attitudes are an important asset that communities can leverage in their efforts to increase bicycle commuting.

Acknowledgements
The visit to Davis of Eva Heinen was partly made possible with support of the Van Eesteren-Fluck & Van Lohuizen Stichting. We want to thank the anonymous reviewers and dr. J.J. Trip for their constructive comments.

References

Anable, J. (2002), *Mobility management in the leisure sector: The application of psychological theory and behavioral segmentation*. PhD thesis, London (University of London, Department of Environmental Science and Technology).

Baarda, D.B. and de Goede, M.P.M. (1997), *Basisboek Methoden en Technieken*, Houten (Educatieve Partners Nederland).

Bamberg, S., I. Ajzen and P. Schmidt (2003), Choice of travel mode in the theory of planned behavior: the roles of past behavior, habit, and reasoned action, *Basic and Applied Social Psychology, 25* (3), pp. 175-187.

Bonham, J. and Koth, B. (2010), Universities and the cycling culture, *Transportation Research Part D, 15* (2), pp. 94-102.

Eagly, A.H. and Chaiken, S. (1993), *The psychology of attitudes*, Belmont, California, USA (Wadsworth Group/Thomson Learning).

Federal Highway Administration (FHWA) (2005), *Bicycle and Pedestrian Provisions in (SAFETEA-LU), SEC. 1807*. Nonmotorized transportation pilot program, via http://www.fhwa.dot.gov/environment/bikeped/legtealu.htm#sec1807.

Gatersleben, B. and Appleton, K. M. (2007), Contemplating cycling to work: attitudes and perceptions in different stages of change, *Transportation Research Part A, 41* (4), pp. 302-312.

Gatesleben, B. and Heddad, H. (2010), Who is the typical bicyclist?, *Transportation Research Part F 13* (1), pp. 41-48.

Gatersleben, B. and Uzzell, D. (2007), Affective appraisals of the daily commute. Comparing perceptions of drivers, cyclist, and users of public transport, *Environment and Behavior, 39* (5), pp. 416-431.

Heinen, E., Van Wee, B. and Maat, K. (2010), Commuting by bicycle, an overview of literature, *Transport Reviews, 30* (1), pp. 59-96.

Heinen, E., Maat, K. and Van Wee, B. (2011), The Effect of Work-related Factors on the Bicycle Commute Mode Choice in the Netherlands. The role of attitudes toward characteristics of bicycle commuting on the choice to cycle to work over various distances. *Transportation Research Part D, 16* (2), pp. 102-109.

Hunecke, M., Blöbaum, A., Matthies, E. and Höger, R. (2001), Responsibility and environment: ecological norm orientation and external factors in the domain of travel mode choice behavior, *Environment and Behavior, 33* (6), pp. 830-852.

Klobucar, M S. and Fricker, J D. (2007), *A Network Evaluation Tool to Improve Real and Perceived Bicycle Safety*. Presented at Transportation Research Board, Washington, D.C., USA.

League of American bicyclists (2010), *Bicycle friendly America*. Washington, D.C. (League of American bicyclists), via http://www.bikeleague.org/programs/bicyclefriendlyamerica/pdfs/bfa_yearbook2010.pdf.

Liamputtong, P. and Ezzy, D. (2005), *Qualitative research methods,* Victoria, Australia (Oxford University Press), 2nd edition.

Ministry of Finance (2009), *State decision 9 February 2009*, nr. CPP2009/109M, Stcrt. nr. 29, via http://www.minfin.nl/Actueel/Besluiten_beleidsregels/2009/02/Omzetbelasting_Aftrek_omzetbelasting_met_betrekking_tot_auto_s_e_d.

Ministry of Finance (2004), *State decision on 22 June 2004*, nr. CPP2004/1454M. via http://www.loonheffing.nl/besluiten/CPP2004-1454M.htm.

Ministry of Transport, Public Works and Water Management (2009), *Letter to the House of Representatives, Rijksinzet op het stimuleren van fietsgebruik* [national government efforts to stimulate bicycle use], August 29th 2009, The Hague: The Netherlands.

Municipality of Davis (2008), *Demographic & Economic Profile*, Davis (Municipality of Davis), via http://cityofDavis.org/ed/demographics.cfm.

Municipality of Delft (2009), *Statistical book of 2008*, Delft (Municipality of Delft), via http://www.gemeentedelft.info/Gemeente_en_democratie/Cijfers_en_onderzoek/Statistisch_jaarboek/Eerdere_jaargangen/Statistisch_Jaarboek_2008.

Pucher, J. and Buehler, R. (2008), Making cycling irresistible: lessons from the Netherlands, Denmark and Germany, *Transport Reviews, 28* (4), pp. 495-528.

Pucher, J. and Buehler, R. (2006), Why Canadians cycle more than Americans: A comparative analysis of bicycling trends and policies, *Transport Policy, 13* (3), pp. 265-279.

Vogelaar, R. (2009), *De superpromoter*, Culenborg (Van Duuren Management).

U.S. Census Bureau (2000), *Census 2000 Data*, Washington, D.C. (U.S. Census Bureau), via http://www.census.gov/population/www/socdemo/journey.html.

U.S. Census Bureau (2010), *2006-2008 American Community Survey 3-Year Estimates*, Washington, D.C. (U.S. Census Bureau), via http://factfinder.census.gov/servlet/DatasetMainPageServlet?_program=ACS&_submenuId=datasets_2&_lang=en&_ts=.

Xing, Y. and Handy, S.L. (in press, 2010), Factors correlated with bicycle commuting: a study in six small U.S. cities, *International Journal of Sustainable Transportation*.

7 Conclusions and discussion

The aim of this thesis is to determine the factors affecting bicycle commuting. Commuting enables people to work at a location spatially separated from the living location. While commuting offers benefits in terms of economic propensity, it can also affect society negatively, for example car commuting can result in congestion and a negative impact on the environment. Cycling offers a number of advantages over other modes of transport. Compared to car commuting, cycling is environmentally sustainable, it requires limited space, bicycle infrastructure is relatively inexpensive, there is limited noise production and it improves the public health. For the individual, cycling is a healthy and cheap form of transportation, and can sometimes prove to be faster than other transport modes, especially in urban areas.

Despite the benefits and the fact that cycling is an option for many commuters, a considerable number of commuters still choose to use other forms of transportation. This thesis aims to explain why individuals vary in their decision to commute by bicycle and their cycling frequency. This knowledge will enable policies to be formulated that promote commuting by bicycle and thus create a more sustainable and healthy society.

In this thesis is assumed that that there are multiple groups of cyclists in terms of cycling frequency, which are affected by different factors. First, most research in the field of commuting and other travel behavior suggests that individuals just make one travel mode choice to reach a certain activity. This dissertation takes into account that there is a considerable number of bicycle commuters who cycle part-time rather than on a daily basis. This mode alternation is expected to affect cycling more than other transportation modes, because bicycle commuters are more dependent on characteristics that vary per day than other modes, such as weather conditions. Second, work characteristics are expected to play a role, since the focus is on commuting. Until now, limited attention has been given to these characteristics. Office norms, for example, might dictate that (for specific occasions) employees wear suits and drive company cars when visiting clients. Third, the attitudes of commuters and the norms of people in their social and work environment are factors that are expected to affect the choice to commute by bicycle. 'Hard factors' can explain bicycle usage only to a limited extent, and cannot explain why individuals in identical situations and with similar socio-demographical characteristics differ in their mode choice decision(s). Attitudes and norms are expected to offer an additional explanation, but has been taken into account only to a limited extent.

Two internet surveys were conducted in four municipalities in the Netherlands to obtain the necessary data. In total, over 4,000 commuters participated in the first survey, which focused on the mode choice of and on the expected factors that influence the decision (not) to cycle to work. A second survey was conducted with some of the participants from the first survey and collected data on the commute mode choice for one specific day during a one-year period.

The remainder of this chapter is organized as follows. First it summarizes the findings of the five papers, each addressing one research question (Section 7.1). Subsequently, Section 7.2 reflects on the results and on the entire research. This chapter ends with policy and research recommendations (Sections 7.3 and 7.4).

7.1 Overview of results

This section provides an overview of the results by answering the five sub-questions, followed by the outcome of the main research question and the added value of this research.

Chapter 2 addressed the first research question:

Which factors of bicycle commuting are reported in the scientific literature?

The factors determining cycling, as found in the literature, are categorized as follows: the built environment, the natural environment, weather conditions, socio-economic characteristics, attitudes, norms and habits. Distance seems by far the most important factor. Other characteristics of the built environment that have a negative effect are traffic lights and stop signs. On the other hand a higher function mixture, the presence of bicycle storage facilities, smaller block size, higher density, the presence and continuity of bicycle infrastructure facilities, as well as bicycle parking facilities and showers at work, influence cycling positively.

The relationship between socio-economic factors and cycling is ambiguous in the scientific literature. The effect of some socio-economic aspects differs between countries. For example, in most countries men cycle more than women, whereas in countries in which cycling is very common, such as Belgium and the Netherlands, women cycle more.

The natural environment has a large influence on both the decision to cycle and the frequency. Hilliness has in general a negative effect on cycling, but experienced cyclists actually prefer hilly environments. Rain, low temperatures and darkness result in fewer people cycling. Nevertheless, commuters are less influenced by temperature than other cyclists, implying that the weather effect is smaller for trips that have to be made anyway and cannot be

postponed, or only for a limited time, opposed to recreational cycling trips.

In addition to the 'hard factors', research suggests that attitudes and social norms influence a person's decision to cycle as well. If a person has a more positive attitude towards cycling, there is a higher probability that he/she will cycle. Moreover, if the environment supports cycling, an individual seems to be more likely to cycle as well. So far, however, only a limited amount of research has been conducted into the relationship between attitudes, norms and cycling.

From the literature review several recommendations are provided for future research. It can be concluded that many bicycle research studies only examine a limited number of factors, and more attention is needed for bicycle-specific factors, such as gradients and weather conditions. Moreover, relatively little is known about the factors affecting cycling frequency, as most research only focuses on mode choice. The literature review also leaves the impression that attitudes play a more significant role in mode choice than has so far been assumed. Therefore, a focus on attitudes and people's social environments in research on the choice to cycle to work and cycling frequency could lead to new insights. Finally, while in some countries cycling has been addressed in academic research, such studies are lacking for other countries. In order to gain better insights into the transferability of knowledge, bicycle research should be conducted across a wider range of countries.

To what extent does the work situation – such as working time, clothing style, working location, opinions of colleagues and need to transport oneself or equipment – affect the decision to commute by bicycle?

Chapter 3 investigates the influence of the employer on the commute mode choice by analyzing which work-related factors affect the decision to cycle to work and the cycling frequency. The results of two binary logit models show that bicycle facilities provided by the employer and attitudes in the workplace – whether of the employer, co-workers, or employees – play an important role in the decision to cycle to work and the cycling frequency. The more positive commuters' attitudes towards cycling are, the more likely it is that they cycle and the more often they cycle. Additionally, if one's colleagues expect a person to cycle to work, someone is more likely both to cycle and to cycle more frequently.

The willingness to support and the preferences of an employer for a healthy and sustainable form of transport such as cycling is reflected by the provision of cycling facilities. The other way around is also true: the provision of facilities for other transportation modes suggest a non-supportive environment for cycling. Two findings indicate that facilities for public transport or car use will decrease cycling. Results show that having bicycle storage inside, changing facilities and a public transport stop within 500 meters of the workplace

increase the chance of being a bicycle commuter. In contrast, the presence of free car parking lowers the likelihood that commuters cycle every day. Providing employees with a free public transport pass or car was found to have a negative impact on bicycle commuting rates.

In addition, commuting distance is found to have a negative impact on an individual's decision to cycle to work, and the frequency with which one cycles. Transportation needs for work affect the commute transportation as well. Workers who need to transport goods are less likely to cycle. The same applies to those employees who need a vehicle during office hours: They are less likely to commute by bicycle. Those who need a bicycle during office hours are more likely to commute by bicycle.

The results suggest that different variables influence the individual's decision to cycle to work, and the frequency with which he or she cycles. The presence of bicycle storage, changing facilities and travel compensation schemes encourage an individual to cycle, but do not affect the frequency. By contrast, the number of hours worked and the working hours only affect whether an individual decides to cycle full-time or part-time. These findings strongly suggest that whether an individual cycles to work is composed of multiple decisions, each of which is made after considering (partially) dissimilar factors.

To what extent is the decision to cycle to work affected by attitudes, the subjective norm, bicycle habit and the perceived possibility to commute by bicycle?

Chapter 4 investigated the effect of attitudes, the subjective norm, habit and the perceived possibility to commute by bicycle. Exploratory factor analysis revealed three dimensions of attitudes to bicycle commuting: direct benefit, long-term awareness and safety. Binary logit models were used to investigate the effect of three commute distance categories on the decision to cycle to work and whether to cycle part-time or full-time. As expected, these factors to a large extent explain the choice to cycle and cycling frequency.

The decision to cycle to work is affected by all three dimensions of attitudes to bicycle commuting, of which "direct trip-based benefit" is the most important dimension. This dimension positively influences the choice to cycle at every distance. Commuter cyclists are more likely to consider the bicycle to be beneficial in terms of time savings, comfort and flexibility, and attach more importance to these benefits. For commuting distances between five and ten kilometers and beyond ten kilometers, a higher score on the dimension "awareness" results in a greater likelihood of cycling to work. This finding indicates that an awareness of the effect of cycling behavior on the environment and health encourages cycling a greater distance. The subjective norm only influences the decision to commute by bicycle over short distances. For longer distances workers are not affected by their perception of what their social environment expects in terms of modes of travel. A positive perception

of the possibility of cycling to work also positively affects the choice to cycle to work. At every distance, people are more likely to cycle if they perceive the activity to be possible. Finally, for all distances, individuals who indicated that they use a bicycle for many other purposes are also more likely to cycle to work.

The decision to cycle to work every day instead of part-time is affected by different dimensions. The dimension "direct benefits" strongly influences the decision to cycle on a daily basis. For commuting distances shorter than five kilometers and longer than ten kilometers, a high score on the safety dimension results in a higher probability of cycling every day. The dimension "awareness" is important in the decision for distances up to five kilometers. This indicates that individuals who consider cycling to be environmentally friendly, healthy and mentally relaxing are more inclined to cycle to work every working day. However, this positive perception of cycling does not affect this choice for longer distances. The habit of cycling positively influences the likelihood of cycling full-time to work. Cyclists are more inclined to cycle to work every day for all distances if they cycle for other purposes as well. The subjective norm for cycling only affects the cycling frequency of cyclists living within five kilometers from their work location.

As anticipated, the results show a higher explanatory power of the models as distance increases, providing an indication that people with a more positive attitude about cycling cycle longer distances. However the findings do not support the other hypothesis that cyclists with a more positive attitude would cycle more often than individuals with a moderate or a negative attitude.

Which day-to-day variable factors affect bicycle commuters in such way that commuters cycle on some days and not on others?

The fourth paper (Chapter 5) addresses the day-to-day mode choice of cyclists. It is assumed that cyclists are particularly likely to alternate mode choices (sometimes commuting by car or public transport), as they are more affected by conditions that change from day to day. This is investigated with the use of longitudinal data for part-time cyclists and the day-to-day mode choice is modeled with Generalized Estimating Equations (GEE).

The results show that factors that can differ on a daily basis have a great influence on the day-to-day choice to cycle, such as weather conditions, work characteristics and trip characteristics. This confirms the assumption that the day-to-day mode choices of many cyclists are affected by different factors than the 'general' mode choice.

More specifically, working somewhere else than the primary location and working at more than one location on a specific day decreases the probability of commuting by bicycle. Commuters needing a car during working hours, needing to transport goods, or wear business attire, are more likely to leave

their bicycles at home. Needing a bicycle during office hours increases the chance of cycling to work. Each additional kilometer (home-to-work distance) decreases the likelihood of commuting by bicycle. Individuals needing to make stops (trip chaining) during their commuting trips are also less likely to cycle to work. Five weather conditions influence cycling behavior. Both the quantity and the duration of rain reduce the chance of cycling. In addition, the inclination to cycle decreases in proportion with an increase in wind speed. And if the sun shines longer or the temperature is higher, the likelihood of commuters to cycle increases; no additional effect of seasons was found. One gender difference was found: Women are less likely to cycle to work in the dark.

Secondly, two groups of part-time cyclists, occasional and frequent cyclists, are identified. Individuals in both groups decide (not) to cycle on that day based on different day-to-day variable factors. Whereas occasional cyclists are encouraged by positive weather conditions, such as temperature and duration of sunshine, frequent cyclists are discouraged from cycling by more practical barriers, including wind speed and the need to be at multiple locations when deciding whether or not to cycle to work.

In what way does the decision to cycle to work differ between countries? More specifically: To what extent do the beliefs about bicycle commuting, and the importance attached to those beliefs, correspond, comparing two bicycle-friendly cities, Delft and Davis?

To answer this question, in total thirty-one interviews were conducted in both cities with commuters. The transcribed interviews were compared on the underlying beliefs and importance attached towards cycling to work (Chapter 6).

Analyses indicate that there is a clear influence of beliefs and norms on cycling behavior. Cyclists always have positive beliefs towards cycling and, most importantly, attach importance to these beliefs. This finding indicates that the attitudes of cyclists should correspond with the outcomes of cycling in order for cycling to be considered. Non-cyclists have more mixed attitudes. Some non-cyclists also attach importance to the benefits of cycling, so there is a mismatch between their behavior and their attitudes.

The narratives reveal similarities between participants in both countries. They share the belief that cycling is healthy and attach similar importance to health benefits. Most cyclists indicate that health benefits encourage them to cycle, whereas non-cyclists agree on these benefits but attach more importance to other factors. Secondly, cyclists in both Delft and Davis share the belief that cycling is enjoyable. This attitude largely corresponds with the actual behavior.

The exploratory analyses also reveal two important differences in the beliefs. First, participants in Davis perceive the bicycle as an unsafe mode of

transportation to a larger extent than the Dutch participants. Although most feel safe cycling in Davis, they emphasize the unsafe traffic situation as a reason not to cycle to or within other cities. In Delft, traffic safety is hardly mentioned. Discussing safety, participants in Delft respond in terms of personal security. Especially for women, cycling at night was not always considered safe. Second, the importance of environmental concerns was more often mentioned in Davis. Some of the participants in Delft emphasize their belief that cycling is environmentally friendly, but attach less importance to it and some refer more often to the environment as a beneficial side-effect.

The norms clearly differ between the countries. Although, inhabitants in both cities seem to have a positive norm towards cycling, participants in Davis experience a negative norm outside Davis. Several participants have experienced negative responses from family or friends when cycling instead of driving. Participants partly explain this in terms of the American and especially Californian culture in which the car plays a prominent role.

These results allow us to answer the main research question.

To what extent is the individual day-to-day choice to commute by bicycle affected by personal attitudes towards cycling to work, social norms, work situation, weather conditions and trip characteristics?

This study took into account the fact that many commuters alternate transportation modes. Two research gaps in the literature were investigated, namely (1) why some people always commute by bicycle and others alternate the bicycle with other modes, and (2) which factors influence the day-to-day choice and to what extent. To explain the day-to-day mode choice of cyclists, we also tested whether non-customary factors in mode choice research partly explain this variation, such as the weather conditions. It can be hypothesized that work characteristics play a role, as well as attitudes and norms.

Two main conclusions can be drawn from the analyses and will now be briefly discussed: the factors affecting bicycle commuting and the distinction between different commuters in terms of factors affecting their mode choice.

This research revealed a multitude of factors affecting the choice to cycle to work and the frequency with which one cycles. It was found that various factors have an effect on bicycle commuting which had not been tested before, including many work-related aspects – including clothing style, working locations, and the opinion of colleagues – , attitudes and norms, and factors that differ day to day, such as precipitation, wind speed, the need to transport goods or the need for a transportation mode. Contrary to other (international) research we did not find a negative effect for heat on cycling behavior. This implies that for Dutch commuter-cyclists very warm weather (e.g. over 30°C) does not play a role in a decision not to cycle. On the contrary, an increase in

temperature always increases the likelihood of cycling. The psychological perspective of this thesis offers additional insight into the motivations and reasons of individual choices as attitudes – beliefs and the importance attached to those beliefs – partly explain the individual mode choice. In Chapter 4 three individual bicycle attitudes were constructed and analyses showed that for different distances the decision to cycle is determined by these attitudes together with the subjective norm, perceived behavioral control and bicycle habit.

This thesis provides evidence that different groups of bicycle commuters exist and that the mode choice of individuals within these groups (partly) depends on different factors. Of all the commuters who consider the bicycle as an option, a certain portion still always travels with other modes of transportation, while another portion use the bicycle on a daily basis, the full-time cyclists. Another type of commuter considers the bicycle an option, but alternates the bicycle with other transportation modes; they belong to the category of part-time bicycle commuters. Non-cyclists seem not to cycle because they consider it impossible, either due to the distance, the need to transport goods or the need of a car during office hours. Although part-time and full-time cyclists are not insensitive to these work-related aspects, additional factors can be identified which have an even greater positive effect: a more bicycle-friendly subjective norm, and better weather conditions.

7.2 Reflection

This section touches upon a number of interesting issues which require further discussion: the transferability of the research findings to other cities within the Netherlands and to other countries, the influence of self-selection, the effect of habit on bicycle use, the effect of new transportation modes on cycling and a reflection on this research, specifically the data-collection.

