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The development of cycling in European countries since 1990

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High pre-World-War-2 modal shares of cycling in European countries sharply decreased during the post-war decades. In the 1990s, European governments introduced policies to increase bicycle use. However, a database or longitudinal study on the development of bicycle use in European countries is lacking. The goal of this paper is to examine to what degree the amount of cycling has increased over the past decades, also in the context of potentially competing modes. Distances travelled per capita according to National Travel Surveys have been collected and were aggregated to seven 4-year periods between 1990 and 2017. Multilevel regression analyses on distance travelled per capita by bicycle, on foot, by public transport, and by passenger car were conducted for all countries. Additionally, analyses were conducted for which the 14 countries with data on bicycle use were divided in three groups categorised according to distance cycled per capita at the beginning of the study period. Distance cycled per capita per year ranged from some 30 km to 900 km. The results of all four regression analyses suggested that distance cycled per capita remained fairly constant over the past decades. Germany is an exception with some 150 km per capita more, in relative terms a 50% increase. Geographical variation in development is evidenced by a substantial increase of distance cycled per inhabitant in the capital cities of the countries included in the study. The outcomes suggest distance travelled on foot and by public transport (bus, tram, and metro) also remained fairly constant while the distance travelled by car increased by about 10% during the study period. We did not find indications that cycling substitutes travel on foot, by public transport or by car.

Keywords: *bicycle use, active transport, sustainable transport, National Travel Survey, Europe.*

1. Introduction

High pre-World War II modal shares of cycling in European countries sharply decreased during the post-war decades, mainly due to mass motorisation and, in some countries, as a result of removing bicycle infrastructure (Stadt Wien, 2020; De la Bruhèze and Veraart, 1999b). The joint 1995 ECMT and OECD publication 'Urban Travel and Sustainable Development' noted that there had been a shift from walking and cycling to motorised modes across European countries (OECD/ECMT, 1995). The publication describes the emergence of more car-dependent lifestyles and increased trip length as activities had become more dispersed due to suburbanisation of the population and relocation of jobs, shops and services to the periphery.

During the 1970s, governments became increasingly concerned about the problems of mass motorisation such as road crashes, congestion, air and noise pollution, and sedentary lifestyles

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(Hydén et al., 1999; De la Bruhèze and Veraart, 1999a). To reduce those problems, policy makers started to aim for substitution of short car trips by non-motorised modes. The European Commission embraced the goal of promoting cycling when broadening its agenda to urban transport in the 1990s (European Commission, 1997, 1998) and commissioned European projects such as WALCYING and ADONIS to develop knowledge to inform policies at the country and city-level (Goodman & Tolley, 2003; OECD/ECMT, 2003). Some governments set explicit goals. For example, the 1990 Dutch Masterplan Bicycle aimed for 30% more bicycle kilometres by 2010 compared to 1995 (Ministry of Infrastructure and the Environment, 1998) while new Dutch policy aims for 20% more by 2027 compared to 2017 (Tour de Force, 2020). Similarly, local governments formulated ambitious goals, for instance raising bicycle modal share by 50% in 1998-2010 for Berlin (Stadt Berlin, 2004), 100% in 2000-2010 for Vienna (Stadt Wien, 1999), and 18% in 2000-2012 for commuting trips in Copenhagen (City of Copenhagen, 2002).

Previous studies have compared the amount of cycling between European countries for a specific period after around 2000 (e.g. Castro et al., 2018; Van Hout, 2007), while others have described the trend within a specific or small group of countries (e.g. Andersen et al., 2018; Banister, 2018; Harms et al., 2014; Scheiner, 2010). While a large country such as the US has the advantage of a National Travel Survey (NTS) covering all states (Buehler et al., 2020; Pucher et al., 2011), the EU does not have an NTS covering all member states, only efforts to harmonize mobility survey data (e.g. the COST project SHANTI, see Armoogum et al., 2014 and Eurostat, 2019). Due to the lack of official harmonised (longitudinal) statistics covering all member states, a description of the development of cycling at the European level is missing.

Although determining the effectiveness of policies is beyond the scope of this paper, this raises the question of whether the packages of policy efforts at national and at municipal levels to encourage cycling were successful at the aggregate national level and to what degree there are geographical variations between and within countries. Policy approaches may differ between national and local governments, and within each nation. Cities may develop cycle infrastructure networks, cycle parking facilities, and local campaigns while national governments are more likely to be responsible for developing guidelines for infrastructure, providing funding, and setting traffic rules such as regarding minimum overtaking distances and liability in the event of crashes. The lack of longitudinal data hampers studies to evaluate such policies. Longitudinal data on cycling are similarly important for other types of research in the field of transport such as road safety (see e.g. Bhatia and Wier, 2011; Aldred et al., 2019a). Before longitudinal studies with cross-country data can be carried out, data sets have to be collected and combined.

To address this longitudinal data gap, this paper sets out to describe trends in bicycle use in European countries from the 1990s and onward. In order to put the trends into perspective, we carried out two analyses in addition to the analysis of bicycle use per country. Firstly, to examine geographical variations we studied the trend of bicycle use in capitals to compare the development between countries as a whole and their large cities. Secondly, to explore the extent to which changes in cycling are associated with change in walking, public transport (bus, tram, and metro) or car use, we examined trends for the latter three modes. This question is important from a public health perspective. With distance held constant, a shift from driving to cycling would improve public health (Mueller et al., 2015). Conversely, a shift from walking to cycling may have health disbenefits due to reduced physical activity per distance travelled (Kelly et al., 2014; De Hartog et al., 2010), although if pedestrians take up cycling they may experience accessibility benefits. Other travel modes were beyond the scope of this study.

2. Research on the development of bicycle use

Studying travel trends at the national level, such as distance travelled by transport modes, has been one of the objectives for setting up National Travel Surveys along with informing traffic models (Wilson, 2003). National Travel Surveys have a long tradition and were regularly conducted in many European countries during recent decades (Armoogum et al., 2014). An NTS collects data on households, persons, trips, and sometimes trip stages and activities. The survey is typically carried out with a diary of one or more days. Trip characteristics are reported about the start and end location, start and end time, mode of travel, purpose of travel or activities undertaken, etc. (Armoogum et al., 2014; Hubrich et al., 2018; Stopher & Greaves, 2007).

Studying the long-term development of cycling beyond timescales longer than about three decades is hampered by the limited availability of systematically repeated country wide travel surveys in most countries. Researchers have used alternative data to study travel behaviour over a longer time period. For instance, De la Bruhèze and Veraart (1999a) combined traffic countings, and, if available, city-level travel surveys for the estimations shown in the left panel of Figure 1 in which walking was excluded. The assumptions needed to combine these sources to estimate the modal share raise the level of uncertainty. It is difficult to reliably aggregate these city level estimates to the level of countries. Another alternative is the use of biographical surveys in which respondents were asked about travel in their childhood and their parents' commuting behaviour (Papon, 2014). This method has been applied in a few countries such as Britain and France (Figure 1 right panel). While this method allows detecting large changes, its reliability is hampered by recall bias and studies often focused only on main mode commuting.

Overall, Figure 1 shows a strong decrease in cycling in the decades after World War II. Changes in the amount of cycling have become smaller during past decades which makes it more difficult to detect these changes using methods such as biographical surveys. Some larger cities have useful time series of reliable traffic count data to describe the development of cycling (Papon, 2014; Steinmeyer & Herrmann-Fiechtner, 2017), but these are difficult to extrapolate to the level of countries. Trends in larger cities such as those in the left panel of Figure 1 tend to differ from countries because circumstances for cycling are more favourable in cities and since cities may invest more in cycle infrastructure. For instance, Harms et al. (2014) showed that cycling over the past decades increased in highly urbanised Dutch areas while the country's total amount of cycling remained constant. Systematic country-wide travel surveys are needed to describe the development of cycling during the past decades. Technologies such as mobile phones equipped with Global Positioning System offer new possibilities to track people accurately in the future but are not yet longitudinally available to examine trends (Stopher and Greaves 2007, Bonnel and Munizaga 2018).

