Cycle highways and their impact on transport behaviour – A comparative study between Denmark and the Netherlands

Abstract:
Cycle highways are high-grade bicycle paths on which cyclists can travel fast and efficiently for long distances. By building this type of infrastructure, governments hope to stimulate cycling and convince commuters to cycle instead of drive. The goals are chiefly to relieve traffic congestion and reduce CO_2 output caused by car-driving commuters. Denmark and the Netherlands have the most developed networks of cycle highways.
This study compares the Danish and Dutch cycle highways and its users by means of a questionnaire survey, a manual bicyclist count and unstructured observation at a bicycle highway in Denmark and in the Netherlands. The goal of the study is to determine the effect of the cycle highways on travel behaviour.

Analysis of the data collection shows that by far the most cycle highway users are commuters who, on average, cycle more than 20 kilometres daily, five days per week. Many of these cyclists did cycle (as much) before the cycle highways were established, indicating a change in transport mode choice and distance. Most Danish cyclists have switched from public transport to cycling, while the majority of the Dutch respondents switched from driving to cycling. From the study it can be concluded that the construction of the cycle highways has led to shift in transport mode and thus have reached their goals.

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1. Introduction

In countries that experience urbanisation and population growth, land use problems often occur. When the population density increases, the competition for space intensifies and the pressure on the city systems, i.e. energy, water, food supply and transportation systems, increases as well. The existing infrastructure network may reach its maximum capacity and building more infrastructure, e.g. roads, takes up scarce and expensive land. Additionally, research shows that building more roads in fact leads to more car traffic (Duranton & Turner, 2011). In short, the study shows that building more roads leads to more economic activities along these roads and thus more traffic. From the research by Duranton and Turner it became apparent that one percent of added road surface leads to one percent more traffic. This increasing of road capacity in order to resolve traffic congestion seems wildly inefficient and unsuitable for expanding cities where the use of land is heavily competed. Turning land into roads so that car drivers can stand still on them with their engines running is a highly inefficient and unsustainable approach to dealing with an increase in population and thus transportation. Reducing car traffic is also beneficial from health, environment and safety perspectives, but in this case the inefficient use of land is the central argument for studying alternatives to car traffic. All in all, this means that growing cities need to focus on public transport and non-motorised traffic to ensure efficient land use and accessibility. The shape of a city, i.e. the urban form, and how citizens travel through this urban form, i.e. the transportation patterns, have a strong influence on the efficiency of land use. The urban-suburban shape, where people live in suburban areas and work in the urban core, is popular in many countries, but often results in much car traffic, causing valuable land resources to be used for road infrastructure.
A possible solution to this problem is to encourage the use of public transport and cycling as the main modes of transport for the traffic between the suburban areas and the urban core, which is mainly commuting traffic. These modes of transport use the infrastructure in a more efficient way, i.e. transporting more people on a given amount of infrastructure. This is illustrated well in figure 1.1, this famous image shows how much road space 69 persons take up in a bus, on bicycles and in cars. Although the bus and bicycle both take considerably less space than the private car, bicycle infrastructure will be the main focus in this report. Although cycling is part of a larger transport system where public transport also plays a considerable role, the bicycle offers advantages in availability, versatility and health benefits that could make it a realistic alternative for the car under the right circumstances. Recently, the Danish and Dutch government have been investing in new bicycle infrastructure in order to make the bicycle a faster mode of transport for commuting distances. How feasible this is, often depends on the presence and quality of the infrastructure. In this report, the impact of infrastructure on cycling behaviour and attitudes towards cycling is researched with a focus on cycling infrastructure in Denmark and the Netherlands. It is acknowledged that investments in public transport facilities and infrastructure can also play a large role in discouraging car use, but because of the recent developments in cycling infrastructure construction, bicycle traffic is the topic of research in this study.

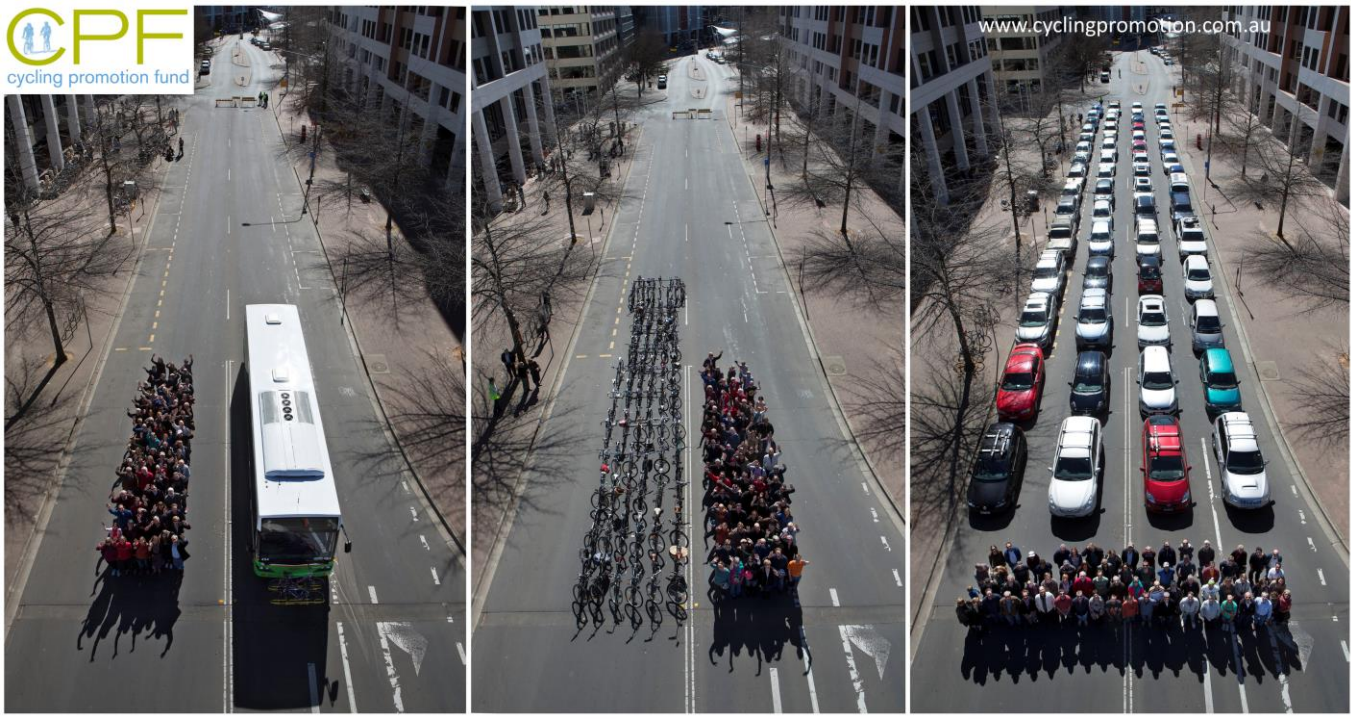


Figure 1.1: The amount of road space taken up by 69 people in a bus, on bicycles and in cars. Source: Australian Cycling Promotion Federation, 2014.

1.1 Cycling in Denmark and the Netherlands

Traditionally, the Netherlands and Denmark, in particular Copenhagen, are cycling-oriented countries. In both the countries, cycling has been integrated in traffic regulation and infrastructure development as well as culturally imbedded. Before and just after the second World War, many European countries had a thriving cycling culture. After its introduction as a leisurely sport activity for the elite, cycling quickly became popular as a mode of transport — especially after the invention of the two-wheeled bicycle in the 1890s, which was much safer than the high-wheel cycle which required riders to maintain their balance while seated high up in the air (Carstensen & Ebert, 2012). During to the Industrial Revolution, the bicycle went into mass-production and therefore became cheaper. This decrease in cost made the bicycle accessible to the working class who, as a result, experienced a major increase in their mobility. For many working-class members, the bicycle was the first form of personal transport they could afford. The role of the bicycle as social emancipator is considerable, giving the working-class access to much more people and places (Furness, 2005). After the war however, private car ownership soared (see figure 1.4), and infrastructure and city planning were centred around the car: distances between work and home became greater and motorways prevailed (Pelzer & Te Brömmelstroet, 2010). As a result, from the 1950s bicycle traffic as a share of all traffic[1] saw a steep decrease in many European cities (see figure 1.2), although the growth of private car ownership was less profound in Copenhagen than in the other European cities (Carstensen et al., 2015, p 152).

[1] The bicycle share of trips, i.e. the mode share of cycling, is the amount of transport by bicycle as a percentage of all transport on land, sometimes also called the bicycle share of the modal split. Generally, the mode share of cycling goes down as travelling distance goes up.

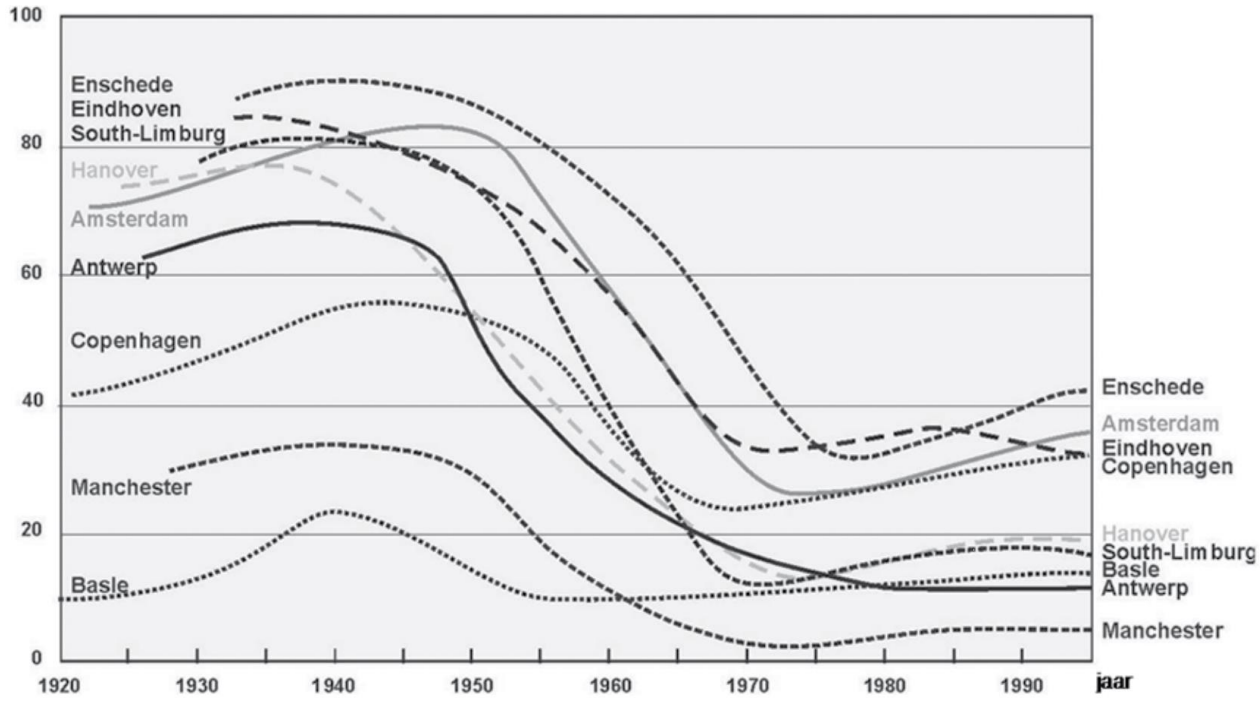


Figure 1.2: Mode share of cycling as a percentage of all transport between 1920-1995. Source: Albert de la Bruhèze & Veraart, 1999, p. 14.

This decline in bicycle mode share was halted in Denmark, primarily Copenhagen, and the Netherlands in the 1970s and the bicycle as a means of transport was reinstated. The negative effects of the car on the environment and space in the city became noticeable and caused a shift in transport and city planning policies and planning policy re-centred around the bicycle as a substantial transport mode in Copenhagen and the Netherlands (Albert de la Bruhèze & Veraart, 1999, pp. 17-24 & 33-40).

1.2 The comeback of cycling in the Netherlands

Up until 1975, the bicycle was a largely neglected mode of transport in the Netherlands — there was little attention or budget for cycling infrastructure development or even maintenance. The primary focus was on facilitating car traffic through a comprehensive plan to build a large network of roads and motorways, taking the infrastructure situation in the United States as an example. As a result of the growth in private car-ownership and the extensive road network, the distances between economic, cultural and social activities — for example school, work, sports and shopping — became greater, making cycling even less attractive. Additionally, the advancement of the motorway and road network meant there was less space available for bicycle lanes and paths (Albert de la Bruhèze & Veraart, 1999). From the 1970s however, the Dutch government focussed their attention on cycling as an alternative for driving, this had a number of reasons.

First, the traffic safety had deteriorated in the previous decennia and in 1972 the annual number of traffic fatalities reached a peak. This put traffic safety on the political agenda; regulating and restricting car traffic were discussed and alternatives like public transport and, mainly, cycling were considered.

Second, in 1973 the Arabian oil producing countries imposed on oil-embargo on many Western countries, including the Netherlands, by increasing the oil price by 70 percent and reducing the

production of oil by 5 percent each month. This caused an oil crisis in the country, exposing the cars' dependency on oil and created a resistance to the expanding network of roads and motorways.
A third reason for the increased attention for cycling in traffic policy, were of financial nature; the Dutch government had more and more difficulty to generate the budgets needed to maintain the pace of the road network development.
These developments resulted in a shift in traffic and infrastructure policymaking, focussing more and more attention on cycling and substantially increasing the budget for the construction of cycling infrastructure. In 1976, the ministry of Traffic and Water management — responsible for planning and building infrastructure — introduced two financial contribution schemes aimed to compensate the backlog in cycle infrastructure from the 1960s. The first scheme consisted of an 80 percent government funding for municipalities when constructing cycling infrastructure and facilities, like bike parking, within the built-up area. The second scheme ensured municipalities and regional authorities of 50 percent funding when building cycling infrastructure along secondary and tertiary roads. Starting out with a budget of 25 million gulden (approximately 11,3 million euro) in 1976, the budget for these schemes reached 53 million gulden (approximately 24 million euro) in 1982. The results were significant: when the contribution schemes were terminated in 1986, cycling infrastructure had been constructed along more than 90 percent of secondary roads and 70 percent of tertiary roads (Albert de la Bruhèze & Veraart, 1999). This trend of facilitating and planning for bicycle traffic has continued — since the 1970s transition in infrastructure planning, there has been a continual increase in kilometres of bicycle infrastructure, cycling safety and bicycle use. The sales numbers of bicycles and cars reflect this change in momentum in the 1970s, see figure 1.3. Bicycle sales increased considerably while car sales have an increase in sales that is halted in the 1970s. Car sales did increase after the 1970s, but so did the population, which means that car sales per capita have not increased.

	Fiets *Bicyde*	*Bromfiets* *Moped*	*Auto* *Car*	*Motor* *Motorcycle*
1951	365	71	.	16,2
1960	519	240	100	12,9
1970	850	284	432	3,9
1980	1.453	57	450	14,5
1990	1.350	84	503	15,5

Figure 1.3: The development of vehicle sales (x 1000) between 1951 and 1990. Source:

1.3 The comeback of cycling in Denmark

In Denmark, a similar trend of increased private car-ownership and a decreased bicycle share in the modal split of transport developed after the Second World War. Wartime rationing on oil, fuel and rubber were not abrogated until the beginning of the 1950s, which limited the advance of the private car initially. In the later part of the 1950s and 1960s however, car traffic grew fast and the car became dominant in traffic — traffic counts on a central street in Copenhagen between 1960 and 1967 showed a doubling in the car share of trips, from 24 percent to 46 percent, while at the same time recording a reduction of the bicycle share with half; from 40 percent to 19 percent (Carstensen et al., 2015, p. 150). The introduction of the car thus caused a shift in the modal split where the car became the dominant transport mode and where transport and infrastructure planning primarily focussed on facilitating car traffic — the general attitude of planners was that the car was the mode of transport for the future and infrastructure planning should focus on improving the speed and flow of car traffic (Carstensen et al., 2015). Compared to other European countries however, private-car ownership in Denmark never expanded as much, as can be seen in figure 1.4.

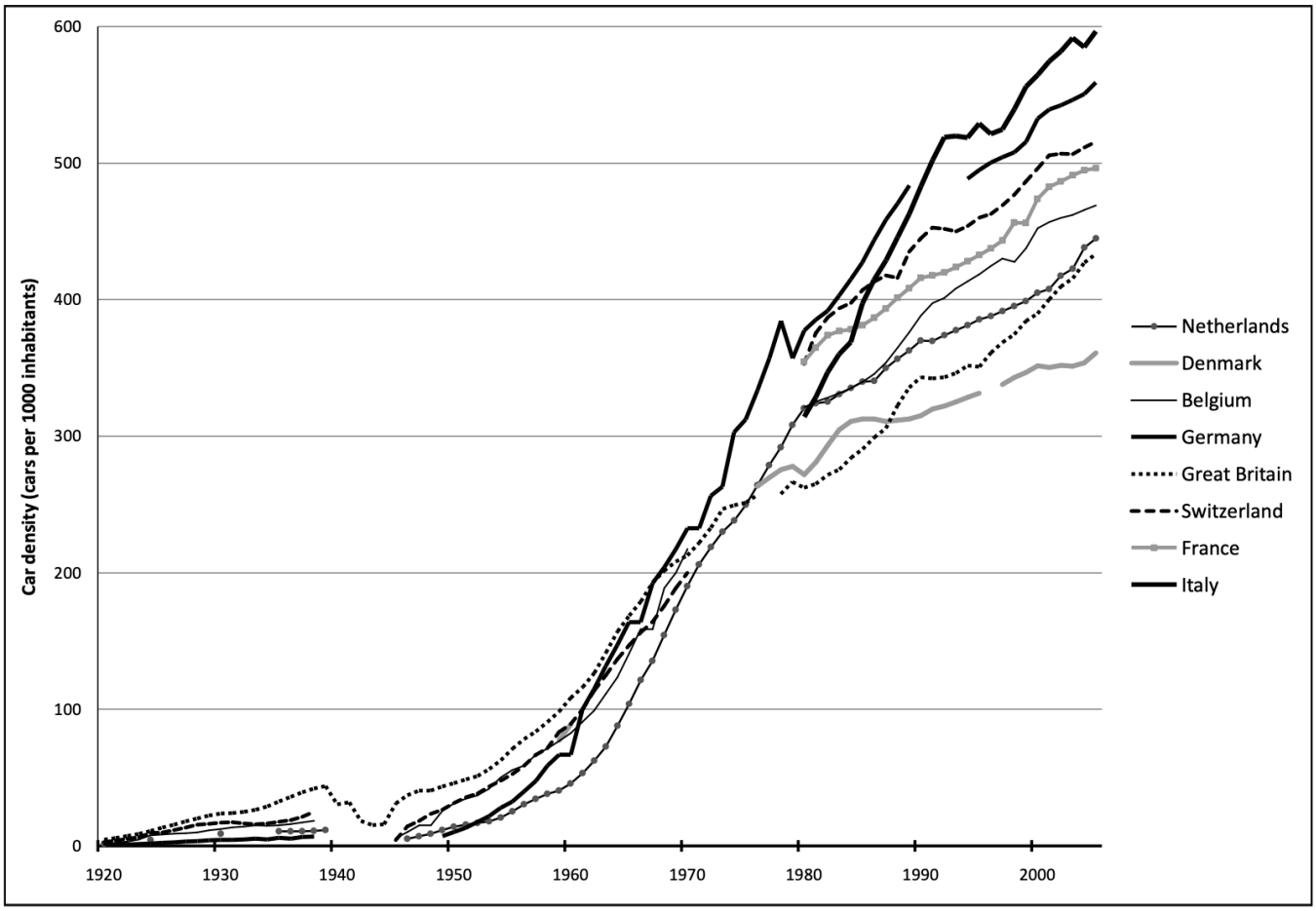


Figure 1.4: Car-ownership per 1000 inhabitants between 1920 and 2005. Source: Oldenziel & de la Bruhèze, 2011.

Several causes for this can be found in the academic literature. First, at the time of the introduction of the car, the city of Copenhagen already had a well-established network of high-quality bicycle infrastructure consisting mostly of bicycle paths, i.e. bicycle roads physically separated from the road for motorised traffic or carriages and trams before the introduction of the car (see section 2.2 for a more elaborate breakdown of cycle infrastructure types). These separated bike paths had already been introduced in Copenhagen in 1928, when the Danish Cyclist Federation noticed that car traffic endangered cyclists and demanded safer tracks for them (Carstensen et al., 2015). As the city expanded after the war, new outer districts were built and bicycle paths would almost always be built alongside the newly constructed car roads leading into the new districts. In this era, several bicycle paths in the rest of Denmark were dissolved, while in Copenhagen, the network remained intact.

	Total (km)	No. of years	Yearly growth (km)	Added (km)	Removed (km)	Net result (km)
1912	35.0	–	–	–	–	35.0
1912–1916	47.6	4.0	3.2	17.9	5.3	12.6
1917–1927	73.5	11.0	2.4	32.0	6.0	25.9
1928–1935	96.4	8.0	2.9	25.1	2.2	22.8
1936–1969	175.0	34.0	2.3	89.3	10.6	78.6
1970–1974	151.6	5.0	−4.7	.8	24.2	−23.4
1975–1985	245.9	11.0	8.6	94.5	.2	94.3
1986–1995	271.2	10.0	2.5	35.4	10.1	25.3
1996–2000	279.4	5.0	1.6	21.8	13.6	8.2
2001–2013	363.4	13.0	6.5	111.6	27.6	84.0
Total, 1912–2013	363.4	101	3.3	428.3	99.9	328.6

Figure 1.5: The growth of the cycle infrastructure network in Copenhagen between 1912 and 2013. Source: Carstensen et al., 2015.

Figure 1.5 shows how the infrastructure network development over the years — a continual growth trend can be seen which would match the development of the city. The negative growth of the network in the 1970s can be explained by the previously discussed general trend in that era where car traffic would dominate infrastructure planning. This is however a small decline in an otherwise continuous expansion of the cycling infrastructure network. An important factor in this might be the lack of a completely car-dedicated traffic planning vision, with a matching budget, from policy makers in Denmark and the Netherlands. In countries like Germany and Sweden, drastic car-centred traffic planning was introduced carried out by large government institutes with consultants and engineers and with considerable budgets. This overall vision was lacking in Denmark and the Netherlands while at the same time the national cycling associations remained powerful players lobbying for cycling and trying to improve the position of the cyclist (Oldenziel & de la Bruhèze, 2011). Although declining, cycling in Denmark — as well as the Netherlands — always remained a substantial mode of transport (see figure 1.2).

This decline was halted and reversed in the 1970s, when Denmark experienced developments that were similar to the Dutch situation in that period — the oil crisis hit the country and lasted for almost a year, which led to a number of things; the limited amount of fuel available and the tremendous price of the fuel reduced the motorised traffic in the country. The oil crisis also increased awareness of energy consumption and the dependence on fossil fuels. The crisis furthermore produced environmental consciousness among the population (Carstensen et al., 2015).

The Danish revival of cycling was unlike the Dutch one, where the construction of cycling infrastructure was made a priority in traffic planning and policy. Instead of governmental contribution schemes, it was mostly environmental, health and cycling organisations that reinstated cycling as a popular mode of transport (Oldenziel & de la Bruhèze, 2011; Carstensen et al., 2015; Carstensen & Ebert, 2012). The Danish Cycling Federation (DCF), founded in 1905, has traditionally had a strong influence on traffic planning, trying to improve the safety for cyclists and advocating for more bicycle infrastructure. In the 1970s, the DCF organised a number of large demonstrations to protest against the growing traffic unsafety for pedestrians and cyclist as well as the plans to build motorways through the city. The municipal government responds to this societal demand, albeit slowly. From 1977, the first new plans for building cycling infrastructure were developed (Albert de la Bruhèze & Veraart, 1999).

1.4 Conclusion

Overall it can be concluded that the Netherlands and Denmark have a strong cycling tradition. Bicycling is a part of the national identity, reflecting the egalitarian and level-headed character often attributed to both the Dutch and Danish society, or as Carstensen and Ebert conclude:

> *"The bicycle played an important role in the growing cohesion of the Dutch and Danish nation states not only in the geographical sense as a common means of transport, but also in a cultural sense as a material object of everyday life with which one could express and demonstrate one's membership in the national community."* (Carstensen & Ebert, 2012, p. 38)

The larger neighbouring countries like Germany and Sweden centred their traffic planning almost entirely around the car adhering to the paradigm of that time that the future of transport was motorised. While these countries built a large car infrastructure network, similar plans in the Netherlands and Denmark were heavily protested against. Furthermore, when the oil crisis struck the Netherlands and Denmark and the negative environmental effects of the car became more and more clear, cycling gained momentum. Beside the ideological aspect, the Danish and Dutch government discovered that supporting and stimulating cycling is also interesting from a political point of view regarding energy and environmental policy (Albert de la Bruhèze & Veraart, 1999). In the 1990s, the Dutch and Danish cycling identities also started to symbolise sustainable urbanism — stimulating cycling and improving cycling condition could shape an accessible city with less noise and pollution (Carstensen & Ebert, 2012).

In the last two decades, there has been an increasing focus on planning and constructing cycling infrastructure where cyclists can increase their speed and experience a minimum of hindrance with traffic lights and crossings where the bicycle has priority and can move as efficient as possible: the *fast cycling routes* or *cycle highways*. The concept originated in the Netherlands, where the first cycle highway was opened in 2004 (Fietsersbond, 2006). Although there is no categorical definition of the cycle highway, the European Cycling Federation mentions a number of characteristics to help identify a cycle highway, see figure 1.6. This is a list of general characteristics and are not hard criteria; the cycle highways may have different features from country to country.

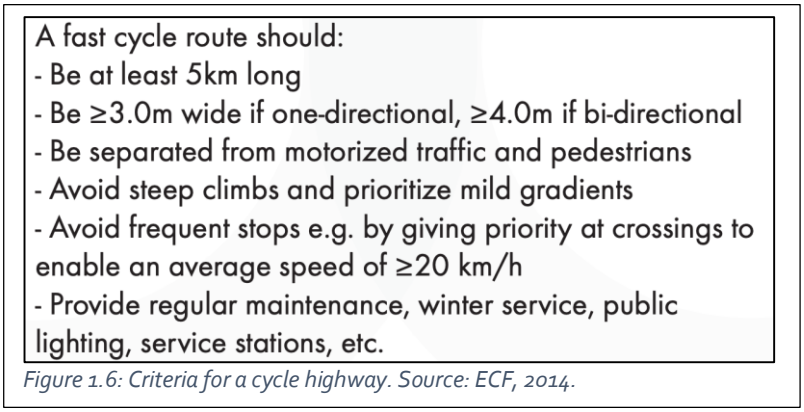


Figure 1.6: Criteria for a cycle highway. Source: ECF, 2014.

1.5 Research question

As described in the introduction, the Netherlands and Denmark have an evident history with stimulating cycling as a mode of transport. Since the 1970s, and arguable before that, they have established themselves as the vanguard of cycling infrastructure development. In recent years, both countries have started constructing cycle highways and have the most developed networks of cycle highways in the world. The cycle highway is a fairly new phenomenon and therefore it is interesting to investigate the intentions and effects of these networks.

From articles and policy documents, the ambitions and objectives of the infrastructure planners becomes clear. In case of the Dutch cycle highways, the initiative was taken by the national government in 2006 in an effort to reduce traffic congestion and improve the accessibility of urban areas. The target audience were commuters who lived within 15 kilometres of their work and who use the car as their mode of transport. By improving the quality of the existing cycling infrastructure and creating a coherent network, together with an educational campaign, the Dutch government tried to persuade the car driving commuters to start commuting by bicycle (Fietsersbond, 2006). The goal of building the Dutch cycle highway network is to make cycling easier and faster, offering a realistic substitute for driving a car up to distances of 15 kilometres in and between urban areas.

The Danish situation is quite similar; in 2009 a collaboration started between the Capital Region of Denmark[2] and 23 municipalities in the region to create a coherent network of cycle highways. The main objectives were to reduce traffic congestion in the region, to improve public health and to reduce the output of CO_2 and NO_x (Nielsen et al., 2018; Sekretariatet for Supercykelstier, 2018). With the network of Danish cycle highways — referred to as *supercykelstier* (plural) and *supercykelsti* (singular) from here on — the city of Copenhagen will be connected to the suburbs through high-grade bicycle routes. The collaborating municipalities hope to cause a decrease in the mode share of car traffic and increase the mode share of cycling traffic between Copenhagen and the suburbs. According to secretariat responsible for planning the cycle highways (*Sekretariatet for Supercykelstier*), the supercykelstier will offer a genuine alternative for distances up till 20.1 kilometres — the average commuting distance in the Capital Region (Sekretariatet for Supercykelstier, 2018a). In section 2.5, the relation between transport mode choice and travel

[2] In Danish: *Region Hovedstaden*. The Capital Region of Denmark is an administrative region of where the capital Copenhagen and 28 other municipalities are in. The area covers 2.561 km² and has approximately 1.826.010 inhabitants. Source: Region Hovedstaden, n.d.

distance will be further explained. More explanation on the Dutch and Danish cycle highway development can be found in chapter 3.

In general, it can be said that the goal of building a network of cycle highways is to increase the number of users, i.e. cyclists, at the expense of car traffic. This poses questions regarding the users and their habits and preferences. The principal object of this research is the relation between the construction of cycle highways and the behaviour of users in the Netherlands and Denmark. To address this matter, the following research question will be answered:

How have the cycle highways influenced travel behaviour in Denmark and the Netherlands?

To guide the research, the following sub-questions will be answered for both countries.

1. *How are the cycle highways used?* This question focusses on travel behaviour on the cycle highway and how it compares to other transport options. By asking this question, insight is gained in how the cycle highway is perceived. For example, if people actually consider it as a type of 'highway' where you travel fast and long distances, or if it is used as a regular bicycle path.
2. *Who are the users of the cycle highways?* This question serves to create a profile of the cycle highway user and why he or she cycles. This can help to determine what the decisive factors are for using the cycle highway. It can also help determine how many have started cycling or cycling more because of the cycle highways, i.e. how much induced traffic there is.

To answer these questions, data on the users from cycle highways must be collected and analysed, this will be done in chapters 5, 6 and 7. In the theory chapter 2, a general overview of the academic literature on cycling will be given in order to place this research within the scientific debate on cycling highways. Chapter 3 will give an introduction into the concept of cycle highways and their development. In the research design and methods chapter 4, the reason for doing this research will be motivated; the methods for data collection is explained and two cycle highways will be selected for comparison, one in Denmark and one in the Netherlands. In chapter 8, directions for further research and limitations of this study are discussed. Chapter 9 concludes the study and gives an overview of the process and results of the research. In the next section, the structure of the research will be described in more detail.

1.6 Research structure

In figure 1.7 below, the research structure is presented. This figure helps to create an overview of the different elements of the report and the direction of the research. As can be expected, the research starts out with an introduction and a research question. Then a literature study follows to create a knowledge base for the author and to anchor the research in the academic debate. The newfound knowledge from the literature will often lead to an adaptation of the research question while the research question itself also directs the literature study — this is represented in the scheme by the two-way arrow indicating that these elements have an iterative relationship. After the study of the existing theory, it is determined what type of research can best contribute to the academic literature and how this will be executed. This is described in the methodology chapter. After the data collection, the results of the research are described, and the results from the data

collection in Denmark and the Netherlands are analysed. Next, the results are discussed in a comparative analysis. This leads into a discussion on how the research has contributed to the existing academic literature and finally, a conclusion sums up the intentions and results of the study and answers the research question.

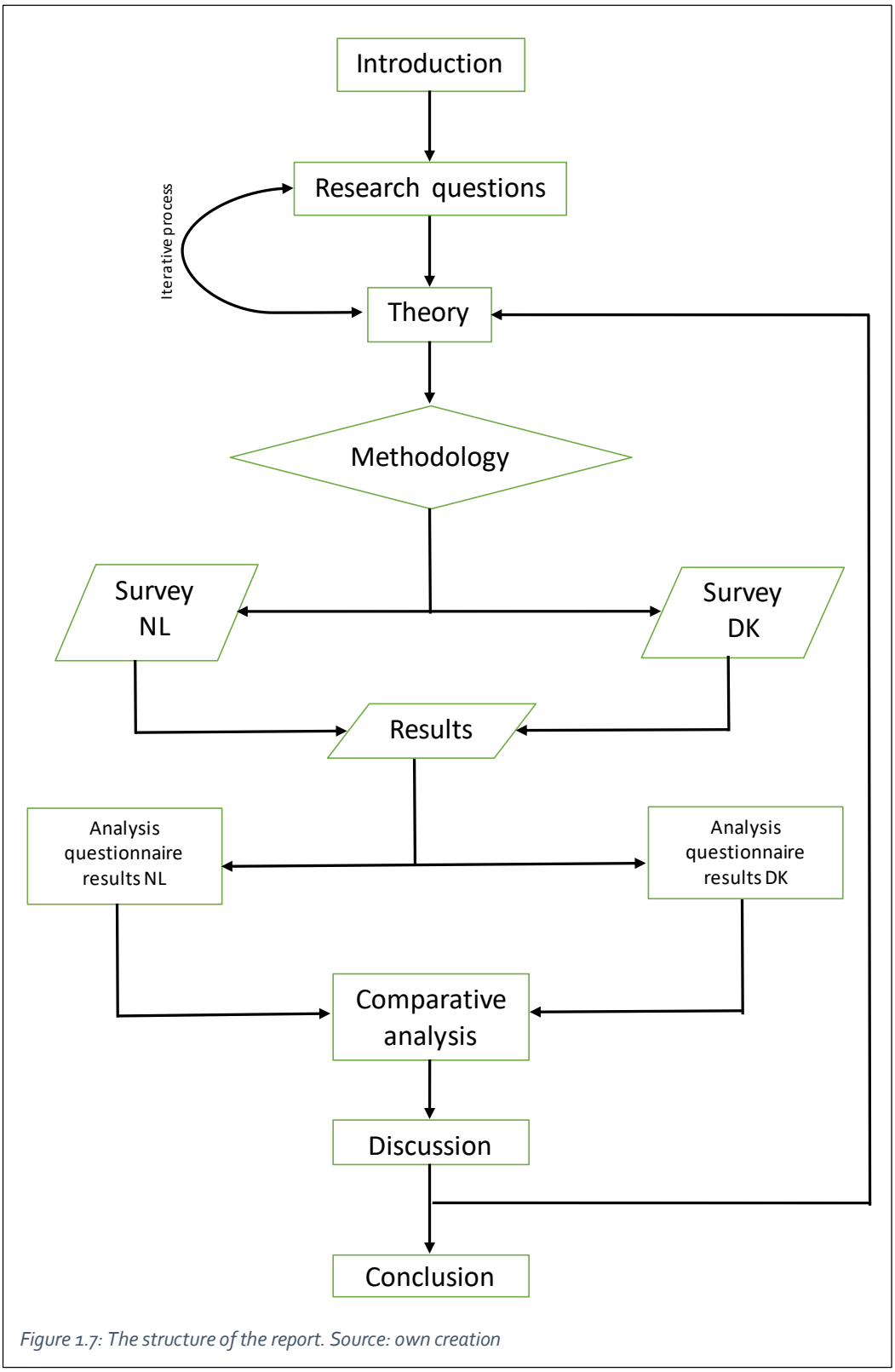


Figure 1.7: The structure of the report. Source: own creation

2. Theory

In this chapter, an overview of the academic literature on cycling as a mode of transport and cycling infrastructure in Denmark and the Netherlands will be given. The motivation behind this is to position this research in an academic context and to support the research question.
The existing literature revolves around several themes i.e. cycling safety, the effect of different kinds of cycling infrastructure and comparative studies, mostly, between European countries and the US and the UK. Another relevant topic is the place of cycling within the total system of commuting transport. Although there is much research on the environmental and health benefits of cycling, they are not the main subject of this research and will therefore not be included in this literature overview. The main focus in this overview is the cycling infrastructure and the effect on cycling volume and attitude towards cycling.

2.1 The land use efficiency of cycling infrastructure

As before mentioned in the introduction, the private car does not efficiently use the road capacity. Moreover, it can be said that the car takes an undemocratic amount of space in the urban environment. Sheller & Urry (2000) describe this negative effect of car mobility on the other users of the urban space, i.e. pedestrians and cyclists. They argue that, although the car offers its user an extended range of mobility, but this goes at the cost of the space and freedom of the other dwellers in the urban space and can even lead to *"[…] destruction of public urban space and introduction of a superficial built environment […]."* (Sheller & Urry, 2000, p. 742).
According to the researchers, increased car traffic leads to suburbanisation which in turn leads to the fragmentation and dispersal of activities and places. Although this allows citizens to have multiple social environments, the time spent driving between them is highly unsocial. Car drivers do not contribute positively to the environment they drive through, on the contrary: cars produce noise, pollution and unsafety for those who are not in a car, i.e. pedestrians and cyclists. As discussed in the introduction, cars also take up a disproportionate amount of space compared to other traffic participants. This is illustrated in figure 2.1, showing an intersection in Paris. This analysis by Copenhagenize Design Co., a Danish traffic planning bureau, shows how much space cars use, but even more so how much space is used for cars. The dark red squares show the space taken up by cars and the light red squares show the amount of space designated for cars. The amount of land that car traffic claims is disproportionate to how many people benefit from it.

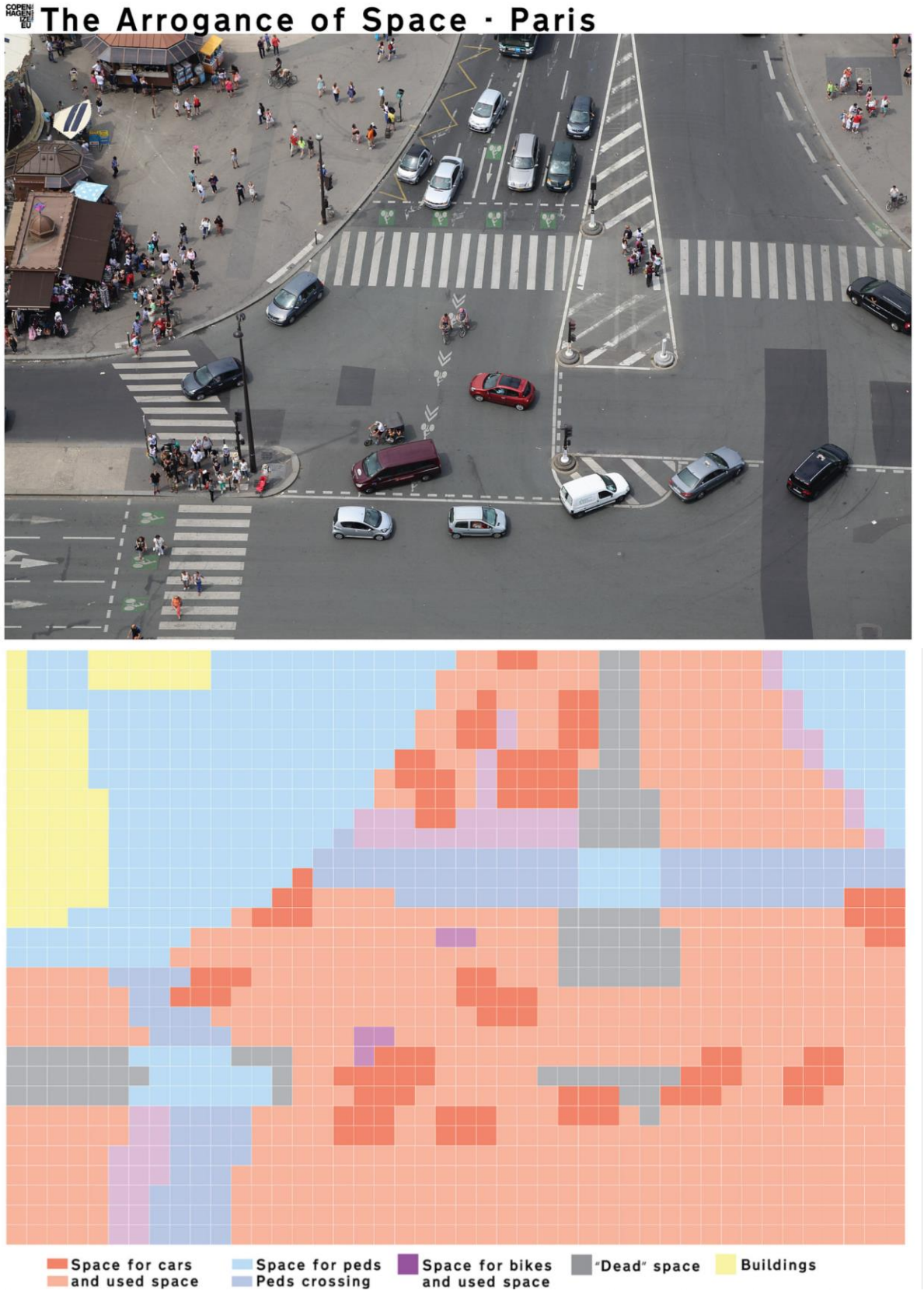


Figure 2.1: The picture shows the utilisation of space by the different road users. The car takes up a disproportionate amount of space. Source: Copenhagenize Design Co., 2014.