Two issues of transferability arise as a result of quantitative data collection in four municipalities in the Netherlands: first the transferability to other countries and second the transferability of the results to the rest of the Netherlands. Transferring results particularly on cycling is difficult due to the large differences between countries in terms of social context, cultural, landscape, weather conditions, the built environment and infrastructure (i.e. the availability of bicycle paths and facilities) as well as the perception of safety, as concluded in Chapter 2. These differences mean that both the direction and the magnitude of the factors on bicycle commuting may differ, for example in countries where the bicycle is not a main transport mode.

The exploration of differences and similarities between Davis and Delft showed that despite the differences in culture and built environment, commuters share beliefs and attach similar importance to aspects related to

cycling. Nevertheless some aspects, such as safety concerns and the importance of the environment differ between the two cities, which indicates that commuters at different locations are affected by partly similar and partly different attitudes. This outcome is likely to be similar for other factors: the magnitude and effect of them may differ. The results, however, may largely correspond with the findings which would be obtained from conducting this research in other countries where cycling is common (such as Denmark). In general, the direction of the factors on the decision to cycle is supposedly valid for most other countries and could be taken as a starting point for policy making.

The second issue refers to transferring the research findings to other Dutch cities and the issue of bias in the selection of the cities. The investigated municipalities have an above average bicycle share in the Netherlands, but no top position. A remarkable aspect of Dutch cities is that they are relatively uniform in terms of infrastructure facilities due to the national infrastructure guidelines formulated by CROW (Dutch Center of expertise on infrastructure, traffic, transport and public space). Therefore, transferring the findings to other Dutch cities would presumably not cause many problems. Nonetheless, there are regional differences in topography (gradient), the supply of transportation alternatives, and perhaps culture. However, the findings leave the impression that the factors on which individual workers decide to commute by bicycle would be largely consistent across cities in the Netherlands.

This research did not take into account self-selection. Self-selection may occur in several ways: residential self-selection and employment self-selection. The first implies that individuals make long-term choices on their living locations based on their transportation preferences. Related to cycling, this would mean that a cycling-minded person chooses a bicycle-friendly residential location and a living location relatively close to work and with a pleasant route between both locations. A result of this might be that cycling-minded individuals may change their residential location in order to live closer to work and within cycling distance of work. In that case, the effect of distance will be overestimated since it is not only a shorter commute distance that encourages someone to cycle, but also their preference for commuting by bicycle. The second type of self-selection is employment self-selection. The employer may be selected on the location as well. If an individual prefers to cycle to work, he or she may initially start searching for work at locations where it would be possible to cycle to in terms of commuting distance and route. In addition, an individual could (partly) select the employer based on the mobility culture within an organization. This is reflected in the acceptance of commuting by bike, as well as bicycle facilities, such as storage, financial compensation or discouragement of car use. Examples of employer self-selection can also be found for other transportation modes. Companies that offer company cars are likely to attract individuals with a preference for car travel.

Distance is one of the main factors in the decision to cycle. When examining this factor, studies have generally focused on travelers whose journeys are shorter than an arbitrarily chosen distance. Other research has included distance as a continuous variable, taking into account individual variation in distance sensitivity. However, Van Wee *et al.* (2006) have argued that an increase in distance has a disproportionately discouraging effect on cycling since the physical effort needed also increases disproportionately. Moreover, Keijer and Rietveld (2000) show that for very short distances – up to 2 kilometers – the bicycle is a less attractive mode of transport. Broadly in accordance with previous findings, we found that individuals working less than 0.5 kilometers from home are less likely to cycle and prefer to walk, compared to individuals with a longer commute. For distances between 0.5 and 3.5 kilometers, an increase in distance does only to a limited extent affect cycling. For commute distances longer than 3.5 kilometers, an increase in distance reduces the likelihood of cycling to work. In this thesis, we modeled distance as a linear effect in Chapter 3 and 5. In Chapter 4 we assumed specifically that different attitudes affect cycling over shorter distances than over longer commutes. We therefore investigated this effect in three distance groups.

Habits play a role in repetitive behavior, such as commuting. This research shows that habit indeed has a great effect on the commuting mode choice (Chapter 4), but Chapter 5 provides evidence that many individuals make a decision on a daily basis. This raises the question of whether bicycle commuting is habitual behavior or behavior made after a daily conscious decision making process. It seems that both are present when deciding whether or not to cycle to work, but work differently for each individual. For some the commuting behavior is largely habitual, which can either be a bicycle, car or public transport habit. Presumably, commuting habit can mostly be found in the group of non-cyclists (car or public transport habit) and full-time cyclists (bicycle habit). Others make a deliberate choice, either once (and thus are full-time or non-cyclists) or choose on a daily basis whether or not to cycle. Findings indicate that these part-time bicycle commuters decide daily how to commute and that the conscious decision prevails over habit in that case.

In this research only the effect of a bicycle habit was investigated. Nonetheless, one could assume that habits for other transportation modes negatively affect the commute cycling frequency. Moreover, other habits in everyday life may indirectly influence the commute mode choice as well. An example of this is wearing a suit to work is more a habit than a necessity. This habit of clothing style does effect cycling.

In the recent past several new transportation modes emerged which could result in a change in bicycle use. One of the promising 'new' modes is the electrical bicycle. This 'bicycle' offers its users additional benefits as it reduces the necessary physical effort. The increase in the usage of electric bikes could result in an increase in the cycling distance and more frequent bicycle

use by people in non-optimal physical condition or in a hilly surrounding. On the other hand, as cycling on an electric bicycle is less healthy than on a regular bike, this trend could affect societies negatively. Various other new modes may appear besides the electric bike, of which many will compete with the bicycle.

In the early stage of the research the data were planned to be collected only from employees approached through their employers. The advantages of this data collection method were expected to be larger than the advantages of approaching respondents at their living location. The main advantages were: all of the individuals approached have work, being less dependent on computer availability at home and data could be collected shortly after the commute journey. Nevertheless, it turned out to be difficult to convince employers to participate. Therefore, a second method of approach was also used: at the residential location in the same municipalities as the employers. In all the analyses the recruitment of the respondents was tested or controlled for. If the same research was to be repeated, approaching individuals exclusively at their residential location from the start is advisable, given the difficulties of finding participating employers.

7.3 Implications for policy

One of the objectives of the governments both in the Netherlands and abroad is to increase the amount of cycling and the cycling frequency. This section reflects on the usefulness for practitioners and the possibilities to transfer the results of the analyses in policy strategies. First, the importance of a separate focus on non-cyclists and part-time cyclists is explained and elaborated upon. Then possible practical incentives of cycling are presented. Finally, several ideas not directly derived from the empirical analyses are explored.

Different focus by different groups

This study revealed that the decision to cycle is based on different factors for different cyclist groups. This information is essential when aiming to encourage cycling, as the different groups are motivated to cycle in different ways. Policies might be more effective in their aim to encourage cycling if they addressed one specific group at a time. Three transitions are possible, namely from non-cyclist to cyclist (Figure 7.1), from occasional to frequent cyclist (Figure 7.2), and from part-time to full-time cyclist (Figure 7.3). These three transitions are now briefly discussed.

Figure 7.1 shows the first aim of encouragement: The transition from non-cycling to part-time cycling. This research has shown that, compared to non-cyclists, cyclists have a more positive attitude towards cycling, experience a more positive subjective norm, live closer to work, are more likely to need a

Figure 7.1 Transition from non-cyclists to cyclists

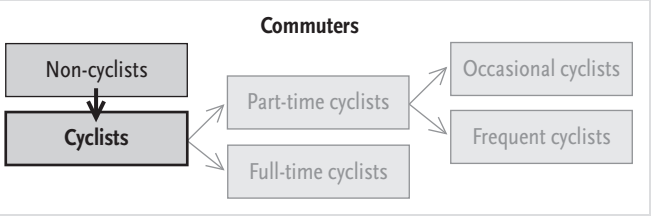


Figure 7.2 Transition from occasional cyclists to frequent cyclists

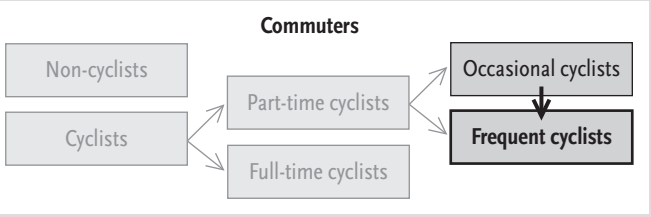
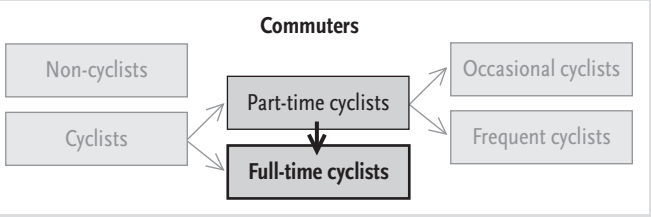


Figure 7.3 Transition from part-time cyclists to full-time cyclists



bicycle during office hours and have bicycle facilities at their working location such as showers and changing facilities. However, they are less likely to need a car during office hours, to need to transport goods or to get a car or free public transportation card from work.

Figure 7.2 shows the second possible transition: Part-time cyclists could be encouraged to cycle more regularly. The frequency with which part-time cyclists cycle is largely affected by factors that vary day to day, such as weather conditions, work characteristics and trip characteristics. Frequent cyclists (those who cycle more than 66.6% of their commuting trips) choose an alternative mode of transportation largely because of factors that complicate cycling, such as strong wind and working at multiple locations, whereas occasional cyclists (those who cycle less than 33.3% of their commuting trips) are affected by factors that make cycling more pleasant, for example nice weather and not wearing a suit.

The third transition is from part-time cyclist to full-time cyclist (Figure 7.3). This research suggests that different variables influence an individual's decision to cycle to work, and whether the individual cycles to work every day

or irregularly. For example, the presence of bicycle storage, changing facilities and travel compensation schemes encourage an individual to cycle, but do not affect the frequency. By contrast, the number of hours worked and an individual's working hours affect only whether an individual decides to cycle full-time or part-time. In addition, it is anticipated that the factors that affect the cycling frequency also increase the likelihood of being a full-time cyclist, as a higher frequency ultimately results in 100%.

Possible incentives

This research has revealed a multitude of factors that either affect the choice to cycle or the frequency of bicycle commuting. This sub-section provides examples and ideas as to how this knowledge can be used to encourage cycling by governments and employers.

Attractive facilities for other transportation modes results in less cycling and therefore if an employer really wishes to encourage cycling, facilities for other transportation modes need to be limited. Both car-related facilities reduce the cycling level, such as a free car, as well as the provision of a free public transportation card. Employers should think over their priorities towards their employees' mode choice and take into account the negative effects of simultaneously encouraging two environmentally-friendly transport modes. In many cases reducing the facilities may not be the best solution for an employer as these facilities are provided to attract the best possible working force. The provision of cycling facilities offers the employer two positive things in one: more bicycle commuting and it does not have the negative effect of becoming a less attractive employer. Examples of these cycling facilities are: bicycle storage, clothing changing facilities and a bicycle contribution.

Another option that might work is that employers could stimulate cycling by clustering factors that affect cycling negatively on certain days, for example the need to transport goods, the need of a car during office hours, the 'need' to wear a suit and working on a different location than the main working location. In various cases these needs are inevitable, but clustering would reduce the number of days that these deterrents of cycling are present and thus provide employees with the option of cycling on other days. Additionally, since both the necessity to transport oneself and the necessity to transport goods is a deterrent of cycling, the employer could provide employees with public company cars, which could be borrowed upon request. By offering this service several commuters may cycle to work and use the company car instead of taking their own car to work.

The weather conditions largely influence the choice to cycle, but can hardly be changed by humankind. Nevertheless (potential) bicycle commuters might be made aware of bicycle favorable weather conditions. An idea which might be worth testing is that an employer could stimulate cycling on the first day

of good weather, by sending an e-mail the day before emphasizing the weather predictions, and perhaps even offering a financial incentive. Moreover, on days with unpredictable weather an employer could stimulate cycling by announcing, for example by a text massage to the mobile phone, the hours during which no rain is predicted. A second way of coping with weather is by reducing the negative impacts of rain, or wind. On popular routes windshields or even a roof could be placed to limit the negative experience of the weather conditions.

The negative effect that darkness has on women when it comes to cycling could be reduced by adjustments in the built environment and in the social context. The effect of the absence of daylight on women probably results from a perception of being unsafe. Providing routes with good street lighting and good visibility for other road users will decrease the effect of the absence of daylight on women. If it is impossible to create such a route to certain employers, these employers could encourage bike-pooling: cycling together on the perceived unsafe routes.

To change cycling behavior not only the facilities and infrastructure should be bicycle-friendly, individuals attitudes and social norms need to support bicycle commuting, too. This thesis has provided insight into the large contribution of attitudes, habits and norms on the decision to cycle to work. To encourage cycling a focus is needed on creating a bicycle-friendly atmosphere. One way could be putting a highly respected person in an exemplary role. Then this person within a country or company sets the example of commuting by bicycle. This behavior may not only result in copying, it also demonstrates a positive attitude to cycling as well and thereby creates a social norm with a more positive perspective on cycling. A second option is 'using' a so-called super-promoter, whose enthusiasm results in copying behavior and following recommendations (Vogelaar, 2009). A super-promoter is an enthusiastic person who shares this enthusiasm with others and is taken seriously. To encourage individuals to cycle this person ideally needs to be someone who switches from car to bicycle, because car-drivers would then identify more easily with this person. Finally, in advertisements and other publicity a more positive and emotionally appealing message should be sent to encourage cycling by simultaneously improving the public image of cycling. Cycling campaigns have used negative images in the past, such as focusing on traffic safety and dangers (Horton, 2007) or only providing factual information, such as that cycling is good for the environment (Te Brömmelstoet *et al*., 2010). The interviews in Delft and Davis showed that liking cycling and the health benefits were shared by almost everyone and acted as motivators to cycle. The first, discussing liking to cycling, evokes very strong positive feelings for most cyclists and these feelings can be used to encourage others to start cycling, as well as to motivate current cyclists to cycle more, to be more proud of being a cyclist and to share their positive feeling with others.

Ideas not directly derived from the empirical analyses

This section discusses additional ideas for employers and policy makers to encourage cycling. Some of these are already being applied within the Netherlands and in other countries, or at certain companies, but could be successful on a larger scale.

Employees and governments could offer additional facilities to encourage cycling. One example which is already used by several employers is a free bicycle mechanical service a few times a year. This ensures that bicycles of their employees are in good conditions and simultaneously encourages employees to cycle to work on that day. Moreover, these employers show their positive attitude towards cycling.

Many employees in the Netherlands have the opportunity to buy a cheaper bicycle through their employer, due to Dutch tax regulations. It is believed that this regulation provide commuters with higher quality bicycles, which encourages cycling. The exact effect of this regulation is unknown, but a similar regulation in other countries or just within a company may result in more cycling.

So far, attention has been given to aspects at work, on the route between home and work, personal attitudes and norms, but not to residential areas. Similar to the working location, bicycle facilities at the living location are likely to influence bicycle use positively. For example a location where the bicycle can be parked safely and close to the front door will encourage cycling.

One last recommendation – not derived from this research – is a potentially useful tactic, called the low-ball effect. The low ball is a persuasion technique in which something is offered at a lower price than it is actually intended to be charged. The success of a low-ball effect is making the first request attractive enough to agree or participate and the second request (the real request) not too extreme so that the person would refuse. This method has proven to be effective in making consumers more energy conserving (Cialdini, 2007). Home owners provided with information about the benefits and necessity of energy saving and methods of doing so did not reduce their energy use, despite their agreement to try to do so. However, when an additional promise was given that their name would be published in the newspaper, home owners did reduce their energy consumption. Remarkably, the effect remained even after a letter was sent explaining that the name-publication could not happen. The most eye-catching was that the participants whose names were not published reduced their energy consumption the most. This effect probably happened because when home owners made the commitment to save energy, they created their own support and started to feel good about themselves and about their socially beneficial behavior. Taking the only non-intrinsic reason, the outside incentive (the name publication), away, stimulated the new self-image further and thereby encouraged even greater energy conservation. To encourage cycling a similar method is conceivable. In theory, the

necessary steps are: (1) providing the non-cycling commuter with information on the benefits of commuting by bike, (2) discussing how to fit bicycle commuting into a daily schedule, preferably by examples of others as this is less pedantic, (3) offering an incentive to those who start cycling, (4) removing incentive. In practice, the most crucial point is finding an effective incentive. This could be publicity, either in the local media or, potentially more effective, in the work setting. The second option has as additional benefit that the norm towards commute cycling could change positively within the organization. Additional research is necessary to determine the effect of different 'incentives'.

7.4 Research recommendations

On the basis of this study, this section offers five recommendations for further research.

First, cross-section research suggests causality, however, more solid conclusions on the causality between bicycle commuting and its determinants ask for longitudinal research. Longitudinal data is very scarce, not only for bicycle commuting, but for general commuting and cycling in general. In the case of the work-characteristics, a research could be designed with one measurement before the availability of bicycle parking or a bicycle contribution, and one measurement after.

Second, this thesis focused specifically on bicycle use for commuting. Cycling for transportation with another purpose may be affected by similar factors, as is stated in Chapter 2. Nevertheless, the strength of the factors may differ. Moreover, as the research on cycling is still limited (compared to other fields), it seems essential to investigate the factors of bicycle use for other purposes, as well.

Third, this thesis has focused to a limited extent on the effect of the built environment on behavior. It is without doubt that bicycle infrastructure plays an important role in the consideration of whether or not to cycle and on the route choice of cyclists. Moreover, it can be assumed that attitudes and norms on cycling are connected with the presence and quality of the bicycle infrastructure. A thorough research on the experience of bicycle facilities and how these facilities affect individual attitudes would offer insight into how the built environment affects the individual. This would offer policy makers practical input on bicycle infrastructure facilities.

Fourth, additional factors could affect bicycle commuting, which could be addressed in future research. These include, but are not limited to, the following aspects: (1) the identity of the commuter and his/her social identification with different groups, (2) the built environment, (3) the fixed weekly commuting patterns of some commuters, such as needing a car on certain

days to pick up children, but having a choice on the remaining days, (4) the time required for commuting in addition to the door-to-door travel time from home, such as showering for bicycle commuters and walking to and from the car for car commuters.

Finally, additional research is necessary to test the effectiveness of the proposed measures in Section 7.3 to encourage non-cyclists to start cycling and part-time cyclists to cycle more frequently. In addition, the effectiveness of current initiatives and policies have not been investigated well. Many initiatives and policies are based on common sense and current use without proof for their effect. It would be advisable not only to concentrate on finding creative new strategies, but also to carefully examine the outcome and unwanted side-effects of the current and past measures on cycling.

References

Cialdini, R.B. (1993), *Influence: The Psychology of Persuasion*, New York (Quill William Morrow).

Horton, D. (2007), Fear of Cycling, in: Horton, D., P. Rosen and P. Cox, *Cycling and society*, Hampshire (Ashgate Publishing Limited), pp. 133-152.

Te Brömmelstoet, M., G. Hulster and E. Crouse (2010), *Münchenierung of Amsterdamize: De fietsrevolutie vanuit een marketing perspectief bezien* [Münchenierung of Amsterdamize: cycling revolution from a marketing perspective], Colloquium Vervoerplanologisch Speurwerk, Roermond, The Netherlands.

Vogelaar, R. (2009), *De superpromoter*, Culenborg (Van Duuren Management).

Appendix A.1

Internet questionnaire part 1

Deze enquête is afgenomen via internet. In verband met routing in de enquête is deze op papier op enkele plaatsen minder goed te lezen.

Beginpagina

Onderzoek naar vervoermiddelkeuze voor reizen van en naar het werk.

Om inzicht te krijgen in de keuze voor een bepaald vervoermiddel van en naar het werk, houdt het onderzoeksinstituut OTB van de Technische Universiteit Delft een onderzoek.

U kunt een belangrijke bijdrage aan dit onderzoek leveren. Vul hiervoor de enquête in. Uw ingevulde gegevens zullen anoniem behandeld worden en voor wetenschappelijke doeleinden gebruikt worden.

Instructie
De enquête bestaat uit blokken met vragen. Leest u de instructie en vragen alstublieft rustig door. Om op de volgende pagina te komen drukt u op ?volgende?. U kunt teruggaan door op ?vorige? te drukken, maar wij verzoeken u hiervan alleen gebruik te maken als u een verkeerd antwoord heeft ingevuld. Het invullen van de enquête duurt ongeveer 20 minuten.

Bij vragen of problemen kunt u contact opnemen met
heinen@verplaatsingsgedrag.nl.

Succes en alvast bedankt voor uw medewerking!

Hoofdsectie

Heeft u een baan?

- [ ] ja, in loondienst
- [ ] ja, als zelfstandige
- [ ] ja, vrijwilligerswerk
- [ ] nee

Als wrkz(4) gelijk is aan 4 ➡ *Wat is uw geslacht?*

Als u op dit moment niet werkzaam bent, is het invullen van deze vragenlijst niet mogelijk, omdat de vragen hoofdzakelijk betrekking op woon–werkverkeer.
Misschien kan één van uw medebewoners de vragenlijst invullen?
Sluit dan dit venster (door op het kruisje rechtsboven te drukken).

➡ ***Beëindig vragenlijst***

Wat is uw geslacht?

- ○ man
- ○ vrouw

Welke situatie is op u van toepassing?

