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ID 1322 | COMMUTING PATTERNS AND CAR DEPENDENCY IN URBAN REGIONS

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ABSTRACT: We have analyzed car dependency in urban regions in the Netherlands, focusing on the lack of alternatives for the car in daily commuting. As geographical factors like distance from home to work and accessibility of job locations shape important conditions for potential behavioral change in car use and ownership, we map out the alternatives to the car for commuting in urban environments in the Netherlands, with emphasis on the bicycle and e-bicycle for shorter distances and combined bike-train for longer distances. In 2014, in the three big cities and some medium-sized cities (30% of the Dutch

population), 60-80% of the commuters have jobs within an acceptable cycling distance (within 7.5 km on average). Moreover, in all big and medium-sized cities and most of the suburban areas in the Netherlands (61% of the population) 60-80% of commuters have a job within e-biking distance (within 15 km on average). These geographical conditions could allow a doubling of the share of the bicycle and the e-bicycle in commuting, becoming the dominant forms of commuting in urban areas in the Netherlands. Looking at trends over time, it appears that in the large cities there is a stabilization of the share of jobs within e-cycling distance, but the medium-sized cities show a decrease. The South Limburg case study examined the potentials of the bike-train combination and found that it provides a reasonable alternative to the car for approximately 5% of employees with jobs located beyond e-biking distances.

1 INTRODUCTION

In the area of transport policy and research there seems to be a wide consensus on the need for alternatives for the car as a daily means of transport in urban areas. The dependency on cars and the consequential massive car use and ownership seem to contradict the spatial and social characteristics of urban areas with respect to accessibility, health, safety, equity and quality of public space (Rogers 1997, Girardet 2004). In urban areas, the space required for driving and parking competes with space for leisure, walking and cycling, green areas, as well as residential and work space (e.g., on-street parking for residents, including room for maneuvering occupies more floor space than the average apartment). A shift to the use of environmentally friendly vehicles such as electric cars will not solve these spatial and social problems. The contributions of self-driving cars are at best uncertain in this respect (perhaps there is locally less parking space needed if self-driving cars are shared, but it may also lead to more car traffic).

In the light of the above, how feasible are changes in car use and ownership, especially in the more developed cities in Europe and North America where they are so ingrained? Although the spatial conditions for walking, the cycling, public transport and car-sharing seem favorable in urban areas – as shown by studies of travel behavior, modal split and car ownership (e.g., Geurs and Wee 2006, Hilbers and Snellen 2006, Kenworthy and Laube 1999, Van de Coevering 2013) – urban areas are increasingly becoming part of regional networks, with jobs and facilities located beyond cycling reach and often at transit poor, car-dependent locations (PBL 2014). The Netherlands, a country known for its relatively compact cities, has been scaling up urban networks, for several decades (Tordoir, 2015). The average commuting distance in the Netherlands has increased from 17.6 in 2003 to 18.6 in 2014 (CBS Statline). In areas with shrinking populations, the average commuting distance increases because there are fewer residents and jobs within the same space (Wiersma et al. 2017, Goudappel Coffeng 2015). Moreover, the biggest growth in jobs in the past 15 years has taken place on motorway sites (PBL 2014). The car seems indispensable for most weekly shopping and social recreational trips (Jeekel 2013).

The trends outlined above indicate increasing car dependency (CD), also including the urban population (Jeekel 2013, Harms 2008). CD does not only relate to car use, but also to car possession. Because both use (space for moving) and possession of cars (space for parking) claim urban space, not only the dependence on everyday use is important, but also the need of owning the car. In figure 1 the various levels of CD are shown. In yellow the car trips having alternative transportation modes that are competitive in terms of travel time and costs. This is the domain of what Jeekel (2013) refers to as 'subjective CD': a habit or lack of information about alternative transport modes. In the Netherlands, in urban, suburban and most rural areas, daily amenities, like schools and shops are within walking and cycling distance (Wiersma et al. 2015, CBS). They form part of the yellow sphere. In this sphere policy aimed at awareness of alternative transport modes, or offering more comfortable and safe bicycle paths, could be effective for behavioral change. Orange are the occasional car trips, for which the car is indispensable, such as a trip to the hardware store, or a holiday home. For this, the use of the private vehicle is necessary, but not the possession, renting or sharing a car being an option. In this sphere, policy aimed at offering attractive arrangements for rent-a car could be effective. Purple is the "hard core" of CD. These are everyday trips without an alternative transport mode, such as daily commuting trips to car dependent locations beyond cycling distance. Research shows that people rarely rent a car for their daily commute (Cervero 2006). The daily dependency on the use of cars for commuting creates thus a 'hard core' of the use and possession of cars, because 1) the trip is in most cases done with the private car, and 2) in addition to driving to work or school, the car is often part of a chain of other movements, for which alternative transport modes are often available (Harms 2003, Urry 2004, Baptista et al. 2014).