Public transport infrastructure and above all bicycle and pedestrian infrastructure have a much higher capacity per square meter. Shifting to bicycle infrastructure can reduce the amount of urban land designated for infrastructure and can thus be used for other functions, e.g. parks, plazas but also retail and real estate. This reasoning produces an economic motive for planning cycling infrastructure, since retail, real estate and other commercial functions are remunerative while roads cost money to build and maintain. A study by Rode et al. (2014) focussed on the relation between transport and urban form. Besides the environmental impact of the different transport modes, the researchers also calculated the capacity and costs of transport infrastructure. Figure 2.2 shows the capacity and costs of different kinds of infrastructure.

The table demonstrates that bicycle infrastructure has a much higher capacity than both motorways and urban streets. Bicycle paths cost a fraction ($100.000 per kilometre) of what car infrastructure costs ($10.000.000 per kilometre). In addition, a bicycle path takes up substantially less space than car infrastructure. Public transport infrastructure also scores much better than car infrastructure in terms of cost and capacity efficiency but is still not nearly as efficient as cycling infrastructure. From a land-use perspective, building bicycle infrastructure is more cost and space efficient while it can be argued that building car infrastructure contributes to social inequality.

Transport Infrastructure	Capacity [pers/h/d]	Capital costs [US$/km]	Capital Costs/Capacity
Dual-lane highway	2,000	10m – 20m	5,000 - 10,000
Urban street (car use only)	800	2m – 5m	2,500 - 7,000
Bike path (2m)	3,500	100,000	30
Pedestrian walkway / pavement (2m)	4,500	100,000	20
Commuter Rail	20,000 – 40,000	40m – 80m	2,000
Metro Rail	20,000 – 70,000	40m – 350m	2,000 - 5,000
Light Rail	10,000 – 30,000	10m – 25m	800 - 1,000
Bus Rapid Transit	5,000 - 40,000	1m – 10m	200 – 250
Bus Lane	10,000	1m – 5m	300 – 500

Figure 2.2: The cost and capacity of different kinds of transport infrastructure. Source: Rode et al., 2014, p. 12.

2.2 Cycling infrastructure types

Quite extensive research has been done on different kinds of cycling infrastructure and what the effects of building and maintaining this infrastructure are. In this section, the different kinds of cycling infrastructure will be discussed. In the subsequent sections, the effects contributed to the different kinds of infrastructure will be explored.

In his transatlantic comparison of cycling infrastructure, Furth (2012) differentiates between four types based on their level of separation from motorised traffic (see figure 2.3). The first type is a shared street with no designated space for cyclists at all. The second type is a separation on the road by a painted stripe. Thirdly, a bike path alongside the road but physically separated from it by a barrier. The last type is the completely independent bike path not parallel to the road for motorised traffic.

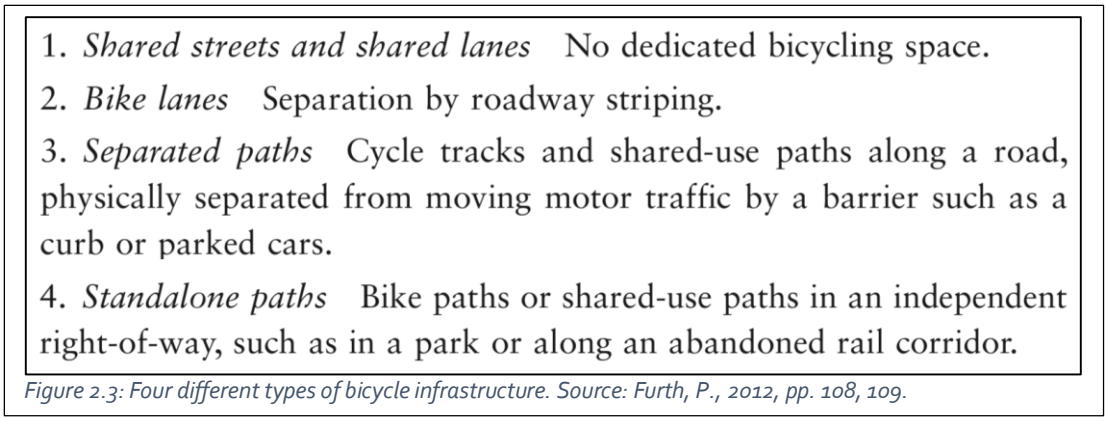

1. *Shared streets and shared lanes* No dedicated bicycling space.
2. *Bike lanes* Separation by roadway striping.
3. *Separated paths* Cycle tracks and shared-use paths along a road, physically separated from moving motor traffic by a barrier such as a curb or parked cars.
4. *Standalone paths* Bike paths or shared-use paths in an independent right-of-way, such as in a park or along an abandoned rail corridor.

Figure 2.3: Four different types of bicycle infrastructure. Source: Furth, P., 2012, pp. 108, 109.

Furth distinguishes these types and uses them in a comparison between the United States and Europe, with a focus on the Netherlands, regarding traffic stress and cycling safety. He argues that there is a correlation between the level of separation from motorised traffic and the amount of *traffic stress* experienced by cyclists, i.e. the noise and danger that the motorised traffic imposes on the cyclists, making it difficult for cyclist to relax while cycling. According to Furth, the more separated a bike path is from motorised traffic, the more comfortable and safer it is to use thus the more people will be inclined to cycle (Furth, 2012, p. 108).

2.3 Effects of cycling infrastructure on mode share of cycling

A study by Skov-Petersen et al. (2017) investigated the effects of improvements in quality and increase of capacity made on two major bike routes in the Capital Region. Two routes were subjected to analysis. The first route is a 15-kilometre-long tangential route which connects several of the suburbs west of Copenhagen in the metropolitan area. The second route is an 18-kilometre-long radial route connecting the suburb Albertslund with downtown Copenhagen, which is the first cycle highway of the supercykelstier network. The researchers set out to find if the upgrading of the cycling infrastructure had any effect on the volume of cyclists on the bike paths, a shift in mode of transport in favour of the bicycle and the cyclist behaviour and perception. The research concluded that the improved infrastructure experienced a significant increase in volume of users. Most users were already cyclists and had started using the improved infrastructure in favour of their previous route. Reason for relaying their route was the improved safety on the upgraded bike paths in terms of riding surface and lighting. There was a small amount of induced cycling recorded; between 4 and 6 percent of the cyclists on the upgraded routes had shifted from other modes of transport to cycling (Skov-Petersen et al., 2017, p. 209). Although the amount of induced cycling was modest, the study supports the argument of Furth (2012) that upgrading the infrastructure will lead to more users.

Additionally, a review of 139 studies on the effects of various interventions on the mode share of cycling, i.e. the share of trips done on bicycle, done by Pucher, Dilll and Handy (2009) demonstrates the effect of providing decent infrastructure on the mode share of cycling. The research considered different types of interventions e.g. integration into public transport, marketing programs and travel related infrastructure. In the review, forty studies related to bicycle infrastructure were considered, all assessing the effect of the constructing, upgrading and maintaining bicycle

infrastructure. The studies showed that both cyclists and non-cyclists prefer to have cycling infrastructure with some degree of separation from motorised traffic. Most of the aggregate-level studies showed that there is a significant relationship between the number of bicycle paths and the mode share of cycling.

2.4 Effects of cycling infrastructure on cycling safety

An article by Pucher (2001) suggests that cycling is safer in countries where the mode share of cyclists is higher and cycling specific infrastructure and facilities are in place e.g. bicycle paths and modified intersections. In another study by Pucher and Buehler (2008), the Netherlands, Denmark and Germany are compared to the United States and the United Kingdom in terms of cycling safety. The United States, as a country with little cycling infrastructure and facilities, has a cycling mortality rate of 5.8 fatalities per 100 million kilometres, the United Kingdom has a mortality rate of 3.6. The Netherlands and Denmark have a mortality rate of respectively 1.1 and 1.5 and Germany has a rate of 1.7 (Pucher & Buehler, 2008, p. 505). In terms of non-fatal injuries, the Netherlands, Denmark and Germany also perform significantly better than the U.S. and the U.K. The first three countries have 1.4, 1.7 and 4.7 cyclists injured per 10 million kilometres while the U.K. and the U.S. have an injury rate of respectively 6.0 and 37.5. Although there is a strong correlation between the two variables of 1: grade of cycling infrastructure and facilities and 2: the mortality and injury rate for cyclists, a causal relationship between the two cannot be proven. More extensive education on how to deal with cyclists in traffic, both for motorists and cyclists, more severe legal consequences for motorists causing an accident with a cyclist and a stricter traffic law enforcement might also be determining factors for the lower injury and fatality rates in the European countries (Pucher & Buehler, 2008, p.519-520). It seems however intuitively safer to physically separate cyclist from the fast, motorised traffic.

A Belgian study by van Hout, Brijs, Daniels & Hermans (2011) explored the relation between the degree of separation from motorised traffic and cyclists' safety i.e. the number of accidents. The results showed that within the built-up area mixing cyclists in with the motorised traffic does not lead to more accidents. Outside the built-up area however, separating cyclists from motorised traffic increased the traffic safety significantly. Separated paths outside the built-up area resulted in good safety performance for cyclists uninfluenced and independent from the intensity of the motorised traffic (van Hout et al., 2011, p. 64).

Besides measurable safety, i.e. objective safety, there is the perceived danger by cyclists, i.e. the feeling of safety that bicycle riders have (or lack) when they cycle. This subjective safety is a strong determinant in the decision to cycle or not to cycle. The presence of high-grade cycling infrastructure has proven to significantly increase the perceived safety of cycling (Klobucar & Fricker, 2007). This phenomenon is linked to the concept of traffic stress, discussed in section 2.2 — the more closely a cyclist is confronted with the noise and speed of the motorised traffic, the less safe he or she will feel.

2.5 Position of cycling within the daily urban system

In this research, cycling is treated as a mode of transport for commuting to work or school and as a mode of transport to leisure activities e.g. the sports club, café or shopping. Cycling as a goal in itself, i.e. for recreational purposes, is left out of consideration.

By far the most commuting trips are made within "*a multi-centred urban area [...] with each part having a function of its own.*" (van der Laan, 1998, p. 235). This kind of area traditionally consisted of an urban core with one or more suburban areas surrounding it — commuting would take place between the residential areas in the suburban areas and the business areas in the urban core. The rise in private car-ownership after the Second World War has had a strong impact on the establishment of this pattern. In many European cities, this hierarchal, dual relationship is no longer the norm; the urban areas have become multi-centred and there is no longer a typical hierarchy between the cores. Examples of multi-centred daily urban systems are the Randstad in the Netherlands and the Rurhgebiet in Germany (van der Laan, 1998).

According to Dieleman, Dijst & Burghouwt (2002), a more compact urban form equals shorter travel distances which makes the bicycle a more realistic modal choice. The researchers argue that "*[t]he increase in scale of schools, sport facilities and so forth reduce the opportunities of using the slower transport modes for travelling. Clustering children's activity places in the neighbourhood of the schools and the design of safe walking and cycling routes would decrease children's dependence on their parents."* (Dieleman et al., 2002, p. 525). Children depend on their parents as taxi drivers, they cannot, or are not allowed to, drive a car themselves. Besides the safety aspect, the travel distance is thus an important argument for people to take the car. This could, as Dieleman et al. argue, be countered by developing a more compact urban form. Another opportunity to overcome this distance issue is the electric bicycle. This is a more recent technological innovation which was not as popular or even commonplace during the study of Dieleman et al. (2002). The electric bicycle allows bicyclists to cycle faster and thus a greater distance than on a conventional bicycle for the same amount of physical effort. In other words, travel distance can increase while travel time stays the same when a cyclist starts using an electric bicycle instead of a conventional one. Although research on electric bicycles has been done, it has mostly focussed of the impact of the electric bike on traffic safety (Wu et al., 2012; Langford et al., 2015; Wang et al., 2005). Extensive research on the effect of the electric bike on modal choice and the daily urban system is limited. Cherry & Cervero (2007) found in their research that users of electric bikes travel considerably further than conventional bike riders, allowing the electric bicyclists to travel further or to more destinations. In their survey, 1198 responses were collected among electric bike riders in two cities: Kumming and Shanghai. The majority of the electric bike riders previously rode the bus and, if the electric bicycle became unavailable, would start riding the bus again instead of riding a conventional bike. The respondents mentioned speed, effort and safety as determining factors for choosing the electric bike. The crowdedness of the public transport was also mentioned as factor to prefer the electric bike over public transport.

3. Cycle highways in the Netherlands, Denmark and other countries

In this chapter, an overview of the history of the planning and construction of cycle highways will be given. The development of cycle highways in the Netherlands and Denmark will be mapped out, recapitulating their history from the first notion of the concept to the current state of the network of cycle highways. To some degree, highway cycle infrastructure has also been developed in other countries, primarily in Europe. Because this study centres around a comparison between the cycle infrastructure in the Netherlands and Denmark, the development in other countries will not be discussed to a great extent — a short overview will be given and, where relevant, they will be compared or referred to.

3.1 Cycle highways in the Netherlands

The first cycle highway in the Netherlands, which makes it the first cycle highway in the world, is a route between the cities of Breda and Etten-Leur in the southern part of the country. The route was inaugurated in 2004 and connects the city centre with residential neighbourhoods and businesses. The further development of cycle highways in the Netherlands, commonly referred to as *fietssnelweg, doorfietsroute* and *snelle fietsroute*, accelerated in 2006 as part of an effort of the ministry of Infrastructure and Environment to reduce traffic congestion on the Dutch roads. Five initial project areas throughout the country were selected where comfortable and efficient routes would be constructed in urban areas where motorised commuting traffic experienced congestion (Fietsersbond, 2006). In the course of three years these five routes were upgraded into cycle highways by building new infrastructure or improving the existing infrastructure. Several intersections have been changed so that the cyclist now has priority. The road surface has been upgraded to high-grade asphalt and several cycling tunnels and bridges have been constructed to reduce interruptions and harsh riding conditions (MuConsult, 2010).

The main concern of the ministry was the fact that trips of more than 7.5 kilometres were considerably less travelled by bicycle then distances up to 7.5 kilometres. These trips are usually commuting trips from the suburbs into urban centres. The program, called *Fiets Filevrij*, intended to make cycling a realistic option for commuting distances over 7.5 kilometres. After the initial five pilot projects, the Dutch government extended the program and offered funding for more bicycle routes across the Netherlands to be upgraded in comfort, efficiency and coherence. This was done by, amongst other things, improving the road surface, building tunnels under major roads and reconfiguring existing cycle paths and intersections in favour of the cyclist (Fietsersbond, 2006). An evaluation of the project in 2009 showed that 8 percent of the users consisted of induced bicycle traffic; this 8 percent of the users were former car commuters that switched to commuting by bicycle (MuConsult, 2010). In figure 3.1, an overview of the cycle highway network in the Netherlands can be seen.

3.2 Cycle highways in Copenhagen

Traditionally, the network of cycling infrastructure in Copenhagen has grown in length every year since 1975. From 246 kilometres in 1975, the network has grown by approximately 33 percent to 363 kilometres of cycling lanes and paths in 2013. In the 2010s, the project of building a network of cycle highways was initiated in the Capital Region of Denmark, linking the inner city to the suburbs in the metropolitan area of Copenhagen. The objective of the project is to construct better infrastructure and facilities for cyclists and create a logical network of routes for commuters, connecting residential areas, educational institutions and offices (Carstensen et al., 2015, p. 146, 151). The first cycle highway opened in 2013 and is a 17-kilometre-long connection between the suburb Albertslund and the centre of Copenhagen. This route is part of a larger program to create a network of 45 routes with a total length of 746 kilometres (Supercykelstier, 2017). As of 2019, eight trajectories with a total length of 167 kilometres have been finished. Efforts consists of upgrading existing infrastructure and constructing new infrastructure — new infrastructure includes both separated paths and standalone paths. So far, seven new routes have been financed, these are expected to be done in 2021 (Sekretariatet for Supercykelstier, 2018, p. 18). See figure 3.1 for an overview of the finished and planned routes in the Danish Capital Region.

The first two routes of the network have been subjected to evaluation by Danish consulting group COWI and the third route has been evaluated by Danish traffic consulting agency Via Trafik. An increase in use was noticed on all three routes that were analysed. Counting posts on different locations and different days showed that the Albertslund route has a 10 percent increase in users while the second and third route, the Farum route and the Ishøj route, have experienced an increase of, respectively, 52 and 31 percent. Presumably, this induced traffic consists mostly of commuters who have started using the cycle highway instead of regular bicycle paths, but there is also a group of cyclists who have switched from commuting by car or public transport to commuting by bike (COWI, 2012, 2014; Via Trafik, 2018). The average cycling speed on the routes has also gone up, mostly due to new crossings, better prioritisation for cyclists and physical improvement of the road surface (Nielsen et al., 2018, p. 22).

3.3 Cycle highways in other countries

In the northern part of Belgium, Flanders, a network of around 110 cycle highway routes, also called *fietssnelwegen* in Flemish, is set up. Hereof, 61 routes are in use. At first glance, this seems like comprehensive network, but as mentioned before: there is no unambiguous definition of what a cycle highway is, and the term can be used freely. The Flemish cycle highways are not separated bike paths, dedicated to bicycle traffic only as is the case with the Danish and Dutch cycle highways. The Flemish *fietssnelwegen* can consist of different types of infrastructure like towpaths, service roads, roads for agricultural vehicles and ordinary residential streets (Fietssnelwegen, 2019). Separation from motorised traffic and unhindered cycling is not promoted or guaranteed.

In the United Kingdom, the city of London is creating a network of cycle highways called Cycle Superhighways. At the introduction of the plan in 2008, 12 routes were proposed linking residential areas to the city centre and stations (Taylor, 2008). The most efforts done under the flag of the Cycle Superhighways seem to comprise the construction of basic cycling infrastructure like bike lanes, traffic lights for bicycles and pedestrian crossings over bicycle paths (Transport for London, n.d.). Facilities like these have been in place on regular bike paths in Denmark and the Netherlands

for a long time and would not make them cycle highways in these countries. The network is therefore, like the case of the Flemish *fietssnelwegen* network, not readily comparable to the Danish and Dutch cycle highways.

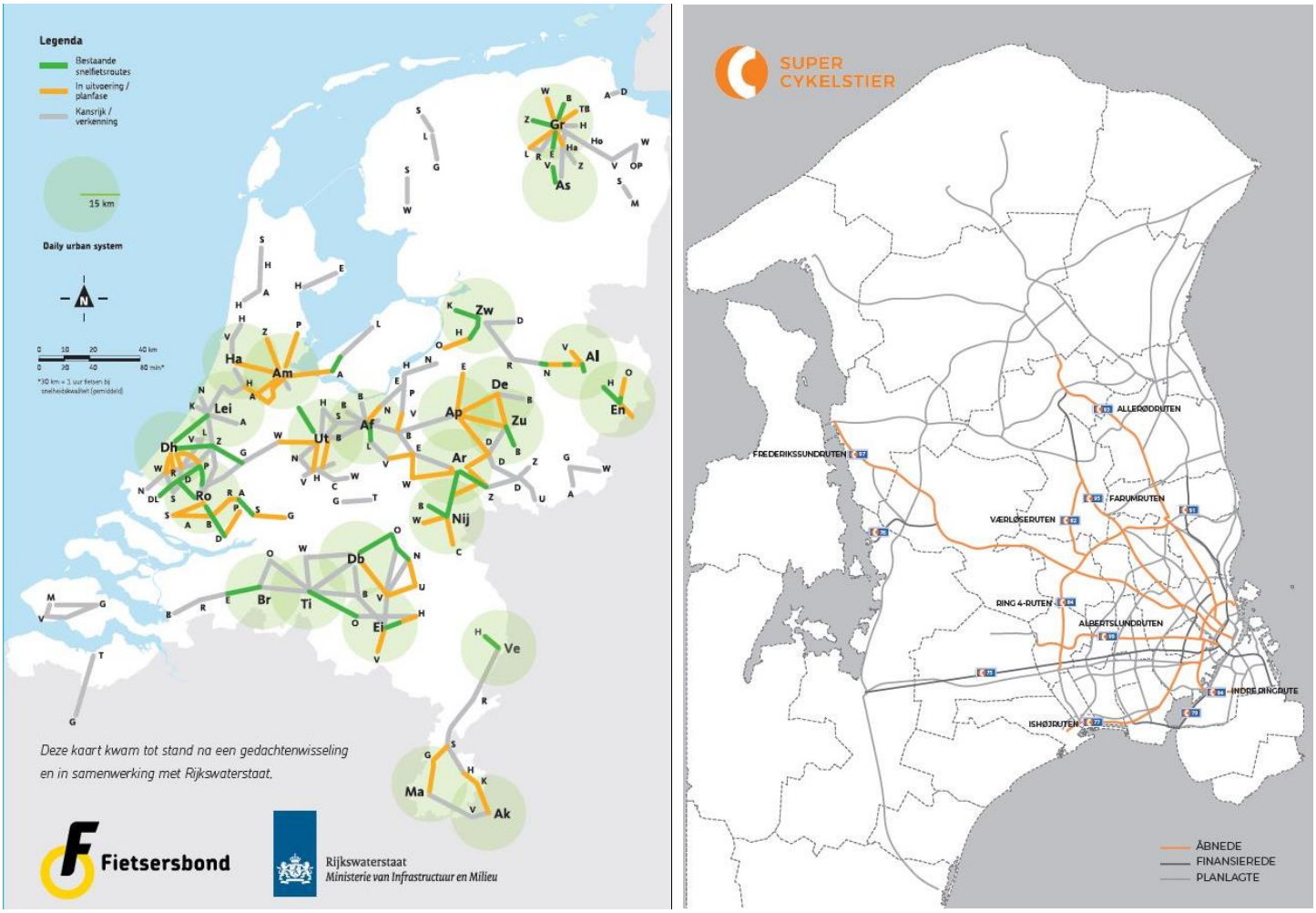


Figure 3.1: On the left, a map of the cycle highway network in the Netherlands as of 2015. On the right a map of all the established and planned cycle highways in the Capital Region of Denmark. Sources: Fiets Filevrij, 2015; Sekretariatet for Supercykelstier, n.d.

4. Research method and design

This chapter aims to describe the nature of the research, the motivation for doing it and how the research questions will be answered. It also provides explanation about the design and execution of the data collection. The main research methods in this study — besides the literature review in the theory chapter 2 — are: a self-completion questionnaire, a manual traffic count and unstructured observation at the surveying locations. Furthermore, data from previous evaluation reports of the Danish and Dutch cycle highways will be used and compared with the data from this research in order to identify trends and changes.

4.1 Research design

This research will build on a previous study by Skov-Petersen et al. (2017), which showed the effect of upgrading the cycle infrastructure in the Copenhagen area. More on this study is found in the theory chapter 2. In this study, besides a tangential route through the suburbs of Copenhagen, the supercykelsti *Albertslundruten* was researched. The aim was to *"investigate the effects of improvements [...] on bicycle volumes and mode share, and cyclists' behaviour, perceptions, and experiences."* (Skov-Petersen et al., 2017). The results showed a significant increase in user volume of the Albertslund route after it had been upgraded to a supercykelsti.

The research of Skov-Petersen et al. (2017) intended to investigate the satisfaction of users with upgrades on the route as well as changes in bicycle volumes on the route and factors in the effects of weather and time of the day, week and year.

> *" [...] the present study includes time of year, week and day as explaining factor and the weekday/weekend ratio as in indication of commute vs recreational cycling. This study further adds a ratio of rush hour/non-rush hour for the same purpose. Correcting for climate and temporal variation may, therefore, be essential for analysing the effect of improved infrastructure. Finally, bicyclists' user-experience and satisfaction are also investigated."* (Skov-Petersen et al., 2013, p. 204)

Building on this knowledge, in this research the reasons for using the cycle highway and the behaviour of the users in Denmark and the Netherlands are subject of investigation. The research design which is best suited for this kind of comparative research is a survey research design. This design fits the nature of the report, where data is collected from a lot of cases — the users of the cycle highways — at a single point in time in order to collect quantifiable data (Bryman, 2008).
An additional reason for choosing a survey data collection method and a traffic count is because this resembles the method used by Skov-Petersen et al. (2017) best. Adapting to their research design makes it more convenient to add to the academic literature and debate on cycle highways.

One of the aims of the research is determining if the users would still cycle if the cycle highway was not there and if not, what transport would they use. The research by Skov-Petersen also included this, but they compared one cycle highway, the Albertslund route, to an upgraded tangential route, *Vestvolden*, through the urban periphery of Copenhagen. This study compares the behaviour of cycle highway users in two countries whereas the Skov-Petersen study focussed on two routes in the Capital Region. The research aims to generate quantifiable data about the characteristics and

habits of cycle highway users in two countries in order to create a profile of them. The international comparison aims to provide a more universal insight into how cycle highways are being used and what their role in the transport system is.

4.2 Data collection method

In order to investigate the use of the cycle highway infrastructure and cyclists' behaviour in the Netherlands and Denmark, an online survey will be held among users of predetermined cycle highways in Denmark and the Netherlands (in section 4.4 and 4.5, the selected cycle highways will be discussed). This approach has been chosen because it produces data which can be statistically analysed and provides insight in the attitudes of the cyclists on cycle highways. It also creates an understanding about how the cycle highways are used, e.g., how often and for what distances
Two questionnaires have been drawn up: A Dutch questionnaire which is distributed among users of the cycle highways in the Netherlands and a Danish equivalent which is distributed in Denmark. The questionnaires both consist of 11 questions regarding the different aspects influencing the behaviour of cyclists and the use of the cycle highway. The same questions are asked in Dutch and Danish.
The software used for the creation, distribution and analysis of the questionnaires is SurveyXact, an internet-based system for administering surveys from Rambøll, a Danish engineering company. It allows researchers to write questionnaires, test them and distribute them — in this case through a QR-code and a link to the website of the survey. With the system, the responses can be managed, filtered and analysed (Rambøll Management Consulting, 2017).

By means of fieldwork, data will be collected. This will entail both handing out invitations to a survey and counting the number of cyclists passing. The survey invitations will be handed out at a traffic light or other point where the cyclists slow down, so there is time to interact with the cyclists. The invitations consist of a piece of paper with a brief text explaining the intentions and a web address with code to access the survey and a QR-code which, if the participants scan the code, gives access to the survey (see appendix 1 and 2). The invitations in Denmark will be handed out on the 12th of December 2018 in the morning rush hour between 07.00 and 09.00 as well as in the evening rush hour between 16.00 and 18.00. In the Netherlands, data will be collected in the same manner on the 3rd of January 2019 on the same rush hour time periods.
In addition to the questionnaires, a manual cyclist count will be performed, recording the number of passing cyclists on the cycle highways in the Netherlands and Denmark. This is done to create additional quantitative data about the cycle highway use. Using a mechanical, hand-held tally counter, the passing cyclists will be counted. Starting at 07.00 in the morning and 16.00 in the evening, the number of passed cyclists per 15 minutes will be recorded during the morning and evening rush hour. Additionally, simple, unstructured observation will take place where the researcher documents remarkable events and behaviour.

4.3 The survey questions

In this section the survey questions will be translated into English and the rationale for asking them will be given. In the introduction the respondent is explicitly asked to always give the answer that matches their opinion best. This is done in order to avoid unanswered questions because respondents do not fully agree with any of the answering options. After the questionnaire the respondents are thanked for their participation and given the possibility to fill out their email

address so that they can receive a copy of the finished report. When explaining the rationale behind the questions it is important to note that the most questions are not self-contained — analyses and conclusion are generally not formed from the responses of one question alone, but rather from combining and comparing the results of two or more questions. The entire questionnaire in Danish and Dutch can be found in appendix 3 and 4.

Q1. What is your average daily cycling distance?
Here the respondent can select an answer from *0-2 kilometre* up to *more than 20 kilometres*. This question helps determining if the cycle highway is used by cyclists as an alternative for commuting by car. This is one of the main goals of both the Danish and Dutch cycle highways, also mentioned in the introduction section 1.5. The goal of the Dutch cycle highways is to make cycling a realistic option for distances up to 15 kilometres between urban cores. In the case of the Danish cycle highways, the goal is to create an alternative for the car up to distances of 20.1 kilometres, the average commuting distance in the Capital Region. If the majority of respondents indicate distances that exceed the abovementioned distances, it can to some extent — in combination with the responses from question seven — be concluded that the cycle highway helps to make cycling an alternative for driving.

Q2. What is/was your primary destination today?
The respondent can choose from the following options: *work; school; shopping; a social visit; a day trip; no destination (I cycle for the exercise).* Also here, this question is related to the goal of the cycle highways, i.e., to encourage commuters to cycle instead of driving a car. The responses to this question will help to determine if this is the case.

Q3. On average, how many days per week do you cycle?
This question, with answering possibilities ranging from one to seven, is asked to determine the frequency that cycle highway users cycle with. Together with the responses to question four, the results for this question helps to create an understanding of the position of cycling amidst the range of transport options.

Q4. What other modes of transport do you use for your daily traveling when you do not cycle?
Here, other transport options are given, i.e., *a car through a car sharing program; a private car; walking (for more than one kilometre); public transport; a taxi; other, namely*. This question serves to create an understanding of the other transport options that cyclists have. It may help finding out whether cycle highway users generally do have a car at their disposal but choose to cycle, or that they do not and cycle out of necessity. The results from question five support this inquiry.

Q5. Why do you cycle? Please arrange the answers below from most important reason on number one to least important on number six.
With this question, the respondent can choose between six reasons why they choose the bicycle and is asked to order them from most important to least important. The options are: *the most comfortable mode of transport; the most practical mode of transport for this trip; the cheapest mode of transport; quickest mode of transport; because it is good for the environment; because it is healthy/for the exercise*. This question supports one of the main objectives of this study: creating a

profile of the user. Although the cycle highways are intended to lure people out of their car, cyclists might also have other reasons for cycling. This question therefore broadens the scope of the creation of the profile, allowing for more explanations for cycling.

Q6. We met on cycle highway X which was opened in XXXX. Did you also bike there before the cycle highway was opened?

Where the 'X' stands, the information concerning the cycle highway in either Denmark or the Netherlands is filled in. The aim of this question is to help determine if the cycle highway changed the transport behaviour of the respondents. The options are 'no' or 'yes'. If a respondent answers 'yes', the frequency and distance before the opening of the cycle highway is also asked, e.g., *yes, the same distance, but a lower frequency*. This will show if the cycle highway has caused the respondents to cycle more often or less often and if it has caused them to cycle longer or shorter distances.

Q7. Would you also cycle if the cycle highway was not there? I.e. would you use the normal bike paths?

This question connects to question six, but in the answering options the respondents, if they select 'no', can choose which mode of transport they would select then, e.g., *no, in that case I would take the car*. The results of this question will help to show whether the respondents would drive if a cycle highway was not provided.

Q8. Did the cycle highway influence your travel time and -distance?

Here the respondent can choose between 'yes' and 'no' with different options for travel time and distance, e.g., *yes, shorter travel time, but longer distance*. It is logical that an important condition for choosing the bicycle is that the travel time of the cyclist is not significantly negatively impacted.

Q9. What kind of bicycle do you have?

The options are: *cargo bike; ladies bike/men's bike; electric bike; mountain bike; racing bike; other, namely*. With this question, combined with question one, some insight can be gathered into the impact of the electric cycle on travelling distance.

Q10. What is your age?

This question, as well as question 11, serve to create a profile of the cycle highway user.

Q11. What is your sex?

Although previous studies have examined the percentage of female cyclists and the impact of the perceived safety on bike paths on this percentage (Koglin & Varhelyi, 2018; Faskunger, 2007), this study does not explore that relation. This question helps to create a general profile of the cycle highway cyclist.

4.4 Surveying conditions in Copenhagen

The cycle highway that was selected for surveying in Denmark is the Farum route, a 20.8-kilometre-long cycle highway that was opened in the spring of 2013 (see figure 4.1). The establishment of the Farum route mostly consisted of upgrading existing cycling infrastructure: LED lighting was installed along the cycle path and in the cycle tunnels and a new asphalt layer was applied and painted blue (Supercykelstier, 2018). This route has been selected because it is the second route of the supercykelstier network, preceded by the Albertslund route in 2012. The four municipalities of Farum, Furesø, Gladsaxe and Copenhagen, which the route passes through, cooperated with the Secretariat of Cycle Superhighways to construct the Farum route. For the most part, the cycle highway runs parallel to the Hillerød motorway (COWI, 2014).

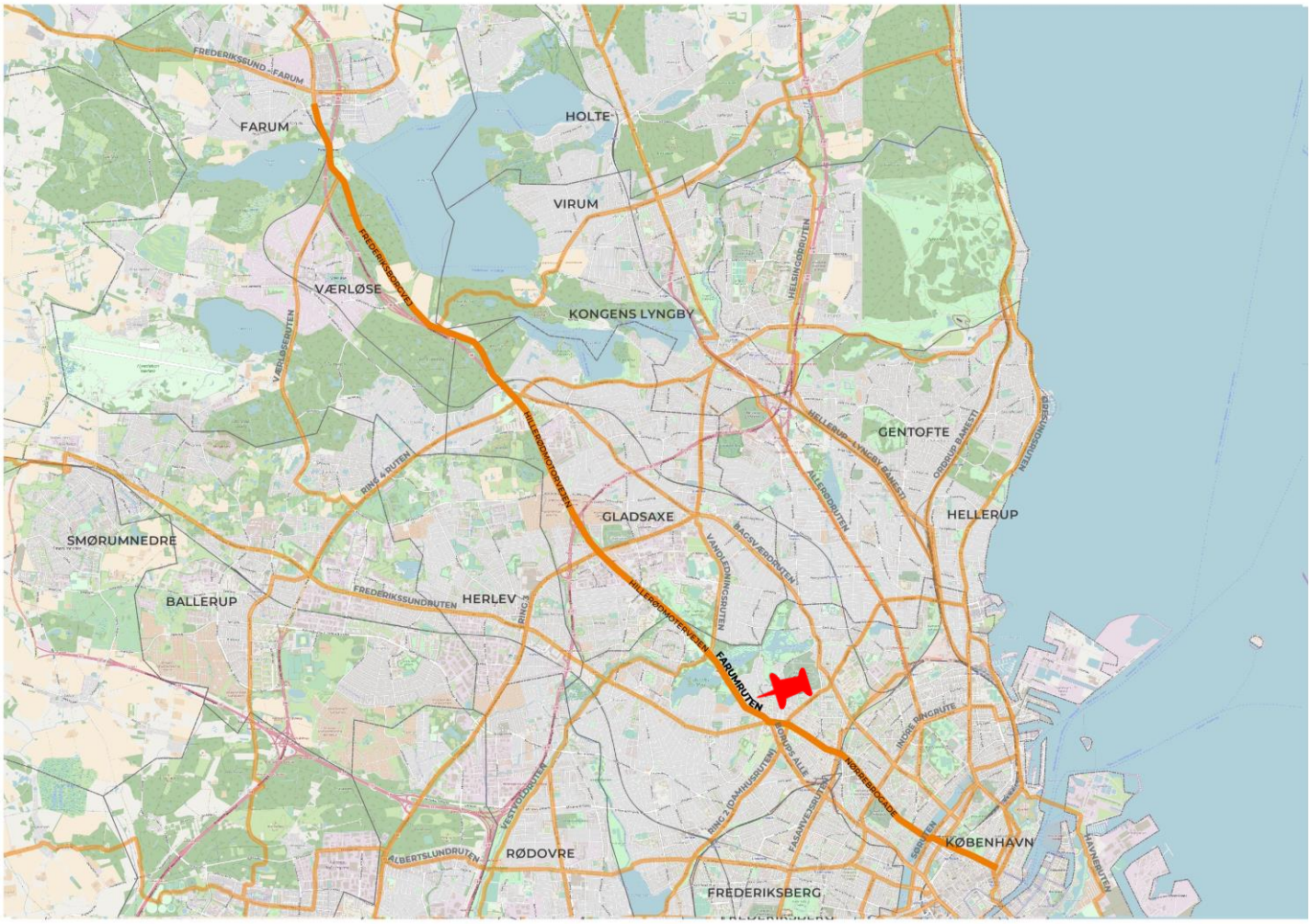


Figure 4.1: The Farum route cycle highway in orange, the red pin indicates the location of data collection. Source: Supercykelstier, 2018. Edited by the author.

Because the Albertslund route has been more extensively researched in the study by Skov-Petersen, the Farum route was an interesting route for research. Because it has been around relatively long, it is probably rather well-known as a cycle highway by its users. Choosing the Farum route will add to the knowledge about the longer-established cycle highways (like the Albertslund route). The most recent evaluation dates back to 2014, only one year after its inauguration (COWI, 2014).

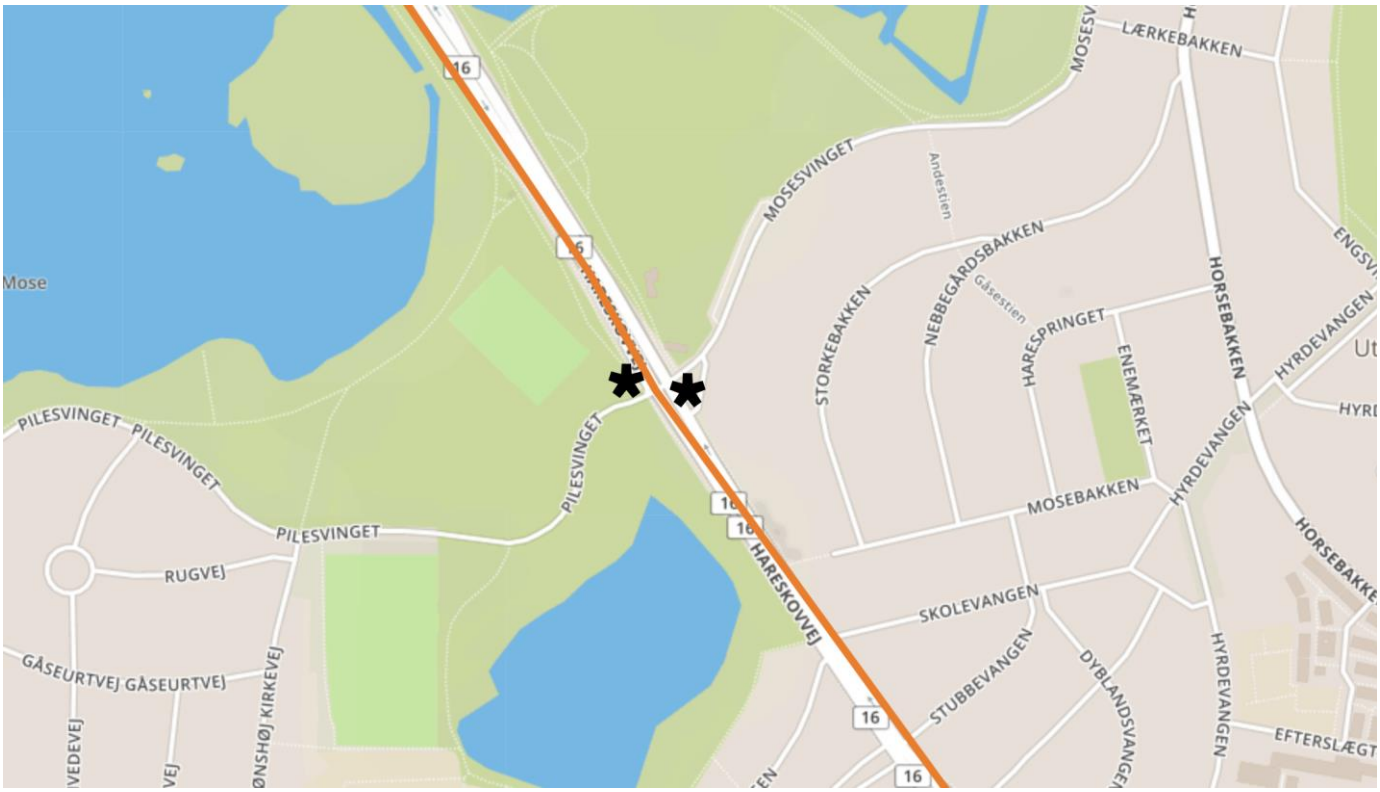


Figure 4.2: The locations of data collection. During morning rush hour data was collected on the Pilesvinget side of the road and in the evening rush hour the data collections was done on the Mosesvinget side. Source: Supercykelstier, 2018. Edited by the author.