- ○ alleenwonend ➡ Ga verder met vraag
- ○ samenwonend met partner/echtgeno(o)t(e) ➡ Ga verder met vraag
- ○ samenwonend met partner/echtgeno(o)t(e) en kind(eren) ➡ Ga verder met vraag
- ○ samenwonend met kind(eren) zonder partner/echtgeno(o)t(e) ➡ Ga verder met vraag
- ○ wonend bij ouders/verzorgers zonder kinderen ➡ Ga verder met vraag
- ○ wonend in studentenhuis zonder kinderen ➡ Ga verder met vraag
- ○ anders, namelijk: [ ] ➡ Ga verder met vraag

Met hoeveel personen, inclusief uzelf, woont u in uw (hoofd)woning?

- ○ 1 ➡ Ga verder met vraag
- ○ 2
- ○ 3
- ○ 4
- ○ 5
- ○ 6
- ○ 7
- ○ meer dan 7

Hoeveel thuiswonende kinderen heeft u?

- ○ 0
- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ meer dan 4

Hoeveel uur per week werkt u gemiddeld werkelijk?

[ ]

Hoeveel dagen per week werkt u gemiddeld?

Volgt u een studie naast uw werk?

- ja, ik volg een voltijd opleiding
- ja, ik volg een deeltijdopleiding
- ja, ik volg een aantal cursussen
- nee

Hoeveel werkgevers heeft u?

- 1
- 2
- meer dan 2

Als hhsam gelijk is aan 2
OF hhsam gelijk is aan 3 ➡ *Heeft uw partner een baan?*

Heeft u een partner?

- ja
- nee ➡ Ga verder met vraag *naar volgende blok–woonlocaties*

Wat is het geslacht van uw partner?

- man
- vrouw

Heeft uw partner een baan?

- hij/zij is in loondienst
- hij/zij werkt als zelfstandige
- hij/zij doet vrijwilligerswerk
- nee ➡ Ga verder met vraag *uitleg adres*

Hoeveel uur per week werkt uw partner gemiddeld?

➡ *uitleg adres*

1 woonlocaties

De volgende vragen gaan over uw woonadres. Wij vragen hiernaar om kenmerken van uw woonplek en de route naar uw werk te kunnen analyseren. De gegevens worden natuurlijk vertrouwelijk behandeld.

Wat is uw woonadres?

straat + huisnummer	
plaats	
postcode	

Zijn er nog andere (woon)adressen waarvandaan u soms wel eens 's ochtends naar uw werk vertrekt? Bijvoorbeeld een tweede woning, woning van vriend, vriendin of ouders.

- ja
- nee ➡ Ga verder met vraag *naar volgende sectie*

Wat is het adres van uw tweede woonadres of woning waar vandaan u soms ('s ochtends) naar uw werk reist?
(wanneer u meerdere extra adressen heeft, kunt u hier dan de meest voorkomende invullen?)
(postcode is niet verplicht, kunt u deze toch invullen indien bekend?)

straat + huisnummer	
plaats	
postcode	

➡ *werksituatie*

4 werksituatie

De volgende vragen hebben betrekking op uw werksituatie.

In welke sector bent u werkzaam?

- landbouw + visserij
- delfstofwinning
- industrie
- openbare nutsbedrijven
- bouwnijverheid– en installatiebedrijven
- handel–, hotel– en restaurantwezen
- transport–, opslag– en communicatiebedrijven
- bank– en verzekeringswezen
- onderwijs/onderzoek
- zorgverlening
- overige dienstverlening
- overheid
- overig, namelijk:

Welke vorm heeft uw dienstverband?

- in vaste dienst
- tijdelijk contract
- interim
- uitzendbasis
- gedetacheerd
- overig, namelijk

Werkt u elke week op dezelfde dagen op dezelfde locaties?

- ja
- nee

Heeft u dagelijks dezelfde werktijden?

- ja
- nee Ga verder met vraag

Op welk tijdstip begint u meestal met werken? (bijvoorbeeld 09:00)

Op welk tijdstip stopt u meestal met werken?

Kunt u zelf bepalen hoe laat u ongeveer op u werk komt?

Op welke tijdstippen van de dag werkt u normaal gesproken meer dan 1 keer per maand? (meerdere antwoorden mogelijk)

- [ ] 's ochtends (06.30–12.00)
- [ ] 's middags (12.00–19.00)
- [ ] 's avonds (19.00–24.00)
- [ ] 's nachts (00.00–06.30)

Kunt u zelf bepalen hoe laat u ongeveer op u werk komt?

- ( ) ja
- ( ) nee

Welke kleding draagt u naar uw werk? (meerdere antwoorden mogelijk)

- [ ] speciale werkkleding, die ik alleen tijdens het werk mag dragen
- [ ] overige speciale werkkleding
- [ ] pak (of vrouwelijke variant)
- [ ] nette kleding
- [ ] vrije tijdskleding
- [ ] overig, namelijk: _____

Waardoor wordt uw kledingkeuze beïnvloed? (meerdere antwoorden mogelijk)

- [ ] dag van de week
- [ ] afspraken buiten de deur
- [ ] afspraken intern
- [ ] activiteiten voor of na het werk
- [ ] het weer
- [ ] het vervoermiddel
- [ ] overig, namelijk: _____

Moet u naar uw werk spullen meenemen, die niet per fiets vervoerd kunnen worden?

- ( ) ja, altijd
- ( ) soms
- ( ) nee, nooit ➡ Ga verder met vraag

Waarvan is de noodzaak om spullen mee te nemen afhankelijk? (meerdere antwoorden mogelijk)

- [ ] dag van de week
- [ ] afspraken buiten de deur
- [ ] afspraken intern
- [ ] activiteiten voor of na het werk
- [ ] overig, namelijk: _____

Heeft u tijdens werkuren een vervoermiddel nodig om uw werk te kunnen doen?

- ( ) ja, altijd
- ( ) soms
- ( ) nee, nooit ➡ Ga verder met vraag *naar sectie wwv*

Welk vervoermiddel gebruikt u tijdens uw werkuren om uw werk te kunnen doen? (meerdere antwoorden mogelijk)

- ☐ lease auto
- ☐ privé auto
- ☐ dienstauto
- ☐ motor
- ☐ scooter/brommer
- ☐ fiets
- ☐ openbaar vervoer
- ☐ taxi
- ☐ anders, namelijk

Wanneer heeft u dit vervoermiddel nodig? (meerdere antwoorden mogelijk)

	altijd	bij afspraken buiten de deur binnen 5 km	bij afspraken buiten de deur verder dan 5 km	binnen de gemeente	buiten de gemeente	binnen dezelfde gemeente
1	☐	☐	☐	☐	☐	
2	☐	☐	☐	☐	☐	
3	☐	☐	☐	☐	☐	
4	☐	☐	☐	☐	☐	
5	☐	☐	☐	☐	☐	
6	☐	☐	☐	☐	☐	
7	☐	☐	☐	☐	☐	
8	☐	☐	☐	☐	☐	
9	☐	☐	☐	☐	☐	

➪ *Wat is het adres van uw (eerste) werklocatie? (postcode is niet verplicht, kunt u deze toch invullen indien bekend?)*

5 werklocaties

Wat is het adres van uw (eerste) werklocatie?
(postcode is niet verplicht, kunt u deze toch invullen indien bekend?)

straat + huisnummer	
plaats	
postcode	

Hoeveel vaste werklocaties heeft u?
(Hierbij al uw werkplekken meetellen, inclusief de reeds genoemde plek. Uw werklocatie thuis telt niet mee)

- ○ 1 ➡ Ga verder met vraag *naar volgende sectie*
- ○ 2 ➡ Ga verder met vraag
- ○ 3 ➡ Ga verder met vraag
- ○ meer dan 3 werklocaties

Bij deze enquete wordt slechts gevraagd naar eigenschappen van maximaal 3 werklocaties. Wilt u bij het invullen van deze enquete uitgaan van de drie locaties waar u het vaakst werkt?

Wat is het adres van uw tweede werklocatie?
(postcode is niet verplicht, kunt u deze toch invullen indien bekend?)

straat + huisnummer	
plaats	
postcode	

Als l_werkg gelijk is aan 2 ➡

Wat is het adres van uw derde werklocatie?
(postcode is niet verplicht, kunt u deze toch invullen indien bekend?)

straat + huisnummer	
plaats	
postcode	

➡ *Werkt u daarnaast wel eens op een andere plek dan op een locatie van uw werkgever? (bijvoorbeeld bij andere bedrijven, thuis of bij andere mensen thuis)*

5a en vaste locatie

Werkt u daarnaast wel eens op een andere plek dan op een locatie van uw werkgever? (bijvoorbeeld bij andere bedrijven, thuis of bij andere mensen thuis)

- ja
- nee ➡ Ga verder met vraag *naar sectie werkdagen*

Kunt u aangeven welke locaties dit zijn?

- thuis
- bezoeken bij bedrijven/organisaties
- bezoeken bij individuen/huishoudens
- anders, namelijk:

Hoe vaak werkt u deze locaties?

	4 of meer keer per week	enkele keren per week	enkele keren per maand	enkele keren per jaar
1	○	○	○	○
2	○	○	○	○
3	○	○	○	○
4	○	○	○	○

Werkt u op vaste dagen op deze locaties?

- ja
- nee

➡ *inleiding wwv*

6 woon–werkreizen

De volgende vragen hebben betrekking op uw woon–werkreis. Alle vragen vanaf dit moment gaan over de verplaatsingen van uw eerste woonplek naar uw eerste werklocaties.
Indien u het afgelopen jaar verhuisd of van baan veranderd bent, wilt u de vragen dan invullen voor uw ***huidige situatie***?

Reisde u het afgelopen jaar iedere dag met hetzelfde vervoermiddel naar uw huidige werklocatie(s)?
(vult u nee in als u meer dan twee keer afgelopen jaar op een andere manier naar uw werk bent gekomen dan 'normaal')

- ○ ja
- ○ nee ➡ Ga verder met vraag

Hoe reisde u het afgelopen jaar van uw huidige woning(en) naar uw huidige werklocatie(s)?

- ○ alleen auto
- ○ alleen fiets
- ○ alleen openbaar vervoer
- ○ alleen lopen
- ○ combinatie van openbaar vervoer en fiets
- ○ combinatie van openbaar vervoer en lopen
- ○ combinatie van auto en fiets
- ○ combinatie van auto en openbaar vervoer
- ○ overig, namelijk: [ ]

➡

U reisde het afgelopen jaar niet iedere dag met hetzelfde vervoermiddel naar uw werk. Hoe reisde u het afgelopen jaar van uw huidige woning naar uw huidige werklocatie?
(meerdere antwoorden mogelijk)

- ☐ alleen auto
- ☐ alleen fiets
- ☐ alleen openbaar vervoer
- ☐ alleen lopen
- ☐ per verplaatsing een combinatie van openbaar vervoer en fiets
- ☐ per verplaatsing een combinatie van openbaar vervoer en lopen
- ☐ per verplaatsing een combinatie van auto en fiets
- ☐ per verplaatsing een combinatie van auto en openbaar vervoer
- ☐ overig, namelijk: [ ]

De volgende vragen gaan in op hoe vaak u met een vervoermiddel naar uw werk reist. Omdat we precies willen weten hoe vaak u hiermee reist en we begrijpen dat dit lastig is om in aantallen te schatten, zullen we dit op verschillende manieren vragen.

Hoe vaak reist u ***gemiddeld per jaar*** met deze vervoermiddelen naar uw werk?

	5 keer per week of meer	4 keer per week	3 keer per week	2 keer per week	1 keer per week	enkele keren per maand	enkele keren per jaar
1	○	○	○	○	○	○	○
2	○	○	○	○	○	○	○
3	○	○	○	○	○	○	○
4	○	○	○	○	○	○	○
5	○	○	○	○	○	○	○
6	○	○	○	○	○	○	○

7	○	○	○	○	○	○	○
8	○	○	○	○	○	○	○
9	○	○	○	○	○	○	○

Kunt u een schatting maken in procenten hoe vaak u over een jaar gezien met deze vervoermiddelen naar uw werk reist?

1	
2	
3	
4	
5	
6	
7	
8	
9	

Kunt u tevens een schatting maken in procenten hoe vaak u in een bepaald seizoen met deze vervoermiddelen naar uw werk reist?

	zomer	winter
1		
2		
3		
4		
5		
6		
7		
8		
9		

➡ *Maakt u wel eens tussenstops tijdens uw reis tussen uw woonlocatie en uw werklocatie?*

8 tussenstops

Maakt u wel eens tussenstops tijdens uw reis tussen uw woonlocatie en uw werklocatie?

- ○ ja
- ○ nee ➡ Ga verder met vraag *sprong beschikbaarheid*

Wat voor tussenstops maakt u tijdens uw reis van uw woonlocatie naar uw werklocatie?

- ☐ inkopen, dagelijks
- ☐ inkopen, niet–dagelijks
- ☐ kinderen ophalen / brengen
- ☐ sociale activiteit (bezoek)
- ☐ sport
- ☐ onderwijs volgen
- ☐ culturele activiteit
- ☐ overige, namelijk: ____

➡ *Hoeveel van deze vervoermiddelen heeft uw huishouden?*

9b beschikbaarheid vervoermiddel

Hoeveel van deze vervoermiddelen heeft uw huishouden?

	0	1	2	3	meer dan 3
auto	○	○	○	○	○
fiets	○	○	○	○	○
motor	○	○	○	○	○
brommer/scooter	○	○	○	○	○

Bent u in het bezit van een rijbewijs voor een personenauto?

- ○ ja
- ○ nee

Kunt u voor uw woon–werkverkeer beschikken over een auto?

- ○ ja, altijd ➡ Ga verder met vraag *geen partner*
- ○ nee, nooit ➡ Ga verder met vraag *geen partner*
- ○ meer dan de helft van de woon–werkverplaatsingen
- ○ minder dan de helft van de woon–werkverplaatsingen

Waarvan hangt de beschikbaarheid van een auto af? (meerdere antwoorden mogelijk)

- ☐ dag van de week
- ☐ noodzaak auto voor iemand in uw huishouden
- ☐ noodzaak auto voor iemand buiten uw huishouden
- ☐ overig, namelijk

Als partner gelijk is aan 1
OF hhsam gelijk is aan 2
OF hhsam gelijk is aan 3 ➡

Heeft uw partner een rijbewijs voor een auto?

- ○ ja
- ○ nee

Als bscvv(2) gelijk is aan 0 ➡ *Krijgt u van uw werkgever een vervoermiddel of openbaarvervoerkaart (bijvoorbeeld een abonnement) ter beschikking gesteld? (een eventuele vergoeding kunt u later aangeven)*

Wat voor fiets(en) heeft ***u zelf***?

	stadsfiets zonder versnellingen	stadsfiets met versnellingen	hybride fiets (tussen stadsfiets en ATB)	mountainbike/ATB	elektrische fiets (met trapondersteuning)	racefiets	vouwfiets	ligfiets	anders, namelijk:
eerste fiets	○	○	○	○	○	○	○	○	
tweede fiets	○	○	○	○	○	○	○	○	
derde fiets	○	○	○	○	○	○	○	○	
vierde fiets	○	○	○	○	○	○	○	○	

Wat was de aanschafprijs van deze fiets(en)?

	0–50€	50–100€	100–200€	200–500€	500–1000€	1000–1500€	meer dan 1500€
eerste fiets	○	○	○	○	○	○	○
tweede fiets	○	○	○	○	○	○	○
derde fiets	○	○	○	○	○	○	○
vierde fiets	○	○	○	○	○	○	○

Waarvoor gebruikt u fiets(en)? (meerdere antwoorden mogelijk)

	woon–werkreizen in het geheel	woon–werkreizen gedeeltelijk (bijv. fiets op het station)	recreatie	sport	inkopen	gebruik ik niet/nauwelijks	overig, namelijk
eerste fiets	☐	☐	☐	☐	☐	☐	
tweede fiets	☐	☐	☐	☐	☐	☐	
derde fiets	☐	☐	☐	☐	☐	☐	
vierde fiets	☐	☐	☐	☐	☐	☐	

Krijgt u van uw werkgever een vervoermiddel of openbaarvervoerkaart (bijvoorbeeld een abonnement) ter beschikking gesteld? (een eventuele vergoeding kunt u later aangeven)

	ja	nee
lease auto	○	○
fiets	○	○
openbaarvervoerkaart	○	○

Krijgt u van uw werkgever een reiskostenvergoeding voor uw woon–werkreis?

- ○ ja
- ○ nee ➡ Ga verder met vraag

Wat voor vergoeding krijgt u?

- ○ standaard vergoeding per kilometer
- ○ benzinekosten
- ○ tegemoetkoming in kosten openbaar vervoer
- ○ anders, namelijk

Heeft uw werkgever een regeling, waarbij de werkgever bijdraagt aan de aanschaf van een fiets?

- ○ ja, een gratis fiets
- ○ ja, een tegemoetkoming
- ○ nee ➡ Ga verder met vraag *naar sectie atti vvm www*

➡ *inleiding attitude vervoersmiddel woon–werkverkeer*

a11attitudes vervoersmiddelen

De volgende vragen vragen naar uw mening over verschillende vervoersmiddelen voor ***woon–werkverkeer***. Gaat u op uw eerste gevoel af.

Ik vind ***autorijden*** voor mijn woon–werkverplaatsing

	zeer mee oneens	enigszins mee oneens	niet mee eens/niet mee oneens	enigszins mee eens	zeer mee eens
statusverlenend	○	○	○	○	○
milieuvriendelijk	○	○	○	○	○
geestelijk ontspannend	○	○	○	○	○
lichamelijk ontspannend	○	○	○	○	○
comfortabel	○	○	○	○	○
tijdbesparend	○	○	○	○	○
flexibel	○	○	○	○	○
goedkoop	○	○	○	○	○
plezierig	○	○	○	○	○
privacy biedend	○	○	○	○	○
gezond	○	○	○	○	○
goed	○	○	○	○	○
verkeersveilig	○	○	○	○	○
sociaal veilig	○	○	○	○	○
passen bij mijn levensstijl	○	○	○	○	○

Ik vind ***fietsen*** voor mijn woon–werkverplaatsing

	zeer mee oneens	enigszins mee oneens	niet mee eens/niet mee oneens	enigszins mee eens	zeer mee eens
statusverlenend	○	○	○	○	○
milieuvriendelijk	○	○	○	○	○
geestelijk ontspannend	○	○	○	○	○
lichamelijk ontspannend	○	○	○	○	○
comfortabel	○	○	○	○	○
tijdbesparend	○	○	○	○	○
flexibel	○	○	○	○	○
goedkoop	○	○	○	○	○
plezierig	○	○	○	○	○
privacy biedend	○	○	○	○	○
gezond	○	○	○	○	○
goed	○	○	○	○	○
verkeersveilig	○	○	○	○	○
sociaal veilig	○	○	○	○	○
passen bij mijn levensstijl	○	○	○	○	○

Ik vind het ***openbaar vervoer*** voor mijn woon–werkverplaatsing

	zeer mee oneens	enigszins mee oneens	niet mee eens/niet mee oneens	enigszins mee eens	zeer mee eens
statusverlenend	○	○	○	○	○
milieuvriendelijk	○	○	○	○	○
geestelijk ontspannend	○	○	○	○	○
lichamelijk ontspannend	○	○	○	○	○
comfortabel	○	○	○	○	○
tijdbesparend	○	○	○	○	○
flexibel	○	○	○	○	○
goedkoop	○	○	○	○	○
plezierig	○	○	○	○	○
privacy biedend	○	○	○	○	○
gezond	○	○	○	○	○
goed	○	○	○	○	○
verkeersveilig	○	○	○	○	○
sociaal veilig	○	○	○	○	○
passen bij mijn levensstijl	○	○	○	○	○

De volgende vragen vragen naar uw belang van enkele eigenschappen van vervoersmiddelen voor ***woon–werkverkeer***. Gaat u op uw eerste gevoel af.

Hoe belangrijk of onbelangrijk vindt u het, dat het vervoermiddel waarmee u ***naar uw werk*** reist, de volgende kenmerken heeft?

	zeer onbelangrijk	onbelangrijk	niet onbelangrijk/niet belangrijk	belangrijk	zeer belangrijk
statusverlenend	○	○	○	○	○
milieuvriendelijk	○	○	○	○	○
geestelijk ontspannend	○	○	○	○	○
lichamelijk ontspannend	○	○	○	○	○
comfortabel	○	○	○	○	○
tijdbesparend	○	○	○	○	○
flexibel	○	○	○	○	○
goedkoop	○	○	○	○	○
plezierig	○	○	○	○	○
privacy biedend	○	○	○	○	○
gezond	○	○	○	○	○
verkeersveilig	○	○	○	○	○
sociaal veilig	○	○	○	○	○
passen bij mijn levensstijl	○	○	○	○	○

inleiding sn

a12 verwachtingen van anderen

De volgende vragen hebben betrekking op uw omgeving. Er wordt gevraagd naar de verwachte mening van uw omgeving.

In hoeverre bent u het eens of oneens met de volgende stelling?

De mensen, die belangrijk voor mij zijn in mijn omgeving, vinden dat ik met de volgende vervoermiddelen naar mijn werk zou moeten reizen.

	zeer mee oneens	enigszins mee oneens	niet mee eens/niet mee oneens	enigszins mee eens	zeer mee eens
auto	○	○	○	○	○
fiets	○	○	○	○	○
openbaar vervoer	○	○	○	○	○

Wat denkt u dat de meeste mensen op uw werk vinden hoe u naar uw werk zou moeten reizen?