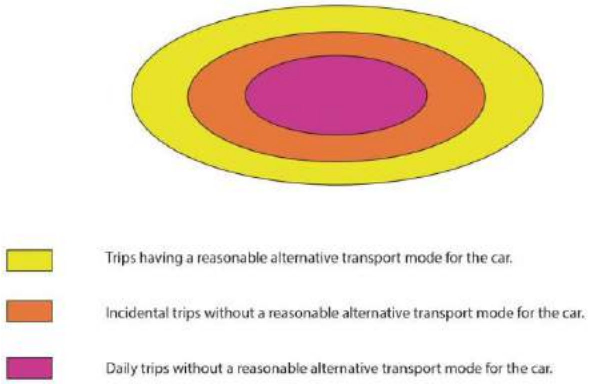

Figure 1. Levels of Car Dependency

Although in urban areas people aren't dependent on cars for trips to amenities, such as shops, health care or schools (Wiersma et al. 2015, CBS 2015), the dependence of using their own car for commute trips beyond cycling distance or to car-dependent locations seems to be an important determinant for a car-dependent lifestyle Determining the extent of this 'hard core' of CD could show the extent of possible behavioral change (using alternative modes and sharing or renting instead of owning a car) in the existing spatial context, thereby giving insight into the possibilities of policies aimed at this behavioral change, not requiring a different location of homes and jobs.

Our study seeks to answer the following research question: How CD are employees in the Netherlands in their daily trips from home to work, and how does this evolve over time? While in the Netherlands' data are largely available on the development of average commuting distances (CBS 2016, PBL 2014, KiM 2013) and the accessibility of jobs (Goudappel Coffeng accessibility map http://www.bereikbaarheidskaart.nl/, PBL 2014, Tordoir 2015), there is no specific overview of the CD of existing and potential future commuting patterns of the urban population. Our study aims to fill this knowledge gap.

We have focused primarily on the potential of the bike or e-bike as an alternative to the car, because in the Netherlands 1) for most people this is the most attractive alternative to the car for short distances (Harms 2006), 2) more jobs are accessible within 30 minutes by e-bicycle than by public transportation (Wiersma et al. 2017, Goudappel 2015), and 3) the potentials of the e-bike for medium distances (5-15 km) seems promising (KPVV 2012, KIM 2016). For longer distances the alternative to the car must include some form of public transport. In this study, we focused on the bike-train combination, because in the Netherlands the bicycle as a transport mode has an ever-growing share of the ride to the station (Kager et al. 2016), and this combination seems to be most competitive alternative to the car in travel time, as it avoids time-consuming and inconvenient public transport transfers (Kager et al. 2016, Schakenbos et al. 2015, Staps 2014). This specification leads to the following sub-questions: 1) To what extent are commuting distances in urban areas within cycling or e-cycling distance, and how do they evolve over time? 2) To what extent is the combination (e-) bicycle-public transport an additional competitive alternative to the car in commuting? 3) Which are the potentials for behavioral change, in relation to the current modal split of commuting? In the next sections we define our case, the research methodology, findings and conclusions.