The fieldwork was carried out on the intersection of the Hareskovvej with the smaller side streets of Pilesvinget and Mosesvinget (see figure 4.2). This intersection was chosen for two reasons. Firstly, because at this point the cycle highway is about to enter the city of Copenhagen. Any closer to the city, the cycle highway is still marked as a cycle highway but is in fact a regular Copenhagen bicycle path with not much of the same qualities it has outside the city, i.e. complete separation from other traffic, bridges and tunnels to cross other infrastructure and traffic signal regulation favouring the cyclists. Many cyclists on the Copenhagen portion of the cycle highway may not even be aware that they are cycling on a supercykelsti.
Surveying on a location near the Farum-side of the route is not preferable for another reason. Here the users may be very well aware of cycling on a cycle highway, but then a large share of cyclists — those joining the cycle highway from suburbs closer to the city— would be left out. Thus, the location has been selected because it can be reasonably expected to provide the largest number of respondents who are aware of cycling on a supercykelsti.

The second reason for surveying at the abovementioned location is that the cycle highway is interrupted by a traffic lights, frequently forcing cyclists to slow down or even come to a complete halt. This creates an opportunity to interact with the cyclists and hand out an invitation to the online survey. This speed reduction is much needed to interact with the cyclists, as the speed of passing cyclists when the light is green usually is far too high to communicate with them. Another option for data collection was the intersection with the Klausdalsbrovej in Herlev where cyclists encounter traffic lights as well. Here however, sensors have been placed in the cycle track, sensing the oncoming cyclists and favouring them at the traffic lights (see appendix 7). This innovation

makes cycling on the Farum route more efficient but makes it harder to collect data, as cyclists rarely have to stop at the traffic light.

4.5 Surveying conditions in the Netherlands

The cycle highway selected for research in the Netherlands is the *fietssnelweg F35* (F35), an all-in-all 62-kilometre-long route in the region of Twente in the eastern part of the country. It is called the F35 because it is a cycling track (*fietspad* in Dutch) that roughly runs parallel to the motorway A35. The route is being developed by the municipalities through which the route travels — Hellendoorn, Wierden, Almelo, Twenterand, Borne, Hengelo, Enschede and Oldenzaal — together with the authorities at provincial level (Regio Twente, 2014). The route stretches from Nijverdal in the western part of Twente to the German border in the east and has branches to urban cores Oldenzaal and Vriezenveen (see figure 4.3). Large sections of the cycle highway run parallel to a train track and the first parts of the route were opened in late 2010 (Kunst, 2010).

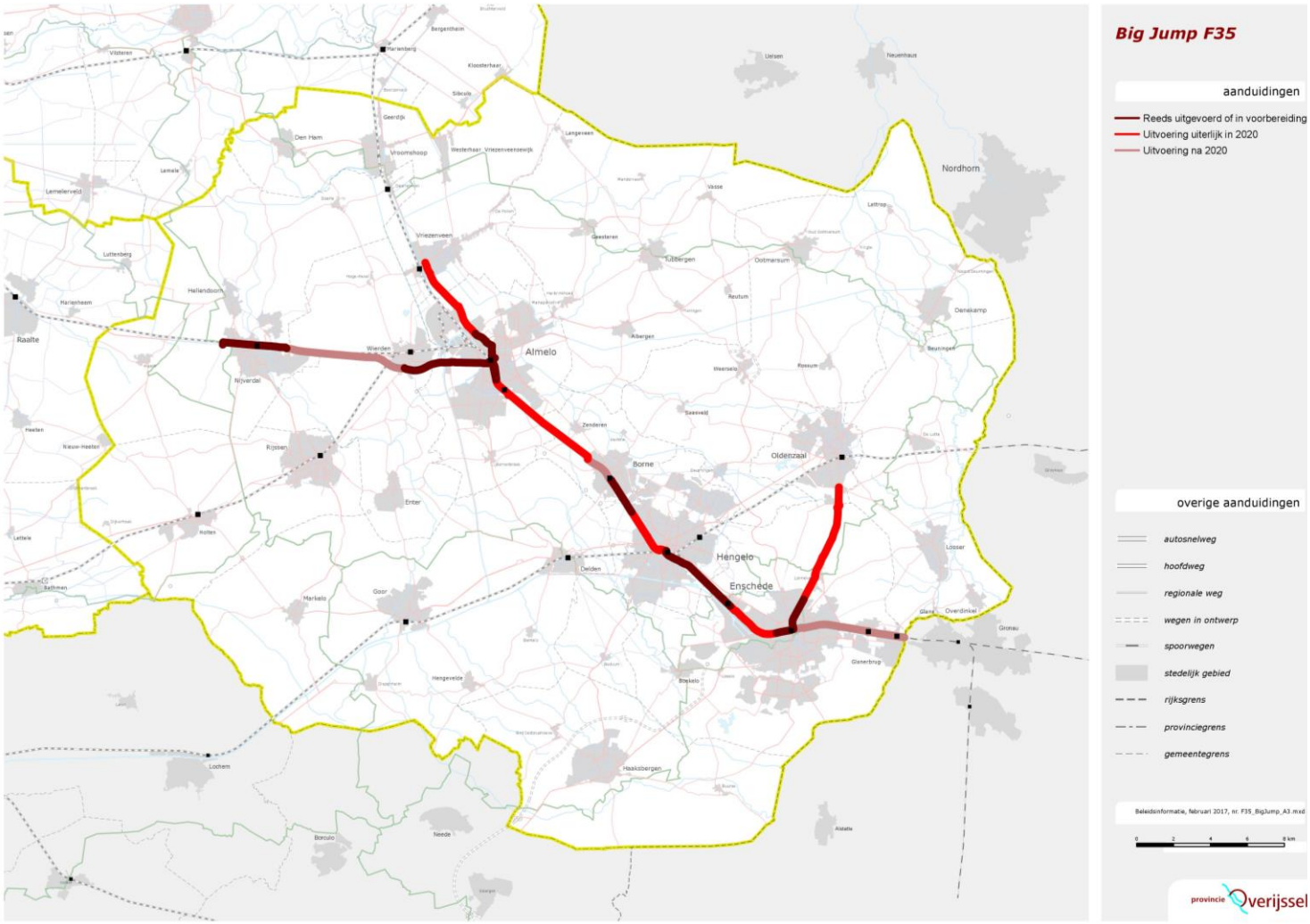


Figure 4.3: A map of the F35. The black sections are completed, the red sections will be completed before 2020 and the grey sections will be completed after 2020. Source: Fietssnelweg F35, 2015.

The F35 has been selected because it shows similarities with the supercykelstier network in Copenhagen; the route passes through several municipalities who cooperated to create uniform and coherent infrastructure. Denmark only has real cycle highways in the Capital Region, while in the Netherlands there are many different ones spread throughout the country with different qualities. Therefore, the Dutch cycle highway that was selected for research and comparison is one that best matches the supercykelstier network in the Capital Region of Denmark. Beyond the route characteristics mentioned above, the promoting and marketing efforts done to brand the F35 as a cycle highway resemble the Danish case. The F35 has also been subjected to an evaluation study on its use and results, just like the Farum route.

The location that was selected to carry out the fieldwork (see figure 4.4), was deliberately chosen because of its resemblance with the Danish surveying location — the surveying was done on the stretch between the smaller town of Borne (pop. 23.124) and the larger city of Hengelo (pop. 80.593), where Borne has about 28 percent the number of inhabitants that Hengelo has (Centraal Bureau voor de Statistiek, 2018). This is approximately in proportion to the population ratio of the Danish suburbs and Copenhagen municipality — Farum (pop. 20.302), Furesø (pop. 40.911) and Gladsaxe (pop. 69.484) together have about 21 percent the number of inhabitants that Copenhagen municipality has (pop. 613.288) (Danmarks Statistik, 2018).

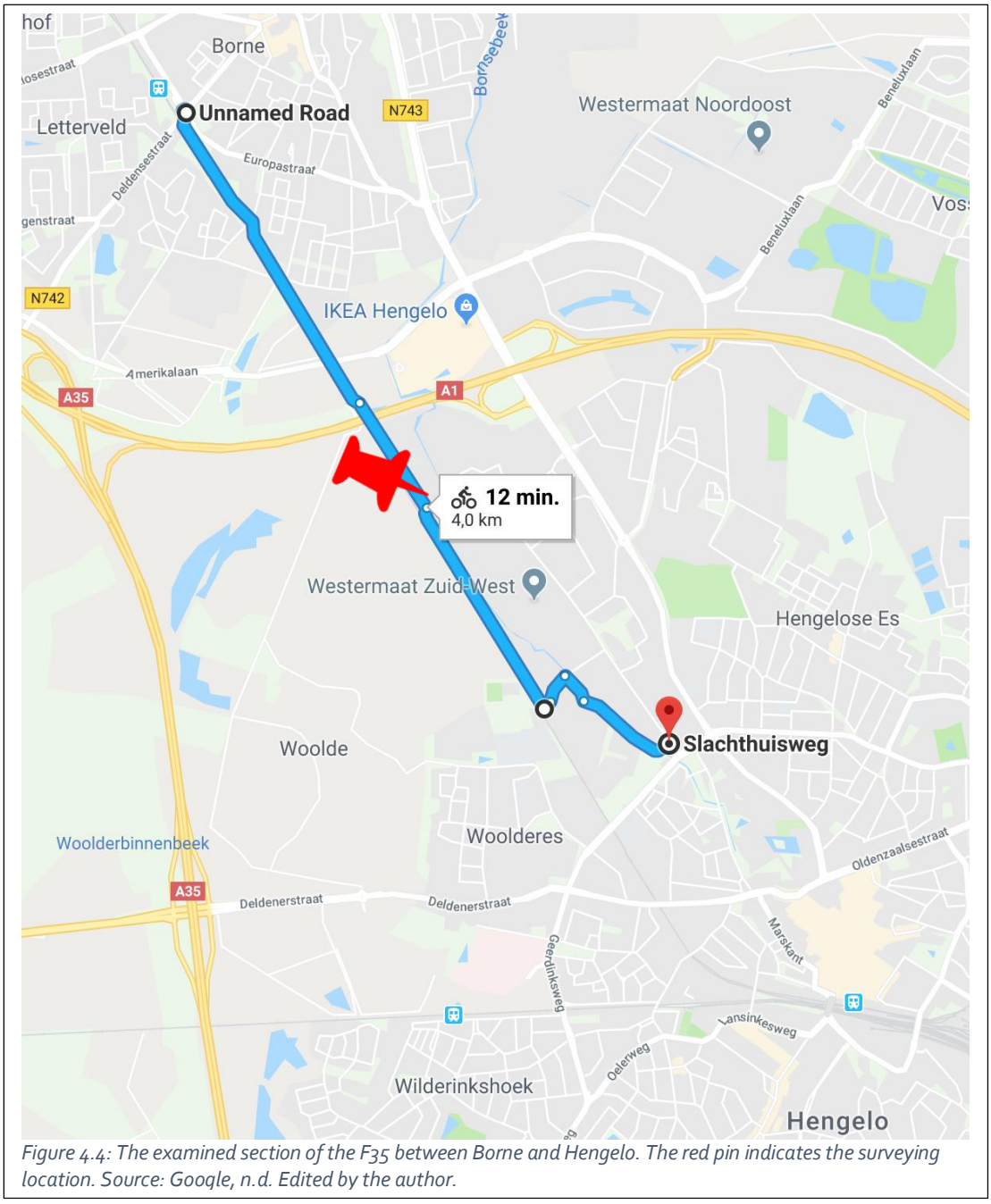


Figure 4.4: The examined section of the F35 between Borne and Hengelo. The red pin indicates the surveying location. Source: Google, n.d. Edited by the author.

Although the cycle highway is much longer than the section between Borne and Hengelo, comparing this specific section to the Farum route is defendable. The F35 is not (yet) an uninterrupted cycle highway: the whole route often includes regular cycling paths, detours and construction works on the route. The section between Borne and Hengelo is however nearly entirely uniform, consistent and recognisable cycle highway. In Borne, the route has a clearly marked beginning at the train station and when arriving in Hengelo, the cyclist is guided through the city centre on regular cycling paths with signs to the other end of the city where the uniform cycle highway continues towards the city of Enschede. This means that, like the Farum route, the section between Borne and Hengelo has a clear beginning and end and is well recognisable as a cycle highway through signs, painted symbols on the road and the width of the road.

4.6 Expectations before the fieldwork

As mentioned in the theory chapter 2, decent bicycle paths which are separated from motorised traffic are safer for cyclists and are preferred by both cyclists and drivers and lead to an increase in the bicycle mode share. It is to be expected that the construction of the cycle highways has led to a larger bicycle mode share. The increased use of the cycle highways can be expected to be either induced cycle traffic, i.e. trips that would otherwise have been made with a different mode of transport, or relocated cycle traffic, i.e. trips that would otherwise have been made on other bicycle paths. In the questionnaire the respondent is asked about this matter.

The fieldwork takes place in the coldest and darkest period of the year — it can therefore be expected that the type of cyclists encountered either would be cycling for financial, lifestyle or ideological reasons and not because it is the most comfortable way of traveling. It is inherent to the nature of cycling that one is exposed to the elements, this can be rather enjoyable in summer time, in winter time however this can be tough and unpleasant. In the questionnaire this consideration is addressed — the respondent is asked for the reasons why he or she is cycling and has to rank six pre-given reasons from most important to least important. It can be expected that the great majority will be on their way to work or school and that very few will be cycling for exercise.

On the day of surveying in the Netherlands, January 3rd, 2019, schoolchildren are still on Christmas holiday. Predictably, very little school going children will be encountered during the Dutch cycle highway survey. There will probably also be working adults who still have Christmas holiday on the day of surveying, for example school teachers, and thus will not be included in either the bicyclist count or survey. In addition, the all over population is lower in the region of the F35 than in the region of the Farum route, see section 4.5 for the population numbers. Therefore, a lower bicyclist count and number of survey participants can be expected on the F35.

4.7 Method for comparative analysis

After the data collection, i.e., the responses from the questionnaires, the results from the bicycle counts and the observations will be used to write a comparative analysis. First, a data analysis for the individual countries will be done, where the response to each question will be discussed. The analysis function of SurveyXact will be used here to create analysis reports.

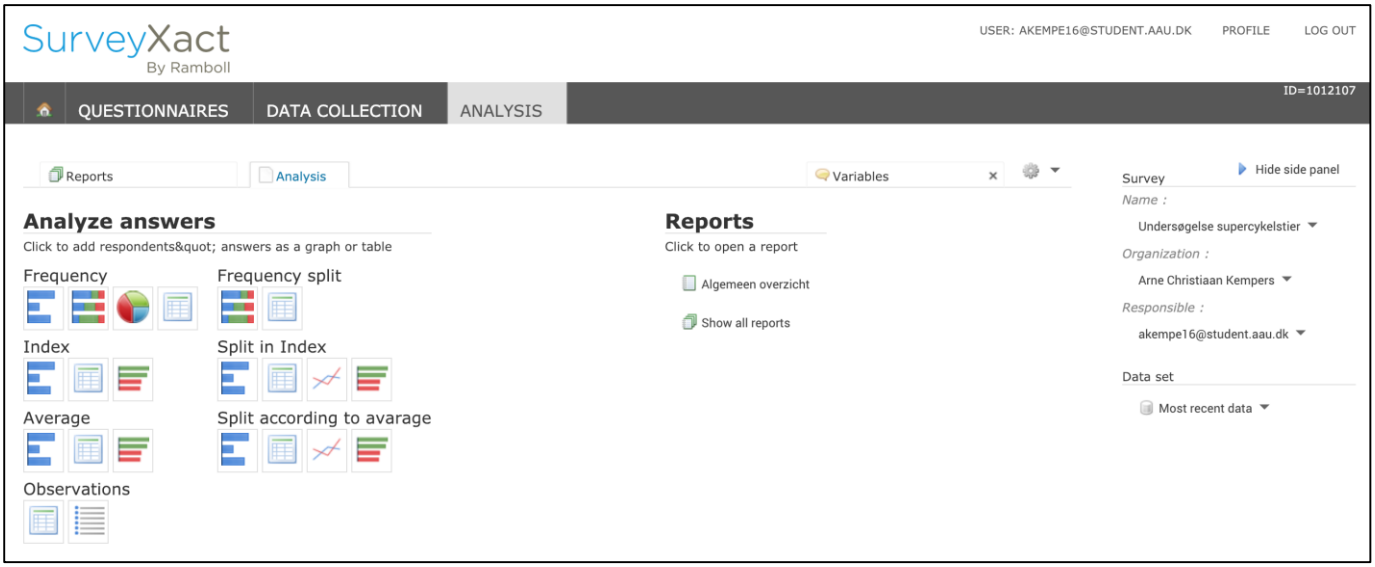


Figure 4.5: Screenshot of the analysis function of SurveyXact. Source: Own creation, 2019.

Figure 4.5 gives an impression of the SurveyXact interface. The SurveyXact program also allows for the aggregation of data, making it possible to combine questions, filter responses and other adaptations. By using this function new data is created from the initial response data and will conceivably contribute to answering the research question. These analyses, in chapter 5 and 6, form the basis of the comparative analysis, in chapter 7, where the data from the two countries is described and compared. In these three chapters, the sub-questions will be answered:

1. *How are the cycle highways used?*
2. *Who are the users of the cycle highways?*

Any remarkable results will be tried to be explained through reasoning and by comparing them with the results from previous evaluation reports of the Dutch F35 (NDC, 2018; Goudappel Coffeng, 2016) and the Danish Farum Route (COWI, 2014).

5. Surveying results from the Farum route in Denmark

During the Farum route fieldwork on the 12th of December 2018, 126 invitations to the online survey were handed out during the morning rush hour and 75 invitations were handed out during the evening rush hour, adding up to a total of 201 distributed invitations to the Danish survey. The lower number of distributed invitations during the evening rush hour has two probable causes. First there is overall more moderate traffic volume during the evening rush hour, this will be discussed further in the bicyclist counting section 5.2. Second, many of the cyclists that were approached during the evening rush hour were the same cyclists that had already been approached in the morning and thus already received an invitation.

5.1 General observations

The reason for choosing the surveying location had been the presence of the traffic light, offering the opportunity to interact with the cyclists. During the morning and evening rush hour however, the traffic light is synchronised with other traffic lights on the route to create a so-called green wave, giving cyclists who maintain a constant speed green light as they approach. This made the handing out of the survey invitations more challenging. Adding to this was the geographical nature of the site where cyclists would approach the traffic light cycling downhill and able to see the light quite far in advance. This resulted in many cyclists reducing speed as soon as they noticed the traffic light turning red, gently rolling down the hill and picking up speed as the light turned green speeding by the surveyor who did not have a chance to interact (see appendix 7 for photos of the surveying location).

From the cyclists who did engage in interaction, two expressed their dissatisfaction with the lack of street lights on the route. Far more cyclists expressed their appreciation for the cycle route and held it in high praise. Relatively few mopeds and scooters were recorded on the Farum route, especially in comparison with the F35.

5.2 Bicyclist counts

The total amount of cyclists in the morning rush hour is 616 and the total amount of evening rush hour cyclists is 464. This adds up to a total of 1080 bicyclists between 07.00 and 09.00 in the morning and between 16.00 and 18.00 in the evening. The bicyclist count on the Farum route shows a significant peak moment during the morning rush hour (see figure 5.1).

The volume of cyclists during the evening rush hour was overall lower and did not show a clear peak moment like the morning rush hour. A possible explanation for this goes as follows: The majority of the working population has the same morning ritual consisting of chiefly: waking up, eating breakfast and going to work. In general, most people wake up and go to work in the morning on a working day. This is reflected in the spike in bicyclist quantity right before office hours. In the evening however, the direction of traffic is less consistent — after office hours, people do not always travel straight from work to home, like they do vice versa in the morning. Some might work late, pick up their children somewhere, go shopping, go out, exercise or engage in some other kind of after work activity. All this means that far less people cycle the home the same way they came on the same consistent time as they do in the morning.
In the COWI evaluation report of the Farum, bicycle counts have been done close to the field work location in this report. In the report a week-long count from 2012 and 2014 is described. An increase in cyclists' volume was discovered. In order to compare bicycle counts, the number of cyclists registered by COWI between 07.00-09.00 and 16.00-18.00 on a Wednesday in 2012 and 2014, is compared with the count from this report on a Wednesday in 2018. The COWI counting station counted 726 cyclists during the morning and evening rush hour in 2012. In 2014, the counting station recorded 1047 cyclists during the two rush hour periods. This is an increase of 44.2 percent between 2012 and 2014 (COWI, 2014, pp. 100-103). Only a slight further increase can be seen between the count in 2014 and the current one, held in December 2018: with 1080 cyclists during the most recent count, the bicycle volume has increased by 3.2 percent between 2014 and 2018. This minimal increase is very likely due to the time of year the counting was done, the 2012 and

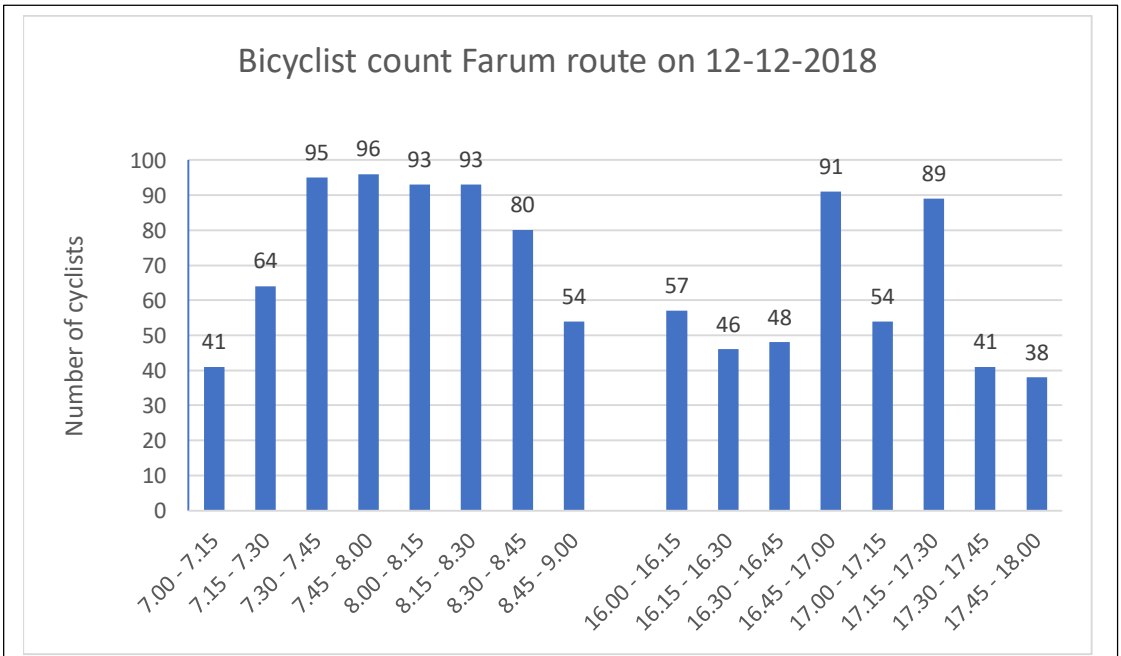


Figure 5.1: Morning and evening rush hour bicyclist count in Denmark. Source: Manual count by the author.

2014 counts have both been done in the third week of June while the 2018 count was done in the second week of December. Naturally, the weather conditions and amount of daylight make it more attractive to cycle in June, while cycling in December can be a rough matter. Another explanation could be that the period between 2012 and 2014 was a period of exceptional growth because the Farum route has only been established in 2013. It is possible that the upgrading and promotion of the route to a supercykelsti has caused this growth in cyclists' volume between 2012 and 2014. Most likely, the relatively modest increase in cyclists between 2014 and 2018 is a combination of the abovementioned factors.

5.3 Questionnaire outcomes

Out of the 201 cyclists that were handed an invitation to the questionnaire, 74 respondents filled in the complete questionnaire. This amounts to a response rate of approximately 38.8 percent on the Farum route. A complete overview of the results per question can be found in appendix 5. The data collection started on the 12th of December 2018 and was closed for respondents on the 14th of January 2019. The last response came in on the 3rd of January.

On the Farum route, by far the most cyclists cycled more than 20 kilometres per day, 47 percent of the respondents filled in this option. This is a remarkable deviation from the other distances, even the 18-20 kilometres category was not chosen nearly as much as the last category (see figure 5.2). This probably means that a lot of the cyclists travel significantly more than 20 kilometres per day. This is very much in line with the targets of the supercykelstier network in the Capital Region — the secretariat expressed in their 'vision plan', that the average commuting distance of 20.1 kilometres and even more, are realistic distances to travel by bike with a supercykelsti in place. This would involve much municipal border crossing bike traffic. The responses show that the Farum route is indeed used for such distances.

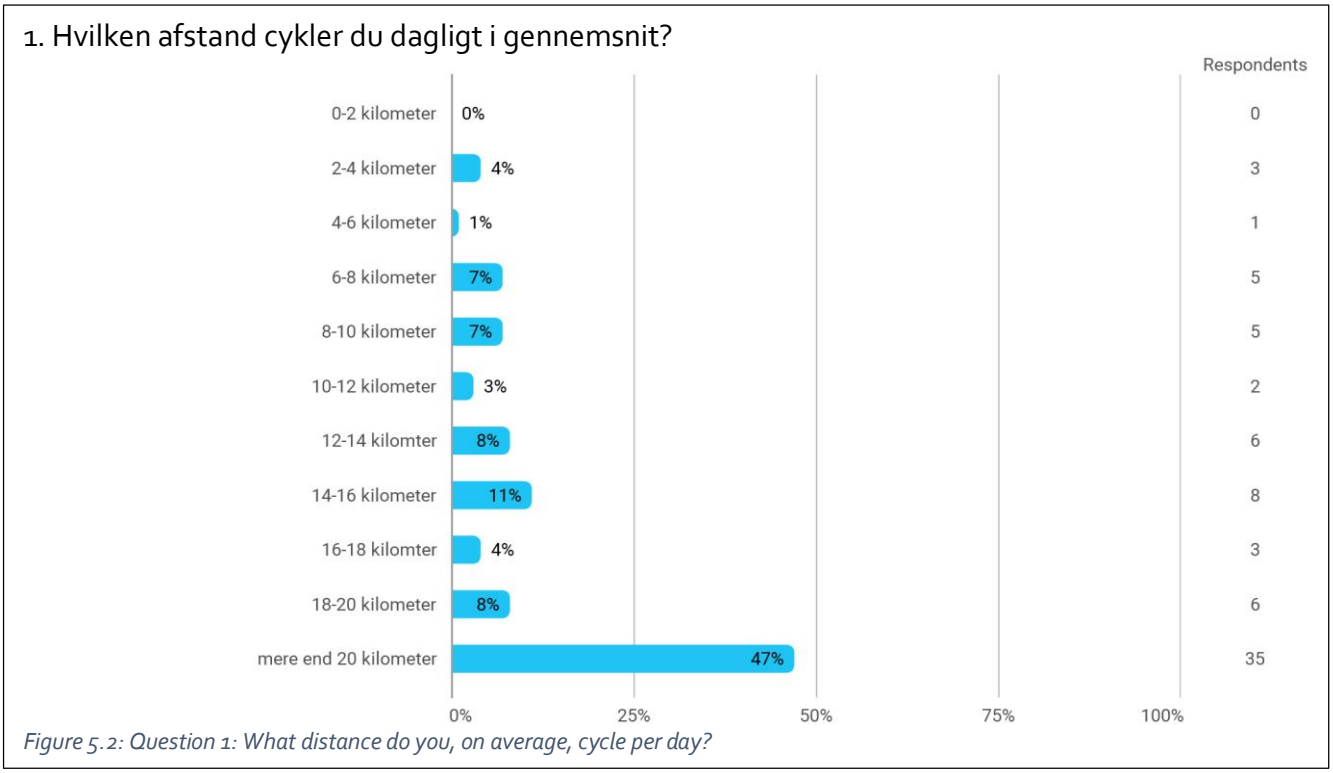


Figure 5.2: Question 1: What distance do you, on average, cycle per day?

3. Hvor mange dage om ugen cykler du gennemsnitlig?

Crossed with: 1. Hvilken afstand cykler du dagligt i gennemsnit?

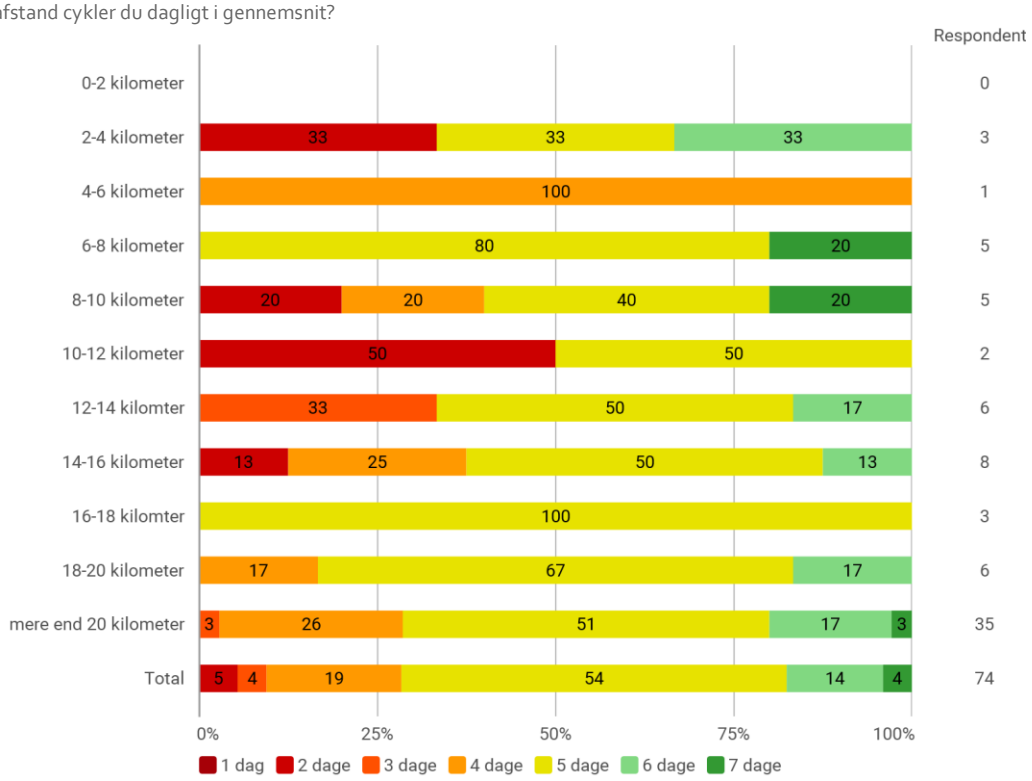


Figure 5.3: Question one combined with question three.

2. Hvad er/var dit primære rejsemål idag?

	Respondents	Percent
Til eller fra arbejdet/praktik	68	91.9%
Til eller fra skolen/universitetet	6	8.1%
Til eller fra indkøb	0	0.0%
Til eller fra besøg af venner/familie	0	0.0%
Til eller fra udflugt (fx. til parken, museet, biografen, sportclub etc.)	0	0.0%
Intet bestemt mål. Jeg cykler for fornøjelsens eller trænings skyld	0	0.0%
Total	74	100.0%

Figure 5.4: Question two showing the travelling destination of the respondents.

From combining question one with question three (see figure 5.3), asking how many days per week the respondent cycles, it becomes apparent that more than half of the group that cycles more than 20 kilometres per day on average cycles five days per week, 26 percent cycles four days per week and 17 percent six days per week. The other long-distance cyclists — from 12-14 kilometres up to the 18-20 kilometres responses — show a largely similar trend of cycling around five days per week. Bases on this analysis and combined with the fact that 91.9 percent of the respondents were underway to work and the other 8.1 percent underway to school or university (see figure 5.4), it can be assumed that the respondents consider cycling on the Farum route a realistic mode of transport for everyday commuting.

4. Hvilket andet transportmiddel bruger du til din daglige transport hvis du ikke cykler? (Flere svar muligt)

	Respondents	Percent
Delebil	1	1.4%
Egen bil	39	54.9%
Gå (mere end 1 kilometer)	13	18.3%
Offentlig transport	48	67.6%
Taxi	3	4.2%
Andre transportmidler netop:	1	1.4%
Total	71	100.0%

Figure 5.5: Question four, showing the other transport modes that respondents use for their daily transport.

At question four (see figure 5.5), respondents were asked which transport modes they use besides cycling. The majority also uses a privately-owned car and public transport. A smaller amount also regards walking distances of over one kilometre as a substitute to cycling. When answering the question, the respondents had the possibility to fill in more than one answer. Out of the 74 respondents, 39 also use their own car for their daily transport. Slightly more, 48 respondents out of 74, indicates to also use public transport besides cycling. Figure 5.6 provides insight in which options the respondents selected. It shows how many respondents indicated to use a particular transport mode as well as the other transport options those respondents selected. In the case of the car this means that out of all respondents who use a car, 51 percent also uses public transport, 10 percent also walks and five percent also uses a taxi for their daily transport.
For the other significant group, public transport, 42 percent of the public transport users also uses their private car for daily transport; 21 percent also walks as a daily mode of transport; and six percent uses a taxi.

4. Hvilket andet transportmiddel bruger du til din daglige transport hvis du ikke cykler? (Flere svar muligt)

Crossed with: 4. Hvilket andet transportmiddel bruger du til din daglige transport hvis du ikke cykler? (Flere svar muligt)

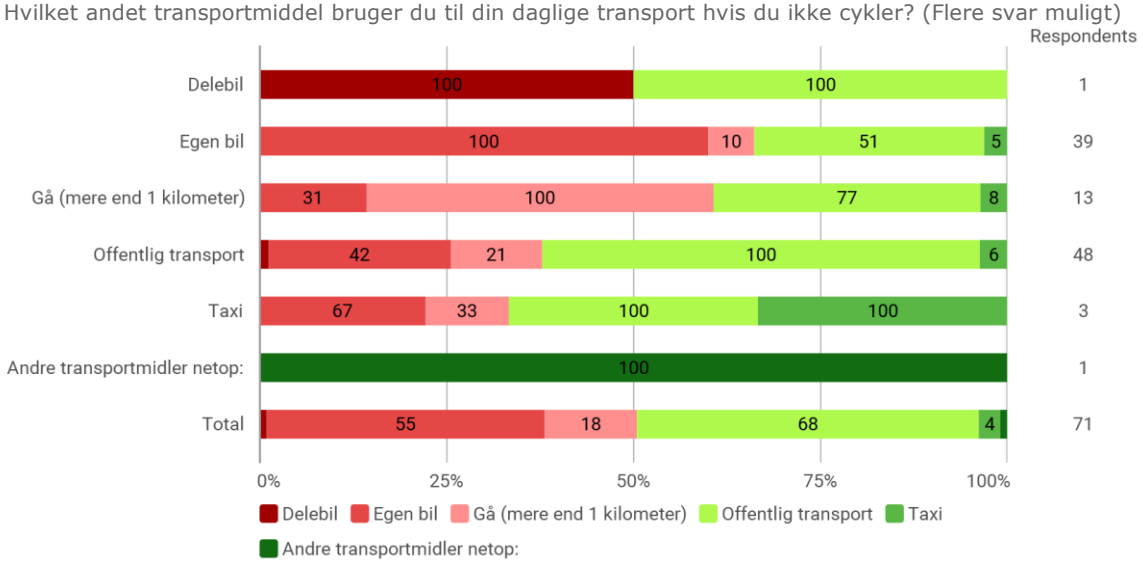


Figure 5.6: Question four showing the other transport options that the respondents have.

Out of the group that replied to walk distances over one kilometre as a daily mode of transport, 31 percent also uses their private car; 77 percent also uses public transport and 8 percent uses a taxi. Walking and using public transport seem to correlate, as the walking share is high amongst public transport users and vice versa. Car use is very low amongst those who walk and conversely is the walking share quite low amongst car users. The cause for this is most likely that a car brings the user grosso modo where he or she needs to be, while public transport usually demands some pre- or post-transport from and to a station or stop and is generally done on foot.

The single respondent who expressed to use a car from a car sharing program also uses public transport. One respondent indicated that, if not cycling, he or she uses a different mode of transport altogether which is: A car borrowed from family. No other transport mode was selected by that respondent.
It is noteworthy that in all but last-mentioned categories, public transport is well represented, with the lowest percentage under the car owners, of which 51 percent indicated to also use public transport. In total 68 percent of the respondents indicate that public transport is an alternative mode of daily transport, beating the private car which 55 percent of the respondents use. This implies that the public transport network between Farum and Copenhagen — and probably in the whole Capital Region — is well developed.

The fifth question enquired about the cyclists' reason for cycling. Six reasons were given, and the respondents were asked to arrange them in order of personal importance. The most important reason on number one and the least important on number six (see figure 5.7).

5. Hvorfor rejser du med cyklen? Arranger venligst svarende herunder fra vigtigste grund som nr. 1 til mindst vigtige grund som nr. 6.

	1	2	3	4	5	6
Mest komfortable option	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Nemmeste transportmiddel for denne her rejse	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Billigeste transportmiddel	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Hurtigeste transportmiddel	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Fordi det er bedre for miljøet	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Fordi det er sundt og giver motion	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

Figure 5.7: At question five the respondents were asked to arrange the above reasons for cycling from most important to least important.

5. Hvorfor rejser du med cyklen? Arranger venligst svarende herunder fra vigtigste grund som nr. 1 til mindst vigtige grund som nr. 6.