- auto
- fiets
- ov
- lopen
- overig
- maakt niet uit

Hoe belangrijk of onbelangrijk vindt u deze mening voor uw vervoerskeuze voor woon–werkreizen?

- ○ zeer onbelangrijk
- ○ onbelangrijk
- ○ noch onbelangrijk/noch belangrijk
- ○ belangrijk
- ○ zeer belangrijk

Wat denkt u dat uw familie/gezin vindt hoe u naar uw werk zou moeten reizen?

- auto
- fiets
- ov
- lopen
- overig
- maakt niet uit

Hoe belangrijk of onbelangrijk vindt u deze mening voor uw vervoerskeuze voor woon–werkreizen?

- ○ zeer onbelangrijk
- ○ onbelangrijk
- ○ noch onbelangrijk/noch belangrijk
- ○ belangrijk
- ○ zeer belangrijk

Wat denkt u dat de meesten van uw vrienden vinden hoe u naar uw werk zou moeten reizen?

auto
fiets
ov
lopen
overig
maakt niet uit

Hoe belangrijk of onbelangrijk vindt u deze mening voor uw vervoerskeuze voor woon–werkreizen?

- zeer onbelangrijk
- onbelangrijk
- noch onbelangrijk/noch belangrijk
- belangrijk
- zeer belangrijk

Als hhpart(4) gelijk is aan 4
OF partner gelijk is aan 2 *Op welke manier reizen uw collega?s gemiddeld per jaar naar het werk? Kunt u een schatting maken hoe de verdeling tussen de vervoerwijzen is?*

Hoe reisde uw partner het afgelopen jaar van uw huidige woning naar zijn/haar werk?
(meerdere antwoorden mogelijk)

- alleen auto
- alleen fiets
- alleen openbaar vervoer
- alleen lopen
- per verplaatsing een combinatie van openbaar vervoer en fiets
- per verplaatsing een combinatie van openbaar vervoer en lopen
- per verplaatsing een combinatie van auto en fiets
- per verplaatsing een combinatie van auto en openbaar vervoer
- overig, namelijk:

Op welke manier reizen uw collega?s gemiddeld per jaar naar het werk? Kunt u een schatting maken hoe de verdeling tussen de vervoerwijzen is?

	bijna iedereen	velen	enkele	niemand
auto	○	○	○	○
fiets	○	○	○	○
openbaar vervoer	○	○	○	○
lopen	○	○	○	○

Ziet u in uw woonomgeving veel mensen fietsen?

- ja
- neutraal
- nee

introductie

a13a perceived behavioral control

De volgende vragen hebben betrekking op de door u ingeschatte mogelijkheid om met een bepaald vervoermiddel naar uw werk te reizen. In hoeverre voelt u zich in staat alleen met de genoemde vervoermiddelen naar het werk te reizen? (dus de gehele reis)

De mogelijkheid om de gehele reis naar mijn werk met de ***auto*** te reizen is

- zeer klein/uitgesloten
- redelijk klein
- niet klein/niet groot
- redelijk groot
- zeer groot

De mogelijkheid om de gehele reis naar mijn werk met de ***fiets*** te reizen is

- zeer klein/uitgesloten
- redelijk klein
- niet klein/niet groot
- redelijk groot
- zeer groot

De mogelijkheid om de gehele reis naar mijn werk met de ***openbaar vervoer*** te reizen is

- zeer klein/uitgesloten
- redelijk klein
- niet klein/niet groot
- redelijk groot
- zeer groot

ervaring

a15ervaring

De volgende vragen richten zich op uw ervaring met verschillende vervoermiddelen.

Mijn ervaring met de volgende vervoermiddelen is over het algemeen

	zeer negatief	tamelijk negatief	neutraal	tamelijk positief	zeer positief
auto	○	○	○	○	○
fiets	○	○	○	○	○
openbaar vervoer	○	○	○	○	○

Mijn ervaring met de volgende vervoermiddelen voor de verplaatsing ***van en naar werk*** is over het algemeen

	zeer negatief	tamelijk negatief	neutraal	tamelijk positief	zeer positief	niet van toepassing
auto	○	○	○	○	○	○
fiets	○	○	○	○	○	○
openbaar vervoer	○	○	○	○	○	○

inleiding habit

a17 habit

De volgende vragen hebben betrekking op uw vervoerskeuze voor andere activiteiten. Stel dat u de volgende activiteiten wilt ondernemen in Nederland. Probeer deze vragen spontaan te beantwoorden en ga hierbij op uw eerste gevoel af.

Welk vervoermiddel zou u kiezen bij de volgende activiteiten?

	auto	brommer/scooter	motor	openbaar vervoer	fiets	lopen	overig
met vrienden op een mooie dag naar het water	○	○	○	○	○	○	○
bij vrienden op bezoek	○	○	○	○	○	○	○
bij familie op bezoek	○	○	○	○	○	○	○
naar een sportactiviteit	○	○	○	○	○	○	○
boodschappen doen in de stad	○	○	○	○	○	○	○
naar het café 's avonds	○	○	○	○	○	○	○
een uitstapje de natuur in	○	○	○	○	○	○	○
dagelijkse boodschappen	○	○	○	○	○	○	○
uit eten	○	○	○	○	○	○	○
naar de bioscoop	○	○	○	○	○	○	○

voornemen inleiding

a17b intentie

Kunt u bij de volgende vragen aangeven hoe groot uw voornemen is om op de fiets naar uw werk te reizen? (de gehele reis)

Mijn voornemen/intentie om de gehele reis naar mijn werk met de fiets te reizen is in het algemeen

- zeer klein
- tamelijk klein
- noch klein, noch groot
- tamelijk groot
- zeer groot

Als vvww1 gelijk is aan 2 ➡ *inleiding positieve aspecten*

Als vvww1 gelijk is aan 2
OF vvww2(2) gelijk is aan 2 ➡ *inleiding positieve aspecten*

➡ *inleiding*

a18b soms fiets wwv

U heeft aangegeven, dat u soms met de fiets naar uw werk reist en soms op een andere manier. De volgende vragen gaan over de situaties wanneer u voor de fiets kiest en de redenen waarom u daarvoor kiest.

Wanneer reist u met de fiets van uw (hoofd)woonlocatie naar uw (eerste) werklocatie?

	altijd	meestal	soms wel, soms niet	meestal niet	nooit	n.v.t.
Als het zomer is	○	○	○	○	○	○
Als het winter is	○	○	○	○	○	○
Als het droog is	○	○	○	○	○	○
Als het sneeuwt	○	○	○	○	○	○
Als het vriest	○	○	○	○	○	○
Als het warm is/hitte (boven 25 graden)	○	○	○	○	○	○
Als het hard waait (meer dan windkracht 8)	○	○	○	○	○	○
Als ik mijn kinderen moet halen of wegbrengen	○	○	○	○	○	○
Als ik mijn kinderen niet hoef te halen of weg te brengen	○	○	○	○	○	○
Als ik geen grote spullen hoef mee te nemen	○	○	○	○	○	○
Als ik grote spullen moet meenemen	○	○	○	○	○	○
Als ik representatief gekleed moet	○	○	○	○	○	○
Als ik niet representatief gekleed moet	○	○	○	○	○	○
Als ik boodschappen moet doen voor of na werk	○	○	○	○	○	○
Als ik geen boodschappen moet doen voor of na werk	○	○	○	○	○	○
Als ik andere activiteiten voor of na het werk onderneem	○	○	○	○	○	○
Als ik geen andere activiteiten voor of na het werk onderneem	○	○	○	○	○	○
Als ik over een auto beschik	○	○	○	○	○	○
Als ik niet over een auto beschik	○	○	○	○	○	○
Als het openbaar vervoer niet rijdt	○	○	○	○	○	○
Als het licht is (daglicht)	○	○	○	○	○	○
als het donker is	○	○	○	○	○	○

Als ik geen zakelijke afspraken buiten de deur heb	○	○	○	○	○	○
Als ik zakelijke afspraken buiten de deur heb	○	○	○	○	○	○

De volgende vragen gaan over de redenen waarom u voor een bepaald vervoermiddel kiest of eventueel zou kiezen voor uw woon–werkreizen.

Welke redenen stimuleren u om met de fiets naar het werk te reizen? (maximaal 5)

- ☐ geringe financiële kosten
- ☐ korte reistijd
- ☐ betrouwbaarheid reistijd
- ☐ betrouwbaarheid beschikbaarheid
- ☐ niveau van comfort
- ☐ privacy
- ☐ gezondheid
- ☐ milieu
- ☐ flexibel qua tijd (vertrek)
- ☐ flexibel qua locatie (ik kan overal naartoe)
- ☐ geestelijke ontspanning
- ☐ lichamelijke ontspanning
- ☐ kleine kans op diefstal voertuig
- ☐ kleine kans op beschadiging voertuig
- ☐ kleine kans op technisch probleem met voertuig
- ☐ combinatie met boodschappen doen
- ☐ combinatie met kinderen wegbrengen
- ☐ combinatie andere activiteiten na/voor werk
- ☐ noodzaak vervoermiddel voor werk
- ☐ goed voorbeeld voor kinderen
- ☐ samen met anderen reizen
- ☐ overig, namelijk: _____

Welke redenen stimuleren u om met de ***auto*** naar het werk te reizen? (maximaal 5 aspecten)

- ☐ korte reistijd
- ☐ betrouwbaarheid reistijd
- ☐ betrouwbaarheid beschikbaarheid
- ☐ niveau van comfort
- ☐ privacy
- ☐ flexibel qua tijd (vertrek)
- ☐ flexibel qua locatie
- ☐ sociaal veilig
- ☐ geestelijke ontspanning
- ☐ van deur tot deur
- ☐ kleding blijft netjes
- ☐ beschut tegen het weer
- ☐ status van auto
- ☐ kleine kans op diefstal voertuig
- ☐ kleine kans op beschadiging voertuig
- ☐ kleine kans op technisch probleem met voertuig
- ☐ combinatie met boodschappen doen
- ☐ combinatie met kinderen wegbrengen
- ☐ combinatie andere activiteiten na/voor werk
- ☐ noodzaak vervoermiddel voor werk
- ☐ samen met anderen reizen

- [ ] financiële kosten

overig,
- [ ] namelijk:

Welke redenen stimuleren u om met het ***openbaar vervoer*** naar het werk te reizen? (maximaal 5 aspecten)

- [ ] reistijd
- [ ] lichamelijke ontspanning
- [ ] geestelijke ontspanning
- [ ] kan andere activiteiten tegelijkertijd ondernemen
- [ ] beschut tegen het weer
- [ ] milieu
- [ ] betrouwbaarheid aankomsttijd
- [ ] geen zorgen over eigen vervoermiddel
- [ ] mag alcohol nuttigen
- [ ] financiële kosten
- [ ] combinatie met boodschappen doen
- [ ] combinatie met kinderen wegbrengen
- [ ] combinatie andere activiteiten na/voor werk
- [ ] goed voorbeeld voor kinderen
- [ ] goede bereikbaarheid centrum stad
- [ ] samen met anderen reizen

overig,
- [ ] namelijk:

Graag zouden wij willen weten of er beperkende factoren zijn, waardoor u een bepaald vervoermiddel niet gebruikt voor uw gehele reis naar uw werk en mogelijkerwijze dit vervoermiddel niet eens overweegt. (dus de gehele reis)

Welke redenen weerhouden u ervan om met de ***fiets*** naar uw werk te reizen? (maximaal 5 aspecten)

- [ ] te kleine afstand
- [ ] te grote afstand
- [ ] te lange reistijd
- [ ] te korte reistijd
- [ ] regen
- [ ] sneeuw, ijzel
- [ ] kou
- [ ] warmte
- [ ] wind
- [ ] geen fiets
- [ ] ik kan niet fietsen
- [ ] te vermoeiend
- [ ] niveau van comfort
- [ ] sociale veiligheid
- [ ] verkeersveiligheid
- [ ] kans op ongeluk
- [ ] kans op diefstal voertuig
- [ ] kans op beschadiging voertuig
- [ ] kans op technisch probleem met voertuig
- [ ] uw kleding
- [ ] spullen mee moeten nemen
- [ ] kom bezweet aan
- [ ] kom verwaaid aan
- [ ] combinatie met boodschappen doen
- [ ] combinatie met kinderen wegbrengen
- [ ] combinatie andere activiteiten na/voor werk
- [ ] noodzaak ander vervoermiddel voor werk

- ☐ onderhoud
- ☐ overig, namelijk: ____

Welke redenen weerhouden u ervan om met de ***auto*** naar uw werk te reizen? (maximaal 5 aspecten)

- ☐ financiële kosten
- ☐ reistijd
- ☐ betrouwbaarheid
- ☐ slechte bereikbaarheid
- ☐ lastig parkeerplaats vinden
- ☐ kosten van parkeren
- ☐ ik heb geen rijbewijs
- ☐ lichamelijk niet in staat
- ☐ geen auto ter beschikking
- ☐ invloed op milieu
- ☐ kans op file groot
- ☐ tijdsduur file
- ☐ verkeersveiligheid
- ☐ kans op ongeluk
- ☐ kans op diefstal voertuig
- ☐ kans op beschadiging voertuig
- ☐ combinatie met boodschappen doen
- ☐ combinatie met kinderen wegbrengen
- ☐ combinatie andere activiteiten na/voor werk
- ☐ slecht voorbeeld voor kinderen
- ☐ slechte bereikbaarheid centrum
- ☐ mag geen alcohol nuttigen
- ☐ frustratie/geestelijke spanning
- ☐ overig, namelijk: ____

Welke redenen weerhouden u ervan om met het ***openbaar vervoer*** naar uw werk te reizen? (maximaal 5 aspecten)

- ☐ onbetrouwbaarheid reisduur
- ☐ onbetrouwbaarheid of voertuig rijdt
- ☐ geen flexibele vertrektijd
- ☐ reisduur
- ☐ privacy
- ☐ frequentie
- ☐ nauwelijks beschikbaar bij de woning
- ☐ nauwelijks beschikbaar bij het werk
- ☐ biedt een slechte verbinding tussen beide locaties
- ☐ noodzaak tot overstappen
- ☐ geen zitplek
- ☐ oncomfortabel
- ☐ rijdt niet (meer) op de tijden, dat ik het nodig heb
- ☐ te weinig ruimte
- ☐ geen vervoermiddel beschikbaar op bestemming
- ☐ kans op technisch probleem
- ☐ combinatie met boodschappen doen
- ☐ combinatie met kinderen wegbrengen
- ☐ combinatie andere activiteiten na/voor werk
- ☐ financiële kosten
- ☐ overig, namelijk: ____

Welke van de volgende voorzieningen zijn er op uw (hoofd)werklocatie aanwezig?

a21 voorzieningen op werk

Welke van de volgende voorzieningen zijn er op uw (hoofd)werklocatie aanwezig?

- ☐ fietsenstalling buiten, onbewaakt
- ☐ fietsenstalling buiten, bewaakt
- ☐ fietsenstalling binnen
- ☐ douches
- ☐ omkleedmogelijkheid
- ☐ bewaakt parkeren auto buiten
- ☐ bewaakt parkeren auto binnen
- ☐ gratis parkeren auto
- ☐ tram/bushalte binnen 500 meter
- ☐ treinstation binnen 1 km
- ☐ oprit snelweg binnen 1 km
- ☐ supermarkt binnen 500 meter
- ☐ winkelcentrum binnen 1 km

Welke van de volgende voorzieningen zijn er bij uw woning?

- ☐ fietsenstalling buiten, onbewaakt
- ☐ fietsenstalling buiten, bewaakt
- ☐ fietsenstalling binnen
- ☐ bewaakt parkeren auto buiten
- ☐ bewaakt parkeren auto binnen
- ☐ gratis parkeren auto
- ☐ tram/bushalte binnen 500 meter
- ☐ treinstation binnen 1 km
- ☐ oprit snelweg binnen 1 km
- ☐ supermarkt binnen 500 meter
- ☐ winkelcentrum binnen 1 km

a22 ervaring fietsroute

Als vvww1 gelijk is aan 2
OF vvww2(2) gelijk is aan 2 ➡

De onderstaande vragen hebben betrekking op de ***fietsroute*** tussen uw (hoofd)woning en uw eerste werklocatie. (dus de gehele route)

Heeft u 1 vaste route naar uw werk?

- ○ ja
- ○ nee

Mocht u de volgende vragen niet precies weten, kunt u deze dan schatten?
Vult u de vraag in voor de meest gefietste route.

Hoe groot is de afstand tussen uw werk en uw woning? (in kilometers)

Hoe groot is het gedeelte van uw route dat over een fietspad of fietsstrook gaat? (in procenten)

Hoeveel verkeerslichten bevinden zich op uw route tussen woning en werklocatie?

Door wat voor type omgeving gaat uw route tussen woning en werklocatie?

	ja	nee
centrum	○	○
stedelijke omgeving	○	○
woonwijk	○	○
buiten bebouwd gebied	○	○
door een park/bos	○	○
langs water (rivier, kanaal, meer, etc.)	○	○

Hoe ervaart u de volgende aspecten van uw route?

	te weinig	tamelijk weinig	precies goed	tamelijk veel	te veel
het aantal kilometers tussen woning en werk	○	○	○	○	○
het aantal verkeerslichten	○	○	○	○	○
het aantal rotondes	○	○	○	○	○
het aantal kruispunten	○	○	○	○	○
het aantal bochten	○	○	○	○	○
het aantal drempels	○	○	○	○	○
de wachttijden tijdens de verplaatsing	○	○	○	○	○
hoeveelheid winkels onderweg	○	○	○	○	○
hoeveelheid auto's	○	○	○	○	○
hoeveelheid fietsers	○	○	○	○	○
uw zichtbaarheid voor overige weggebruikers	○	○	○	○	○
de verlichting	○	○	○	○	○
de afwisseling in bebouwing	○	○	○	○	○

de hoeveelheid groen	○	○	○	○	○

Hoe ervaart u de volgende aspecten?

	zeer negatief	tamelijk negatief	neutraal	tamelijk positief	zeer positief
de directheid van de route	○	○	○	○	○
de wachttijden tijdens de verplaatsing	○	○	○	○	○
de gemiddelde kwaliteit van het wegdek	○	○	○	○	○
het soort fietsvoorziening (fietspad, fietsstrook)	○	○	○	○	○
het ontwerp van de kruisingen	○	○	○	○	○
de verkeersdrukte van auto's	○	○	○	○	○
de verkeersdrukte van fietsers	○	○	○	○	○
uw zichtbaarheid voor overige weggebruikers	○	○	○	○	○
de verlichting	○	○	○	○	○
de afwisseling in bebouwing	○	○	○	○	○
aanwezigheid van winkels onderweg	○	○	○	○	○
het uitzicht	○	○	○	○	○
de kwaliteit van de groenvoorziening	○	○	○	○	○

Welke aspecten zijn het meest belangrijk voor u? (maximaal 5 aspecten)

- ☐ hoeveelheid fietsers
- ☐ kwaliteit wegdek
- ☐ zichtbaarheid voor overige weggebruikers
- ☐ afwisseling bebouwing
- ☐ aantal drempels
- ☐ uitzicht
- ☐ soort fietsvoorziening
- ☐ verkeersdrukte auto's
- ☐ aantal bochten
- ☐ directheid van de route
- ☐ hoeveelheid winkels langs de route
- ☐ kwaliteit groenvoorziening
- ☐ mogelijkheid tot meerdere routes
- ☐ verlichting
- ☐ aantal kruispunten
- ☐ hoeveelheid auto's
- ☐ hoeveelheid groenvoorziening
- ☐ verkeersdrukte fietsers
- ☐ aantal verkeerslichten
- ☐ afstand
- ☐ wachttijd tijdens verplaatsing
- ☐ ontwerp kruisingen

Wat is uw totaal oordeel over de fietsroute tussen uw woning en uw werk?

- ○ zeer negatief
- ○ tamelijk negatief
- ○ neutraal
- ○ tamelijk positief
- ○ zeer positief

➡ *persoonlijke gegevens*

a23 vroegere situatie werk/woning

De volgende vragen hebben betrekking op uw vroegere woon– en werksituatie.

In welk jaar bent u verhuisd naar uw huidige woning?

Sinds welk jaar werkt u bij de werkgever, waar deze enquête wordt afgenomen?

persoonlijke gegevens

a24 persoonlijk vragen eind

Ten slotte zouden wij u ook nog een aantal persoonlijke vragen willen stellen. Wij hopen, dat u ook deze zou willen beantwoorden, omdat deze gegevens een grote bijdrage leveren aan ons onderzoek. Wij willen benadrukken, dat deze gegevens uitsluitend voor onderzoeksdoeleinden gebruikt worden en niet aan uw naam gekoppeld zullen worden.

Wat is uw geboortejaar? [ ]

Wat is uw hoogst voltooide opleiding?

- Basisschool
- LBO
- VMBO
- MULO
- MMS
- MBO
- MAVO
- HAVO
- VWO
- HBS
- HBO
- Universiteit/WO
- wil ik niet zeggen

Hoeveel verdient u netto per maand?

- minder dan 500€
- 500–1000€
- 1000–1500€
- 1500–2000€
- 2000–2500€
- 2500–3000€
- >3000€
- weet ik niet
- wil ik niet zeggen

Hoeveel verdient uw huishouden netto per maand?

