CREATE has received funding from the European Union's
Horizon 2020 research and innovation programme
under grant agreement N° 636573

Project acronym:	**CREATE**
Project title:	**Congestion Reduction in Europe - Advancing Transport Efficiency**

D3.2

One technical report per Stage 3 city

Berlin, Copenhagen, London, Paris, Vienna

Date of preparation:	**16th December 2016**
Start date of project:	**1st June 2015**
Duration:	**36 month**
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Prepared by:	**Oliver Roider, BOKU**
Checked by:	**Regine Gerike, TUD**
Verified by:	**Peter Jones, UCL**
Status:	**x**
Dissemination level:	**Public**

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Project acronym: **CREATE**

Project title: **Congestion Reduction in Europe - Advancing Transport Efficiency**

D3.2 - Technical report for Stage 3 city

Berlin

Work Package 3 "Quantitative Analysis of Travel"

Date of preparation:	**November 2016**
Start date of project:	**1st June 2015**
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Version:	**1.2**
Prepared by:	**Manuel Fiechtner, SenStadtUm**
	Julius Menge, SenStadtUm
	Rico Wittwer, TUD
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Verified by:	**Peter Jones, UCL**
Status:	**Final**
Dissemination level:	**Public (PU)**

Table of Contents

1 CREATE project

CREATE's work is based on 3 main challenges/activities:

- to establish which policies were most effective at controlling congestion, reducing car use and promoting sustainable transport,
- whether such policies are transferable to other cities,
- how cities are going to respond to the challenges of rapid population growth and new transport technologies in the future.

In other words, and more specifically, CREATE aims to help five cities from Eastern Europe and the Euro-Med countries to decouple traffic from economic growth, with the support of five Western European cities that have already passed the critical phase of rapid increase in car ownership, and are now moving towards a sustainable transport system. CREATE sets out to study and look at options to further improve network efficiency and reduce the overall need to travel in those advanced cities.

CREATE uses knowledge gained from stakeholder interviews, data analysis, detailed research and historical studies in order to develop tools, guidance and teaching packages, providing capacity building and opportunities to enable less advanced cities to accelerate their shift towards a more sustainable mobility system.

This in-depth investigation, supported by leading analysts and a major provider of real-time traffic data will permit CREATE to investigate changing patterns of road traffic and car use, success factors behind decreasing car usage and lessons learnt.

1.1 Concept and approach

The CREATE project is based on four central innovative ideas or assumptions:

1. The way in which the "congestion" debate is framed in a city underlies how transport system performance is measured.
2. The existence of a 3-stage "Transport Policy Evolution Cycle" spread over 40+ years, which gradually shifts the policy emphasis and investments priorities from catering for road traffic growth to building up a liveable city.
3. The examination of future mobility options given a rapidly growing urban population (and a mobility densification), with policy measures which can achieve congestion reduction, promote sustainable mobility, while meeting wider policy goals.
4. Promoting the "policy transfer" of understanding gained from investigating the above mentioned ideas, to those cities which are coping with rapid growth in car ownership and promoting "pro-car" policies. This would provide them with insights into how to short-circuit the 3-stage historical "Transport Policy Evolution Cycle".

1.2 Objectives

The CREATE project is based on achieving four high-level objectives:

1. To explore the nature and the causes of urban road traffic congestion, developing and applying a set of policy relevant and practical indicators of urban road congestion and transport network performance. This will provide network managers and policy makers with metrics to establish the degree to which efficient and sustainable urban mobility is being delivered in the CREATE cities.
2. To work with five economically advanced Western European capital cities, which have already passed through the "peak car" phenomenon, examining how they have succeeded in

decoupling economic growth from traffic growth. It will be particularly interesting to discern which transport and non-transport factors have been most effective in reducing car use, thus encouraging greater use of sustainable modes.

3. To develop specific guidance and promote capacity-building for professionals in the group of cities (Eastern European and Euro-Med) which are at the earlier stages in their economic development, with a view to help them to adopt policies based on sustainable mobility, rather than becoming car dependant cities.
4. To address the serious future issues starting to emerge in many of the CREATE cities due to rapid increases in population and employment, thus potentially overwhelming all modes of transport. Via the investigation of the potential for new technologies, and the changes in business and social habits, there are chances for better managing the transport systems and reducing the overall need to travel as well.

2 About this document

The primary aim of WP3 is to analyse the transport policy evolution cycle as described in Deliverable 2.1 for the five stage 3 cities, from their stage 1 condition to their current status as stage 3 city. The development of relevant travel indicators is mapped over time in order to quantify this trajectory and to identify the various factors which have contributed to observed changes in behaviour – particularly the observed reductions in car driver modal shares.

This deliverable documents the analysis of the data to provide an overview of city development and characteristics as input for further analysis. Trends in congestion and travel behaviour (by purpose, mode, etc.) are measured, charting the emergence of "peak car" and the growth in the use of sustainable modes of travel in different parts of the urban and peri-urban areas. A descriptive analysis for each stage 3 city is conducted across the years. Indicators of changes in conditions in each city are analysed, including traffic volumes, speed, congestion, public, transport patronage, modal shares of different modes depending on data availability.

Indicators of possible causes of changed travel patterns are covering demographic changes, economic developments, car ownership, labour-market, land use, or government policies. Analysis is distinguished between different segments of population in different parts of the cities over time. Data are mainly based on any kind of statistical sources available as well as household travel surveys and are to be documented for the longest possible period of time in each city. Most of data, but in particular household travel survey data, should be available in all stage 3 cities at least 20 years back from 2014, in some cases from the 1970s, and should provide information of the stage 1 situation in the particular city.

The contents of this deliverable are based on the analysis scheme provided in Deliverable 3.1. Technical internal report, detailed analysis scheme for WP3 to ensure the generation of comparable figures over time for all stage 3 cities. The list of indicators to be documented is subdivided into 2 levels: (1) "must-have-indicators" which all stage 3 cities should have to provide and (2) "nice-to-have-indicators" representing additional analyses of specific data available in case these data are easy to access. Additionally, any other documentation of data or further cross analysis of data of interest in a particular stage 3 city are highly appreciated and should be added accordingly.

This deliverable is organised as follows: The city specific framework as the basis for the analysis is presented in chapter 2. Chapter 3 and 4 are dealing with transport supply data and policies influencing travel demand in the city documented in chapter 6. Freight transport is described in chapter 7. Summary and conclusions are documented in Section 8.

3 City specific framework conditions

3.1 Spatial characteristics

3.1.1 Area definitions

This section is to provide basic information and a description of each area type according to the definition as proposed in Deliverable 3.1:

- Inner-city: city centre or central business district(s)
- Outer-city: city area beyond inner-city but within the city boundary
- Peri-urban I: area bordering the city (e.g. closest ring around city), fulfilling the criteria of high population density, high density of workplaces, high number of commuters to or from the municipalities
- (Optional) Peri-urban II: wider commuting catchment area

Berlin is the capital of Germany and its largest city, with a population of about 3.5 million inhabitants. Berlin is one of the 16 German Federal states (Bundesländer) and has been an independent city-state since the German reunification. It is situated within the Federal state of Brandenburg, which completely surrounds Berlin. Berlin covers an overall area of 892 km²; its border with Brandenburg spans a distance of 234 km.

Various ways have been used so far to define and describe the city centre of Berlin, depending on whether the focus is on urban space or mobility. For the CREATE project the inner-city is referred to according to the household survey on travel behaviour SrV, 2013 (see Figure 3-3). Accordingly, the area within the so-called S-Bahn-Ring is referred to as the inner-city. Here, the administrative, cultural and social centres of the city are situated. The inner-city area is very densely populated, but also has some large recreational areas such as the Tiergarten, Zoological Garden, and Tempelhofer Field.

One challenge for the data acquisition process in CREATE is Berlin's past, specifically the reunification with Germany in 1991. This led not only to the consolidation of different administrative entities of two the former independent city-bodies, but also to the new spatial classification of 23 new boroughs. These 23 boroughs were then reduced to 12 in 2001 (which are still present today), increasing, even further, the challenges in data acquisition and provision of comparable information (see Figure 3-1).

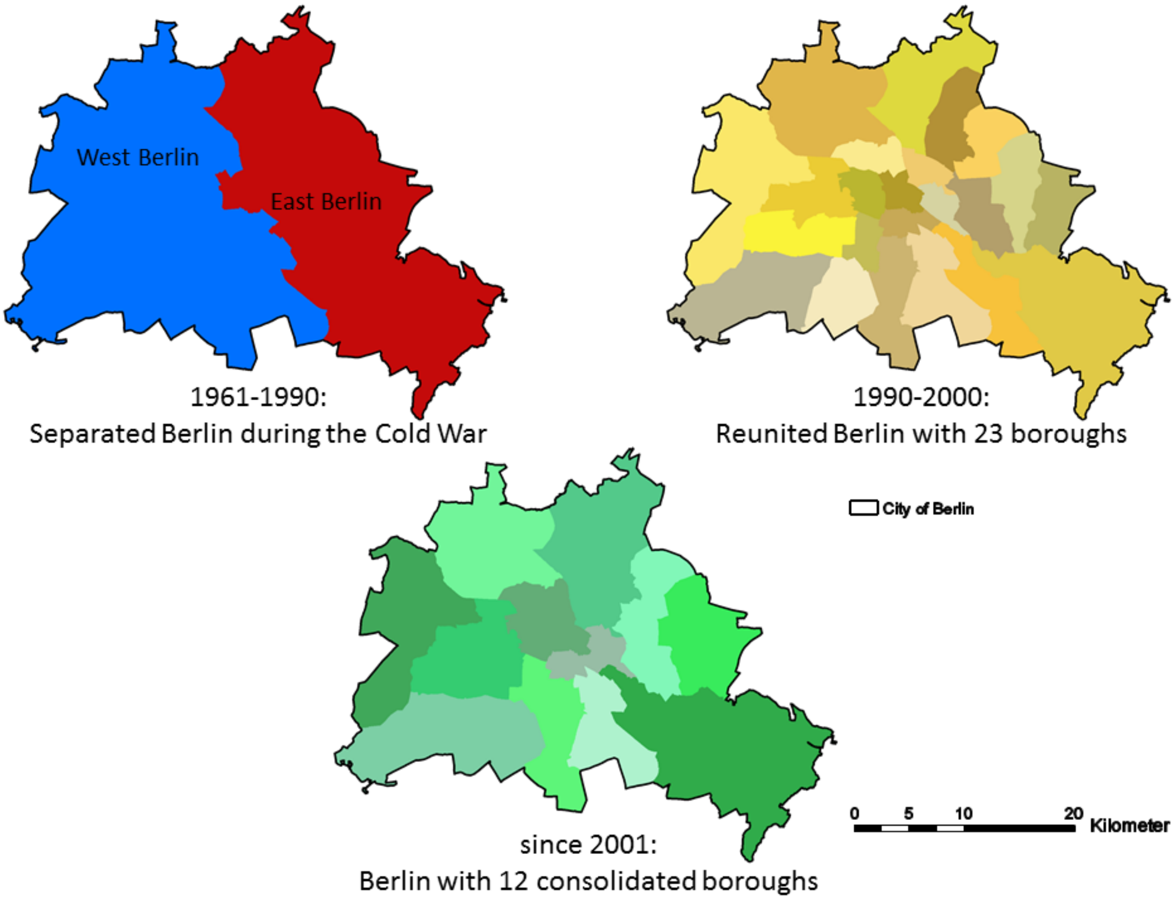

Figure 3-1: Maps of the divided city of Berlin (West and East Berlin), the reunified city with 23 boroughs and the (present) consolidated city with 12 boroughs
Source: SenStadtUm

The outer-city covers the rest of the city area and is far larger than the inner-city; it has more inhabitants, but is far less densely settled and has a higher proportion of greenspace and trees.

Peri-urban I, the area of the so-called urban-rural relationship (SUZ), includes the 50 municipalities and cities located around Berlin which belong to the Federal State of Brandenburg. This also includes the city of Potsdam with its currently more than 160,000 residents.

There have been considerable reorganisations in the Brandenburg community structures, also in recent years, with its biggest reform in 2003, which saw the number of communities change from 1,479 (in 1998) to 416 (see Figure 3-2).