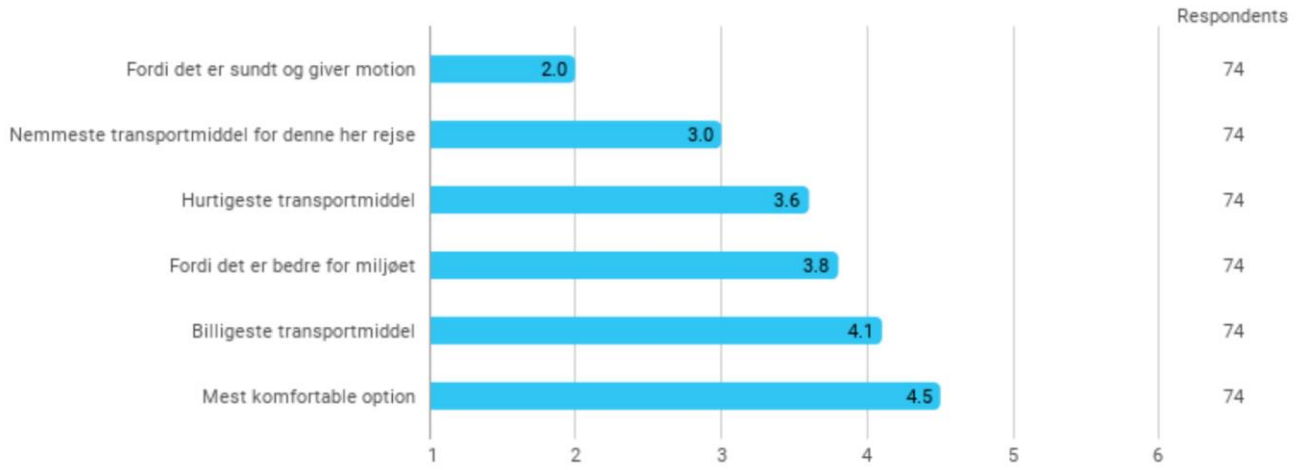


Figure 5.8: The results of question five with most important reason for cycling on top and least important below.

The results of the question can be seen in figure 5.8. By far the most respondents cycle because of the exercise they get out of it and because it is healthy. The second most important reason for cycling is because it is the most practical mode of transport for this trip, i.e., commuting. This means that the majority of the respondents deems cycling more practical than driving or taking public transport. That cycling is more practical than public transport can be argued: a bicycle is always available and ready to go when an individual wants to travel, public transport often requires walking to and from a station and is not always directly available. Depending on the time of day and location of the travelling individual, transport might not be available at all. Furthermore, with a bicycle, an individual can travel exactly where he or she want go, while public transport does so rarely. That many respondents consider cycling more practical than driving is at least remarkable — the car offers the same advantages as the bicycle in terms of availability and accessibility, plus it offers transport for longer distances without major physical exercise and in relative comfort. It could be suggested that many cyclists think cycling is a more practical mode of transport than the car because of municipal transport policy measures. Both policy measures to improve cycling conditions and policy measures to impede driving, primarily in the city of Copenhagen, have possible made cycling more practical than driving. This assertion can be defended by the fact that, without any restrictions on car use and cycling, driving is far more practical — greater distances can be travelled faster and more baggage can be transported. Policy measures like increasing parking rates, converting parking spaces for cars into parking spaces for bicycles, reducing speed limits for cars and closing down certain streets for car traffic make both driving a more expensive and time-consuming mode of transport and cycling a safer and faster mode of transport (Københavns Kommune, 2018). Although this type of policy also entails making car use and ownership more expensive, the results to question five shows that the economical reason for cycling was chosen very little, only surpassed by the comfort reason. The questionnaire results suggest that the respondents do not cycle because it is cheaper than, e.g., driving a car. Traffic congestion experienced by car commuters could also be a reason for deeming cycling to be more practical although during the surveying, no major traffic congestion was observed.

Unsurprisingly, the cyclists do not cycle because it is the most comfortable option, this reason was selected the least out of all six given reasons. Considering the day the surveying was done, it is imaginable that cycling is not as comfortable as it could be. It was in the dark time of the year and the temperature was around freezing. It is likely that, if this questionnaire would have been done in summer time, a lot more respondents would have chosen comfort as a reason for cycling. The weather conditions might also have influenced the responses to the first question (figure 5.2), separating the hardened commuter cyclists from the relaxed leisurely cyclist.

At question six, see figure 5.9, the respondents were asked if they travelled on the route before it was upgraded to a supercykelsti in 2013. Before the establishment of the Farum route, major parts of the route were already separated or standalone bicycle paths with tunnels and bridges to cross other roads (COWI, 2014). It is therefore interesting to see that more than half the respondents did not cycle there before the establishment of the supercykelsti. It is probable that of this percentage, some respondents did not live in the area yet before 2013. It is however also possible that the establishment and promotion of the Farum route has convinced some respondents to travel by bicycle. Out of the 45 percent that did cycle on the route before it became a supercykelsti, 32 percent answers that they travel the same distance and with the same frequency as before. Five of the respondents answer that they cycled a shorter distance before they started using the supercykelsti. A reason for this could be that, although they have to cycle a longer distance, cyclists prefer the safety and quality of the Farum route over a shorter, but more dangerous regular bicycle path. This phenomenon of rerouting by the cyclist is also encountered by Skov-Petersen et al. (2017) in their analysis of the Albertslundroute.

6. Vi træffedes på supercykelstien Farumruten som blev etableret i 2013. Cyklade du også der før supercykelstien blev etableret?

(Afstanden er gennemsnitlige afstand du cyklede per uge, og frekvens betyder hvor mange gange om ugen du cyklede før supercykelstien var her.)

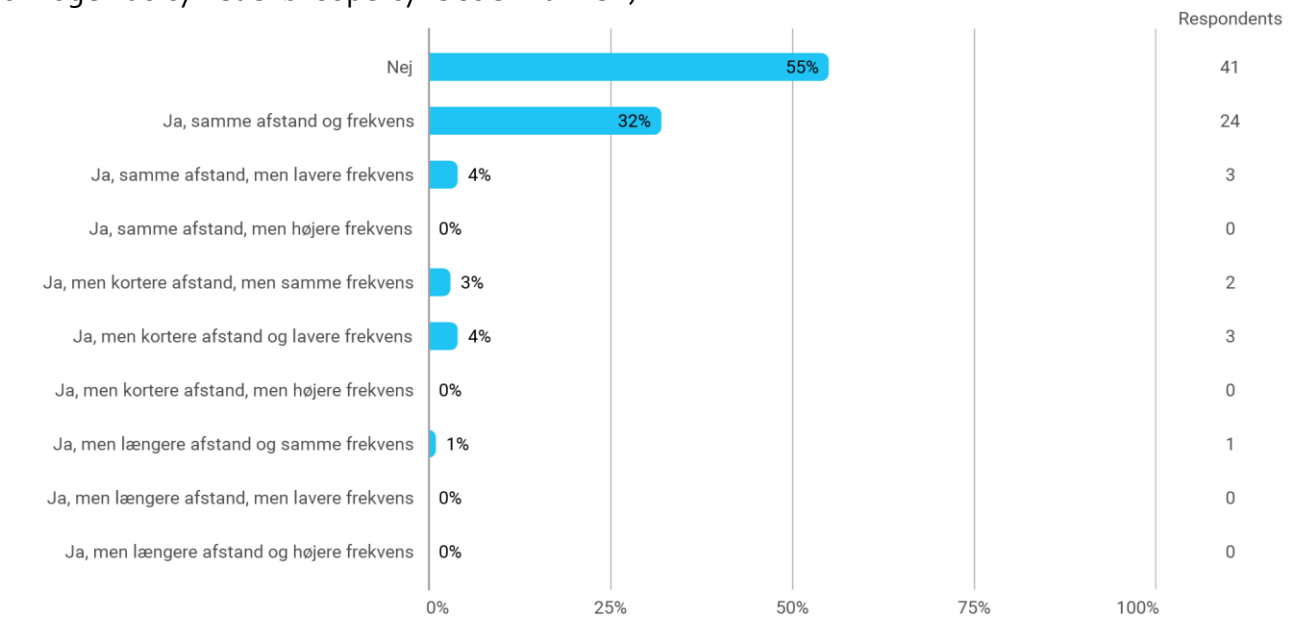


Figure 5.9: Question six showing changes in cycling behaviour after the establishment of the Farum route.

They found that the majority of new users on the Albertslund route, were cyclists who relocated from other routes. The amount of rerouted cyclists might have been even larger if the Farum route was not already an adequate route before the upgrade to supercykelsti in 2013. Only one respondent cycled a longer distance before 2013 and has seen his or her travel time reduced by the Farum route. Out of all respondents, 65 percent has started cycling more frequent since the establishment of the Farum route.

7. Ville du også bruge cyklen hvis supercykelstien ikke var her? Dvs. om du ville bruge de almindelige cykelstier.

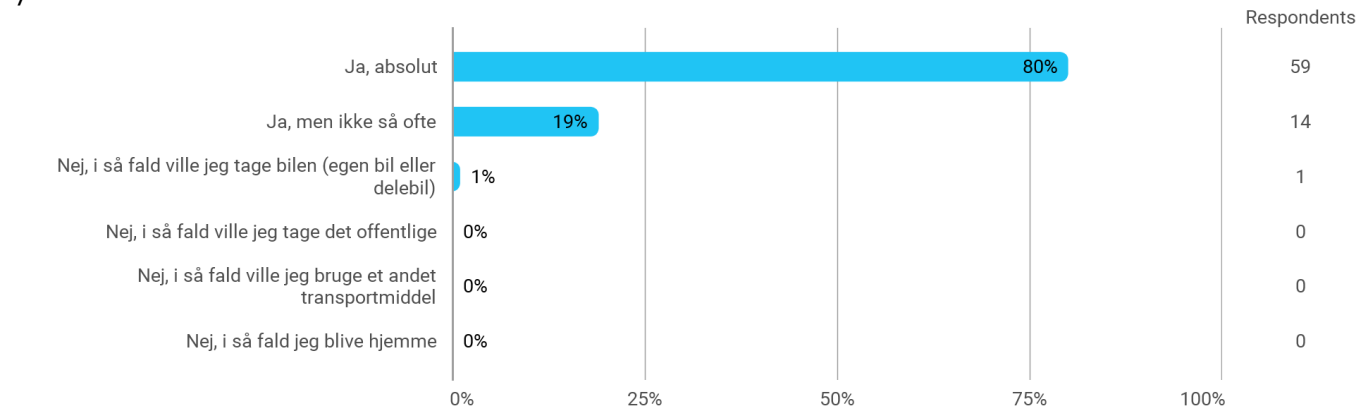


Figure 5.10: Question seven showing cycling behaviour if the Farum route would not be there.

Question seven (see figure 5.10) is somewhat a continuation of question six. The results reflect how committed the respondents are to cycling and if the supercykelsti has influence on this. At question seven, 80 percent of the respondents indicate that they would definitely cycle even if the route was not a supercykelsti. This could be explained by the already high standard of the route before it became a supercykelsti. Another reason could be the type of cyclist that responded, i.e., the hardened commuter that cycles regardless the conditions. Fourteen respondents (19 percent) however, replied that they would not cycle as often if they had to use the normal bicycle paths. This could allude to a success for the Farum route.

In figure 5.11, question four and seven are combined. Here it becomes apparent what modes of transport the second group — those who would not cycle so often if the route was not a supercykelsti — would take. Out of the 14 respondents from this group, half of them expressed to use a car for their daily transport if not cycling. 79 percent of these respondents also replied that they use public transport. There is one respondent who would not cycle at all, but drive a car if the Farum route was not there. This newly generated bicycle traffic because of the Farum route is called *induced cycling* in the study by Skov-Petersen et al., (2017, p. 204) and in their study they found out that the establishment of the Albertslund route caused around 5 percent induced traffic in their survey. Based on this study, no definitive number of induced traffic can be given, at least one respondent is an induced cyclist and the fourteen others could be induced cyclists on some days. What can be said, based on this analysis, is that the volume of cyclists on the route has increased since it became a supercykelsti in 2013.

4. Hvilket andet transportmiddel bruger du til din daglige transport hvis du ikke cykler? (Flere svar muligt)

Crossed with: 7. Ville du også bruge cyklen hvis supercykelstien ikke var her? Dvs. om du ville bruge de almindelige cykelstier.

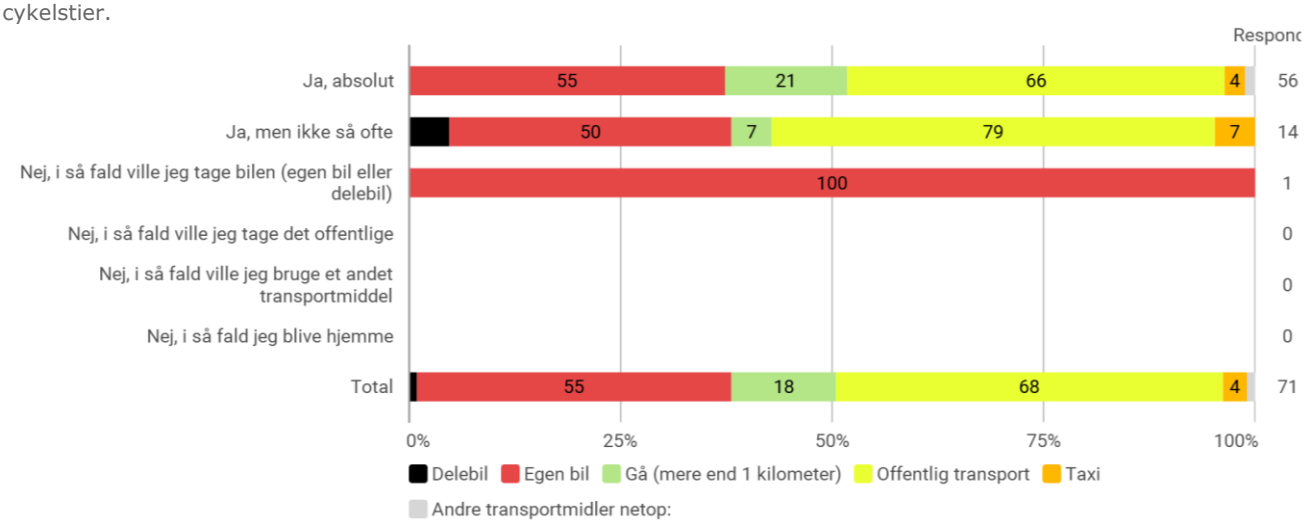


Figure 5.11: Combination question four and question seven.

8 Har supercykelstien påvirket din gennemsnitlige daglige rejse-tid og -afstand?

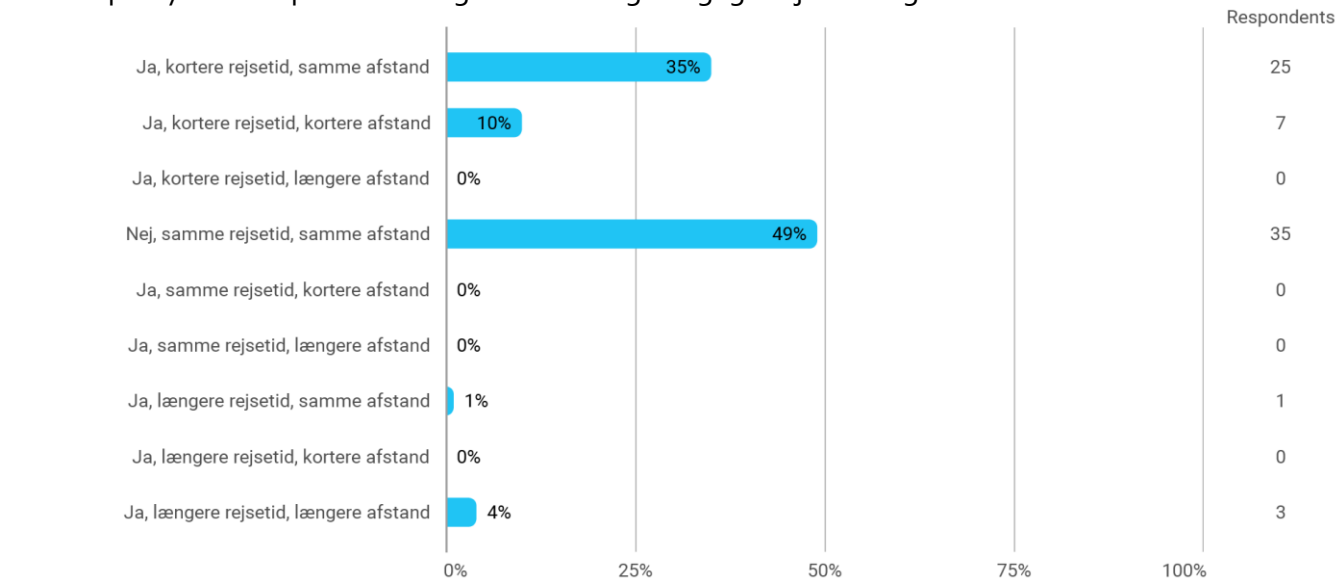


Figure 5.12: Question eight showing the impact of the Farum route on travel time and distance.

Question eight enquired the respondents about their daily travel time and distance: *Has the supercykelsti affected your average daily travel time and distance?* (see figure 5.12). Around half of the respondents expressed that the supercykelsti has not affected their travel distance and travel time. 35 percent of the respondents expresses that their travel distance has gone down, but their travel time has remained the same. Remarkable are the three respondents that indicate both their travel time and distance have gone up since they are using the Farum route. These respondents might have switched from the car to cycling for exercise reasons and take the additional travel time and distance for granted.

When aggregating question eight with question three in figure 5.13, the three respondents with longer travel time and distance appear to be dedicated and loyal cyclists: Two of them cycle five days per week on average and the other one four days per week on average.
Question nine, ten and eleven were general questions about the cyclists themselves and not about their travel behaviour. These questions were asked last on purpose because they require the least thinking and attention. The questions that required some thinking of the respondent, like travel distance and reasons for cycling, were asked at the beginning of the survey to ensure the respondents full attention.

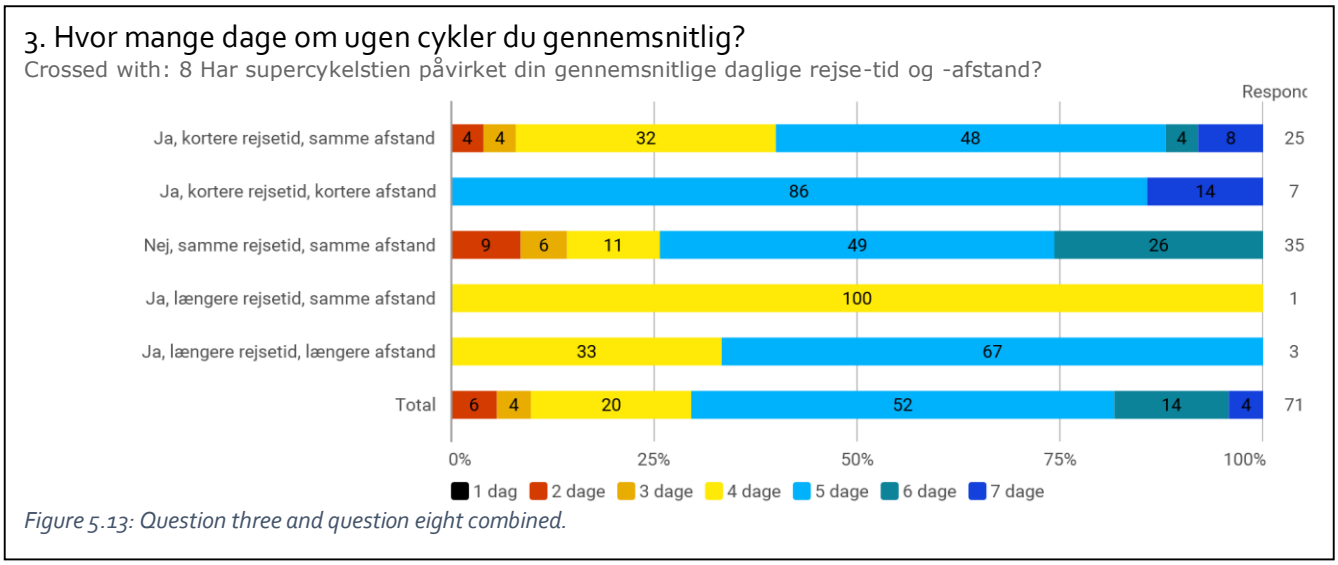


Figure 5.13: Question three and question eight combined.

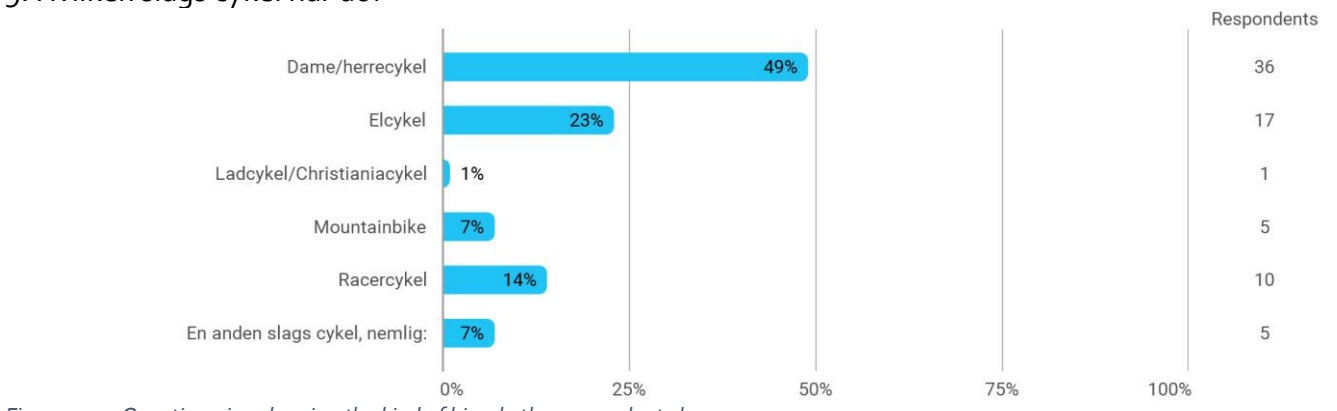


Figure 5.14: Question nine showing the kind of bicycle the respondents have.

Question nine enquired the respondents about the type of bicycle they own, see figure 5.14 for the responses to this question. Around half of the respondents owns a regular men's or ladies bike. The other two large groups are electric bicycles (23 percent) and race bikes (14 percent). It could be anticipated that these two groups of bicycle owners on average also travel longer distances, since the cruising speed of race bikes and electric bikes is generally higher than on a regular bicycle. Commuters with these kind of bikes can thus traverse greater distances then commuters on regular bikes in the same time frame. In order to investigate this, the data from question one — the average daily cycling distance — and the data from question nine are compared (see figure 5.15). The electric bicycle and the race bicycle do constitute a substantial part of the long distance cyclists — fourteen out of the 58 cyclists that cycle more than 12 kilometres per day have an electric bicycle and nine out of the 58 have race bicycles. The regular men's and ladies bike, however, is significantly represented in all categories except the 14-16 kilometres category where there is the same amount of regular bicycles as electric and race bikes. These results are remarkable, even on distances greater than 20 kilometres the regular bicycle is still the most common one. Possible explanations for this could be the high purchase costs of electric and race bicycles or the exceptional quality of the infrastructure.
Five respondents indicated to have another bike than the ones given as answering options. Four of these respondents expressed that they have a City Bike, which are electric bikes which can be rented through a bike-share scheme and can be picked up at docking stations throughout the city. One respondent expresses that he has a cyclo-cross bike with mudguards.

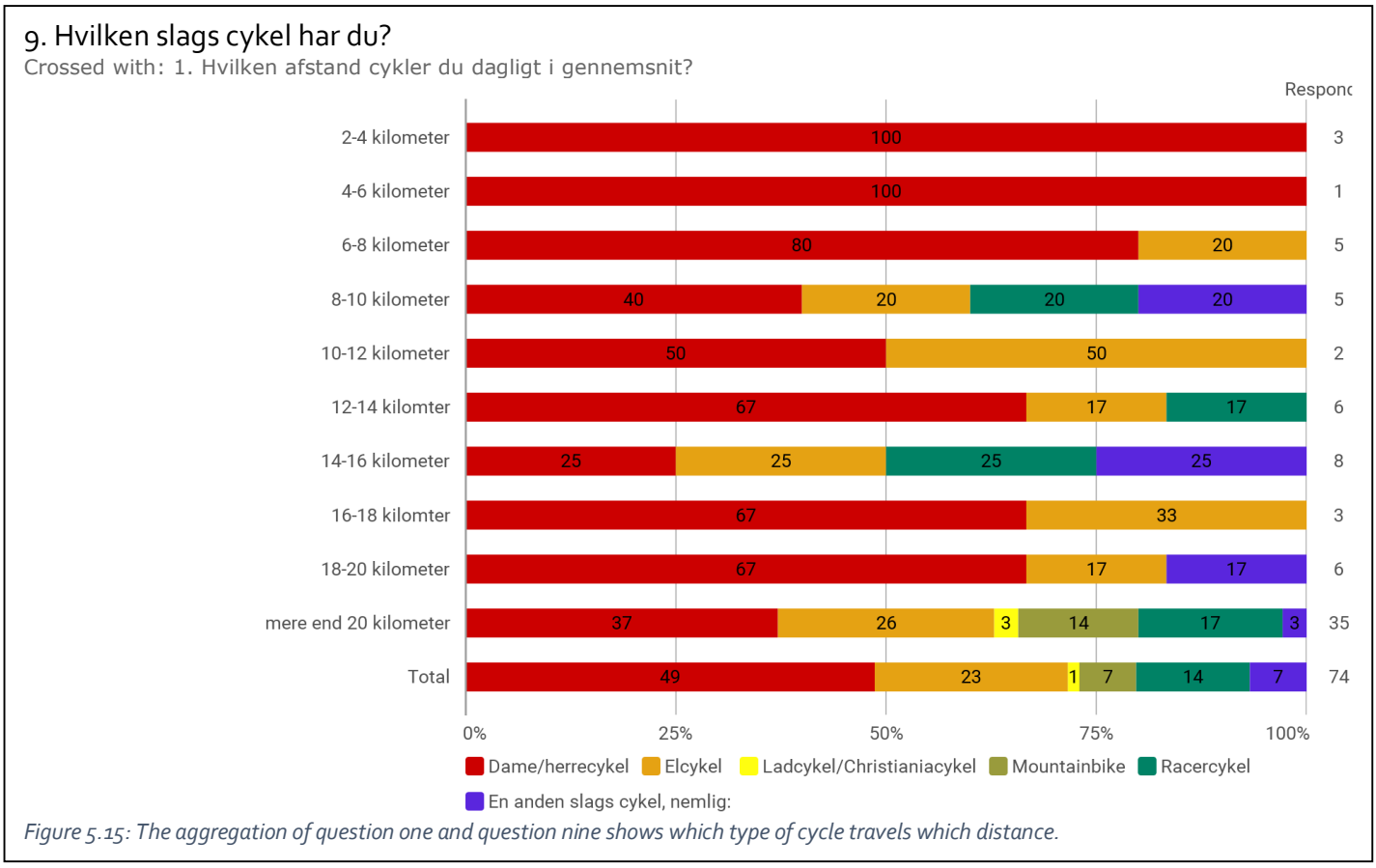


Figure 5.15: The aggregation of question one and question nine shows which type of cycle travels which distance.

Question ten enquired about the respondents age. In figure 5.16, the data about age and sex is represented. The average age for both men and women is very similar, but there are more men than women among the respondents.
In figure 5.17, the data on the respondents' age and their average cycling distance is combined. It is noteworthy that the average age does not drop as the cycling distances increase — the numbers vary per distance category, but no decreasing trend can be discovered. The average age for the respondents cycling the longest distance is however higher than the average age of the respondents in the first, second and third measured distance category. It seems thus, that age does not play a large role in the decision to cycle and the cycling distance. More likely, physical fitness and lifestyle seem to be deciding factors in choosing the bicycle as a transport mode.

10. Hvad er din alder?
Split on: 11. Hvad er dit køn?

	Observed minimum	Observed maximum	Average	Respondents
Kvinde	21.00	63.00	45.36	33
Mand	23.00	64.00	45.63	41
Total	21.00	64.00	45.51	74

11. Hvad er dit køn?

	Respondents	Percent
Kvinde	33	44.6%
Mand	41	55.4%
Total	74	100.0%

Figure 5.16: Question 10 and 11, representing the information on age and sex of the respondents.

10. Hvad er din alder?
Split on: 1. Hvilken afstand cykler du dagligt i gennemsnit?

	Observed minimum	Observed maximum	Average	Respondents
0-2 kilometer	-	-	-	0
2-4 kilometer	34.00	54.00	42.33	3
4-6 kilometer	27.00	27.00	27.00	1
6-8 kilometer	21.00	58.00	36.20	5
8-10 kilometer	37.00	56.00	48.20	5
10-12 kilometer	44.00	56.00	50.00	2
12-14 kilomter	28.00	52.00	40.83	6
14-16 kilometer	44.00	61.00	51.75	8
16-18 kilomter	49.00	63.00	55.67	3
18-20 kilometer	21.00	53.00	36.50	6
mere end 20 kilometer	23.00	64.00	47.06	35
Total	21.00	64.00	45.51	74

Figure 5.17: Question 10 and 1, showing the age data per distance category.

11. Hvad er dit køn?

Crossed with: 1. Hvilken afstand cykler du dagligt i gennemsnit?

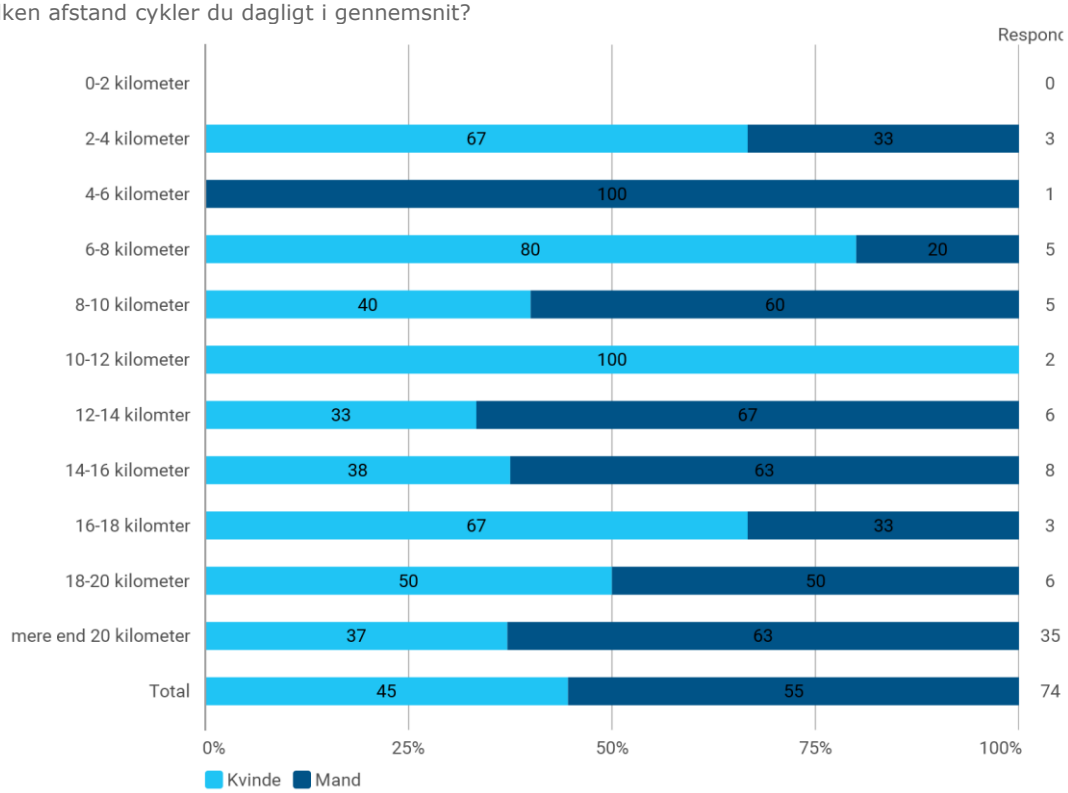


Figure 5.18: Here cycling distances is shown in comparison with sex.

Aggregating the sex information with the information on cycling distances, see figure 5.18, shows how many women and how many man cycle a certain distance. On the longest distances, more than 20 kilometres, the men are better represented, but on the third longest distance, 16-18 kilometres, the women are better represented. In the 18-20 kilometre category, the number of women and men is equal. Men in general are more represented in this figure, because there are more male respondents than female respondents.

In figure 5.20, the average age per cycling frequency category is displayed. Here a slight decrease in age can be discovered as cycling frequency goes up. In general, the youngest cyclists can be found in the category that cycles six days per week. The 'three days per week' category is also young, but this is a small category, which makes it less significant when analysing.

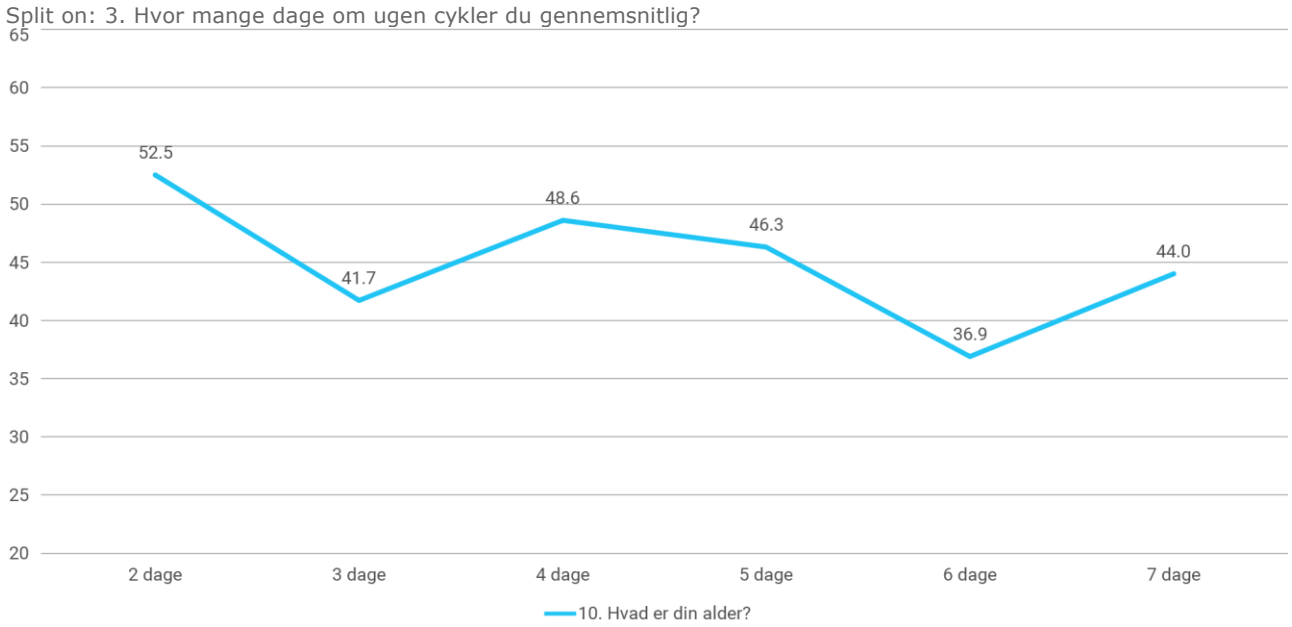


Figure 5.20: Question 10 and 3, showing average age per cycling frequency.

5.4 Conclusion

In general, the cyclists on the Farum route are cycling enthusiasts who commute long distances by bicycle and consider their commuting journey an exercise. To some degree this might be a consequence of the time of the year the surveying was done, which was quite cold and dark. Most cyclists cycle five days per week and the most important reason for doing so is because cycling is a work-out and healthy.

About half of the cyclists did not see their daily travel time and distance affected by the establishment of the Farum route as a supercykelsti and 80 percent would cycle just as often if there was no supercykelsti. The majority of the cyclists in the long-distance category, cycle these distances five days per week and they do so on varying types of bicycles. Most cyclists indicate to cycle on a regular ladies or men's bike, furthermore there are quite a few electric bicycles and race bikes. The results of the questionnaire suggest that the influence of the electric bicycle on cycling distance is limited, the amount of electric bicycles is not proportionate to the length of the average daily cycling trip. Sex and gender do not seem to affect cycling distance either. When not cycling, public transport is the most popular transport mode, 68 percent of the respondents indicated to use public transport. The second most popular alternative transport mode is the private car; 55 percent of the respondents indicate to drive as an alternative to cycling. That public transport is more popular than driving suggests that the public transport network is well developed and that transport policy aimed at restraining car use, pays off.

6. Surveying results from the F35 in the Netherlands

The fieldwork at the F35 on the 3rd of January 2019 resulted in a total of 240 distributed invitations — in the morning rush hour 143 invitations were handed out and during the evening 97 invitations were handed out. The reason for this proportioning is that a large number of cyclists already had been encountered in the morning, as was the case with the surveying on the Farum route.

6.1 General observations

Although the bicycle count shows a lower total number of cyclists on the F35 than on the Farum route, more survey invitations have been handed out. The lower number of cyclists was to be expected, see section 4.6 about ex ante expectations. The high amount of survey invitations that were handed out however, was unpredicted. This can be explained by the nature of the infrastructure. The surveying in Denmark, although done at a traffic light, took place at a downhill section of the route. This made it harder to confront cyclists when the traffic light was green as they would pass by at great speed. The F35 is an almost entirely flat route, much like the rest of the Netherlands. Cyclist would pass by at a moderate speed and even had to reduce their pace because of a bend in the road. More photos of the surveying location can be found in appendix 7.

This made handing out the survey invitations considerably easier to do than on the Farum route, by standing in the curve of the road, the invitations could easily be handed out to the cyclists who mostly had a moderate pace. Although a few cyclists speeded by and could not be approached, many cyclists even stopped and enquired into the intentions of the survey.
The F35 Borne-Hengelo has very few interruptions and only has traffic lights where a bus lane needs to be crossed. However, since only four busses would pass every hour, the number of cyclists having to stop for a red light is negligible. The cyclists can otherwise cycle uninterrupted between Borne and Hengelo on a wide cycle path, clearly indicated as cycle highway with the F35 logo, running mostly parallel to a railroad. The absence of motorised traffic makes it a quiet and serene route, especially compared to the Farum route, which runs parallel to a major motorway. During the surveying, numerous mopeds were observed, much more than on the Farum route.

6.2 Bicyclist counts

During the surveying in the Netherlands, 263 cyclists were counted in the morning rush hour and 337 were counted during the evening rush hour (see figure 6.1). The total number of cyclists that were counted during the fieldwork is 600. This number is notably lower than the number of cyclists counted on the Farum route, i.e., 1080 cyclists. There are two apparent causes for this. The first one is the fact that on the day of surveying school children and many adults still had Christmas holiday and thus did not commute to school or work that day. This is foreseen and described in the expectations section 4.6. The other reason is the mere size difference, both in population and length of the infrastructure — the population of the municipalities which the Danish supercykelsti crosses is considerably higher than the population of the municipalities which the examined section of F35 crosses i.e. Borne and Hengelo.

