Ministry of Infrastructure and the Environment

Cycling and walking:

the grease in our mobility chain

KiM Netherlands Institute for Transport Policy Analysis

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Summary

Cycling and walking - known as the 'active modes' - play a key role in the Netherlands' mobility system. Dutch people walk and cycle during virtually every trip: we travel by foot or bike in half of all trips we undertake, in a tenth of all the kilometres travelled, and in one-third of the time we spend on mobility. Three distinct trends have emerged. First, since 2004, we cycle (+9%) and walk (+13%) more frequently and for longer distances. The e-bike plays a major role in the increasing popularity of cycling and is no longer solely the domain of recreational senior citizens. Second, a spatial differentiation has emerged: the share of trips undertaken by bicycle has increased primarily in cities. And third, the differences among particular population groups have increased. The active modes are moreover frequently used for recreational purposes, in which the longest distances are travelled. However, in recent years there has been a notable increase in the frequency with which people cycle, and the distances they cover, in commuting to work.

The Ministry of Infrastructure and the Environment (I&E) is engaged in the development of a liveable, accessible and safe Netherlands. In the Mobility Policy Document, the policy of the Ministry (formerly named the Ministry of Transport, Public Works and Water Management) primarily focuses on the roles of cars and public transportation in the main (road) network. However, given the increasing focus on the entire, door-to-door trip, cycling and walking have become more important, including in the Infrastructure and Spatial Planning Structural Review (SVIR), and in the Optimising Use Programme and Better Regulation Programme Hence, in this retrospective study, the KiM Netherlands Institute for Transport Policy Analysis maps the various ways in which cycling and walking are interwoven in the mobility system and what the effects are. Our research focuses on the roles that active modes have in the functioning of the entire mobility system, particularly in urban areas. In this study we present the current state of active modes and the developments that have occurred in recent years; we map the extent to which certain characteristics of the city, and of population groups within cities, impact how much people walk and cycle; and we offer a glimpse of the effects that cycling and walking have on accessibility, traffic safety and liveability. This study is based on literature studies and analyses of various data sets pertaining to mobility, including the 'Dutch National Travel Survey' (OViN) report by Statistic Netherlands (CBS).

Dutch people cycle and walk more frequently and further

Dutch people walk or cycle in half of all trips undertaken, for a tenth of all kilometres travelled, and in one-third of the total time spent on mobility. In terms of the use of these 'active modes' collectively, the Netherlands ranks second in the world, behind only Switzerland, where people walk very frequently. Compared to other countries, Dutch people walk infrequently, but the Dutch cycle much more than people in other countries.

In recent years, the frequency and the distances that Dutch people cycle and walk has increased: Dutch people cycle and walk more frequently and further. Hence, people more frequently commute to work and school by bicycle, and slightly less frequently for shopping. The active modes also play an important role in the travel to and from public transportation. For nearly 50 percent of all trips between home and the station people use a bicycle, and for 15 percent of access trips to the station people walk.

Trips made by bicycle or by foot often have recreational purposes: that is, in one-fifth of all trips by bicycle, and in one-third of all trips by pedestrians. Pedestrians and cyclists moreover travel longer distance for recreational purposes than they do for other trip purposes.

Population groups differ in their use of active modes

Personal characteristics and trends, such as increasing numbers of one-person households, increasing numbers of people living in cities, larger numbers of senior citizens, and larger numbers of people of non-Western origin, can lead to changes in the roles that active modes have in Dutch peoples' travel behaviour. Women cycle and walk significantly more frequently than men, which can be related to the fact that women more often work part-time and work closer to home. And people of non-Western backgrounds walk twice as much as people with a native Dutch background, although the non-Westerners cycle significantly less frequently. The composition of the population in a certain postal code area strongly affects the share of trips undertaken by bicycle in that area.

Bicycle congestion increasing, primarily in cities

The use of active modes is not only determined by population characteristics but also by the degree of urbanization and size of the city. Within cities, walking and cycling are the most important transport modes. This is primarily due to the compactness of our (inner)cities, with amenities situated at a distance that we generally find acceptable to traverse by foot or bike.

Cities however vary on this point. For example, in the four major cities, people cycle relatively less and walk more than in many of the mid-sized cities. For example: in the major cities of Rotterdam and The Hague, cycling accounts for 14% and 18% of all trips, respectively, while in the smaller university cities of Leiden, Groningen, Zwolle and Leeuwarden, more than 40% of all trips undertaken locally are by bicycle. Nonetheless, there are significant differences among the mid-sized cities in terms of the extent of bicycle use.

The increase in the number of bicycles in the cities, and especially in the number of extra-wide bicycles (such as carrier bicycles), and bicycles of varying speeds, has resulted in congestion on the bicycle paths. On some occasions there are even 'bicycle traffic jams', which not only impacts the flow of traffic but can also result in confrontations between cyclists on the bicycle paths.

Popularity of e-bikes

The e-bike is an interesting development in our bicycling country. New (or modified) types of bicycles are increasingly appearing on our bike paths, ranging from electric carrier bikes to Segways. However, no other type of bicycle has had such a major, measureable impact as the e-bike. E-bikes are the only bicycle models whose sales are increasing; for all other bike models, sales figures are declining.

Of all kilometres travelled by bicycle, e-bikes are used for approximately one-tenth (12 percent) of that total. The distances we cover on e-bikes are approximately one and a half times longer than for regular bicycles; for home-to-work commutes, e-bikers cycle twice as far as cyclists on regular bicycles. E-bikes moreover allow seniors to continue cycling later in life. But, notably, e-bikes are no longer the sole domain of seniors: increasing numbers of people under the age of 65 are e-biking, and also more frequently to and from work.

Cycling and walking are healthy pursuits but increase safety risks

Depending on the situation, an increase or decrease in cycling and walking can have various social effects on accessibility, safety and the liveability of a region. Consequently, owing to increased bicycle use in cities, certain bicycle parking racks and bicycle paths now face capacity bottlenecks. Concurrently, the same (e-)bikes ensure that in the Netherlands transportation poverty – a situation in which a person, due to limitations, is incapable of participating in activities – plays a smaller role than in other countries. A significant portion of the Dutch population can indeed reach many local amenities by bicycle, which is in stark contrast to the situation in the United States or England, for example.

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Cycling and walking can be linked with important health benefits. Absentee rates due to illness for instance are lower when cycling frequency increases and the distances cycled are longer. Cycling and walking are also environmentally friendly; they do not result in emissions of air pollutants, such nitrogen and sulphur dioxide, particulates and CO_2. However, the trend is that cyclists now account for a greater share of the total traffic fatalities, and especially of the numbers of seriously injured. The percentage of pedestrian fatalities has remained constant.

Promoting active modes requires more than good infrastructure

The Netherlands has a long and proud history of policy focused on active modes. From the 1970s to the present day, major investments are continuously made in new cycling infrastructure, focusing on the accessibility, safety and liveability of cities. Since 2007, local authorities have been responsible for establishing cycling and pedestrian policies.

Recent insights into the effectiveness of Dutch cycling policy reveal that while major successes have indeed been achieved in many areas in the cities, in order to fully promote bicycle use we must do more than merely constructing cycling infrastructure (hardware): the governance and implementation strategies are also important (orgware), as well as the necessary education-programs and campaigns (software). And the same applies to pedestrian policy. Unfortunately, there is a lack of comprehensive ex-post evaluations of measures for promoting active modes. In addition, because trips made with active modes are rarely recorded (especially those by pedestrians), it can remain difficult to clearly interpret active mode developments.

1 Introduction

When James Robertson, an American from Detroit, Michigan, opened a local newspaper one day in early 2015, his life changed forever. An article in the newspaper recounted his remarkable tale, of how, back in 2005, Robertson faced a dilemma: with his car broken down and many local bus routes cancelled, Robertson could only reach his workplace via one of the last remaining bus routes. However, the closest bus stop was a one-hour walk from his home, and on the other end the bus stopped some 11 kilometres from the factory where he worked. The distances to and from the bus stops he covered by…foot. For ten long years Robertson walked those 34 kilometres every day, to and from work, day in and day out, in good weather and bad. A reader of the article about his plight, published in the *Detroit Free Press*, decided to start a crowdfunding campaign for Robertson that ultimately raised $360,000. With a free car that he also received as a gift from a local car dealership, James Robertson now drives to work in 20 minutes.

In the Netherlands' highly developed mobility system, cycling and walking play key roles. But walking 34 kilometres to and from work, every day, for ten years? Now that, even from the Dutch perspective, is remarkable. Many Dutch people would opt to travel at least part of way by (electric) bicycle. Approximately 15% of all Dutch people commute to work by bicycle, yet very few people walk to work: even for an urban-orientated country like the Netherlands, the numbers of Dutch people who walk to work is so small that this group of pedestrians is too small to be included in the mobility statistics. This report therefore focuses on such statistics, as well as on much more information pertaining to the question of how much and how far we cycle and walk in the Netherlands.

Perhaps the question arises: why such extensive research about the position that cycling and walking occupy in the total mobility system? The work of the Ministry of Infrastructure and the Environment (I&E) focuses on a liveable, accessible and safe Netherlands. In the Mobility Policy Document, these objectives are primarily approached on the national level, in terms of responsibility for (national) roads and the (state) railway network. Policy moreover is primarily focused on the role of cars and public transportation. However, given the increasing attention devoted to the entire door-to-door trip and the primary position of the traveller, cycling and walking are becoming increasingly important. Cycling and walking – collectively known as the 'slow modes' or, more positively, as the 'active modes' – play key roles in the first and last segments of the door-to-door trip; consequently, cycling and walking are inextricably linked to the other modalities. For the majority of train trips, people travel by bicycle or foot to and from the train station, for example.

There are moreover interesting shifts observed in the extent to which Dutch people use the active modes. The number of trips we take by bicycle has remained relatively constant over the past 20 years. However, over the past ten years people have started cycling longer distances, and more people are now riding bicycles. Since 2004, the number of kilometres cycled in the Netherlands has increased by 9%; however, while the percentage of all trips undertaken by bicycle has remained unchanged, the number of bicycle kilometres has increased. We also see growth in walking. Moreover, we observe that the locations where people walk or cycle frequently are changing, and also that the number of bicycle kilometres increasingly differs among the various groups of Dutch people (Harms et al., 2014). Hence, we observe that some people increasingly cycle more frequently and for longer distances, while others walk more frequently or more frequently use public transportation. Due to these effects, people particularly cycle more in the cities, where the effects of this shift are easy to see: bicycle paths in the cities are

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overcrowded and at certain times of day bicycle traffic jams even occur. Much less is known about pedestrians, however, and this is primarily due to the fact that people often make short, non-home related trips, and often, in national mobility surveys, such as MON and OViN[1], forget to record the access and egress trip-segments to and from their primary transport mode.

The above-stated factors are however not the only reasons for closely examining the active modes. In politics and policymaking, interest in the active modes is rising, as illustrated for example by the initiative of various governments aimed at strengthening cycling policy through the so-called 'Tour de Force' project (regional); by recent motions proposed in the Dutch Parliament; and by the facilitating of cycling measures in the Optimising Use Programme. Recent research by GGD Haaglanden (2014) revealed that the number of Dutch people suffering from obesity and loneliness in the Randstad (the Amsterdam-Utrecht-The Hague-Rotterdam conurbation) will rise sharply in the coming years. In 2020, half of the Randstad's adult population will be lonely and overweight, according to this study.

Children will also increasingly be brought to school by car instead of by bicycle. The result: local 'traffic jams' around schools, declining traffic safety levels around schools, and children having increasingly fewer independent interactions with traffic (SCP, 2013). These problems will be primarily concentrated in urban areas. Environmental considerations (cycling and walking create virtually no emissions) and economic aspects (cycling and walking are much more inexpensive than travelling by car or public transport) are also closely interrelated with cycling and walking.

In short, cycling and walking are seemingly part of our national DNA, yet the field is constantly in motion. An overview study of the contributions that cycling and walking make within the total mobility system is therefore pertinent. In this project, the KiM Netherlands Institute for Transport Policy Analysis maps the ways in which cycling and walking are intertwined in the mobility system and what the resulting effects are. We have done this by focusing on their role in the functioning of the total mobility system, particularly in urban areas. In this report we present the facts and figures behind the use of the active modes and the developments that have occurred in past years; moreover, we map the differences that exist between cities and provide insights into the effects that cycling and walking have on accessibility, traffic safety and liveability.

These aspects are all interrelated. The policy-relevant effects of cycling and walking depend on the number of trips undertaken with the active modes, but also on the question of who takes these active trips and for what purposes. And this is partly influenced by personal and household characteristics, the quality and quantity of infrastructure for cycling and walking, and other spatial characteristics. In order to ascertain how all these aspects are interrelated, and thus be able to clearly identify the role of the active modes in the total mobility system, more information is required than the currently fragmented amount of available knowledge. In this report we have mapped what is currently known and unknown about the active modes. Filling in the knowledge gaps will allow us to show how more aspects are interrelated. Later, KiM will publish a series of essays outlining the importance of the active modes in the Netherlands mobility system in future.

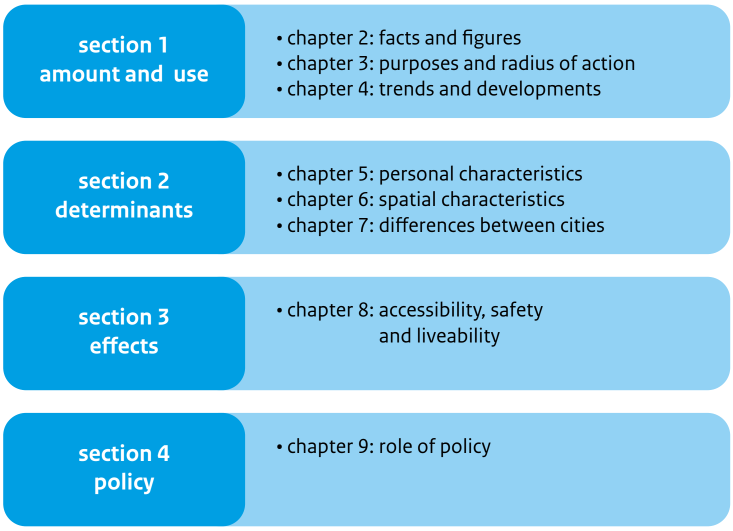
[1] The OviN is the only recent data source that provides a nationwide and differentiated overview of travel behaviour in the Netherlands, but it does have certain limitations for the research of cycling and walking. Appendix 1 explains the possibilities and limitations that this data source offers this research.

Structure

This report consists of four sections (see also Figure 1.1). In the introductory section, we provide an overview of the scale and use of cycling and walking in the Netherlands (Chapters 2 to 4). In addition to facts and figures about amounts, possession and use (Chapter 2), we examine the purposes for walking and cycling and the distances covered (Chapter 3). We also devote attention to the trends and developments in cycling and walking (Chapter 4). In section two we focus on the factors that influence cycling and walking, such as personal characteristics and spatial conditions (Chapters 5 and 6, respectively). In addition, we examine the differences between the various cities and within the cities, and we explain the observed differences (Chapter 7). Section three of the report pertains to the effects that cycling and walking have on accessibility, safety and liveability (Chapter 8).

The roles of policy and ex-ante and ex-post evaluations are featured prominently in the final section (Chapter 9). Chapter 10 presents the final conclusions.

Figure 1.1 Leeswijzer



Where relevant, we differentiate between cycling and walking. In each section we first present the situation as it pertains to cycling, and then to walking. For cases in which differentiation is irrelevant, we jointly describe the active modes.

2

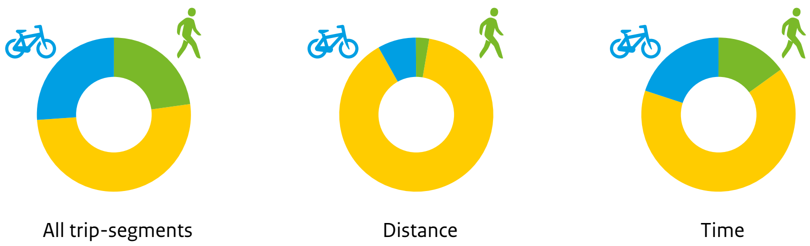
Facts and figures about cycling and walking

Dutch people cycle and walk as part of nearly every trip: we cycle or walk in half of all trip-segments, in one-tenth of all kilometres travelled, and for one-third of the time we spend on mobility. In the collective use of these 'active modes', the Netherlands ranks second internationally, behind Switzerland, a ranking that is primarily due to cycling, as compared to other countries Dutch people walk very infrequently. The e-bike in particular is gaining in popularity in the Netherlands: of the total number of bicycle kilometres, more than one-tenth (12 percent) are travelled by e-bike. Cycling and walking have positive effects on peoples' health and well-being. This chapter focuses on the facts and figures pertaining to the active modes.

Cycling and walking in the Netherlands

Dutch people cycle or walk as part of nearly every trip: not only when we walk or cycle for the entire route, but also as the access and egress trip-segments for other main transport modes, such as cars, train or buses. Approximately one-third of the time that Dutch people spend on mobility is spent on walking or cycling, accounting for approximately one-tenth of all kilometres travelled, particularly short trips, and for nearly half of all the trip-segments in the Netherlands (Figure 2.1).

Figure 2.1 Percentage of travel time, kilometres and trip-segments in the total amount of mobility travelled by foot and by bicycle. Source CBS OViN 2010 – 2014; adapted by KiM



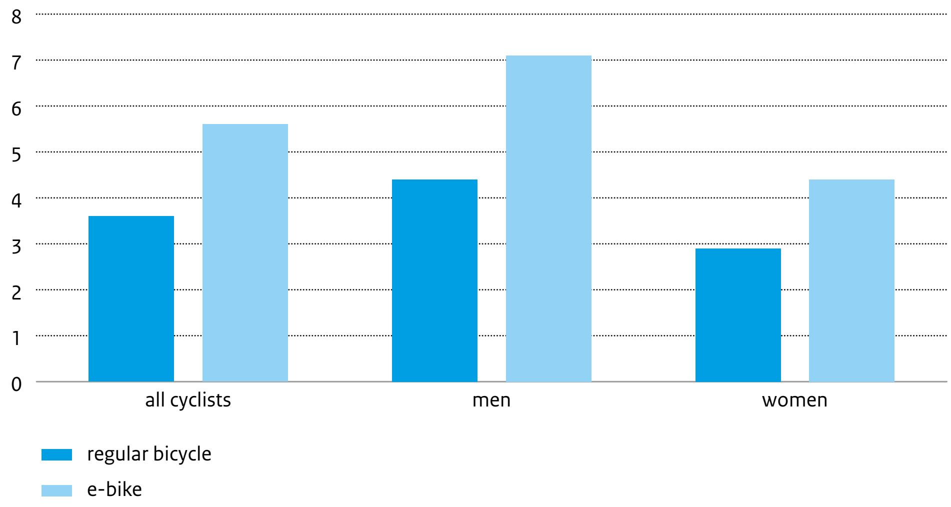
In these figures, the distances that, for example, people travel to reach their cars – using a personal transport mode, such as a bike, skateboard or other type of transport mode – are not counted as a separate trip-segment. We do however count cycling or walking to public transport modes (buses, trams, trains, metro) as pre- and post-transport trip-segments, but not to personal transport modes. This also applies to the other analyses featured in this report.

Emerging types of bicycles: the e-bike and speed pedelec

Sales of e-bikes increased by 16 percent in 2014, as compared to the previous year. E-bikes are particularly popular among senior citizens: more than one-quarter of all people aged 65+ have access to an e-bike. For adults under the age of 40, only 1 percent have e-bikes, while for people in their 40s that figure is 5 percent, and for people in their 50s approximately 10 percent.