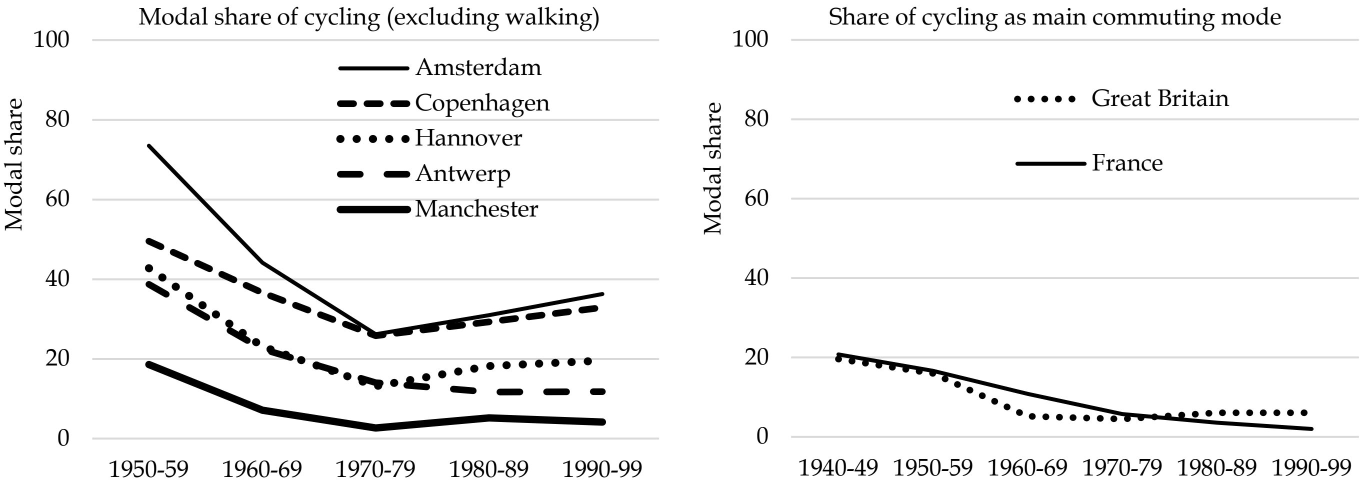


Figure 1. Modal share of cycling: in the left panel excluding walking in large European cities (De la Bruhèze & Veraart, 1999a); in the right panel including walking for commuting in Britain (Pooley & Turnbull, 2000, p. 13) and France (Papon, 2016, p. 13)

3. Data and methods

This study uses National Travel Surveys to examine the development of bicycle use, walking, public transport and car use since 1990 in European countries. We describe travel by distance per capita because distance is an important indicator for measuring travel activities and infrastructure load and also serves as an exposure measure for road safety statistics, i.e. to determine casualties per distance travelled (de Geus et al., 2012; Götschi et al., 2016). It is reported more frequently than travel time (Götschi et al., 2016; Hajnal & Miermans, 1996). If necessary, distance may be translated into time as the core indicator for physical activity (Kelly et al. 2014) based on assumptions on travel speed. Modal share is a less suitable indicator for our comparison as it depends on the use of other travel modes, so a similar share of cycling may represent different absolute amounts of cycling (distance and/or time). We also aim to provide a description of the development of cycling in the capitals of the countries included in this study as an indication of possible geographical variations. In contrast to distance travelled by bicycle, on foot, and by public transport, distance travelled by passenger cars is reported by IRTAD (International Traffic Safety Data and Analysis Group) in the Road Safety Database of the International Transport Forum (OECD/ITF, 2021). Distance travelled by all car occupants (drivers and passengers) is included, except for distance travelled by taxi. We took these data to describe the trend in travel by passenger cars in Section 4.5. As we use data by OECD/ITF (2021) only, we do not further describe travel by car in the remainder of Section 3.

3.1 Data

National Travel Surveys were included that distinguished cycling and walking as separate categories and covered all trip purposes to achieve a sufficiently comprehensive estimate. National Travel Surveys about commuting only or with a combined category of cycling and walking were excluded. Cross-sectional studies were used as a starting point to collect NTS data reported by statistical offices, transport departments, or national research institutes (Castro et al., 2018; Van Hout, 2007).

Table 1 summarises the data collection, references, and adjustments for each included country and capital (countries ranked from top to bottom according to distance cycled at the beginning of the study period). We report data as kilometres travelled per capita per year. If not reported in this format, we extrapolated daily distances to annual values (multiplying by 365) and country values to per capita values (distance travelled in the country divided by the number of inhabitants). For the latter, we took population data from the IRTAD database (OECD/ITF, 2021) or data from statistical offices in case population data were required for a specific age range. We took 1990 as the beginning of the study period as data for the 1980s were largely lacking across countries. However, distance travelled in 1990 in France was estimated by interpolating distance travelled in 1994 and 1982 (see Table 1). For Sweden, distance travelled in 1990 could have been estimated from an NTS performed in 1984/1985 but was excluded due to differences in method and a more restricted age range compared with the later Swedish National Travel Surveys. However, Tight et al. (1989), citing the 1984/1985 Swedish NTS, yielded a similar amount of cycling as our first estimate for 1994-1997. For Finland, distance travelled around 1990 could have been estimated from an NTS performed in 1992 but it was excluded. The age range changed and insufficient details were available to correct for this change. Moreover, the 1998/1999 NTS utilised telephone interviews while the 1992 NTS was a paper and pencil survey.

The following decisions were taken regarding the inclusion of study areas. Only Flanders, the northern part of Belgium housing 58% of the Belgian population, is included in the analyses of this study as its travel surveys cover a longer time period and yield more stable estimates of cycling. The figures for Belgium (Cornelis et al., 2011; Federale Overheidsdienst Mobiliteit en Vervoer, 2017). vary strongly between surveys while the changes are not in line with the Flemish figures based on a more frequently conducted travel survey, e.g. cycling would have remained fairly stable in Flanders –the area with the highest distance travelled by bicycle per capita– between 2009 and 2016 according to the Flemish travel survey while it would have doubled in Belgium in the same time period according to the Belgian travel survey. While Castro et al. (2018) combined the outcomes of the NTS from Northern Ireland and England to estimate the amount of travel for the UK, we decided to include both as separate study areas. Both National Travel Surveys are of sufficient quality, and these areas are physically separated. The data in some cases thus refers to regions but for ease of writing we use the term countries. BMVI (2020) reports distance travelled per mode since 1976 in Germany, but we took data since 1994 because of the reunion of Germany in 1990 and methodological changes in the models on which estimates before 1994 are based (see Scheiner, 2010).

We took distance cycled per capita in capitals based on five of the National Travel Surveys (see Table 1) and complemented these with information about four capitals reported in the Cross-City Comparison report of the Congestion Reduction in Europe-Advancing Transport Efficiency (CREATE) project (Wittwer & Gerike, 2018, p.64), i.e. CREATE, i.e. Berlin, Copenhagen, Paris, and Vienna. Similar to that report, we provide distance travelled per capita after 1990 for two periods as widely separated in time as possible. The second-largest Italian city, Milan, was included in the analysis because data from Rome was not available. As Switzerland does not have an official capital, we took data on cycling in the agglomeration of Zürich, the largest Swiss city. For capitals for which we did not have data on distance cycled per capita we sought data on numbers of cyclists recorded by loop detectors or other types of counters (see Table 1).

Table 1. Data sources and calculations per country

Country	Remarks and adjustments	Frequency	Respon-dents	Nr. survey days (in diary)	Type of day	Age range (years)	Modes reported as main/stage-mode
Netherlands (NL)	Total distance travelled (SWOV, 2018) was divided by population (OECD/ITF, 2021). The age range was 12+ for the 1990-1993 travel surveys while it included all ages for subsequent surveys. SWOV (2019) provided distance extrapolated by Statistics Netherlands to all ages using the 1994-1995 surveys and population. Raw NTS data were analysed to estimate distance cycled per capita in Amsterdam. The Dutch NTS switched from a household-based to a person-based survey in 2010 (Statistics Netherlands) resulting in 25% more distance walked (estimated by dividing walking km in 2010-2012 by 2007-2009) after years of being almost constant. Distance walked up to 2009 was raised by 25%. Distance travelled by other travel modes was hardly affected by the change.	Annual	2017: 37	1	All	0-99	All stages
Denmark (DK)	Total distance cycled up to 2009 (Danish Road Directorate, 2019) was divided by population between 10 and 84 years (Statistics Denmark, 2019). Distance travelled per mode since 2010 was estimated by multiplying the modal share of distance per mode (Christiansen & Baescu, 2020, p. 8) by total distance travelled by all transport modes (Danish Road Directorate, 2019).	Annual	2014: 10	1	All	10-84	All stages
Belgium, Flanders (BE FL)	Total distance travelled per day was multiplied by the share of the distance travelled per travel mode (Hajnal & Miermans, 1996, p. 63-64; Zwerts & Nuyts, 2004, p. 134; Janssens et al, 2020, p. 44, 84). Bicycle and moped km were combined in the results of the 1994 survey. The share of bicycle km in the 2000 and 2008 surveys were used to split the 1994 figures (92% of the total by bike).. Numbers of cyclists counted at 15 locations were taken from Kesteloot, Verstraeten, and Himbert (2018, p. 10).	Variable; annually in recent years	2017: 2	1	All	6+	Main modes
Switzerland (CH)	Distance travelled per travel mode per person per day were multiplied by 365 (BFS, 2017, p. 34, 36). For Zürich, the share of daily travel distance by bicycle was multiplied by total daily travel distance and by 365 (Hofer, 2015, p. 3; Hofer, 2017, p. 6, 14).	5 years	2015:57	1	All	6+	All stages
Finland (FI)	Distance travelled per person per day per mode (Finnish Transport Agency, 2018, p. 15; Finnish Transport Agency, 2012, p. 19) were multiplied by 365. The 2016 Finish NTS was restricted to domestic trips. Distance travelled in 2010 was reported both for all trips (Finnish Transport Agency, 2012, p. 19) and for domestic trips (Finnish Transport Agency, 2018, p. 15). Comparison of these figures yielded a factor of 1.00 for cycling, 1.04 for walking and 1.08 for bus, tram, and metro to raise	6 years	2016: 31	1	All	6+	Main modes