2 THE NETHERLANDS AND SOUTH LIMBURG CASE STUDY

The broader case is the current and future situation in urban areas in the Netherlands, especially municipalities of 100,000 inhabitants or more and their interwoven suburban areas (see Figure 2). Within the European context, the urban areas in the Netherlands are relevant because size and density are typical of many urbanized parts of Europe. At present, almost half of the people in the Netherlands live in medium-sized cities, ranging from 50,000 to about 1,000,000. This reflects the situation in most of Europe, where only a minority live in larger metropolitan areas such as Paris, London or Berlin (Giffinger 2007). This share is increasing at the expense of peripheral and rural areas. Second, most cities in the Netherlands are part of polycentric regions where daily urban systems are becoming intertwined, as is the case in many urban areas in Europe, such as Northern England, parts of Germany and northern Italy. In one respect the Dutch situation is atypical: the widespread use of bicycles in everyday life, in comparison with in size and density comparable urban areas in other countries. Nevertheless, although behaviors may be different, the spatial conditions for bicycle use, as determined by urbanization patterns, are similar to many urban areas in Europe. We investigated commuting distances across the entire territory of the Netherlands, and looked at the bicycle-train combination specifically in the South Limburg region.

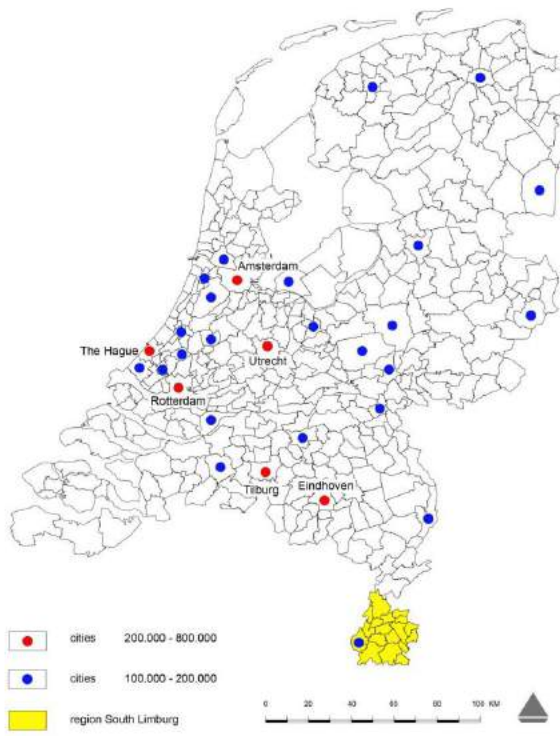

Figure 2. Cities of more than 100,000 inhabitants in the Netherlands

3 RESEARCH METHODOLOGY

3.1 COMMUTING DISTANCES WITHIN (E-)BICYCLE DISTANCE

The basis for this study consists of data on commuting distances, measured between the geographic centers of the commuters' home and work municipalities (CBS 2014). We have defined 5 km Euclidian distance one-way (or about 7,5 km real, on-the-network distance) as the maximum acceptable distance to cover daily by bicycle, 10 km Euclidian distance each way (or about 15 km real distance) for the e-bike (based on KiM 2016). For each municipality we have mapped out the percentage of employees who have jobs within cycling distance and e-cycling distance in 2014. We assumed that employees who have jobs in their own municipality live within bicycle distance from their jobs, given the geographical size of most urban and suburban municipalities in the Netherlands. Of course, there is a minority of people who work in the opposite side of the city. This would still be within a maximum of 15 km (10 km Euclidian distance), and therefore still be within e-bicycle distance. Furthermore, we assumed that employees with jobs in a nearby municipality, with a geographical center within 10 km of the geographical center of their home town, are within e-bicycle distance. Figure 3 shows a schematic view of the geographical size of municipalities in the Netherlands and corresponding commuting distances. We have distinguished two possible situations: people who hold jobs within their own municipality and those who have jobs in another municipality. The left side shows that commuting trips for people living in municipality A and working in A are on average within bicycle distance. The right side shows that commuting trips for people who live in municipality A or B and hold a job in B or A, respectively, are on average within e-cycling distance. In all other the job is located beyond bicycle or e-bicycle range.