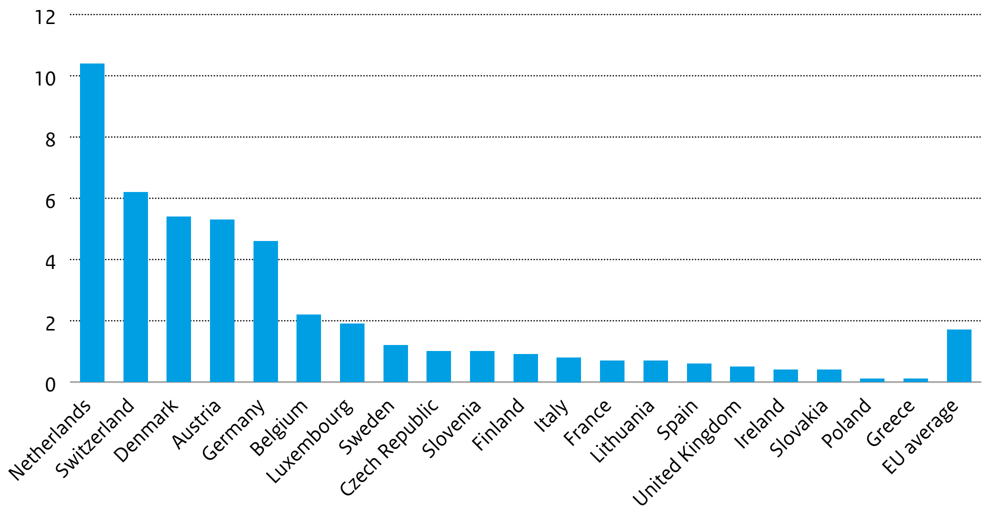
Of the total bicycle kilometres, more than one-tenth (12 percent) are travelled by e-bike, and the average distance covered per trip-segment is 5.6 kilometres (OViN, 2013-2014), which is approximately 2 km further than the average distance travelled per trip-segment by a ‘regular’ bicycle. This ratio is largely the same for men and women, although men on average cycle longer distances on both regular bicycles and e-bikes (Figure 2.2).

Figure 2.2 Average distance cycled on a regular bicycle and an e-bike, for all cyclists, and according to gender. Source: CBS OViN (2013-2014); adapted by KiM



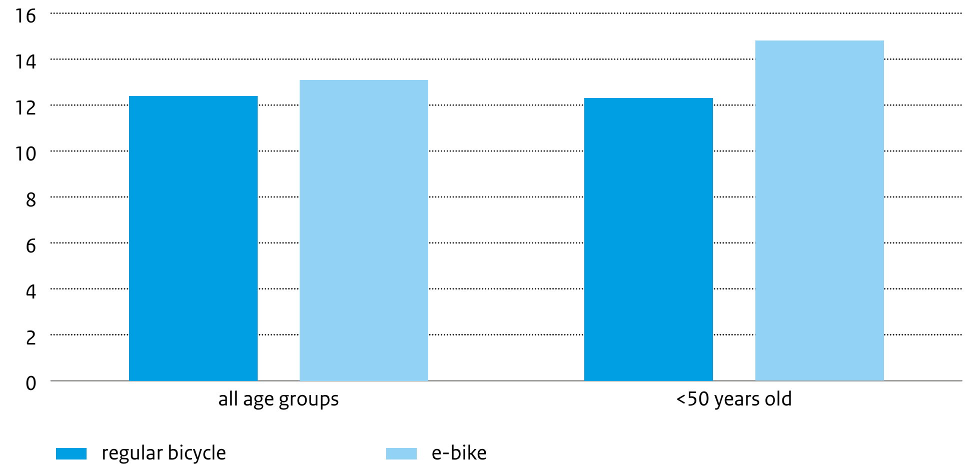
In 2012, the Netherlands was the world leader in e-bike sales per 1,000 inhabitants. Figure 2.3 compares the Netherlands to the other 26 EU countries. This figure also provides an average for the entire European Union (Fishman & Cherry, 2015).

Figure 2.3 Number of e-bikes sold per 1,000 inhabitants in the 27 EU countries. Source: Fishman & Cherry (2015)



On average the difference in rates of speed between e-bikers and 'regular' cyclists is limited: approximately 0.7 kilometres per hour (OViN, 2013-2014). There is however a greater speed differential for cyclists under the age of 50: an average of 2.2 kilometres per hour (Figure 2.4).

Figure 2.4 The speed differential (in km/h) between e-bikes and regular bicycles is limited, but is greater for cyclists under the age of 50 than for senior citizens. Source: CBS OViN (2013 – 2014); adapted by KiM



Use of e-bikes increases with age. Adults under the age of 50 use e-bikes for only 3 percent of all bicycle kilometres, and for 6 percent of the home-to-work-related bicycle kilometres (OViN, 2013-2014). Adults aged 50 to 65 years old travel by e-bike for 17 percent of all bicycle kilometres (and for the same proportion - 17 percent - of their home-to-work kilometres), while for people aged 65 to 75 years old that figure is 34 percent, and 45 percent for those aged 75+ (Figure 2.5, left). Senior citizens use e-bikes primarily for leisure time activities and shopping. Adults under the age of 65 also use e-bikes for work-related trips (Figure 2.5, right).

Figure 2.5 Percentage of e-bike trips according to purpose (left), and the percentage for the e-bike in the total number of bicycle kilometres (2013-2014), according to age and gender (right). Source: CBS OViN (2013-2014); adapted by KiM

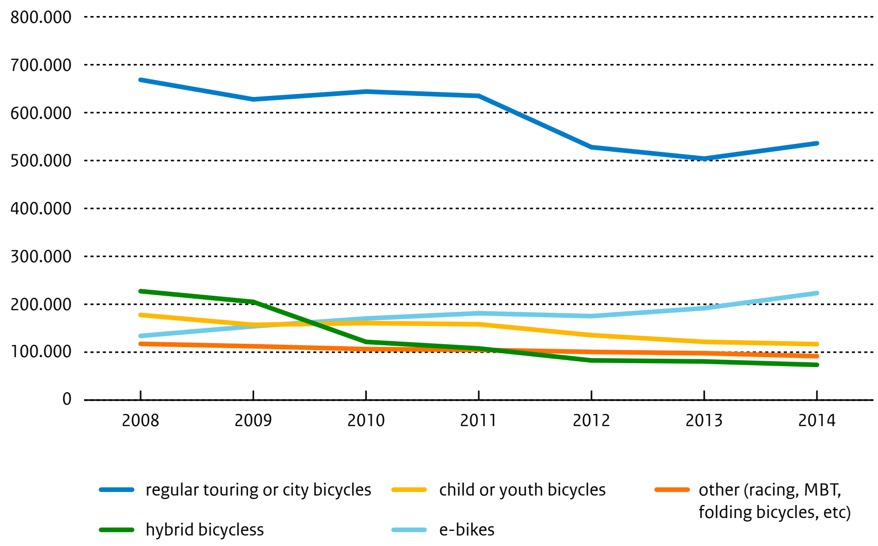
An extra-fast type of e-bike has recently come onto the market: the speed pedelec. With speed pedelecs, cyclists can reach maximum speeds of 45 kilometres per hour. However, one must be at least 16 years old to ride a speed pedelec and have a WA-insurance policy. Moreover, speed pedelecs must have license plates, like mopeds. Until 1 January 2017, a speed pedelec will be regarded as a moped. During the first six months of 2015, a total of 2,063 electric mopeds were sold, of which 795 were speed pedelecs (www.tweewieler.nl). RAI-BOVAG even cites a figure of 1,800 speed pedelecs sold in the first six months of 2015 (www.bovag.nl). The speed pedelec - the fastest type of e-bike - has therefore captured a relevant market share within just 6 months.

Bicycle ownership in The Netherlands

It was estimated that in 2012 there were 22.3 million bicycles in the Netherlands, of which approximately one million were electric (BOVAG-RAI, 2015). Of the 16.6 million people residing in the Netherlands in 2012, this amounts to 1.3 bicycles per person. And Dutch people also continue to purchase bicycles, these figures remain in flux. From 2006 to 2014, more than one million new bicycles were sold each year (BOVAG-RAI, 2015). Approximately half of all the new bicycles sold were city bikes, although the sales of bicycles that do not have electric pedal support have declined in recent years. The sales of regular bicycles did however sharply increase in 2014, but this was entirely due to a reduction in governmental bicycle-related tax schemes that came into effect as of 1 January 2015. Conversely, e-bikes account for an increasingly larger share of all new bicycle purchases. From 2007-2013, the number of new e-bikes sold more than doubled: from 89,000 per year in 2007 to 223,000 per year in 2014 (BOVAG-RAI, 2015), see Figure 2.6. This renders e-bikes the fastest growing type of new bicycles sold. In the Netherlands, approximately 750,000 used bicycles are sold each year (Rabobank, 2014).

According to Statistics Netherlands (CBS), 107,055 bicycle thefts were officially reported in 2013 (2015), although the actual number of stolen bicycles is likely much higher. A report published in 2009 found that, in principle, only 45 percent of all bicycle thefts are reported (Ministry of Transport, Public Works and the Environment, 2009). Compared to 2013, the number of reported bicycle thefts in 2014 increased to 113,779, which amounts to 311 bicycles stolen per day. The number of violent incidents associated with bicycle thefts decreased slightly from 159 incidents in 2013 to 148 in 2014 (nu.nl).

Figure 2.6 Number (x 1,000) of bicycles sold according to type, 2008-2014. Source: RAI-BOVAG (2015); adapted by KiM



Everybody on the bicycle path

With all this cycling, it is unavoidable that congestion occurs at certain locations on the bicycle paths. The street in the Netherlands that is most congested with bicycles is in Utrecht (Table 2.1) According to the website fietssnelwegen.nl (an initiative of Goudappel Coffeng), bicycle congestion on three of the five streets in the Netherlands that have the most bicycle traffic will increase in the coming years, as compared to 2011; in two cases (the Spoorbaanpad in Almere and the Antonius Deusinglaan in Groningen), the congestion will decrease.

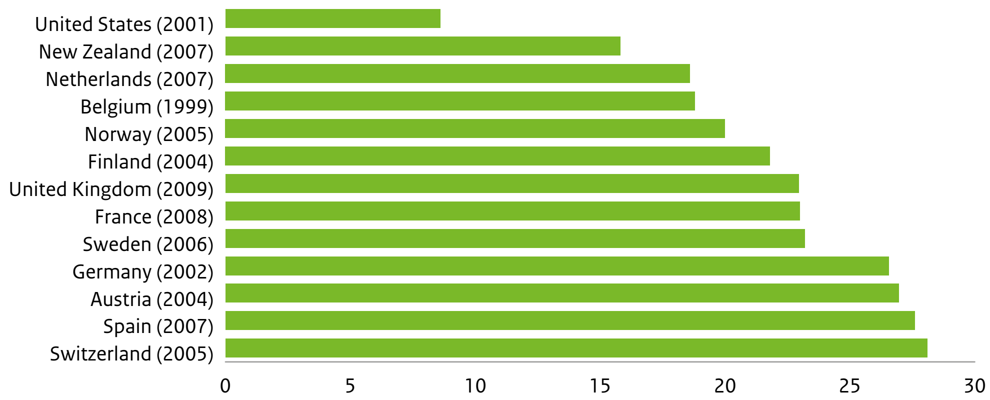
Table 2.1 Overview of the five streets in the Netherlands that have the most bicycle traffic. Source: www.fietssnelwegen.nl

Rank	City	Steet name	Number of cyclists per day in 2011	Expected number of cyclists per day in 2020
1	Utrecht	Neude	18.700	22.400
2	Almere	Spoorbaanpad	21.000	20.700
3	Rotterdam	Coolsingel	18.000	19.300
4	Groningen	Antonius Deusinglaan	19.400	19.000
5	Den Bosch	Stationstunnel	14.000	18.600

Cycling and walking in other countries

Partly due to the ease with which we opt to use bicycles instead of other transport modes, Dutch people walk relatively infrequently compared to other countries. If we look at the total active transport (cycling and walking combined), Switzerland claims the highest percentage, with the Netherlands in second place at 47 percent (Bassett Jr. et al., 2008). According to recent figures by CROW (Figure 2.7), people walk less in the Netherlands than they do in neighbouring countries (CROW, 2014).

Figure 2.7 The percentage of pedestrian trips in various OECD countries. Source: CROW (2014)



Perceptions of cycling and walking

In 2007, KiM conducted research into perceptions of car, bicycle and public transport use. This research revealed that 27 percent of Dutch people perceived bicycles as an attractive transport mode, which placed bicycles in second place behind cars (67 percent). A positive correlation exists between the use of and opinions about bicycles: Dutch people who use bicycles frequently (multiple times per week) have more positive views of bicycles than do people who use this transport mode less frequently (Harms et al., 2007). As based on the 13 quality aspects (Figure 2.8), the bicycle scored the highest for both home-to-work travel and leisure time travel of all modalities for aspects related to calmness, low costs and reliability. The car had the highest scores for aspects related to comfort, convenience, flexibility and speed, while public transportation scored the lowest in all aspects.

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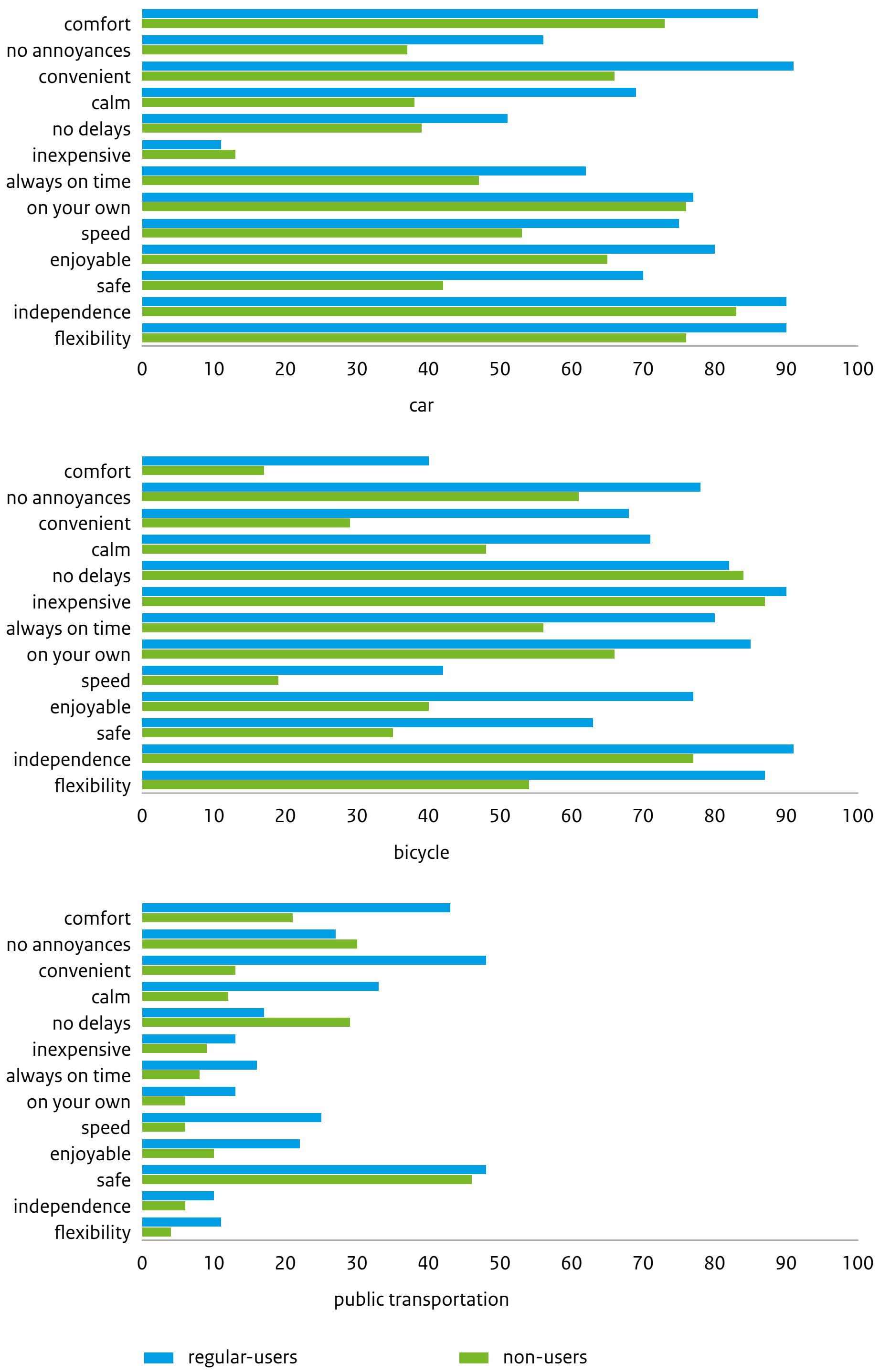
Figure 2.8 The perception of thirteen quality aspects for the car, the bicycle and public transportation . Source: Harms et al. (2007)



In addition to the perception of the trip itself, movement or physical exercise, and cycling in particular, have positive effects on personal well-being (Hendriksen & Van Gijlswijk, 2010). Cycling enhances one's self-esteem (Cavill & Davis, 2007), provides feelings of freedom and independence, and gives people a positive feeling because they can achieve the purpose of the trip through their own efforts (Hillman & Morgan, 1992).

The question is whether the emergence of e-bikes changes the mobility perceptions of cycling; to date, this question has not been researched. However, we do know that e-bikes put more people in a position to cycle: people who have no interest in riding regular bicycles, older people with less physical strength or those with physical disabilities (Gojanovic et al., 2011; Louis et al., 2012; Sperlich et al., 2012). For these people, the renewed possibility of once again cycling is a positive experience.

Very little research has been conducted about the perceptions of walking in the Netherlands, and certainly not within the past 20 years. Pedestrians are routinely overlooked in larger research studies, such as '*Mobiliteitsbeleving gesegmenteerd*' (AVV, 2002), '*Beleving en beeldvorming van mobiliteit*' (Harms et al., 2007) and '*Wie ik ben en waar ik ga*' (Council for Transport and Water Management, 2010). The only Dutch research that we are aware of pertaining to the perceptions of pedestrians as compared to those of other transport modes is a study conducted in 1993 by the *Voetgangersvereniging* (Pedestrians' Association). In a diary project, titled '*Voetgangers tellen mee*' ('Pedestrians also count') (Knippenbergh et al., 1993), in which 270 households recorded their trips over the course of two days, the participants were asked to detail their most pleasant and least pleasant trips of the week. Walking was most frequently cited as both the most pleasant and least pleasant trip, followed by cycling (Knippenbergh et al., 1993). Cycling and walking seemingly result in intense experiences, which can be both positive and negative.

International studies have however devoted significant attention to the perceptions of pedestrian trips, particularly from the perspective of well-being. Walking is the foremost transport mode in which one encounters and interacts with people en route. International research, including Montgomery (2013), reveals that this type of interaction can engender feelings of self-esteem and personal well-being. The physical movement of walking itself also influences feelings of well-being, according to various research studies (Ekkekakis et al., 2008; Montgomery, 2013).

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3

Purpose and radius of action of cycling and walking

The extent to which Dutch people cycle and walk in and among the various cities differs per city. The active modes play an important role in the access to and egress from public transportation, especially on the home-side. Nearly half of all trips between a person's home and the train station are made by bicycle, while 15 percent are by foot. The active modes are frequently used for a recreational purpose, with this purpose accounting for one-fifth of all bicycle trips and one-third of all pedestrian trips. Moreover, Dutch people travel longer distances for recreational pursuits than they do for grocery shopping, for example.

Purposes for the active modes

The majority of bicycle and walking trips occur over relatively short distances; however, they can still serve many purposes and destinations. For the Netherlands as a whole, a recreational purpose (excursions/taking a walk) accounts for one-fifth of all bicycle trip-segments and one-third of all pedestrian trip-segments. Moreover, one-fifth of all cycling and walking trip-segments are related to shopping and grocery shopping (Figure 3.1).