	the 2016 estimates to represent all trips. Numbers of cyclists counted at the border of the Helsinki peninsula on a weekday in June in 1997–2016 were taken from City of Helsinki (2018, p.11).						
Germany (DE)	Total distance travelled per mode (BMVI, 2003, p. 224; BMVI, 2011, p. 224; BMVI, 2014, p. 224; 2016, p. 224; 2017, p. 224; 2018, p. 224; 2020, p. 224) was divided by population (OECD/ITF, 2021). BMVI (2017, see p. 212-214) combines an annual mobility panel (Deutsches Mobilitätspanel, MOP) since 1996 and a travel survey (Mobilität in Deutschland, MiD) since 2002. The development reported by BMVI is in line with both sources (see for comparison for instance BMVI, 2019, p. 19; KIT, 2011, p. 46; 2018, p. 85).	MOP: annually MiD:6-9 years	MOP2016: 4 MiD2016: 60	MOP: 7 MiD: 1	MOP: All MiD: All	MOP: 10+ MiD: all ages	Main modes
Sweden (SE)	Total distance cycled and walked between 1995 and 2014 (Trafikanalys, 2015, p. 12) was divided by population between 10 and 84 years (Statistics Sweden, 2019). For 2014 up to 2016, distance cycled per person per day was taken from Trafikverket (2017, p. 8). Total distance travelled by bus was taken from Statistics Sweden (2021) and divided by total population. Numbers of cyclists counted at 14 locations in the city centre (Innerstaden) were downloaded from Stockholms Stad (2020).	Variable; annual in recent years	2016: 4	1	All	6-84	All stages
Norway (NO)	Distance cycled and walked per person per day in different age/gender groups (13+ years) was multiplied by 365 days and the population in the age/gender groups. The sum of all age/gender groups (total personkm) was divided by total population to obtain the average distance cycled per capita for Norway (all years) and for Oslo in 2013-17 (Bjørnskau, 1988, 1993, 2000, 2003, 2008, 2011, 2015, 2020). Cycling and walking per capita for Oslo for 1990-94 was estimated by multiplying the average number of cycle trips per person by the average trip length (Hjorthol, 1999, p. 35). Personkm by bus, tram and metro is taken from Farstad et al. (2020, p. 35). Population figures are taken from Statistics Norway (2021).	Varies	2013: 60	1	All	Cycle & walk: 13+ Bus, tram, metro: All	All stages
Ireland (IE)	Using the results of the 2009, 2012, 2013, 2014, and 2016 National Travel Surveys, distance travelled was estimated by multiplying modal share, an assumed total 3 trips per person per day (see Castro et al., 2018), and average trip distance per mode (CSO, 2011, p. 8-9; 2015, 2017). Numbers of cyclists counted at 33 locations in the city centre of Dublin (at the 'Canal Cordon') were downloaded from Data.gov.ie (2020).	Varies	2016: 11	1	All	18+	Main modes
Austria (AU)	Total distance travelled per mode (BMVIT, 2016, p. IV) was divided by population (OECD/ITF, 2021).	18 years	2013: 38	2	Work-days	6+	Main modes
Italy (IT)	The percentage of mobile people (respondents in the sample reporting journeys) was multiplied by the average number of journeys per mobile person per day, modal share, and the average length of trips per mode (ISFORT, 2015, p. 3-4, 6, 10, 14). The number of cyclists counted along an 11-km long route through Milan was taken from Polinomia (2019, p. 3).	Annual	2015: 8	5	Work-days	14-80	Main modes

United Kingdom, England (UK ENG)	Average distance travelled per mode per year was taken from Department for Transport (2012, p. 27) for 1995-2000 and Department for Transport (2018, Table NTS0303) for 2002-2017 and converted to km per year.	Annual	2017: 15	7	All	0-99	Main modes
France (FR)	Average distance travelled by bicycle and on foot per year based on the French travel survey was taken from Papon (2016, p. 13). Distance cycled and walked in 1990 were estimated by interpolating distance cycled in 1994 and 1982.	Variable	2008: 19 (households)	2	All	6+	All stages
United Kingdom, Northern Ireland (UK NIR)	Average distance travelled per mode per year were taken from Department for Infrastructure (2020) and converted to km per year.	Annual	2015-2017: 5	7	All	0-99	All stages
Netherlands (NL)	Total distance travelled (SWOV, 2018) was divided by population (OECD/ITF, 2021). The age range was 12+ for the 1990-1993 travel surveys while it included all ages for subsequent surveys. SWOV (2019) provided distance extrapolated by Statistics Netherlands to all ages using the 1994-1995 surveys and population. Raw NTS data were analysed to estimate distance cycled per capita in Amsterdam. The Dutch NTS switched from a household-based to a person-based survey in 2010 (Statistics Netherlands) resulting in 25% more distance walked (estimated by dividing walking km in 2010-2012 by 2007-2009) after years of being almost constant. Distance walked up to 2009 was raised by 25%. Distance travelled by other travel modes was hardly affected by the change.	Annual	2017: 37	1	All	0-99	All stages

3.2 Issues regarding data quality

Table 1 includes a number of columns with characteristics of National Travel Surveys to illustrate differences between countries. We did not adjust for differences between National Travel Surveys conducted in different countries, because a comparison of countries was not the main goal of this study. For instance, we did not correct for different age ranges in National Travel Surveys of different countries. Given the longitudinal nature of our study, we did adjust for changes in surveys of a country over time or excluded measurements where we had insufficient data to adjust for the changes. The adjustments are described in Table 1, column titled remarks and adjustments.

The size of National Travel Surveys can be described by frequency with which it is conducted and sample size. The sample size varies but for some areas such as Flanders and Northern Ireland, a low sample size is compensated by a high frequency. Nevertheless, National Travel Surveys with smaller sample sizes tend to exhibit greater (random) variations.

Most of National Travel Surveys employ one-day travel surveys while a minority apply a diary for 2, 5 or 7 days. Aggregate statistics can generally be produced in a comparable manner with one-day and multi-day National Travel Surveys, although the latter may increase the respondent burden and related survey dropout as well as recall issues if respondents fill in diaries on the last of several reporting days (Armoogum et al., 2014).

The adjustments for changes in surveys of countries over time provide some insight into how large other biases may be if such changes would go undetected. We describe examples of the impact on the estimated distance cycled per capita. Almost all National Travel Surveys concern all weekdays except two in which respondents were asked about workdays. The last two French National Travel Surveys suggest the distance cycled per day over the whole week is some 7% longer than the distance cycled during workdays. Most National Travel Surveys cover all or almost all ages, for instance people of 6 years and older. A few surveys exclude younger people up to 18 years. Based on the Dutch NTS we estimate that those over 18 years of age travel some 9% longer distance by bicycle than the average among all age groups. The National Travel Surveys are about evenly distributed between those covering main modes of transport only and those covering all trip stages, for instance including trips to and from railway stations. We took distance travelled by main modes in Flanders as this measure was available for all National Travel Surveys. Distance travelled during all trip stages was available for later National Travel Surveys and those for the last study period suggest distance cycled during all stages is some 3% longer than distance cycled as main mode of transport only. The impacts of NTS differences regarding the type of day, age range and main mode versus all trip stages tend to be in the order of approximately 10%.

We could correct for most of the changes within travel surveys. However, contrary to earlier travel surveys, the 2008 French NTS based trip distance on a modelling approach instead of estimations by respondents (Papon, 2014). In accordance with Castro et al. (2018), we assumed a total of 3 trips per person per day to estimate distance cycled per capita using the outcomes of the Irish National Travel Surveys. These changes and additional assumptions may increase uncertainty. In the results section, we discuss whether these data may bias the outcomes.

3.3 Issues regarding the measurement of walking

Data quality issues were described with examples regarding cycling in the previous Section. The same issues apply to an even greater degree to the measurement of distance walked making it even more difficult to compare countries. Walking is important to be able to travel by other modes, for instance short stages to public transport stops to travel by train or bus and short walks to a car parking to drive (Rietveld, 2000). While the last National Travel Surveys in Flanders measured 3% less distance by bicycle for main mode trips as compared to all stages, the same difference is 18% for walking. According the Rietveld (2000) the difference is even greater because the short walks to a parked car are hardly reported in surveys. Recently, Methorst (2021) identified two other functions of walking that are poorly covered by travel surveys. Firstly, ‘circulation’ or round-trip walking for recreation and walking by professionals such as postal workers. Recreational round trips may include walking the dog, city walks and the like. Secondly 'sojourning', meaning activities on foot not aimed at getting at a specific destination, such as strolling down the street and children playing outdoors. While the latter primarily increases the time spend in public space the former also results in a substantial distance walked in public space. By using different sources of information to estimate the distance walked, Methorst (2021) estimated that walking for all stages and including circulation walks would yield an at least 50% greater distance walked per capita in the Netherlands than previously measured by the Dutch National Travel Survey (see also Schepers and Methorst, 2020). As travel surveys may differ in the completeness with which they measure these important functions of walking, there may be greater differences in measurement accuracy between countries as compared to other travel modes. Great caution is thus required when comparing distance walked between countries. Assuming the measurements were stable over time, or that method changes are sufficiently corrected for, we may tentatively draw conclusions on the trend over time for the function of main mode walking which is likely to be covered best in travel surveys and the function that is also most likely to compete with cycling.