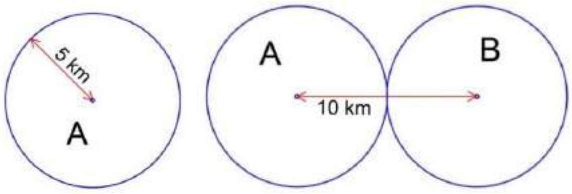

Figure 3. Schematic view of the geographical size of municipalities in the Netherlands and corresponding commuting distances

3.2 POTENTIALS OF THE BICYCLE-TRAIN COMBINATION

Given the fact that the average distance from home to a train station in urban areas in the Netherlands varies between 2 and 4 km (KPVV 2017), we can deduct that the travel times from home to and from the station by bicycle would take on average about 15 minutes. Against this background, we assume that one can store the bike without significant delay; there is a 15 minutes train frequency; no train–train transfers are needed; and the job location is within 500 m from the destination rail station. Under these conditions the bike-train combination could be competitive – though not in all cases – in terms of door-to-door travel time, and a reasonable alternative to the car (especially taking considering parking costs and occasional effects of congestion in rush hour into account) (See figure 4). We explored how many employees would benefit from this combination, using data from the E'til (http://www.etil.nl/contact/) for South Limburg, available from the Province of Limburg (Vaessen and Knoors 2015). These data show the number of employees per municipality working in economic centers, on the level of zip code 4. This indicates how many people per municipality in 2014 had jobs at transit locations, defined as within 500 m from a train station.

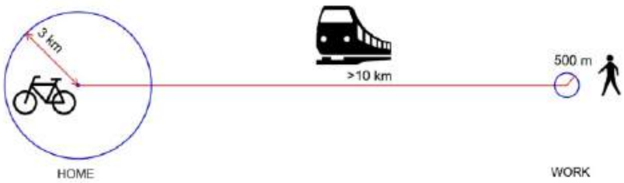

Figure 4. Schematic view of the components of the bike-train combination in urban areas

4 FINDINGS

4.1 THE RELATION BETWEEN URBAN DENSITY AND POTENTIALS FOR THE (E-)BIKE

Figure 4 compares the densities of the municipalities in the Netherlands, defined by the number of addresses per square kilometer (left-hand side), with the percentage of commuting trips within bicycle distance for those municipalities (right-hand side). The cities with more than 100,000 inhabitants and some satellite towns ('groeikernen') mostly have densities above 1,500 addresses per square kilometer, while smaller towns and suburban areas mostly have densities between 1,000 and 1,500 addresses. There is an urban concentration in western, central and the southeastern Netherlands, sometimes described as an 'urban field', as opposed to some smaller and less dense conurbations towards the north and southwest. The right side shows municipalities where more than 50% of their residents live within an acceptable cycling distance (7.5 km) from their jobs, on average, per municipality in 2014. As expected, it shows high scores (above 60%) for the big cities and some medium-sized cities with high densities. However, most cities with high densities in the heart of the above described 'urban field' seemingly have moderate (50-60%) scores. The satellite towns (groeikernen) mostly have scores below 50%. Of the entire population of the Netherlands 8% lives in municipalities with between 70% and 80% reach, 22% in municipalities with scores between 60% and 70%, another 20% in municipalities with scores between 50 and 60%, and the rest (50%) in municipalities with scores below 50%.