Figure 3.1 Division of purposes of trip-segments for the active modes in the Netherlands. Source: CBS OViN (2010-2014) adapted by KiM

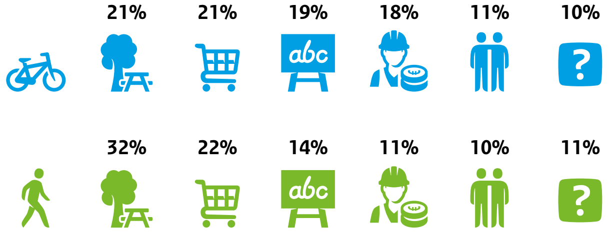
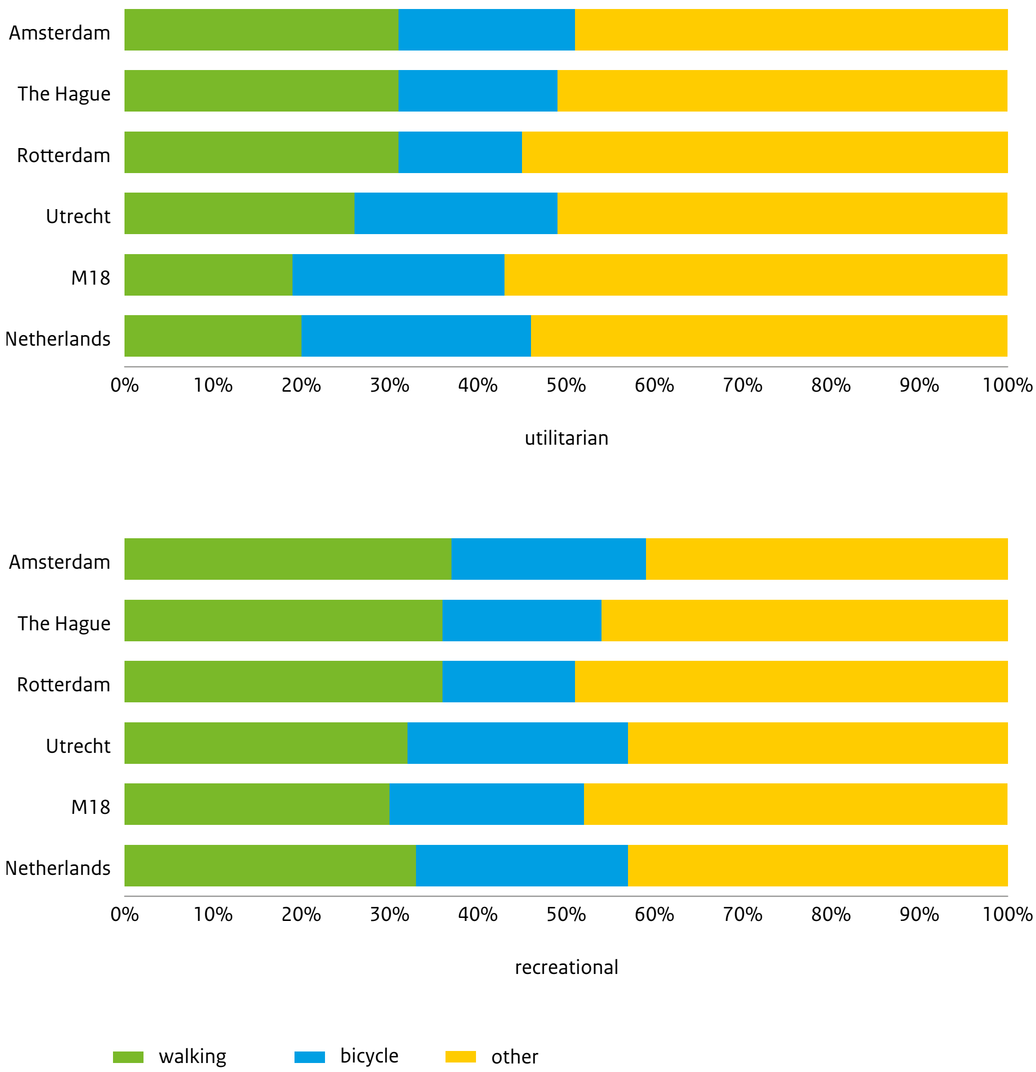


Figure 3.1 reveals that recreational pursuits and the active modes are closely interrelated: one-third of all pedestrian trip-segments and one-fifth of cycling trip-segments have recreational purposes. In order to verify what effects this high percentage of recreational trips has on the modality split, as depicted in Figure 3.1, we have created a breakdown according to utilitarian and recreational trip-segments (Figure 3.2). Utilitarian trip-segments include all trip-segments that have a specific objective, such as rides to

work, educational purposes, dropping off and picking up children or grocery shopping.[2] Only trip-segments with the purpose of 'Excursions/taking a walk, 'Hobby/sport' and 'Other leisure time pursuits'' derived from the OViN are counted as recreational rides. When we compare these figures, no sharp deviation between utilitarian and recreational trip-segments in the percentage of cycling emerges. This is however the case for the percentage of pedestrian trip-segments: people walk comparatively more for recreational purposes than for utilitarian trip-segments. In Figure 3.2, we differentiate between the four major cities of Amsterdam, The Hague, Rotterdam and Utrecht, and the eighteen mid-sized cities (the latter collectively), and the percentage of trip-segments for the Netherlands as a whole.

Figure 3.2 Percentages of trip-segments by foot, by bicycle and with other transport modes for utilitarian trip-segments (above) and recreational trip-segments (below) in the G4, the M18, and the average for the Netherlands. Source: CBS OViN (2010-2014); adapted by KiM



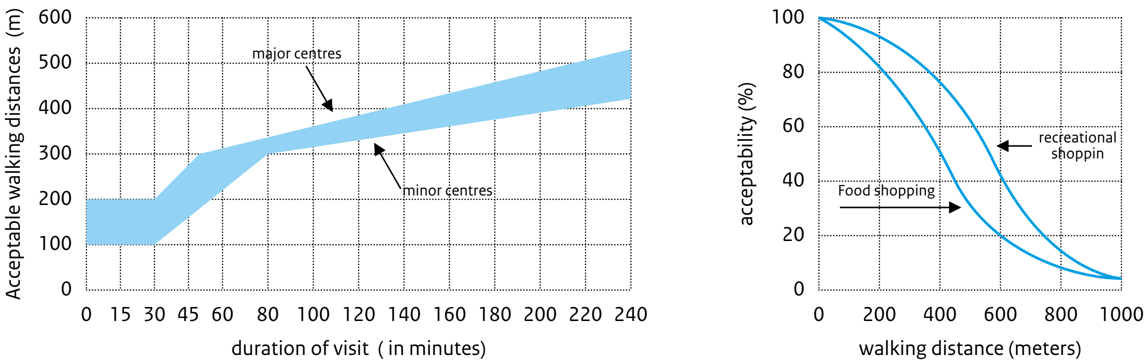
2 The comprehensive list of trip purposes in the OviN that are regarded as utilitarian is: To and from work; Business trips in work environment; Transport as profession; Picking up/Dropping off persons and goods; Education/following courses; Shopping/Grocery Shopping; Visits/overnight stays; Services/personal care; and Other purpose.

Acceptable walking and cycling distances

The distance to the (intermediate) destination plays a decisive role in the choice of whether to travel to a certain location by foot or by bicycle, regardless of whether this is the primary transport mode or serves as access or egress to another transport mode. In order to ascertain where the border lies between 'nearby' and 'too far away', we speak in terms of 'acceptable' walking and cycling distances.

It is difficult to provide an overview of acceptable walking distances to various facilities. We have not found an overview of this based on Dutch research, and moreover many sources are vague about the origins of their figures. Where acceptable walking distances are denoted and described, they differ per type of destination or purpose. As such, CROW (2014) found that acceptable walking distances differ per person and per trip purpose, and also depend on the quality of the route. It is likely that people have varying acceptable walking distances for different destinations: the more important or valued the destination, the longer the acceptable walking distance (Figure 3.3). The maximum distance is moreover related to the duration of the visit and convenience, such as the need to carry grocery bags (CROW, 2004). The route to be walked also makes a difference: if the route is attractive, people are prepared to walk 1.5 times further than they are for a less attractive route (Bach & Pressman, 1992). In foreign countries, walking distances are often longer than in the Netherlands, which is likely related to the fact that Dutch people prefer to ride bicycles for trips covering longer distances.

Figure 3.3 Acceptable walking distance between parking place and store: dependent on the duration of the visit and purpose of visit. Source: CROW (2004)



Some sources differentiate between preferred distances, acceptable distances and maximum distances. The ASVV from 2004 (a guidebook for designing infra facilities within the built-environment[3]) indicates the acceptable walking distances from a parking place to a certain facility; moreover, walking is designated as a type of egress mode. This version of the ASVV also provides recommended maximum straight-line walking distances to train stations and bus/tram stops (CROW, 2004). Depending on the street pattern, the actual walking distance, as compared to the straight-line distance, is approximately 1.2 times longer.

Table 3.1 provides an overview of the published figures in this research field. Unfortunately, no information about acceptable cycling distances was found in the available literature.

[3] The ASVV (CROW, 2004) was updated in 2012, the latest version is available at www.crow.nl

Table 3.1 Acceptable walking distances per type of trip

Type of trip	Acceptable walking distance according to the literature
Parking place to home	150 meters (CROW, 2004)
Parking place to shopping place	300 meters (CROW, 2004) 1,000 meters (Carley, 1996)
Parking place to recreational location	300 meters (CROW, 2004)
Parking place to educational establishment	300 meters (CROW, 2004) 1,000 meters (KpVV, 2013)
Public Transport: Bus stop	350 meters straight-line(CROW, 2004)
Public Transport: Tram/Metro	700 meters straight-line (CROW, 2004)
Public Transport: Train station	1,000 meter (CROW, 2004) 10 minutes walking = ca 800 meters (Leidelmeijer & Damen, 1999) 1.3 – 2.2 kilometers (Keijer & Rietveld, 2000) 760 meters (ITF, 2012)

In addition, other research studies raise questions about these types of 'acceptable' distances. For train use, a 'distance-decay function' occurs around train stations: people who live or work in close proximity to train stations use the train more frequently than people who live and work in areas situated further away. Train use per resident and workplace gradually decreases as the distance from the train station increases. Moreover, train use never totally decreases down to 'zero': there are always people for whom the effort required to travel to a train station is worth it, even if they also live or work at greater distances from the station. The willingness to walk or cycle to and from the train station is also important and is to a large extent related to the quality of the transport services offered (in the same way that valued destinations results in longer acceptable walking distances). This was found in a substantial amount of literature (Egeter, 1993; Van Nes, 2002; Schäffeler, 2004; Van Eck, 2010; Van der Blij, 2010). The number of departure possibilities per hour plays an important role, resulting in acceptable distances that are longer than those presented in Table 3.1. Further, in reality, a phenomenon emerges in which some people prefer to walk or cycle somewhat longer distances to an intercity train station that offers numerous departure possibilities per hour than to use a nearby local station offering limited train services.

Because the situational differences are of great influence, it is difficult to compile 'acceptable' walking and cycling distances in firm figures. The figures derived from literature moreover are not all relevant to the situation in the Netherlands. Hence, in addition to international literature, we also examined the actual number of trips made by foot and by bicycle. Table 3.2 shows the cumulative division of walking, cycling and e-cycling in percentages and covering varying distances (up to 30 kilometres). In the Table, the color blue denotes the type that is closest to the 90 percent value.[4]

[4] The 90 percent value corresponds to the generally accepted upper limit of 7.5 kilometres for trips by bicycle and 2.5 kilometres for pedestrian trips for all purposes collectively.

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Table 3.2 Cumulative distribution of trips by foot, by bicycle and by e-bike for distances up to 30 kilometres, per purpose, with a (blue) highlighting of the 90th percentile

		0,1 to 0,5 km	0,5 to 1,0 km	1,0 to 2,5 km	2,5 to 3,7 km	3,7 to 5,0 km	5,0 to 7,5 km	7,5 to 10 km	10 to 15 km	15 to 20 km	20 to 30 km
All purposes	Walking	34%	57%	88%	92%	94%	98%	99%	99%	100%	100%
	Bicycle	4%	15%	56%	72%	80%	91%	94%	97%	98%	99%
	E-bike	3%	11%	43%	57%	65%	79%	84%	91%	93%	97%
Home-to-work	Walking	46%	71%	96%	98%	99%	99%	99%	99%	100%	100%
	Bicycle	2%	9%	43%	63%	73%	89%	93%	98%	99%	100%
	E-bike	0%	4%	24%	42%	49%	72%	81%	93%	99%	99%
Shopping	Walking	40%	68%	94%	97%	98%	99%	99%	100%	100%	100%
	Bicycle	6%	25%	74%	87%	92%	98%	99%	99%	100%	100%
	E-bike	3%	16%	56%	73%	81%	92%	95%	98%	98%	99%
Education	Walking	43%	72%	97%	99%	99%	100%	100%	100%	100%	100%
	Bicycle	2%	10%	43%	60%	69%	85%	91%	97%	99%	100%
	E-bike	12%	24%	55%	56%	60%	78%	80%	91%	92%	97%
Leisure time	Walking	25%	43%	75%	86%	89%	96%	98%	99%	100%	100%
	Bicycle	4%	13%	52%	69%	77%	89%	91%	95%	96%	98%
	E-bike	2%	8%	35%	46%	53%	69%	73%	82%	85%	93%

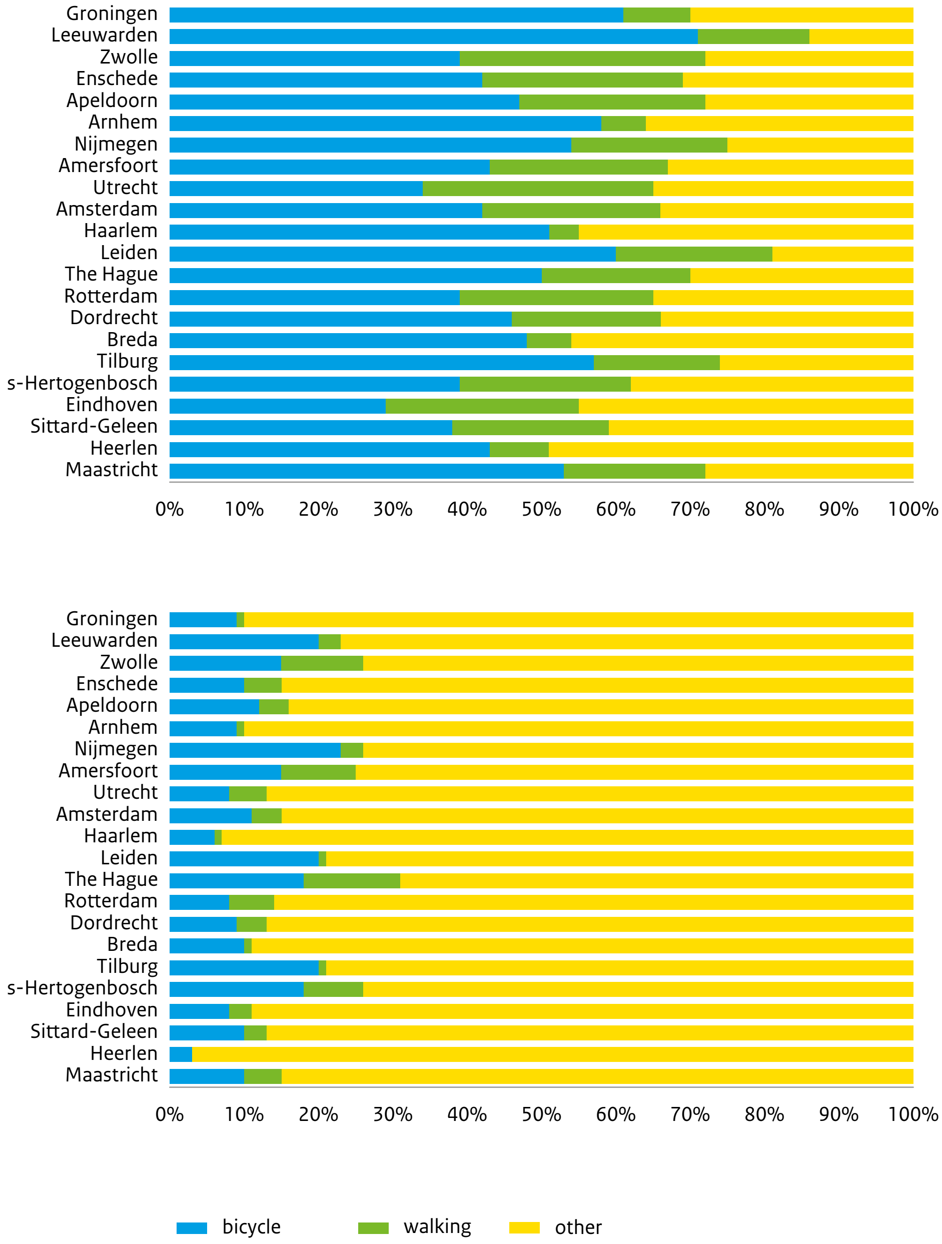
A number of points emerge in Table 3.2. For trips undertaken by foot, a considerable share (14 percent) of the trips occurs over a longer distance. For three of the four researched trip purposes, the acceptable distance for the e-bike extends to approximately 15 kilometres. When we look more closely at the varying trip purposes, clear distinctions emerge. For home-to-work commutes, the maximum acceptable distance for regular bicycles and e-bikes differ by a factor of two: with regular bicycles, people are prepared to cycle approximately 7.5 kilometres to their workplace, while the radius of action for the e-bike for the same purpose is approximately twice that distance. For leisure time purposes, this even extends to a factor of three: 10 kilometres for a 'regular' bicycle and 30 kilometres for an e-bike. There are also differences for pedestrian trips. Hence, the longer acceptable distances for leisure trips undertaken by foot seemingly push the average upwards. For other trip purposes, very few trips by foot cover distances longer than 2.5 kilometres.

Appendix 2 provides additional background information relevant to the active modes in terms of what is understood about areas of influence and length of distances (straight-line distances and isochrones).

Trips within and between cities

In cities, the active modes – walking and cycling – are the most important transport modes, although major differences exist among the various cities. Chapter 6 delves deeper into the reasons behind these differences. The active modes however are not only used for trips within cities; rather, people also walk and cycle between cities, although this occurs far less frequently than within cities. For home-to-work trips between cities, the bicycle (including e-bikes) is a much used transport mode. Here, too, there are major differences between cities: hence, people who travel to The Hague from outside the city to work will comparatively travel more frequently by bicycle than people who travel to Groningen from outside the city to work, for example. Groningen in turn has a larger percentage of bicycle trips within the city than The Hague. Figure 3.4 shows the percentage of home-to-work trips made by foot, by bicycle and by other transport modes, both within and between cities. Unlike Figure 6.2 (which shows the total mobility), this Figure only accounts for home-to-work trips.

Figure 3.4 Percentage of cycling and walking for home-to-work trips that occur within cities (above) and between cities (below). Source: CBS OViN (2010 – 2014); adapted by KiM



Cycling and walking as access and egress mode

The active modes play a key role in access to and egress from public transportation. For multimodal trips, we understand this to mean trips in which more than one type of transport mode is used. We exclude walking to a personal transport mode (bicycle, car, etc.).

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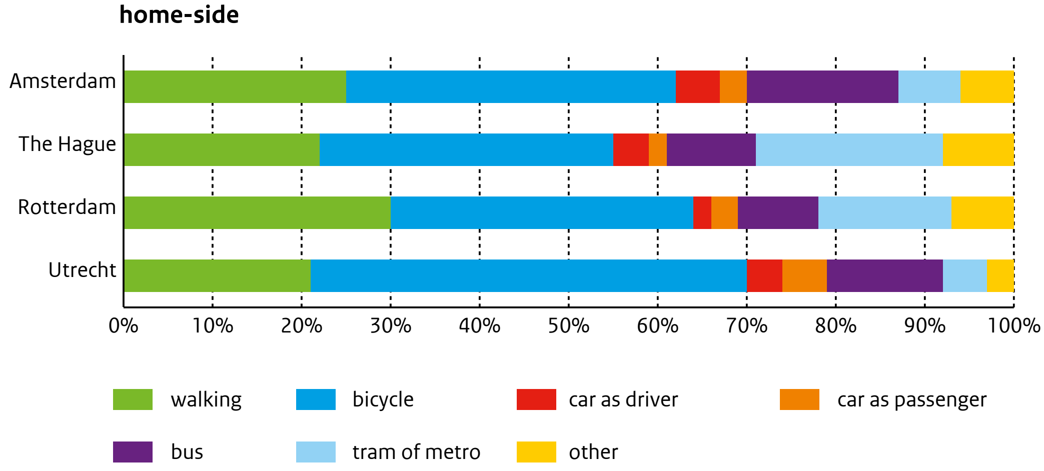
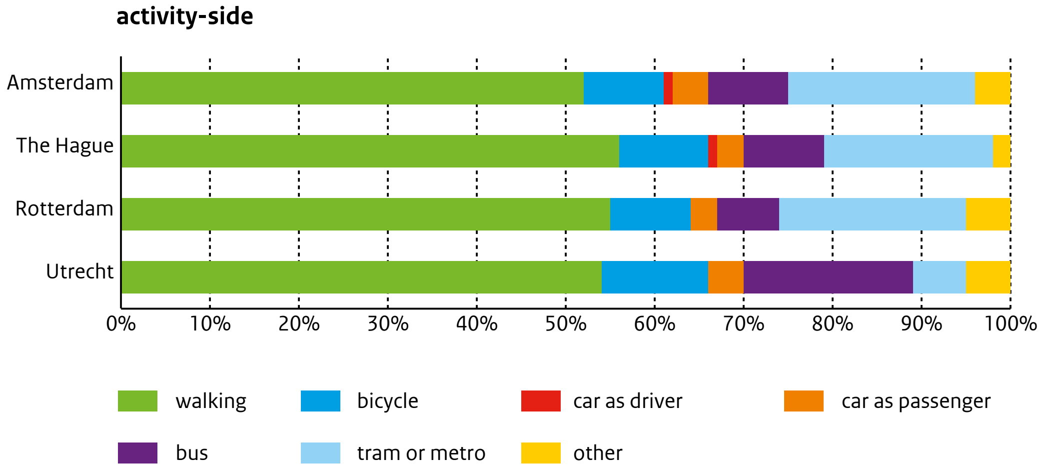
Nearly half of all trips between a person's home and the train station are made by bicycle, and 15 percent by foot.[5] The bicycle is used as a transport mode on the activity-side in at least one-tenth of all cases, and walking in half of the cases.[6] This difference is due to the fact that people have access to their personal transport modes more frequently on the home-side and less frequently on the activity-side (Figure 3.5).