3.4 Issues regarding the measurement of public transport

Measuring the distance travelled by public transport entails additional uncertainties. Firstly, countries either report all public transport in one category or distinguish different types of public transport, for instance bus, tram, metro, and train. National Travel Surveys reporting one combined category of public transport are excluded because the train is mainly used for long trips that are unlikely to compete with cycling. Travel by train may even encourage cycling for travel to railway stations. Preferably we would have included local and exclude non-local bus transport but the English National Travel Survey was the only one in our sample distinguishing both types (Department for Transport, 2018). For reasons of consistency we include all travel by bus, tram and metro. In German-speaking countries, this category is named as 'Öffentlicher Straßenpersonenverkehr' (BMVI, 2020). Second, monitoring the use of public transport is difficult with a small sample size because comparatively few trips using public transport are reported. This possibly explains the large fluctuations between measurements of bus, tram and metro in Flanders. To estimate distance travelled by bus, Statistics Sweden (2021) multiplies distance travelled by bus by occupation rates based on older data regarding bus occupancy rates. Because of the differences in reported public transport categories and methodology we cannot draw any conclusions on differences in distance travelled by public transport between countries. Assuming the methodologies have remained stable during the study period, or that method changes have been corrected for sufficiently, we may be able to draw tentative conclusions on trends over time. Relating possible changes to potential competition with cycling has to be done with caution because we cannot distinguish between short and long distance bus trips.

3.5 Statistical analyses

To assess trends over time in distance travelled per mode in European countries, multilevel linear regression models were fitted on distance travelled per capita using IBM SPSS Statistics 26. Multi-level models were necessary because our data were nested in time (i.e., seven 4-year periods with data averaged over multiple years if available for that country) and nested within countries. We incorporated a random intercept term for countries to examine these patterns in trends. We tested for a linear (one continuous variable for time ranging from 1 for time period 1990-1993 to 7 for time period 2014-2017) and a parabolic trend (time and time squared as variables). A parabolic trend may describe a decrease followed by an increase. The Akaike Information Criterion (AIC) was used to compare the fits across both models. Models for cycling were fitted for all countries pooled and separately for groups of countries with a high, medium. and low amount of bicycle use. Distances cycled per inhabitant for the two time periods for each capital were compared using a paired samples t-test.

4. Results

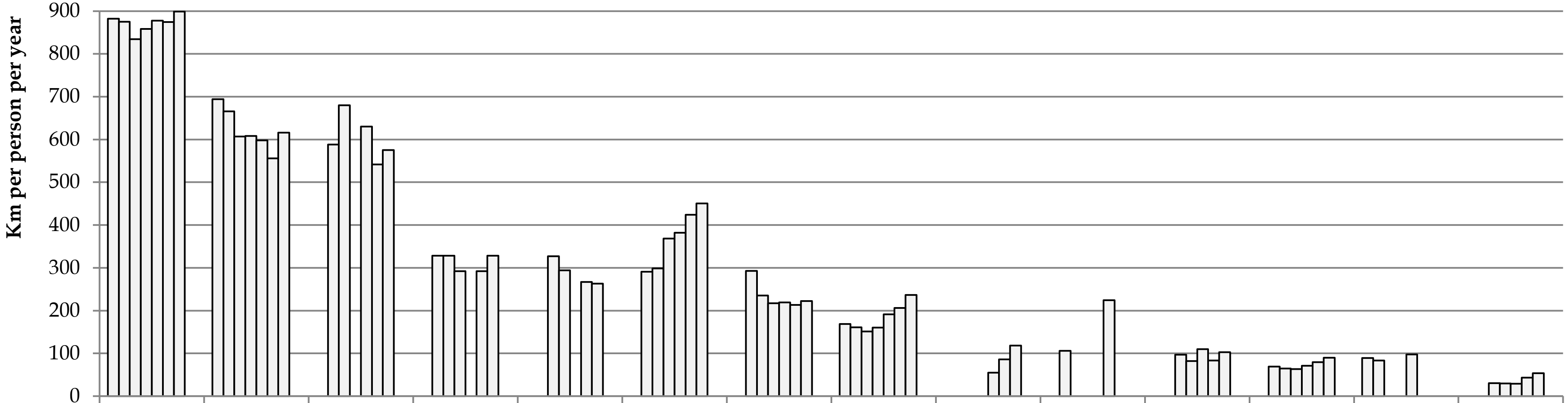
We identified 14 European countries with National Travel Surveys in which cycling was distinguished and found data on the development of cycling in most of their capitals. Except for Denmark, walking was reported in all countries. The IRTAD database contained data on distance travelled by passenger cars in 11 countries. The total population of these countries in 2015 was some 334 million inhabitants. Within the United Nations Statistics Division of Europe (east, north, south, and west), most of the 14 countries are Western, and Northern European countries. Among Eastern and Southern European countries, only Italy has an NTS that allows to estimate the amount of cycling. On average, five 4-year periods per country were covered, amounting to 71 data points.

4.1 Geographical variations of cycling

Distance cycled per capita per year ranged from some 30 km to 900 km. This variation is large and exceeds differences due to quality issues related to data acquisition in National Travel Surveys that we expect to be in the order of approximately 10%, see Section 3.2. This allows us to distinguish groups of countries according to the amount of cycling. Figure 2 shows the development and values per country with countries ranked from left to right according to distance cycled at the beginning of the study period. The Figure includes a table with values per data point and population size at the bottom in 2015. Based on the distance cycled at the beginning of the study period, we distinguished three groups of countries:

- High: 600 km to 900 km (NL, DK, BE FL)
- Medium: 150 km to 300 km (CH, FI, DE, SE, NO)
- Low: 30 km to 100 km (IE, AT, IT, UK ENG, FR, UK NIR)

These three groups of study regions are depicted in Figure 3 to illustrate geographical variations. Countries with middle to high starting levels tend to be concentrated in the middle of Europe and Scandinavia while low starting levels occur in the south and west of Europe.



	Nether-lands (NL)	Denmark (DK)	Belgium (BE FL)	Switzer-land (CH)	Finland (FI)	Germany (DE)	Sweden (SE)	Norway (NO)	Ireland (IE)	Austria (AU)	Italy (IT)	UK, England (UK ENG)	France (FR)	UK, Northern-Ireland (UK NIR)
1990-1993	882	694						169					89	
1994-1997	875	666	588	329		291	293	161		106		69	83	
1998-2001	835	607	680	329	327	299	235	151			97	64		31
2002-2005	858	608		292	294	368	217	160			82	63		30
2006-2009	878	598	630			382	219	191	55		110	71	97	29
2010-2013	875	556	542	292	267	424	213	206	86	225	84	80		43
2014-2017	899	616	575	329	263	451	222	236	118		103	90		54
Population 2015 (million)	17	6	6	8	5	81	10	5	5	9	61	55	64	2

Figure 2. Distance cycled per capita per year between 1990 and 2017, and population size in 2015

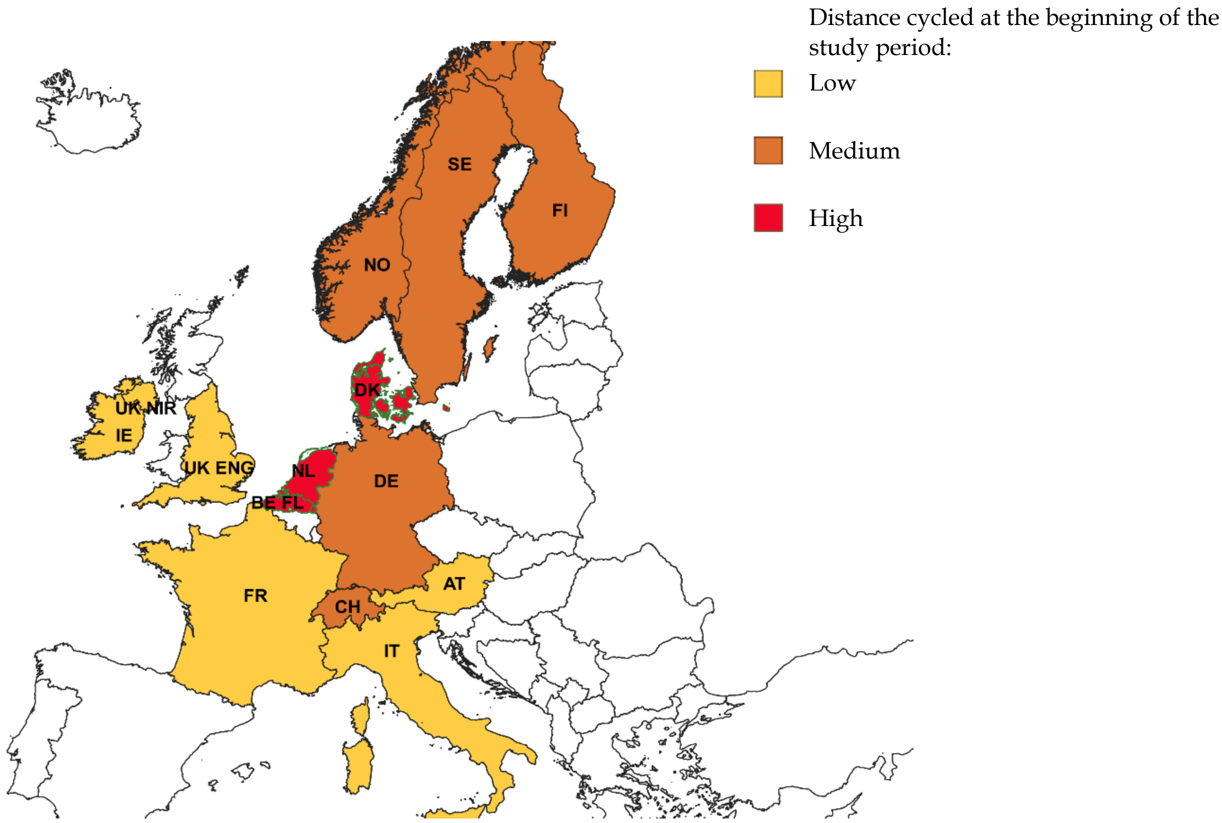


Figure 3. Study regions according to categories of distance cycled per capita per year at the beginning of the study period