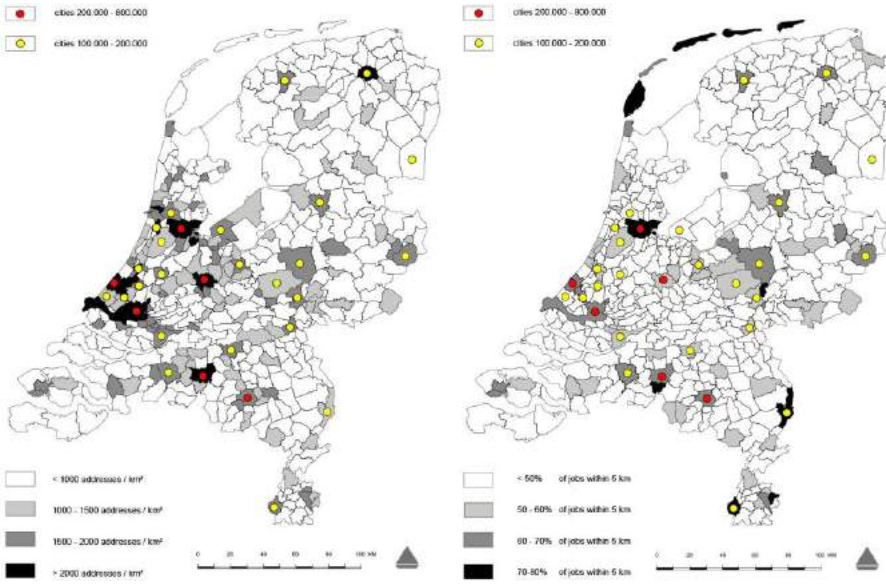

Fig. 5. Urban densities and potentials for the bicycle in commuting, Source: CBS 2014

Figure 6, right side, shows the percentage of workers living within an acceptable e-bicycle range (15 km) from their work, on average per municipality in 2014. As expected, there are more municipalities with high scores than in Figure 5. However, apparently there is no direct relation with density. Apart from the big cities in the west, high scores (above 60%) are found in suburban areas with lower densities, sometimes even below 1,000 addresses/km2. In some cases, the scores of suburbs are higher than the adjacent medium-sized central cities (see the black areas next to cities, marked with yellow or red dots). Also remarkable are the extensive areas with high (more than 60%) e-bicycle potentials in the less populated periphery of the country. Finally, it appears that almost the entire southern wing of the Randstad and almost the whole of South Limburg, in urban as well as in suburban areas, where three-quarters of people live on average within 15 km of their workplace, thus within e-bicycle distance. Of the entire population of the Netherlands, 31% live in municipalities with between 70% and 80% of the workforce having a job on average within 15 km, 30% in municipalities with scores between 60% and 70%, a quarter (26%) in municipalities with scores between 50% and 60%, and the rest (13%) in municipalities with scores below 50%.

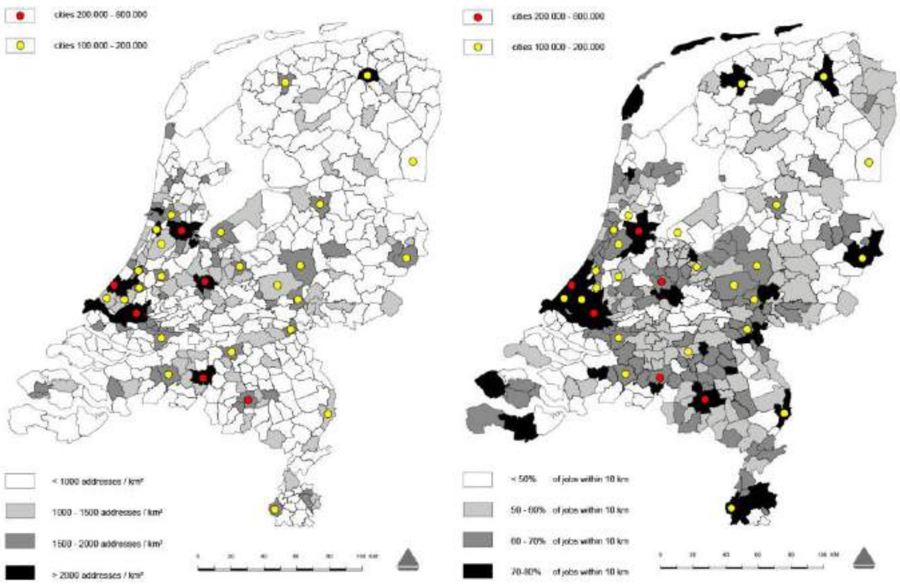

Fig. 6. Urban densities and potentials for the e-bicycle in commuting, Source: CBS 2014

4.2. DEVELOPMENTS IN COMMUTING DISTANCES

To explore how commuting distances evolve over time, we considered the changes in home–work distances in cities with populations over 100,000, between 2005 and 2014 (Figure 7). Except in the big cities, in most cities the percentage of people holding a job within an average distance of 15 km is decreasing, resulting in an average decrease of 4% between 2005 and 2014. This seems consistent with the observations of Tordoir (2015) regarding the upscaling of urban networks in the Netherlands. It is slightly less, however, than the increase in average commuting distance across the Netherlands from 17.6 km in 2003 to 18.6 km in 2014, which amounts to 6% (CBS 2016).