Figure 3.5 Access to and egress from train on the home-side and the activity-side in the G4. Source: CBS OViN (2011-2013); adapted by KiM





Recent research by UvA has revealed that the bicycle and train can bolster each other, owing to their unique characteristics (Kager et al., 2015). Bicycles offer people the possibility of quickly reaching other parts of the city from a (urban) core area, and bicycles are flexible and offer a relatively high degree of freedom of choice, while trains quickly transport people over greater distances between (urban) core areas. This bicycle-train combination can result in higher door-to-door travel speeds than other (combinations of) transport modes. The UvA study also revealed that the number of trips per person in which the combination of bicycle and train was used increased by 5 percent per year in recent years.

[5] Of which 10 percent were less than 1 kilometre.

[6] Of which nearly 40 percent were less than 1 kilometre.

4 Trends and developments in cycling and walking

From 2004 to 2014, bicycle use increased by 9 percent, primarily for home-to-work commutes and educational purposes. People use bicycles for shopping less frequently than they did ten years ago. Since 2004, pedestrian trips have increased at a faster rate (13 percent). People walk more frequently and for longer distances, particularly for leisure time purposes[7]. Trends, such as an increase in the number of single-person households, larger numbers of people residing in cities, and larger numbers of senior citizens and people of non-Western ethnic origin, can lead to changes in the percentage of active mode use in the travel behaviour of Dutch people. We explain these findings below.

Cycling more frequently and further

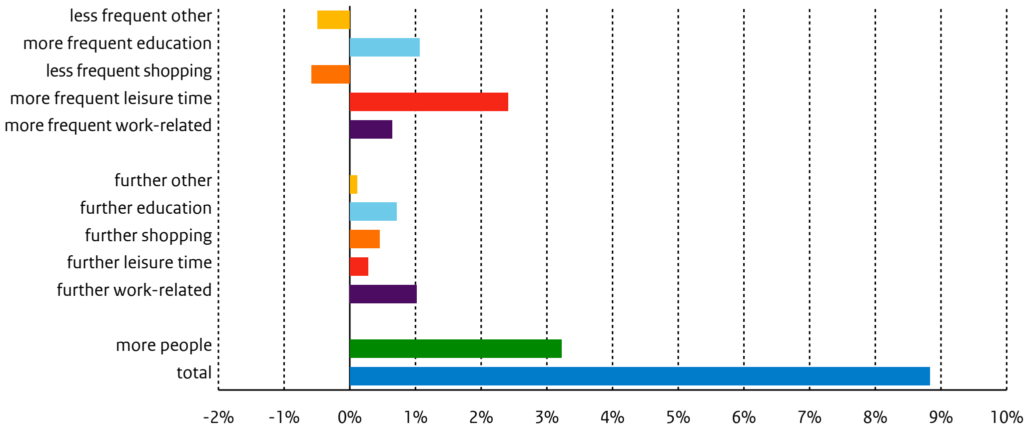
For decades Dutch people have made approximately one-quarter of all their trips by bicycle. Moreover, the number of kilometres that they cycle per year has increased by 9 percent since 2004. Both the growth in the number of people cycling and the increase in mobility per person (more frequent and longer trips) contribute to the increased number of bicycle kilometres.

The use of bicycles has primarily increased for leisure time trips, trips to and from educational institutions, and for home-to-work commutes (Figure 4.1). Women in particular more frequently use bicycles for travelling to work and for education purposes. This growth is related to the increase in women's participation in the labour market. Home-to-work commuting distances have also increased.

For shopping, the bicycle on average is used less frequently than ten years ago (but used to cover longer distances), with the economic recession possibly playing a role in this (Raatgever, 2014). The increasing importance of online shopping could also play a role here, although firm evidence for this is lacking.

[7] To describe the trends in bicycle use and walking, we used the findings of the 'Dutch National Travel Survey' (OViN) for the years 2010 to 2014, as well as the findings of the OViN's predecessor, the Netherlands Mobility Study (MON) (2004 to 2009).

Figure 4.1 Decomposition of the development of bicycle use (according to the effects of more people, higher trip-frequency and longer trip distance for five trip purposes), 2004-2014. Source: RWS/CBS, MON (2004-2009)/OViN (2010-2014); adapted by KiM



A large share of the increase in bicycle use is attributed to e-bikes, which senior citizens in particular use frequently. Year by year fluctuations in bicycle use can be significantly attributed to weather: temperature, snow days and hours of sunshine have a major impact on bicycle use (see also KiM 2015).

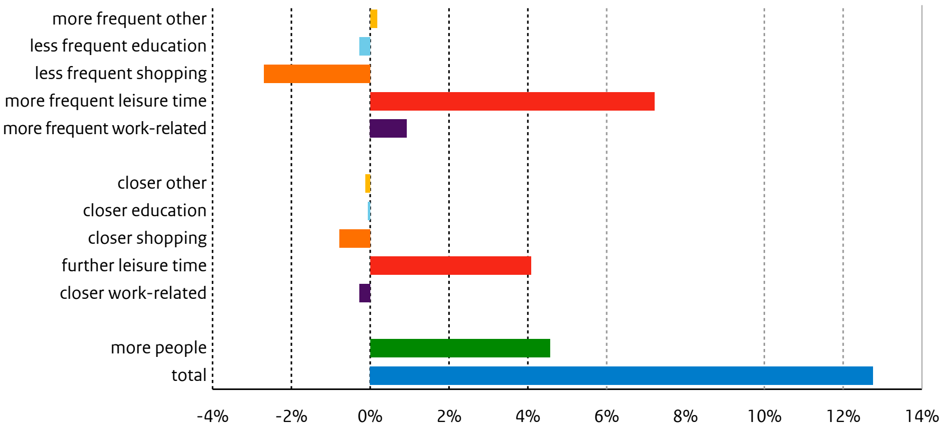
Walking: 13 percent increase

Since 2004, the number of kilometres people travel by foot has increased by 13 percent. Approximately 4.5 percent of this growth is attributed to population growth, while approximately 5 percent is due to greater distances being travelled by foot, and nearly 3 percent attributed to the fact that people now walk more frequently (Figure 4.2). Moreover, people are especially prone to walking further and more frequently for leisure time purposes.

Closer analysis of developments per age group suggests that the increase in walking corresponds to a decrease in car use as drivers (for men) and car use as passengers (for women and children). The underling drivers behind these shifts require additional research.

This explanation cannot properly explain part of the growth, particularly the increase in walking in the years immediately following 2005.

Figure 4.2 Decomposition of the development of walking (according to the effects of more people, higher trip-frequency and longer trip distance for five trip purposes), 2004-2014. Source: RWS/CBS, MON (2004-2009)/OViN (2010-2014); adapted by KiM



A glimpse into the future

The following trends could result in changes to the amount of cycling and walking that Dutch people do in future:

- Single-person households cycle more frequently on average than some other types of households. The number of single-person households will continue to increase in the coming years. If this trend continues, the use of bicycles will subsequently also increase (CROW, 2014).
- The major cities face parking problems of varying degrees. Many cities strive to be sustainable cities and hence prohibit cars. Moreover, within the city, one can reach a variety of facilities within relatively short distances. This can lead to further increases in the amount of cycling and walking in the city.
- Dutch people are increasingly residing in cities. The percentage of people living in cities increased from 39 to 48 percent in less than 20 years, while the percentage residing in rural areas declined from 39 percent 20 years ago to 32 percent today. In the city, the volume of bicycles increased by 22 percent, while in rural areas it declined by 9 percent.
- This trend for city living means that the distances to services in rural areas are continuously increasing. Consequently, it is increasingly difficult to reach such services by foot or bicycle; hence, the e-bike, with its larger radius of action, could become increasingly important, especially for people who do not have access to cars.
- Senior citizens travel shorter distances on average, but they also cycle less frequently. The increasing ageing of the population could perhaps result in walking becoming increasingly important for the self-reliance of senior citizens. The e-bike can indeed play a role in keeping seniors mobile for a longer time and over greater distances.
- People of non-Western ethnic origin - a group which cycles relatively infrequently but walks frequently - is the fastest growing population group in the Netherlands. This could serve as an indication that walking will become increasingly important in future.

5 Determinants: personal characteristics and demographics

Numerous personal characteristics - each in its own way - are related to the extent to which a person will use the active modes. Hence, teenagers cycle more frequently than any other age group, while children under the age of 12 and people aged 65+ walk the most frequently. Women cycle and walk more often than men. The higher one's personal income, the less frequently the person walks or cycles. People of non-Western ethnic origin walk twice as much as people of native Dutch background but they cycle significantly less. The composition of the household also determines the use of the active modes. Only in the four major cities is there an observable relationship with education levels: highly educated people cycle more frequently and lower educated people walk more frequently; however, this relationship is not observed in the Netherlands as a whole.

Walking, cycling and the seven D's

There are major social and spatial differences in the extent to which people walk or cycle. In this context, English-language literature sources occasionally cite the seven D's (Ewing & Cervero, 2010):

- density (of built-environment and land use);
- diversity (of land-use and destinations);
- design (pattern of the street network);
- destination (accessibility thereof);
- distance (to public transportation);
- demand (management of mobility);
- demographics (socio-economic factors).

These various 'drivers' are explored in the following chapters.

Personal characteristics and the relationship with the use of active modes

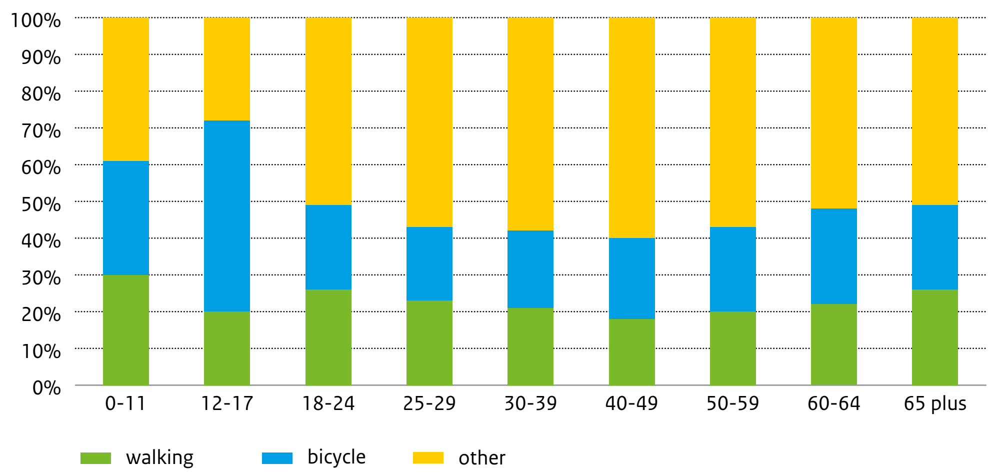
Age, gender, personal income, education level, ethnic background and household composition are the six demographic characteristics routinely cited in literature in relation to the active modes (Harms, 2007; Heinen, 2011; Bonham & Wilson, 2012; Garrard et al., 2012; Scheepers et al., 2013; CROW, 2014; Harms et al., 2014). These personal characteristics also occasionally reveal the interactions that occur with other factors, such as spatial factors, or with each other, when we look at their relationships to mobility.

The factors described in international literature are therefore not always directly applicable to the situation in the Netherlands. In the following sections we explore each of these six personal characteristics, and determine if, and how, each characteristic is related to the use of active modes in the Netherlands. While it is indeed true that the differences discussed are significant ($p<.05$), in practice they occasionally only have minor effects. The figures cited here provide more insights.

Age

As pertains to the situation in the Netherlands, there is a clear relationship between the age of the person travelling and the extent to which he or she walks or cycles. The relationship with bicycles differs from that of walking, however. Teenagers aged 12 to 17 cycle the most frequently of all age groups – boys in this age group cycle more than girls – but they walk relatively infrequently. Conversely, in the group aged 25 and above, cycling is very infrequent. Children up to age 12 and senior citizens (65+) account for largest percentage of trips by foot, while people in their 40s walk the least. That young children and senior citizens relatively frequently opt to walk is unsurprising, as their options are relatively limited: for example, they do not (or no longer) possess a driver's license.

Figure 5.1 Modal split of trip-segments according to age

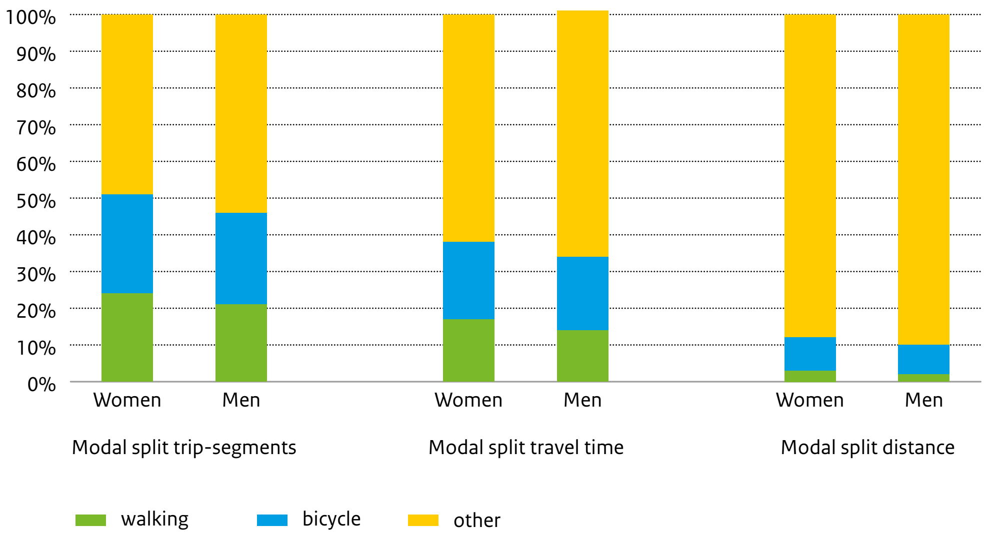


Gender

There is also a relationship between gender and the percentage of cycling and walking trips as compared to other transport modes. However, cycling and walking differ less significantly according to gender than to age. Consequently, for the gender segment, we have therefore decided to consider the active modes jointly.

Women use the active modes significantly more frequently than men (Figure 5.2), who (particularly men above age 25) use the car for the largest share of their trips. This can be related to the fact that women more frequently work part-time and work closer to home than men (Schaap et al., 2013). We also know that mothers who take their children to school or preschool relatively frequently use bicycles for this purpose, while fathers more frequently use cars for the same purpose (Schaap et al., 2013).

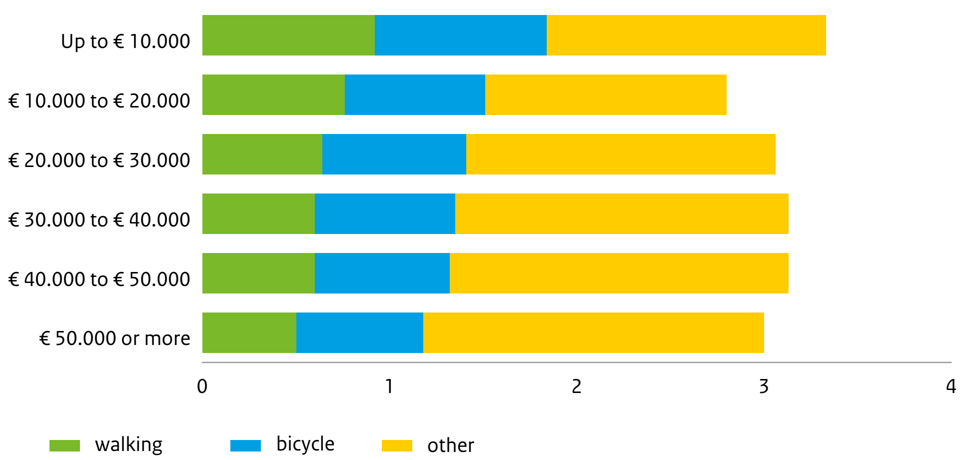
Figure 5.2 Modal split of trip-segments according to gender. Source: CBS OViN (2010-2014); adapted by KiM



Income level

According to international literature, income disparity is clearly related to walking (poorer people walk more frequently, and richer people less frequently), but has much less of an impact on cycling. In the Netherlands, that wealthier people walk less frequently is an observed phenomenon. Moreover, both active modes seemingly adhere to the same pattern: the higher a person's income, the less he or she uses the active modes. Figure 5.3 shows how many trip-segments per day a person makes by the active modes and by other transport modes.

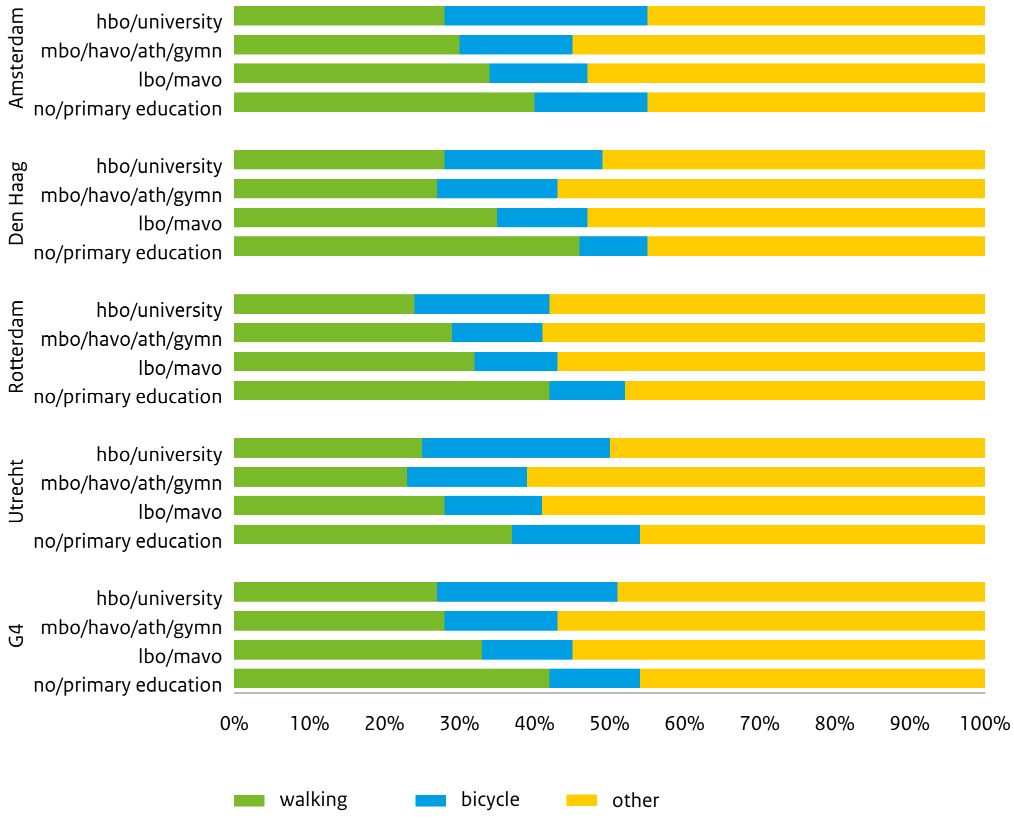
Figure 5.3 Number of trip-segments per person per day according to income level. Source: CBS OViN (2010-2014); adapted by KiM



Education level

For the Netherlands as a whole, there is no discernible relationship between a person's education level and their use of the active modes. However, for the Netherlands' four major cities, and Amsterdam in particular, there is such a relationship, especially in the use of bicycles. In order to remove the effect of students from the equation, our analysis only focuses on the population aged 25 years and older, hence the group that in principle has completed its formal education. However, even then, we still observe a relationship between education level and bicycle use: higher educated people cycle more frequently than people of lower education levels. For the percentage of walking, the reverse is observed: the higher the education level, the less frequently a person walks. Figure 5.4 shows the differences among the population of people aged 25+ in the four major cities.