- minder dan 500€
- 500–1000€
- 1000–1500€
- 1500–2000€
- 2000–2500€
- 2500–3000€
- 3000–3500€
- 3500–4000€
- 4000–5000€
- >5000€
- weet ik niet
- wil ik niet zeggen

Wat voor beroep heeft u?

algemeen management
productie leiding
engineering
(productie) planning
research &development
logistiek
technische dienst
marketing
verkoop
PR/ reclame
inkoop
accountancy
controlling
administratie
personeelszaken
opleiding &training
EDP – auditing
IT– management
informatieanalyse
systeemontwerp/programmeren
systeembeheer
consulting
medisch
juridisch
onderwijs
strategie/beleid
secretariaat
militair
politie/brandweer
overig

In welk land bent u geboren?

Nederland → *Tot welke etnische groepering rekent u zich?*
Suriname
Ned.Antillen/Aruba
Indonesië
Turkije
Marokko
Duitsland
Ver.Koninkrijk (UK)
België
Somalië
Iran
Irak
Afghanistan
Ghana
anders
weet niet
wil ik niet zeggen

In welk jaar bent u in Nederland komen wonen?

??? jaartal
(4–cijfers)

weet ik niet

wil ik niet zeggen

Tot welke etnische groepering rekent u zich?

- Nederlands
- Surinaams
- Antilliaans/Arubaans
- Indonesisch
- Turks
- Marokkaans
- Duits
- Engels/Iers
- Belgisch
- Somalisch
- Iranees
- Irakees
- Afghanistaans
- Ghanees
- Moluks
- anders
- weet ik niet
- wil ik niet zeggen

Hoe vaak sport u gemiddeld per week?

- nooit
- 1 keer
- 2 keer
- 3 keer
- 4 keer
- 5 keer
- 6 keer
- meer dan 6 keer

inleiding 2

Hoe lang sport u totaal gemiddeld per week?

- 0 tot 1 uur
- 1 tot 2 uur
- 2 tot 3 uur
- 3 tot 5 uur
- 5 tot 10 uur
- meer dan 10 uur

Welke sporten beoefent u regelmatig? (u kunt meer dan 1 sport aangeven)

Graag zouden wij u nog een aantal andere persoonlijk vragen voorleggen. Wij willen nogmaals benadrukken dat uw antwoorden vertrouwelijk zullen worden behandeld. Met het invullen van deze vragen zou u ons enorm helpen.

Wat is uw lengte? (in centimeters)

Wat is uw gewicht in kilo's?

- < 40
- 40–45
- 46–50
- 51–55
- 56–60
- 61–65
- 66–70
- 71–75
- 76–80
- 81–85
- 86–90
- 91–95
- 96–100
- 101–105
- 106–110
- 111–115
- 116–120
- 121–125
- > 125
- weet ik niet
- wil ik niet zeggen

Vervolgonderzoek

a25eind

Ten slotte willen wij u vragen of u bereid bent om mee te werken aan het vervolgonderzoek waarin de vervoerskeuze voor woon–werkverkeer over een langere periode wordt onderzocht.

Dit zal gebeuren door u eens in de 2 tot 3 weken te vragen welk vervoermiddel u die dag gebruikt heeft voor uw reis naar uw werk en naar de achterliggende redenen daarvoor. Door deze manier van onderzoek kan achterhaald worden welke factoren uw vervoerskeuze beïnvloeden. Deze vragen zullen 1 à 2 minuten in beslag nemen.

Onder de deelnemers van dit vervolgonderzoek zullen wederom 40 staatsloten verloot worden.

Wij hopen dat u ook wilt meewerken aan dit vervolgonderzoek.

Wilt u meewerken aan het vervolgonderzoek?

- ja
- nee ➡ Ga verder met vraag *kans op staatslot*

Wat is uw naam?

voornaam achternaam

Wat is uw e–mailadres?

Wat is uw telefoonnummer? (niet verplicht)

➡ *Heeft u nog op? of aanmerkingen naar aanleiding van deze vragenlijst?*

Als u kans wilt maken op 1 van de 40 staatsloten, vult u dan onderstaande gegevens in. Uw gegevens worden vertrouwelijk behandeld. Indien u niet wilt meeloten, druk u dan op ?verder'.

Wat is uw naam?

voornaam achternaam

Wat is uw e–mailadres?

Heeft u nog op? of aanmerkingen naar aanleiding van deze vragenlijst?

➡ ***Beëindig vragenlijst***

Afsluitende pagina

Hartelijk dank voor uw medewerking.

Mocht u nog vragen of opmerkingen hebben, dan kunt u contact opnemen met heinen@verplaatsingsgedrag.nl.

Appendix A.2

Internet questionnaire part 2

Deze enquête is afgenomen via internet. In verband met routing in de enquête is deze op papier op enkele plaatsen minder goed te lezen.

Beginpagina

U heeft aangegeven mee te willen werken aan het vervolgonderzoek naar vervoermiddelkeuze voor woon–werkverkeer.
De vragenlijst zal ongeveer 2–3 minuten in beslag nemen.

Instructie
De enquete bestaat net als de eerste enquete uit blokken met vragen. Leest de instructie en vragen alstublieft rustig door. Om op de volgende pagina te komen drukt u op ?volgende?. U kunt teruggaan door op ?vorige? te drukken, maar wij verzoeken u hiervan alleen gebruik te maken als u een verkeerd antwoord heeft ingevuld.

Bij vragen of problemen kunt u contact opnemen met
heinen@verplaatsingsgedrag.nl

Succes en alvast bedankt voor uw medewerking!

Hoofdsectie

Voor welke dag vult u deze enquete in? (wij verzoeken u de enquete in te vullen voor de dag dat u de e–mail ontvangen heeft)

Werkt u vandaag of heeft u vandaag gewerkt?

- ja, ik werk op dit moment Ga verder met vraag
- ja, ik ga vandaag nog werken Ga verder met vraag
- ja, ik heb vandaag gewerkt Ga verder met vraag
- nee

Aangezien u vandaag niet gewerkt heeft, kunt u dit keer geen bijdrage leveren aan de enquete. Wij zullen u binnenkort wederom benaderen.

Beëindig vragenlijst

heeft gewerkt

Waar heeft u grotendeels vandaag gewerkt?

- ○ thuis ➡ Ga verder met vraag
- ○ op vaste werkplek ➡ Ga verder met vraag
- ○ op een andere locatie

Op welk adres heeft u vandaag gewerkt?
(postcode is niet verplicht)

straat + huisnummer	
plaats	
postcode	

Heeft u vandaag nog op een andere locatie gewerkt?

- ○ ja
- ○ nee

Als loc1a gelijk is aan 1
EN mrdloca gelijk is aan 2 ➡ ***Beëindig vragenlijst***

Als mrdloca gelijk is aan 2 ➡ *Hoe bent u vandaag naar uw werk gereisd?*

Waar heeft u vandaag nog meer gewerkt?

- ☐ thuis
- ☐ op vaste werkplek
- ☐ op een andere locatie
- ☐ op meerdere andere locaties

Hoe bent u vandaag naar uw werk gereisd?

- ○ alleen auto
- ○ alleen fiets
- ○ alleen openbaar vervoer
- ○ alleen lopen
- ○ combinatie van openbaar vervoer en fiets
- ○ combinatie van openbaar vervoer en lopen
- ○ combinatie van auto en fiets
- ○ combinatie van auto en openbaar vervoer
- ○ overig, namelijk:

Hoe laat bent u vandaag begonnen met werken? (bijvoorbeeld 08 00)

uren	minuten

Hoe laat bent u vandaag gestopt met werken? (bijvoorbeeld 19 00)

uren minuten

Welke kleding droeg u vandaag op uw werk?

- speciale werkkleding, die ik alleen tijdens het werk mag dragen
- overige speciale werkkleding
- pak (of vrouwelijke variant)
- nette kleding
- vrije tijdskleding (ook casual)
- overig, namelijk:

Heeft u vandaag spullen moeten meenemen naar uw werk, die niet makkelijk per fiets of openbaar vervoer vervoerd kunnen worden?

- ja
- nee

Heeft u vandaag tijdens werkuren een vervoermiddel nodig gehad om uw werk te kunnen doen?

- ja
- nee ➡ Ga verder met vraag

Welk vervoermiddel heeft u vandaag tijdens werktijd gebruikt? (meerdere antwoorden mogelijk)

- [ ] lease auto
- [ ] privé auto
- [ ] dienstauto
- [ ] motor
- [ ] scooter/brommer
- [ ] fiets
- [ ] openbaar vervoer
- [ ] taxi
- [ ] anders, namelijk

Heeft u vandaag tussenstops gemaakt tijdens uw reis van uw woonlocatie naar uw werklocatie of van uw werklocatie naar uw woonlocatie? En zo ja, welke? (meerdere antwoorden mogelijk)

- [ ] geen tussenstops gemaakt
- [ ] inkopen, dagelijks
- [ ] inkopen, niet–dagelijks
- [ ] kinderen ophalen / brengen
- [ ] sociale activiteit
- [ ] sport
- [ ] onderwijs volgen
- [ ] culturele activiteit
- [ ] werkgerelateerd
- [ ] carpool stop (ophalen/ wegbrengen meerijder)
- [ ] overige, namelijk:

Als vv_a gelijk is aan 1 ➡

Waarom bent u vandaag met de auto naar uw werk gekomen? (meerdere keuzes mogelijk)

- [ ] dat doe ik in principe altijd
- [ ] ik heb vandaag (voor de verandering) de beschikking over een auto
- [ ] ik heb vandaag (voor de verandering) geen beschikking over een fiets
- [ ] vanwege de weersverwachting
- [ ] vanwege de werktijden
- [ ] vanwege activiteiten voor/na het werk
- [ ] vanwege zakelijk afspraken
- [ ] vanwege mijn kleding
- [ ] omdat ik veel spullen mee moest nemen
- [ ] omdat ik vandaag met iemand mee kon rijden
- [ ] comfort
- [ ] vanwege lichamelijk situatie
- [ ] vanwege lichamelijke condite (moeheid)
- [ ] overig, namelijk

Als vv_a gelijk is aan 2

Waarom bent u vandaag met de fiets naar uw werk gekomen? (meerdere keuzes mogelijk)

- [ ] dat doe ik in principe altijd
- [ ] ik heb vandaag (voor de verandering) geen beschikking over een auto
- [ ] vanwege de weersverwachting
- [ ] vanwege de werktijden
- [ ] vanwege activiteiten voor/na het werk
- [ ] vanwege zakelijk afspraken
- [ ] omdat ik geen spullen mee moest nemen
- [ ] omdat ik vandaag geen lift (met de auto) kon krijgen
- [ ] omdat ik vandaag met iemand mee kon fietsen
- [ ] omdat ik vandaag graag wilde bewegen
- [ ] overig, namelijk

Als vv_a gelijk is aan 3

Waarom bent u vandaag met het openbaar vervoer naar uw werk gekomen? (meerdere keuzes mogelijk)

- [ ] dat doe ik in principe altijd
- [ ] ik heb vandaag (voor de verandering) geen beschikking over een auto
- [ ] ik heb vandaag (voor de verandering) geen beschikking over een fiets
- [ ] vanwege de weersverwachting
- [ ] vanwege de werktijden
- [ ] vanwege activiteiten voor/na het werk
- [ ] vanwege zakelijk afspraken
- [ ] vanwege mijn kleding
- [ ] omdat ik spullen mee moest nemen
- [ ] omdat ik vandaag niet met iemand mee kon rijden
- [ ] comfort
- [ ] vanwege lichamelijk situatie
- [ ] vanwege lichamelijke condite (moeheid)
- [ ] overig, namelijk

Als vv_a gelijk is aan 4

Waarom bent u vandaag lopend naar uw werk gekomen? (meerdere keuzes mogelijk)

- [ ] dat doe ik in principe altijd
- [ ] ik heb vandaag (voor de verandering) geen beschikking over een auto
- [ ] ik heb vandaag (voor de verandering) geen beschikking over een fiets
- [ ] vanwege de weersverwachting
- [ ] vanwege de werktijden
- [ ] vanwege activiteiten voor/na het werk
- [ ] vanwege zakelijk afspraken
- [ ] omdat ik geen spullen mee moest nemen
- [ ] omdat ik vandaag geen lift (met de auto) kon krijgen
- [ ] omdat ik vandaag met iemand mee kon lopen
- [ ] omdat ik vandaag graag wilde bewegen
- [ ] overig, namelijk

Als vv_a gelijk is aan 5

Waarom bent u vandaag met een combinatie van openbaar vervoer en fiets naar uw werk gekomen? (meerdere keuzes mogelijk)

- [ ] dat doe ik in principe altijd
- [ ] ik heb vandaag (voor de verandering) geen beschikking over een auto
- [ ] vanwege de weersverwachting
- [ ] vanwege de werktijden
- [ ] vanwege activiteiten voor/na het werk
- [ ] vanwege zakelijk afspraken
- [ ] vanwege mijn kleding
- [ ] omdat ik spullen mee moest nemen
- [ ] omdat ik vandaag niet met iemand mee kon rijden
- [ ] omdat ik vandaag graag wilde bewegen
- [ ] overig, namelijk

Als vv_a gelijk is aan 6

Waarom bent u vandaag met een combinatie van openbaar vervoer en lopen naar uw werk gekomen? (meerdere keuzes mogelijk)

- [ ] dat doe ik in principe altijd
- [ ] ik heb vandaag (voor de verandering) geen beschikking over een auto
- [ ] ik heb vandaag (voor de verandering) geen beschikking over een fiets
- [ ] vanwege de weersverwachting
- [ ] vanwege de werktijden
- [ ] vanwege activiteiten voor/na het werk
- [ ] vanwege zakelijk afspraken
- [ ] vanwege mijn kleding
- [ ] omdat ik spullen mee moest nemen
- [ ] omdat ik vandaag niet met iemand mee kon rijden
- [ ] omdat ik vandaag graag wilde bewegen
- [ ] overig, namelijk

Als vv_a gelijk is aan 7

Waarom bent u vandaag met een combinatie van fiets en auto naar uw werk gekomen? (meerdere keuzes mogelijk)

- ☐ dat doe ik in principe altijd
- ☐ vanwege de weersverwachting
- ☐ vanwege de werktijden
- ☐ vanwege activiteiten voor/na het werk
- ☐ vanwege zakelijk afspraken
- ☐ vanwege mijn kleding
- ☐ omdat ik spullen mee moest nemen
- ☐ omdat ik vandaag niet met iemand mee kon rijden
- ☐ omdat ik vandaag met iemand mee kon rijden
- ☐ omdat ik vandaag graag wilde bewegen
- ☐ overig, namelijk _____

Als vv_a gelijk is aan 8 ➡

Waarom bent u vandaag met een combinatie van auto en openbaar vervoer naar uw werk gekomen? (meerdere keuzes mogelijk)

- ☐ dat doe ik in principe altijd
- ☐ ik heb vandaag (voor de verandering) geen beschikking over een fiets
- ☐ vanwege de weersverwachting
- ☐ vanwege de werktijden
- ☐ vanwege activiteiten voor/na het werk
- ☐ vanwege zakelijk afspraken
- ☐ vanwege mijn kleding
- ☐ omdat ik spullen mee moest nemen
- ☐ omdat ik vandaag met iemand mee kon rijden
- ☐ overig, namelijk _____

Als vv_a gelijk is aan 9 ➡ ***Beëindig vragenlijst***

Waarom bent u vandaag op deze manier naar uw werk gekomen? (meerdere keuzes mogelijk)

- ☐ dat doe ik in principe altijd
- ☐ ik heb vandaag (voor de verandering) geen beschikking over een auto
- ☐ ik heb vandaag (voor de verandering) geen beschikking over een fiets
- ☐ vanwege de weersverwachting
- ☐ vanwege de werktijden
- ☐ vanwege activiteiten voor/na het werk
- ☐ vanwege zakelijk afspraken
- ☐ vanwege mijn kleding
- ☐ omdat ik spullen mee moest nemen
- ☐ omdat ik vandaag niet met iemand mee kon rijden
- ☐ omdat ik vandaag met iemand mee kon rijden
- ☐ omdat ik vandaag graag wilde bewegen
- ☐ overig, namelijk _____

➡ ***Beëindig vragenlijst***

Hoe laat bent u vandaag begonnen met werken? (bijvoorbeeld 09:00)

_____

Hoe laat bent u vandaag gestopt met werken? (bijvoorbeeld 17:00)

moet nog werken

Waar gaat u vandaag grotendeels werken?

- ○ thuis ➡ Ga verder met vraag
- ○ op vaste werkplek ➡ Ga verder met vraag
- ○ op een andere locatie

Op welk adres gaat u vandaag werken?
(postcode is niet verplicht)

straat + huisnummer	
plaats	
postcode	

Gaat u vandaag nog op een andere locatie werken?

- ○ ja
- ○ nee

Als loc1b gelijk is aan 1
EN mrdlocb gelijk is aan 2 ➡ ***Beëindig vragenlijst***

Als mrdlocb gelijk is aan 2 ➡ *Hoe reist u vandaag naar uw werk?*

Waar gaat u vandaag nog meer werken?

- ☐ thuis
- ☐ op vaste werkplek
- ☐ op een andere locatie
- ☐ op meerdere andere locaties

Hoe reist u vandaag naar uw werk?

- ○ alleen auto
- ○ alleen fiets
- ○ alleen openbaar vervoer
- ○ alleen lopen
- ○ combinatie van openbaar vervoer en fiets
- ○ combinatie van openbaar vervoer en lopen
- ○ combinatie van auto en fiets
- ○ combinatie van auto en openbaar vervoer
- ○ overig, namelijk:

Hoe laat begint u vandaag met werken? (bijvoorbeeld 08 00)

uren	minuten

Hoe laat stopt u vandaag met werken? (bijvoorbeeld 19 00)

uren minuten

Welke kleding draagt u vandaag op uw werk?

- speciale werkkleding, die ik alleen tijdens het werk mag dragen
- overige speciale werkkleding
- pak (of vrouwelijke variant)
- nette kleding
- vrije tijdskleding (ook casual)
- overig, namelijk:

Moet u vandaag spullen meenemen naar uw werk, die niet makkelijk per fiets of openbaar vervoer vervoerd kunnen worden?

- ja
- nee

Heeft u vandaag tijdens werkuren een vervoermiddel nodig om uw werk te kunnen doen?