4.2 Cycling trend analysis: stable

Multilevel regression analyses on distance cycled per capita were conducted for all countries together and for the three groups of countries categorised according to distance cycled per capita at the beginning of the study period. Across the models, the AIC scores suggested parabolic trend lines fit the data best. Table 2 shows the results. The resulting trendlines are depicted in Figure 4. In these regression analyses, the constants are statistically significant, while the regression parameters for time and time squared are not. The latter being insignificant suggests there was no significant change in any of the groups of countries. Results may be insignificant due to small sample size, but Figure 4 shows that changes over time are also small in absolute terms.

Table 2. Multi-level regression analyses on distance cycled per capita (95% CI)

		Starting level distance cycled		
Variable	All Countries	High	Middle	Low
Constant	317 (167 to 467)*	765 (459 to 1071)*	277 (161 to 393)*	71 (3 to 139)*
Time	-19 (-44 to 5)	-28 (-76 to 19)	-9 (-56 to 39)	-1 (-30 to 27)
Time squared	2 (0 to 5)	2 (-3 to 8)	2 (-4 to 7)	1 (-2 to 4)
Countries	All	NL, DK, BE FL	CH, FI, DE, SE, NO	IE, AU, IT, UK Eng, FR, UK NIR

* significant at the 5%-level

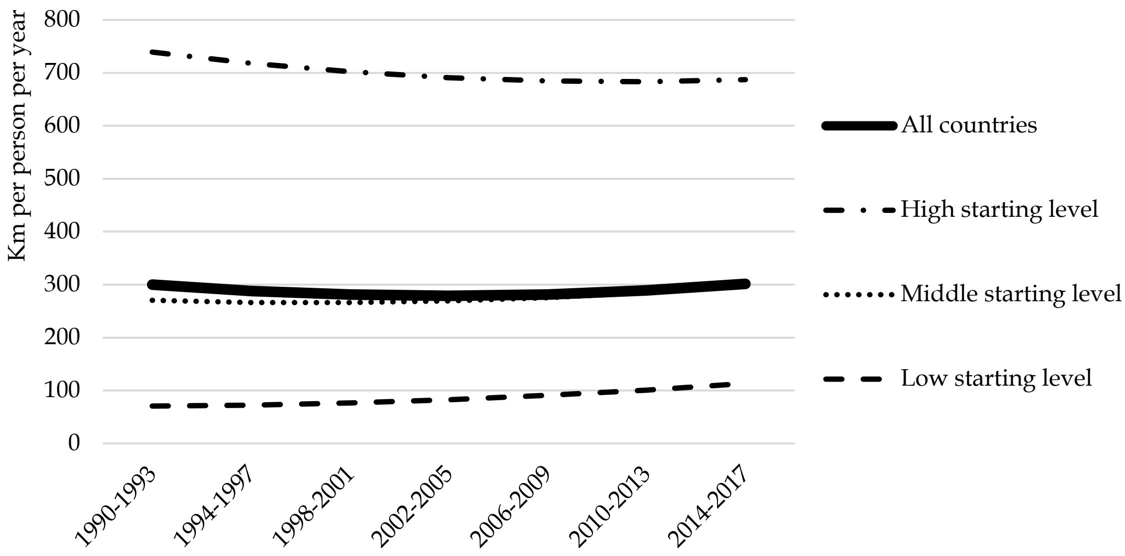


Figure 4. The development of distance cycled per capita per year in European countries between 1990 and 2017

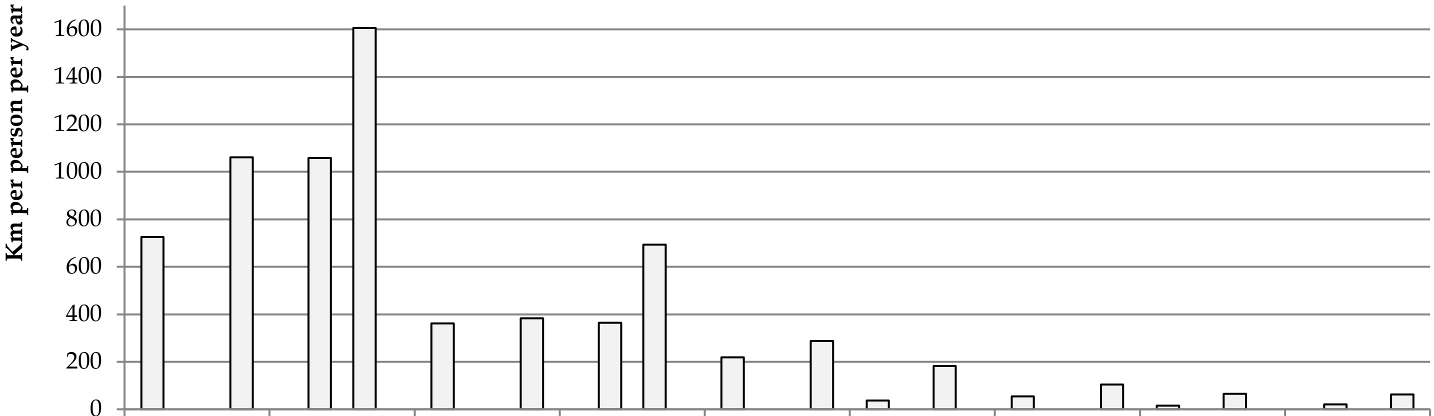
Additional assumptions had to be made to estimate distance cycled per capita in Ireland and in 2006-2009 for France, two countries with few km cycled per capita. Based on our estimates, distance cycled per capita in France hardly changed during the study period. Ireland experienced an increase which is large in relative terms, but modest in absolute terms. Excluding these countries from our trend analyses would not have altered the results of the trend analyses that the change of distance cycled per capita was non-significant.

4.3 Cycling trends in individual countries: a rise in Germany

Interpreting trends within countries should be done with even more caution than interpreting the results of our pooled models. To conclude on an upward or downward trend, we believe it should occur at multiple time points, be based on a large sample, and be large in both absolute and relative terms. For instance, a change over 100 km per capita that is consistent with a relative change of at least 10%. Observing a gradual development at multiple time points reduces the chance that changes are due to random variation or a change of NTS methodology at a specific moment. Taking 100 km per capita as a minimum to conclude that there is a change also makes sense from a policy perspective. None of the countries in the groups with a high and low distance cycled per capita at the beginning of the study period match these rules of thumb. An exception within the group of countries with a medium starting level is Germany. The German estimates are based on a combination of an NTS with a large sample size and a yearly mobility panel. Between 1994 and 2017, distance cycled per capita increased by over 150 km, consistent with an increase of over 50%. The increase in Germany is particularly impressive as the country houses the largest population of any European country (excluding Russia), 81 million in 2015 consistent with almost 25% of the total population in the countries in our sample.

4.4 Cycling trends in capitals: a 50% increase

Figure 5 shows distance cycled per inhabitant in nine capitals according to National Travel Surveys which ranged from some 15 km to over 1500 km, an even larger variation than among countries. Capitals are ranked from left to right corresponding to their countries in Figure 3. According to these figures, the inhabitants of Copenhagen cycle the greatest distance per year. Two time periods are included for each capital, separated in time after 1990 as much as the available data allowed us. Most capitals experienced a rise in cycling. On average inhabitants of the capitals covered over 50% longer distance during the second time period compared with the first. Comparison of distance cycled during the first and second time period using a paired-sample t-test shows this increase is statistically significant (t(8) = 2.9, P = 0.020).



	Amsterdam (NL)	Copenhagen (DK)	Zürich (CH)	Berlin (DE)	Oslo (NO)	Vienna (AU)	London (UK ENG)	Paris (FR)	Belfast (UK NIR)
1990-1994	725		361		219	37	54	15	
1995-1999		1059		365					21
2010-2014		1606		694		183		66	
2013-2017	1061		383		288		105		63

Figure 5. Distance cycled per capita per year in capitals

For the remaining cities we took numbers of cyclists counted at fixed locations in city centres. Figure 6 shows that the number of cyclists counted in these cities has increased over the years. It is uncertain how volumes of cyclists counted at fixed locations are related to distance cycled per capita. We do not have information about the lengths of trips of cyclists passing by the counting locations. Loop detectors may be located where volumes of cyclists are high and countings may not be representative of the population of cyclists. Although we cannot draw conclusions on the exact change of distance cycled per capita, increased volumes of cyclists at fixed locations provide tentative support for the hypothesis that distance cycled per capita developed in the same direction as in capitals with National Travel Surveys. However, given the uncertainties, National Travel Surveys are needed to draw conclusions.