Figure 5.4 Modal split of trip-segments according to education level (population of people aged 25 and older). Source: CBS OViN (2010-2014); adapted by KiM



Ethnic origin

Previous studies have clearly shown that immigrants cycle less frequently and for shorter distances (Harms, 2007). The children of immigrants frequently walk to primary school because their parents cycle infrequently and also deem cycling dangerous. It is often possible for these children to walk to school, because the distances they must travel to school in a small city are manageable. However, when these children start to attend secondary schools, walking is no longer an option, and hence immigrant children relatively frequently travel to school by public transportation (Verhoeven, 2009; ITF, 2012).

Our analyses reveal that differences in percentages of cycling and walking exist between people of non-ethnic Dutch origin and people of native Dutch origin. People of non-Western origin walk on average twice as much as native Dutch people, but they cycle significantly less. People of Western ethnic origin also walk somewhat more frequently and cycle less frequently than native Dutch people, but there is less of a difference compared to people of non-Western ethnic origin (Figure 5.5).

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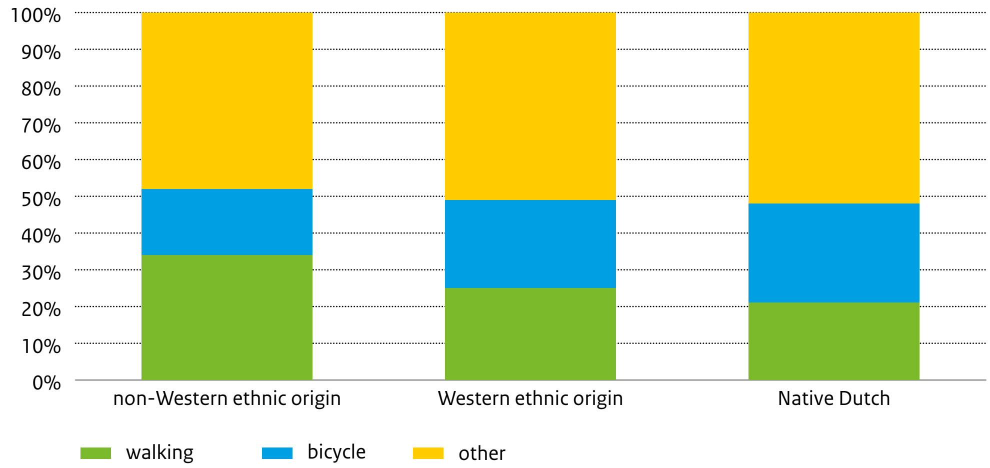
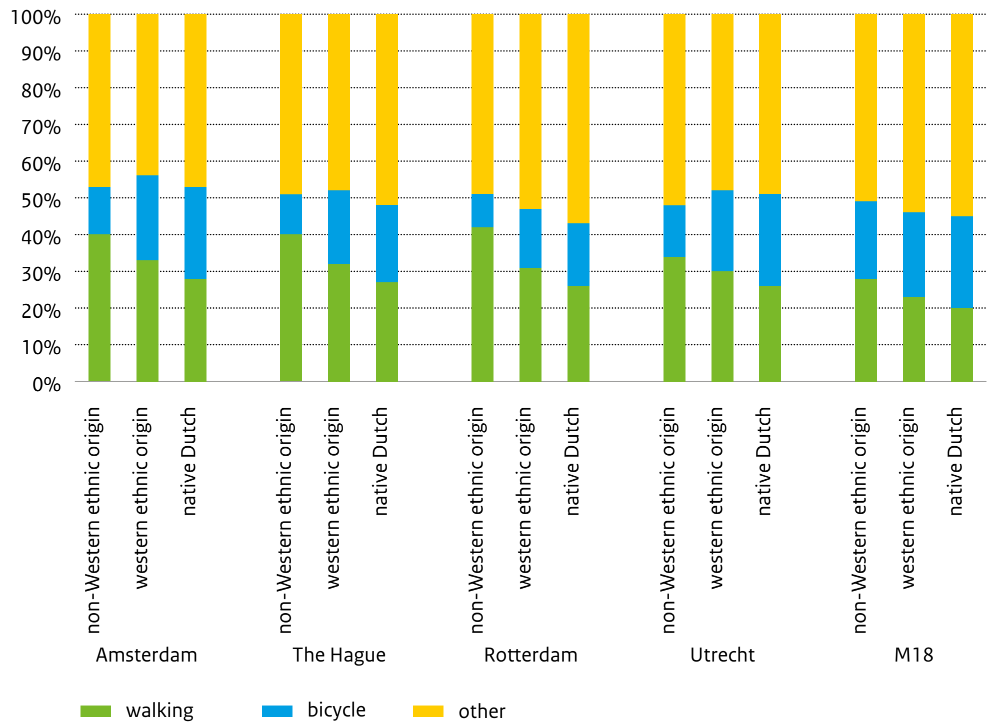
Figure 5.5 Modal split of trip-segments according to ethnic origin (for the entire Netherlands). Source: CBS OViN (2010-2013); adapted by KiM



Our analyses moreover reveal that the differences among the native Dutch population and the non-Western ethnic population are greater in some cities than in others. Hence, the differences in pedestrian trips between native Dutch people and people of non-Western ethnic origin are greater in Rotterdam than in Utrecht or in the 18 mid-sized Dutch cities (which, for purposes of clarity, we have presented together; see Figure 5.6). Another combined-effect (not shown in the Figure) is related to urbanization and ethnic origin. Hence, we observe that young native Dutch people cycle more frequently in proportion to the more urbanized the area in which they live, while people of non-Western origin in similarly highly urbanized areas cycle less frequently. In Chapter 6, we examine the relationship between the use of the active modes and spatial characteristics, while in Chapter 7 we explain the differences between cities.

Figure 5.6 Modal split of trip-segments according to ethnic origin for the G4 and M18. Source: CBS OViN (2010-2014); adapted by KiM

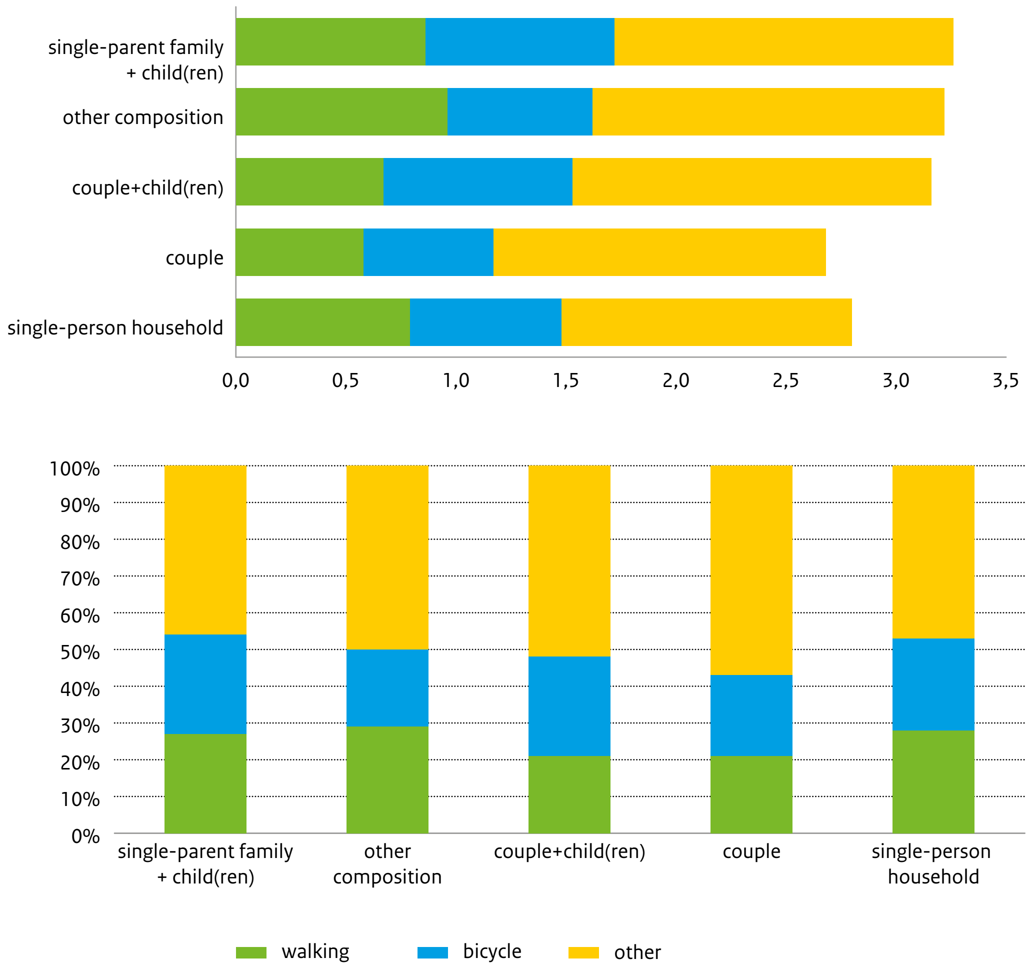


Household composition

The composition of a household is not only related to the percentage of cycling and walking, but some types of households are also simply much more mobile than other types. Hence, a household comprised of a couple with children makes on average 3.2 trips per person per day, while a couple without children makes approximately 2.6 trips per person per day. At first glance, this does not appear to be large difference, but people from the former type of household are, according to this data, at least 20 percent more mobile per person, and families with children are also in general larger households than families without children. The percentages of cycling and walking in these trips also differ according to household type.

Single-person households relatively frequently use one of the active modes, while a couple with children uses other transport modes (the car, for example) for a larger percentage of their trips. Figure 5.7 shows the mobility in trips per person per day (above) and the percentages in the modal split for the various household types (below).

Figure 5.7 Mobility in trips per person per day (above) and modal split (below) according to type of household. Source: CBS OViN (2010-2014); adapted by KiM



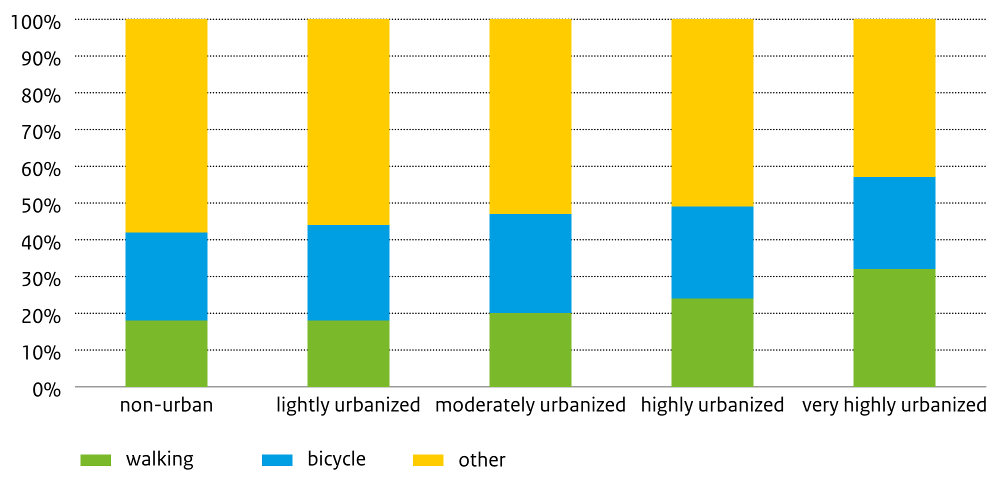
6 Determinants: spatial characteristics

The active modes are the most important transport modes within cities. Use of the active modes is partly determined by the characteristics of the spatial environment, including the degree of urbanization and size of the city. As pertains to the situation in the Netherlands, there are no data sources available to support our analyses of each of the spatial determinants as cited in international literature. We observe however that the percentage of cycling and walking is related to the degree of urbanization and size of the city (particularly the four major cities, compared to the 18 mid-sized cities). Hence, residents of highly urbanized areas, particularly young adults, cycle and walk relatively frequently. People cycle less and walk more in the four major cities than they do in the mid-sized cities. However, within these 18 mid-sized cities, substantial differences are observed in the extent to which bicycles are used.

Degree of urbanization

Residents of highly urbanized areas walk relatively frequently and often use public transport (Figure 6.1), and they use cars comparatively less frequently. This relationship also applies to travel time. The relationship between the degree of urbanization and distances travelled with the active modes is weak.

Figure 6.1 Modal split of trip-segments according to degree of urbanization. Source: CBS OViN (2010-2014); adapted by KiM



Differences due to degrees of urbanization are seemingly further magnified among young adults. Young adults from (very highly) urbanized areas walk more frequently, cycle more frequently and use public transport more frequently than young people from non-urban areas. The latter travel comparatively more frequently by car, spend more time travelling and travel longer distances.

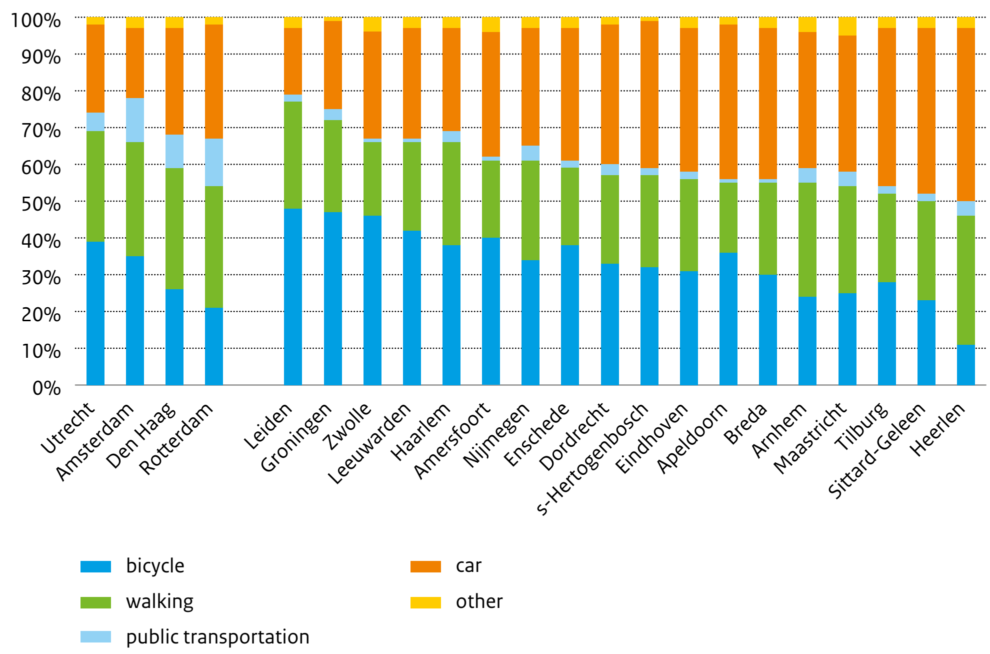
Size of cities (G4 and M18)

We not only examined the active modes in relation to an area's degree of urbanization, but also in relation to the four major cities (G4: Amsterdam, Rotterdam, The Hague and Utrecht) and the 18 mid-sized cities (M18), in terms of percentage of trips, travel time and trip distance. The active modes are the most important transport modes within cities. The various cities do differ in this regard, however, particularly when we compare the four largest cities with the 18 mid-sized cities. Hence, the percentage of walking in the 18 mid-sized cities varies between 17 (Apeldoorn) and 26 percent (Nijmegen), while the percentages in Rotterdam, The Hague and Amsterdam are higher (32 percent). Figure 6.2 shows the percentages of pedestrian and bicycle trips in the 22 city regions. Unlike Figure 3.4, which only presents home-to-work trips, Figure 6.2 covers all trip purposes.

There is comparatively less cycling in the four major cities than in the majority of the 18 mid-sized cities, and this is particularly the case in Rotterdam (14 percent) and The Hague (18 percent). Outside of the four major cities, cycling is particularly popular in the university cities of Leiden, Groningen, Zwolle and Leeuwarden (as well as in Amersfoort and Haarlem), where more than 40 percent of all local trips are made by bicycle. In Arnhem, Maastricht, Tilburg, Sittard and Heerlen, relatively few trips are made by bicycle: the percentage for the bicycle in the local trips is 30 percent or less. In a number of cities where cycling is relatively infrequent, the percentage of walking is comparatively high: in Heerlen, nearly one-third of local trips are by foot, while in Maastricht and Arnhem this figure is approximately 30 percent.

It is possible that the percentage of cycling in the four major cities is further dampened by the relatively high use of buses, trams and metros. In Amsterdam, Rotterdam and The Hague, public transport accounts for more than 10 percent of all trips, in Utrecht 5 percent, and in the other cities studied an average of 2 percent.

Figure 6.2 Modal split of trips within the 22 city regions. Source: CBS OViN (2010-2014); adapted by KiM



The four major cities clearly deviate from the other cities. However, there are also substantial differences in the amount of bicycle use within the 18 mid-sized cities. In Groningen and Leiden, for example, nearly one-third of all trips are by bicycle, while in Heerlen that figure is less than 10 percent. Other cities where there is a relatively large percentage of cycling include Leeuwarden (29 percent), Zwolle (29 percent), Amersfoort (28 percent), Enschede (28 percent) and Haarlem (26 percent). Conversely, in Arnhem (18 percent), Sittard-Geleen (18 percent), Breda (19 percent) and Maastricht (19 percent), cycling claims a relatively small share.

7 Determinants: Explanation for the differences between cities

Differing demographic and spatial characteristics influence the extent to which people walk or cycle. Which of these characteristics, or combinations thereof, is decisive for cycling and walking, and to what extent can these characteristics explain why some cites are seemingly preeminent cycling or pedestrian cities, and others are not? The composition of the population in a particular postal code area has a major impact on the percentage of cycling. Age of the population, levels of personal income, the number of people of non-Western ethnic origin and the percentage of certain types of households play key roles in this regard. The spatial characteristics, particularly distances to urban facilities within a postal code area, play a role in terms of explaining the differences between cities in their use of the active modes.

Explaining the differences between postal code areas and between cities

The Mobility Report 2014 includes a number of possible explanations for the differences that exist between urban areas in terms of their use of transport modes, such as cycling and walking (KiM, 2014). In this study, we used regression analysis to examine these differences. However, because the number of municipalities and number of researched variables are disproportionate, the analysis is based on postal code areas (3 digit level). The following provides an indication of the size of a postal code area: the city of Leeuwarden consists of three postal code areas, while Utrecht includes seven such areas.

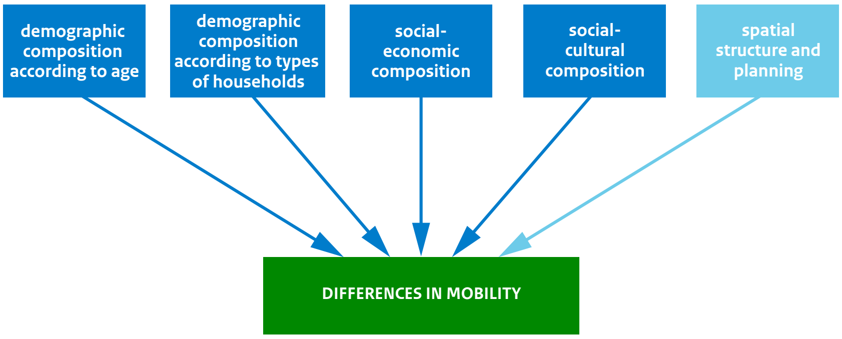
The municipalities were also researched individually; however, owing to their limited number, the findings had too low a degree of reliability and were too indistinct. Ultimately, the analysis included information about 22 municipalities and 112 postal code areas. Appendix 1 provides an overview of the data sources we used. A comprehensive account of the research is available on the KiM website (www.kimnet.nl) (In Dutch).