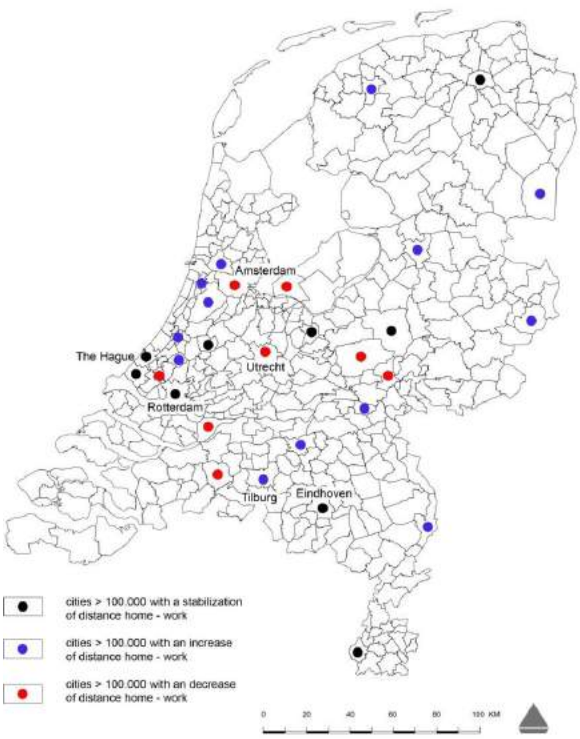

Fig. 7. Developments in home–work distances 2005-2014, in cities with over 100,000 inhabitants, Source: CBS 2014,2016

4.3 POTENTIALS OF THE BIKE-TRAIN COMBINATION IN SOUTH LIMBURG

Figure 8 (left hand side) shows the percentage of people with jobs within acceptable e-bike distance in the South Limburg region . In Figure 8 (right hand side) this percentage is added up with the percentage of employees with jobs on rail-oriented locations beyond 15 km, having thanks to the bike-train combination a reasonable alternative to the car (following our assumptions, see above). This results in a gain of approximately 5% to 6% of commuting trips that have a reasonable alternative to the car. Compared with the scores of the (e-)bicycle, shown on the left side, this has almost no visible effects in the figure. Only two municipalities score above 70% thanks to this addition, but that is because the score of the e-bicycle for these municipalities was already close to 80%. It must be also kept in mind that these figures only reflect the potential use of public transport as an extension of the (e-)bicycle, and not as a transport mode in its own right, which might of course for some travelers and trips be an important option to have.

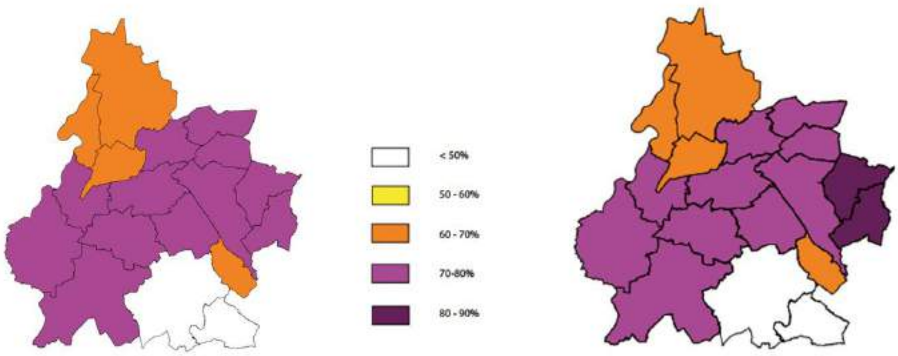

Fig.8. Left hand side: Percentages of employees living on average within e-bicycle distance from their work , per municipality. Right hand side:, Percentages of employees living on average within e-bicycle distance from their work , added up with the potential bike-train combination, per municipality (2014), Source: CBS and E'til