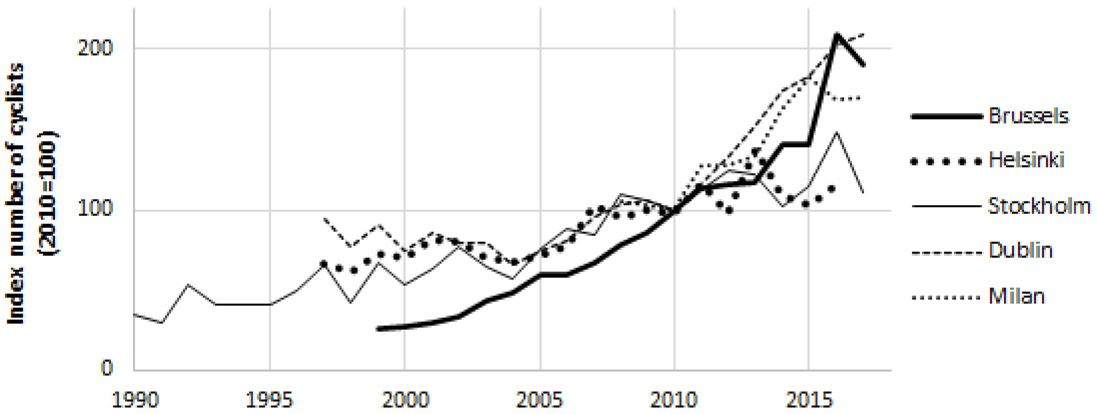


Figure 6. Index (2010=100) of numbers of cyclists counted at fixed locations in city centres

4.5 Trend in walking, public transport and driving: only car use increased

Three travel modes potentially competing with the bicycle are travel on foot, public transport (bus, tram, and metro) or by passenger car. Table 4 describes regression analyses to examine the trends in distance travelled per capita with these three travel modes. The trends lines are depicted in Figure 7. The values on the left vertical axis for distance by car are larger by a factor of 5 than the values for walking and public transport on the right vertical axis meaning that the same differences in Figure 7 are greater for car use. Figure 8 up to 10 show the distance travelled per capita for the individual countries with countries ranked similar to Figure 2, meaning that countries where people cycle longer distances are shown at the left side while countries with less cycling are shown at the right side.

Distance walked per capita per year ranged from some 200 km to 700 km. The distance people cover per year on foot differs less between countries than the distance travelled by bicycle. We do not observe countries with more cycling to experience less walking. From a longitudinal perspective, we would expect a decrease of walking in Germany if a rising distance covered by bicycle were to substitute travel on foot. That is not the case as we do not observe a decrease in Germany. Table 3 shows the results of multilevel regression analyses on distance walked per capita. The regression parameters for time being insignificant suggests that distance walked did not significantly change during the study period. Figure 9 shows the development of distance travelled by bus, tram and metro (bus only in Denmark, Sweden and Ireland). The differences in public transport categories and measurement methodologies described in Section 3.5 render cross-country comparisons too unreliable. The results of the regression analyses in Table 3 suggest the distance covered by bus, tram and metro remained fairly stable during the study period.

Figure 10 shows the development of distance travelled by car. The whole of Belgium instead of Flanders is included because the IRTAD database only gives statistics for the entire country. During the study period, distance travelled by car per capita per year ranged from some 8,500 km to 12,000 km. The results of multilevel regression analyses in Table 3 suggest that the distance travelled by car per capita significantly increased during the study period (the parameter for time is significant). The average distance travelled by car for all countries increased by about 10% during the study period. This increase was observed primarily in the 1990’s and levelled off around 2000. This is the reason why the parameter for time squared in Table 3 is less than zero.

The six countries at the left side of Figure 10, where people cycle the most, showed on average some 1,000 kilometres travelled by car less than the five countries at the right side where people cycle the least. There is a possibility that part of this difference is due to more cycling in the countries at the left side, but the difference may also be due to other factors such as land use. A stronger indication of cycling substituting driving would be a reduction of distance covered by car in Germany, the country experiencing the greatest increase of distance cycled per capita between 1994 and 2017. That is not the case as we do not observe the increase of distance travelled by car in Germany from 1994 to 2017 to be less than the average experienced in other countries. To summarize, we did not find indications that cycling substitutes travel on foot, by public transport or by car.

Table 3. Multi-level regression analyses on distance on foot and by car per capita (95% CI)

Variable	Walking	Bus, tram, and metro[1]	Car use
Constant	248 (157 to 338)*	838 (628 to 1049)*	9211 (8528 to 9894)*
Time	31 (-1 to 62)	-13 (-61 to 36)	696 (447 to 945)*
Time squared	-2 (-6 to 1)	0 (-5 to 5)	-66 (-96 to -36)*

* significant at the 5%-level
[1] Bus only in Denmark, Sweden and Ireland

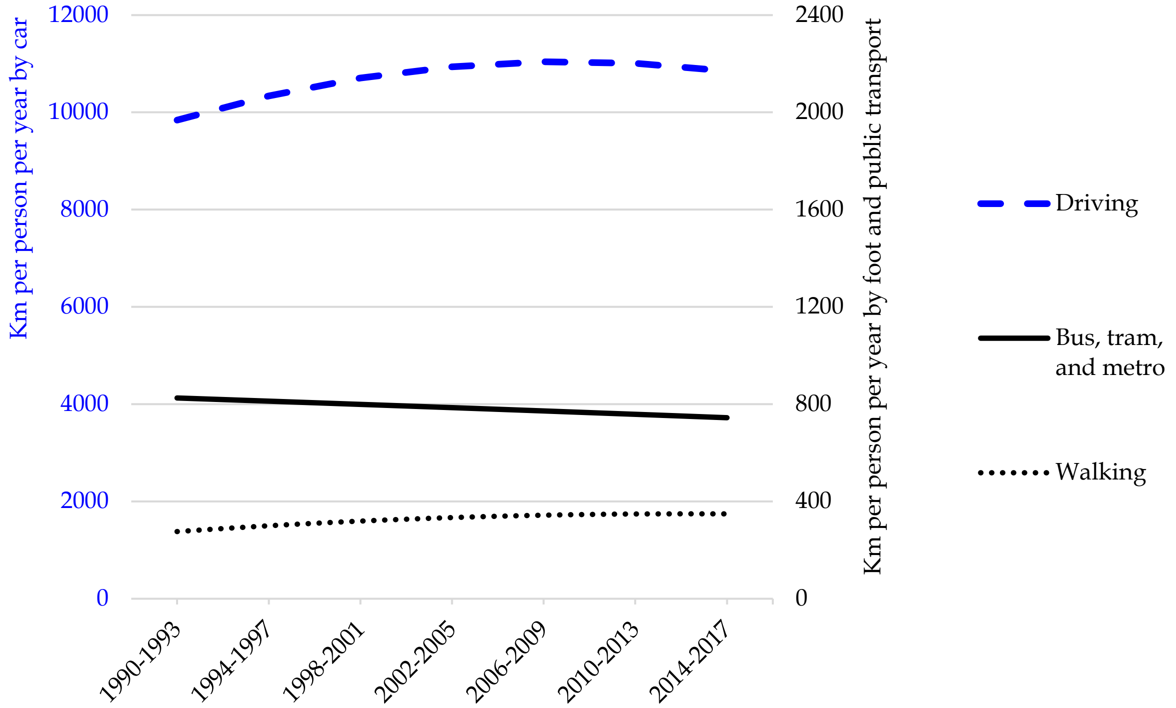
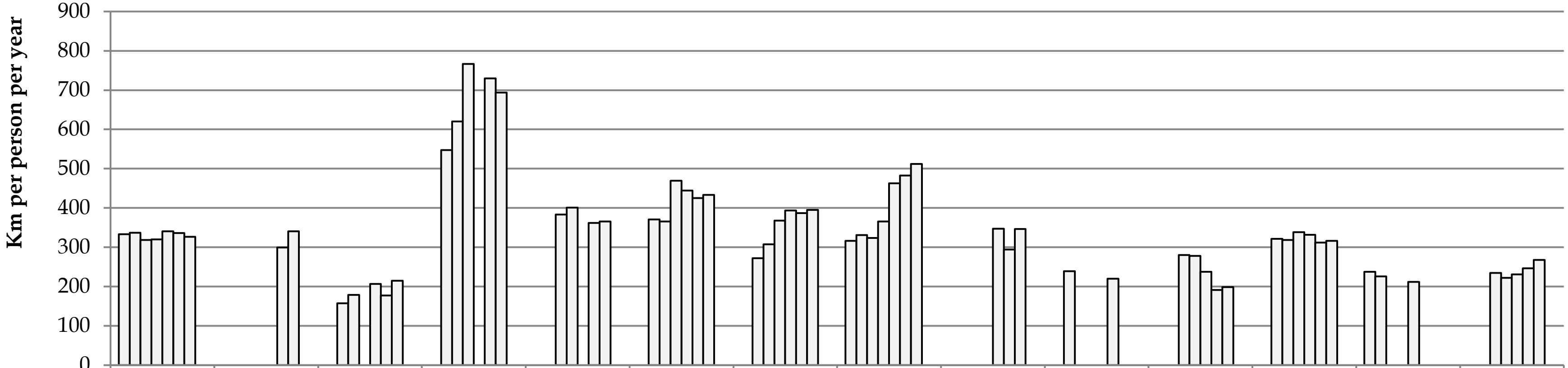
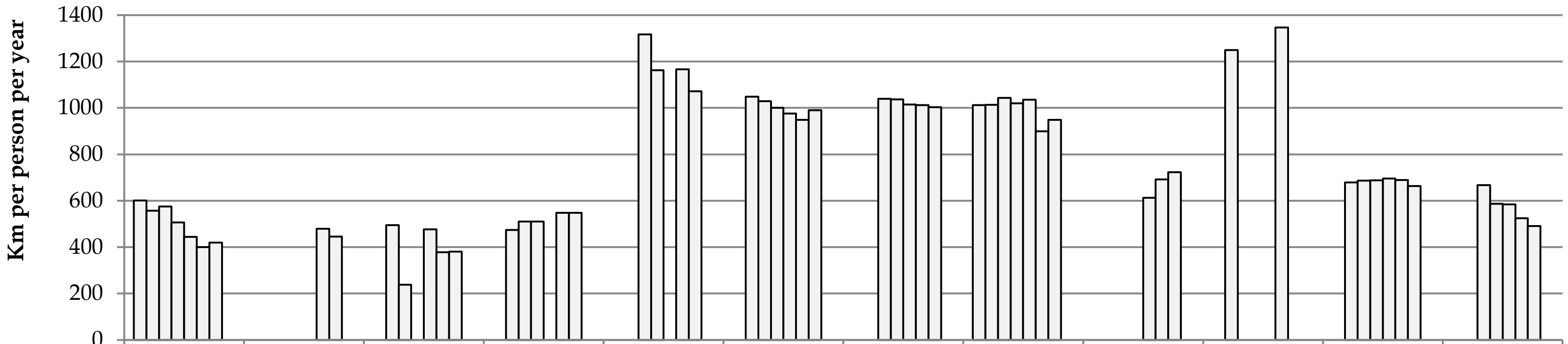