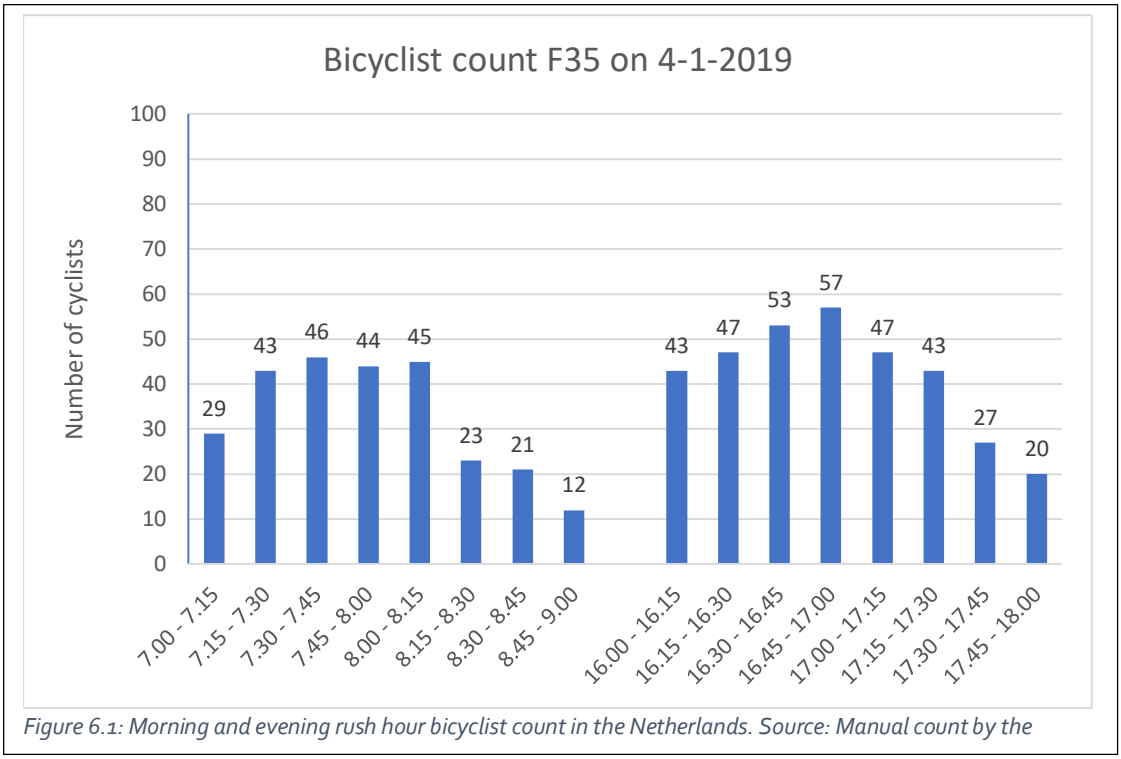


Figure 6.1: Morning and evening rush hour bicyclist count in the Netherlands. Source: Manual count by the

This element of population size is further described in section 4.5. The length of uninterrupted cycle highway is also greater in Denmark; the Farum route is 20.8 kilometres long and the F35 between Borne and Hengelo is four kilometres long (Google, n.d.). The effect of this can be anticipated with an example: A commuter who has to travel, say, ten kilometres to work, will be more inclined to travel by bicycle if he can ride nearly the entire way on a cycle highway (as could be the case with the Farum route) then if he could ride on a cycle highway for four kilometres and would have to travel the remaining distance on regular cycling paths where he would encounter traffic lights, non-prioritised intersections, motorised traffic and more nuisances. The above scenario could partially explain the lower volume of cyclists on the F35 compared to the Farum route.

A possible explanation for the higher number of cyclists during the evening count than during the morning count, could be the proximity of an IKEA, a gym and other shops combined with the Christmas holiday argument. A few cyclists announced that they visited or were about to visit the IKEA, making it plausible that a fair number of cyclists were not commuters. This is also reflected in the survey results, for example in figure 6.4. It is logical that people in their holiday are more inclined to go to the shops between 16.00 and 18.00 than between 07.00 and 09.00. This rationale would help explain the higher volume of cyclists in the evening rush hour on the F35 — whereas the count on the Farum route on an ordinary weekday showed the opposite.

On the F35, a multitude of pedestrians, was observed. Although not counted or included in the survey, it is an observation worth noting, since there were no pedestrians observed on the Farum route. This can be explained by the different characteristics of the two compared cycle highways. The Farum route is, on the whole, narrower than the F35 and cyclists at times achieve high speeds due to unlevelled terrain, i.e. the supercykelsti traverses rolling terrain with hills and dells. The F35 on the other hand, is quite wide and is completely level, both eliminating high speeds due to downhill terrain and allowing users to see other traffic participants long in advance and adapt their behaviour to it. Moreover, walking on the F35 is legally allowed where it is not on the Farum route.

The section of F35 where the count was held, has been subjected to a bicycle count before. In April 2016, the mobility consulting group Goudappel Coffeng counted the number of cyclists on the same location and on the same time intervals. In the morning rush hour, 344 cyclists were counted and in the evening rush hour 340 cyclists were counted, in total of 684 cyclists (Goudappel Coffeng, 2016). The explanation for the higher volume in the 2016 count is the same as the Danish case: the weather conditions cause more people to cycle in April then in January.

6.3 Questionnaire outcomes

Out of the 240 questionnaire invitations that were handed out to cyclists of the F35, 90 recipients filled out the questionnaire completely. This amounts to a response rate of exactly 37.5 percent on the F35, which is similar to the Danish response rate of 38.8 percent. A complete overview of the results per question can be found in appendix 6. The data collection started on the 3rd of January 2019 and was closed for respondents on the 16th of January 2019. The last response came in on the 9th of January.

The cyclists on the F35 show a varying pattern in their average daily cycling distance, which is shown in figure 6.2. While the majority indicates to cycle more than 20 kilometres per day, it is not a great majority and the distances under 10 kilometres are also represented. There are several conceivable explanations for this. The most obvious reason is that the surveying was done on the 4th of January when many people still had Christmas holiday. Therefore, many respondents probably did not cycle as far as they would on a working day. The question however, asked clearly about their average daily cycling distance, not their cycling distance on the day of surveying. Also possible is that many of the respondents are pensioners who would not cycle there on a regular day — these respondents probably cycle lesser distances on average than a commuter. This argument is confirmed by calculating the average age per cycling destination, see figure 6.3. This calculation

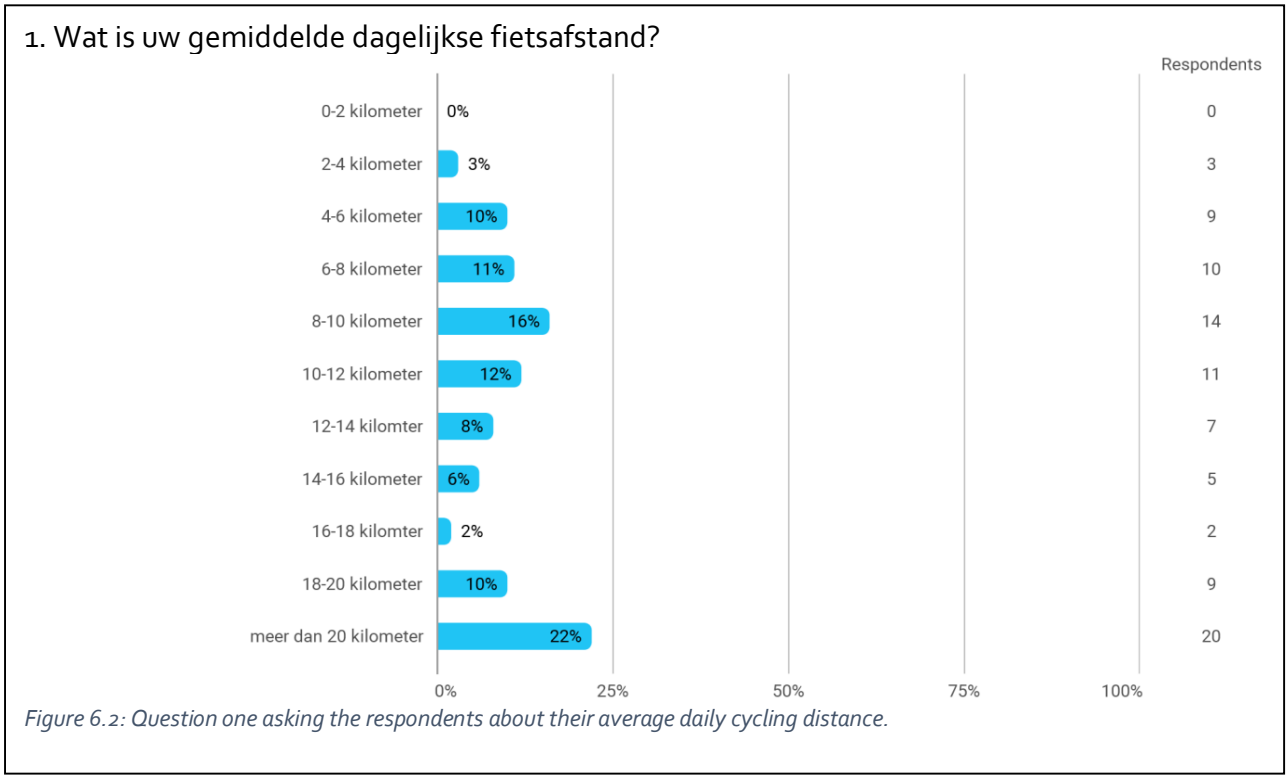


Figure 6.2: Question one asking the respondents about their average daily cycling distance.

shows that the average age of those going shopping or visiting friends is higher than the age of those commuting to work or school. The respondents that were out on a daytrip were quite young, but these two respondents might still have had Christmas holiday on the day of surveying.
Another explanation involves the distance between Borne and Hengelo, which is around four kilometres. Commuters between Borne and Hengelo would thus on average travel eight kilometres, which is reflected in the survey result. The respondents who replied 'more than 20 kilometres', might be commuters who commute from the cities Almelo or Enschede which are situated further down the F35, with Almelo to the northwest of Borne and Enschede to the southeast of Hengelo (see figure 4.3 for an overview of the F35 and the before mentioned cities). These commuters travel the F35 for a much longer distance than the distance between Borne and Hengelo.

10. Hoe oud bent u?

Split on: 2. Wat is/was uw voornaamste bestemming vandaag?

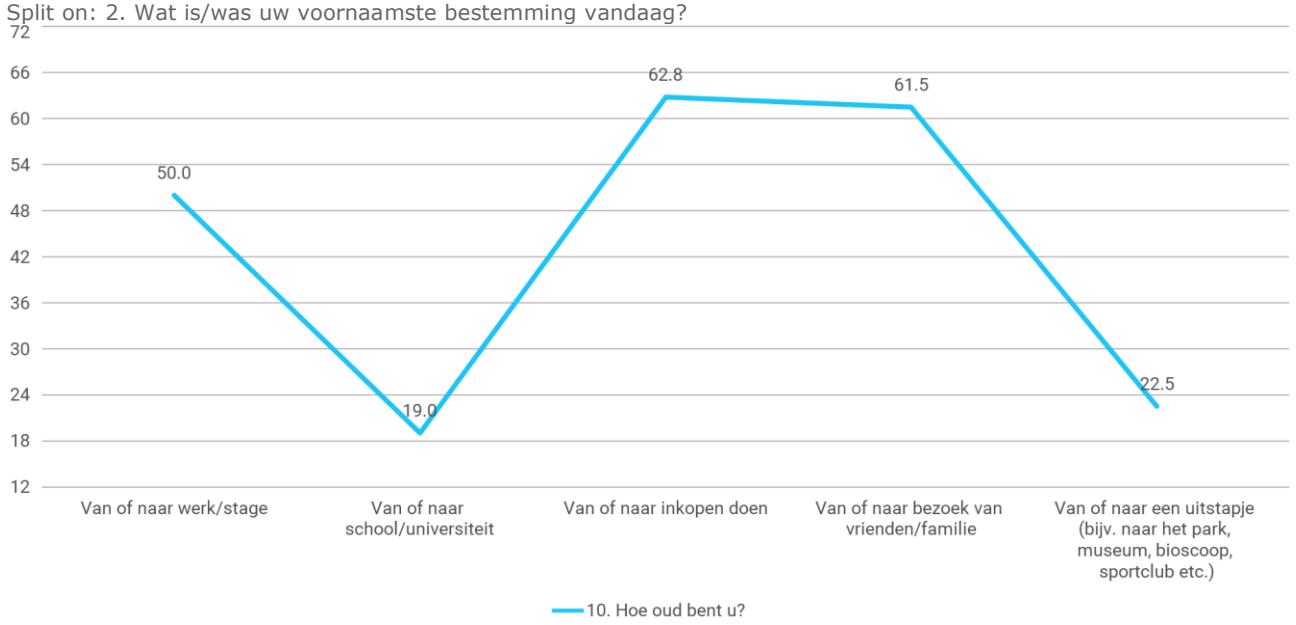


Figure 6.3: Question 2 and 10, showing average age per cycling destination.

2. Wat is/was uw voornaamste bestemming vandaag?

	Respondents	Percent
Van of naar werk/stage	78	87.6%
Van of naar school/universiteit	2	2.2%
Van of naar inkopen doen	5	5.6%
Van of naar bezoek van vrienden/familie	2	2.2%
Van of naar een uitstapje (bijv. naar het park, museum, bioscoop, sportclub etc.)	2	2.2%
Geen bestemming, ik fiets voor ontspanning of als training	0	0.0%
Total	89	100.0%

Figure 6.4: Question two showing the respondents' main travelling destination on the day of surveying.

The results of questions two (see figure 6.4), show that the majority, 87.6 percent of the respondents, is commuting despite the Christmas holiday. This mitigates the presumed holiday effect on the average travelling distance. When aggregating the results from questions one and two (see figure 6.5), it becomes clear that all but two cyclists who cycle distances over 10 kilometres, are commuters. Two cyclists who were out on a shopping trip responded that they cycle respectively 12 to 14 and 16 to 18 kilometres per day. These are very possibly cyclists who commute to work on bike, but were still on Christmas holiday on the day of surveying. The average cycling distance of the non-commuters is considerably lower, which can be seen as a confirmation of the pensioners' argument: those who are not commuters cycle lesser distances on average.

The objective of building high-grade cycle highways in the Netherlands is to make cycling a faster mode of transport so it can compete with the cars on travelling distances over 15 kilometres. The Cycling Union (*Fietsersbond*) — who are organising intergovernmental cooperation to develop a cycle highway network in the Netherlands — settled on this distance because 61 percent of the Dutch population lives within 15 kilometres of their work. By building a cycle highway network, this distance can be covered in less time and should incentivise people to cycle instead of drive. An additional reason for creating cycle highways is the rise of electric bicycles; to maximise their potential in competing with the car, suitable infrastructure is required where electric bicycles can safely reach high cruising speeds (Fietsersbond, 2013). The analysis of questions one and two shows that indeed many commuters cycle distances over 15 kilometres.

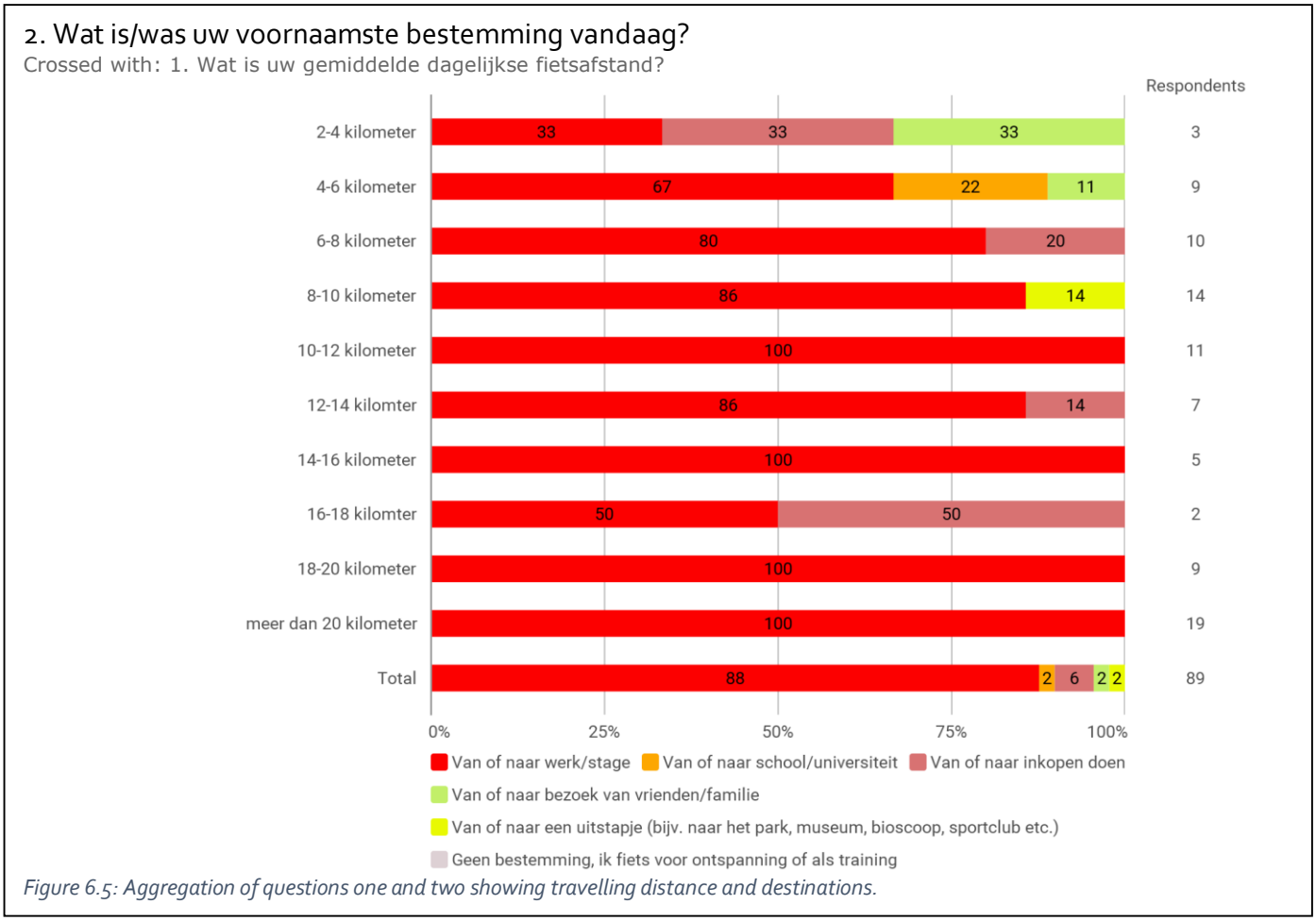


Figure 6.5: Aggregation of questions one and two showing travelling distance and destinations.

3. Hoeveel dagen per week fietst u gemiddeld?

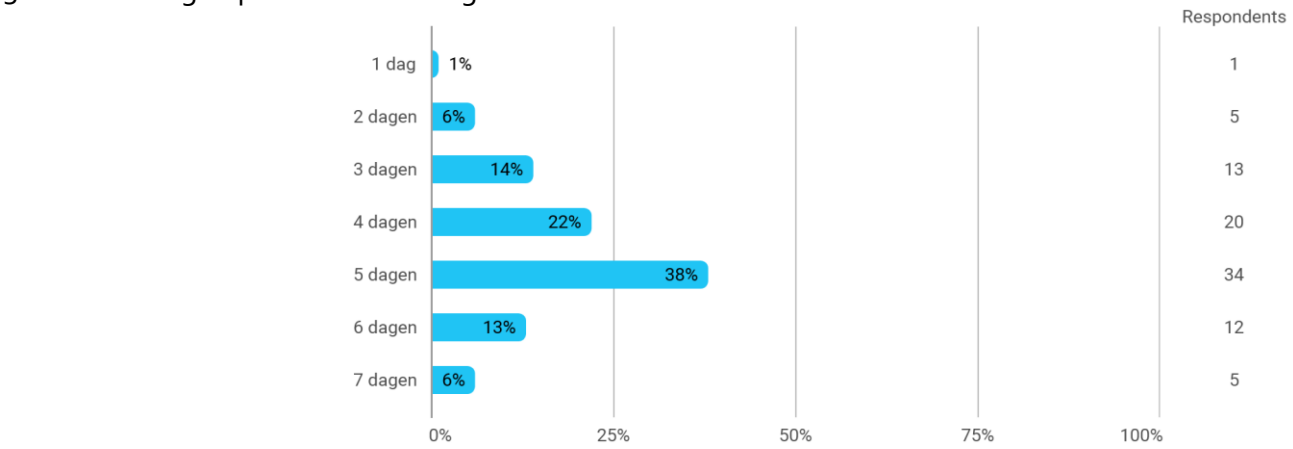


Figure 6.6: Question three," how many days a week do you cycle on average?"

At question three, the average daily cycling distance of the respondent was examined (see figure 6.6). The results in the figure show a normal distribution; most respondents indicate that they cycle five days per week on average (38 percent), while the number of respondents continues to decline the further from the mean.

The responses to question four, depicted in figure 6.7, show the alternative transport options of the respondents. The results show that 82 percent of the respondents also uses a car for their daily transport, which is a great majority. To a lesser degree the respondents replied to use public transport: 26 percent of the respondents. This could be explained by the topography of the region; the F35 is located in the region of Twente in the eastern part of the Netherlands. This is a rural region and, for Dutch terms, thinly populated part of the country. In these kind of regions, people generally rely on a car since public transport tends to be less developed in rural regions.
The share of cars through a car-sharing program is negligible as well as taxi use and walking. Ten respondents have indicated that they have a mode of transport that they use for their daily transport which is not amongst the given options: Three of these respondents indicated 'none', meaning that the bicycle is their only means of transport; two respondents replied that they use a motorbike; two respondents replied that they use an airplane; two respondents replied that they ride-share with someone; one respondents replied that he uses a company van as an alternative to cycling.

4. Welke andere transportmiddelen gebruikt u voor uw gemiddelde reisafstand indien u niet fietst? (Meerdere antwoorden mogelijk)

	Respondents	Percent
Deelauto	3	3.3%
Eigen auto	74	82.2%
Lopen (meer dan 1 kilometer)	6	6.7%
Openbaar vervoer	23	25.6%
Taxi	1	1.1%
Anders, namelijk:	10	11.1%
Total	90	100.0%

Figure 6.7: Question four, showing the other transport options of the respondents.

4. Welke andere transportmiddelen gebruikt u voor uw gemiddelde reisafstand indien u niet fietst? (Meerdere antwoorden mogelijk)

Crossed with: 3. Hoeveel dagen per week fietst u gemiddeld?

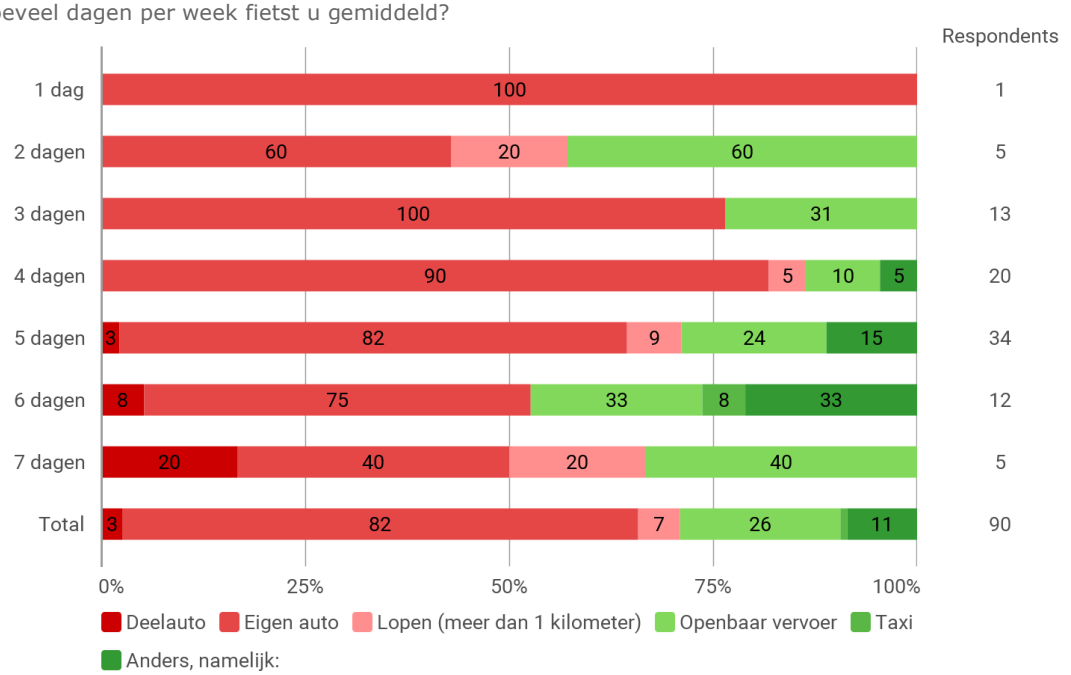


Figure 6.8: Combining questions three and four showing cycling frequency and other transport options of the respondents.

In figure 6.8, question three is aggregated with question four — which explores the other transport options of the respondents — and shows that private car use and public transport use is proportionally equally distributed among the different cycling frequencies. Public transport use is quite low among the respondents who cycle four days per week, only 10 percent use public transport and only 5 percent walk or use a taxi. Car use, on the other hand, is above average. It is plausible that these respondents drive on the days that they are not cycling. This also implies that cycling is the only feasible alternative for driving, possibly because the public transport infrastructure is not adequate in the region.

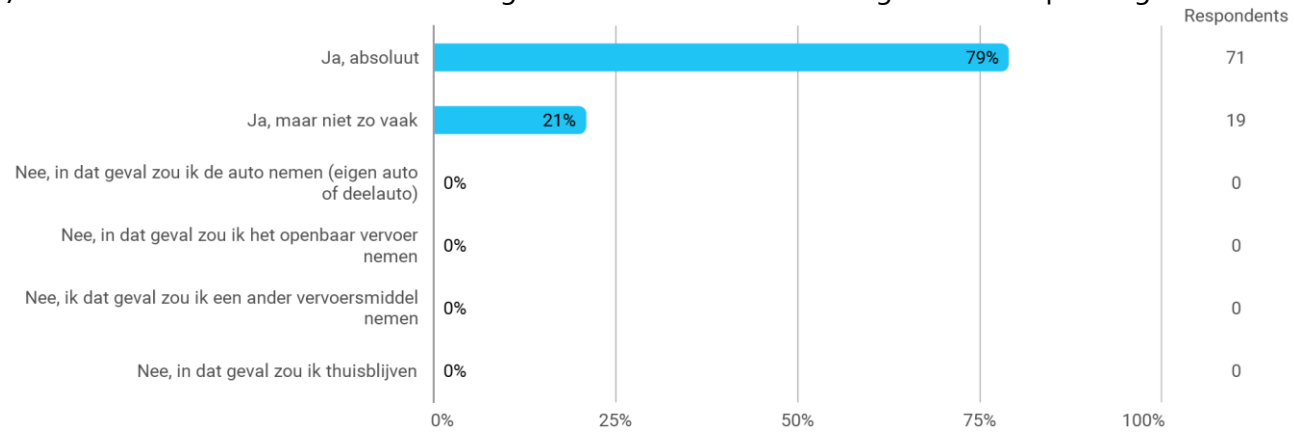


Figure 6.9: Question seven, showing that all respondents would cycle if the F35 would not be there. 79 percent would cycle nonetheless, 21 percent would also cycle if the F35 was not there, but not as often as they do with the F35.

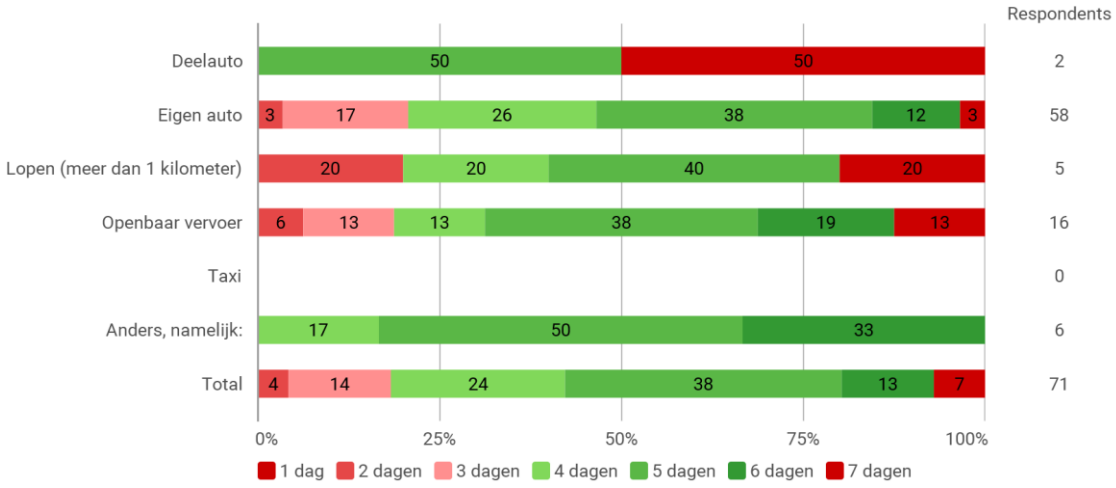
In order to determine if the F35 has made cycling a realistic alternative or if cycling was already a realistic alternative before the F35 was established, first the responses to question number seven are displayed in figure 6.9. The responses show that the majority, 79 percent, of the cyclists on the F35 are dedicated cyclists who would also cycle in case the F35 was not there. A share of 21 percent of the respondents would not cycle as often if the F35 was not there and the rest, 79 percent, would cycle regardless of the cycle highway being there or not. These groups are the main subject of our next analysis.

Subsequently, question three and four are combined and filtered per answer to question number seven, see figure 6.10. Here question three and four are aggregated and split up by response to question number seven. The top graph shows cycling frequency and other transport options of the respondents who indicated that they would absolutely cycle even if the F35 was not there. The graph below shows cycling frequency and other transport options of the respondents that would not cycle so often if the F35 was not there. Of this group, a high share — 84 percent — uses a private car as an alternative to cycling, corresponding with the percentage in the overall responses to question four — 82 percent. Therefore, it can be assumed that the majority of this group would be inclined to drive their private car more days per week and cycle less days per week if the F35 would not be there. It must be remarked that respondents had the option to select more than one answer to question seven, so there are car using respondents who also marked public transport as an alternative. Nevertheless, the car drivers make up the majority.

Filter: 7. Zou u ook fietsen als de fietssnelweg er niet was? Dwz. zou u de gewone fietspaden gebruiken? = [Ja, absoluut]

3. Hoeveel dagen per week fietst u gemiddeld?

Crossed with: 4. Welke andere transportmiddelen gebruikt u voor uw gemiddelde reisafstand indien u niet fietst? (Meerdere antwoorden mogelijk)



Filter: 7. Zou u ook fietsen als de fietssnelweg er niet was? Dwz. zou u de gewone fietspaden gebruiken? = [Ja, maar niet zo vaak]

3. Hoeveel dagen per week fietst u gemiddeld?

Crossed with: 4. Welke andere transportmiddelen gebruikt u voor uw gemiddelde reisafstand indien u niet fietst? (Meerdere antwoorden mogelijk)

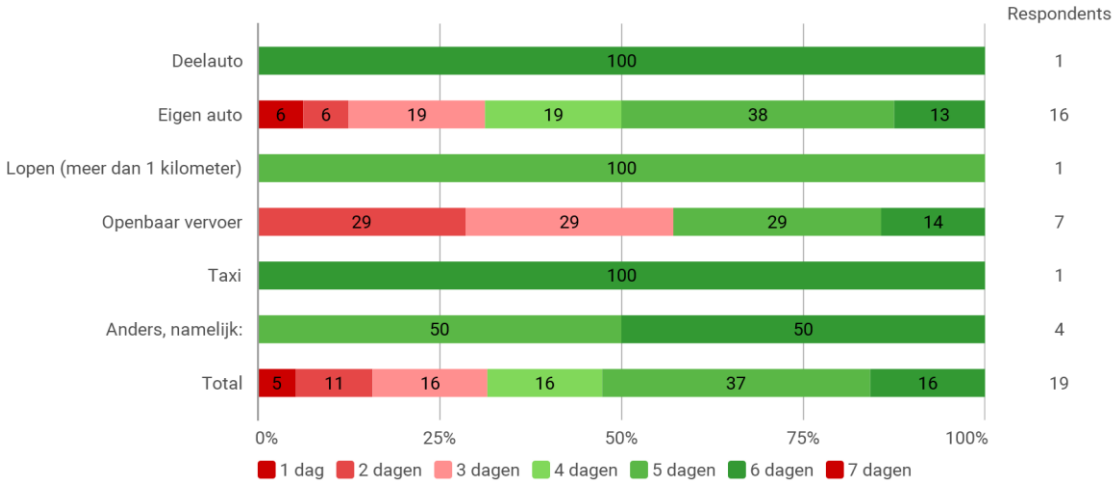


Figure 6.10: Question three and question four, showing cycling frequency combined with other transport options filtered by answer to question number seven i.e. 'yes, absolutely' and 'yes, but not as often'.

5. Waarom fietst u? Rangschik s.v.p. de onderstaande antwoorden van belangrijkst op nummer een tot minst belangrijk op nummer zes.

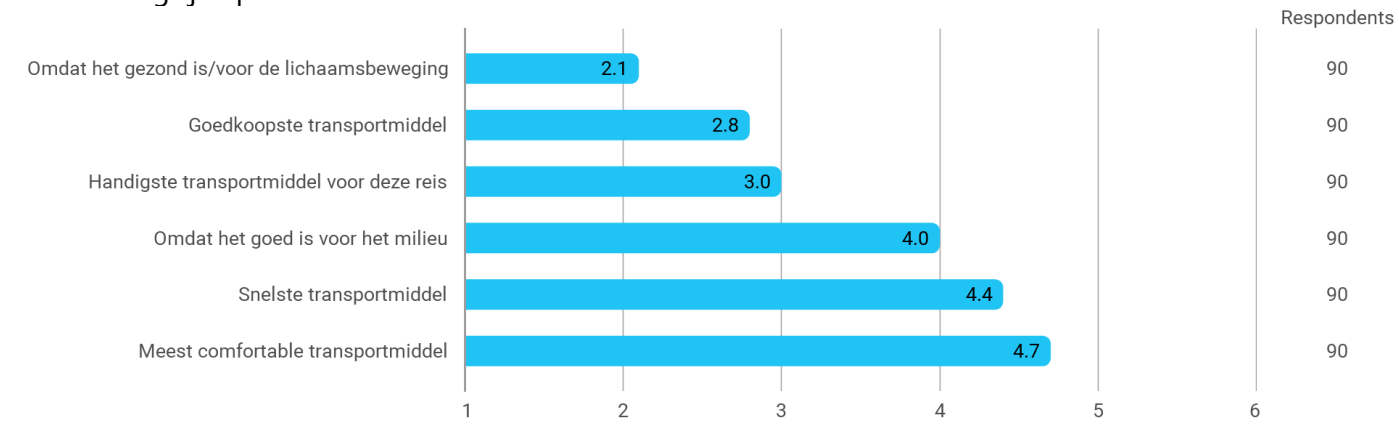


Figure 6.11: The results of question five, asking the respondents to classify the six given reasons from most important on top to least important

Question five enquired the respondents about their reasons for cycling. In figure 6.11, the results are presented. The question was asked in the same way it was asked in the Danish survey and the answering options, as well as the entire survey, were entirely the same in Danish and in Dutch.
The respondents indicate that the most important reason for cycling is the health benefit. It seems that many cyclists consider cycling as a practical combination of exercise and transport. As second and third most important reason, respondents selected respectively because it is the cheapest mode of transport and because it is the most practical mode of transport for this trip. The financial aspect and the practical aspect might be strongly related, for example when drivers have to park their car in a city. It might both be troublesome finding a parking space and expensive to park in a parking garage or on a paid parking street. The construction of the F35 in combination with car-discouraging measures in cities, e.g., one-way streets, speed bumps, closing down streets for car traffic and reducing speed limits for cars, might also have made cycling the more practical and cheaper option. In general, space is taken away from motorised traffic and given to bicycle traffic (Regio Twente, 2014). From this question it can nevertheless not be concluded that the bicycle is also the faster mode of transport — the reason 'because it is the fastest mode of transport', was rarely given as main reason only surpassed by the reason 'because it is the most comfortable mode of transport', which is the least important reason to cycle for the respondents. Again, this does not come as a surprise since the surveying conditions on the F35 were cold and dark.

Figure 6.12 shows the responses to question six which explored the cycling habits of the respondents before the F35 was opened. The majority of the respondents, 40 percent, cycled the same distance and the same frequency before the F35 was built. More than a fifth of the respondents, 21 percent, replied that they did not cycle before the F35 was opened in 2010. In order to find out how often this group of 21 percent cycles nowadays, the responses for question one are filtered to show only results that replied *nee* ('no' in Dutch) to question six, shown in figure 6.13. From this group of 19 respondents, approximately one-third cycles more than 20 kilometres per day. This is a remarkable increase: from not cycling to cycling more than 20 kilometres per day on average. This '20 km plus' group consists solely of commuters; this has been established in figure 6.5.

6. We troffen elkaar op de fietssnelweg F35 die in 2010 werd geopend. Fietste u ook voordat deze fietssnelweg werd geopend?

(De afstand is de afstand die u gemiddeld fietste per week, met frequentie wordt bedoeld hoeveel keer per week u fietste voordat de fietssnelroute werd geopend.)

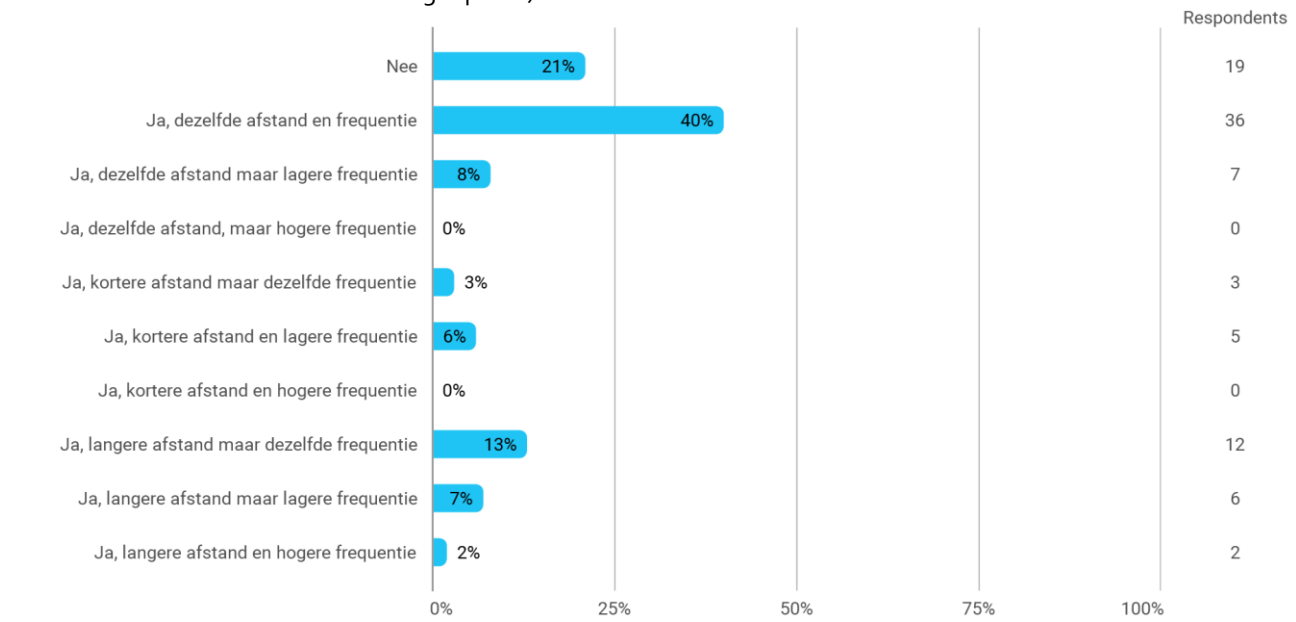


Figure 6.12: Question six, showing cycling habits of the respondents before the F35 was established.