4.4. ACTUAL VS. POTENTIAL TRANSPORT MODE OPTIONS IN COMMUTING

4.4.1 ACTUAL VS. POTENTIAL USE OF THE (E)-BICYCLE FOR COMMUTING

So far, we explored the geographical conditions for the potential use of bicycle, e-bicycle, and bike-train mode for commuting. An interesting question is to what extent the potentials for bicycle, resp. e bicycle use are currently being used. Table 1 shows the percentages of employees having jobs within bicycle distance, compared with the actual bicycle use for commuting, on average in four groups of municipalities, also showing the parts of the Dutch population living in these four groups in 2014. (based on own calculations on Netherlands Travel Survey-data (OViN), CBS 2014).

Percentage of employees having jobs within 7.5 km	Actual bicycle use for commuting	Percentage of population
70-80%	39%	8%
60-70%	37%	22%
50-60%	35%	20%
0-50%	28%	50%

Table 1. Percentages of employees having jobs within bicycle distance, compared with the actual bicycle use for commuting, on average in four groups of municipalities, also showing the parts of the Dutch population living there, in 2014 (OViN, CBS 2014).

It seems that, viewing home–work distances as conditional for potential behavioral change, about 30% of the Dutch population lives in municipalities in which a doubling of bicycle use for commuting would be possible.

Percentage of employees having jobs within 15 km	Actual bicycle and e-bicycle use for commuting	Percentage of population
70-80%	36%	31%
60-70%	33%	30%
50-60%	30%	26%
0-50%	27%	13%

Table 2. Percentages of employees having jobs within e-bicycle distance, compared with the actual bicycle and e-bicycle use for commuting, on average in four groups of municipalities, also showing the parts of the Dutch population living there, in 2014 (OViN, CBS 2014).

4.4.2 ACTUAL VS. POTENTIAL MODAL SPLIT FOR COMMUTING IN THE SOUTH LIMBURG REGION

Following the results for South Limburg, we compared the current modal split in South Limburg (OViN, CBS 2014) with the potential modal split, adding up the potentials for e-bicycle and bicycle-train combination. This results in the following potential modal split for commuting in South Limburg (see Table 3), as shaped by home-work distances and accessibility of job locations through the bicycle-train combination.

Actual modal split South Limburg region	Potential Modal split South Limburg region
Car: 60%	Car: 23%
Alternatives fort he car: 38%	Alternatives fort he car: 75%
Other: 2%	Other: 2%
Total: 100%	Total: 100%

Table 3. Actual and potential modal split for commuting, as determined by geographical factors, and with the use of the e-bicycle and the bike-train combination, in the South Limburg region in 2014. (OViN, CBS 2014).

5 CONCLUSIONS

To determine the 'hard core' of CD in urban areas, we addressed the following questions: 1) to what extent are commuting distances in urban areas within cycling or e-cycling distance, and how do they evolve over time? 2) to what extent is the combination (e-)bicycle-public transport an additional competitive alternative to the car in commuting? 3) which are the potentials for behavioral change, in relation to the current modal split of commuting?

The findings indicate the following conclusions:

1. Although distances from home to work have been increasing, reaching an average of 18.6 km in the Netherlands in 2014, in the three big cities and some medium-sized cities, 60-80% of the commuters have jobs within an acceptable cycling distance (on average within 7.5 km). Almost one-third (30%) of the Netherlands lives in these cities. Next, in all big and medium-sized cities and most suburban areas in the Netherlands (61% of the population) 60-80% of the commuters has a job within e-bicycle distance (on average within 15 km). Looking at trends over time, between 2005 and 2014, it appears that in the large cities there is a stabilization or a decrease of the home–work distance within e-cycling distance, but in most medium-sized cities there is a modest increase. In all cities with over 100,000 inhabitants there is an average increase of about 4% in the home–work distance, compared to an average 6% increase across the Netherlands in the same period.
2. We selected the South Limburg region as a case to examine the potential of the bike-train combination for distances beyond 15 km. At present, in the South Limburg region, approximately 5% of employees with jobs outside e-bike distance have a reasonable alternative to the car in their daily commute with the bike-train combination.
3. In urban environments (61% of the total population) the current home-work distances shape conditions for a potential doubling of the use of the (e)-bicycle for commuting, from about one-third to about two-third of commute trips, thus potentially becoming the dominant transport mode for commuting in urban areas.