Figure 7. *The development of distance travelled per capita per year on foot, by public transport (bus, tram, and metro), and by car between 1990 and 2017*



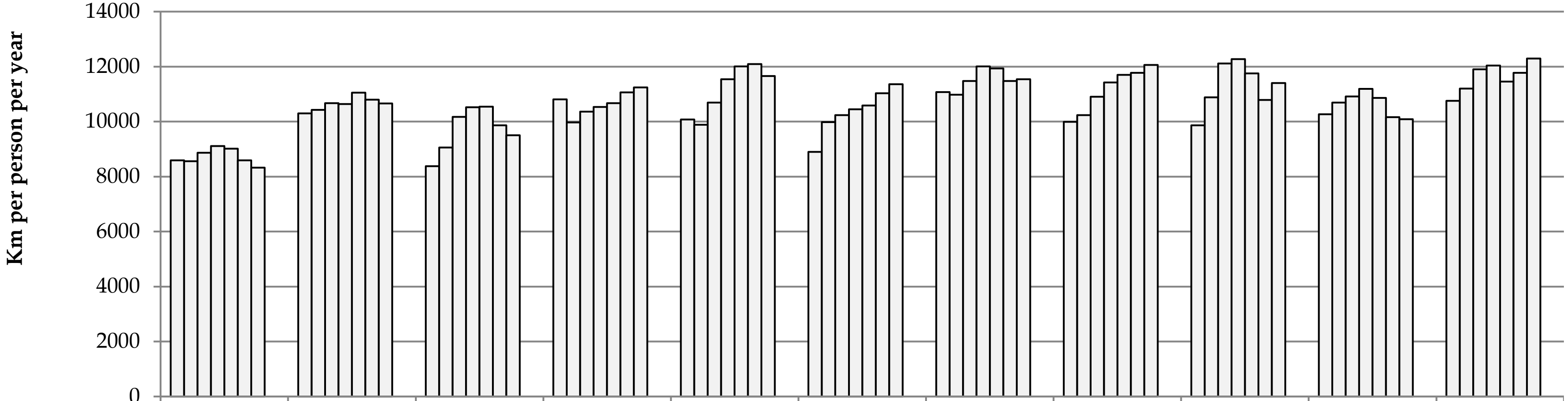
	Nether-lands (NL)	Denmark (DK)	Belgium (BE FL)	Switzer-land (CH)	Finland (FI)	Germany (DE)	Sweden (SE)	Norway (NO)	Ireland (IE)	Austria (AU)	Italy (IT)	UK, England (UK ENG)	France (FR)	UK, Northern-Ireland (UK NIR)
1990-1993	333							316					238	
1994-1997	337		157	548		371	272	331		239		322	226	
1998-2001	319		179	621	384	366	307	324			280	319		235
2002-2005	320			767	401	470	368	366			278	339		222
2006-2009	340		207			445	394	463	347		238	332	212	231
2010-2013	336	300	177	730	362	425	387	483	294	220	191	312		246
2014-2017	327	341	215	694	366	433	395	512	346		199	316		268
Population 2015 (million)	17	6	6	8	5	81	10	5	5	9	61	55	64	2

Figure 8. *Distance walked per capita per year between 1990 and 2017, and population size in 2015*



	Nether-lands (NL)	Denmark (DK)	Belgium (BE FL)	Switzer-land (CH)	Finland (FI)	Germany (DE)	Sweden (SE)	Norway (NO)	Ireland (IE)	Austria (AU)	UK, England (UK ENG)	UK, Northern-Ireland (UK NIR)
1990-1993	601							1012				
1994-1997	557		495	475		1048		1014		1250	679	
1998-2001	575		239	511	1317	1029	1039	1043			687	668
2002-2005	506			511	1163	1000	1036	1020			688	587
2006-2009	444		477			975	1015	1036	613		696	584
2010-2013	400	479	378	548	1167	948	1012	899	693	1347	689	525
2014-2017	419	446	380	548	1072	990	1003	948	722		663	491
Population 2015 (million)	17	6	6	8	5	81	10	5	5	9	55	2

Figure 9. Distance travelled by bus, tram or metro (bus only in Denmark, Ireland, and Sweden) per capita per year between 1990 and 2017, and population size in 2015



	Nether-lands	Denmark	Belgium	Switzerland	Finland	Germany	Sweden	Norway	Italy	United Kingdom	France
1990-1993	8589	10294	8374	10803	10077	8900	11076	9986	9868	10267	10754
1994-1997	8558	10422	9052	9970	9890	9981	10978	10232	10885	10696	11197
1998-2001	8862	10665	10172	10367	10696	10233	11475	10906	12111	10913	11902
2002-2005	9105	10641	10526	10527	11541	10443	12007	11424	12272	11194	12036
2006-2009	9014	11049	10547	10669	12002	10585	11933	11700	11752	10862	11457
2010-2013	8595	10798	9864	11067	12091	11033	11475	11770	10786	10161	11769
2014-2017	8321	10659	9498	11242	11656	11359	11544	12058	11403	10083	12294
Population 2015 (million)	17	6	11	8	5	81	10	5	61	65	64

Figure 10. Distance travelled by passenger cars per capita per year between 1990 and 2017, and population size in 2015 (OECD/ITF, 2021)

5. Discussion

5.1 General findings

European countries experienced a strong decrease in distance cycled per capita between World War 2 and the start of our study period in 1990 due to trends such as mass motorisation (OECD/ECMT, 1995). Sufficient National Travel Survey data are available since 1990 to describe trends in cycling within Europe. At the level of countries, our results suggest distance cycled per capita remained fairly constant since 1990. If there is a change at all, it is small in light of the uncertainties of NTS data. It would also be small compared to the large decrease after World War 2 and bold goals such as the 1990 Dutch target of a 30% increase of cycling between 1995 and 2010, which was not achieved. Accounting for all uncertainties in National Travel Surveys, only one of the fourteen included countries –Germany– experienced an increase. Even though policy in several countries aimed to increase cycling, remaining at a stable level may be regarded as an achievement given the continuing rise of car use in European countries (OECD/ITF, 2021). For instance, all levels of Dutch government invested almost €0.5 billion per year in bicycle infrastructure over the last decades (Ligtermoet, 2014). Possibly there would have been a decrease without these policies.

However, cycling did rise substantially in almost all capitals, whether high- or low-cycling at the start of the period. This is in line with Dutch research by Harms et al. (2014), who found cycling to increase in highly urbanised areas while it decreased in rural areas. The same is true for France (Papon & de Solère 2010). Similar research would be needed to examine whether other countries with a stable general trend also experienced a decrease in rural areas. A study by BMVI (2019) suggests that the increase in Germany manifested itself primarily in urban areas, while only a few less urbanised areas of the country experienced a decrease. An interesting question is what explains the differences found here between capital city and country-wide trends and to what degree these differences are related to policies. Many capital cities have seized on cycling for a range of purposes, including global city branding, and in some cases, this has been associated with quite significant investment. For instance, within England, London has been spending substantially more per head than the rest of the country in cycling and updated its cycling infrastructure guidance six years before a similar document appeared at national level Aldred et al., 2019b). More detailed (longitudinal) data would be needed to study such questions, including for instance data on changes in investment and/or infrastructure.