Filter: 6. We troffen elkaar op de fietssnelweg F35 die in 2010 werd geopend. Fietste u ook voordat deze fietssnelweg werd geopend?
(De afstand is de afstand die u gemiddeld fietste per week, met frequentie wordt bedoeld hoeveel keer per week u fietste voordat de fietssnelroute werd geopend.) = [Nee]

1. Wat is uw gemiddelde dagelijkse fietsafstand?

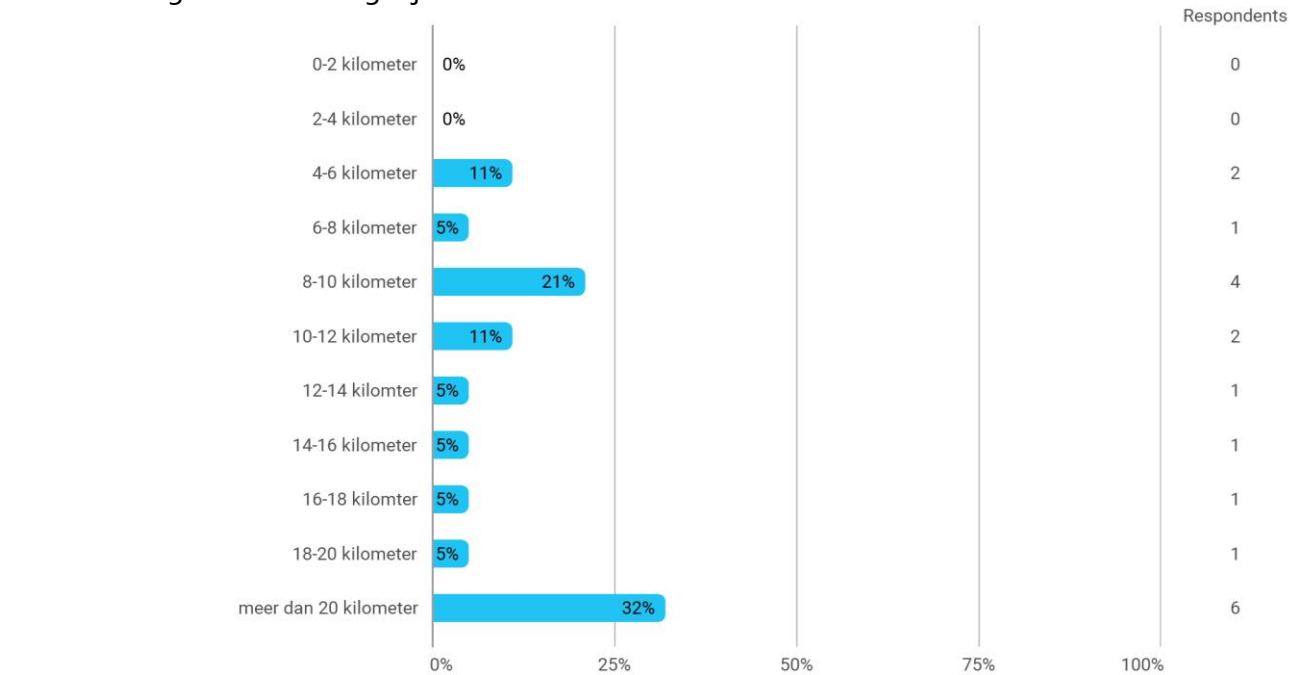


Figure 6.13: Question one filtered by reply 'no' to question six, showing the average cycling distance of the cyclists that did not cycle before the F35 was established.

Although the question was clearly and unambiguously formulated, it is possible that some misinterpreted the question. It is however also possible that the establishment and promotion of the F35 in 2010 have indeed motivated people to start cycling to their work. Figure 6.14 shows the alternative modes of transport this group of novice cyclists has. The majority of this group also has a car at its disposal. With some reservation, it can be said the construction and promotion of the F35 has convinced approximately 21 percent of the respondents to start commuting by bicycle, out of which 84 percent might have used a car for commuting. Of this 84 percent, indeed, some might also use other transport options, but private car use is paramount.

Filter: 6. We troffen elkaar op de fietssnelweg F35 die in 2010 werd geopend. Fietste u ook voordat deze fietssnelweg werd geopend?
(De afstand is de afstand die u gemiddeld fietste per week, met frequentie wordt bedoeld hoeveel keer per week u fietste voordat de fietssnelroute werd geopend.) = [Nee]

4. Welke andere transportmiddelen gebruikt u voor uw gemiddelde reisafstand indien u niet fietst? (Meerdere antwoorden mogelijk)

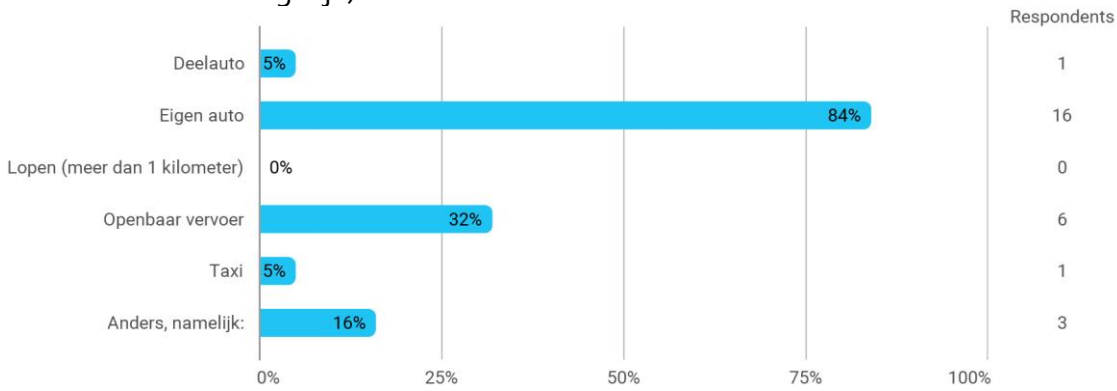


Figure 6.14: Question four filtered by response 'no' to question six.

Question eight examined the impact of the F35 on travel time and distance of the respondents, the results can be seen in figure 6.15. The results reveal that 34 percent of the cyclists has seen a reduction in their travel time and for 39 percent both travel distance and travel time was reduced. This amount to 73 percent of the respondents that have to spend less on travelling, be it time or effort. The responses to question eight — filtered to show only the respondents who at question six, replied that they did not cycle before the establishment of the F35 — are shown in figure 6.16. It shows that the majority of the novice cyclists (69 percent) has benefitted from the F35, either in travel time, travel distance or both. Three out of the 19 cyclists have experienced an increase in their travel time, travel distance or both. That they cycle nonetheless might be explained by the responses to question five, which showed that the most important reason for cycling is the exercise element. Furthermore, it has not been determined by how much the travel distance and travel time has gone up or in fact, down for the respondents. The F35 has however been built with the intention to provide motorists a fast and easy alternative for driving. From the findings it could be concluded that this objective has been achieved.

8 Heeft de fietssnelweg uw reistijd en -afstand beïnvloed?

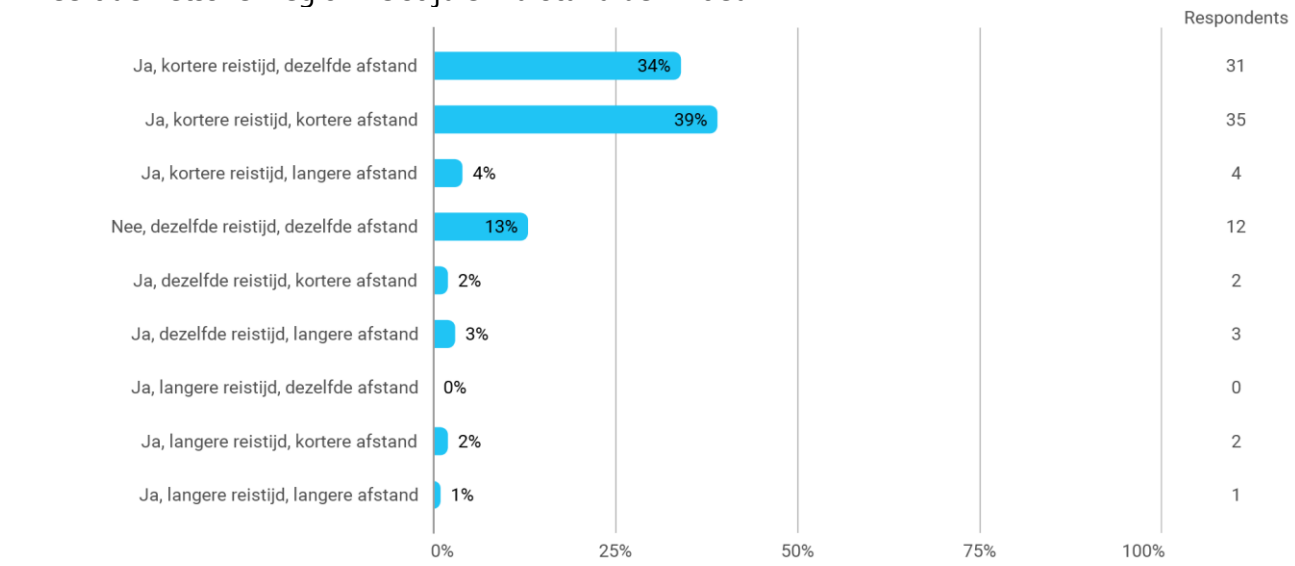


Figure 6.15: Question eight, investigating the effect of the F35 on travel time and distance of the respondents.

Filter: 6. We troffen elkaar op de fietssnelweg F35 die in 2010 werd geopend. Fietste u ook voordat deze fietssnelweg werd geopend?
(De afstand is de afstand die u gemiddeld fietste per week, met frequentie wordt bedoeld hoeveel keer per week u fietste voordat de fietssnelroute werd geopend.) = [Nee]

8 Heeft de fietssnelweg uw reistijd en -afstand beïnvloed?

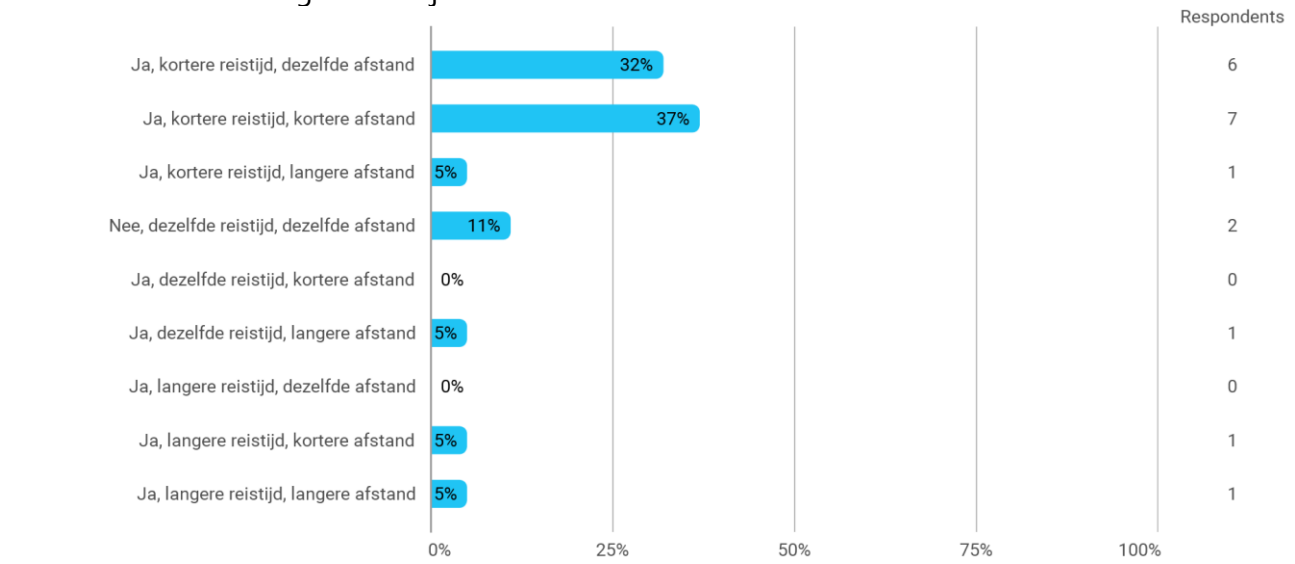


Figure 6.16: Question eight filtered with question six, showing the answers of the 'no'-repliers to question six.

Question nine explored the bicycle type that respondents have; in figure 6.17 the results are shown — a *bakfiets* is Dutch for cargo bike; *dames/herenfiets* means ladies/men's bike in Dutch. The majority of the respondents, 49 percent, has an electric bicycle. A remarkably large number, even larger than the regular men's/ladies bicycle, cargo bike, mountain bike and racing bike together. There were six respondents who filled in that they have one or more bicycles that are not mentioned in the answering options. The types of cycles mentioned are: A tricycle; a Pick Up men's bike (a type of transport bike made by Dutch bicycle company Sparta); an electric and a regular bicycle (the respondent thus indicated that he or she owns two bicycles); a transport bike; a trekking bike.

9. Wat voor fiets heeft u?

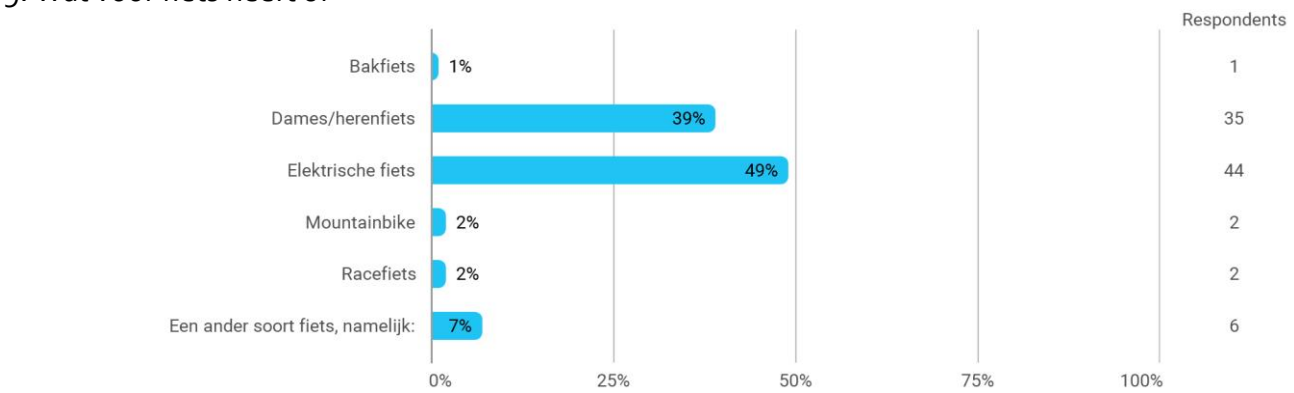


Figure 6.17: Question nine, the different bike types owned by the respondents.

In order to investigate the effect of the electric bicycle, first question nine is combined with question one in figure 6.18. This will show the share of electric bicycles per average daily cycling distance. From the data modification it can be concluded that, grosso modo, the share of electric bicycles increases as average cycling distances increase. When observing the average cycling distances, up to ten kilometres not more than 40 percent has an electric bicycle. The distance of *10-12 kilometre* is an outlier with an electric bicycle share of 64 percent. Then the percentage drops again and rises again with 100 percent electric cycle use amongst the *16-18 kilometre* respondents, 78 percent among *18-20 kilometre* respondents and 60 percent among the *over 20 kilometre* respondents. In figure 6.19, the cycle ownership is shown for respondents who answered 'same distance, but lower frequency' to question six; for respondents who answered 'no' to question six and for respondents who replied 'same distance and same frequency' to question six. This calculation shows that out of those who cycle more frequent now than before the opening of the F35, a majority owns an electric bicycle. Under the respondents who started cycling after the F35 was established, the share of electric bikes is higher than average, while under the respondents whose cycling distance and frequency has not been affected by the F35, the electric bicycle ownership is relatively low.

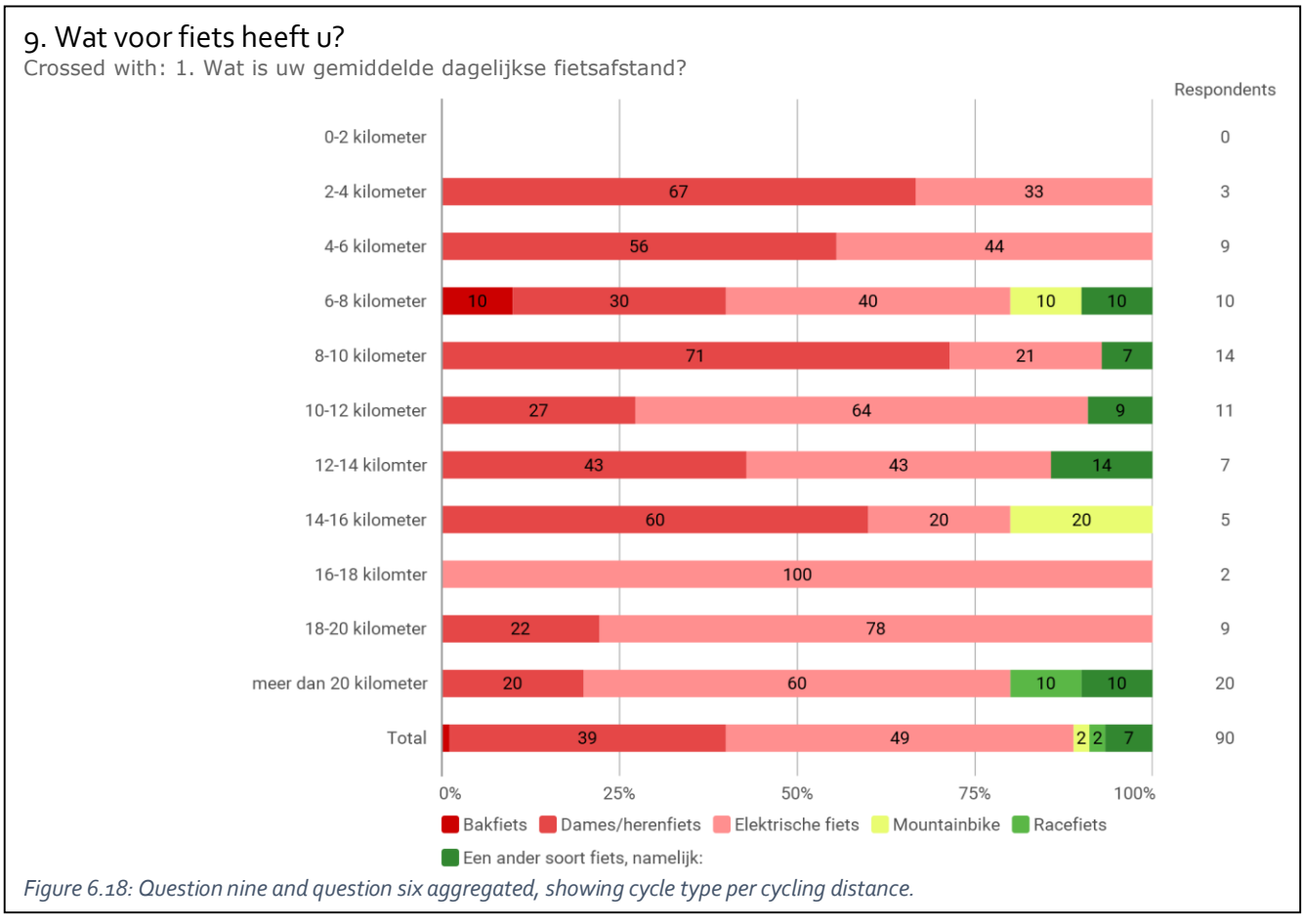
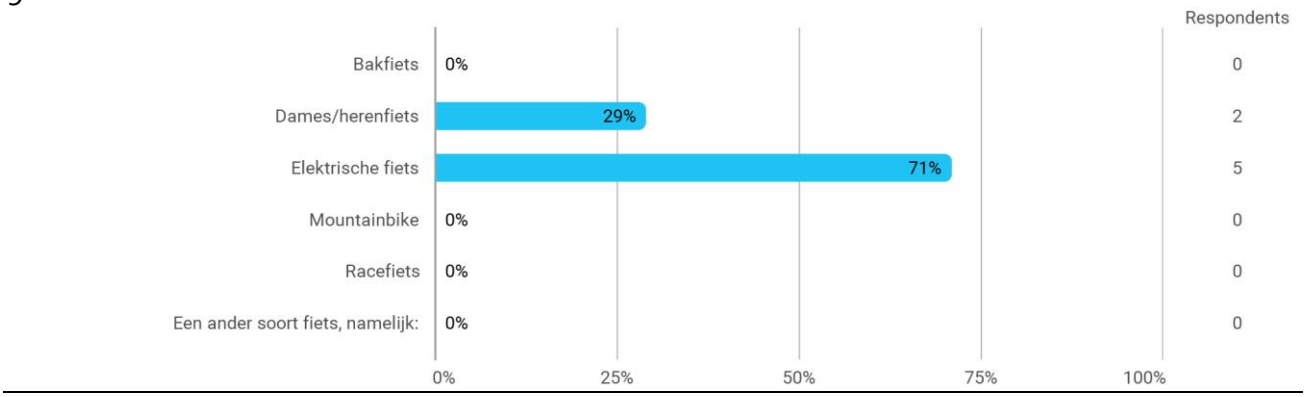


Figure 6.18: Question nine and question six aggregated, showing cycle type per cycling distance.

These results suggest that there might be a relation between the construction of the cycle highway, electric bicycle ownership and the distance people cycle. It is known that one motivation for constructing the F35, like all other cycle highways in the Netherlands, was to provide adequate infrastructure for electric cyclists, i.e., infrastructure where they can safely achieve their maximum speed (Fietsersbond, 2013; Regio Twente, 2014). Based on this research it is probable that this effort has been successful and that people who have electric bicycles have started cycling more or people that did not cycle at all before the F35, have started using an electric bicycle on the F35.

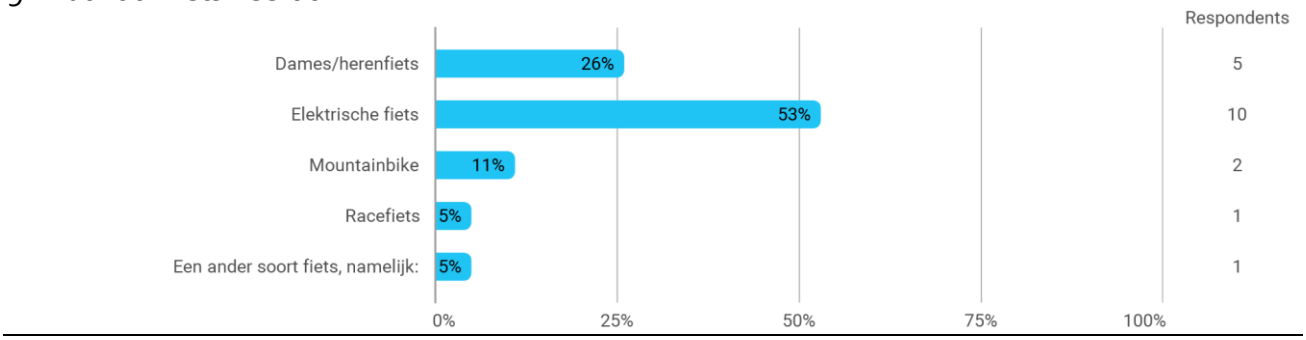
Filter: 6. We troffen elkaar op de fietssnelweg F35 die in 2010 werd geopend. Fietste u ook voordat deze fietssnelweg werd geopend? = [Ja, dezelfde afstand maar lagere frequentie]

9. Wat voor fiets heeft u?



Filter: 6. We troffen elkaar op de fietssnelweg F35 die in 2010 werd geopend. Fietste u ook voordat deze fietssnelweg werd geopend? = [Nee]

9. Wat voor fiets heeft u?



Filter: 6. We troffen elkaar op de fietssnelweg F35 die in 2010 werd geopend. Fietste u ook voordat deze fietssnelweg werd geopend? = [Ja, dezelfde afstand en frequentie]

9. Wat voor fiets heeft u?

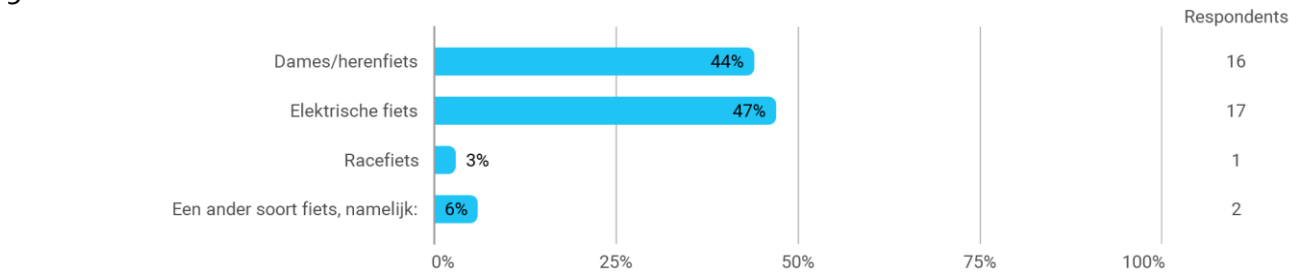


Figure 6.19: Question nine filtered for the following responses to question six: Yes, the same distance, but lower frequency; No; Yes, the same distance and frequency.

The increase of electric cycle use after the establishment of the F35 in 2010 must be seen in correspondence with the increasing popularity and thus overall quantity of electric bicycles. In figure 6.20, the sales numbers of different types of bicycles in the Netherlands is represented. While the regular bicycle, *stadsfiets*, is experiencing a continual decrease in sales numbers, the sales of electric bicycle are advancing steadily. It feasible to assume that the introduction of the electric bicycle and the construction of the F35 has persuaded people to start cycling more often and more frequent.

Question 10 and 11, see figure 6.21, provide insight in the age and sex of the respondents. The average age of man and women is quite similar and the average respondent age is 49.71 years. The number of male respondents is considerable higher than the number of female respondents, meaning that there are more male users of the F35 than there are female users.

(x 1.000)	2010	2011	2012	2013	2014	2015	2016	2017
Totaal nieuwe fietsen	**1.215**	**1.198**	**1.035**	**1.008**	**1.051**	**983**	**928**	**957**
Stadsfiets	655	638	530	507	534	410	402	399
Elektrische fiets	166	181	175	192	223	276	271	294
Kinderfiets	164	166	142	126	121	138	109	116
Hybride incl. tracking bike	118	105	81	78	71	49	54	51
Overig (incl. racefietsen, MTB/ATB, vouwfietsen)	111	109	106	106	102	111	92	97

Figure 6.20: Sales numbers of different types of bicycles in the Netherlands between 2010 and 2017. Source: BOVAG-RAI, 2018.

10. Hoe oud bent u?

Split on: 11. Wat is uw geslacht?

	Observed minimum	Observed maximum	Average	Respondents
Vrouw	23.00	71.00	48.81	32
Man	14.00	69.00	50.21	57
Total	14.00	71.00	49.71	89

11. Wat is uw geslacht?

	Respondents	Percent
Vrouw	33	36.7%
Man	57	63.3%
Total	90	100.0%

Figure 6.21: Question 10, showing age information for females and males. Question 11, showing the sex of the respondents.

In figure 6.22, the age per cycling distance is presented. The average age of the respondents does not go down as the distances go up and the average age for the four longest distance categories even surpasses the total average age.

10. Hoe oud bent u?

Split on: 1. Wat is uw gemiddelde dagelijkse fietsafstand?

	Observed minimum	Observed maximum	Average	Respondents
0-2 kilometer	-	-	-	0
2-4 kilometer	36.00	62.00	50.00	3
4-6 kilometer	14.00	71.00	43.33	9
6-8 kilometer	35.00	69.00	49.56	9
8-10 kilometer	17.00	62.00	41.93	14
10-12 kilometer	23.00	59.00	49.82	11
12-14 kilomter	29.00	60.00	46.57	7
14-16 kilometer	30.00	66.00	54.80	5
16-18 kilomter	56.00	60.00	58.00	2
18-20 kilometer	44.00	65.00	54.89	9
meer dan 20 kilometer	45.00	69.00	54.65	20
Total	14.00	71.00	49.71	89

Figure 6.22: Question 10 and 1, showing respondents age per distance category.

11. Wat is uw geslacht?

Crossed with: 1. Wat is uw gemiddelde dagelijkse fietsafstand?

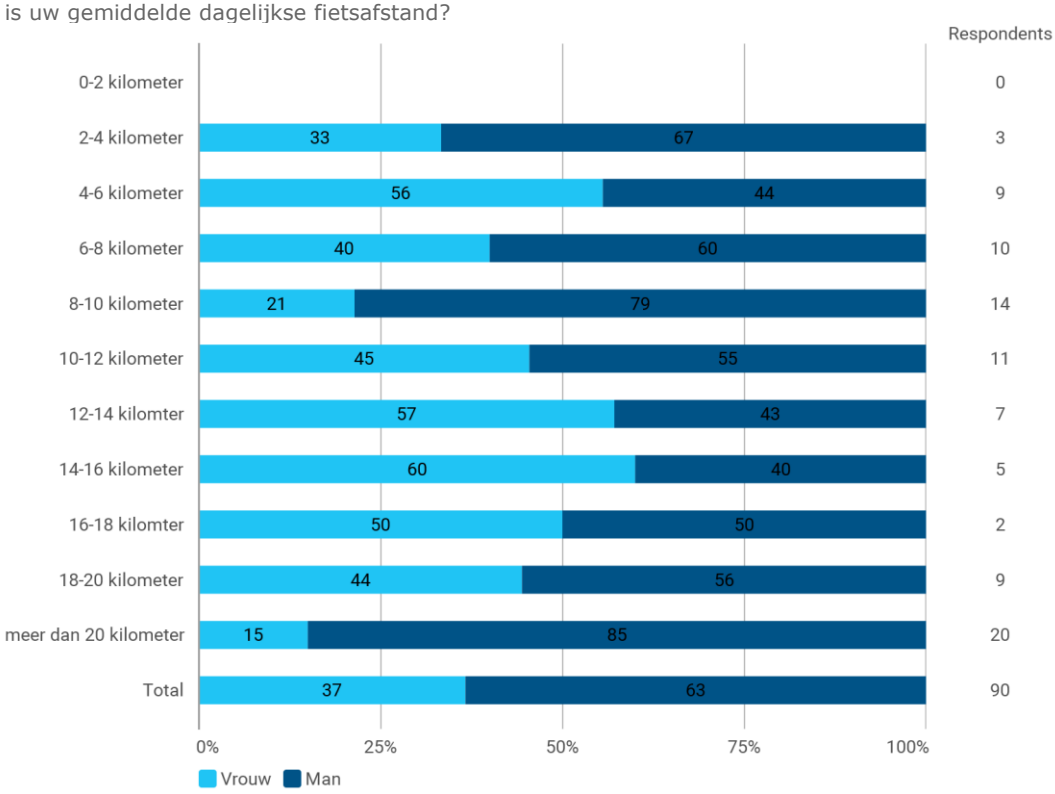


Figure 6.23: The percentage of male and female cyclists per distance category.

Figure 6.23 shows the share of male and female cyclists per cycling distance category. Because 63 percent of the respondents is male, it can be expected that in many distance categories the majority of the respondents is male. On the intermediate distances however, the women seem to be much more represented. In the 'over 20 kilometres' category, the men are in the majority.

6.4 Conclusion

It can be concluded that the users of the F35 are regular cyclists but the distances travelled vary greatly. It is probable that some cyclists use the F35 to travel between Borne and Hengelo and that some — around 22 percent of the respondents — travel further than Hengelo or Borne, they might live or work in cities like Almelo, Enschede, Oldenzaal and Nijverdal, which are also part of the F35 network. Despite the holiday season, many respondents were travelling to or from work on the day of surveying and many of the commuters travel considerable distances. The car is by far the most popular alternative mode of transport for the respondents, 82 percent of the respondents indicate to use a private car in addition to their bicycle for their daily transport. Public transport, the second most popular option, follows with quite some distance; only 26 percent of the respondents use public transport as an alternative transport mode. The popularity of the car can be explained by the topography of the region Twente which is a rural and thinly populated area. In rural regions, car transport is often dominant as there is no large customer base to support an extensive public transport network. Cycling seems to be the best alternative to driving in the region and it is likely that the bicycle is preferred for journeys into city, where car use is more expensive and inconvenient.

The opening of the F35 seems to have motivated a significant amount of people to start cycling or to cycle more often. This development must be seen in connection with the increased popularity of the electric bicycle during the last decade which has allowed people to travel further and faster than on a regular bicycle for the same amount of physical effort. This element seems to be crucial, much more than sex or age, which does not seem to affect cycling distances that much.

7. Comparing the Farum route with the F35

In this chapter, remarkable findings, differences and similarities from the Danish and Dutch questionnaires will be discussed. A profile of the Danish and Dutch cycle highway user will be created and compared. Additionally, the position of cycling amongst the other transport options will be discussed.

The response rates to the Danish and Dutch survey were quite similar; on the Farum route 38.8 percent of the distributed invitations were used and on the F35 37.5 percent of the recipients filled in the questionnaire. During the COWI evaluation of the Farum route in 2014, a similar survey was done where invitations to a questionnaire were handed out to cyclists on the route. Out of the 2437 questionnaire invitations that were handed out at three locations along the route, in total 904 respondents filled out the questionnaire. This adds up to a response rate of 37 percent, which is only slightly lower than the response rate to the questionnaire in this study (COWI, 2014).
In the most recent evaluation research of the F35, a questionnaire survey is done as well. In similar style to the COWI report and this study, flyers with an invitation to a questionnaire were distributed among cyclists on the F35. The survey was held on a different section of the F35, about 3.3 kilometres to the south-east of the surveying location in this report. In total 250 flyers were handed out to cyclists on the route and 76 people participated in the survey, which results in a response rate of 30.4 percent (NDC, 2018).

From the bicycle counts it showed that the Farum route, with 1080 cyclists, is a more heavily trafficked route than the F35, where 600 cyclists were counted. This is partly due to the day of surveying on the F35, i.e., in the Christmas holiday. But a more holistic explanation is the fact that the F35 traverses an area with a smaller population than the area through which the Farum route runs.

7.1 Profiling the user group

A remarkable result is the average distance that the Danish and Dutch cyclists travel on a daily basis. Both respondent groups have a majority that cycles more than 20 kilometres per day although this group is significantly larger on the Farum route. The Danish cyclists seem to be well-trained long distance cyclists, while the Dutch cyclists appear to be more casual cyclists that also travel considerable distances, but often with an electric bicycle. Although the entire F35 will be longer than the Farum route when it is entirely finished, 62 kilometres versus 20.8 kilometres, the section between Borne and Hengelo is four kilometres long. As mentioned before, a commuter who has to travel 20.8 kilometres to work, might be more inclined to travel by bicycle if nearly the entire route is a cycle highway. This is possible on the Farum route, but not (yet) on the F35. This might explain the higher average distance travelled by the Danish respondents.

In both groups, the large majority of the respondents is commuting. For both the construction of the Farum route and the F35, the main objective was to stimulate people to commute by bicycle. This seems objective seems to have been achieved. Firstly, although the bicycle counts in previous evaluation studies were higher, it can be assumed that this is due to the weather conditions and if the previous bicycle counts had been performed in December and January, the number would have been considerable lower. Secondly, in both the Danish and Dutch respondent group, there is a

significant group that indicate that they did not cycle at all or not so often before the cycle highways were constructed. There is thus a share of induced bicycle traffic.
Furthermore, the Danish respondent group appear to be more reliant on public transport as a daily mode of transport, while the Dutch group as definitely more dependent on the car. But in general, both the Danish and the Dutch groups are avid cyclists who on average cycle 4.78 and 4.52 days per week respectively (see figure 7.1). This means that many of the respondents cycle to their work every day.

	Observed minimum	Observed maximum	Average	Respondents
3. Hvor mange dage om ugen cykler du gennemsnitlig?	2.00	7.00	4.78	74

	Observed minimum	Observed maximum	Average	Respondents
3. Hoeveel dagen per week fietst u gemiddeld?	1.00	7.00	4.52	90

Figure 7.1: Question 3, showing the average cycling frequency of the Danish and the Dutch respondents.

For both groups, the most important reason to cycle is the health benefit. Getting enough exercise and living a healthy lifestyle are thus the main drivers behind cycling. This applies to the Danish cyclists even more than to the Dutch cyclists; the Danish respondents indicate that by far the most important reason to cycle is the exercise, followed on a distance by the argument that it is the most practical mode of transport. It is to be expected that the practicality argument would be significant in a dense urban area where car mobility is restricted by congestion and transport policy. For the Dutch respondents, getting exercise is also the most important argument, but not in the absolute sense as it is for the Danish cyclists. Many cyclists also seem to cycle because it is the cheapest transport option.

The average age of the Danish cyclist on the Farum route is 45.51 years old and on the F35 the cyclists are 49.71 years old on average. From the survey results, the impression arises that age is not a significant factor for many of the other variables, e.g., cycling distance and frequency. Age does seem to affect the bicycle type of the Dutch respondents, that is, the Dutch electric bicycle owners are oldest of any category, both in the Danish and the Dutch survey, see figure 7.2 for the average age per bicycle type. On the Farum route however, the electric bicycle owners are not the oldest, but still above the average age.

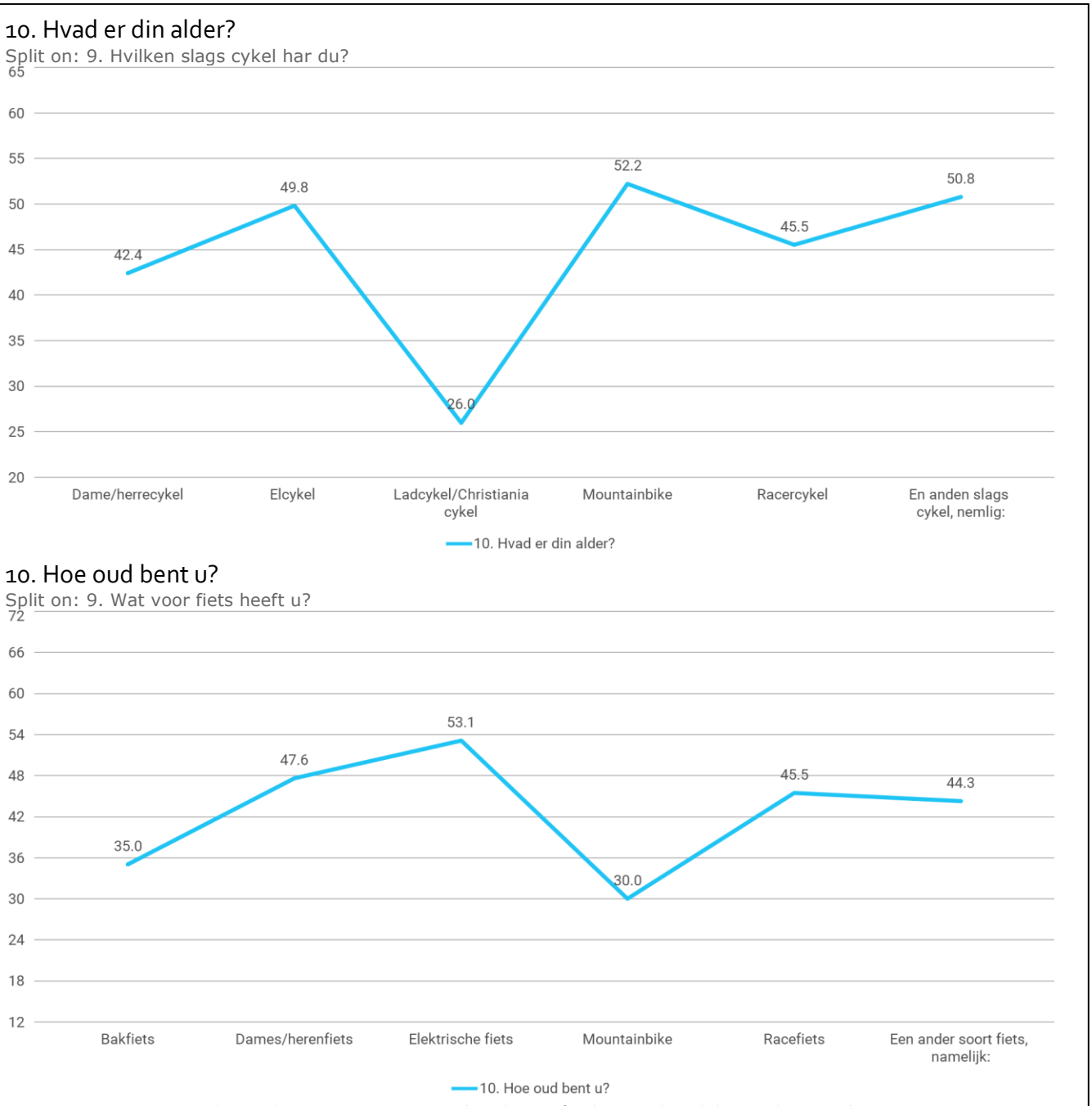


Figure 7.2: Question 10 and nine, showing average age per bicycle type for the Danish and the Dutch respondents.