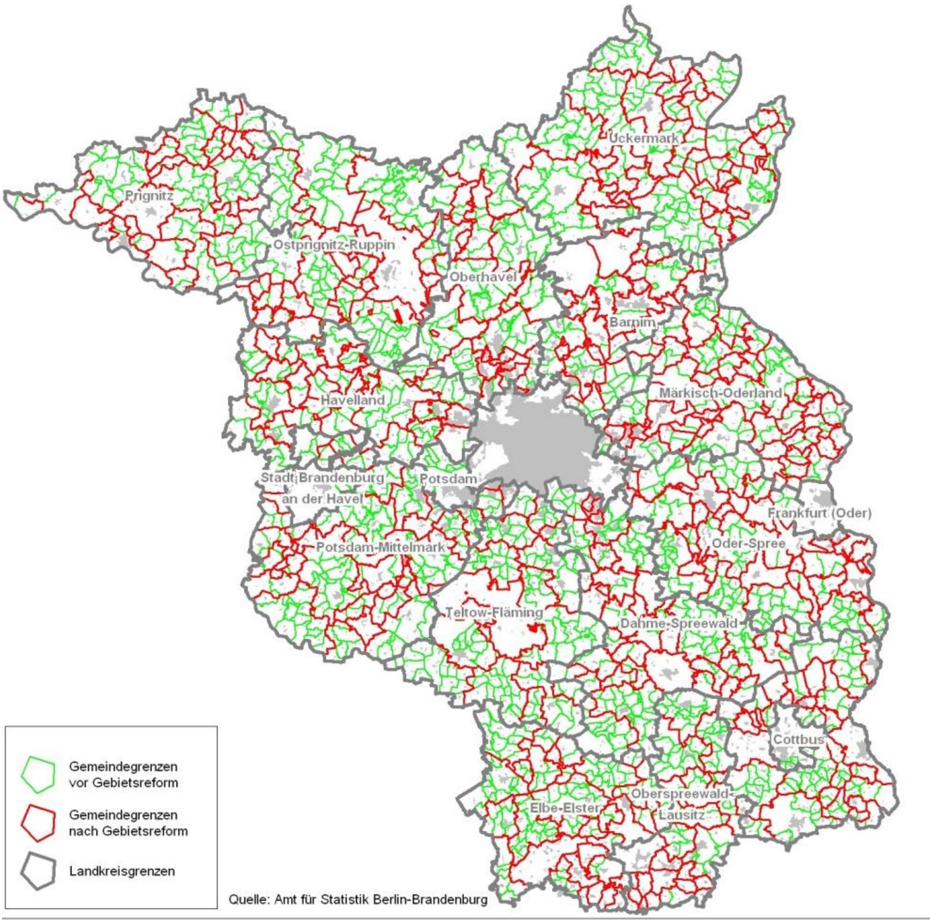

Figure 3-2: Changes in municipality structures in Brandenburg in 2003 (green before 2003, red after 2003)
Source: MIL 2015 based on AfS-data

The green lines represent the former community borders until 2003; the red lines resemble the new borders since 2003. Data from the former structure have not been consistently transferred to the new community structure, creating significant challenges in data handling.

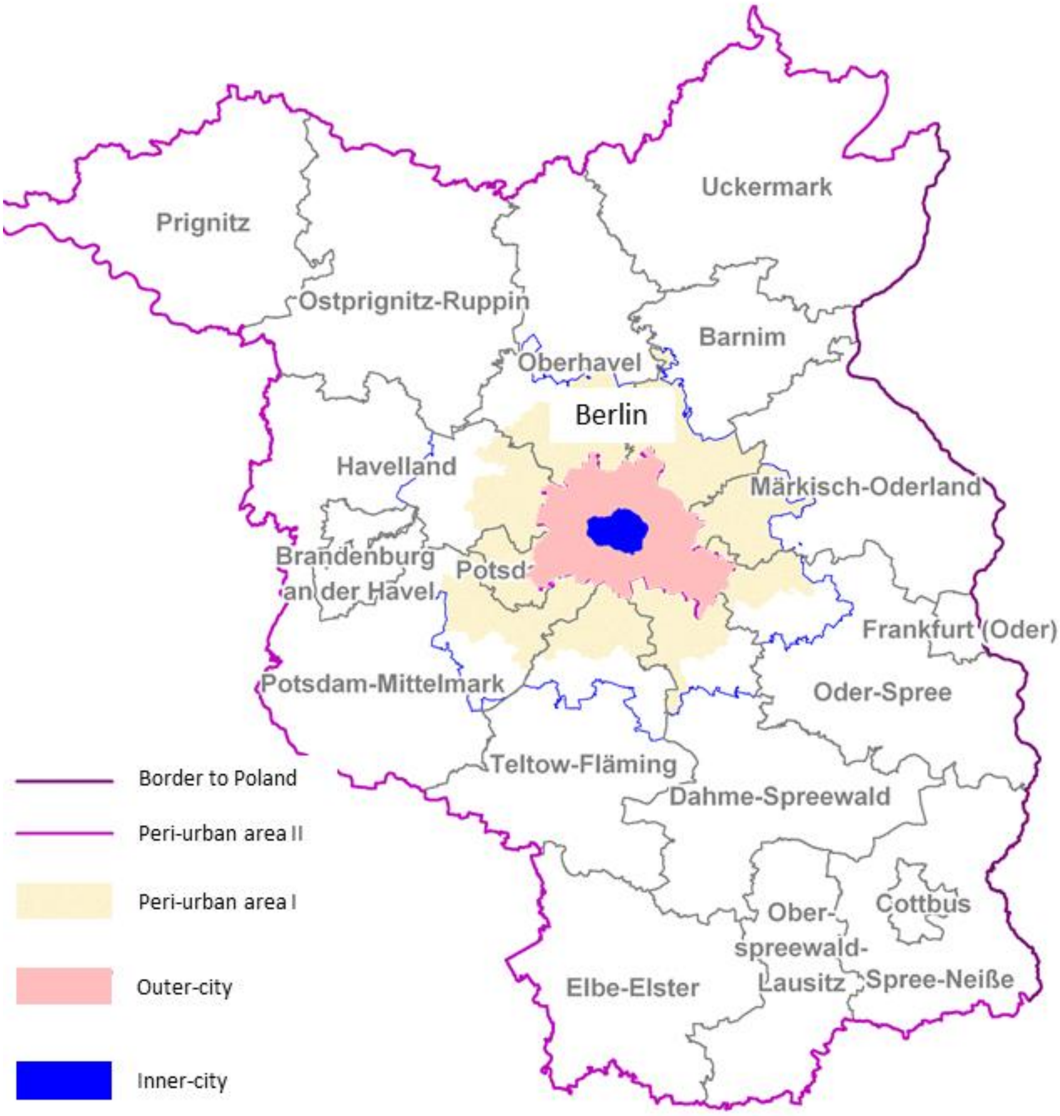

Figure 3-3: Area types of the stage 3 city "Berlin" (2015)
Source: SenStadtUm based on AfS BB 2016d

As a result, there is often no consistent data available for the Peri-urban I area. Taking this into consideration, it was decided to use values representing the entire Federal State of Brandenburg, alternatively representing the Peri-urban II area (see Figure 3-3).

However, challenges like this do not only exist for the Peri-urban areas: Also within Berlin, many statistics are not available on a scale detailed enough to define the S-Bahn ring. Therefore, CREATE used a modified classification of the inner-city, regarding the two downtown boroughs of Mitte and Friedrichshain-Kreuzberg, which are the only districts (almost) entirely located within the S-Bahn ring, as the alternate inner-city. This means that, for certain parts of the analysis, of City West near the Zoological Garden and Kurfürstendamm are handled as part of the outer city (see Figure 3-4). This is a sound approach for this project,though it does not reflect spatial reality or even the self-perception of Berlin's residents.

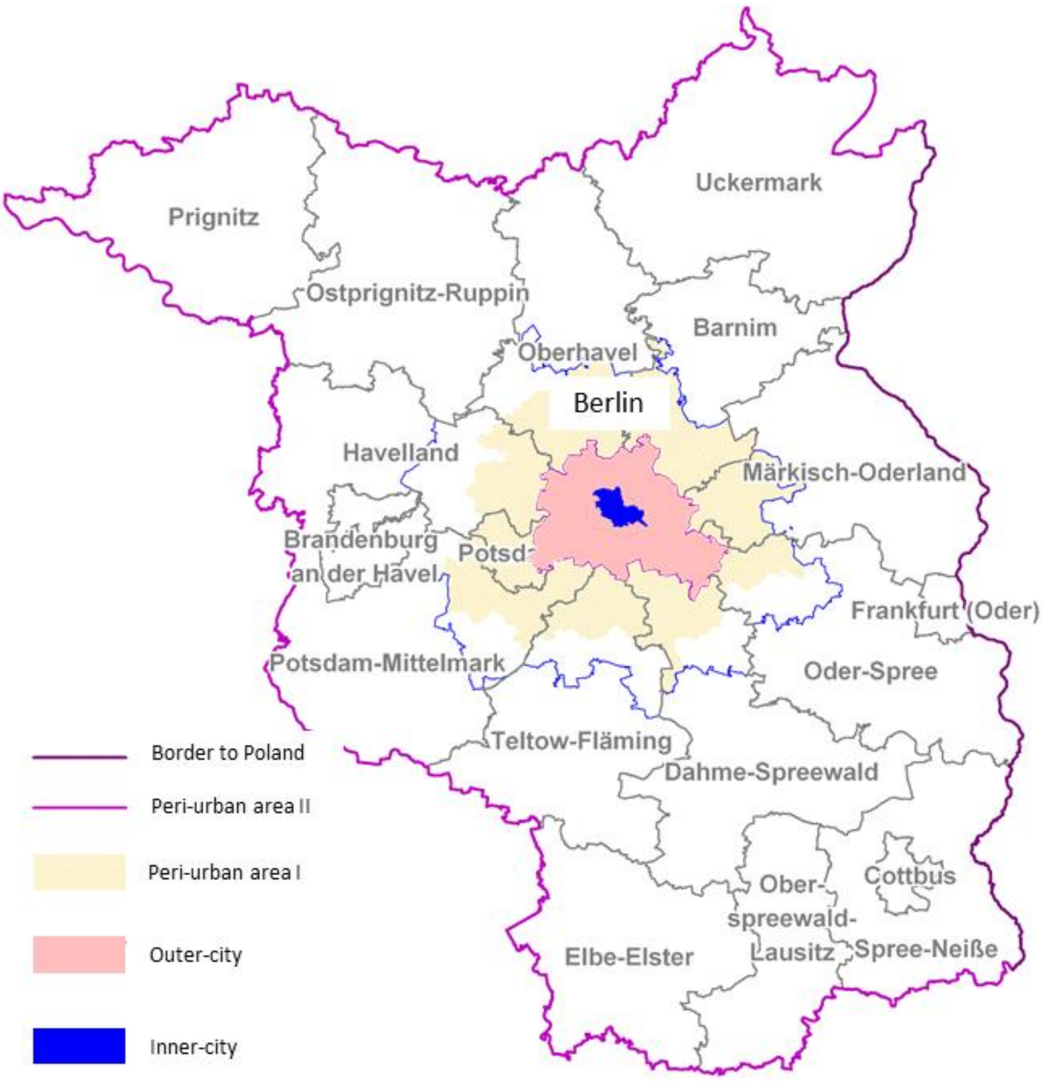

Figure 3-4: Area types of the stage 3 city "Berlin" – alternate inner-city (2015)
Source: SenStadtUm based on AfS BB 2016d

In summary: the City of Berlin has a total surface area of 892 km²; the inner city covers almost 90 km², the outer city area more than 800 km². Berlin's surrounding areas (Peri-urban I) covers more than 2,800 km², the Federal state of Brandenburg has a surface area of almost 30,000 km² (see Table 3-1).

Table 3-1: Size of study area [km^2]

Area type	total surface area [km^2] (2014)
Inner-city	89.79
Outer-city	800.86
Peri-urban I	2,864.44
Peri-urban II (including Peri-urban I)	29,654.34

Source: SenStadtUm based on AfS 2016 © Amt für Statistik Berlin-Brandenburg, Potsdam, 2016

3.1.2 Land use

In 2014, 53 % of the inner-city surface was made up of settlement areas (54 % in 2008) with around 32 km² (see Table 3-2). In the outer-city, 41 % of the surface was for settlement. Within the Peri-urban I area, only 13% of the surface was designated for settlement.

15 % of the inner-city and 12 % of the outer-city surface areas were designated as recreational (see Table 3-3). In Peri-urban I, only 2 % of the surface area was defined as recreational, though, obviously, many more areas than that were used for recreation.

The amount of agricultural areas and forests was below 1 % (0.05 km²) in the inner city and around 24 % in the outer city (see Table 3-4). 71 % of the Peri-urban I area was agricultural, both in 2014 with 2,023.24 km² and in 2008 with 2,037.37 km².

The transport infrastructure areas, mainly in the outer city and in Peri-urban I, faced slight changes between 2008 and 2014 (see Table 3-5). With approximately 14.5 km², the share of transport infrastructure areas in the inner city stayed constant at 24 %. In the outer city, the area decreased by almost 4 km², from 121.99 (15 %) to 118.44 km² (14 %). The reason being that some former railway areas were reclassified and redeveloped for apartments and industrial or shopping facilities. In contrast, the transport infrastructure area in Peri-urban I increased by about 15 km² (1% increase from 176.29 to 192.54 km², from 6 % to 7 % in total). The major reason for this increase is the construction process of the future airport BER.

The surface area of the semi-natural space has changed only slightly in Berlin (see Table 3-6). In the inner city, the percentage reduced from 3% (1.51 km²) to 2% (1.39 km²). Also in the outer city, the area decreased by 1.5 km², but remained constant with a 2 % surface area. The decline in semi-natural area in Peri-urban I, on the other hand, was far greater. The surface area decreased from 153.74 km² to 84.36 km², a deficit of nearly 70 km². The share decreased by 2 % from 5 % to 3 %. Here, the areas that could not be allocated to any other use changed significantly over all.