- ja
- nee ➡ Ga verder met vraag

Welk vervoermiddel gebruikt u vandaag tijdens werktijd? (meerdere antwoorden mogelijk)

- lease auto
- privé auto
- dienstauto
- motor
- scooter/brommer
- fiets
- openbaar vervoer
- taxi
- anders, namelijk

Bent u vandaag van plan tussenstops te maken tijdens uw reis van uw woonlocatie naar uw werklocatie of van uw werklocatie naar uw woonlocatie? En zo ja, welke? (meerdere antwoorden mogelijk)

- geen tussenstops gemaakt
- inkopen, dagelijks
- inkopen, niet–dagelijks
- kinderen ophalen / brengen
- sociale activiteit (bezoek)
- sport
- onderwijs volgen
- culturele activiteit
- werkgerelateerd
- carpool stop (ophalen/ wegbrengen meerijder)
- overige, namelijk:

Als vv_b gelijk is aan 1 ➡

Waarom bent u van plan vandaag met de auto naar uw werk te reizen? (meerdere keuzes mogelijk)

- [ ] dat doe ik in principe altijd
- [ ] ik heb vandaag (voor de verandering) de beschikking over een auto
- [ ] ik heb vandaag (voor de verandering) geen beschikking over een fiets
- [ ] vanwege de weersverwachting
- [ ] vanwege de werktijden
- [ ] vanwege activiteiten voor/na het werk
- [ ] vanwege zakelijk afspraken
- [ ] vanwege mijn kleding
- [ ] omdat ik veel spullen mee moest nemen
- [ ] omdat ik vandaag met iemand mee kon rijden
- [ ] comfort
- [ ] vanwege lichamelijk situatie
- [ ] vanwege lichamelijke condite (moeheid)
- [ ] overig, namelijk

Als vv_b gelijk is aan 2

Waarom bent u van plan vandaag met de fiets naar uw werk te reizen? (meerdere keuzes mogelijk)

- [ ] dat doe ik in principe altijd
- [ ] ik heb vandaag (voor de verandering) geen beschikking over een auto
- [ ] vanwege de weersverwachting
- [ ] vanwege de werktijden
- [ ] vanwege activiteiten voor/na het werk
- [ ] vanwege zakelijk afspraken
- [ ] omdat ik geen spullen mee moest nemen
- [ ] omdat ik vandaag geen lift (met de auto) kon krijgen
- [ ] omdat ik vandaag met iemand mee kon fietsen
- [ ] omdat ik vandaag graag wilde bewegen
- [ ] overig, namelijk

Als vv_b gelijk is aan 3

Waarom bent u van plan vandaag met het openbaar vervoer naar uw werk te reizen? (meerdere keuzes mogelijk)

- [ ] dat doe ik in principe altijd
- [ ] ik heb vandaag (voor de verandering) geen beschikking over een auto
- [ ] ik heb vandaag (voor de verandering) geen beschikking over een fiets
- [ ] vanwege de weersverwachting
- [ ] vanwege de werktijden
- [ ] vanwege activiteiten voor/na het werk
- [ ] vanwege zakelijk afspraken
- [ ] vanwege mijn kleding
- [ ] omdat ik spullen mee moest nemen
- [ ] omdat ik vandaag niet met iemand mee kon rijden
- [ ] comfort
- [ ] vanwege lichamelijk situatie
- [ ] vanwege lichamelijke condite (moeheid)
- [ ] overig, namelijk

Als vv_b gelijk is aan 4

Waarom bent u van plan vandaag lopend naar uw werk te reizen? (meerdere keuzes mogelijk)

- ☐ dat doe ik in principe altijd
- ☐ ik heb vandaag (voor de verandering) geen beschikking over een auto
- ☐ ik heb vandaag (voor de verandering) geen beschikking over een fiets
- ☐ vanwege de weersverwachting
- ☐ vanwege de werktijden
- ☐ vanwege activiteiten voor/na het werk
- ☐ vanwege zakelijk afspraken
- ☐ omdat ik geen spullen mee moest nemen
- ☐ omdat ik vandaag geen lift (met de auto) kon krijgen
- ☐ omdat ik vandaag met iemand mee kon lopen
- ☐ omdat ik vandaag graag wilde bewegen
- ☐ overig, namelijk _____

Als vv_b gelijk is aan 5

Waarom bent u van plan vandaag met een combinatie van openbaar vervoer en fiets naar uw werk te reizen? (meerdere keuzes mogelijk)

- ☐ dat doe ik in principe altijd
- ☐ ik heb vandaag (voor de verandering) geen beschikking over een auto
- ☐ vanwege de weersverwachting
- ☐ vanwege de werktijden
- ☐ vanwege activiteiten voor/na het werk
- ☐ vanwege zakelijk afspraken
- ☐ vanwege mijn kleding
- ☐ omdat ik spullen mee moest nemen
- ☐ omdat ik vandaag niet met iemand mee kon rijden
- ☐ omdat ik vandaag graag wilde bewegen
- ☐ overig, namelijk _____

Als vv_b gelijk is aan 6

Waarom bent u van plan vandaag met een combinatie van openbaar vervoer en lopen naar uw werk te reizen? (meerdere keuzes mogelijk)

- ☐ dat doe ik in principe altijd
- ☐ ik heb vandaag (voor de verandering) geen beschikking over een auto
- ☐ ik heb vandaag (voor de verandering) geen beschikking over een fiets
- ☐ vanwege de weersverwachting
- ☐ vanwege de werktijden
- ☐ vanwege activiteiten voor/na het werk
- ☐ vanwege zakelijk afspraken
- ☐ vanwege mijn kleding
- ☐ omdat ik spullen mee moest nemen
- ☐ omdat ik vandaag niet met iemand mee kon rijden
- ☐ omdat ik vandaag graag wilde bewegen
- ☐ overig, namelijk _____

Als vv_b gelijk is aan 7

Waarom bent u van plan vandaag met een combinatie van fiets en auto naar uw werk te reizen? (meerdere keuzes mogelijk)

- ☐ dat doe ik in principe altijd
- ☐ vanwege de weersverwachting
- ☐ vanwege de werktijden
- ☐ vanwege activiteiten voor/na het werk
- ☐ vanwege zakelijk afspraken
- ☐ vanwege mijn kleding
- ☐ omdat ik spullen mee moest nemen
- ☐ omdat ik vandaag niet met iemand mee kon rijden
- ☐ omdat ik vandaag met iemand mee kon rijden
- ☐ omdat ik vandaag graag wilde bewegen
- ☐ overig, namelijk _____

Als vv_b gelijk is aan 8 ➡

Waarom bent u van plan vandaag met een combinatie van auto en openbaar vervoer naar uw werk te reizen? (meerdere keuzes mogelijk)

- ☐ dat doe ik in principe altijd
- ☐ ik heb vandaag (voor de verandering) geen beschikking over een fiets
- ☐ vanwege de weersverwachting
- ☐ vanwege de werktijden
- ☐ vanwege activiteiten voor/na het werk
- ☐ vanwege zakelijk afspraken
- ☐ vanwege mijn kleding
- ☐ omdat ik spullen mee moest nemen
- ☐ omdat ik vandaag met iemand mee kon rijden
- ☐ overig, namelijk _____

Als vv_b gelijk is aan 9 ➡ ***Beëindig vragenlijst***

Waarom bent u van plan vandaag op deze manier naar uw werk te reizen? (meerdere keuzes mogelijk)

- ☐ dat doe ik in principe altijd
- ☐ ik heb vandaag (voor de verandering) geen beschikking over een auto
- ☐ ik heb vandaag (voor de verandering) geen beschikking over een fiets
- ☐ vanwege de weersverwachting
- ☐ vanwege de werktijden
- ☐ vanwege activiteiten voor/na het werk
- ☐ vanwege zakelijk afspraken
- ☐ vanwege mijn kleding
- ☐ omdat ik spullen mee moest nemen
- ☐ omdat ik vandaag niet met iemand mee kon rijden
- ☐ omdat ik vandaag met iemand mee kon rijden
- ☐ omdat ik vandaag graag wilde bewegen
- ☐ overig, namelijk _____

➡ ***Beëindig vragenlijst***

Hoe laat begint u vandaag met werken? (bijvoorbeeld 09:00)

_____

Hoe laat stopt u vandaag met werken? (bijvoorbeeld 17:00)

werkt nu

Waar werkt u vandaag?

- ○ thuis ➡ Ga verder met vraag
- ○ op vaste werkplek ➡ Ga verder met vraag
- ○ op een andere locatie

Op welk adres werkt u vandaag?
(postcode is niet verplicht)

straat + huisnummer	
plaats	
postcode	

Heeft u vandaag nog op een andere locatie gewerkt en/of gaat u dit doen?

- ○ ja
- ○ nee

Als loc1c gelijk is aan 1
EN mrdlocc gelijk is aan 2 ➡ ***Beëindig vragenlijst***

Als mrdlocc gelijk is aan 2 ➡ *Hoe bent u vandaag naar uw werk gereisd?*

Waar werkt u vandaag nog meer?

- ☐ thuis
- ☐ op vaste werkplek
- ☐ op een andere locatie
- ☐ op meerdere andere locaties

Hoe bent u vandaag naar uw werk gereisd?

- ○ alleen auto
- ○ alleen fiets
- ○ alleen openbaar vervoer
- ○ alleen lopen
- ○ combinatie van openbaar vervoer en fiets
- ○ combinatie van openbaar vervoer en lopen
- ○ combinatie van auto en fiets
- ○ combinatie van auto en openbaar vervoer
- ○ overig, namelijk:

Hoe laat bent u vandaag begonnen met werken? (bijvoorbeeld 08 00)

uren	minuten

Hoe laat bent u van plan vandaag te stoppen met werken? (bijvoorbeeld 19 00)

uren minuten

Welke kleding draagt u vandaag op uw werk?

- speciale werkkleding, die ik alleen tijdens het werk mag dragen
- overige speciale werkkleding
- pak (of vrouwelijke variant)
- nette kleding
- vrije tijdskleding (ook casual)
- overig, namelijk:

Heeft u vandaag spullen moeten meenemen naar uw werk, die niet makkelijk per fiets of openbaar vervoer vervoerd kunnen worden?

- ja
- nee

Heeft u vandaag tijdens werkuren een vervoermiddel nodig (gehad) om uw werk te kunnen doen?

- ja
- nee ➡ Ga verder met vraag

Welk vervoermiddel gebruikt u vandaag tijdens werktijd? (meerdere antwoorden mogelijk)

- lease auto
- privé auto
- dienstauto
- motor
- scooter/brommer
- fiets
- openbaar vervoer
- taxi
- anders, namelijk

Maakt u vandaag tussenstops tijdens uw reis van uw woonlocatie naar uw werklocatie of van uw werklocatie naar uw woonlocatie? En zo ja, welke? (meerdere antwoorden mogelijk)

- geen tussenstops gemaakt
- inkopen, dagelijks
- inkopen, niet–dagelijks
- kinderen ophalen / brengen
- sociale activiteit (bezoek)
- sport
- onderwijs volgen
- culturele activiteit
- werkgerelateerd
- carpool stop (ophalen/ wegbrengen meerijder)
- overige, namelijk:

Als vv_c gelijk is aan 1 ➡

Waarom bent u vandaag met de auto naar uw werk gekomen? (meerdere keuzes mogelijk)

- [ ] dat doe ik in principe altijd
- [ ] ik heb vandaag (voor de verandering) de beschikking over een auto
- [ ] ik heb vandaag (voor de verandering) geen beschikking over een fiets
- [ ] vanwege de weersverwachting
- [ ] vanwege de werktijden
- [ ] vanwege activiteiten voor/na het werk
- [ ] vanwege zakelijk afspraken
- [ ] vanwege mijn kleding
- [ ] omdat ik veel spullen mee moest nemen
- [ ] omdat ik vandaag met iemand mee kon rijden
- [ ] comfort
- [ ] vanwege lichamelijk situatie
- [ ] vanwege lichamelijke condite (moeheid)
- [ ] overig, namelijk

Als vv_c gelijk is aan 2

Waarom bent u vandaag met de fiets naar uw werk gekomen? (meerdere keuzes mogelijk)

- [ ] dat doe ik in principe altijd
- [ ] ik heb vandaag (voor de verandering) geen beschikking over een auto
- [ ] vanwege de weersverwachting
- [ ] vanwege de werktijden
- [ ] vanwege activiteiten voor/na het werk
- [ ] vanwege zakelijk afspraken
- [ ] omdat ik geen spullen mee moest nemen
- [ ] omdat ik vandaag geen lift (met de auto) kon krijgen
- [ ] omdat ik vandaag met iemand mee kon fietsen
- [ ] omdat ik vandaag graag wilde bewegen
- [ ] overig, namelijk

Als vv_c gelijk is aan 3

Waarom bent u vandaag met het openbaar vervoer naar uw werk gekomen? (meerdere keuzes mogelijk)

- [ ] dat doe ik in principe altijd
- [ ] ik heb vandaag (voor de verandering) geen beschikking over een auto
- [ ] ik heb vandaag (voor de verandering) geen beschikking over een fiets
- [ ] vanwege de weersverwachting
- [ ] vanwege de werktijden
- [ ] vanwege activiteiten voor/na het werk
- [ ] vanwege zakelijk afspraken
- [ ] vanwege mijn kleding
- [ ] omdat ik spullen mee moest nemen
- [ ] omdat ik vandaag niet met iemand mee kon rijden
- [ ] comfort
- [ ] vanwege lichamelijk situatie
- [ ] vanwege lichamelijke condite (moeheid)
- [ ] overig, namelijk

Als vv_c gelijk is aan 4

Waarom bent u vandaag lopend naar uw werk gekomen? (meerdere keuzes mogelijk)

- ☐ dat doe ik in principe altijd
- ☐ ik heb vandaag (voor de verandering) geen beschikking over een auto
- ☐ ik heb vandaag (voor de verandering) geen beschikking over een fiets
- ☐ vanwege de weersverwachting
- ☐ vanwege de werktijden
- ☐ vanwege activiteiten voor/na het werk
- ☐ vanwege zakelijk afspraken
- ☐ omdat ik geen spullen mee moest nemen
- ☐ omdat ik vandaag geen lift (met de auto) kon krijgen
- ☐ omdat ik vandaag met iemand mee kon lopen
- ☐ omdat ik vandaag graag wilde bewegen
- ☐ overig, namelijk _____

Als vv_c gelijk is aan 5

Waarom bent u vandaag met een combinatie van openbaar vervoer en fiets naar uw werk gekomen? (meerdere keuzes mogelijk)

- ☐ dat doe ik in principe altijd
- ☐ ik heb vandaag (voor de verandering) geen beschikking over een auto
- ☐ vanwege de weersverwachting
- ☐ vanwege de werktijden
- ☐ vanwege activiteiten voor/na het werk
- ☐ vanwege zakelijk afspraken
- ☐ vanwege mijn kleding
- ☐ omdat ik spullen mee moest nemen
- ☐ omdat ik vandaag niet met iemand mee kon rijden
- ☐ omdat ik vandaag graag wilde bewegen
- ☐ overig, namelijk _____

Als vv_c gelijk is aan 6

Waarom bent u vandaag met een combinatie van openbaar vervoer en lopen naar uw werk gekomen? (meerdere keuzes mogelijk)

- ☐ dat doe ik in principe altijd
- ☐ ik heb vandaag (voor de verandering) geen beschikking over een auto
- ☐ ik heb vandaag (voor de verandering) geen beschikking over een fiets
- ☐ vanwege de weersverwachting
- ☐ vanwege de werktijden
- ☐ vanwege activiteiten voor/na het werk
- ☐ vanwege zakelijk afspraken
- ☐ vanwege mijn kleding
- ☐ omdat ik spullen mee moest nemen
- ☐ omdat ik vandaag niet met iemand mee kon rijden
- ☐ omdat ik vandaag graag wilde bewegen
- ☐ overig, namelijk _____

Als vv_c gelijk is aan 7

Waarom bent u vandaag met een combinatie van fiets en auto naar uw werk gekomen? (meerdere keuzes mogelijk)

- ☐ dat doe ik in principe altijd
- ☐ vanwege de weersverwachting
- ☐ vanwege de werktijden
- ☐ vanwege activiteiten voor/na het werk
- ☐ vanwege zakelijk afspraken
- ☐ vanwege mijn kleding
- ☐ omdat ik spullen mee moest nemen
- ☐ omdat ik vandaag niet met iemand mee kon rijden
- ☐ omdat ik vandaag met iemand mee kon rijden
- ☐ omdat ik vandaag graag wilde bewegen
- ☐ overig, namelijk _____

Als vv_c gelijk is aan 8 ➡

Waarom bent u vandaag met een combinatie van auto en openbaar vervoer naar uw werk gekomen? (meerdere keuzes mogelijk)

- ☐ dat doe ik in principe altijd
- ☐ ik heb vandaag (voor de verandering) geen beschikking over een fiets
- ☐ vanwege de weersverwachting
- ☐ vanwege de werktijden
- ☐ vanwege activiteiten voor/na het werk
- ☐ vanwege zakelijk afspraken
- ☐ vanwege mijn kleding
- ☐ omdat ik spullen mee moest nemen
- ☐ omdat ik vandaag met iemand mee kon rijden
- ☐ overig, namelijk _____

Als vv_c gelijk is aan 9 ➡ ***Beëindig vragenlijst***

Waarom bent u vandaag op deze manier naar uw werk gekomen? (meerdere keuzes mogelijk)

- ☐ dat doe ik in principe altijd
- ☐ ik heb vandaag (voor de verandering) geen beschikking over een auto
- ☐ ik heb vandaag (voor de verandering) geen beschikking over een fiets
- ☐ vanwege de weersverwachting
- ☐ vanwege de werktijden
- ☐ vanwege activiteiten voor/na het werk
- ☐ vanwege zakelijk afspraken
- ☐ vanwege mijn kleding
- ☐ omdat ik spullen mee moest nemen
- ☐ omdat ik vandaag niet met iemand mee kon rijden
- ☐ omdat ik vandaag met iemand mee kon rijden
- ☐ omdat ik vandaag graag wilde bewegen
- ☐ overig, namelijk _____

➡ ***Beëindig vragenlijst***

Hoe laat bent u vandaag begonnen met werken? (bijvoorbeeld 09:00)

_____

Hoe laat stopt u vandaag met werken? (bijvoorbeeld 17:00)

Afsluitende pagina

Hartelijk dank voor uw medewerking.

Indien u verhuist of van baan verandert, zou u dit dan per e–mail willen doorgeven aan: heinen@verplaatsingsgedrag.nl

Ook bij vragen of opmerkingen kunt u contact opnemen met heinen@verplaatsingsgedrag.nl

Samenvatting

Fietsgebruik voor woon-werkverkeer

Eva Heinen

Doelstelling en onderzoeksvragen

Dit proefschrift heeft als doel de determinanten voor fietsen naar het werk te bepalen. Fietsen als vervoermiddel levert de maatschappij grote voordelen op, omdat het een gezondere manier van transport is, het relatief goedkope infrastructuur vereist en tevens minder milieuvervuilend is dan vervoer per auto of openbaar vervoer. De fiets biedt de gebruiker zelf ook voordelen. De fiets is immers goedkoop in gebruik, is sneller op sommige, vooral binnenstedelijke routes en fietsen levert een positieve bijdrage aan de conditie en gezondheid.

Veel mensen kiezen toch voor een ander vervoermiddel dan de fiets voor hun woon-werkreis ondanks de voordelen van fietsen. Zelfs voor reizen over korte afstanden verkiezen sommige forenzen een ander vervoermiddel boven de fiets. Bovendien reist een gedeelte van de fietsforenzen niet dagelijks met de fiets, maar wisselt deze af met de auto of het openbaar vervoer. Stimulering van fietsen naar het werk maakt al jaren deel uit van veel vervoersbeleid. Een grondiger inzicht in de factoren die fietsgebruik beïnvloeden is essentieel om effectiever beleid te formuleren.

Onderzoek naar woon-werkverkeer en ander reisgedrag gaat er meestal vanuit dat individuen altijd op dezelfde manier naar een bepaalde activiteit reizen. Hierdoor wordt er geen rekening gehouden met de mogelijkheid dat veel reizigers hun vervoermiddel afwisselen, en bijvoorbeeld de ene dag met de auto en de volgende dag met de fiets reizen. Sommige mensen wisselen hun vervoerwijze echter wel af. Fietsers zijn afhankelijk van veel aspecten die per dag verschillen, zoals bijvoorbeeld de weersomstandigheden. Vanwege deze dagelijkse verschillen wisselt een deel van de forenzen de fiets af met een ander vervoermiddel, en fietst dus in feite in deeltijd. Aspecten die in de huidige literatuur nauwelijks of geen aandacht krijgen zijn (1) waarom sommige mensen altijd met de fiets naar het werk reizen en anderen afwisselend reizen met de fiets en een ander vervoermiddel en (2) welke factoren deze dagelijkse keuze beïnvloeden. Dit proefschrift onderzoekt deze dagelijkse keuze voor het gebruik voor de fiets en de keuze om in het geheel niet, parttime of fulltime te fietsen.

Dit onderzoek richt zich op een aantal, voor onderzoek naar vervoermiddelkeuze niet doorsnee, factoren om de keuze om te fietsen te verklaren, waarvan een effect verwacht kan worden, zoals het weer en woon-werkafstand. Aangezien het onderzoek zich richt op woon-werkverkeer, spelen kenmerken van het werk vermoedelijk tevens ook een rol. Bedrijfsnormen kunnen bijvoorbeeld werknemers voorschrijven om een pak te dragen, of een auto van

de zaak te rijden wanneer ze cliënten bezoeken. Wanneer een individu een auto nodig heeft voor het werk, wordt mogelijk verwacht dat diegene ook een auto voor de woon-werkverplaatsing gebruikt. De cultuur van de werkgever blijkt tevens uit de financiële compensatie, stimulansen en fietsvoorzieningen op het werk (fietsenstalling, douches); of juist het tegenovergestelde, namelijk autovriendelijk beleid dat de positie van de fiets binnen het bedrijf verzwakt, zoals gratis parkeren. We verwachten dat de aanwezigheid van voorzieningen voor andere vervoermiddelen dan de fiets, financiële compensatie voor andere vervoermiddelen, het werken in sectoren welke niet fietsvriendelijk zijn, de noodzaak goederen voor het werk te vervoeren of de noodzaak voor werk te reizen een negatieve invloed heeft op het fietsgedrag voor woon-werkverkeer.

Een tweede type factoren dat beperkt is meegenomen in eerdere studies zijn de attitudes van de reizigers en de normen in hun sociale omgeving. 'Harde' kenmerken, zoals kosten en reistijd, en socio-demografische kenmerken kunnen niet verklaren waarom individuen met een gelijke situatie verschillen in hun keuze om wel of niet met de fiets naar het werk te reizen. We veronderstellen dat attitudes hierin een rol spelen. Attitudes zijn het product van persoonlijke overtuigingen (bijvoorbeeld: fietsen naar mijn werk is ontspannend) en het belang dat iemand aan deze overtuigingen hecht (bijvoorbeeld: 'ik vind het belangrijk dat mijn vervoermiddel ontspannend is'). We verwachten dat naar mate iemands attitude richting fietsen positiever is, iemand ook eerder geneigd is te fietsen en dit ook vaker zal doen.

Ten slotte is in Nederland in beperkte mate wetenschappelijk onderzoek uitgevoerd naar fietsen voor woon-werkverkeer. Aangezien Nederland op fietsgebied een koploperspositie heeft in de wereld, zou een goed begrip van de keuze om te fietsen nuttig zijn voor Nederland, maar ook voor andere landen.

Deze kennisleemtes leiden tot de volgende hoofdvraag en deelvragen.

In hoeverre wordt de dagelijkse individuele keuze om naar het werk te fietsen beïnvloed door attitudes richting fietsen, sociale normen, de werksituatie, socio-demografische kenmerken, weersomstandigheden, en kenmerken van de reis?