Electric bicycles are generally less popular in Denmark, an observation that is supported by comparing electric bicycle sales numbers in Denmark and the Netherlands (see figure 7.3). Even when taking into consideration that the Netherlands has more than three times the inhabitants Denmark has, the electric bicycle is still far more popular in the Netherlands than in Denmark. The reasons for this are not directly clear and investigating this does not fall within the scope of this study.

x 1.000	2014	2015	2016
Totaal	**1.140**	**1.358**	**1.667**
Duitsland	480	535	605
Nederland	223	276	273
België	130	141	168
Frankrijk	78	102	134
Italië	51	56	124
Oostenrijk	50	77	87
Groot-Brittannië	50	40	75
Denemarken	20	50	45
Zweden	18	30	45
Spanje	18	25	40
Finland	15	15	20
Tsjechië	-	1	15
Polen	4	4	10
Litouwen	-	-	4
Ierland	-	-	3
Luxemburg	-	1	3
Portugal	1	1	3
Estland	-	-	2
Griekenland	1	1	2
Hongarije	1	1	2
Roemenië	-	1	2
Slowakije	-	-	2
Kroatië	-	-	1
Letland	-	-	1
Slovenië	-	-	1
Cyprus	-	1	1
Malta	-	-	1
Bulgarije	-	-	-

Figure 7.3: Electric bicycle sales in the EU. Source: BOVAG-RAI,

Both the Danish and the Dutch cycle highway users seem to be avid cyclists who cycle more than four days per week on average. The Danish cyclists are sportier types who cycle longer distances and consider cycling primarily as a form of exercise. The Dutch cyclists cycle primarily for the exercise aspect, but are to a great extent also motivated to cycle because it is the cheapest mode of transport. The average distance travelled by the Dutch cyclists is shorter and more than half of the cyclists use an electric bicycle. This reaffirms the conclusion that the Danish cyclists are stauncher, uncompromising cyclists while the Dutch cyclists are more relaxed and practical cyclists who unite the benefits of physical activity and financial advantage by cycling.

7.2 Competing with alternative transport options

Within the spectrum op transport modes, the bicycle primarily competes with the car and public transport and to a lesser extent with the taxi, walking and shared cars. This understanding has been confirmed by the responses to the questionnaires — the car and public transport are by far the most chosen options when the respondents were asked about their alternative transport modes. The distribution of users per transport mode differs rather much between the two surveyed groups.

On the Farum route, the cyclists are, besides being cyclists, predominantly public transport users. The share of respondents that walks as a daily mode of transport is also significantly higher amongst the Farum route cyclists then amongst the F35 cyclists. This is a logical consequence of the high share of public transport use, since public transport rarely takes the commuter to its exact destination. Often, walking from and to a public transport station or stop is required which explains the relatively high percentage of walking under the Farum route respondents. With this knowledge, it can be argued that the area where the Farum route is in, i.e. the Capital Region, has a well-developed and widespread public transport network that is a realistic mode of transport for commuters.

Cyclists on the F35 primarily drive as an alternative mode of transport and the percentage of public transport users is relatively low, with a low percentage of walking as a result. As mentioned before, the reason for this can be found in the character and type of area the F35 is in — Twente is a rural and thinly populated area of the Netherlands. The population lives in smaller urban concentrations or in the countryside, where public transport is less extensive and cannot offer efficient and frequent transport for the majority of the inhabitants. It is plausible that most of the inhabitants depend on a car as a reliable mode of transport besides the bicycle. In the urban cores of the region, car traffic is more inconvenient and more expensive. It is probable that the bicycle is therefore a more popular mode of transport for journeys to the urban cores.

What does this say about the bicycle and the cycle highways? It means that the F35 predominantly has to compete with car traffic, while the biggest competitor for the bicycle on the Farum route is public transport. From this can be deduced that the car is the number one challenger to the bicycle in rural areas where there are few restrictions on motorised traffic and the public transport network is not extensive enough. In urban areas however, where car traffic is impeded both by congestion and by traffic planning policy — e.g. by making driving more expensive and inconvenient — the public transport is usually well developed and the main competitor of the bicycle.
As an advantage over public transport, the bicycle is always available and takes the traveller to its exact destination, much like a car. In addition to this, the Farum route offers the cyclists an efficient and safe route. As an advantage over the car, the bicycle is cheaper and offers the combination of physical activity with transport.

The F35 and the Farum route offer cyclists an efficient and convenient connection between cities in the region. Although the average travelling distance is lower than on the Farum route, electric bicycles prevail on the F35, especially on the longer distances. It is probable that for many Dutch respondents the electric bicycle is the main alternative to driving a car, while the Danish respondents rely more on regular ladies and men's' bikes as well as racing bikes. The F35 has been planned to accommodate the electric bicycle user and to stimulate more (electric) cycling and less driving (Regio Twente, 2014). When comparing measured electric bicycle percentages between previous evaluation studies and this study, an increase in electric bicycle use can be observed. Results from a questionnaire held in 2016, shows an average[3] 27 percent of cyclists who have an electric bicycle (Goudappel Coffeng, 2016). An evaluation report from June 2018 shows that 47 percent of the respondents use an electric bicycle (NDC, 2018). From the current study, a slight increase since June 2018 can be observed: 49 percent of the respondents indicated to use an electric bicycle.
From the data on cycling frequency and cycling distance of the Farum route and F35 cyclists, it can be concluded that the cycle highways are used as intended: accommodating commuting cyclists who travel distances of over 15 kilometres between urban areas.

[3] The invitations for the questionnaire were distributed on two locations. On the first location, 26 percent of the respondents used an electric bike; on the second location, 28 percent used an electric bike (Goudappel Coffeng, 2016).

8. Discussion and reflection

The goal of this research is to contribute to the academic debate on cycling as a transport mode. Cycle highways are a relatively new phenomenon and although the results from this study suggest that they are successful, the development is still young and the long term effects on mobility behaviour are not yet known. Together with the electric bicycle, which is also a relatively new phenomenon, cycle highways may cause a shift in transport behaviour. The growth of population in urban areas and the further development of the electric bicycle in terms of battery life and maximum speed, might advance the development of cycle highway infrastructure.

The regional authorities in Denmark and the Netherlands, who oversee the construction of the cycle highways, regard commuting distances of up to 20 kilometres and over, as feasible on a bicycle and this assumption has been confirmed by the results of this study. The research into cycle highways is, like cycle highways themselves, quite young. More study into the topic needs to be done in order to fully map the impact and potential of building cycle highway infrastructure. This study contributes to the knowledge base, but has its shortcomings. More investigation into the reasons for cycling could have been done, this aspect has been featured in the questionnaire, but could have been worked out more.
Secondly, the study could have focussed more on how the cycle highways are valued and perceived. These variables were investigated in the previous evaluation report of the cycle highways, but were disregarded in this study. Obtaining more of this type of feedback might be an area for future research.

Other suggestions for further research that might be interesting are:
Firstly, the relation between cycling distance, other transport options and electric bicycle ownership can be further examined, e.g., how many electric bicycle riders have switched from the car to cycling and how important was the cycle highway in making this decision.
Another area of research that could contribute to the cycle highway theory, is a study amongst commuters who never or rarely cycle: the non-users. It is likely that there are several factors that determine choice of transport mode. There are hard values, like travel time and cost, and there are soft values like lifestyle, comfort and perception that influence choice of transport mode. Although the physical cycling infrastructure can help the promotion of cycling, the construction of cycling infrastructure is not the only means of evoking a shift in transport mode choice; economic incentives, marketing and policy may also have an impact on mode choice (Forsyth & Krizek, 2010). More research in this area provides more data on cycling habits and can help planning appropriate cycling infrastructure.

9. Conclusion

As the population in urban regions grows, space becomes more scarce and expensive. At the same time, the pressure on the infrastructure network increases — more people have to transport themselves on the infrastructure network, which causes congestion. The majority of the congestion is caused by people commuting to and from work. Building more roads for cars is not fixing the problem and arguably leads to even more congestion. In order to efficiently use the scarce land, an innovative solution is needed to cause a shift in transport behaviour. In Denmark and the Netherlands, one of these solutions has come in the form of cycle highways: comfortable, safe and direct cycling routes between urban cores. By offering commuters an efficient and fast cycling route, the Danish and Dutch authorities hope to stimulate cycling and decrease car traffic.

Denmark and the Netherlands are leaders in planning and building cycle highways. This study set out to find who the users of cycling highways are and how cycle highways have influenced travel behaviour in Denmark and the Netherlands. Two similar cycle highways have been examined and compared, one in Denmark, the Farum route in the Capital Region of Denmark, and one in the Netherlands, the F35 which runs through Twente in the east of the country. By doing the study, an answer to the following research question has been produced:

How have the cycle highways influenced travel behaviour in Denmark and the Netherlands?

The results of the study show that the cycle highways have stimulated a number of commuters to start cycling. In the Dutch case, most of these cyclists would otherwise travel by car, while the Danish cyclists would mostly use public transport. These commuters are often frequent cyclists who, on average, cycle more than four days per week.
The Danish cyclists travel longer distances than the Dutch and are averagely younger, 45 years versus 50 years. The women/man ration on the Farum route is 45/55 and on the F35 it is 37/63.
The majority of the cyclists on the F35 also uses a car for their daily transport, but very little use public transport. The Danish respondents have a much higher share of public transport users, even higher than the percentage of car users. This can be explained by the types of regions that the cycle highways are in. The Farum route connects the capital city Copenhagen with the suburbs, while the F35 connects several medium-sized cities in an otherwise rural area. Public transport is typically better developed in highly urbanised areas, while people in rural areas usually depend on a car for their daily transport. Electric bicycle ownership is much higher under the Dutch cycle highway users, even though the Danes travel longer distances. The results of the research suggest that the Danish cycle highway user is generally a sportive cyclist who cycles to get physical exercise. The Dutch also cycle for exercise, but are more pragmatic cyclists and cycle also because it is financially beneficial. Amongst both respondent groups, induced bicycle traffic has been identified: cyclists who have started cycling only after the cycle highway was established.

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Appendix

Appendix 1. The Danish survey invitation

The front and backside of the Danish survey invitation.

Appendix 2. The Dutch survey invitation

Hallo fietser! Ik ben student aan de Aalborg Universiteit in Kopenhagen en omdat u om een fietssnelweg fietst, wil ik u graag een paar vragen stellen. De enquête duurt minder dan 5 minuten en is geheel anoniem. Bij voorbaat dank!

Gebruik s.v.p. deze link: www.survey-xact.dk/collect
en gebruik de volgende code: XRHC-MDHG-3516 of gebruik de QR-code hiernaast.

AALBORG UNIVERSITET

F35 FIETSSNELWEG

The front and backside of the Dutch survey invitation.

Appendix 3. The Danish questionnaire

Hej Cyklist,
Tak for at du vil deltage i denne undersøgelse med i alt 11 spørgsmål. Jeg studerer Land Management på Aalborg Universitetet i København og skriver mit speciale om supercykelstier i Danmark og Holland, blandt andet supercykelstien hvor vi træffedes. Med dette spørgeskema vil jeg skabe en profil af supercykelstiernes brugere.

Dine svar bliver brugt anonymt som data i min research. Husk venligst altid at vælge det svar som **bedst stemmer overens** med din opfattelse.

Hvis du vil vide mere om supercykelstier, så besøg Supercykelstiers hjemside

1. Hvilken afstand cykler du dagligt i gennemsnit?

(1) ❑ 0-2 kilometer

(2) ❑ 2-4 kilometer

(3) ❑ 4-6 kilometer

(4) ❑ 6-8 kilometer

(5) ❑ 8-10 kilometer

(6) ❑ 10-12 kilometer

(7) ❑ 12-14 kilomter

(8) ❑ 14-16 kilometer

(9) ❑ 16-18 kilomter

(10) ❑ 18-20 kilometer

(11) ❑ mere end 20 kilometer

2. Hvad er/var dit primære rejsemål idag?

(1) ❑ Til eller fra arbejdet/praktik

(6) ❑ Til eller fra skolen/universitetet

(2) ❑ Til eller fra indkøb

(3) ❑ Til eller fra besøg af venner/familie

(4) ❑ Til eller fra udflugt (fx. til parken, museet, biografen, sportclub etc.)

(5) ❑ Intet bestemt mål. Jeg cykler for fornøjelsens eller trænings skyld

3. Hvor mange dage om ugen cykler du gennemsnitlig?

(1) ❑ 1 dag

(2) ❑ 2 dage

(3) ❑ 3 dage

(4) ❑ 4 dage

(5) ❑ 5 dage

(6) ❑ 6 dage

(7) ❑ 7 dage

4. Hvilket andet transportmiddel bruger du til din daglige transport hvis du ikke cykler? (Flere svar muligt)

(5) ❑ Delebil

(2) ❑ Egen bil

(4) ❑ Gå (mere end 1 kilometer)

(1) ❑ Offentlig transport

(3) ❑ Taxi

(6) ❑ Andre transportmidler netop: _____

5. Hvorfor rejser du med cyklen? Arranger venligst svarende herunder fra vigtigste grund som nr. 1 til mindst vigtige grund som nr. 6.

	1	2	3	4	5	6
Mest komfortable option	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Nemmeste transportmiddel for denne her rejse	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

	1	2	3	4	5	6
Billigeste transportmiddel	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Hurtigeste transportmiddel	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Fordi det er bedre for miljøet	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Fordi det er sundt og giver motion	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

6. Vi træffedes på supercykelstien Farumruten som blev etableret i 2013. Cyklade du også der før supercykelstien blev etableret?

(Afstanden er gennemsnitlige afstand du cyklede per uge, og frekvens betyder hvor mange gange om ugen du cyklede før supercykelstien var her.)

(5) ❑ Nej

(1) ❑ Ja, samme afstand og frekvens

(2) ❑ Ja, samme afstand, men lavere frekvens

(11) ❑ Ja, samme afstand, men højere frekvens

(3) ❑ Ja, men kortere afstand, men samme frekvens

(4) ❑ Ja, men kortere afstand og lavere frekvens

(9) ❑ Ja, men kortere afstand, men højere frekvens

(8) ❑ Ja, men længere afstand og samme frekvens

(7) ❑ Ja, men længere afstand, men lavere frekvens

(6) ❑ Ja, men længere afstand og højere frekvens

7. Ville du også bruge cyklen hvis supercykelstien ikke var her? Dvs. om du ville bruge de almindelige cykelstier.

(4) ❑ Ja, absolut

(1) ❑ Ja, men ikke så ofte

(2) ❑ Nej, i så fald ville jeg tage bilen (egen bil eller delebil)

(6) ❑ Nej, i så fald ville jeg tage det offentlige

(7) ❑ Nej, i så fald ville jeg bruge et andet transportmiddel

(8) ❑ Nej, i så fald jeg blive hjemme

8 Har supercykelstien påvirket din gennemsnitlige daglige rejse-tid og -afstand?

(1) ❑ Ja, kortere rejsetid, samme afstand

(6) ❑ Ja, kortere rejsetid, kortere afstand

(8) ❑ Ja, kortere rejsetid, længere afstand

(2) ❑ Nej, samme rejsetid, samme afstand

(4) ❑ Ja, samme rejsetid, kortere afstand

(5) ❑ Ja, samme rejsetid, længere afstand

(3) ❑ Ja, længere rejsetid, samme afstand

(9) ❑ Ja, længere rejsetid, kortere afstand

(7) ❑ Ja, længere rejsetid, længere afstand

9. Hvilken slags cykel har du?

(5) ❑ Dame/herrecykel

(4) ❑ Elcykel

(3) ❑ Ladcykel/Christianiacykel

(6) ❑ Mountainbike

(1) ❑ Racercykel

(2) ❑ En anden slags cykel, nemlig: _____

10. Hvad er din alder?

___

11. Hvad er dit køn?

(1) ❑ Kvinde

(2) ❑ Mand

Tusind tak for din hjælp! Hvis du vil læse mit speciale, så skriv din email adresse herunder. Så får du en kopi når det er færdigt.

_____

Appendix 4. The Dutch questionnaire

Halllo fietser,

Bedankt dat u wil deelnemen aan deze enquête bestaande uit 11 vragen. Ik studeer Land Management aan de Aalborg Universiteit in Denemarken en ik schrijf mijn scriptie over fietssnelwegen in Nederland en Denemarken, onder andere de Fietssnelweg F35 waar we elkaar troffen. Ik wil een profiel creëren van de fietssnelweggebruiker en heb daarom deze vragenlijst opgesteld.

Uw antwoorden zijn anoniem en worden gebruikt als data in mijn onderzoek. Selecteer a.u.b. altijd het antwoord dat **het meest overeenkomt** met uw opvatting.

Voor meer informatie over fietssnelwegen, ga naar de website van Fietssnelweg F35

1. Wat is uw gemiddelde dagelijkse fietsafstand?

(1) ❑ 0-2 kilometer

(2) ❑ 2-4 kilometer

(3) ❑ 4-6 kilometer

(4) ❑ 6-8 kilometer

(5) ❑ 8-10 kilometer

(6) ❑ 10-12 kilometer

(7) ❑ 12-14 kilomter

(8) ❑ 14-16 kilometer

(9) ❑ 16-18 kilomter

(10) ❑ 18-20 kilometer

(11) ❑ meer dan 20 kilometer

2. Wat is/was uw voornaamste bestemming vandaag?

(7) ❑ Van of naar werk/stage

(6) ❑ Van of naar school/universiteit

(2) ❑ Van of naar inkopen doen

(3) ❑ Van of naar bezoek van vrienden/familie

(4) ❑ Van of naar een uitstapje (bijv. naar het park, museum, bioscoop, sportclub etc.)

(5) ❑ Geen bestemming, ik fiets voor ontspanning of als training

3. Hoeveel dagen per week fietst u gemiddeld?

(1) ❑ 1 dag

(2) ❑ 2 dagen

(3) ❑ 3 dagen

(4) ❑ 4 dagen

(5) ❑ 5 dagen

(6) ❑ 6 dagen

(7) ❑ 7 dagen

4. Welke andere transportmiddelen gebruikt u voor uw gemiddelde reisafstand indien u niet fietst? (Meerdere antwoorden mogelijk)

(5) ❑ Deelauto

(2) ❑ Eigen auto

(4) ❑ Lopen (meer dan 1 kilometer)

(1) ❑ Openbaar vervoer

(3) ❑ Taxi

(6) ❑ Anders, namelijk: _____

5. Waarom fietst u? Rangschik s.v.p. de onderstaande antwoorden van belangrijkst op nummer een tot minst belangrijk op nummer zes.

	1	2	3	4	5	6
Meest comfortable transportmiddel	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Handigste transportmiddel voor deze reis	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Goedkoopste transportmiddel	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Snelste transportmiddel	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Omdat het goed is voor het milieu	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑
Omdat het gezond is/voor de lichaamsbeweging	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑

6. We troffen elkaar op de fietssnelweg F35 die in 2010 werd geopend. Fietste u ook voordat deze fietssnelweg werd geopend?

(De afstand is de afstand die u gemiddeld fietste per week, met frequentie wordt bedoeld hoeveel keer per week u fietste voordat de fietssnelroute werd geopend.)

(5) ❑ Nee

(1) ❑ Ja, dezelfde afstand en frequentie

(2) ❑ Ja, dezelfde afstand maar lagere frequentie

(11) ❑ Ja, dezelfde afstand, maar hogere frequentie

(3) ❑ Ja, kortere afstand maar dezelfde frequentie

(4) ❑ Ja, kortere afstand en lagere frequentie

(9) ❑ Ja, kortere afstand en hogere frequentie

(8) ❑ Ja, langere afstand maar dezelfde frequentie

(7) ❑ Ja, langere afstand maar lagere frequentie

(6) ❑ Ja, langere afstand en hogere frequentie

7. Zou u ook fietsen als de fietssnelweg er niet was? Dwz. zou u de gewone fietspaden gebruiken?

(4) ❑ Ja, absoluut

(1) ❑ Ja, maar niet zo vaak

(2) ❑ Nee, in dat geval zou ik de auto nemen (eigen auto of deelauto)

(6) ❑ Nee, in dat geval zou ik het openbaar vervoer nemen

(7) ❑ Nee, ik dat geval zou ik een ander vervoersmiddel nemen

(8) ❑ Nee, in dat geval zou ik thuisblijven

8 Heeft de fietssnelweg uw reistijd en -afstand beïnvloed?

(1) ❑ Ja, kortere reistijd, dezelfde afstand

(6) ❑ Ja, kortere reistijd, kortere afstand

(8) ❑ Ja, kortere reistijd, langere afstand

(2) ❑ Nee, dezelfde reistijd, dezelfde afstand

(4) ❑ Ja, dezelfde reistijd, kortere afstand

(5) ❑ Ja, dezelfde reistijd, langere afstand

(3) ❑ Ja, langere reistijd, dezelfde afstand

(9) ❑ Ja, langere reistijd, kortere afstand

(7) ❑ Ja, langere reistijd, langere afstand

9. Wat voor fiets heeft u?

(3) ❑ Bakfiets

(5) ❑ Dames/herenfiets

(4) ❑ Elektrische fiets

(6) ❑ Mountainbike

(1) ❑ Racefiets

(2) ❑ Een ander soort fiets, namelijk: _____

10. Hoe oud bent u?

___

11. Wat is uw geslacht?

(1) ❑ Vrouw

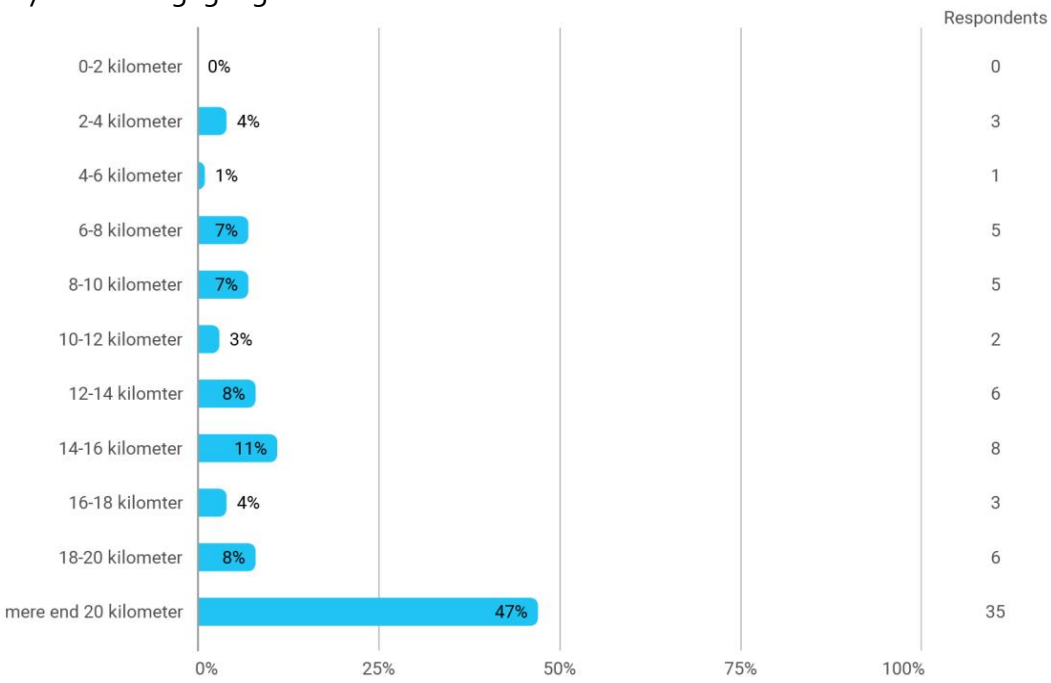
(2) ❑ Man

Hartelijk bedankt voor uw hulp! Indien u het resultaat wil lezen, kunt u hieronder uw emailadres invullen. U krijgt dan een kopie van het onderzoek toegestuurd wanneer het klaar is.

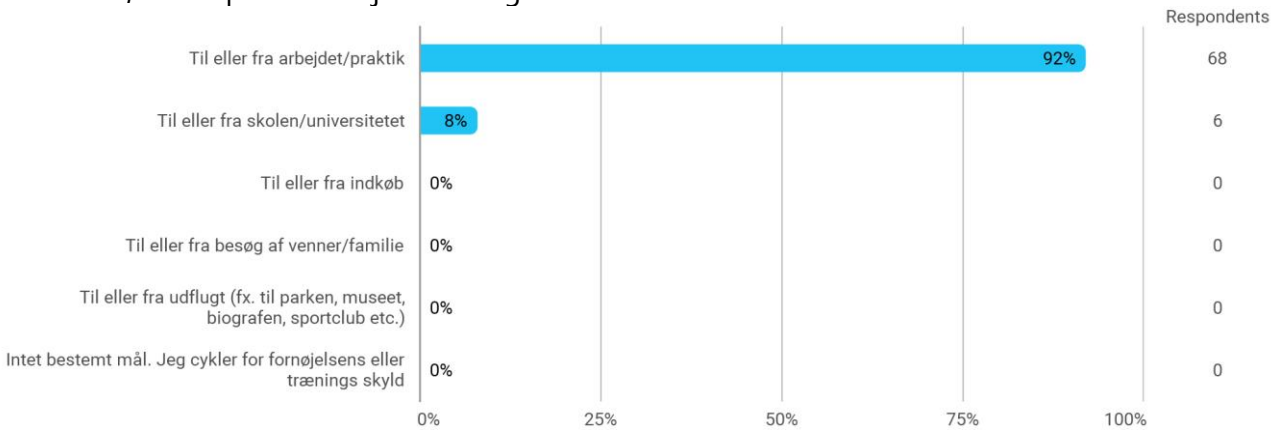
_____

Appendix 5. The Danish questionnaire results

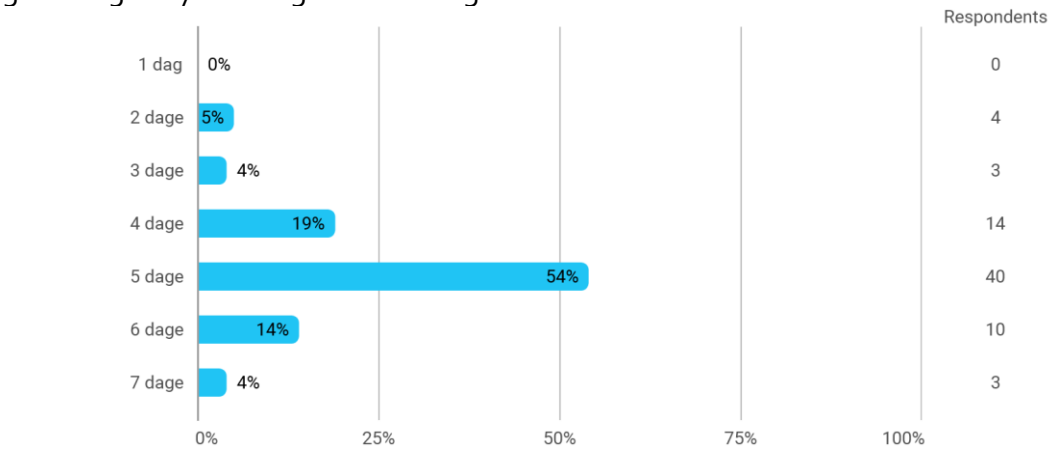
1. Hvilken afstand cykler du dagligt i gennemsnit?



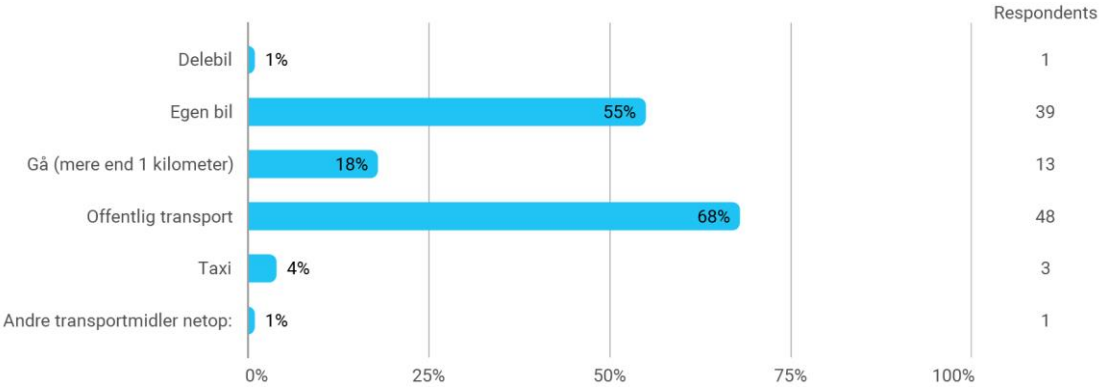
2. Hvad er/var dit primære rejsemål idag?



3. Hvor mange dage om ugen cykler du gennemsnitlig?

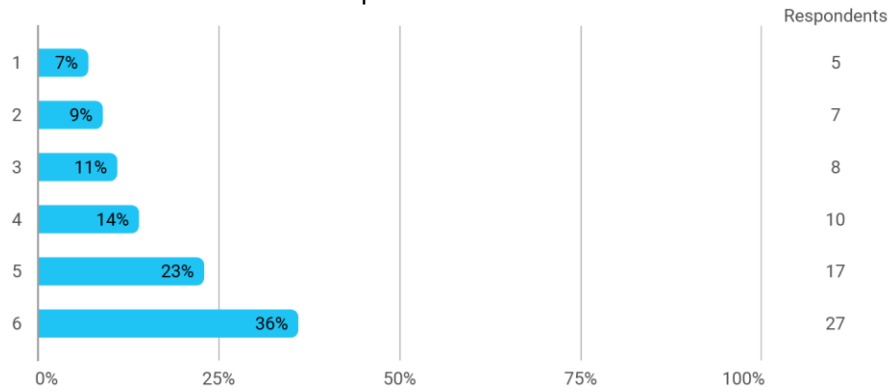


4. Hvilket andet transportmiddel bruger du til din daglige transport hvis du ikke cykler? (Flere svar muligt)

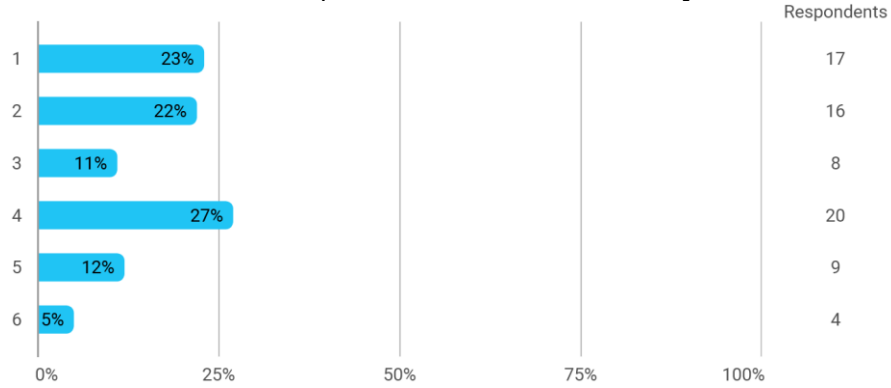


Here one respondent indicated that, if not cycling, he used a different mode of tranport than the abovementioned, which is: A car borrowed from family.

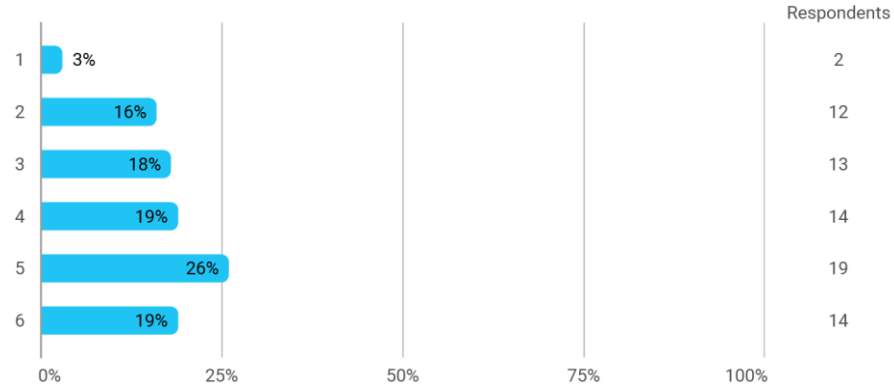
5. Hvorfor rejser du med cyklen? Arranger venligst svarende herunder fra vigtigste grund som nr. 1 til mindst vigtige grund som nr. 6. - Mest komfortable option



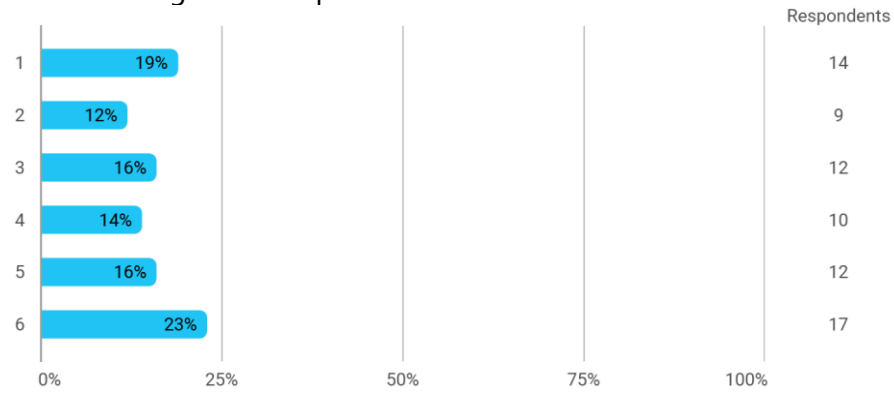
5. Hvorfor rejser du med cyklen? Arranger venligst svarende herunder fra vigtigste grund som nr. 1 til mindst vigtige grund som nr. 6. - Nemmeste transportmiddel for denne her rejse



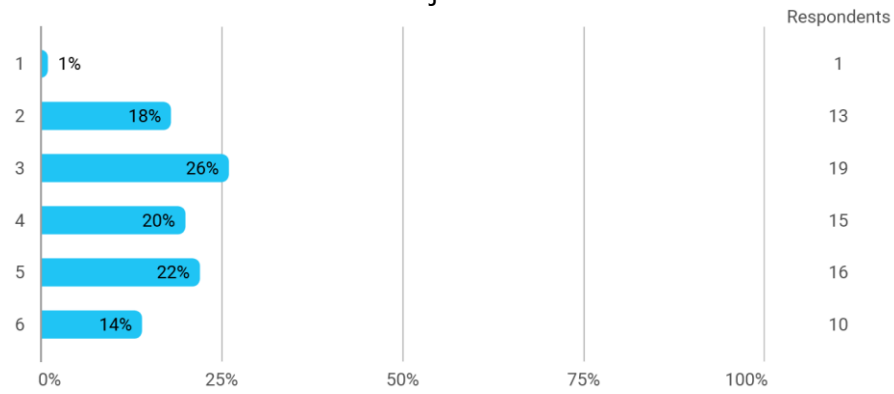
5. Hvorfor rejser du med cyklen? Arranger venligst svarende herunder fra vigtigste grund som nr. 1 til mindst vigtige grund som nr. 6. - Billigeste transportmiddel



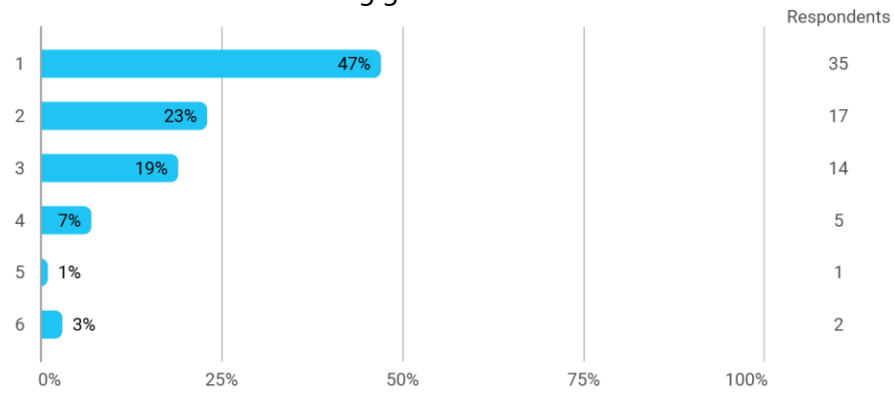
5. Hvorfor rejser du med cyklen? Arranger venligst svarende herunder fra vigtigste grund som nr. 1 til mindst vigtige grund som nr. 6. - Hurtigeste transportmiddel



5. Hvorfor rejser du med cyklen? Arranger venligst svarende herunder fra vigtigste grund som nr. 1 til mindst vigtige grund som nr. 6. - Fordi det er bedre for miljøet

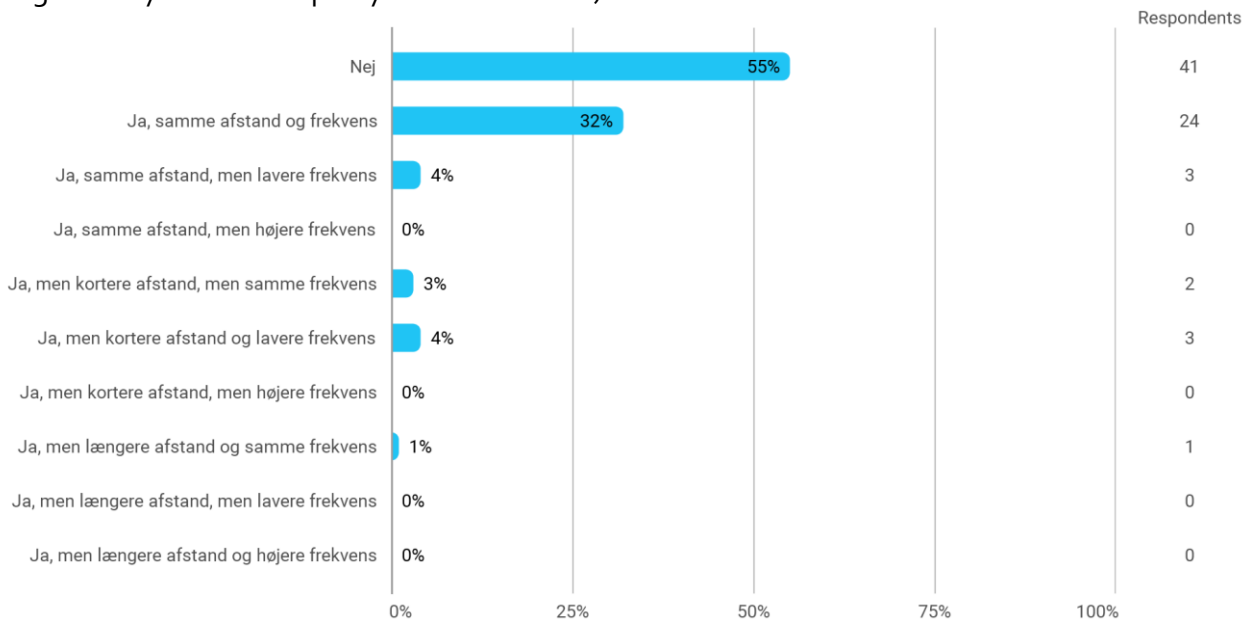


5. Hvorfor rejser du med cyklen? Arranger venligst svarende herunder fra vigtigste grund som nr. 1 til mindst vigtige grund som nr. 6. - Fordi det er sundt og giver motion

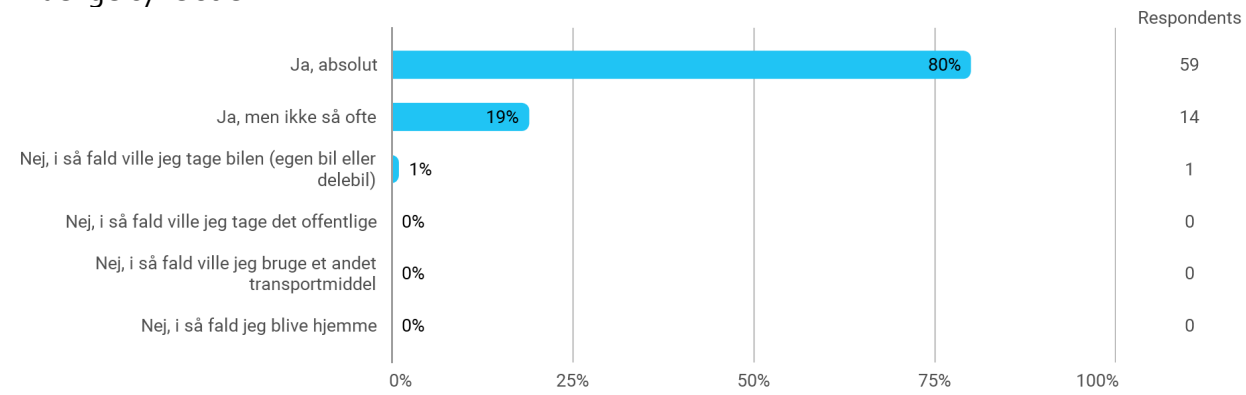


6. Vi træffedes på supercykelstien Farumruten som blev etableret i 2013. Cyklade du også der før supercykelstien blev etableret?