The amount of water areas did not change significantly between 2008 and 2014 (see Table 3-8). 5 % of the inner-city (2.74 km²), 7 % of the outer-city (56.92 km²) and 4 % of the Peri-urban I area (118.71 km²) were classified as water areas in 2014. The share only slightly increased from 4 % to 5 % in the inner-city.

Table 3-2: Surface of settlement area [km^2]

	Reference year			
Area type	**2014**	**2008**	**2014**	**2008**
Inner-city (alternate)	31.93	32.07	53%	54%
Outer-city (alternate)	343.73	342.76	41%	41%
Peri-urban I	378.91	381.91	13%	13%
Peri-urban II				

Source: SenStadtUm based on AfS 2016 © Amt für Statistik Berlin-Brandenburg, Potsdam, 2016

Table 3-3: Surface of recreational area [km^2]

	Reference year			
Area type	**2014**	**2008**	**2014**	**2008**
Inner-city (alternate)	9.27	8.90	15%	15%
Outer-city (alternate)	97.48	92.25	12%	11%
Peri-urban I	66.69	40.34	2%	1%
Peri-urban II				

Source: SenStadtUm based on AfS 2016 © Amt für Statistik Berlin-Brandenburg, Potsdam, 2016

Table 3-4: Surface of agricultural area and forest [km^2]

	Reference year			
Area type	**2014**	**2008**	**2014**	**2008**
Inner-city (alternate)	0.05	0.02	0%	0%
Outer-city (alternate)	201.54	202.83	24%	24%
Peri-urban I	2023.24	2037.37	71%	71%
Peri-urban II				

Source: SenStadtUm based on AfS 2016 © Amt für Statistik Berlin-Brandenburg, Potsdam, 2016

Table 3-5: Transport infrastructure area [km²]

	Reference year			
Area type	**2014**	**2008**	**2014**	**2008**
Inner-city (alternate)	14.50	14.58	24%	24%
Outer-city (alternate)	118.44	121.99	14%	15%
Peri-urban I	192.54	176.29	7%	6%
Peri-urban II				

Source: SenStadtUm based on AfS 2016 © Amt für Statistik Berlin-Brandenburg, Potsdam, 2016

Table 3-6: Semi-natural area [km²]

	Reference year			
Area type	**2014**	**2008**	**2014**	**2008**
Inner-city (alternate)	1.39	1.51	2%	3%
Outer-city (alternate)	13.68	15.17	2%	2%
Peri-urban I	84.36	153.74	3%	5%
Peri-urban II				

Source: SenStadtUm based on AfS 2016 © Amt für Statistik Berlin-Brandenburg, Potsdam, 2016

Table 3-7: Forest area [km²]

	Reference year			
Area type	**2014**	**2008**	**2014**	**2008**
Inner-city (alternate)	0.04	0.00	0%	0%
Outer-city (alternate)	163.61	162.23	20%	20%
Peri-urban I	923.01	911.87	32%	32%
Peri-urban II				

Source: SenStadtUm based on AfS 2016 © Amt für Statistik Berlin-Brandenburg, Potsdam, 2016

Table 3-8: Water area [km²]

	Reference year			
Area type	2014	2008	2014	2008
Inner-city (alternate)	2.74	2.57	5%	4%
Outer-city (alternate)	56.92	56.90	7%	7%
Peri-urban I	118.71	117.20	4%	4%
Peri-urban II				

Source: SenStadtUm based on AfS 2016 © Amt für Statistik Berlin-Brandenburg, Potsdam, 2016

Figure 3-5 reflects the very few changes in land use between 2008 and 2014 in the 4 area types at a glance.

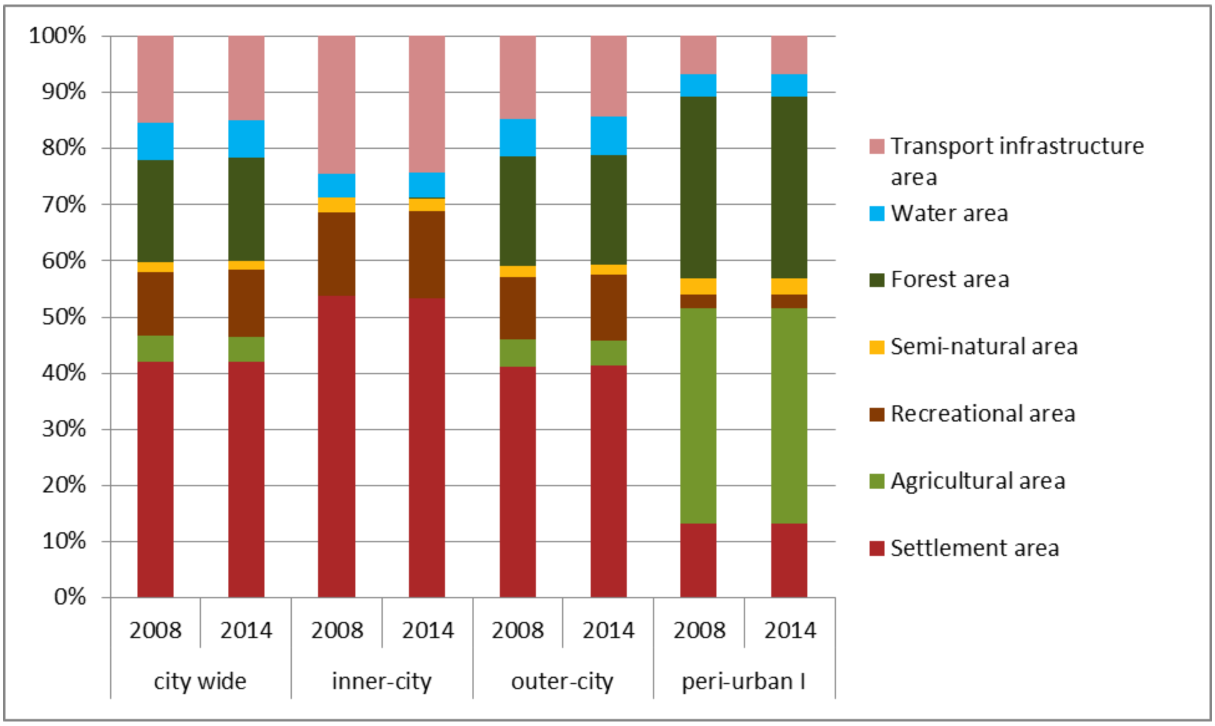

Figure 3-5: Changes in land use between 2008 and 2014 for area types

Source: SenStadtUm based on AfS 2016 © Amt für Statistik Berlin-Brandenburg, Potsdam, 2016

3.2 Demographics and economy

3.2.1 Population development

Methodical remarks

There are two different approaches for collecting data which concern the development of the number of inhabitants in Berlin: population projection (national/federal) and population register (local). The data of both sources are either collected or produced by the Bureau for Statistic Berlin-Brandenburg. For the State of Brandenburg, only data from the population projection is available for CREATE because the population register is gathered on the local level and only reported to the Bureau for Statistic Berlin-Brandenburg in a specially aggregated format.

Population projections on a national or federal level are based on the current census. Using it as a baseline, the statistically recorded births and inflows as well as the deaths and emigration are counted and allocated monthly. Until 2011, the Berlin population projection was based on the 1991 census. Since 2013, the census of 2011 has been used. Data for the time between 2011 and 2013 were adjusted afterwards using the 2011 census data, allowing for a constant data source since 2011.

In contrast, the population register (local) consists of all people registered in Berlin with their principal residence and their secondary residence, although usually only the people with a principal residence in Berlin are counted. Data are available for all of the necessary area definitions in CREATE which allows for local analyses and differentiations; however, inaccuracies due to missing change-of-address notifications are possible. Until 2011, the number of inhabitants in Berlin, based on the population projections and the population register, differed by 3%. In 2011, the new census revealed bigger deviations than expected due to missing change-of-address notifications by emigrants. The new numbers differed by around 5%. Data before 2011 were adjusted accordingly. Due to the different means of collecting the data, the population register was not changed at all. Hence, Berlin had 3,562,166 inhabitants in 2014 according to the population register and 3,469,849 inhabitants according to the population projections.

In CREATE, the increase of the total inhabitants for Berlin is described using the population register; while for Peri-urban I, the numbers from the population projection are used.

The development of Berlin's number of inhabitants since reunification can be divided into 4 stages (see Figure 3-6). The first stage from 1991 until 1993 is marked by a short increase in total population due to foreign immigration. From 1993 to 1999 (Stage 2), the number of inhabitants decreased dramatically as a result of rapidly growing suburbanisation. In Stage 3, from 1999 to 2004, the step-by-step relocation of the capital-city functions back to Berlin led to a slight increase in the total population in Berlin, while the number of inhabitants in Peri-urban I area continued to increase. After finishing the process of relocation in 2004, the number of inhabitants started to grow, both in the inner- and outer-city. Since 2010 the total population increased rapidly by more than 5 %. In comparison to 1991, the eastern inner city regions witnessed the highest increase. The development differed very much in the state of Brandenburg (Peri-urban I & II). Around 40 % more inhabitants live in the surrounding regions of Berlin (Peri-urban I) today compared to 1991. The number increased from 660,000 people in 1991 to almost 920,000 people in 2013. In contrast, the regions with former industrial sites suffered from severe emigration. Since the end of the 20th century, mostly families and middle aged people moved to the suburbs of Berlin (see AfS BB 2015a, p. 10, 2015b, p. 10).

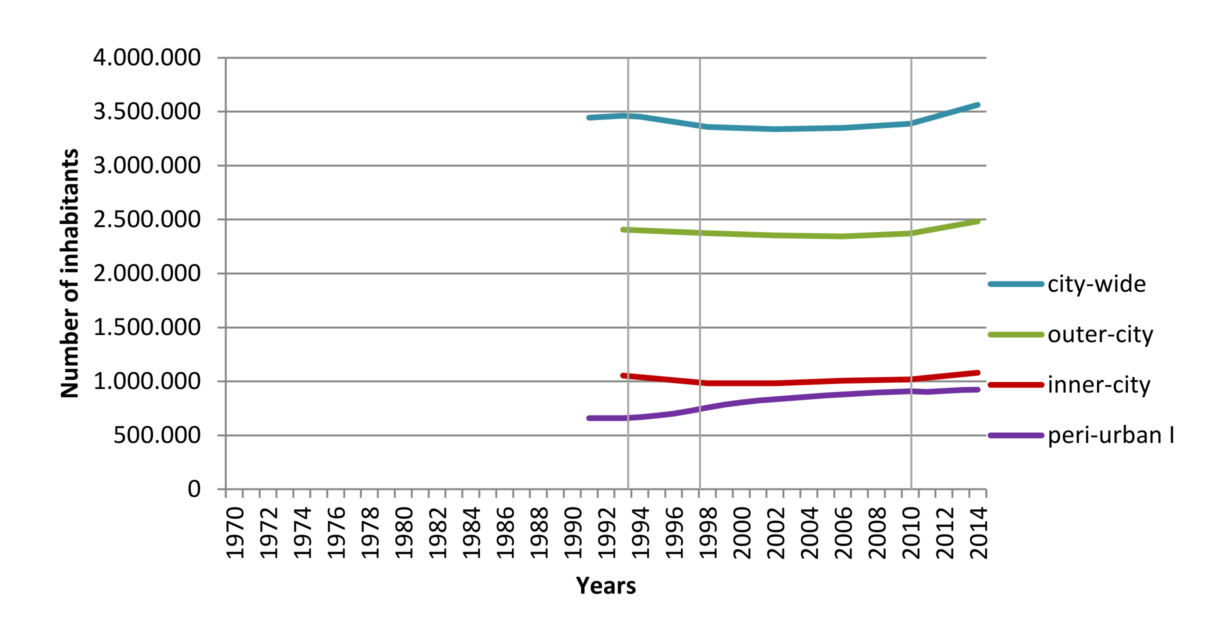

Figure 3-6: Development of the total number of inhabitants by area types [number]
Source: SenStadtUm based on © Amt für Statistik Berlin-Brandenburg, Potsdam, 2016

3.2.2 Household size

The average household[1] size in Berlin decreased continuously during the last 25 years. While only 45 % of the households in Berlin where single-person household in 1991, this increased to almost 54 % in 2014[2]. The share of households with three or more persons declined, meanwhile, from around 25 % to less than 18 % today[3]. Despite these developments, the share of two-person households maintained around 30 %. An increase in the number of elderly people over 65 years in Berlin did not lead to a rise in the number of single-households. In 1991, more than 51 % of the inhabitants over 65 lived in single-households; since 2005, the share stayed around 40 %.

The greatest changes in household structures took place in the eastern districts of Berlin. Here the share of one-person households increased from 1991 to 2014 by 18.1 percentage points, three-and-more-person households decreased proportionately by 18.0 percentage points. In an attenuated form these trends can be found in the other urban areas as well. The household structures have changed the least in the western districts (see AfS BB 2015a, p. 22).