Cycling remaining at a stable level seems to fit in a broader picture of fairly stable use of other transport modes. This study looked at three transport modes that potentially compete with cycling. Distance walked and distance travelled by bus, tram and metro remained fairly stable as well. The distance travelled by car increased by about 10% during the study period, but this increase mainly manifested itself during the 1990s after which it remained fairly constant. The increase in car use is the most significant change in mobility because the magnitude of this increase is approximately equal to the total distance travelled by bicycle and on foot. We did not find indications that cycling substitutes travel on foot, by the above forms of public transport or by car.

5.2 Transferability of findings

The results of this study apply to most European countries, except those in Eastern Europe for which no NTS data were available. The European context may differ from other parts of the world, especially the non-Western context where mass motorisation commenced later such as in China. According to Hu and Yin (2018), cycling accounted for 63% of total traffic in 1980 in the Chinese capital Beijing, which dropped to 38% in 2002 and 12% in 2014. Europe also differs from the US where bicycle infrastructure is rare and low-density sprawl is common (Pucher & Buehler, 2008). Residents in the US cycle only some 30 to 50 km per capita per year. Distance cycled remained roughly at the same level between 2001 and 2017 (Buehler et al., 2020; Pucher et al., 2011). This cycling level corresponds to the lower-level countries in the "low group" in this paper and both the US and the "low group" in this paper experienced a similar fairly constant level of cycling over the past decades.

5.3 *Study limitations*

This study was possible because of the availability of travel surveys over the last decades in many European countries. Changes over time such as an expansion of the age range have been corrected for in this study. Bias may be limited as underreporting of bicycle trips tends to be fairly small (see e.g. Aschauer et al., 2018). However, it is possible that changes may have gone unnoticed and some changes are hard to correct for. For instance, the yearly Dutch NTS changed in 2010. Up to 2009 postal surveys were sent out while those who did not respond were contacted by telephone for a phone interview. As of 2010, Statistics Netherlands used a mixed method NTS in which people are approached for a web interview (CAWI; Computer-Assisted Web Interview), while those who do not respond are called for a telephone interview if their telephone number is known (CATI; Computer-Assisted Telephone Interview) or otherwise a face-to-face interview (CAPI; Computer-Assisted Personal Interview) (Statistics Netherlands, 2014). Similarly, the 2016 Finnish NTS changed from telephone interviews to a multi-method (telephone/online/letter) approach (Finnish Transport Agency, 2018, p. 33). We assume that this change of methodology has only a minor impact on the outcomes as distance cycled remained fairly stable before and after the change. However, there is no certainty as both methods have not been applied in parallel. Even if National Travel Surveys are based on an identical methodology over time, there is a risk that the outcomes change because of for instance declining response rates resulting in a changed composition of the sample (Wilson, 2003). For example, a changing proportion of highly educated people who may have different travel behaviour may bias the outcomes if these changes are not sufficiently corrected for. Also, respondents may become more aware of cycling distances due to the introduction of new technologies such as apps to track rides (see e.g. STRAVA, 2020). To expand the possibilities for more detailed cross-country comparisons and monitoring, authorities may need to harmonise their National Travel Surveys such as recommended in the SHANTI project and may need to introduce the use of new technologies to reduce problems related to surveys (Armoogum et al., 2014; Shen & Stopher, 2014).

Another limitation of this study is that we lack information to explain the fairly constant level of cycling at the national level in most countries and the increase in capitals, for instance information on policies. To be able to conduct research on why the amount of cycling does or does not change, we would need to have longitudinal data on policies, their implementation and changes in other circumstances (Harms et al., 2016). Relevant transport policies are for instance policies to provide bicycle infrastructure and car parking fees (Rietveld & Daniel 2004). Land-use policies to increase cycling may aim to increase residential densities and mixed land-use (Heinen et al., 2010). We recommend expanding research on bicycle use by collecting data on relevant measures, policy efforts, and other factors that may affect bicycle use.

There are specific problems in measuring the distance travelled on foot and by public transport. The underreporting of trips on foot in National Travel Surveys is greater than of trips by other travel modes (Methorst, 2021). A limitation of measurement of bus, tram, and metro is that we were unable to restrict to the short distance trips that may be substituted by cycling. Especially the bus is also used for long trips for which the bicycle is usually not a useful alternative. This limits our ability to determine the extent to which the bicycle competes with bus, tram, and metro.

5.4 *Research recommendations*

We recommend improving the availability and presentation of existing data by relevant national agencies, or the compilation of an international database by an international institution comparable to the European 'Community Road Accident Database' (EU, 1993). Harmonisation would be desirable if corrections for changes are made available in order to allow longitudinal studies, over a period of time stretching back to before such a harmonisation effort. For European Member

States, Eurostat is developing European guidelines on Passenger Mobility Statistics (Eurostat, 2018).

Longitudinal data covering more countries would allow us to answer a variety of research questions, especially if more details regarding segments of the population and geographic variables are available. For instance, it has been found that countries where many people cycle tend to have a larger share of female and older cyclists and a more equal share of trips for both work and non-work rather than primarily for work (Garrard et al., 2008; Goel., et al, 2021). It would be valuable to study such a distinction using data from more countries and longitudinally to study to what degree the demographic composition of the cycling population changes over time in areas with growing numbers of cyclists such as Germany. Other interesting details could relate to journey lengths, purposes, cycling frequency and the like. For instance, in 2015-2017 the average journey by bicycle in Northern Ireland (the area with the lowest level of bicycle use; Department for Infrastructure, 2020) is approximately 8 km as compared to only 3 km in the Netherlands, while the average car trip is longer in the Netherlands (Statistics Netherlands, 2020). On the other hand, Dutch cyclists cycle more frequently. In a study among Dutch cyclists in 2016, 76% said they cycle at least once per week (Valkenberg et al. 2017), as compared to 47% in Northern Ireland (Department for Infrastructure, 2020). An interesting hypothesis would be whether a growth of cycling participation in Northern Ireland would lead to more frequent and shorter journeys by bicycle.

A more geographically oriented question is for instance a distinction of the development of cycling in urban and rural areas (see e.g. Harms et al., 2014; Andersen et al., 2018). Our results for capitals as compared to their countries show how substantial geographical variations are. Cycling may start to rise first in the densest part of urban areas, and then spread to the suburbs and the periphery, for example in the Paris region (Dusong, 2018). An interesting question would be to study the date when the low point of cycling occurred, by smaller spatial zones, in different national contexts.

Finally, more abundant and accurate cycling data may help cycling safety analyses by providing a reliable measure for exposure over a longer period of time for longitudinal research. Cycling exposure helps to estimate crash risk (Dozza, 2017) and to study how cycling safety responds to a growth or decrease of bicycle use (see e.g. Bhatia and Wier, 2011; Aldred et al., 2019a). Distinguishing by type of bicycle, for instance regular bicycle versus electric bicycle, would also help to better interpret changes.

6. Conclusions and recommendations

Distance cycled per capita remained fairly constant over the past decades in European countries and this conclusion applies to countries with low, medium and high amounts of cycling during the 1990's. Germany is an exception with some 150 km per capita more, in relative terms a 50% increase. The general stable level of cycling is likely to hide geographical variations evidenced by a substantial increase of cycling in capitals. The outcomes suggest that distance travelled on foot and by bus, tram, and metro also remained fairly constant while the distance travelled by car increased by about 10% during the study period. The increase in car use is the most significant change in mobility because the magnitude of this increase is approximately equal to the total distance travelled by bicycle and on foot. We did not find indications that cycling substitutes travel on foot or by car.

The EU ministers for Transport (2015) adopted a Declaration on Cycling to call the European Parliament for an EU roadmap for cycling to be included in the Commission Work Programme to increase bicycle use in Europe. Policy makers aimed for the same goal at the beginning of the 1990s which has unfortunately not been reached in the vast majority of member states. Although it was not the aim of this paper to study the effectiveness of policies, it seems necessary to intensify and/or change policies to achieve these goals in the future and to attain benefits such as reduced air pollution, greenhouse gas emissions, and improved health (Khreis et al., 2016). Policies may aim for land-use to provide important destinations within reach by bicycle in combination with measures to restrict car use by for instance road pricing, car parking fees, circulation plans and road safety measures to make cycling safer and more comfortable by bicycle infrastructure and traffic calming (Cornago, et al., 2019; Janssen et al., 2018; Pucher & Buehler, 2008; Rietveld & Daniel 2004; Schepers et al., 2017).

Trends such as urbanisation and the emergence of electric bicycles may overcome some of the barriers due to long distances and altitude differences (Fishman & Cherry, 2016; Harms et al., 2014). The COVID-19 pandemic is a more recent trend that led to an increase of distance cycled in Switzerland (IVT et al., 2021). The increase also seems to be occurring in the Netherlands but De Haas, Hamersma en Faber (2020) indicate that this could be due to weather conditions. For now, we can only speculate on the long-term effect on cycling of the pandemic, but it is possible that we will see changes in travel behaviour, for example regarding the use of public transport. Several European cities have provided temporary solutions for cyclist, so called pop-up bike lanes, to promote transportation allowing for physical distancing. If these solutions are made permanent it might have a positive effect on cycling (UCI, 2020).

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