Composition of the population

The explanatory analysis reveals that four factors are most influential in terms of the differences between urban areas in their use of the active modes:

- the social-cultural composition of the population in an urban area (specifically, the percentage of people of non-Western ethnic origin): there is comparatively less cycling and more walking in areas with high percentages of people of non-Western ethnic origin (such as in parts of Amsterdam, Rotterdam and The Hague).
- the social-economic composition of the population in an urban area (particularly with regard to personal incomes): in areas with higher than average personal income levels, there is a relatively large use of bicycles, and people walk comparatively less frequently (this is particularly the case in Haarlem and Leiden). In areas with predominately lower income levels and high unemployment rates, the opposite is true: here, people cycle relatively less and walk more (particularly evident in Leeuwarden, Rotterdam and Tilburg).
- the demographic composition of the population in a 3-postal code area (primarily according to age): in areas with relatively young populations (read: many 25 to 45 year olds, such as Utrecht), the percentages of cycling and walking are significantly higher than in areas with a larger percentage of older people (read: aged 45+, such as Heerlen and Sittard-Geleen);
- the percentage of certain types of households in an urban area: in areas with a relatively large number of singe-person households without children (such as Groningen, Leiden, Maastricht and Nijmegen, where many university students reside), the percentage of cycling and walking is higher than in areas with many families with children (such as Apeldoorn, Dordrecht and Haarlem).

Figure 7.1 Various factors collectively explain the differences in the percentages of cycling and walking among cities; herein, the spatial characteristics are inextricably linked



Spatial planning

The spatial planning of an area, as well as the quality and quantity of the available infrastructure, is to a lesser degree than previous factors an explanation for differences in the use of the active modes: the percentage of cycling and walking is particularly related to the distance to facilities. Moreover, a strong correlation exists between the population composition on the one hand, and the spatial and infrastructural differences on the other. Hence, a neighbourhood comprised of houses, and a neighbourhood comprised of apartment buildings, do not only differ in terms of their predominate types of housing but also in the supply of facilities and other spatial characteristics, as well as in the characteristics of the people who reside in that neighbourhood.

International literature establishes a strong correlation between spatial variables and the composition of the population (see for example Van Acker et al., 2010). This therefore raises the question of causality: is the composition of the population influenced by the spatial planning, or vice versa? Based on the findings of this study, we cannot provide a definitive answer to this question. However, insights derived from literature point to the effects of self-selection: people of a certain background (young, of non-Dutch ethnic origin) often choose to live in a certain neighbourhood that has specific spatial characteristics (Bohte, 2010).

In our analysis, we have moreover only examined (highly) urbanized areas, which means that we restricted the variation in spatial variables in advance (that is to say: our analyses excluded rural areas). Consequently, the effects of certain characteristics were possibly attenuated.

Other explanatory variables

In the analyses conducted on the municipality level, another background characteristic of the population emerges as a highly explanatory variable: the dominant religion in a city. This variable is unknown on the 3-postal code level, but it is known per city. A high percentage of Protestants residing in a city has a positive effect on the degree of cycling in that city and a negative effect on the degree of walking (particularly in Amersfoort, Apeldoorn, Dordrecht, Leeuwarden and Zwolle). In cities where more Catholics reside, there is less cycling and more walking (Breda, Heerlen,'s-Hertogenbosch, Maastricht, Nijmegen, Sittard-Geleen and Tilburg). In fact, many other explanatory variables were omitted because areas within a city were considered jointly; these analyses are therefore less informative.

The findings of the explanatory analyses not only reveal major differences between the cities but also within the various cities in terms of the importance of differentiating factors. In other words: in some neighbourhoods in urban areas the differences between cycling and walking were primarily determined by the demographic composition of the population, while in other neighbourhoods the social-cultural aspects were seemingly decisive. This means that conclusions about explanations for differences in mobility among cities must be made with requisite caution. Among cities that differ from one another, there can in fact be neighbourhoods that are very similar.

There are of course also other factors that help explain the percentage of active mode use in a city, such as differences in the available infrastructure, in parking fees, and in mobility policy (see also KiM's Mobility Report 2014, 2014). Recent findings from research conducted by Harms et al. (2015) reveal that such factors, in addition to an area's social-spatial characteristics, also play a role in explaining the differences in (changes to) bicycle use. Hence, the quantity and quality of bicycle infrastructure plays a role, as does the degree to which car use is discouraged (by infrastructural adaptations or parking policy) and the way in which policy is organized: a well-organized and implemented policy, such as the formulation of measurable objectives, the promotion of citizen participation, adaptability, and space offered for experimentation (see further Harms et al. 2015).

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8

Social effects of cycling and walking

Cycling and walking are healthy activities. Absenteeism due to illness is proportionally lower as the frequency of cycling and length of the distances cycled increase. Cycling and walking are also environmentally friendly. Moreover, the active modes reduce car dependency and the likelihood of transport poverty occurring in a city. Conversely, with these social benefits also come social costs. Hence, an increase in the number of (extra-wide) bicycles results in congestion on the bicycle paths and hence in conflicts between the various bicycle path users. Cyclists also account for a larger share of the number of traffic fatalities, and particularly in the number of seriously injured. The number of pedestrians among those killed in traffic accidents has however remained constant.

Costs and benefits of the active modes

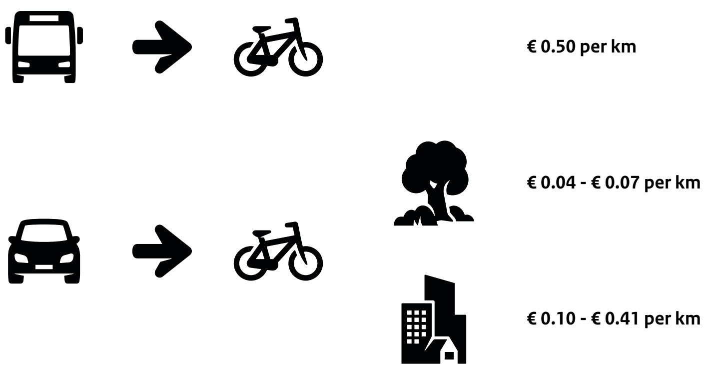
Depending on the situation, an increase or decrease in cycling and walking can have effects on the accessibility, safety and liveability of a region. The active modes however can also affect various other social factors. Hence, more exercise has an effect on health, the use of the active modes plays a role in the perception of a particular location, and bicycles can help limit transport poverty.

In this chapter we look at the various effects resulting from the use of the active modes, which can also be expressed in economic terms: as social costs and benefits. It is estimated that annually some 100 billion bicycle kilometres are travelled in the 27 EU countries. In a comprehensive study, the European Cyclists' Federation (Küster & Blondel, 2013) calculated the economic benefits of cycling in terms of health benefits, congestion reduction, fuel savings, reduction of CO_2 emissions and noise, and benefits for the cycling industry and tourism. Based on this calculation, the economic benefits of cycling in the EU countries amounted to at least 205 billion euro, of which approximately half derived from the health effects.

In a quick scan, the Decisio agency also compiled a number of figures pertaining to the (economic) benefits of increased bicycle use[8]. These figures expressed the amount that society saves when a person switches from the car or bus to the bicycle. The switch from other modalities to the bicycle has a positive social effect of between 0.04 and 0.50 euro cents per kilometre, depending on the location where the kilometres are travelled and the original modality (Figure 8.1). In the switch from the car to the bicycle, the positive benefits are primarily accrued through the reduced congestion for other traffic, while in the switch from the bus to the bicycle it primarily derives from savings in public transportation subsidies. Conversely, the introduction of paid bicycle parking has a negative social cost-benefit balance (Ommeren & Goedhart, 2011).

[8] In the calculations used to arrive at these findings, the out-of-pocket travel costs, travel time and maintenance costs are included. Moreover, the figures are highly dependent on the local situation; they therefore have a wide bandwidth. In a concrete case study, these aspects must be included in the calculations.

Figure 8.1 Social benefits of switching from the car or bus to the bicycle (euro per km). Source: Ommeren & Goedhart (2011)



A cost-benefit analysis of two bicycle projects in Copenhagen revealed that a bicycle kilometre generates 0.16 euro cents for (Danish) society, while a car kilometre costs 0.10 euro cents during non-peak hours and 0.20 euro cents during peak hours (COWI, 2009). Nijland and Van Wee (2006) cite a Norwegian study pertaining to the costs and benefits of constructing bicycle paths. The study found that the benefits were four to five times greater than the costs, while the share derived from the associated health benefits was 55-75 percent (Sælensminde, 2004). Cycling for 30 minutes per day yields a social savings of 500 to 4,000 euro per year, depending on the person's level of (in)activity (Lind, 2005).

Accessibility

The extent that Dutch people cycle and walk has a number of discernible effects related to accessibility, particularly in cities. Hence, due to increased bicycle use, capacity bottlenecks emerge in bicycle parking racks and on some bicycle paths, yet we also see that bicycles also lower the probability of transport poverty in the Netherlands. The active modes play a role in a large number of trips by public transportation as access and egress mode, and thus the accessibility of public transport also benefits from cycling and walking. The e-bike moreover ensures that people have a larger radius of action when travelling by bicycle, and because some car drivers switch to e-bikes, e-bikes contribute to the improved accessibility of car travel.

In this section we describe the positive and negative effects on accessibility derived from the active modes current role and the increases that have occurred in recent years.

Capacity bottlenecks

There are more bicycles than people in the Netherlands. And all these bicycles can travel along some 35,000 kilometres of bicycle paths (Fietsersbond, 2012). The group of users of the bicycle paths has expanded steadily in recent years: regular bicycles are no longer the only users, but rather are now joined by e-bikes, speed pedelecs, mopeds, scooters, three-wheel bikes, crate-bikes, Segways, recumbent bikes and various other new modalities that all use the bicycle paths. Moreover, the use of other cycle path vehicles has also rapidly increased in recent years; for example, since 2008, the number of kilometres travelled by moped has increased sharply by nearly 55 percent (CBS, 2015)

In the large cities, the increasing use of extra-wide bicycles, such as three-wheelers and crate-bikes, has increased congestion on the bicycle paths (Kwantes et al., 2012). This is primarily due to the increasing use of bicycle paths during peak hours in the city and also owing to differences among users of the same bicycle path.

Two years ago, one in five cyclists said they experienced time delays on bicycle paths. The major culprits for such delays were traffic lights, the immediate impact of too many cyclists on the bicycle path, and people who cycled too widely and/or next to each other (Blankers, 2012). Many bicycle trips occur during the peak hours (Figure 8.2 above), and this becomes even more apparent when we specifically look at the highly and very highly urbanized areas (Figure 8.2 below).

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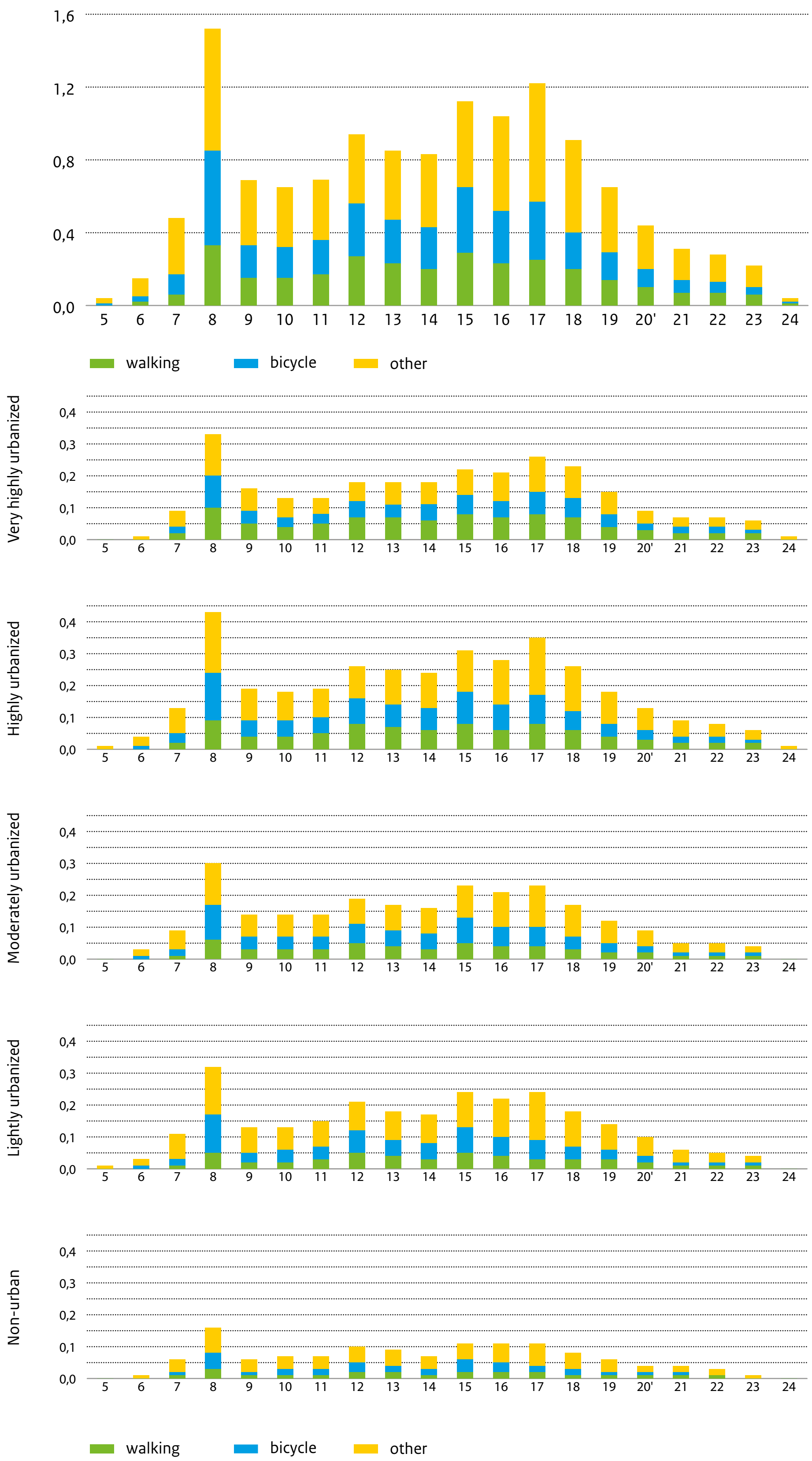
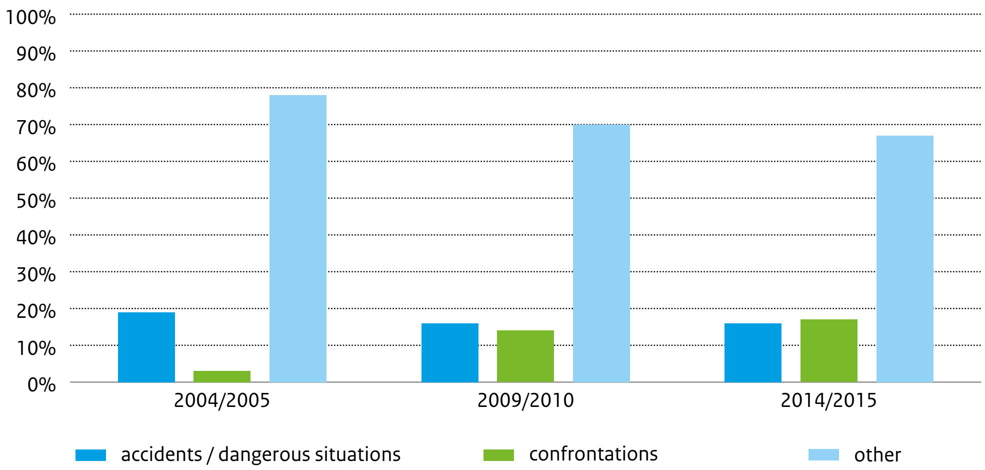
Figure 8.2 Division of trips (in billions) during the day (according to hour of arrival), entire Netherlands (above) and per degree of urbanization, both for working days. Source: CBS OViN (2010-2014); adapted by KiM



Various sources report that the number of conflicts on the bicycle paths has increased. TNO concluded in a study of bicycle conflicts that differences in the widths of bicycles and the varying speeds at which they travel could be reasons for conflicts and dangerous situations arising (TNO, 2013). In an interview on a health-care website, GezondheidCo.nl (2014), a trauma surgeon stated that the differences in speeds at which the various users of bicycle paths travel have increasingly led to accidents. The doctor stated that senior citizens riding e-bikes were particularly at risk. The figures cited by the trauma surgeon were in agreement with the records kept by Statistics Netherlands, according to the authors (GezondheidenCo, 2014).

A picture also emerges in the media of increasing numbers of conflicts among the various bicycle path users. Using LexisNexis' online newspaper search engine (www.nexis.com), we analysed all the articles from a major Dutch newspaper in which the word 'bicycle path' appeared in the years 2004/2005 (n=68), 2009/2010 (n=69) and 2014/2015 (n=95)[9] . The 232 selected articles were categorized according to content and divided into various broad categories: safety, conflicts, and other. The percentage and total number of newspaper articles in which cyclists, scooters and other bicycle path users got in each other's way (' confrontations') increased over the years. Whereas in 2005 confrontations on bicycle paths were rare (3 percent, n=20), that figure had risen to 14 percent by 2010 (n=10), and 17 percent in 2015 (n=16) of all articles with the search word 'bicycle path' (Figure 8.4).

Figure 8.3 Percentage of articles with search word 'bicycle path' in a major Dutch newspaper in 2004/2005, 2009/2010 and 2014/2015. Source: www.nexis.nl; adapted by KiM



In 2005, conflicts on the bicycle path were very rarely an issue in the newspaper we analysed, with only two articles citing such an issue: in Raalte, moped drivers were riding on the bicycle paths, whereby the police conducted checks (police officers went undercover for a month but ultimately only issued three tickets); and in the South Holland reservoir area, dangerous situations arose between groups of racing cyclists and walkers. However, by 2010, in both newspaper articles and especially letters to the editor, terms like 'war' and 'fight' frequently appeared, indicating that users of the bicycle paths were feeling increasingly frustrated. In 2015, reports of conflicts having occurred appeared, frequently followed by proposals for solutions. The fact that different types of users - of varying characteristics, riding bicycles of varying widths and at varying speeds - are increasingly using the bicycle paths has led to capacity bottlenecks in some locations, primarily during peak hours and increasingly in the city.

[9] For each year, 25 August was chosen start date (25 August 2004 - 25 August 2005, and so forth). All types of articles published in the newspaper were considered, including news articles and letters to the editor. This newspaper was chosen due to its large print run.

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Accessibility by public transportation

The active modes play an important role in the access and egress trip-stages to and from public transportation, particularly on the home-side: nearly half of all trips between a person's home and the train station are made by bicycle, and 15 percent by foot. Many people have (their own) bicycles on the home-side, but presumable this is less often the case on the activities-side, although the OV public-transport rental bikes offer a solution to this.

In recent years, a sharp increase in the use of public-transport rental bikes (OV-*fiets*) has been observed: from 33,000 trip-segments in 2003 to some 1.5 million trip-segments in 2014. Owing the rapid increase in the number of public-transport rental bikes, these bicycles cannot always be parked in the existing bicycle parking racks. In attempt to meet this growing demand, NS Dutch Railways opened temporary new locations called 'pop-up stores', which are only open during daytime hours (www.treinreiziger.nl).

Everyone en route

Transport poverty is defined as a situation in which a person, owing to a lack of possibilities for making trips, is unable to engage in a set of activities that a given society deems as normal. For example, people remain unemployed because transport poverty prevents them from joining the labour market, or a person's health suffers because he or she cannot easily reach health services. Moreover, transport poverty can also result in social isolation, because a person is unable to maintain relations with family or friends (Martens et al., 2011).