3.2.3 Gender balance and age class distribution

Due to the reunification, comparable data on gender balance and age-class distribution are only available after 1994. Figure 3-7 illustrates the reduction of the surplus of female residents in Berlin and within the age group of over 65 years in the Peri-urban I area from 1994 to 2014. Whereas in 1994, there were 2.26 times more women in this age group, in 2014, the imbalance dropped to 1.34 times more women in Berlin. In the Peri-urban I area the imbalance changed in the same age group from 1.97 times more women in 1994 to only 1.28 times more women in 2014.

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[1] A household is defined in this case as a group of people living together and forming an economic unit. The analysed numbers are based on the Mikrozensus, which is calculated upon a 1 %-sample of all inhabitants of the Federal State of Berlin (see Bömermann 2013, p. 42 & AfS BB 2015a, p. 22).

[2] The share was relatively steady since 2006.

[3] The share stayed the same since 2006 as well.

All in all, the gender imbalance decreased both in Berlin and the Peri-urban I area. The Peri-urban I area is further characterised by a great gap in the age group of 45-65 years, in both gender as well as in years (see Figure 3-7).

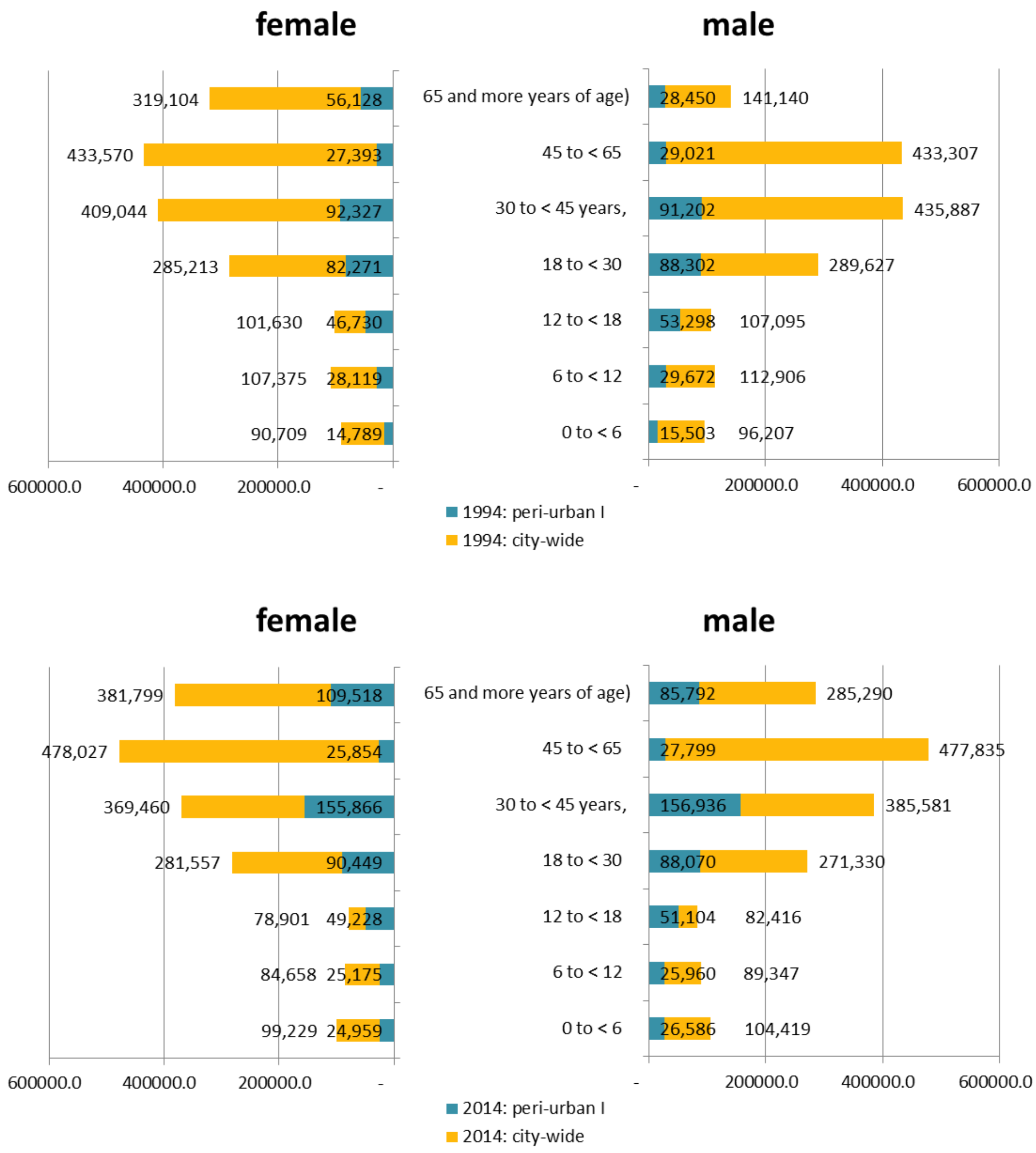

Figure 3-7: Comparison of gender balance of population in 1994 and 2014 (Total number of residents according to gender)

Source: SenStadtUm based on AfS 2016 © Amt für Statistik Berlin-Brandenburg, Potsdam, 2016

3.2.4 Ownership of driving licence by age class

Based on the latest HTS in Berlin, the ownership of driving licence by age class and gender in Berlin can be analysed citywide for the year 2013 (see Figure 3-8).

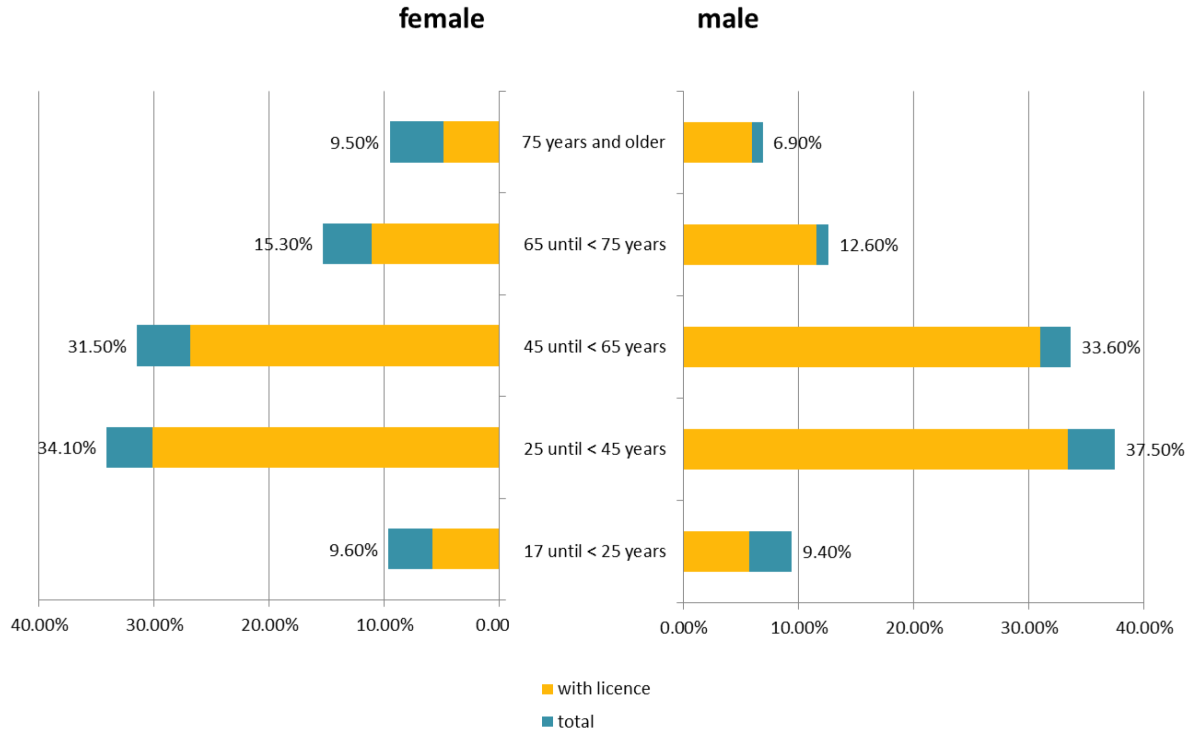

Figure 3-8: Ownership of driving licence by age class and gender 2013 in Berlin (city-wide)
Source: SenStadtUm based on Ahrens et al. 2015, Tab. 11.1

Especially the younger age groups of up to 45 years show a near balance in gender with 60-61 % having a driving licence for the age group 17-25 and 88-89 % within the age group 25-45 years. Between 45-65 years the share of people with a driving licence decreased compared to the younger age group. Over 65 years, both shares decrease even further. For people over 45 years of age, far less female citizens own a driving licence compared to males. Over 75 years, 86 % of males and only 51 % of females are licensed to drive a car. In total, 87.5 % of males and 78.6 % of females over 17 years of age in Berlin own a driving licence (see Ahrens et al. 2015, Tab. 11.1 and Figure 3-8).

3.2.5 Employment status of residents

The employment status in Berlin went through some severe changes since the reunification. In 1991, more than 71 % of Berlin's inhabitants within hireable age were actively employed: more than 65 % of all women and 77 % of all men. The rates dropped dramatically between 1991 and 2004: only 55.9 % of the women and 59.4 % of the men were employed. The rates rose again to an employment rate of 68.9 % in 2014. Younger adults seem to become employed later, the rate of employed inhabitants below the age of 25 declined from 55 % to 37 %. In contrast, the rate of employed inhabitants over the age of 55 rose from around 42 % to 62 %. Similar developments can be observed by analysing the unemployment rate. The percent of unemployed inhabitants rose dramatically until 2005 and did not fall back to the low mark of 1991 until 2014. During this period the share of unemployed men slightly increased from 1991 to 2014, whereas the share of unemployed women declined. The job market reflects these developments as well: From 1991 until 2006 the number of people in part-time positions doubled. This was mainly caused by a huge increase in the number of women working part-time which remained consistently 20 % higher than the number of men (see AfS BB 2015a, pp. 44–48).

3.2.6 Number of workplaces

Unfortunately no consistent data on the number of workplaces are available for either the city or the Peri-urban area. Therefore, the total number of people in paid-labour positions at the location was analysed; this included people living in other areas working in this area and excluded people living in this area but working elsewhere. In addition, due to the reunification, no data are available before 1990. After 1990, the metropolitan area faced a period of profound reconstruction of the employment market, especially in the former eastern part of Berlin and the Peri-urban area of the newly founded State of Brandenburg. The total number of people in paid labour positions at the location decreased (in Brandenburg rapidly) (see Figure 3-9). The Peri-urban area suffered a severe process of reconstruction in the industrial sector until 1993; Berlin, however, lost several workplaces. In the early 21st century, unemployment rates were high in Berlin and its surrounding areas, just as in the rest of Germany. Since around 2005, the economy and the number of people in paid-labour positions increased significantly; whereas this positive process remained static in the Peri-urban area since, roughly, 2010. Berlin, therefore, has more than 100.000 more people in paid-labour positions; whereas Brandenburg never reached the total number of people in paid-labour positions since the time of the reunification (see AfS BB 2016a, p. 11, 2016b, p. 11).

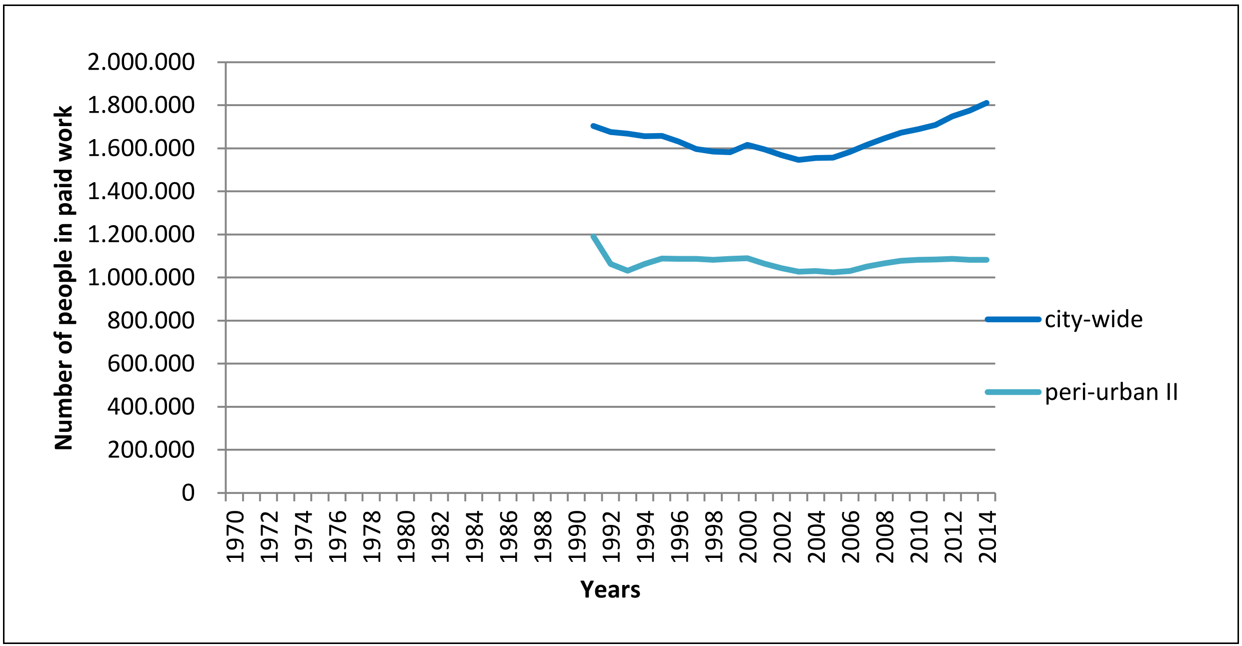

Figure 3-9: Development of the total number of people in paid labour (at place of labour) by area type
Source: SenStadtUm based on AfS BB 2016a, p. 11, 2016b, p. 11

Both in Berlin and in Brandenburg, most people in paid-labor worked in the tertiary sector (see Figure 3-10). After the reunification, merely 7 % of the people in paid-labor positions in Brandenburg worked in the primary sector. In 2014, this share decreased to 2.8 %. The share of people working in the secondary sector intensely decreased in Brandenburg by more than 35 % and in Berlin by more than 50 %. In 2014, 87.8 % of the people in paid-labor positions in Berlin and 74.4 % of the people in paid-labor positions in Brandenburg worked in the tertiary sector. This is an increase of nearly 20 % and 30 %, respectively (see AfS BB 2016a, p. 11, 2016b, p. 11).