1. *Welke factoren voor het gebruik van de fiets voor woon-werkverkeer komen naar voren uit de wetenschappelijke literatuur?*
2. *In hoeverre beïnvloedt de werk-situatie – zoals de werktijden, kledingstijl, werklocatie, mening van collega's en de noodzaak om te reizen of goederen te vervoeren – de keuze om naar het werk te fietsen?*
3. *In hoeverre wordt de keuze om naar het werk te fietsen bepaald door individuele attitudes richting fietsen, de subjectieve norm, gewoontegedrag en de ingeschatte mogelijkheid om te fietsen?*
4. *Welke dagelijks wisselende factoren bepalen dat fietsforenzen op sommige dagen wel, en op andere dagen niet naar het werk fietsen?*

5. *In hoeverre verschilt de keuze om te fietsen tussen landen? Specifieker: in welke mate komen overtuigingen (beliefs) richting fietsen naar het werk en het belang wat hieraan gehecht wordt overeen in Delft en Davis?*

In voorgaande studies naar woon-werkverkeer is de vervoermiddelkeuze doorgaans gedefinieerd als het vervoermiddel waarmee voornamelijk naar het werk gereisd wordt of waarmee het grootste gedeelte van de reis wordt afgelegd. Vooral voor fietsers is deze definitie problematisch, aangezien hun reisgedrag in grote mate afhankelijk is van een aantal veranderende dagelijkse factoren, zoals het weer. Dit proefschrift onderscheidt verschillende groepen van fietsers. Allereerst onderscheiden we niet-fietsers en fietsers. Fietsers zijn gedefinieerd in woon-werkreizigers die de gehele afstand tussen woning en werk per fiets overbruggen. Voor- en natransport met de fiets vallen buiten dit onderzoek. Een tweede onderscheid is tussen mensen die altijd naar het werk fietsen en fietsforenzen die soms met andere vervoermiddelen naar het werk te reizen. Fulltime fietsers zijn forenzen die elke werkdag de volledige afstand naar het werk per fiets afleggen. Parttime fietsers zijn forenzen die op sommige dagen naar het werk fietsen en op andere dagen met de auto of het openbaar vervoer reizen. Ten slotte is er een onderscheid in fietsfrequentie. Parttime fietsers kunnen op een continuüm van de fietsfrequentie geplaatst worden, waarbinnen verschillende groepen fietsers vallen. Enerzijds is er een categorie mensen, regelmatige fietsers, waarvan de fiets het voornaamste vervoermiddel is. Zij proberen zoveel mogelijk te fietsen, zolang de situatie aan een aantal voorwaardes voldoet (of aan andere niet voldoet). Hun redenering volgt waarschijnlijk de volgende vorm: “Ik fiets, behalve wanneer…”. Anderzijds gebruikt een andere groep parttime fietsers, de incidentele fietsers, voornamelijk een ander vervoermiddel, behalve als de omstandigheden om te fietsen goed zijn. Hun gedachte volgt meer de vorm: “Ik fiets alleen als …”. De veronderstelling is dat deze verschillende groepen van fietsers hun beslissing om naar het werk te fietsen op basis van andere factoren maken. Concreter wordt er verwacht dat (1) de redenen waarom mensen in het geheel wel of niet fietsen verschillen van de redenen die de fietsfrequentie beïnvloeden, (2) fietsers en niet-fietsers om andere redenen (niet) fietsen, en (3) de dagelijkse keuze om te fietsen verschilt van de algemene vervoermiddelkeuze en op basis van andere factoren gemaakt wordt.

Methoden

Om dit te analyseren zijn data verzameld met behulp van een internet-enquête onder inwoners en werknemers in de gemeenten Delft, Zwolle, Midden-Delfland en Pijnacker-Nootdorp. Dit heeft geresulteerd in meer dan 4.000 respondenten. Daarnaast heeft een gedeelte van deze respondenten gedurende een jaar aan een vervolgonderzoek meegewerkt. Deze respondenten ontvingen eens per twee weken een e-mail waarin gevraagd werd naar de vervoer-

middelkeuze van die specifieke dag en de omstandigheden van die dag. Daarnaast zijn in totaal 31 diepte-interviews met forenzen afgenomen in Delft en Davis. Hierbij is ingegaan op hun vervoermiddelkeuze en de achterliggende gedachtes en attitudes.

Resultaten en conclusies

Fietsen in de wetenschappelijke literatuur

Hoofdstuk 2 plaatst op basis van bestaande wetenschappelijke literatuur de factoren van de keuze voor de fiets voor woon-werkreizen en de fietsfrequentie in een aantal categorieën: de gebouwde omgeving, de natuurlijke omgeving, weersomstandigheden, socio-economische kenmerken, attitudes, normen en gewoonte. Afstand lijkt verreweg de meest belangrijke factor. Andere kenmerken van de gebouwde omgeving die het fietsen negatief beïnvloeden, zijn verkeerslichten en stopborden op de fietsroute. Aan de andere kant hebben de volgende ruimtelijke factoren een positieve invloed op fietsen: een hogere mate van functiemenging (bijvoorbeeld: woningen, winkels, voorzieningen), de aanwezigheid van fietsenstallingen, kleinere blokgrootte, hogere bebouwingsdichtheid, de aanwezigheid en de continuïteit van specifieke fietsinfrastructuur en voorzieningen voor de fiets, zoals fietsparkeervoorzieningen en douches op het werk. De relatie tussen socio-economische factoren en fietsen is niet eenduidig in de wetenschappelijke literatuur en verschilt tussen landen. Bijvoorbeeld, in de meeste landen fietsen mannen meer dan vrouwen, terwijl in de landen waar fietsen is heel gebruikelijk, zoals België en Nederland, vrouwen meer fietsen. De natuurlijke omgeving heeft een grote invloed op zowel het besluit om te fietsen als de fietsfrequentie. Relief heeft in het algemeen een negatief effect op de fietsen, maar ervaren fietsers hebben een voorkeur voor een heuvelachtige omgeving. (De kans op) regen, lage temperaturen en duisternis leiden ertoe dat minder mensen de fiets pakken. Toch beïnvloedt de temperatuur forenzen minder dan andere fietsers. De wetenschappelijke literatuur suggereert bovendien dat attitudes en sociale normen de keuze om te fietsen beïnvloeden. Als een persoon een meer positieve houding ten aanzien van fietsen heeft, is er een grotere kans dat hij/zij fietst. Bovendien, als de omgeving een persoon steunt om te fietsen, dan lijkt deze persoon een grotere kans te hebben om te fietsen.

Werkkenmerken en fietsgedrag

Hoofdstuk 3 onderzoekt de invloed van de werkgever op de vervoermiddelkeuze en analyseert welke werkgerelateerde factoren de beslissing om op de fiets naar het werk te reizen en de fietsfrequentie beïnvloeden. De uitkomsten van twee zogenoemde binaire logit modellen tonen aan dat de fietsvoorzieningen die de werkgever aanbiedt en een positieve houding richting fietsen op de werkvloer – dan wel van de werkgever of collega's – een positieve invloed hebben op de beslissing om op de fiets naar het werk te reizen. Naar-

mate forenzen positiever staan tegenover het gebruik van de fiets voor woon-werkverkeer, neemt hun fietsfrequentie toe. Hetzelfde geldt als de forens denkt dat collega's verwachten dat hij/zij naar het werk zou moeten fietsen.

Een positieve attitude ten aanzien van fietsen van de werkgever komt tot uitdrukking in het aanbieden van fietsvoorzieningen. Tevens wijst het aanbieden van faciliteiten voor andere vervoersmiddelen op een niet-ondersteunende omgeving voor fietsen. De resultaten tonen dat er een grotere kans is dat iemand een fietsforens is als op de werklocatie een inpandige fietsenstalling, kleedruimtes of een openbaarvervoer halte binnen 500 meter aanwezig is. De aanwezigheid van gratis parkeren voor de auto resulteert in een lagere kans op fulltime fietsers. Het aanbieden van een gratis Ov-kaart of de auto blijkt tevens de keuze om te fietsen negatief te beïnvloeden. Deze twee resultaten wijzen erop dat voorzieningen voor het openbaar vervoer of de auto, fietsen negatief beïnvloeden.

Daarnaast resulteert een langere woon-werkafstand in een kleinere kans dat iemand naar het werk fietst en tevens in een lagere fietsfrequentie. Mensen die goederen moeten vervoeren voor hun werk, fietsen minder vaak naar hun werk. Hetzelfde geldt voor mensen die een voertuig nodig hebben tijdens werkuren. Mensen die daarentegen een fiets nodig hebben tijdens kantooruren, fietsen vaker naar hun werk. Ondanks dat veel werkgevers tegenwoordig leenfietsen en soms zelfs leenauto's aanbieden, is een noodzaak tot een bepaald vervoermiddel, voor het vervoeren van goederen of het maken van een dienstreis, blijkbaar nog steeds invloedrijk op de vervoermiddelkeuze voor het woon-werkvervoer.

De resultaten tonen dat de factoren die van invloed zijn op de keuze om naar het werk te fietsen en op de fietsfrequentie, van elkaar verschillen. De keuze om naar het werk te fietsen wordt beïnvloed door de aanwezigheid van een fietsenstalling, de aanwezigheid van kleedruimtes, en een compensatie voor de reiskosten, maar deze factoren hebben geen effect op de fietsfrequentie. Daarentegen zijn het aantal gewerkte uren en de werktijden alleen van invloed op de vraag of een individu beslist om fulltime of parttime te fietsen. Deze bevinding suggereert dat de keuze om naar het werk te fietsen en om fulltime naar het werk te fietsen twee afzonderlijke beslissingen zijn, waarop gedeeltelijk verschillende factoren invloed hebben.

Attitudes en normen

Hoofdstuk 4 richt zich op het effect van attitudes, de subjectieve norm, gewoonte en de ingeschatte mogelijkheid om naar het werk te fietsen op de keuze om naar het werk te fietsen over de verschillende afstanden. Een zogenoemde exploratieve factoranalyse toont drie dimensies van attitudes aan: (i) direct nut, (ii) bewustzijn en (iii) veiligheid. De dimensie "direct nut" bevat vooral de variabelen die verband houden met tijdsbesparing, comfort, flexibiliteit en aangenaam. De dimensie "bewustzijn" is opgebouwd uit de variabe-

len milieuvriendelijkheid, gezondheid en mentale ontspanning. De derde dimensie, "veiligheid", bevat de variabelen verkeersveiligheid en sociale veiligheid. Vervolgens is op basis van binaire logit modellen de statistische relatie geschat op drie afstandscategorieën tussen enerzijds de drie voorgaande attitude dimensies, de subjectieve norm, fietsgewoonte en de ingeschatte mogelijkheid en anderzijds het besluit om al dan niet naar het werk te fietsen. Zoals verwacht, verklaren deze factoren de keuze om met de fiets te reizen en de fietsfrequentie voor een groot deel.

De beslissing om met de fiets naar het werk te gaan wordt beïnvloed door alle drie de attitude dimensies, waarvan "direct nut" de belangrijkste factor is. Mensen die fietsen tijdsbesparend, gemakkelijk en flexibel vinden en dit ook belangrijk vinden, zijn vaker fietsers, onafhankelijk van de afstand. Voor de attitude dimensie "bewustzijn" verschilt het effect per afstand. Op korte afstand heeft deze dimensie geen effect, maar voor langere woon-werkafstanden gebruiken forenzen die voldoende belang hechten aan de positieve effecten van fietsen voor het milieu en hun gezondheid vaker de fiets dan forenzen die hier minder belang aan hechten. Deze laatste vinden de voordelen voor het milieu en hun gezondheid blijkbaar niet opwegen tegen de toegenomen moeite om te fietsen over langere afstanden. Voor de dimensie "veiligheid" is geen statistisch significante relatie met de keuze voor de fiets gevonden. Bovendien bestaat er voor elk van de drie afstandscategorieën ook een positieve relatie tussen een positieve inschatting van de "fietsbaarheid" van de woon-werkreis en de keuze om te fietsen. De mening van de sociale omgeving daarentegen beïnvloedt alleen het reisgedrag voor korte afstanden. Bij langere afstanden worden forenzen niet of in beperkte mate beïnvloed door wat zij denken dat hun sociale omgeving van hen verwacht. Dit geeft aan dat fietsen over langere afstanden meer een beslissing is die op basis van individuele overwegingen genomen wordt. Naast bovenstaande factoren, speelt ook de fietsgewoonte een rol. Personen die vaak de fiets gebruiken voor andere verplaatsingen, zoals uitgaan of vrienden bezoeken, blijken ook vaker woonwerkfietsers te zijn.

Individuele attitudes bepalen niet alleen de keuze van het vervoersmiddel, maar ook de fietsfrequentie en dus de keuze tussen fulltime of parttime fietsen. Vooral de dimensie "direct nut" heeft een grote invloed op de fietsfrequentie. Forenzen die fietsen naar hun werk voldoende veilig vinden of hieraan geen belang hechten (dus forenzen met een positieve attitude ten aanzien van veiligheid) hebben eveneens een grotere kans om dagelijks naar het werk te fietsen. Dit geldt echter enkel voor afstanden korter dan 5 kilometer en langer dan 10 kilometer. Het is onduidelijk waarom veiligheid geen invloed heeft op reizen tussen de 5 en 10 kilometer. De dimensie "bewustzijn" beïnvloedt de beslissing alleen op afstanden tot 5 kilometer. Dit betekent dat personen die van mening zijn dat fietsen milieuvriendelijk, gezond en geestelijk ontspannend is, meer geneigd zijn om iedere dag naar het werk te fietsen.

Echter, deze positieve attitude dimensie speelt geen rol bij mensen die verder van hun werk wonen. De eigen inschatting van de fietsbaarheid heeft geen invloed op de fietsfrequentie. Deze uitkomst bevestigt de juistheid van het model: als een persoon naar het werk fietst, beschouwt deze fietsen sowieso als mogelijk, ongeacht de fietsfrequentie. De subjectieve norm heeft daarentegen wel invloed op de fietsfrequentie. De sociale omgeving beïnvloedt fietsers die binnen een straal van 5 kilometer van hun werkplek wonen. Als mensen het gevoel hebben dat hun omgeving fietsen naar het werk niet passend vindt, fietst men dus minder vaak. Fulltime fietsforenzen fietsen ook vaker voor andere doeleinden. Personen die regelmatig met de auto of met het openbaar vervoer reizen zijn blijkbaar ook sneller geneigd om deze vervoermiddelen ook af en toe te gebruiken voor hun woon-werkverplaatsing.

Zoals verwacht, hebben modellen die het fietsgedrag verklaren over een grotere afstand een hogere verklarende kracht dan de modellen over korte afstand (<5 kilometer) wat een indicatie is dat mensen met een meer positieve houding richting fietsen ook over langere afstanden fietsen. De bevindingen ontkrachten echter een tweede verwachting dat fietsers met een positievere attitude een hogere fietsfrequentie zouden hebben dan personen met een matige of een negatieve houding.

De dagelijkse keuze voor de fiets

Hoofdstuk 5 richt zich op de dagelijkse keuze om (niet) te fietsen. Veel fietsers kiezen soms voor een alternatief vervoermiddel, omdat ze beïnvloed worden door omstandigheden die veranderen van dag tot dag. Deze dagelijkse afwisselende keuze is onderzocht met het gebruik van longitudinale gegevens van parttime fietsers, die over een periode van een jaar zijn verzameld, en deze keuze is gemodelleerd met Generalized Estimating Equations (GEE).

De resultaten laten zien dat factoren die per dag kunnen verschillen een grote invloed hebben op de keuze om naar het werk te fietsen, zoals weersomstandigheden, werkkenmerken en kenmerken van de reis. Dit resultaat bevestigt de veronderstelling dat de dagelijkse vervoermiddelkeuze van veel fietsers afhankelijk is van andere factoren dan de 'normale' factoren in vervoermiddelkeuze onderzoek.

Specifieker, de kans om naar het werk te fietsen neemt af wanneer een individu ergens anders dan op de vaste werklocatie werkt of wanneer men op een dag op meerdere locaties werkt. Tevens reizen forenzen minder vaak met de fiets wanneer zij een auto tijdens werkuren nodig hebben, goederen moeten vervoeren of een pak dragen. Aan de andere kant reizen mensen die een fiets nodig hebben tijdens werktijd vaker met de fiets naar het werk. Elke extra kilometer (woon-werkafstand) vermindert de kans dat mensen op de fiets naar het werk reizen. Ook zijn forenzen die tussenstops maken tijdens hun woon-werkreis minder geneigd om te fietsen.

Vijf weersomstandigheden beïnvloeden de dagelijkse keuze om te fietsen.

Zowel de hoeveelheid neerslag als de duur ervan verlagen de kans dat mensen op de fiets gaan. Tevens neemt de kans om te fietsen af bij een toename van de windsnelheid. Temperatuur en zonneschijn hebben daarentegen een positief effect. Bij zowel een hogere temperatuur als wanneer de zon langer schijnt is de kans groter dat mensen fietsen. Van alle geteste interactieeffecten is alleen die tussen geslacht en aanwezigheid van daglicht significant: vrouwen zijn minder geneigd naar het werk te fietsen in het donker dan mannen. Vrouwen zijn dus gevoeliger voor de afwezigheid van daglicht.

Twee groepen van part-time fietsers zijn gevormd, incidentele en regelmatige fietsers, en individuen in deze groepen baseren hun keuze om op een bepaalde dag (niet) te fietsen op verschillende dagelijks wisselende omstandigheden. Daar waar incidentele fietsers vooral beïnvloed worden om te fietsen door positieve weersomstandigheden, zoals een hoge temperatuur en de duur van zonneschijn, worden regelmatige fietsers ontmoedigd door meer praktische barrières, zoals harde wind en de noodzaak om op meerdere locaties te werken.

Vergelijking tussen Delft en Davis

Hoofdstuk 6 onderzoekt de verschillen en overeenkomsten in attitudes en normen tussen fietsers in Delft en Davis in Californië. Hiervoor zijn in totaal 31 interviews afgenomen met forenzen in beide steden. De interviews zijn met elkaar vergeleken op de onderliggende overtuigingen (*beliefs*) over fietsen naar het werk en belang dat mensen hechten aan deze overtuigingen.

De analyses wijzen op een duidelijke invloed van attitudes en normen op het fietsgedrag. Fietsers hebben bijna altijd positieve overtuigingen richting fietsen, en nog belangrijker: zij hechten belang aan deze overtuigingen. Niet-fietsers hebben een meer gemixte attitude ten aanzien van fietsen. Sommige niet-fietsers hechten net als fietsers belang aan de gevolgen van fietsen naar het werk, en dus bestaat er een mismatch tussen hun gedrag en hun attitude.

De interviews tonen gelijkenissen tussen de deelnemers in beide landen. Zij delen de overtuiging dat fietsen gezond is en vinden deze positieve gezondheidseffecten belangrijk. De meeste fietsers geven aan dat de gezondheidsvoordelen hen aanmoedigen te fietsen, terwijl niet-fietsers deze voordelen erkennen, maar meer belang hechten aan andere factoren. Ten tweede delen fietsers in Delft en Davis de overtuiging dat fietsen leuk is.

Uit de verkennende analyses blijken ook twee belangrijke verschillen in attitudes tussen de steden. Ten eerste zien de deelnemers uit Davis de fiets in grotere mate als een onveilig vervoermiddel dan de Nederlandse deelnemers. Hoewel fietsen in Davis vaak wel als veilig wordt ervaren, benadrukken zij de onveilige verkeerssituatie als een reden om niet naar of in andere steden te fietsen. In Delft wordt de verkeersveiligheid nauwelijks genoemd. Wanneer de veiligheid aan de orde komt reageren deelnemers uit Delft niet in termen van verkeersveiligheid, maar hebben hun reacties betrekking op persoonlij-

ke veiligheid. Mensen beschouwen het vooral voor vrouwen niet altijd veilig om 's nachts te fietsen. Ten tweede benadrukken deelnemers in Davis vaker het belang van het milieu. Deelnemers in Delft delen de overtuiging dat fietsen milieuvriendelijk is, maar lijken hier minder belang aan te hechten. Sommigen noemen het effect van hun fietsgedrag een gunstig neveneffect, geen hoofdreden om te fietsen.

De normen in beide landen verschillen duidelijk van elkaar. Deelnemers uit Davis ervaren regelmatig een negatieve norm van mensen buiten Davis. Verschillende deelnemers krijgen negatieve reacties van familie of vrienden omdat ze fietsen en niet met de auto rijden. Deelnemers verklaren dit deels aan de hand van de Amerikaanse en vooral Californische cultuur waarin de auto een prominente rol vervult. Daartegenover staat dat de inwoners in beide steden een positieve norm richting fietsen lijken te hebben.

Conclusies

Op basis van de gehele dissertatie kunnen de volgende conclusies getrokken worden. Deze dissertatie levert ondersteuning voor de aanname dat er meerdere groepen fietsforenzen zijn, die elk door (gedeeltelijk) andere factoren beïnvloed worden. Een deel van de reizigers voor wie de fiets een optie is, fietst daadwerkelijk naar het werk. Een deel hiervan fiets elke dag, het andere deel slechts af en toe en wisselt de fiets af met een ander vervoermiddel. De voornaamste reden voor niet-fietsers om niet te fietsen lijkt voor een deel in de mogelijkheid om te fietsen te liggen: of de afstand is te groot, of er moeten spullen vervoerd worden, of zij hebben een auto nodig voor hun werk. Parttime en fulltime fietsers zijn ook gevoelig zijn voor kenmerken van hun werk en trip, maar er spelen ook andere factoren een rol, zoals de weersomstandigheden en een positievere fietsnorm.