Our overall conclusion is as follows: In the Netherlands the urban fabric seems appropriate for the daily use of the e-bicycle for commuting. In urban areas and their interwoven suburban areas the (e-)bicycle currently has a remarkable potential for increasing its share in daily work commutes, even replacing the car as the dominant transport mode. Looking at the specific case study of South Limburg, the added potential of the bicycle-train combination currently seems modest.

6 REFLECTIONS AND FURTHER RESEARCH

Although current home–work distances shape conditions for a doubling of the use of the (e-) bicycle in commuting in urban areas, this is of course not a sufficient factor for behavioral change. Extensive research has been carried out, addressing the non-spatial factors of behavioral change (see e.g., Van Acker et al. 2010). The differences between potential and realization shown in Table 1 and 2 underscore this challenged.

Nevertheless, for the sake of discussion, it would be interesting to try to estimate some implications for car dependency in urban areas. Only looking at the (e-)bicycle as an alternative to the car (without the use of public transport) and considering that about 50% of the population of urban areas commutes daily, it follows that only 10-20% of the urban and suburban population currently are dependent of the daily use of a car, due home–work distance in excess of 15 km. The rest of the population should be considered to lie outside the 'hard core' of CD, and in the second or third level of CD (see Figure 1). Assuming that dependency on the car for commuting can be considered as the major determinant for car ownership and that everyone might need access to a car occasionally, this results in a theoretical market for car sharing or renting – or the 'car as a service' – for at least 80% of the urban and suburban population.

Although potentials for alternative transport modes as determined by geographical factors will not necessarily lead to behavioral change, it is informative for the resilience of urban structures in the Netherlands in relation to possible desired or necessary behavioral changes in relation to e.g. climate change (reduction of the use of cars) or the livability of cities (reduction of use and ownership of cars). It appears that this resilience is not dependent on high densities; the e-bicycle seems well suited for medium-size and even suburban areas as an alternative for the car. A question for further research would be to examine to what extent the urban structures and resulting commuting patterns in the Netherlands are representative for Europe at large.

Although the added potential of the bicycle-train combination currently seems modest, this does not reduce the importance of public transport: due to the increasing home–work distances, especially in medium-sized cities, the importance of regional public transport as an alternative to the car will increase on distances beyond 15 km. Next, and beyond this study, the importance of the availability of public transport options that do not depend on a good inter-modality with (e-) bicycles for certain trips and travelers should be acknowledged.

7 LIMITATIONS

We have assumed that people who work within their municipality on average live within 7.5 km of their workplace, given the geographical size of most Dutch municipalities and due to the concentration of residents and jobs in the more central parts of those municipalities. An analysis on a finer scale would obviously lead to a more nuanced picture. For instance, in the northwestern peripheral and rural areas of the country there are municipalities with a large geographical size, but without an urban core. Although it appeared from the model that in some of these municipalities the score of employees having a job in their own municipality was between 50% and 60 %, we adapted the score in these cases as being below 50%, as it was obvious that the average commute distance in these cases was beyond 7,5 km. A special position is taken by the big cities of Amsterdam and Rotterdam, in particular because their urban area is significantly larger than the medium-sized cities. As a result, on the basis of this analysis it is uncertain whether residents who work in these cities live on average less than 7,5 km from their work. On the other hand, it seems that precisely in these cities, through a well-developed urban transport network, alternatives to car commuting are in abundance. As stated above, looking at the specific case study of South Limburg, the added potential of the bicycle-train combination currently seems modest. Partly this is due to our research method: 1) We have assumed that all commute trips within 15 km potentially could be undertaken by the (e-) bicycle – on average around 70% in the South Limburg region – leaving as potential for the bike-train option only the rail-oriented jobs beyond 15 km. 2) We didn't take into account the rail-oriented job locations outside the region of South Limburg. Finally, we did not study the potential impact of technological and socio-economic developments, such as an increase in telecommuting or flexible work contracts, on the future commuting patterns.

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