Of all Dutch households, 28 percent do not own cars (CBS, 2012). When these people want to travel, they are always dependent on walking or cycling, which can be as a door-to-door trip or as part of a trip-segment: to the bus stop, train station or a shared car. The only exceptions are people with special needs who use special target group transport. People who do not have access to cars, or do not possess driver's licenses, can be driven somewhere by family members who do own cars, but travelling independently can only be done by bicycle, by foot or by public transport. This means that for a significant share of the Dutch population pedestrian and cycling provisions allow people to independently engage in activities.

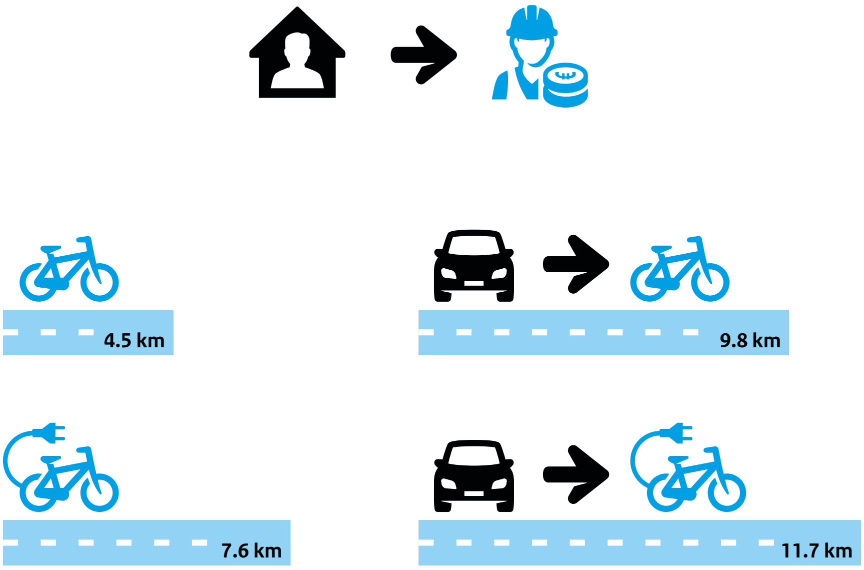
As the international comparative study in Chapter 2 revealed: people in the United States walk and cycle much less frequently and, moreover, the country is largely dependent on cars (Pucher et al., 1999). Consequently, people residing in US cities or neighbourhoods where the distances to health care facilities or healthy food are long will only have access to these basic needs if they own a car. In some areas, this has created so-called 'food deserts' and 'care deserts', areas where, owing to a person's limited transport options, a percentage of the population has no access to basic needs (Coveney & O'Dwyer et al., 2009). An international comparative study found that there is much less transport poverty in the Netherlands than in England, for example, which is primarily due to the fact that Dutch cities are relatively more compact and that Dutch people can reach many facilities by bicycle (Martens et al., 2011; Martens, 2013). The bicycle therefore plays a decisive role in the fight against and prevention of transport poverty.

Switching from cars to e-bikes

Although much of the research about e-bikes to date has been qualitative in nature, the research does suggest that e-bikers are routinely people who have switched from cars. Hence, in a recently published summary article (2015), Fishman and Cherry detailed a number of research studies pertaining to e-bikes. Although e-bike use is clearly developing in the Netherlands, the authors note that China remains ahead of the Netherlands in e-bike development. In China, one-quarter of all e-bike rides replace car rides, and only a small percentage (7 percent) are undertaken by regular bicycles (Fishman & Cherry, 2015). Data from the Fietsberaad (Van Boggelen & Van Roijen, 2013) reveals that people who switch from cars to regular bicycles cycle an average of 9.8 kilometres to reach their workplace, while people who switch from cars to e-bikes travel at least 12 kilometres (Figure 8.5). The distances travelled from home-to-work by regular bicycle are shorter on average - less than 5 kilometres by regular bicycle. The car commuter who switches to an e-bike therefore travels a distance that is on average 2.5 times longer than the distances travelled by commuters riding regular bicycles. Consequently, this shows that e-bikes can be used to replace longer car trips with bicycle trips. Because the radius of action increases, the e-bike is seemingly a new type of bicycle that can and will significantly alter the mobility options of its users.

However, some considerations still remain in support of using cars to travel shorter distances and not switching to e-bikes, such as the need to carry baggage.

Figure 8.4 Average home-to-work distance for cycling commuters (left) and for cycling commuters who previously travelled to work by car (right). Source: Fietsberaad (2013); adapted by KiM



Liveability

Walking and cycling contribute to improving liveability. Cycling and walking do not emit air pollutants, such as nitrogen and sulphur dioxide, particulates and CO2, and they do not generate noise. Moreover, the spatial use of bicycles and walking, as measured by the amount of space required for a parking place, is substantially less than that of passenger cars, for example: Parking a bicycle requires a surface area of 1.5 m^2, while parking a car on the street requires approximately 11 m^2.

Traffic safety

Cyclists account for nearly one-third of all the traffic fatalities that occur annually in the Netherlands: in 2014, 185 of the 570 traffic fatalities were cyclists (CBS, 2015). The number among the seriously injured was even higher, at more than 10,000 (or 60 percent of all seriously injured persons were cyclists, according to a study by SWOV (2014)). Moreover, annually, tens of thousands of cyclists (approximately 71,000 in 2011) require emergency medical help (SWOV, 2012). Cyclists have also increasingly claimed a larger share of the total traffic fatalities in recent years, and particularly a higher share among the seriously injured (KiM, 2014). The percentage of pedestrians among the total traffic fatalities has remained constant: 49 of the people killed in traffic accidents in 2014 were pedestrians, which is 9 percent of the total number of traffic fatalities (CBS, 2015).

Per kilometre travelled, the risk of being killed or seriously injured when travelling by foot or by bicycle is highest for senior citizens (aged 75+) (SWOV, 2012). The majority of fatal bicycle accidents (60 percent) occur in the built-environment and at intersections (both in and outside of the built-environment) (Reurings et al., 2012; SWOV, 2015); in 2014, there were nearly as many pedestrian victims (26) in the built-environment as outside of it (24).

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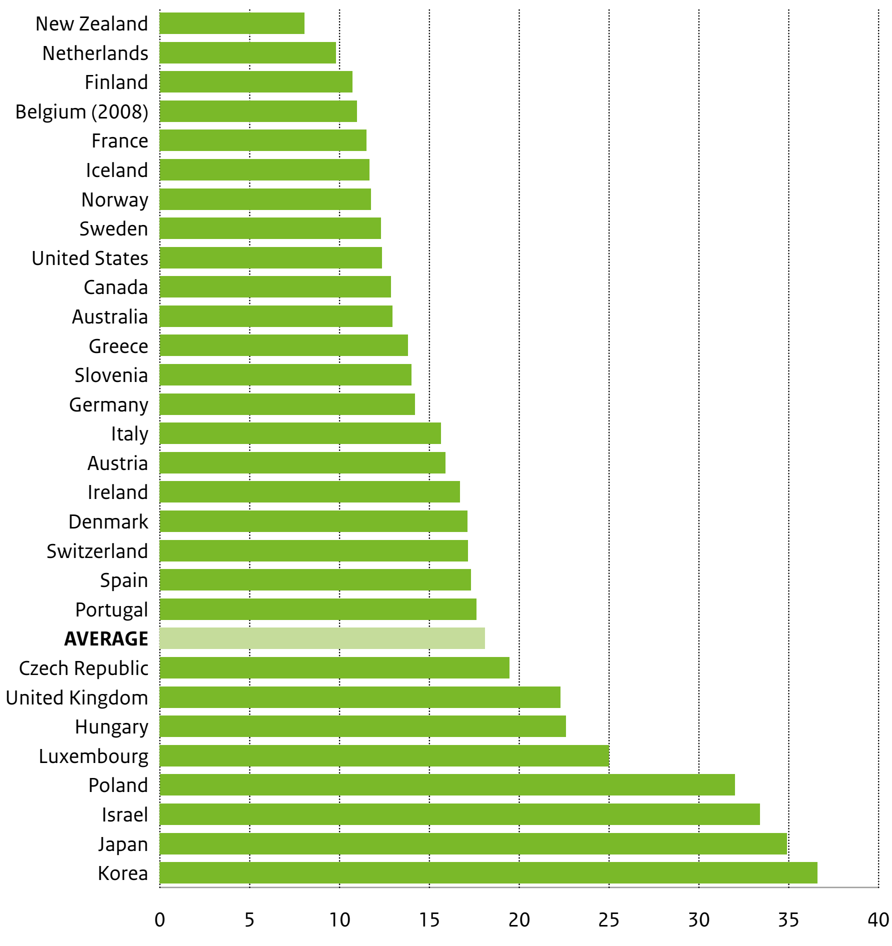
Compared to other countries, a very low percentage of traffic fatalities in the Netherlands involve pedestrians, although from this we should not immediately surmise that the safety situation for pedestrians in the Netherlands is excellent. Rather, this can partly be explained by the fact that there are relatively few pedestrians in the Netherlands, because cycling is so popular. Moreover, the number of pedestrians as traffic fatalities has also decreased in the majority of countries surveyed, as it also has in the Netherlands, which can be attributed to improved safety, but also to the fact that at present fewer children walk. Senior citizens are overrepresented in the fatality figures: an average of 13 to 20 percent of the population is aged 65+, yet more than 50 percent of all the pedestrians killed in traffic are aged 65+ (ITF, 2012); see also Figure 8.5.

Figure 8.5 Pedestrian fatalities as a percentage of all traffic fatalities. Source: ITF (2012)



If we also include accidents that involve falling, the figures are much higher. Figures from the emergency services reveal that for every recorded traffic accident there are four separate incidents involving tripping and falling (CROW, 2014). Research by VeiligheidNL found that two-thirds of all hospitalizations were accidents resulting from falling incidents in public places, and such incidents have experienced explosive growth in recent years: by 100 percent between 2006 and 2011. As a result of accidental tripping incidents, 160 pedestrians died, 11,000 pedestrians were hospitalized, and 48,000 pedestrians were treated by the emergency services in 2011. Approximately three-quarters (77 percent) of pedestrians were injured by a fall. This figure is lower for cyclists, at 60 percent. The associated direct medical costs (not including home-care costs after being released from hospital) for injured cyclists and pedestrians amounted to 220 and 120 million euro, respectively (Den Hertog et al., 2013). Given the Netherlands' ageing population, these figures and the associated costs will continue to rise. Forecasts for the total number of future falling incidents (both at home and elsewhere) indicate that the number of deaths, hospitalization and emergency treatments required due to falling incidents will increase by a factor of 1.7 to 1.8 (Den Hertog et al., 2013).

These figures must be approached cautiously, however. Various sources provide information about the numbers of bicycle accidents. The BRON traffic accident registration, which records accidents registered by the police, is the only source that includes detailed information about the accident; the BRON files are also used in traffic accident analyses. In addition, there are three available sources in the medical sector, each with its own objective: the National Medical Registration (LMR) for hospitals; the LIS injury information system, which includes the causes of the injuries that people received emergency treatment for at one of fourteen hospitals around the country; and the OBIN (Accidents & Mobility in the Netherlands), an ongoing survey of self-reported injuries from accidents and sports-related injuries. Each of these sources has its limitations, however. Hence, the BRON is incomplete, unrepresentative and unstable over time. LMR is incomplete (although more complete than BRON) and occasionally incorrect regarding transport modes, for example. Based on the LMR and BRON, SWOV annually estimates the number of seriously injured people. However, since 2009, a lack of hospital inpatient records in BRON means it is no longer possible to determine the number of seriously injured according to age and transport mode.

Other social effects

The health benefits associated with switching from cars to bicycles include reduced emissions of air polluting particles (SO2, NOX and PM10) and greenhouse gasses (CO2), and increased physical activity. The disadvantages are inhalation of air pollutants and an increased risk of traffic-related accidents. The health benefits substantially outweigh the disadvantages, however: the average increase in life-expectancy due to the physical exercise of cycling is 3 to 14 months more than a possible decrease due to inhalation of polluted air (0.8 to 40 days) and the increased risk of traffic accidents (5 to 9 days) (Hartog et al., 2010; Fishman & Cherry, 2015; Mueller et al., 2015).

Employees who routinely cycle to work (3-4 days per week, 2-4 kilometres) are sick an average of one day per year less than employees who cycle to work less than one time per week. The more frequently people cycle, and the longer the distances they cycle, the lower their absentee rate due to illness.

Van Kempen el al. (2010) also arrived at this conclusion. If a person (especially a younger man) replaces a short car ride with a bicycle ride, his or her propensity for illness decreases due to the increased physical activity (Hendriksen, 2009). It is possible that this is partly attributable to the fact that healthy people are more willing and able to opt to ride a bike - a form of self-selection. The health effects due to noise disturbance or inhalation of polluted air are negligible. A negative effect of switching to a bicycle is the higher probability of being involved in a traffic accident.

As previously stated, e-bikes offer people the possibility of travelling longer distances than regular bicycles, which is likely to positively impact one's experiences and feelings of objective self-reliance and self-confidence. Moreover, with e-bikes it is easier to ride up hills, cycle against the wind and carry heavy bags, and they also allow more people to cycle: people who do not like to ride regular bicycles, older people who are physically weaker or people with physical disabilities (Gojanovic et al., 2011; Louis et al., 2012; Sperlich et al., 2012). Although e-bikes require less physical exertion to ride, they do still meet the average requirements set for healthy movement (NISB 2015).

E-bikes do however have their disadvantages: they are heavier and more expensive than regular bicycles, and replacing their batteries requires additional costs. Moreover, as previously stated, e-bikes require less physical exertion to ride than regular bicycles and therefore are less beneficial to one's health (Behrendt, 2013), e-bikes are too fast for the existing bicycle infrastructure (Du et al., 2013; Kahn, 2014; Papoutsi et al., 2014; Schepers et al., 2014; Yang et al., 2014), e-bikes are not as safe as regular bicycles (Fishman & Cherry 2015), and the e-bike's battery has negative environmental effects (Fishman & Cherry 2015).

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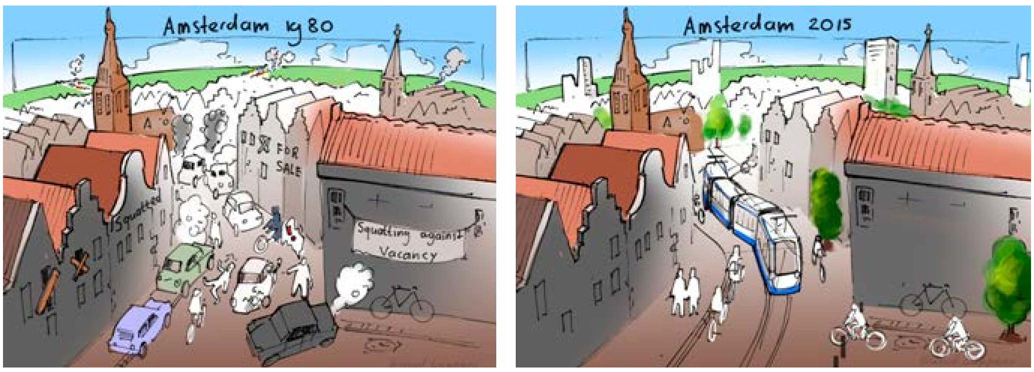
Policy focused on cycling and walking

The Netherlands has a rich tradition of policy focused on the active modes. Starting in the 1970s, substantial investments have been made in new cycling infrastructure. Such investments were made to help offset the sharp rise in car ownership rates and car use and the negative impact this has on accessibility, liveability and safety in cities (De La Bruheze & Veraart, 1999; Oldenziel & De La Bruheze, 2011). Over the past decades, substantial changes have been made to the designs of many streets and roads in Dutch cities (see Figure 9.1). Successful policies have not only been implemented on the municipal level, but also in national programs whose stated objectives are to improve the urban and rural conditions for cycling (De La Bruheze & Veraart, 1999). Since 2007, regional governments are responsible for cycling and pedestrian policy.

Recent insights into the effectiveness of Dutch cycling policy (Harms et al., 2015) reveal that major successes were achieved at many locations within cities, but that more is needed to promote bicycle use than simply the construction of cycling infrastructure (hardware): cycling policy and dedication to cycling-related goals must also be in place (orgware), including required programs and campaigns (software). The same applies to pedestrian policy. Unfortunately, there is often a lack of good ex-post evaluations of measures for promoting the active modes. Moreover, the limited recording of trips taken with the active modes (particularly for pedestrians) means that developments can be difficult to identify.

This chapter explores the effectiveness of bicycle and pedestrian policies in ex-ante and ex-post evaluations, and considers current and future developments.

Figure 9.1 Illustration of changes to the streetscape in many Dutch cities.



Ex-ante evaluation of policy

A social cost-benefit analysis (SCBA) is devised for conducting ex-ante evaluations of major infrastructural measures, such as MIRT projects. For this purpose, the Ministry of Infrastructure and the Environment uses the OEI methodology (Overview Effects Infrastructure). However, this methodology is rarely used for active modes infrastructure, because investments in pedestrian and cycling infrastructure are relatively limited, and also because these are frequently regional or municipal projects, for which applying a SCBA is less useful.

SCBAs for pedestrian or cycling infrastructure are therefore not as well-developed as those for large infrastructure projects (Wee & Börjesson, 2015). Hence, information about travel time valuation (for various groups of bicycle users), travel times and price elasticities is lacking: cyclists and pedestrians moreover do not fit particularly well in transport models; we do not know very much about pedestrians or cyclists as part of the mobility chain; and ex-post evaluations of active mode measures are rarely available (Van Ommeren & Goedhart, 2011). This type of weighing is also highly dependent on context. For example, owing to issues such as cultural differences and the varying base-levels of cycling and walking, studies conducted in other countries are of limited applicability to the situation in the Netherlands.

A recent graduate study (Van Ginkel, 2014) made a first attempt at establishing the Value of Time (VoT) for bicycles. This value is used in SCBAs to calculate the benefits of new or improved infrastructure for certain transport modes. The value that Van Ginkel (2014) arrived at for bicycles is higher than the VoT routinely used for cars. The author stated that this is primarily due to the fact that the time spent cycling is unproductive time, and that cyclists cannot multitask while cycling. For longer cycling trips (lasting more than 30 minutes), or for cyclists who derive more pleasure from cycling, the VoT is lower, according to the study. Due to the study's practical limitations (limited number of surveyed cyclists, limited number of locations studied, only one research season), it is implausible to surmise that this VoT is applicable to all bicycle trips and hence sufficiently reliable for use in SCBA calculations. However, this study did importantly conclude that the travel time gains that can be achieved from constructing cycling infrastructure can provide major benefits, particularly regarding an increase in comfort (Van Ginkel, 2014).

Ex-post evaluation of policy

The regional policy currently in place generally consists of a mixture of many relatively small measures, such as constructing bicycle paths, providing bicycle parking provisions, creating car-free city centres, and so on. It is often difficult to ascertain the effects of individual measures, as the totality of measures primarily determines the bicycle-friendliness of a particular location. Hence, a key finding of individual research studies into the effectiveness and efficiency of cycling policy is that in fact it is difficult to arrive at conclusions that can then be translated into effective cycling policy, as was for example recently revealed in a research study of the effectiveness of Dutch municipal cycling policy (Harms et al., 2015).

Because assessments of the effectiveness of policy measures are fragmented, the effects of cycling policy are best derived from meta-studies (Rietveld & Daniel 2004; Pucher et al., 2010). According to Harms et al. (2015), three types of meta-evaluations can be distinguished: *evaluative* meta studies , which calculate the effects of measures following their implementation and the causal connections revealed between measures and effects; *quantitative* meta-studies, which compare the policies of various cities or regions; and *qualitative* meta studies, which study the roles that the various aspects play in available case studies (without making statements about the overall impact of the effects).

Because there are so few available ex-post evaluation studies of active mode policy measures, it remains difficult to ascertain if causal relationships exist between policy interventions and the effects on bicycle use. According to an overview study by Harms et al. (2015), many of the *quantitative* meta-studies are currently accepted without comparisons in time, whereby it is difficult to relate causes and consequences to one another. However, we can draw conclusions from some studies. One much-cited study by Rietveld and Daniel (2004) found that parking costs and relative bicycle travel times are key factors for cycling policy. Raising car parking fees, and reducing bicycle travel times as compared to cars, results in increased bicycle use. The research conducted by Harms et al. (2015) found that the following factors are important

for successful cycling policy:
- Making bicycle use more attractive, for example by improving the amount and quality of bicycle infrastructure ('hardware' pull-regulations)
- Making car use less attractive, for example through infrastructural modifications or parking policy ('hardware' push-regulations);
- A well-organized and implemented policy, such as formulating measurable objectives, promoting citizen participation, adaptability, and space provided for experimentation ('orgware');
- Marketing, communication and education, such as traffic education courses for children ('software');
- Taking into account specific social-spatial characteristics of areas, cities and neighbourhoods.