In dit proefschrift zijn factoren onderzocht die de keuze beïnvloeden om naar het werk te fietsen. Verschillen tussen dagen beïnvloeden de dagelijkse vervoermiddelkeuze, zoals neerslag, windsnelheid, de noodzaak om goederen te vervoeren of de noodzaak voor een vervoermiddel voor dienstreizen. Tevens beïnvloeden kenmerken van de werkomgeving, attitudes en normen de keuze om te fietsen en de fietsfrequentie. In tegenstelling tot eerder (internationaal) onderzoek is er geen negatief effect van hitte gevonden. Dit betekent dat de Nederlandse fietsforens erg warm weer (meer dan 30°C) niet als reden beschouwt om niet te fietsen. Integendeel, hoe warmer het weer, hoe groter de kans dat men op de fiets naar het werk reist.

De aandacht voor psychologische aspecten biedt extra inzicht in de redenen voor fietsgebruik en verklaart mede het gedrag aan de hand van overtuigingen en het belang gehecht aan deze overtuigingen. In hoofdstuk 4 zijn drie overkoepelende individuele fietsattitude dimensies gevormd en analyses tonen aan dat deze samen met de subjectieve norm, ingeschatte mogelijkheid om te fietsen en de gewoonte om te fietsen, de keuze om te fietsen over

verschillende afstanden bepalen. Dit toont aan dat individuele overwegingen voor een groot deel de beslissing om te fietsen bepalen.

Beleidsimplicaties

Een van de beleidsdoelen van overheden zowel in Nederland als in andere landen is het vergroten van het fietsaandeel en de fietsfrequentie. Hierna volgen een aantal mogelijke beleidsimplicaties van dit onderzoek. Allereerst komt het belang van een focus per doelgroep aan bod, vervolgens een aantal praktische stimulerende ingrepen voor fietsgebruik die betrekking hebben tot de factoren die in dit proefschrift naar voren zijn gekomen.

Doelgroepenaanpak

Deze studie toont aan dat verschillende groepen fietsers op ander factoren hun keuze baseren om wel of niet naar het werk te fietsen. Deze informatie is essentieel bij het streven naar bevordering van fietsen, aangezien deze verschillende groepen dus ook op een andere manier gemotiveerd kunnen worden. Beleid per doelgroep is daarom effectiever dan beleid dat geen onderscheid maakt. In het doel mensen meer te laten fietsen zijn er drie doelgroepen te onderscheiden, met elk hun eigen transitie: niet-fietsers naar fietsers, incidentele naar frequente fietsers, en parttime naar fulltime fietsers.

Mogelijke stimulerende ingrepen

Als een werkgever de voorzieningen voor andere vervoerswijzen beperkt, stimuleert die daarmee het fietsgebruik. Voorzieningen voor andere vervoerswijzen resulteren namelijk in een lager fietsgebruik. Dit geldt zowel voor auto gerelateerde faciliteiten, zoals een gratis auto, als voor het aanbieden van een gratis openbaarvervoerkaart. Werkgevers zouden kunnen nadenken over hun prioriteiten ten aanzien van de vervoermiddelkeuze van hun werknemers en rekening houden met het negatieve effect op fietsgebruik wanneer ze gelijktijdig ook het openbaarvervoer- of autogebruik stimuleren. In veel gevallen is een beperking van faciliteiten voor de auto of openbaar vervoer niet de meest geschikte oplossing voor een werkgever, omdat deze worden aangewend om personeel aan te trekken. Het aanbieden van fietsvoorzieningen biedt de werkgever mogelijk twee positieve dingen in één: meer woon-werkverkeer op de fiets, wat resulteert in gezondere werknemers, en niet de nadelen van het beperken van de voorzieningen voor andere vervoermiddelen. Voorbeelden van deze fietsvoorzieningen zijn: fietsenstalling, kleedruimtes en een fiets bijdrage.

Een andere optie, die kan werken, is dat werkgevers het fietsen stimuleren door op bepaalde dagen factoren die fietsen negatief beïnvloeden te clusteren, zoals de noodzaak om goederen te vervoeren, de noodzaak van een auto tijdens de kantooruren, de 'noodzaak' om een pak te dragen en werken op een andere locatie dan de hoofdwerklocatie. Vaak zijn deze zaken onvermij-

delijk, maar clustering beperkt het aantal dagen dat deze beperkingen om te fietsen een rol spelen en biedt daarmee medewerkers de mogelijkheid om te fietsen op andere dagen. Bovendien kan een werkgever auto's bezitten die werknemers op aanvraag kunnen gebruiken, waardoor een aantal forenzen met de fiets naar het werk kan reizen en een dienstauto gedurende de dag kan gebruiken, in plaats van in hun eigen auto naar het werk te reizen. Deze maatregel kan het fietsgebruik vergroten aangezien zowel de noodzaak tot een vervoermiddel en de noodzaak om goederen te vervoeren waarvoor veelal een auto nodig is, een negatieve uitwerking hebben op het fietsgebruik.

De weersomstandigheden beïnvloeden de keuze om te fietsen sterk, maar kunnen nauwelijks worden veranderd door de mens. Wel kunnen (potentiële) fietsforenzen bewust worden gemaakt wanneer er fietsgunstige weersomstandigheden zullen optreden. Een idee dat mogelijk het testen waard is, is dat de werkgever op een dag voordat het goed fietsweer is een e-mail stuurt waarbij de gunstige voorspellingen benadrukt worden, en misschien zelfs een financiële prikkel wordt aangeboden voor een bepaald aantal fietsers. Bovendien kan een werkgever op dagen met wisselvallig weer het fietsen stimuleren door een aankondiging te sturen, bijvoorbeeld in de vorm van een smsbericht, op welke uren er geen regen verwacht wordt. Een tweede manier van omgaan met het weer is het verminderen van de negatieve effecten van regen of wind. Op populaire routes kan windscherm of zelfs een overkapping geplaatst worden om de negatieve ervaring van de weersomstandigheden te beperken.

Het negatieve effect dat duisternis heeft op vrouwen als het gaat om fietsen kan worden verminderd door aanpassingen in de gebouwde omgeving en in de sociale context. Het effect van de afwezigheid van daglicht op vrouwen met betrekking tot fietsen is waarschijnlijk een gevolg van een onveilig gevoel. Het creëren van routes met goede straatverlichting en een goede zichtbaarheid door andere weggebruikers zal leiden tot een afname van het effect van het ontbreken van daglicht op vrouwen. Indien het onmogelijk is om een dergelijke route te creëren richting bepaalde werkgevers, kunnen deze werkgevers vrouwen aanmoedigen samen te fietsen op de vermeende onveilige routes.

Om het fietsgedrag te veranderen zijn niet alleen fietsvriendelijke faciliteiten en infrastructuur noodzakelijk, maar dienen ook de individuele attitudes en sociale normen het fietsen voor woon-werkverkeer te ondersteunen. Dit proefschrift toont dat attitudes, gewoonten en subjectieve norm een grote bijdrage leveren aan het besluit op de fiets naar het werk te reizen. Om fietsgebruik te stimuleren is een positieve focus op het fietsen nodig. De voorbeeldfunctie van een gerespecteerd persoon kan hierbij een stimulerende rol vervullen. Deze persoon kan een voorbeeld zijn binnen een land of een bedrijf. Dit kan niet alleen leiden tot het kopiëren van het gedrag, maar toont tevens een positief standpunt over fietsen en creëert daarmee een positievere socia-

le norm naar fietsen. Een tweede mogelijkheid is een zogenaamde superpromoter, wiens enthousiasme resulteert in het kopiëren van het gedrag en de volgen van diens aanbevelingen (Vogelaar, 2009). Een superpromoter is een enthousiaste persoon, die dit enthousiasme deelt met anderen en daarbij ook serieus genomen wordt. Idealiter zou dit iemand zijn die van de auto overgestapt is op de fiets, omdat automobilisten zich hiermee gemakkelijker kunnen identificeren. Tot slot kunnen advertenties van de overheid of fietsorganisaties en ander fietspromotiemateriaal een positievere en meer op de emotie gerichte boodschap bevatten, waardoor het imago van het fietsen verbetert. Fietscampagnes hebben in het verleden gebruik gemaakt negatieve beelden, zoals op verkeersveiligheid en de gevaren van het fietsen, of door alleen feitelijke informatie te verstrekken, zoals fietsen is goed voor het milieu. Uit de interviews in Delft en Davis blijkt dat bijna alle mensen het leuk vinden om te fietsen en de gezondheidsvoordelen belangrijk vinden, en dat deze factoren motiveren om te fietsen. Het leuk vinden van fietsen roept zeer sterke positieve gevoelens van de meeste fietsers en deze gevoelens kunnen worden gebruikt om anderen aan te moedigen om te beginnen met fietsen, evenals om mensen die al fietsen te stimuleren om meer te fietsen, en om fietsers trotser te laten zijn op het feit dat zij fietsen en om dit positieve gevoel te delen met anderen.

Aanbevelingen voor verder onderzoek

De gevonden factoren die van invloed zijn op het reizen per fiets naar het werk zijn (nog) niet zijn getest op een causaal verband. Het is dus onduidelijk of veranderingen in voorzieningen daadwerkelijk een gevolg hebben op het fietsgedrag. Om dit te onderzoeken en harde conclusies over de causaliteit te kunnen trekken, is longitudinaal onderzoek noodzakelijk, waarbij gegevens over langere periode verzameld worden. Een voorbeeld is onderzoek naar het effect van werkkenmerken, waarbij een meting vóór de mogelijkheid tot het goed stallen van de fiets of voor een fietsbijdrage, en een meting erna, zodat het effect van de interventie vastgesteld kan worden.

Ten tweede richt dit proefschrift zich in het bijzonder op fietsgebruik voor woon-werkverkeer. Vergelijkbare factoren beïnvloeden waarschijnlijk het fietsen voor andere doeleinden, zoals vermeld in hoofdstuk twee. Niettemin kan de sterkte van de factoren verschillen. Daarbij komt dat het onderzoek naar fietsen (in Nederland) nog beperkt is (in vergelijking met andere onderzoeksgebieden), en het lijkt daarom aanbevelingswaardig om de factoren van fietsgebruik voor andere doeleinden uitgebreid te onderzoeken.

Ten derde heeft dit proefschrift slechts beperkt aandacht voor het effect van de gebouwde omgeving op het gedrag. Fietsinfrastructuur heeft vrijwel zeker grote invloed op de keuze al dan niet te fietsen en op de routekeuze van de fietsers. Bovendien hangen attitudes en normen over fietsen vermoedelijk af van de aanwezigheid en kwaliteit van de fietsinfrastructuur. Een diepgaand

onderzoek naar de ervaringen van infrastructurele fietsvoorzieningen en de manier waarop deze voorzieningen de individuele attitudes beïnvloeden, kan inzicht verschaffen in de invloed van de gebouwde omgeving op fietsgedrag. Dergelijk onderzoek verschaft beleidsmakers mogelijk praktische kennis over het effect van fietsinfrastructuur.

Ten slotte is aanvullend onderzoek nodig om de effectiviteit van maatregelen die als doel hebben het fietsgebruik te stimuleren te testen. Het effect van huidige initiatieven en beleid om het fietsen te stimuleren is nauwelijks onderzocht. Daardoor zijn veel initiatieven en beleid gebaseerd op 'slechts' gezond verstand en eerder geformuleerd beleid. Het is daarom verstandig niet alleen te concentreren op het vinden van nieuwe (creatieve) strategieën, maar ook het effect van de maatregelen zorgvuldig te onderzoeken en ongewenste neveneffecten in kaart te brengen om fietsgebruik effectiever te stimuleren.

Curriculum vitae

Eva Heinen was born on 15 November 1981 in Voorburg and spent most of her childhood in Rotterdam. In 2004, she received her bachelors degree in Architecture from Delft University of Technology and continued her studies at the University of Amsterdam, where she received her masters degree in Urban and Regional Planning in 2005. After graduation she worked as a government trainee and gained experience in the former Ministry of Housing, Spatial Planning and the Environment (VROM), the former Netherlands Institute of Spatial Research (RPB) and the Transport Department at the Dutch Embassy in Berlin. In 2007, she started her PhD research at OTB Research Institute for the Built Environment, part of Delft University of Technology. During her research she spent three months at the University of California in Davis as a visiting scholar. She is currently a member of the editorial board of 'Rooilijn', a Dutch journal for science and policy in spatial planning, and is also a member of the Transportation Research Board (TRB) Bicycle Committee.

Sustainable Urban Areas

1. Beerepoot, Milou, **Renewable energy in energy performance regulations. A challenge for European member states in implementing the Energy Performance Building Directive**
2004/202 pages/ISBN 90-407-2534-9 (978-90-407-2534-0)

2. Boon, Claudia and Minna Sunikka, **Introduction to sustainable urban renewal. CO_2 reduction and the use of performance agreements: experience from The Netherlands**
2004/153 pages/ISBN 90-407-2535-7 (978-90-407-2535-7)

3. Jonge, Tim de, **Cost effectiveness of sustainable housing investments**
2005/196 pages/ISBN 90-407-2578-0 (978-90-407-2578-4)

4. Klunder, Gerda, **Sustainable solutions for Dutch housing. Reducing the environmental impact of new and existing houses**
2005/163 pages/ISBN 90-407-2584-5 (978-407-2584-5)

5. Bots, Pieter, Ellen van Bueren, Ernst ten Heuvelhof and Igor Mayer, **Communicative tools in sustainable urban planning and building**
2005/100 pages/ISBN 90-407-2595-0 (978-90-407-2595-1)

6. Kleinhans, R.J., **Sociale implicaties van herstructurering en herhuisvesting**
2005/371 pages/ISBN 90-407-2598-5 (978-90-407-2598-2)

7. Kauko, Tom, **Comparing spatial features of urban housing markets. Recent evidence of submarket formation in metropolitan Helsinki and Amsterdam**
2005/163 pages/ISBN 90-407-2618-3 (978-90-407-2618-7)

8. Kauko, Tom, **Between East and West. Housing markets, property prices and locational preferences in Budapest from a comparative perspective**
2006/142 pages/ISBN 1-58603-679-3 (978-1-58603-679-9)

9. Sunikka, Minna Marjaana, **Policies for improving energy efficiency in the European housing stock**
2006/251 pages/ISBN 1-58603-649-1 (978-1-58603-649-2)

See next page

10. Hasselaar, Evert, **Health performance of housing. Indicators and tools**
2006/298 pages/ISBN 1-58603-689-0 (978-1-58603-689-8)

11. Gruis, Vincent, Henk Visscher and Reinout Kleinhans (eds.), **Sustainable neighbourhood transformation**
2006/158 pages/ISBN 1-58603-718-8 (978-1-58603-718-5)

12. Trip, Jan Jacob, **What makes a city? Planning for 'quality of place'. The case of high-speed train station area redevelopment**
2007/256 pages/ISBN 978-1-58603-716-1

13. Meijers, Evert, **Synergy in polycentric urban regions. Complementarity, organising capacity and critical mass**
2007/182 pages/ISBN 978-1-58603-724-6

14. Chen, Yawei, Shanghai Pudong. **Urban development in an era of global-local interaction**
2007/368 pages/ISBN 978-1-58603-747-5

15. Beerepoot, Milou, **Energy policy instruments and technical change in the residential building sector**
2007/238 pages/ISBN 978-1-58603-811-3

16. Guerra Santin, Olivia, **Environmental indicators for building design. Development and application on Mexican dwellings**
2008/124 pages/ISBN 978-1-58603-894-6

17. Van Mossel, Johan Hendrik, **The purchasing of maintenance service delivery in the Dutch social housing sector. Optimising commodity strategies for delivering maintenance services to tenants**
2008/283 pages/ISBN 978-1-58603-877-9

18. Waterhout, Bas, **The institutionalisation of European spatial planning**
2008/226 pages/ISBN 978-1-58603-882-3

19. Koopman, Marnix, Henk-Jan van Mossel and Ad Straub, **Performance measurement in the Dutch social housing sector**
2008/140 pages/ISBN 978-1-58603-962-2

20. Pal, Anirban, **Planning from the bottom up. Democratic decentralisation in action**
2008/126 pages/ISBN 978-1-58603-910-3

21. Neuteboom, Peter, **On the rationality of borrowers' behaviour. Comparing risk attitudes of homeowners**
2008/112 pages/ISBN 978-1-58603-918-9

22. Itard, Laure and Frits Meijer, **Towards a sustainable northern European housing stock. Figures, facts and future**
2008/226 pages/ISBN 978-1-58603-977-6

23. Janssen-Jansen, Leonie, Marjolein Spaans and Menno van der Veen, **New instruments in spatial planning. An international perspective on non-financial compensation**
2008/258 pages/ISBN 978-1-58603-978-3

24. Coolen, Henny, **The meaning of dwelling features. Conceptual and methodological issues**
2008/164 pages/ISBN 978-1-58603-955-4

25. Van Rij, Evelien, **Improving institutions for green landscapes in metropolitan areas**
2008/226 pages/ISBN 978-1-58603-944-8

26. Van der Veen, Menno, **Contracting for better places. A relational analysis of development agreements in urban development projects**
2009/394 pages/ISBN 978-1-60750-005-6

27. Meesters, Janine, **The meaning of activities in the dwelling and residential environment. A structural approach in people-environment relations**
2009/284 pages/ISBN 978-1-60750-012-4

28. Lux, Martin, **Housing policy and housing finance in the Czech Republic during transition. An example of the schism between the still-living past and the need of reform**
2009/300 pages/ISBN 978-1-60750-058-2

29. Maat, Kees, **Built environment and car travel. Analyses of interdependencies**
2009/174 pages/ISBN 978-1-60750-064-3

30. Van Bueren, Ellen, **Greening governance. An evolutionary approach to policy-making for a sustainable built environment**
2009/326 pages/ISBN 978-1-60750-078-0

31. Makasa, Paul, **The 1996 Zambia National Housing Policy**
2010/500 pages/ ISBN 978-1-60750-566-2/978-1-60750-567-9 (online)

32. Van Eijk, Gwen, **Unequal networks. Spatial segregation, relationships and inequality in the city**
2010/366 pages/ SBN 978-1-60750-555-6/978-1-60750-556-3 (online)

33. Guerra Santin, Olivia, **Actual energy consumption in dwellings. The effect of energy performance regulations and occupant behaviour**
2010/252 pages/ISBN 978-1-60750-650-8 (print)/
ISBN 978-1-60750-651-5 (online)

34. Doff, Wenda, **Puzzling neighbourhood effects. Spatial selection, ethnic concentration and neighbourhood impacts**
2010/190 pages/ISBN 978-1-60750-648-5 (print)/
ISBN 978-1-60750-649-2 (online)

35. Bohte, Wendy, **Residential self-selection and travel. The relationship between travel-related attitudes, built environment characteristics and travel behaviour**
2010/210 pages/ISBN 978-1-60750-655-3 (print)/
ISBN 978-1-60750-656-0 (online)

36. De Vries, Paul, **Measuring and explaining house price developments**
2010/226 pages/ISBN 978-60750-665-2 (print)/ISBN 978-60750-666-9 (online)

37. Blom, Inge, **Environmental impacts during the operational phase of residential buildings**
2010/204 pages/ISBN 978-60750-673-7 (print)/ISBN 978-60750-674-4 (online)

38. Hoekstra, Joris, **Divergence in European welfare and housing systems**

2010/232 pages/ISBN 978-60750-667-6 (print)/ISBN 978-60750-668-3 (online)

39. Arko-Adjei, Anthony, **Adapting land administration to the institutional framework of customary tenure. The case of peri-urban Ghana**
2011/280 pages/ISBN 978-60750-746-8 (print)/ISBN 978-60750-747-5 (online)

40. Dankert, Ritske, **Balanceren tussen uitvoering en bewuste afwijking van beleid. De implementatie van strategisch voorraadbeleid door woningcorporaties**
2011/374 pages/ISBN 978-90-5199-527-5 (print)/ISBN 978-90-5199-528-2 (online)

Copies can be ordered at www.dupress.nl.

Delft Centre for Sustainable Urban Areas carries out research in the field of the built environment and is one of the multidisciplinary research centres at TU Delft. The Delft Research Centres bundle TU Delft's excellent research and provide integrated solutions for today's and tomorrow's problems in society. OTB Research Institute for Housing, Urban and Mobility Studies and the Faculties of Architecture, Technology, Policy and Management and Civil Engineering and Geosciences participate in this Delft Research Centre.

Cycling is cheaper, healthier and in urban environments often faster than other transport modes. Nevertheless, even at short distances, many individuals do not cycle. This thesis aims to explain why commuters vary in their decision to bicycle. Results indicate that the individual (day-to-day) choice to commute by bicycle is affected by personal attitudes towards cycling to work, social norms, work situation, weather conditions and trip characteristics. Additionally, this thesis provides evidence that different groups of bicycle commuters exist: non-cyclists, part-time cyclists and full-time cyclists. The mode choice of individuals within these groups (partly) depends on a number of different factors. Non-cyclists seem not to cycle because they consider it impossible, either due to the distance involved, their need to transport goods, the need for a car during office hours, or a negative subjective norm. The decision to cycle among part-time or full-time cyclists is also affected by these factors, but additional factors can be identified. Finally, the day-to-day choice to cycle is based on work characteristics, weather conditions and trip characteristics. Part-time cyclists who cycle only occasionally are encouraged by pleasant weather conditions, while frequent cyclists are found to be discouraged by more practical barriers, such as where they need to work on that day.

9 781607 507710

ISBN 978-1-60750-771-0 (print)
ISSN 1574-6410 (print)
ISBN 978-1-60750-772-7 (online)
ISSN 1879-8330 (online)

DELFT UNIVERSITY PRESS IS AN IMPRINT OF IOS PRESS