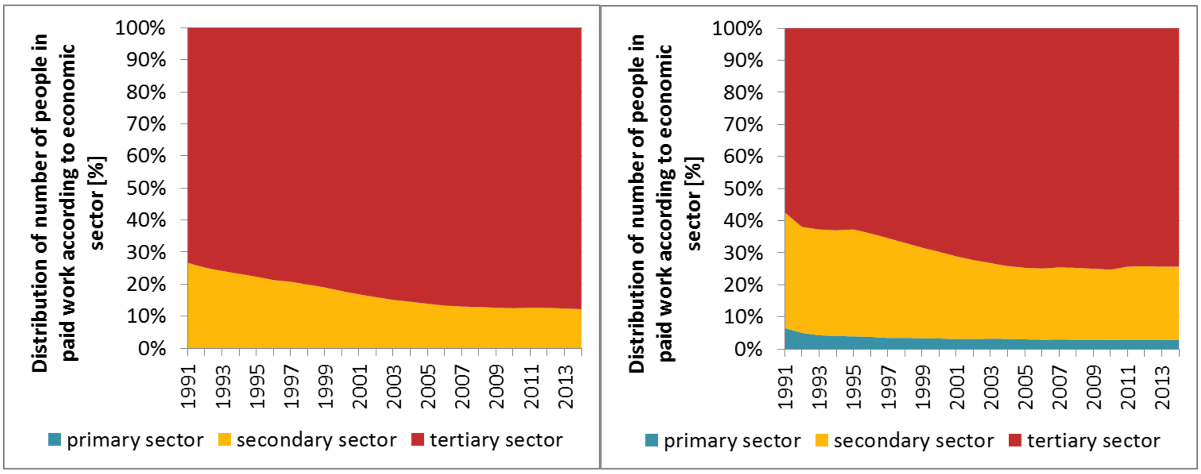

Figure 3-10: Development of the distribution of workplaces according to economic sectors (left Berlin/city-wide, right Brandenburg/Peri-urban II)

Source: SenStadtUm based on AfS BB 2016a, p. 11, 2016b, p. 11

3.2.7 GDP per capita

Due to the reunification no data before 1990 are available concerning GDP per capita. After the reunification, the State of Berlin and Brandenburg showed enormous differences in the GDP per capita, with Berlins GDP per capita being twice as high as the GDP in Brandenburg (see Figure 3-11). Therefore, Brandenburg achieved an enormous increase in the GDP per capita until the beginning of the 21st century, whereas, the GDP per capita in Berlin increased moderately during this period. After a decrease until 2004/2005 due to the aftermath of a Germany-wide stagnation of economy, the GDP per capita increased very similarly both in Berlin and in Brandenburg from 2005 onwards. Berlin's GDP per capita in 2014 was more than € 31,000, and the citizens of Brandenburg had a GDP per capita of more than € 23,000. From 1996 forward, the harmonized consumer price index for Germany increased from 76.2 % (of the 2014 100 % value) with a short pause in 2009 at 92 %, reaching 100 % in 2014 (see Figure 3-11).

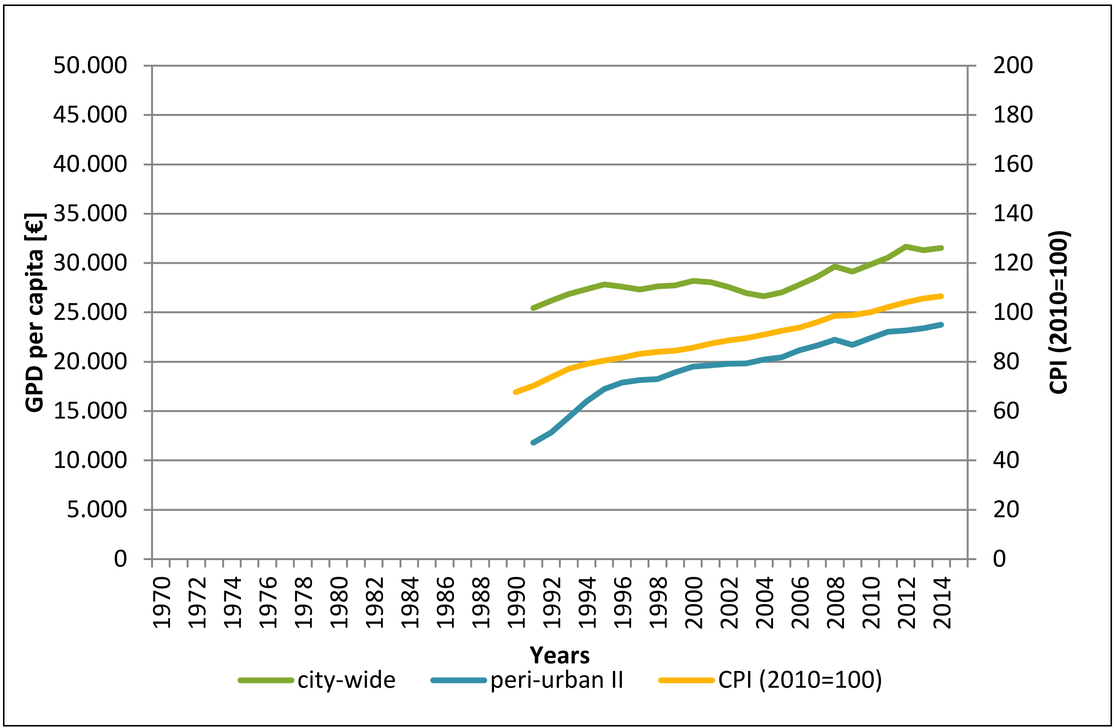

Figure 3-11: Development of the GDP per capita [€/capita]

Source: SenStadtUm calculation based on AfS BB 2016f, Tab. 15-16 & 23-24, Destatis 2016

3.2.8 Tourism

Tourism became an increasingly more important commercial sector for the capital region of Berlin over the last 23 years with strong impacts on other related commercial sectors and the transport system. Due to reunification, no data prior to 1992 are available for either Berlin or Brandenburg (Peri-urban II area). Since the reunification, the numbers of visitors and available beds in accommodations has seen a massive increase with more than twice as many visitors and available beds in 2015 compared to 1992 (see Figure 3-12).

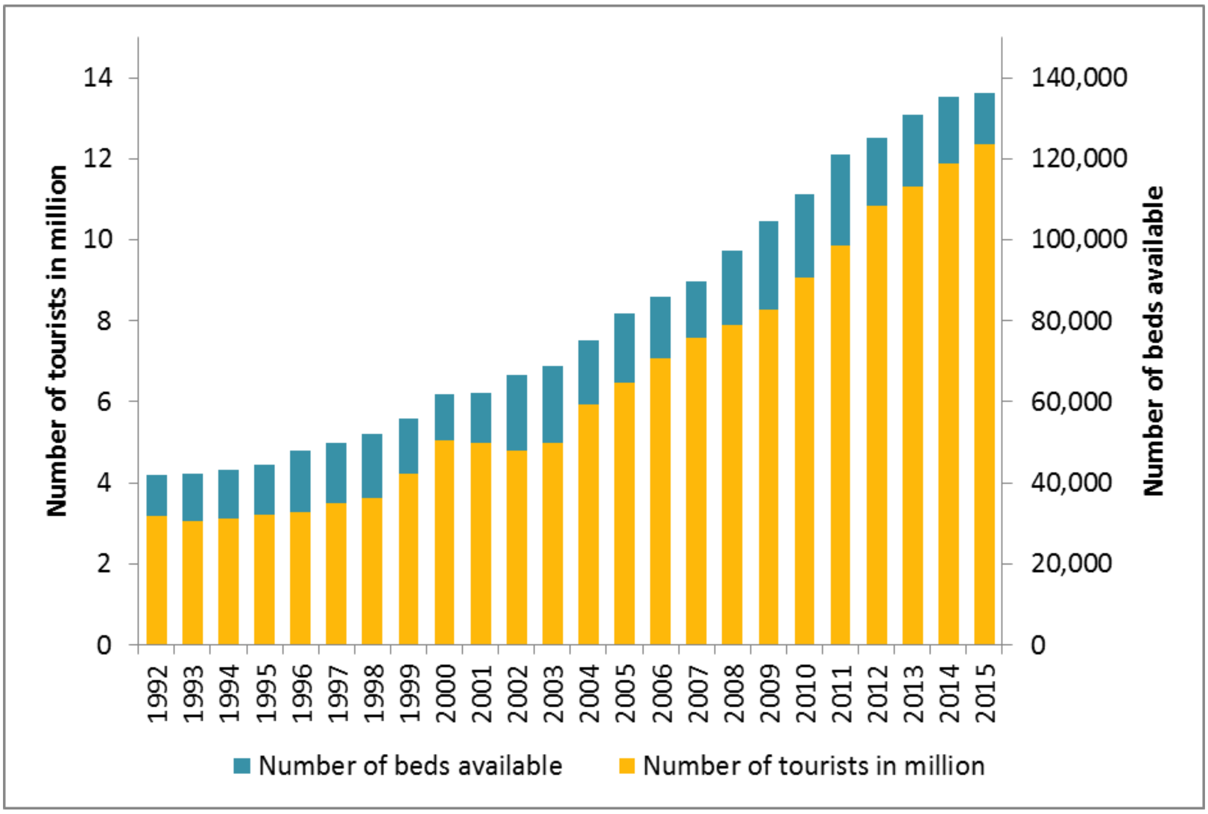

Figure 3-12: Development of the number of tourists and available beds in accommodation facilities in Berlin

Source: SenStadtUm based on AfS BB 2016e

The increase in the number of available beds and in the number of visitors rose almost simultaneously between 2001-2003, in which the number of visitors slightly decreased due to a crisis in worldwide tourism after the 9/11 terrorist attacks in the USA (see Langer 2010, pp. 36–39). Since 2004 the number of visitors increased again to more than 12 million visitors in 2015 (see Figure 3-12). The number of overnight stays increased in the same period from about 7,9 million in 1992 to more than 30 million in 2015 (see AfS BB 2016e). Most of the accommodations are located in the inner-city boroughts Mitte and Friedrichshain-Kreuzberg and in the western city borough Charlottenburg-Wilmersdorf. These 3 boroughs also have the most number of visitors and overnight stays (see AfS BB 2006-2015). Compared to the rest of Germany, Berlin is by far the most visited city area (see Langer 2010, pp. 36–37). Similar to Berlin, tourism in Brandenburg gained importance for the local economy, but with much fewer dynamics and less volume (see Figure 3-13).