Less is known about the effectiveness of pedestrian policy, however, but many of the previously mentioned factors should also be applicable. In 2012, the NHTV conducted research focused on the position of pedestrians in the policies of various Dutch municipalities (Spapé & De Leeuw, 2012). This study highlighted the following points:
- Data:
  - A minimal amount of research has been conducted regarding pedestrians. Interventions, which are important for pedestrians, are rarely based on available data or figures.
  - Municipalities need more data for policy.
- Evaluation and coherence of policy:
  - The importance of pedestrian policy and the added value of pedestrians are often underestimated.
  - Pedestrian policy measures are often taken on an ad hoc basis.
  - Municipalities particularly focus attention on specific areas, such as shopping centres, areas around schools and train stations, but not on residential areas.
  - Pedestrian policy is lacking on the upper municipality level. Municipalities receive insufficient policy frameworks from the national government, provinces and city regions.

Current and future policy for cyclists and pedestrians
Regional governments have been responsible for regional traffic and transport decisions since 2007, and thereby for cycling and pedestrian policy. The current regional policy consists of a mixture of many relatively small measures, such as constructing cycle paths, the responsibility for providing bicycle parking provisions, rendering city centres car-free, and so forth. Additionally, increasing numbers of municipalities are devoting attention to pedestrians; examples of municipalities with pedestrian policies in place include Eindhoven, Amsterdam, and The Hague. Utrecht and Rotterdam are more explicitly focused on cyclists; however, Utrecht is also currently devising a specific pedestrian policy. In addition to the municipalities' efforts, a number of national and regional initiatives are also of influence on current and future policy for cyclists (and to a lesser degree for pedestrians). The most important initiatives are summarized below.

First, the collective governments recently launched a project called 'Tour de Force', an initiative of Fietsstad Zwolle, which involved drafting a collective agenda for cycling policy (Van Boggelen, 2015). With Tour de Force, the collective governments aim to utilize the 'power of bicycles' and thus give a major boost to the social vitality of cities and regions. The goal is to bolster and support new and existing initiatives through the creation of favourable conditions, with the focus on collecting and disseminating new knowledge and data, promoting new forms of organization, and financing and promoting (technological) innovations.

Second, the national government is initiating 'Agenda City' (www.agendastad.nl), in which attention is focused on liveability in cities. The national government invited cities and other stakeholders, including provincial governments, knowledge institutions, companies and societal representatives, to contribute to this agenda. The so-called 'proof of the pudding' will be the development of urban coalitions and 'city deals', in which cities connect to stated aims pertaining to circular development and sustainable development, economic and technological innovation, transitions in transport and homes, new types of management and digital government, and so forth. Although Agenda City's line of approach is much broader than merely cycling, promotion of the active modes is part of the 'Transitions in Transport' theme.

Third, the national government has recently drafted a parliamentary letter drawing attention to the increased use of bicycles and bicycle path congestion in cities (Ministry of I&E, 2015). The national government indicated that it was prepared to assist regional governments through facilitation (including with improved data and models and a bicycle app derived from the Optimising Use Programme), promotion (researching the options of starting school at different hours) and experimentation (offering space for customization). The 'FietsTelWeek' recently provided additional data about bicycle use (September 2015): during that week, the Cyclists' Federation, municipalities and provinces deployed a cycle app on smartphones to map bicycle speeds and cycle routes. The resulting information can be used to further customize cycling policy.

Fourth, the national government promotes cycling and walking through:
- financially supporting regional government via the BDU Policy;
- cycling measures within the Optimising Use Programme;
- expanding bicycle parking racks at train stations via Prorail;
- construction of regional high-speed bicycle paths, in conjunction with the Cyclists' Federation and regional governments;
- granting subsidies to organizations that promote bicycle use, such as the Cyclists' Federation.

In addition to the Ministry (I&E), other departments also promote cycling and walking. The Ministry of Economic Affairs promotes the use of bicycles by foreign tourists through NBTC Holland Marketing. The Ministry of Health, Welfare and Sport uses NISB research to promote a bicycle-friendly design of local surroundings.

The Netherlands, cycling country par excellence?

The Netherlands develops many initiatives pertaining to cycling and pedestrian policy, and certainly enjoys a fine reputation with regard to bicycles. However, the Netherlands' status as the preeminent cycling country of Europe, which for years has gone unchallenged, is seemingly changing. For although the percentage of cycling in the Netherlands remains unquestionably the highest among all European countries (cycling claims a 26 percent share in the Netherlands, followed by Denmark at 19 percent, and Germany at 10 percent), other characteristics also contribute towards making a country a cycling country. Since 2013, the European Cyclists' Federation has maintained a ranking of the most cycling-focused countries in Europe, which involves grading each country according to five characteristics: the percentage of cycling (in which the Netherlands traditionally scores high), bicycle safety, the importance of cycling tourism, the size of the commercial bicycle market, and (the influence of) cycling advocacy groups (see Figure 9.2). In 2013, the Netherlands and Denmark were both ranked first; however, in 2015, Denmark surpassed the Netherlands. The Netherlands now ranks second on the list of most bicycle-friendly countries. While it remains true that Dutch people cycle the most, in terms of the number of new bicycle purchases and the amount (and hence the influence) of cycling advocacy groups, Denmark scores higher (ECF, 2015).

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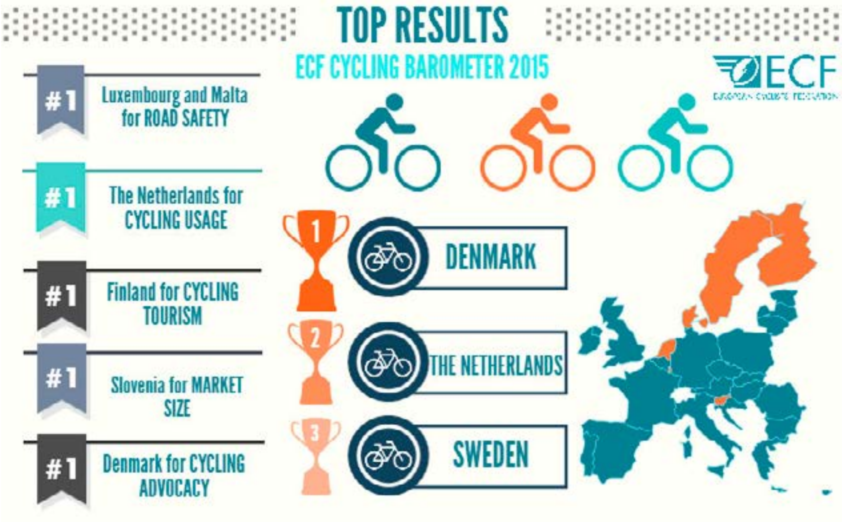
Figure 9.2 The barometer of the European Cyclists' Federation in 2015. Source: European Cyclists' Federation (2015)



10
Conclusion: what gear is the Netherlands in as a cycling and walking country?

After reading this background report, one thing is certainly clear: cycling and walking play an important role in our Dutch mobility system. There are more bicycles than people in the Netherlands, and the percentage of bicycles in the Netherlands is the highest of all EU countries. Due to our compact (inner) cities, destinations within the city are usually situated at distances that we deem acceptable to travel to by bicycle or by foot. The percentage of the active modes in Dutch mobility is very high: nearly half of all trips are undertaken with the active modes, and approximately one-third of our travel time is spent walking or cycling. And the list goes on: cycling and walking are healthy activities, even when taking into account the higher associated safety risks; the active modes reduce dependency on cars, (the likelihood of) transport poverty in cities, and are environmentally-friendly. Moreover, in a large percentage of train trips, one or the other types of active modes serve as access or egress mode.

Change has indeed been observed in the active modes. The high percentage of active mode use has remained constant for many years, but in recent years we see that in three aspects of mobility, things are starting to shift. First, we see that the numbers of kilometres travelled using the active modes are increasing: since 2004, we cycle and walk more frequently and for longer distances. The growth in the number of pedestrian kilometres can be traced back to population growth, particularly among the group of people of non-Western ethnic origin, who walk frequently, while the increase in cycling is largely attributed to the rapid rise of e-bikes. Second, we observe a spatial differentiation. Bicycle use has primarily increased in the city, resulting in congestion on city bicycle paths. And third, we observe that major differences exist between certain population groups in the Netherlands: people of non-Western ethnic origin primary walk and walk frequently (and they are the fastest growing population group in the Netherlands); more women now cycle as a result of their increasing participation in the labour market; and e-bikes allow older people to remain cycling later in life.

The e-bike is an interesting development in our cycling country. There are increasingly more (or modified) types of bicycles on the bicycle paths, ranging from electric three-wheel bikes to Segways, but none of these various types has had such a large and measurable impact as the e-bike. E-bikes are the only type

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of bikes for which sales figures are rising; for all other types of bikes, sales are down. Riding e-bikes, we can cover distances that are approximately 1.5 times as long as those for regular bicycles; for home-to-work commutes, e-bikers cycle twice as far as regular cyclists. Moreover, e-bikes are no longer solely the domain of senior citizens: people under the age of 65 are increasingly using e-bikes, and people are increasingly using e-bikes to cycle to work. The difference in speed compared to a regular bicycle remains limited, however.

In this report we have also attempted to unravel and explain how cities differ in terms of cycling percentages. The composition of the population in a certain postal code area seemingly has a profound effect on the percentage of cycling. Moreover, spatial characteristics also play a role; namely, the distance to facilities within a postal code area.

The Netherlands has a rich tradition of policy focusing on the active modes. Starting in the 1970s, major investments have been made in new infrastructure, focusing on the accessibility, liveability and safety of cities. The construction of cycling infrastructure has generally had a positive cost-benefit ratio. However, in order to promote bicycle use, more is needed than simply constructing cycling infrastructure (hardware). Cycling policy and dedication to cycling objectives must be well established, as well as the requisite programs and campaigns (software). The same applies to pedestrian policy. Unfortunately, there is a lack of good ex-post evaluations of measures for promoting the active modes. Moreover, because trips using the active modes (particularly by pedestrians) are often underreported in travel surveys, developments can be difficult to interpret.

All this exploration still leaves a number of questions unanswered. How will the described developments continue? What does this mean for policies pertaining to cyclists and pedestrians? And what gear is the Netherlands in as a cycling and walking country?

The importance of cycling and walking in the total mobility system in future will be further explored in a collection of essays to be published later (in Dutch).

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Appendixes

Appendix 1 Background to the figures cited

This report provides an overview of the use of the active modes in the Netherlands, as based on analyses of data derived from Statistic Netherlands' 'Dutch National Travel Survey' (OViN). The OViN is a comprehensive and specialized survey that provides insights into the daily mobility of the Dutch population[10]. Since 2010, approximately 40,000 Dutch people have been surveyed annually. The OViN is intended to make statements about people's mobility and the totality of trips undertaken, including the travel kilometres of the Dutch population.

Four additional data sources were used in the (explanatory) analyses described in Chapter 7:
- a dataset based on the CBS figures pertaining to districts and neighbourhoods and which includes for every relevant neighbourhood therein the demographic characteristics, distances to facilities, property data, and so forth (CBS, 2015);
- a dataset based on a customized version of the OviN, including social-economic data (number of employed people, average home-to-work distance, and so forth) for each city therein; and
- a dataset based on an inventory made by the Dutch Cycling Union (Fietsersbond) (2000-2010), including, for a number of cities, objective information pertaining to cycling policy (such as budgets, reports) and subjective assessments of possibilities for cycling (such as social safety).

Other data sources exist in which mobility is recorded (particularly internationally); however, among the various data sources, the figures for walking and cycling trips can vary considerably. There are numerous possible reasons for this, including the varying criteria used to record certain trips (minimum distance levels), differences in the instructions or questions given to the respondents, or differences in how the recorded trips are checked.

Multiple other studies found that the traditional manner of surveying travel behaviour resulted in an underreporting of shorter trips. This was also the case in the OViN. In 2005, the Rijkswaterstaat Transport Research Centre (AVV) researched the underreporting of walking trips (Methorst 2005). That research revealed that the MON 2004 had underreported pedestrian kilometres by 40 percent. Although the study was limited in scope, we can however cautiously surmise that the MON/OViN data is too low in terms of the number of pedestrian trips per day (0.54 pppd); the AVV research from 2005 (Methorst 2005) estimated this to be approximately 1.0 pppd. The average trip distance was estimated to be 710 meters, compared to 1,075 meters in MON 2004.

Since 2013, the KiM Netherlands Institute for Transport Policy Analysis has had access to a new mobility behaviour data source: the Netherlands Mobility Panel (MPN). The MPN is a longitudinal household panel that KiM started in 2013, in collaboration with the University of Twente and Goudappel Coffeng. The MPN focuses on expanding insights into the factors that play roles in changing travel behaviour, such as major events in a person's life. The MPN inquires about the various locations people have visited rather than the trips that were undertaken. Participants are also explicitly asked to record all access and egress trip-segments made to collective transport modes (for example, the transport mode a person used to travel to the bus stop) (Hoogendoorn-Lanser et al., 2014).

[10] The OViN only recorded the trips people made on one day and thereby provided no insight into the number of Dutch people who never cycle. The rides or kilometres per person are thus averaged over all Dutch people, regardless of whether they have ever cycled.

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In order to study what effects the new approach in the MPN had on the recording of walking and cycling trips, we compared the average active mode trip distances in the MPN and in the OViN. The MPN figures show a lower average distance per pedestrian trip or bicycle trip. Where the average bicycle trip (with the bicycle as main transport mode) in the OViN covers 3.7 kilometres, in the MPN it is significantly shorter at 3.0 kilometres. Walking trips in the MPN are also shorter: an average of 1.3 kilometres, compared to 1.7 kilometres in the OViN. This indicates that there was a better recording of shorter trips in the MPN.

Due to this approach, people on average recorded slightly more trips in the MPN, and the average recorded trip distances in the MPN are shorter. Trips up to 5 kilometres in particular are better represented in the MPN (54 percent of all trips in the OViN, compared to 62 percent in the MPN).

Despite the OViN's limitations in certain areas, the OviN is the only data source that covers the entire country and provides a differentiated view of travel behaviour in the Netherlands. The MPN does not have enough respondents (slightly more than 5,000) to achieve this objective. For this reason, we primarily rely on the OViN in our analyses. Where necessary, we use figures from the MPN in order to indicate how the figures could be interpreted or enhanced.

Appendix 2 A bit more about distances: areas of influence, straight-line distances and actual distances.

In urban design, the starting point is often a certain area of influence around a facility or provision. In the case of a train station, NS Dutch Railways uses the so-called circles theory (*kringentheorie*) in order to estimate the number of travellers who use a train station. According to this theory, the calculation to determine how many people would use a station is dependent on the number of potential users in successive circles of 500 meters (up to 500 meters, 500 to 1,000 meters, 1,000 to 1,500 meters, and so on). In each successive circle the percentage of public transport use per head of the population decreases (Van der Blij et al., 2010). At issue here then are not only the travellers who travel by foot to and from the train station, but also the travellers who opt to use another type of pre- and post-transport. This theory is also used for bus stops, whereby the primary focus is then on the people who walk to the bus stop. In addition, areas of influence are also considered as a means of predicting the number of people who will visit other facilities, such as shopping centres.

The size of the area of influence depends on the time that people are prepared to travel to reach a specific destination, and this is dependent on the importance that a person attaches to reaching that destination. Hence, it holds that people are prepared to spend an average of five minutes on walking to a bus stop (Van der Blij et al. 2010), but 12 minutes on walking to a train station (Rijkswaterstaat, 2004-2009). The time that it costs to arrive somewhere is often calculated, rather than observed, and deviations can creep into the choices that are made therein. Consequently, the calculated time that it takes to walk from A to B is usually based on a theoretical speed and the straight-line distance: the area of influence around a provision is then presented as a circle (or multiple circles in the case of circles theory). This however is only correct in an open-field scenario, with equal distances from each point in the circle. In reality, the area of influence is much smaller, which is partly a consequence of the presence of existing buildings and other obstacles, and of waiting times at traffic lights. If we want to more precisely determine the acceptable travel time to a certain destination, we must consider the speed of travel and the street pattern.

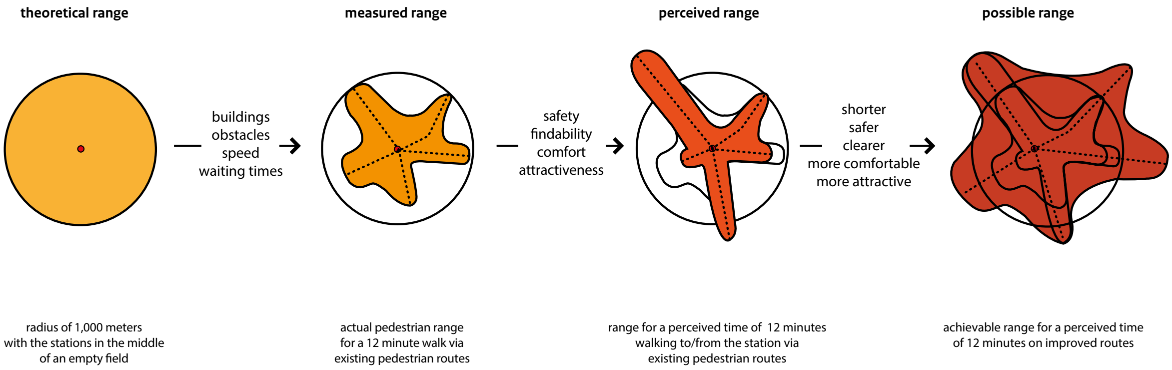
We shall use a train station as an example. In order to know what the area of influence is, we must look at the time that people are prepared to spend on travel. If our starting point is 12 minutes walking with a speed of five kilometres per hour, we arrive at a distance of 1,000 meters (Rijkswaterstaat, 2004-2009). For cyclists, another distance applies: because cyclists travel approximately three times as fast, the distance is then approximately three times longer. What applies to both modes however is that the distance must be measured according to the existing street patterns. We call the line that - measured according to the existing streets - connects all points equidistant from the centre of the circle the accessibility isochrone. The more intricate the street pattern, the more the shape of the isochrone will resemble a circle. Even in cities with intricate street patterns, the average actual distance to travel is also approximately 1.2 times 'as far as the crow flies' (or straight-line distance). In the best case scenario, one walks or cycles via a direct route to one's destination. If a street pattern is grid-shaped (which is often the case), it could be that one must deviate while walking or cycling to a factor of 1.4 (root 2) (Wittenberg, 1980).

The illustration in Figure B2.1 shows two cities with differing street patterns around a train station, including two circles around the stations with a radius of 800 (light orange) and 1,200 meters (dark orange), respectively, and the accompanying accessibility isochrones in the same color. One can see that the area to be reached by foot is much smaller in the example on the left (Den Bosch) than in the example on the right (Hilversum).

Figure B2.1 Accessibility circles and isochrones around the Den Bosch (left) and Hilversum (right) train stations

An isochrone better represents the actual area of influence than a circle. If we take this a step further, we can also include the waiting time at traffic lights or unregulated crossing points in order to determine the actual possible speed of travel. A step further could be the perceived time. Research has shown that people are poor at estimating time (Van Hagen 2011), and that people have shorter estimations of time the more attractive a route is, and longer estimations the less attractive a route is deemed to be. This applies to both pedestrians, who are prepared to walk 1.5 times as far for attractive routes (Bach and Pressman 1992), and cyclists, according to research of cyclists' perception of travel time conducted by NS Dutch Railways and Goudappel Coffeng in Utrecht. An isochrone of the access and egress time experience could have long points extending beyond the standard time isochrone along attractive routes and indentations at places where there are unattractive routes. A schematic representation of the range around a station would then appear as in Figure B2.2.

Figure B2.2 From theoretical accessibility to perceived accessibility. Source: Molster and Schuit (2013).



Colophon

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