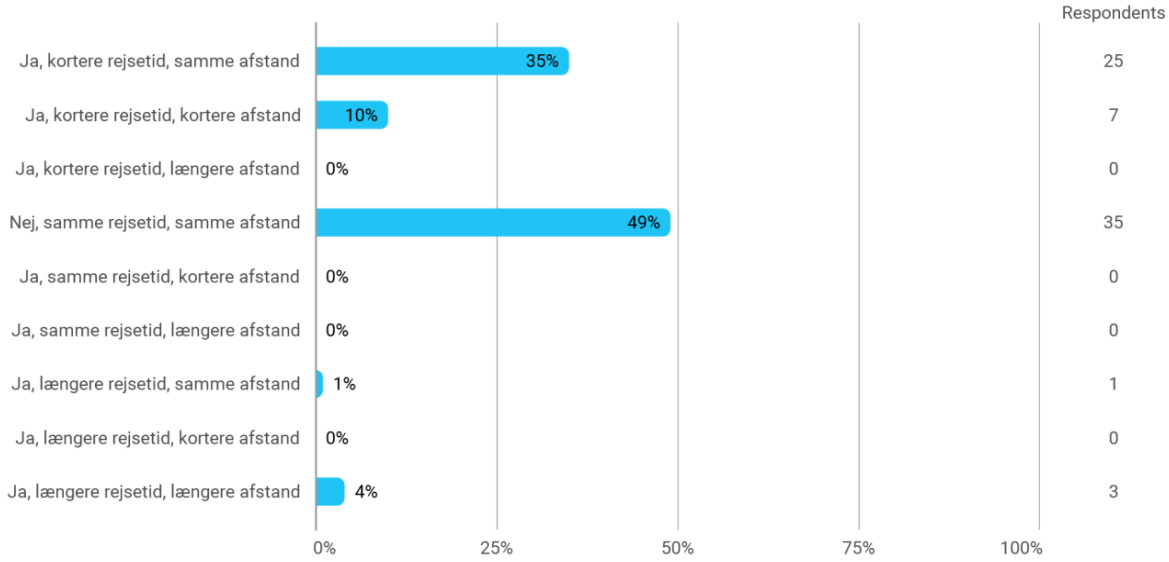
(Afstanden er gennemsnitlige afstand du cyklede per uge, og frekvens betyder hvor mange gange om ugen du cyklede før supercykelstien var her.)



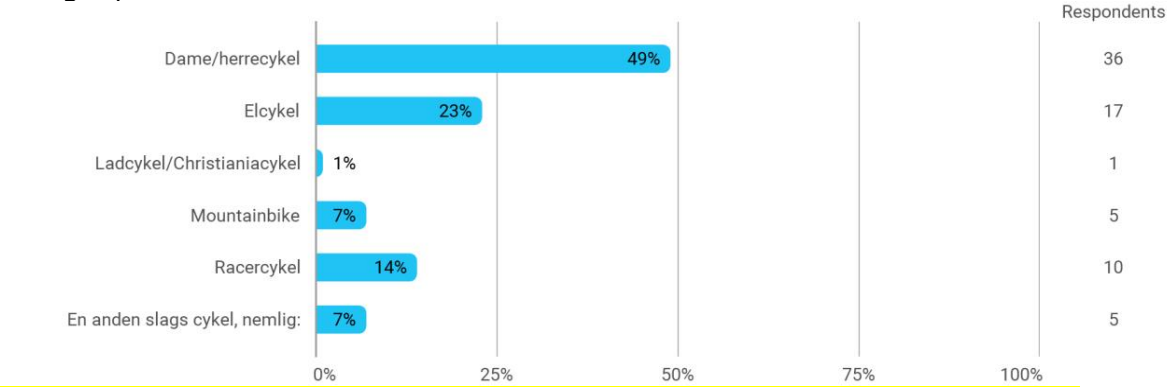
7. Ville du også bruge cyklen hvis supercykelstien ikke var her? Dvs. om du ville bruge de almindelige cykelstier.



8 Har supercykelstien påvirket din gennemsnitlige daglige rejse-tid og -afstand?

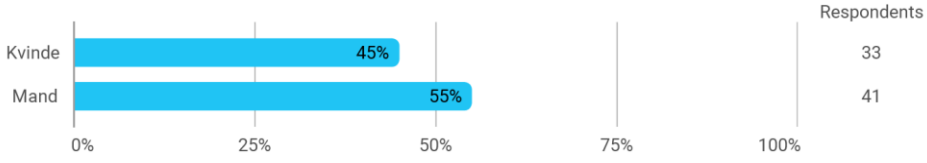


9. Hvilken slags cykel har du?

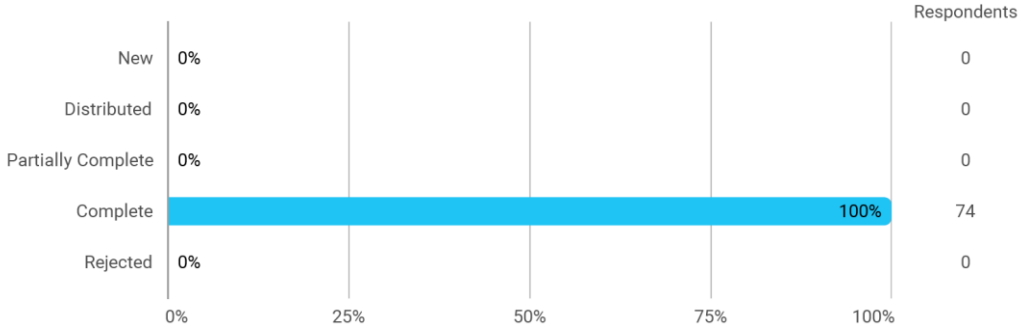


Five respondents indicated to have another bike than the ones given as answering options. Four respondents expressed that they have a City Bike, which are electric bikes which can be rented through a bike-share scheme and can be picked up at docking stations throughout the city. One respondent expresses that he has a cyclo-cross bike with mudguards.

11. Hvad er dit køn?

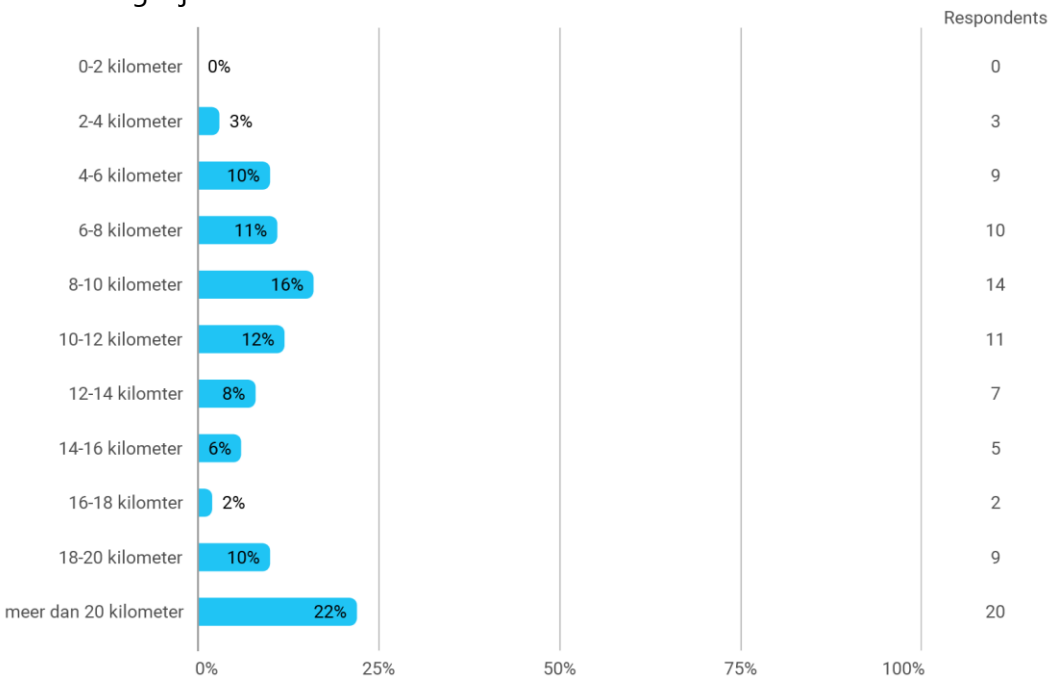


Overall Status

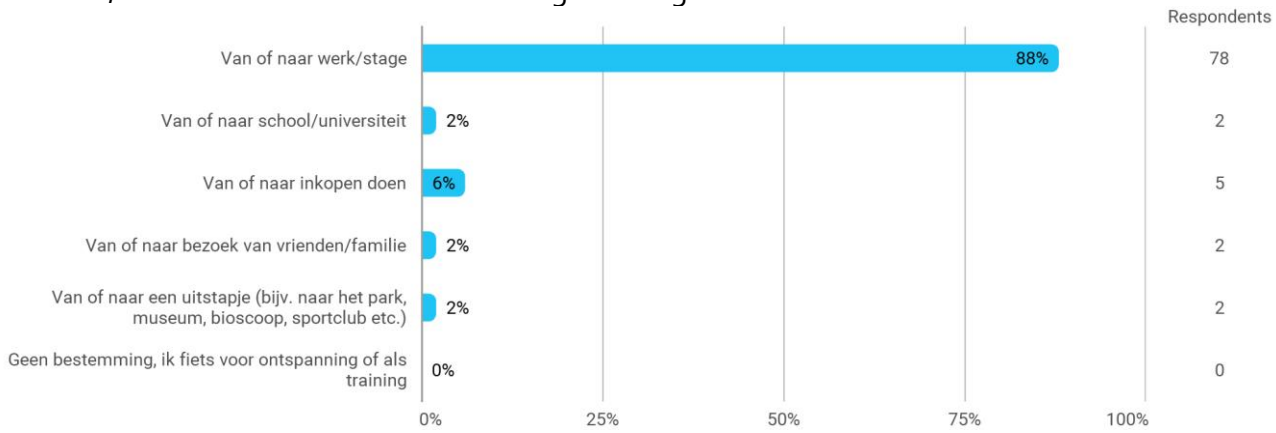


Appendix 6. The Dutch questionnaire results

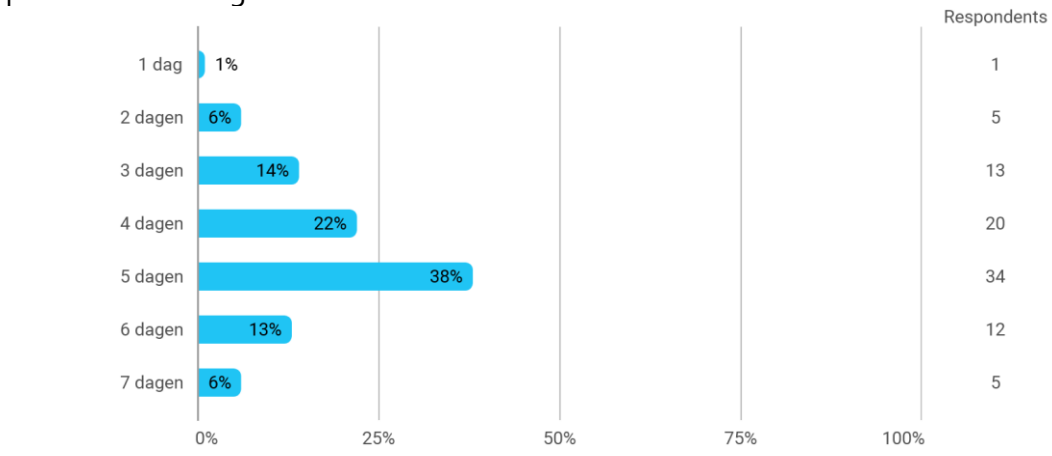
1. Wat is uw gemiddelde dagelijkse fietsafstand?



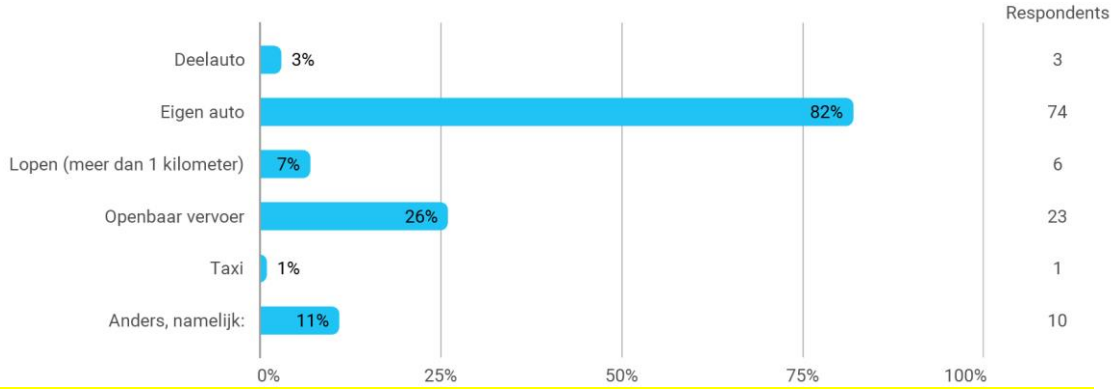
2. Wat is/was uw voornaamste bestemming vandaag?



3. Hoeveel dagen per week fietst u gemiddeld?

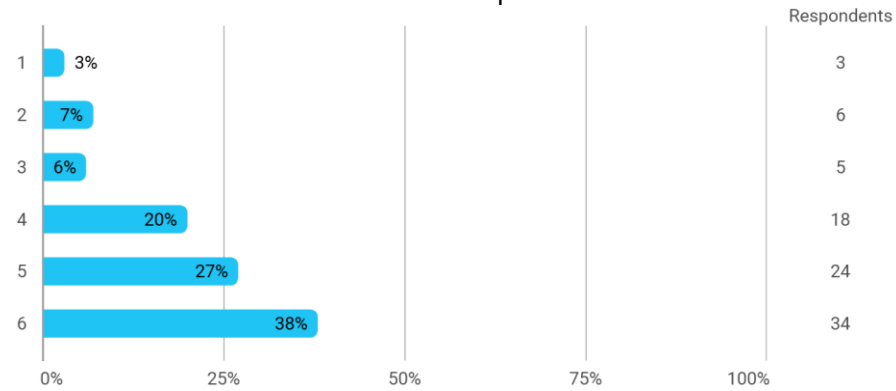


4. Welke andere transportmiddelen gebruikt u voor uw gemiddelde reisafstand indien u niet fietst? (Meerdere antwoorden mogelijk)

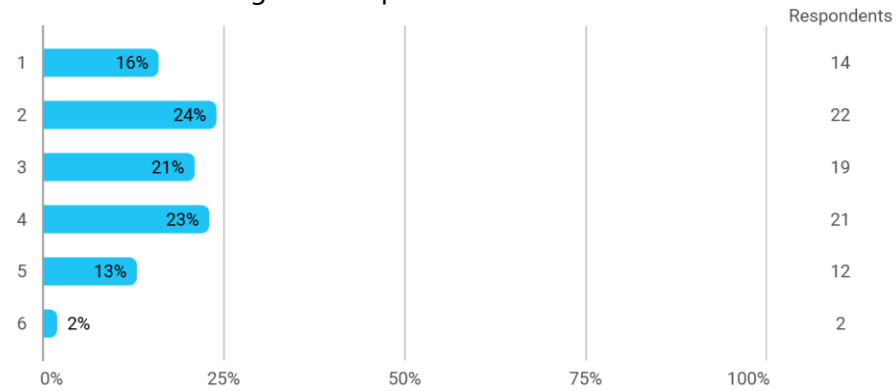


At this question, ten alternative transport modes were given. Three respondents indicated *'none'*, meaning that the bicycle is their only means of transport. Two respondents replied that they use a motorbike. Two respondents replied that they use an airplane. Two respondents replied that they ride-share with someone. One respondent replied that he used a company van as an alternative to cycling.

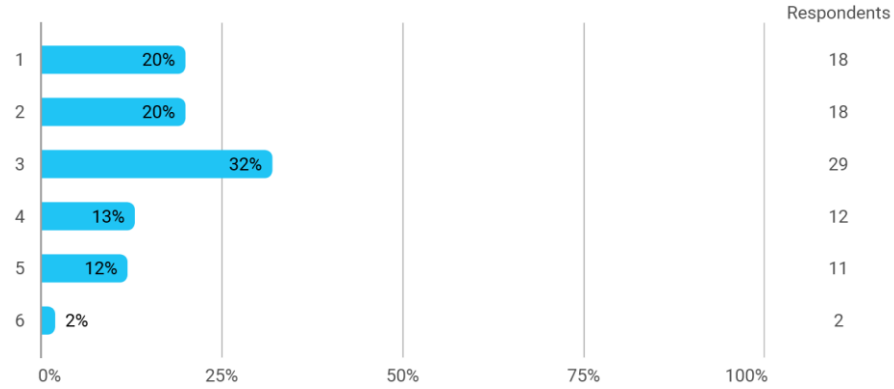
5. Waarom fietst u? Rangschik s.v.p. de onderstaande antwoorden van belangrijkst op nummer een tot minst belangrijk op nummer zes. - Meest comfortable transportmiddel



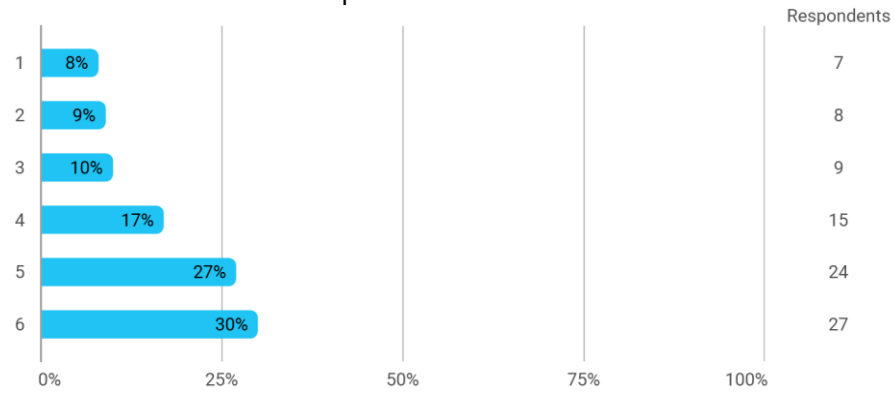
5. Waarom fietst u? Rangschik s.v.p. de onderstaande antwoorden van belangrijkst op nummer een tot minst belangrijk op nummer zes. - Handigste transportmiddel voor deze reis



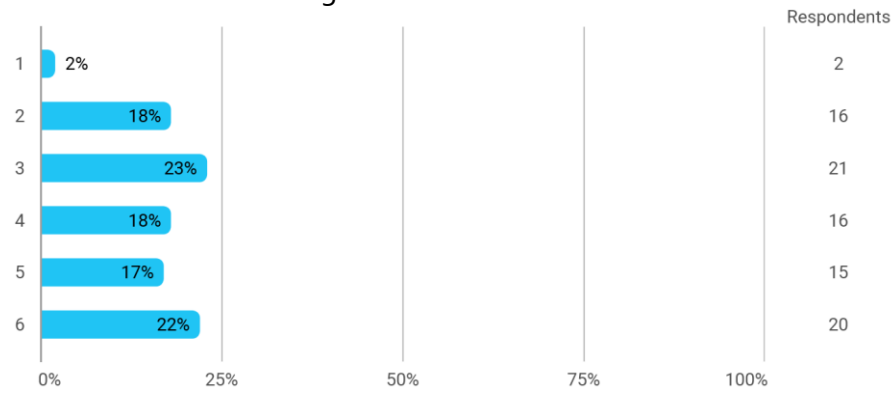
5. Waarom fietst u? Rangschik s.v.p. de onderstaande antwoorden van belangrijkst op nummer een tot minst belangrijk op nummer zes. - Goedkoopste transportmiddel



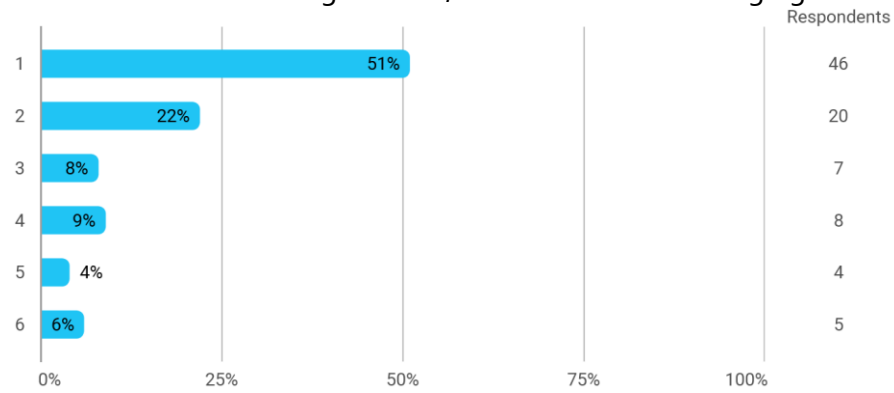
5. Waarom fietst u? Rangschik s.v.p. de onderstaande antwoorden van belangrijkst op nummer een tot minst belangrijk op nummer zes. - Snelste transportmiddel



5. Waarom fietst u? Rangschik s.v.p. de onderstaande antwoorden van belangrijkst op nummer een tot minst belangrijk op nummer zes. - Omdat het goed is voor het milieu

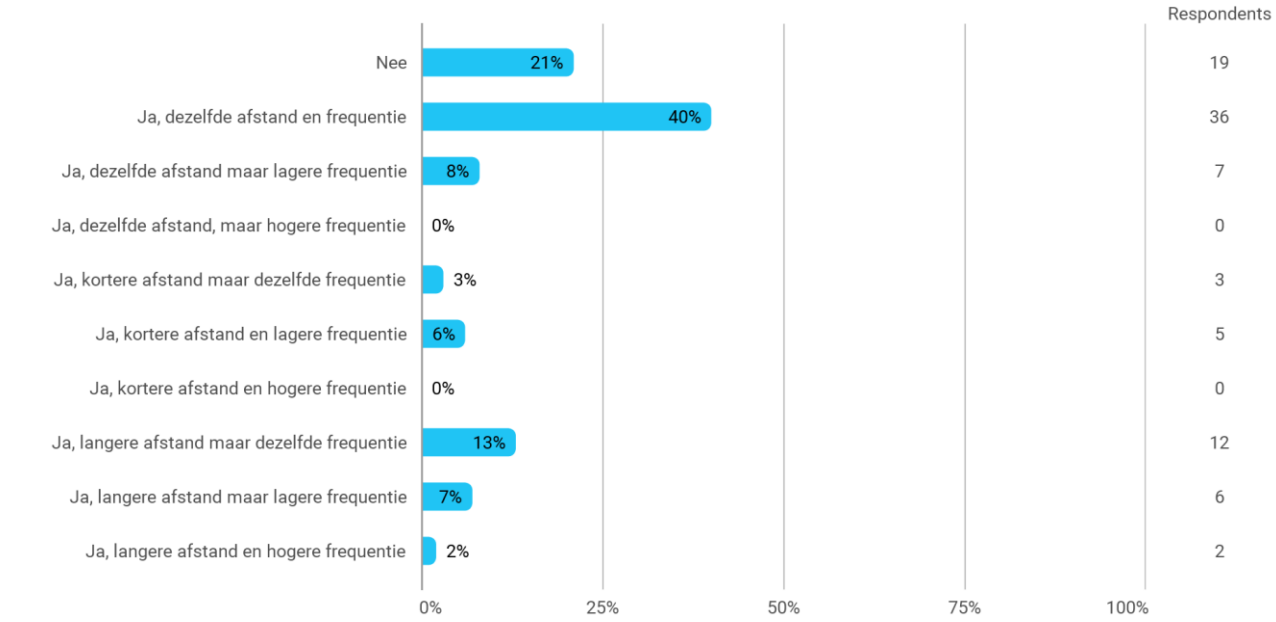


5. Waarom fietst u? Rangschik s.v.p. de onderstaande antwoorden van belangrijkst op nummer een tot minst belangrijk op nummer zes. - Omdat het gezond is/voor de lichaamsbeweging

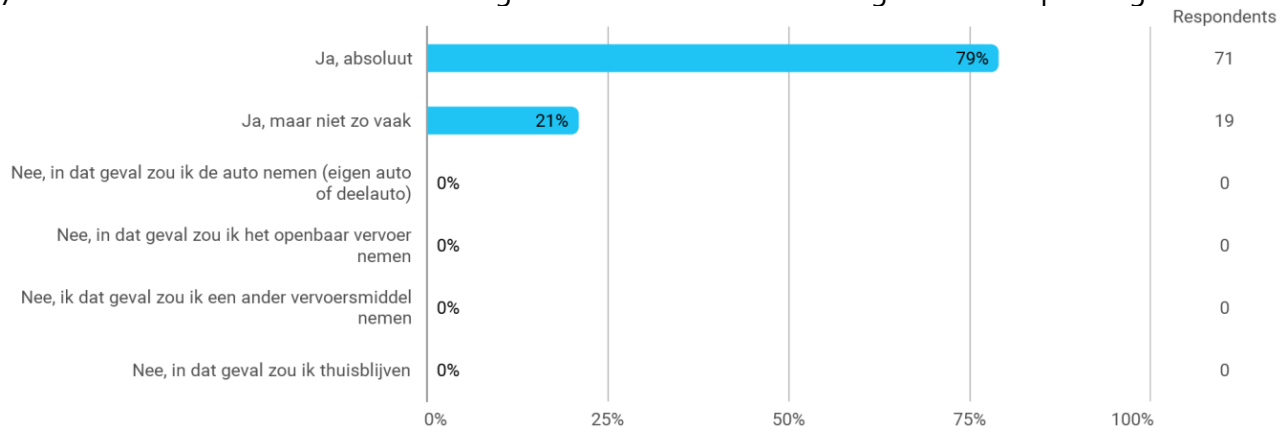


6. We troffen elkaar op de fietssnelweg F35 die in 2010 werd geopend. Fietste u ook voordat deze fietssnelweg werd geopend?

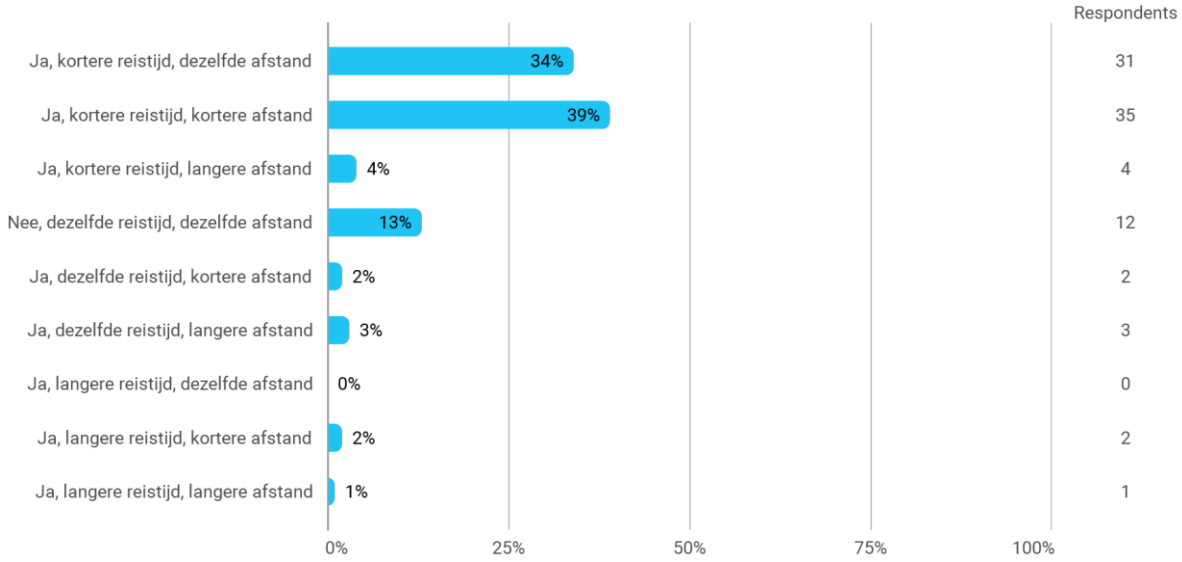
(De afstand is de afstand die u gemiddeld fietste per week, met frequentie wordt bedoeld hoeveel keer per week u fietste voordat de fietssnelroute werd geopend.)



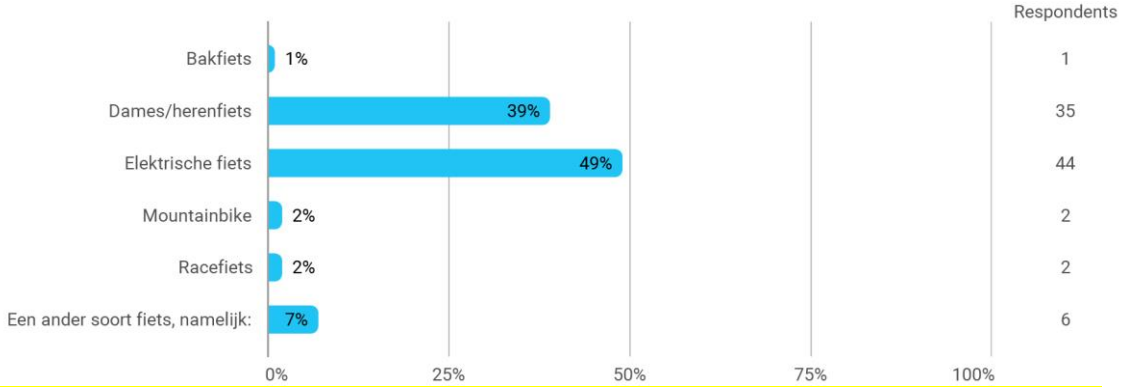
7. Zou u ook fietsen als de fietssnelweg er niet was? Dwz. zou u de gewone fietspaden gebruiken?



8 Heeft de fietssnelweg uw reistijd en -afstand beïnvloed?

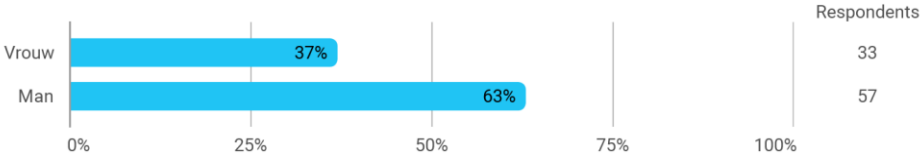


9. Wat voor fiets heeft u?

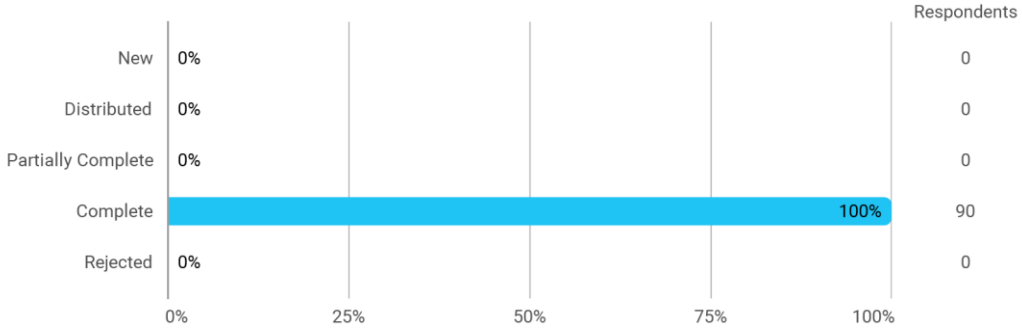


At question 9, six respondents filled in that they have one or more bicycles that are not mentioned in the answering options. The types of cycles mentioned are: A tricycle, a Pick Up men's bike (a type of transport bike made by Dutch bicycle company Sparta), an electric and regular bicycle (the respondent thus indicated that he or she owns two bicycles), a transport bike and a trekking bike.

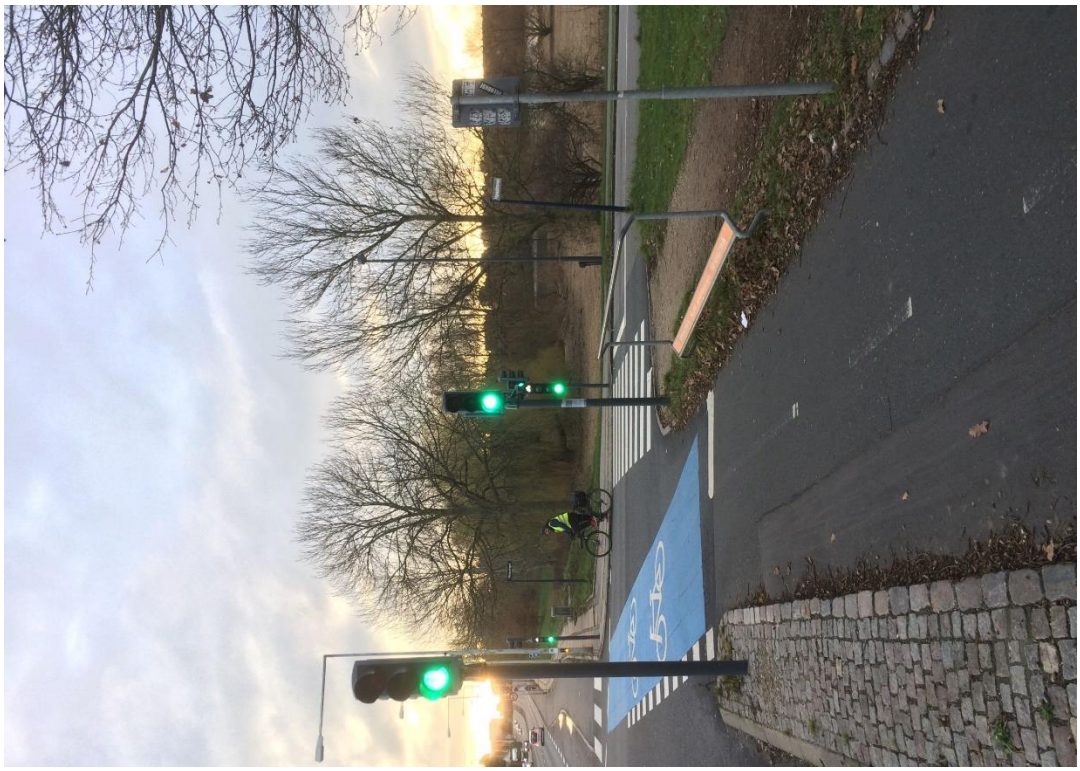
11. Wat is uw geslacht?

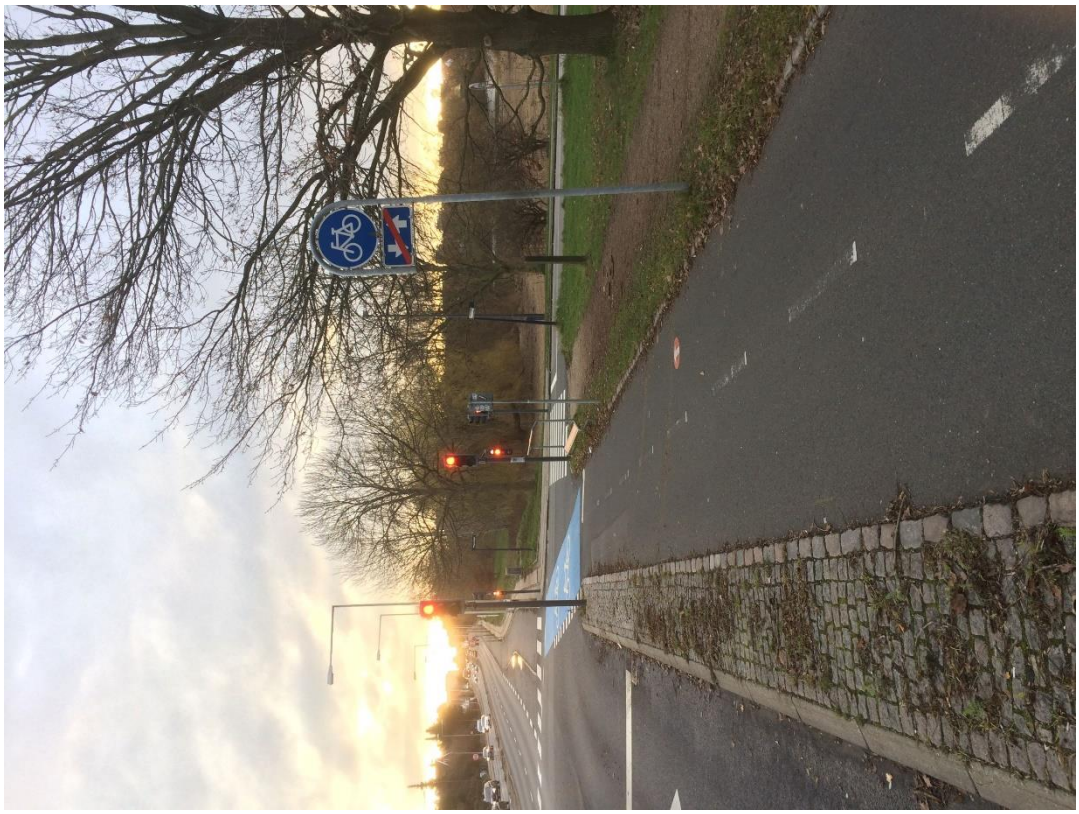


Overall Status



Appendix 7. Surveying site photos





The surveying location on the Farum route. The surveyor was positioned behind the footrest-installation on the right side of the cycle track. Source: Arne Kempers, 2018.

The crossing with Klausdalsbrovej. The sensors can clearly be seen. By riding over the sensors, the cyclists get a green light and can carry on cycling without stopping. This is not an ideal location to hand out survey invitations. Source: Arne Kempers, 2018.

The surveying location on the F35. The surveyor can be seen standing at the traffic light. The surveying location was one of the few locations where cyclists had to reduce their speed because of a bend in the road. Busses passed only once every fifteen minutes, so cyclists rarely had to stop. Source: Hanna Blomquist, 2019.