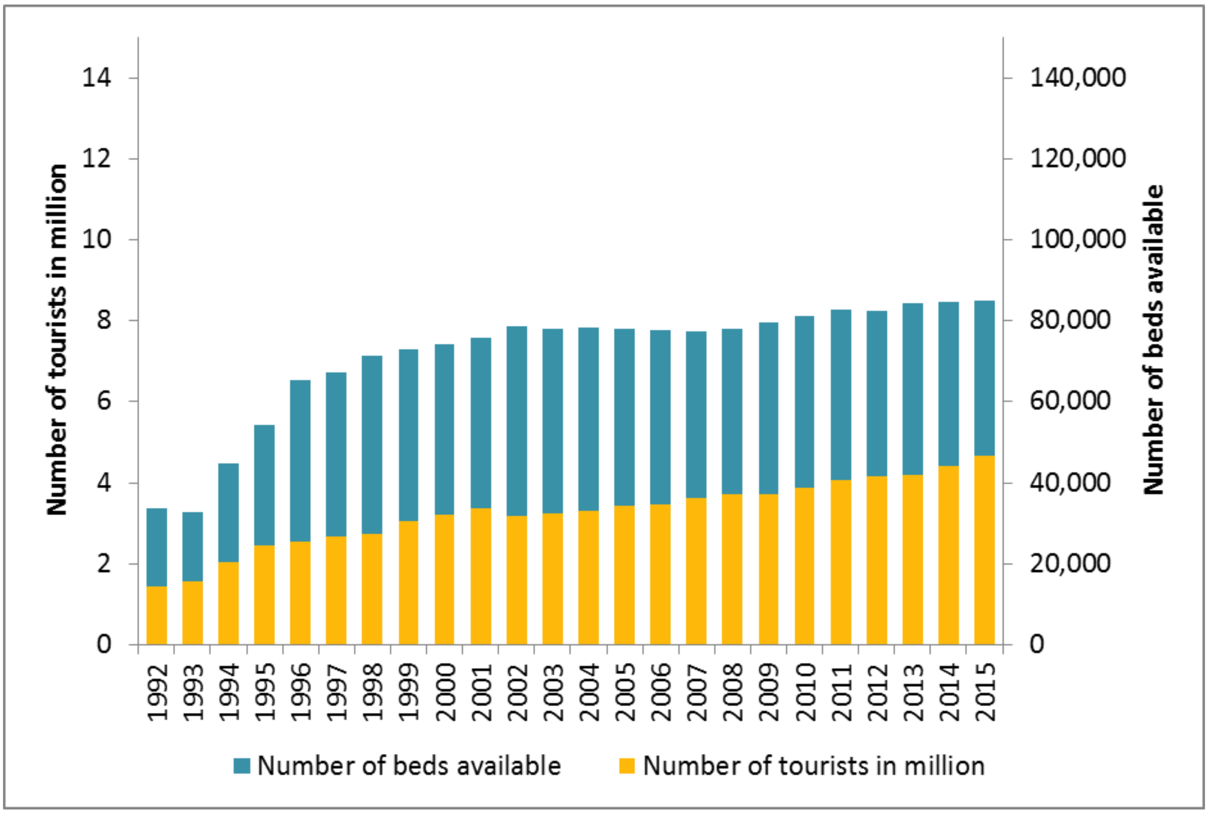

Figure 3-13: Development of the number of tourists and available beds in accommodation facilities in Brandenburg

Source: SenStadtUm based on AfS BB 2016e

Subsequent to the reunification, the number of available beds increased quickly: from around 33,000 in 1992 to more than 70,000 in 1998. In contrast, the number of visitors increased at a much slower rate: from less than 1.5 million in 1992 to more than 4.6 million in 2015. Similar to Berlin, the number of visitors dropped slightly after 9/11 but witnessed a moderate increase in the following years (see Langer 2010, pp. 38–39).

Whereas in Berlin, more than half of the available accommodation facilities are solely in hotels, the most available accommodation facilities in Brandenburg are divided between camping sites (more than 34 %) and hotels (27 %) (see Langer 2010, pp. 36–39).

3.2.9 Number of students (university/college)

Higher education has changed both in the capital region and the rest of Germany since the reunification. Many new universities and technical colleges were founded. Most of the degrees were changed to bachelor and master programs, and enrolment increased (see Figure 3-14 & Eltfeld 2011, pp. 41–45).

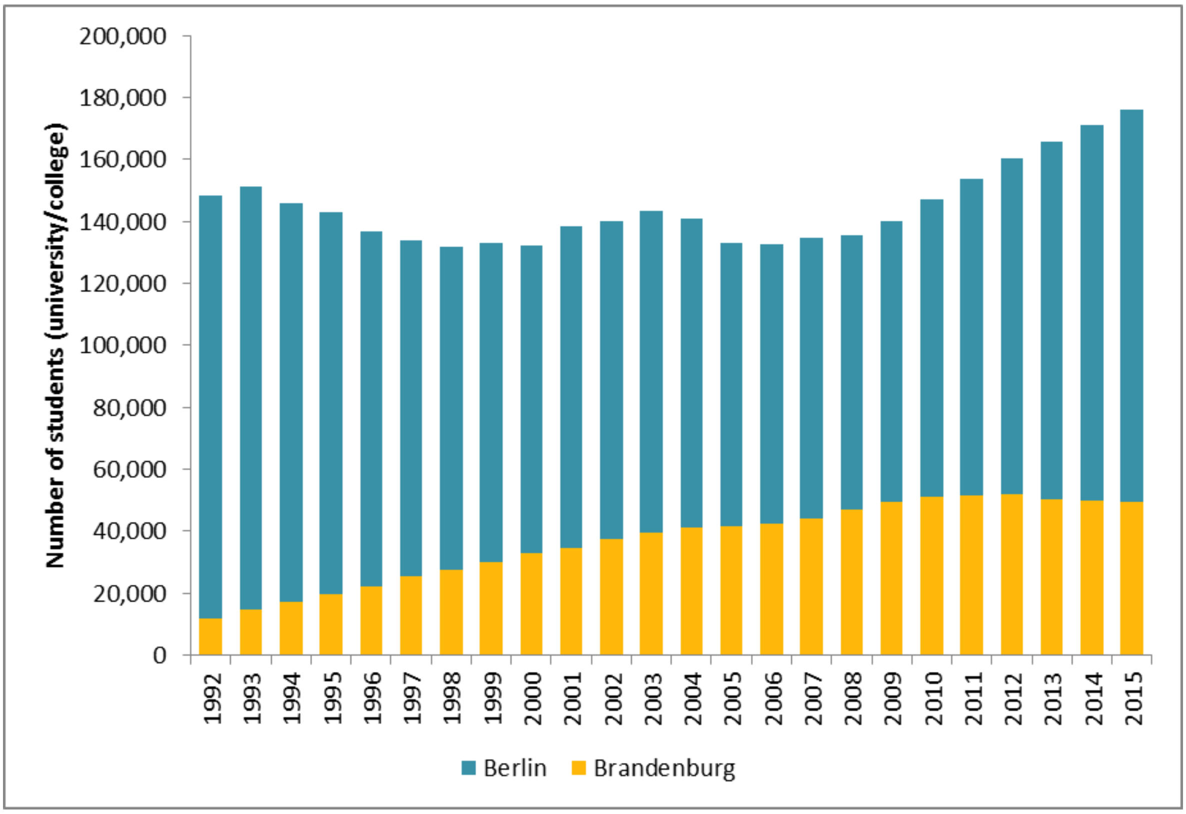

Figure 3-14: Development of the number of students (university/college) in Berlin and Brandenburg
Source: SenStadtUm based on AfS BB 2016c

After the reunification and the drop in total pollution leading up to 2002 in Berlin, the number of enrolled students decreased from about 150,000 in 1992/93 to about 130,000 in 2000. Additionally, there was a reduction of the budgets for all public universities and technical colleges. Besides a peak between 2001 and 2004, the number of students remained steady until 2008. This changed from 2009 onwards, with a constant rise from 140,000 students to more than 175,000 students in 2015. The total number of inhabitants in Berlin increased similarly during the same time period (see Figure 3-6 & Figure 3-14). Most students were enrolled in universities, whereas the number of students at technical colleges more than doubled since 2002 with the foundation of many new colleges (see Eltfeld 2011, pp. 41–42; AfS BB 2016c).

Leading up to 2008, Brandenburg's enrolment numbers continued to increase from around 12,000 students to nearly 47,000 students (more than three times more students). This increase continued from 2009 to 2012. Since 2013, the number of students registered in Brandenburg has been decreasing yearly. Again, this development is mirrored by the overall decreasing number of inhabitants and, especially, of young adults in Brandenburg (see Figure 3-14 & AfS BB 2015c, Tab. 01.15).

4 Transport supply

4.1 Road infrastructure and parking

Berlin's road network contains several high-speed motorways, a wide network of main streets and roads, a very dense network of minor side streets and a high density of low speed zones as well as some recreational streets. Most motorways have a maximum speed limit of 80 km/h with some sections reduced to 60 km/h. The main roads mostly have a speed limit of 50 km/h which is higher in some streets outside of populated areas. Minor roads within the city usually have a speed limit of 30 km/h.

4.1.1 Road network

Table 4-1: Speed limits according to types of infrastructure (Berlin)

Type of infrastructure	Speed limit (max. allowed speed)
Motorways	Mostly 80 km/h, some sections with 60 km/h
Main streets and roads (except motorways, within city limits)	Mostly 50 km/h, higher for some roads outside of densely populated areas, some sections with 30 km/h
Side streets and roads (within city limits)	30 km/h
Low-speed zones (e.g. areas with max. 30 km/h, shared space)	30 km/h, some recreational streets with a walking speed of 4 to 7 km/h

Source: SenStadtUm

Due to changes on an administrative level, no data on the length of the road network prior to 1998 is available. Until this time, many infrastructure projects on the enlargement of the road network were already finished. The length of the road network in Berlin is grouped in two ways: either it is based on data, provided by each borough, which distinguish between roads under federal control (motorways and federal roads) and non-classified roads (side streets and roads), or it is based on the local-linkage function level within the main road network (SenStadtUm responsible) and the side road network (boroughs responsible). Only a long term analysis, based on the first classification, is possible. Side streets and roads (non-classified roads) make up the highest proportion of the total road network. In 1998, almost 5,000 km of the about 5,200 km road network of Berlin were side streets (see Figure 4-1).

The length of the side street network increased up to 5,300 km until 2014, while the length of the total network increased to more than 5,500 km. In the same period, the length of the motorway network grew from about 63 km to 76.7 km; the length of the federal roads went down from 189.2 km to 169 km (see Figure 4-1).

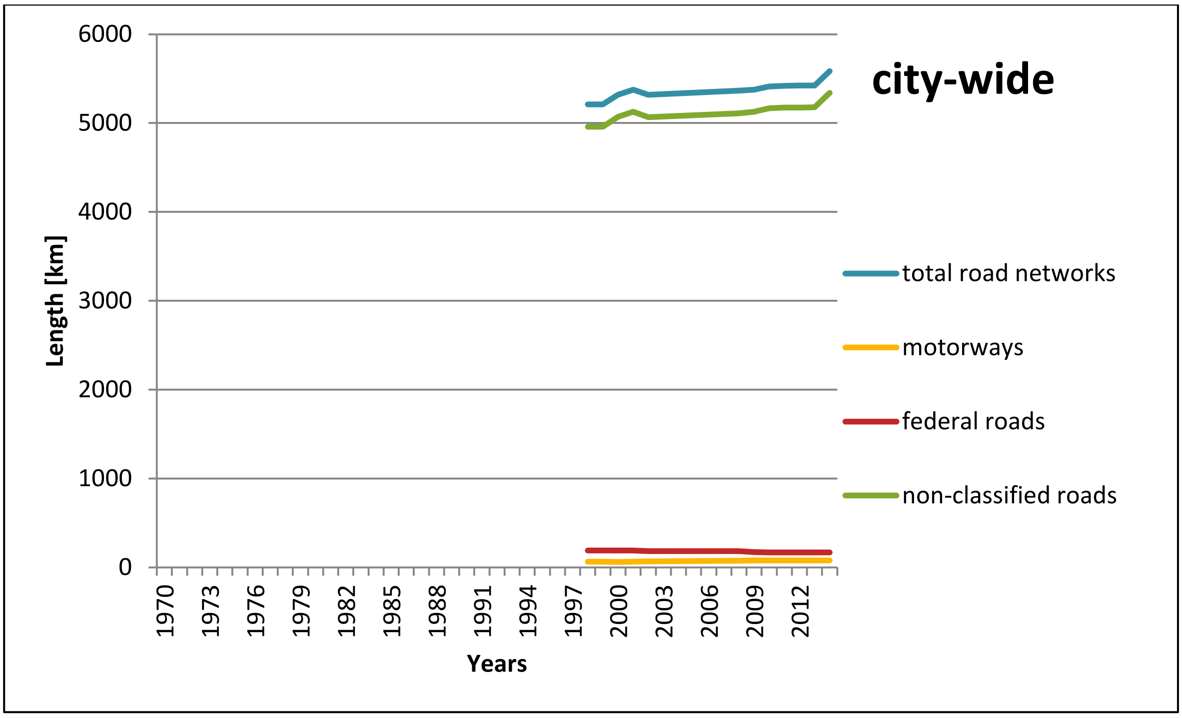

Figure 4-1: Development of length of road network (not considering multiple lanes) [km]
Source: SenStadtUm based on SenStadtUm 2001-2014; AfS BB 2006-2015

The development of low speed zones with a speed limit on 30 km/h cannot be analysed during this period due to changes on administrative level in responsibility. There are two different types of low speed zones or roads in Berlin. First, the standard speed limit in the feeder network or minor roads is set to 30 km/h. Currently, 70-75 % of the total road network in Berlin (without motorways) can be considered part of low-speed zones. Second, about 17 % of the main roads have at least a temporal speed limit of 30 km/h due to safety and noise reduction reasons (see SenStadtUm 2014b, pp. 22–23).

4.1.2 Parking space

The number of on-street parking lots is not measured in Berlin. This information is only compiled when surveys are to be carried out in identified potential management areas. During these surveys, the number of parking lots is collected within these areas. The number of off-street car parking lots has been collected for shopping centres and specific operators by the VIZ online platform (Centre for traffic information) on behalf of SenStadtUm (see VIZ Berlin 2016).

There are no data concerning the searching time for a parking space in Berlin, and, although there is no quantitative measuring of the parking spaces in Berlin, a qualitative estimation is possible. Since the reunification, the number of parking spaces on private ground increased due to development areas and housing projects (especially for shopping centres, supermarkets and underground car parks). Simultaneously, the number of available parking spaces on public ground (on-street parking) decreased due to the implementation of bus lanes, bicycle lanes and changes in street design. Currently, new demands for on-street infrastructure are merging, such as carsharing- and bike-sharing stations, changeover stations, and zones for delivery. Most of these services focus on the inner-city areas with a high level of competition for the use of public space.

4.2 Public transport, taxi supply and car-sharing

4.2.1 Public transport network

Berlin's local public transport network consists of several (mostly) integrated systems with a very long and dense network infrastructure. These systems include the Metro (U-Bahn) and S-Bahn (urban rail systems), regional railway services, a tramway system, a bus network and a number of ferry services. There is also a large number of common interchange stations between the different modes of transportation. The public transport network, in its current layout, is product of more than 150 years of network development. Most regional and inner-city rail connections and most inner-city U-Bahn conceptions were built up to the beginning of the Second World War. After the destruction of large parts of the inner-city and the transport network, the network was gradually reopened after the war. Due to the separation of Berlin, the transport networks were also divided and began to develop in different directions, creating, over time, two almost completely separate networks. In West Berlin all tramways were removed and were replaced with a bus network as well as a gradually developed and wide spread U-Bahn network. The S-Bahn network was closed down for political reasons in West Berlin until the mid-80s. In East Berlin, only three major rail projects were finished in order to connect newly-built large housing estates. In the 70s and 80s, the S-Bahn network was expanded[4], but only one U-Bahn extension was realised[5]. In contrast to West Berlin, the tramway network was resorted and enlarged.

After the reunification, several infrastructure projects were developed to restore the S-Bahn network to its layout before the construction of the Berlin Wall. In addition, small expansions of the U-Bahn network and the reintroduction of the tramway in former West Berlin were realised (see Kalender 2012, pp. 313–544).

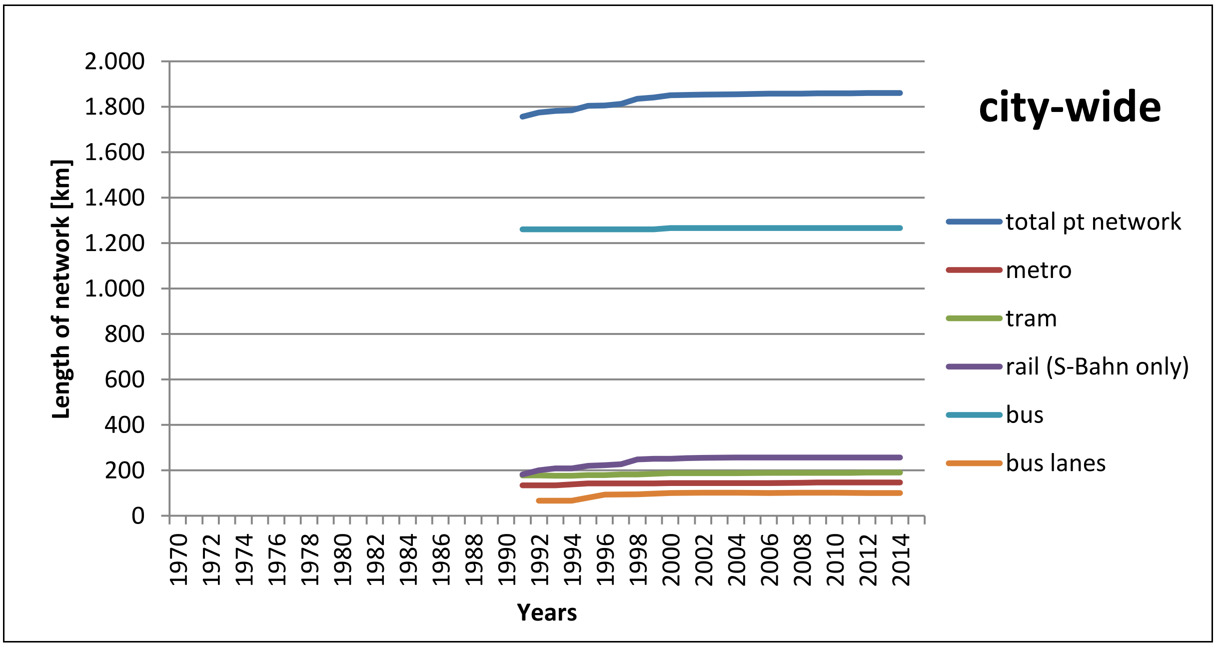

Figure 4-2: Development of the length of public transport network by mode (length of infrastructure of all urban lines in regular service on weekdays) [km]
Source: SenStadtUm based on SenStadtUm 2001-2014; CNB 2016b

[4] The S-Bahn to Marzahn and Hohenschönhausen.

[5] The U5 from Tiergarten to Hönow.

In total, the length of the PT network increased from around 1,750 km in 1991 to almost 1,900 km in 2012. Most of this increase was caused by the reconstruction of the S-Bahn network. One of the most import projects was the gradual reopening of the S-Bahn-ring (circular line) leading up to 2002. The S-Bahn network currently contains of more than 250 km of tracks. It started 1991 at 182 km. With some distributed projects and 1 major project reintroducing the tram in former West Berlin the tramway network increased from a total length of 178.3 to 191.2 km. The length of the Bus network is difficult to count due to several adjustments to the bus routes. Easier to measure is the increase in the length of dedicated bus lanes from under 70 km in 1991 up to more than 100 km today. Beside smaller extensions the U-Bahn network shows only a slight increase in length from of around 10 km from 134.5 to 146.3 km (see SenStadtUm 2001-2014 & Figure 4-2).

4.2.2 Public transport supply

Public transport is the first choice for many people in Berlin - more than a quarter of all daily trips are made with public transportation. Most of the trips to work (38.7 %) and to education (31 %) are realised with the public transport. 34 % of all routes to and from Berlin are realised by train and bus. Public transport, therefore, is of great importance for the increasing number of commuters (see SenStadtUm 2014b, p. 15).

Unfortunately, data on the development of the public transport service supply for all systems in Berlin are only available from 2004 onwards (see Figure 4-3). The service supply decreased in this period sharply, which was mainly due to the BVG strike of 2008. By 2014, the total scheduled (offered) public transport service supply nearly reached the values of 2004. The S-Bahn service supply did not change despite the so called S-Bahn-crisis, since only the planned annual mileage is regularly documented (which consistently was at about 29 million used-train-km). With the U-Bahn and the buses, the service supply gradually increased slightly from 2009 onwards.

The U-Bahn service supply increased from 20.1 in 2009 to 21.18 million used-train-km. The bus service supply increase from 87.6 to 88.46 million used-coach-km per year. The tram service supply, however, has been reduced (from 21 to 19.28 million used-train-km). Since 2015, the scheduled service supply for bus, tram and U-Bahn-service was increased with tighter time tables due to rapid population growth (see SenStadtUm 2001-2014; CNB 2016b).

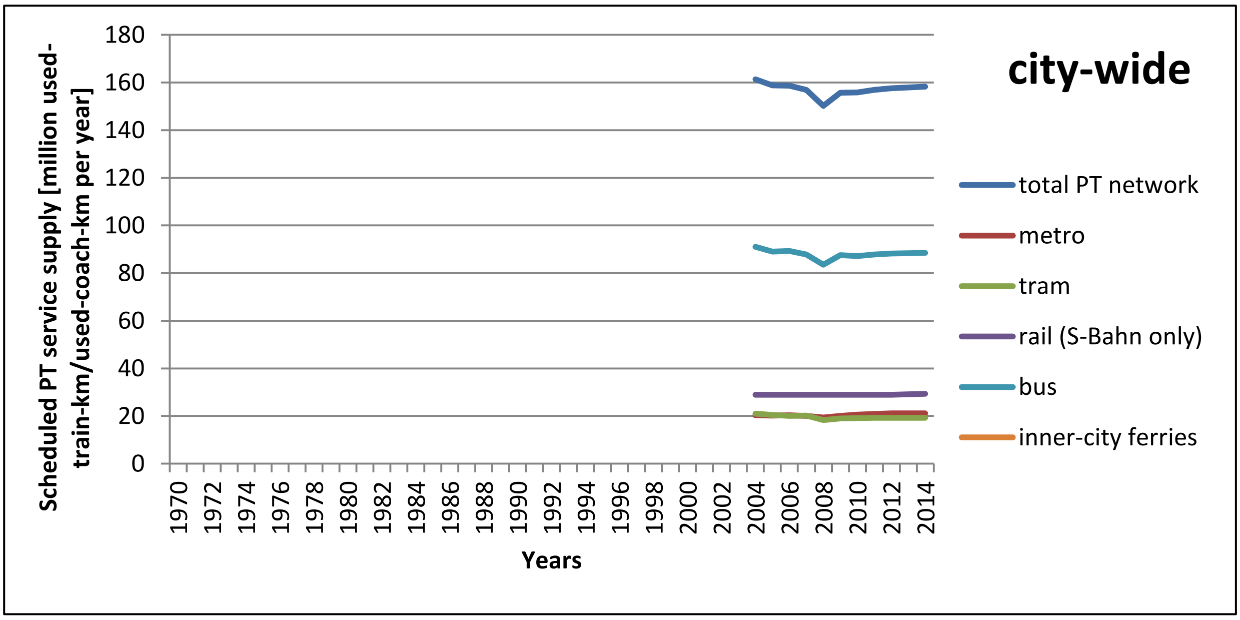

Figure 4-3: Development of the scheduled (offered) public transport service supply, all types [million seat-km per year]

Source: SenStadtUm based on SenStadtUm 2001-2014; CNB 2016b

Currently there are two major PT operators in Berlin for the local traffic, the S-Bahn Berlin and the BVG with its bus-, tram- and U-Bahn-network.

The S-Bahn Berlin is a rail-based rapid transit system. It mostly operates in Berlin and its surrounding suburbs. Later, the Berlin U-Bahn was built partly to complement the S-Bahn system and to improve the inner-city connections. The S-Bahn started as a special tariff "Berliner Stadt-, Ring- und Vorortbahnen" for the separated cross-city, circular, and suburban railways in 1920. The system was the backbone of Berlin's development into a metropolis of the industrial age and built to connect the outskirts and suburbs of Berlin with the city centre. Before that, the separated commuter lines, cross-city liens and the circular line had been operating since the mid and late 19^{th} century. In 1930 the services were combined and the S-Bahn Berlin was created. After the First World War, little by little the steam-drawn system was converted into a fully electrified system using third-rail electrical power transmission. The S-Bahn labelling is used in many parts of Germany and other German-speaking countries. The only other German heavy rail system using third-rail electrification is the S-Bahn Hamburg.

After the construction of the Berlin Wall, the S-Bahn was operated in two separate subnetworks of the Deutsche Reichsbahn (DR), the national railway company of the GDR (German Democratic Republic), both in East and West Berlin. This and the construction of the Berlin Wall led to West Berlin politicians to call for the boycott of the S-Bahn. As a result, passenger numbers fell dramatically until the early 80s. In December 1983, the BVG took over the operating rights of the S-Bahn in West Berlin based on an agreement between the Deutsche Reichsbahn and the Senate of West Berlin. Due to necessary investments less important lines had to be closed. With the opening of the Berlin Wall in November 1989 and the reunification, most links were re-established. After the reunification, BVG and Deutsche Reichsbahn operated the services together until 1994. Administratively, the divided S-Bahn networks remained separate until 1994. DR and BVG (absorbing BVB of East Berlin in 1992) operated different lines end to end despite the former party's territories or parts of Berlin. In 1994 the DR and the former West Germany's Deutsche Bundesbahn merged into the Deutsche Bahn. The S-Bahn was then operated by the newly formed S-Bahn Berlin GmbH as a subsidiary of Deutsche Bahn, and the BVG withdrew from running S-Bahn services. Step by step broken links were re-established in order to restore the S-Bahn network to its 1961 status. In 2002, the re-establishing of the important S-Bahn-ring was finished, the circular service was re-introduced in 2006 (see Kalender 2012, pp. 381-386, 459-471, 518-525; SenStadt 2007, pp. 169–171).

As the S-Bahn Berlin service today is appointed via the VBB, it has no own tariff system any more (see SenStadtUm 2014c, p. 20). The transport service is currently appointed and controlled by the Senate Department for Urban Development and the Environment. The S-Bahn Berlin GmbH is a 100 % subsidiary of the Deutsche Bahn AG and organised under the DB Regio AG. Currently the S-Bahn operates 15 lines and 166 stations (see SenStadtUm 2014c, p. 8, 2014b, pp. 46–49; CNB 2016a).

The Berliner Verkehrsbetriebe (Berlin Transport Company, short still BVG) is the main public transport company of Berlin. It operates the city's U-Bahn- (underground railway), tram-, bus- and ferry-networks. The abbreviation BVG is used generally and comes from the company's original name, Berliner Verkehrs Aktiengesellschaft (Berlin Transport Corporation). Later the company was renamed Berliner Verkehrsbetriebe. During the division of Berlin, the BVG was split into the BVG (Berliner Verkehrsbetriebe Gesellschaft - West Berlin) and the BVB (Berliner Verkehrsbetriebe - East Berlin or. Kombinat Berliner Verkehrsbetriebe (BVB)). The current formal name was re-adopted after the reunification. The BVG is owned by the Federal State of Berlin. It has a steering committee headed by the current Senator of Finance. The transport service is appointed and controlled by the Senate Department for Urban Development and the Environment (see Kalender 2012, pp. 213-221; 362; 537-539; CNB 2016a).

The Berliner Verkehrs Aktiengesellschaft (BVG) was formed in 1928, by merging the private operator of the city's buses, with the private operator of the U-Bahn and the public operator of the city's trams (see Kalender 2012, pp. 213–221). The tram network includes regular and Metro tram lines; the bus network includes regular and Metro bus lines. The U-Bahn now covers nine lines with 173 stations and a total length of 146.3 km. The tram network with its 22 tram lines and 377 stops has a length of 191.2 km. 9 of these tram lines are part of the Metro network, which provides a high quality service for areas with no or thin U-Bahn and S-Bahn services. These Metro tram lines have an M prefix to their route number and are the only tram routes operating 24 hours a day. For a long time, the remaining network was within the boundaries of the former East Berlin, since all the routes in the former West Berlin were abandoned and replaced by busses and, on some branches, with U-Bahn lines during the period of the city's division. However, there have been some extensions of routes across the former border since reunification, most remarkably to the city's new main railway station Berlin Hauptbahnhof (lines M5, M8 and M10). The Bus network consists of 149 daytime bus routes serving 2,634 stops. By night there is a night bus network of 63 bus routes with around 1,500 stops. Currently 17 of the BVG bus routes are part of the Metro network. Like the Metro tram routes, these Metro bus routes can be recognised by an M prefix to their route number. Furthermore, 13 BVG-operated bus routes are express routes with an X prefix to their route number. Currently 6 passenger ferry routes are operated by the BVG (see SenStadt 2007, pp. 22–26, SenStadtUm 2014c, pp. 94–106, 2014b, pp. 46–55).

Service frequency per public transport type (average and peak time)
In Berlin, the PT rush hour, non-busy period, period of low traffic intensity and night service are defined differently according to the two main operators and the day of the week (see Table 4-2 &

Table 4-3).

Table 4-2: Times of service for U-Bahn, tram and bus (BVG)

Category	Monday – Friday [am/pm]	Saturday [am/pm]	Sunday [am/pm]
Service time	04.30/05.30 am until 00.30/01.00 am	05.30/07.00 am until 01.00 am	07.00/08.00 am until 00.30 am
Period of low traffic intensity	04.30/05.30 am until 06.00/06.30 am	05.30/07.00 am until 10.00 am	07.00/08.00 am until 00.30 am
Peak time	06.00/06.30 am until 09.00 am	./.	./.
Non-busy period	09.00 am until 02.00 pm	10.00 am until 06.00/08.00 pm	./.
Peak time	02.00 pm until 07.00 pm	./.	./.
Non-busy period	07.00 pm until 09.00 pm	./.	./.
Period of low traffic intensity	09.00 pm until 00.30/01.00 am	06.00/08.00 pm until 01.00 am	./.
Night service	00.30 am until 04.30/05.30 am	01.00 am until 05.00/05.30 am (Night between Fri/Sat)	01.00 am until 07.00/08.00 am (Night between Sat/Sun)

Source: SenStadtUm based on SenStadtUm 2014c, p. 32

Table 4-3: Times of service for S-Bahn

Category	Monday – Friday [am/pm]	Saturday [am/pm]	Sunday [am/pm]
Service time	04.00 am until 01.00 am	05.00 am until 01.00 am	07.00 am until 01.00 am
Period of low traffic intensity	04.00 am until 06.00 am	05.00 am until 07.00 am	07.00 am until 09.00 am
Peak time	06.00 am until 09.00 am	./.	./.
Non-busy period	09.00 am until 02.00 pm	07.00 am until 08.00 pm	09.00 am until 08.00 pm
Peak time	02.00 pm until 07.00 pm	./.	./.
Non-busy period	07.00 pm until 09.00 pm	./.	./.
Period of low traffic intensity	09.00 pm until 01.00 am	08.00 pm until 01.00 am	08.00 pm until 01.00 am
Night service	./.	01.00 am until 05.00 am (Night between Fri/Sat)	01.00 am until 07.00/08.00 am (Night between Sat/Sun)

Source: SenStadtUm based on SenStadtUm 2014c, p. 31

Minimum intervals are defined for each PT mode individually (see Table 4-4).

Table 4-4: Minimum intervals during traffic periods by PT mode

PT mode with basic service [minutes]	Minimum intervals during traffic periods [minutes]			
	peak time	**non-busy period**	**period of low traffic intensity**	**night service**
S-Bahn [20]	10	20	20	30/60 only on weekends
U-Bahn [10]	10	10	10	15/30
Metro lines (bus/tram) [10]	10	10	20	30
Bus/tram [20]	20	20	20	30
Local trains [60]	60	120	120	./.

Source: SenStadtUm based on SenStadtUm 2014c, p. 32

Delays in and the reliability of PT systems alongside with the PT customer satisfaction are important indicators for the PT-performance and service quality.

The quality of the PT-performance in Berlin is measured by the key indicators reliability and punctuality for each PT-operator. The PT-performance and customer satisfaction is measured since 2005 for the S-Bahn Berlin (see Figure 4-4). A punctual ride for the S-Bahn is defined as following: A train, which delays no shorter than four minutes from departure time, is considered punctual.

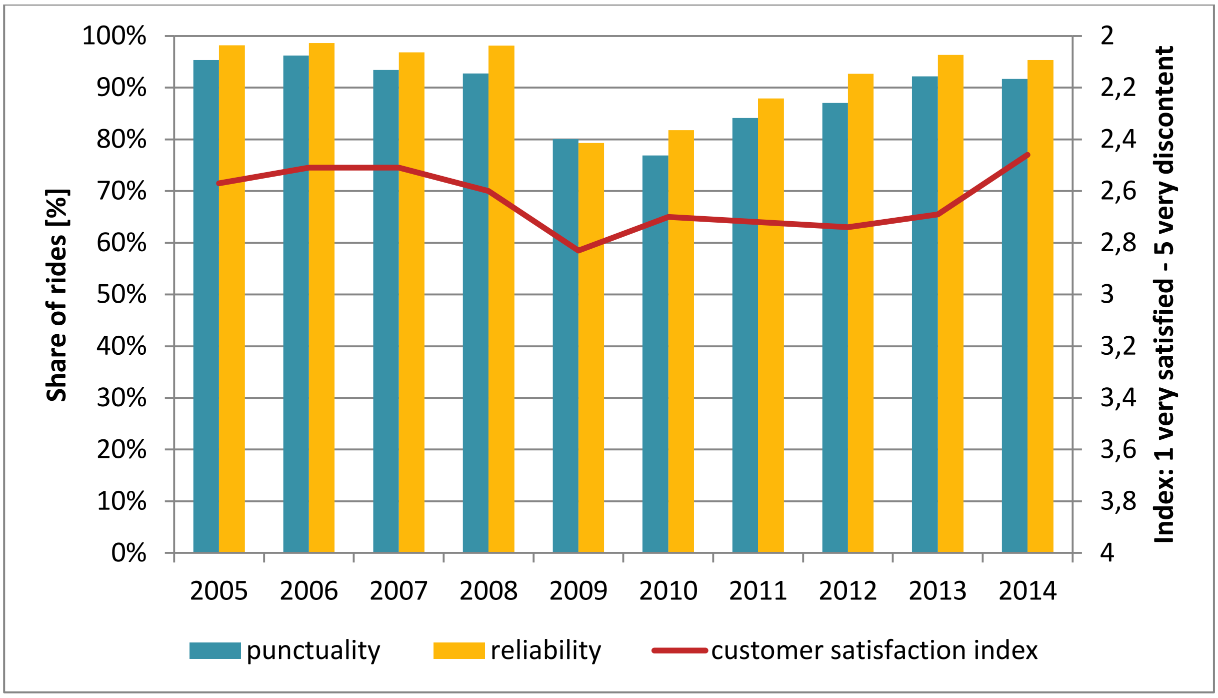

Figure 4-4: PT-performance and customer satisfaction for the S-Bahn Berlin, 2005-2014
Source: SenStadtUm based on VBB 2006-2015

Figure 4-4 reflects the effects of the S-Bahn crisis from 2009 until 2012. Both the punctuality and reliability rate fell from values above 90 % to a punctuality and reliability rate below 80 %. Thus, the customer satisfaction index fell to 2.8. Slowly, the performance of the S-Bahn increased from 2010 to 2013 to values above 90 % performance-rates. In 2014, the customer satisfaction was nearly good again.

The punctuality and reliability can also be analysed for the BVG from 2009 until 2014 for each the U-Bahn-, tram- and bus-service (see Figure 4-5). For the BVG, a different definition of a punctual ride was specified: A service is considered punctual, if the departure is no less than one and a half minute before or no less than three minutes after the scheduled departure time.

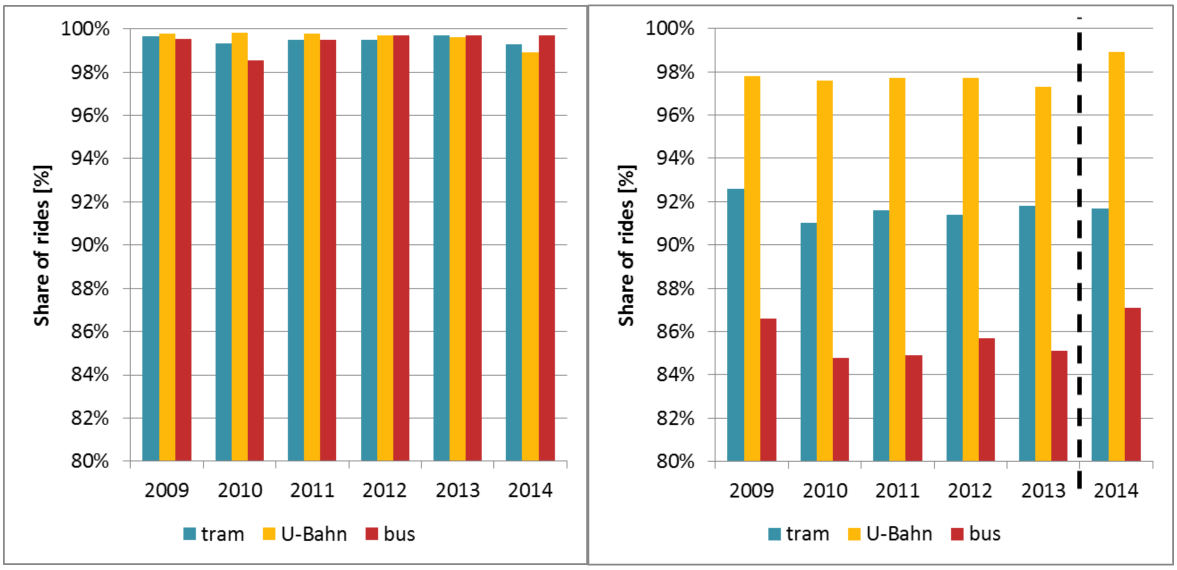

Figure 4-5: PT-performance for the BVG, 2009-2014 (left reliability, right punctuality rate)
Source: SenStadtUm based on VBB 2006-2015

All systems show a rather undisturbed high reliability rate above 98 %, whereas the punctuality rates differ. The U-Bahn is the most punctual service with usual rates above 97 %. The second most punctual service is the tram, with an acceptable punctuality rate around 92 %. For the bus service, the share of punctual rides with only 85-87 % is poor. Several measures (e.g. extension of PT-prioritization) were set up to improve the punctuality of tram and especially bus services. Due to a change in measuring and counting punctual rides, the values in 2014 are hardly comparable to previous years (see Figure 4-5 & SenStadtUm 2016a, p. 31).

Current situation and history of pricing policy and tariffs

Before the reunification, there were two completely independent tariff systems in East and West Berlin. These separate systems had to be merged gradually after the reunification.

All PT services are coordinated by Verkehrsverbund Berlin-Brandenburg (VBB) and can be used with a common public transport tariff structure. The common tariff area for Berlin covers the city of Berlin and areas beyond the city boundaries and can be split into three zones. The central part of the city (inside the S-Bahn-ring) is considered zone A and the outer parts of Berlin City zone B. A larger area outside the city borders is covered by zone C (see Senatsverwaltung für Bauen, Wohnen und Verkehr Berlin 1999, pp. 58–59).

The VBB manages and connects the transport authorities for Berlin and Brandenburg. The federal state of Berlin is represented by the Senate Department for Urban Development and the Environment and the federal state of Brandenburg, is represented by the Ministry for Infrastructure and Regional Planning (see Senatsverwaltung für Bauen, Wohnen und Verkehr Berlin 1999, pp. 58–59; CNB 2016a).

For the whole VBB region (Berlin & Brandenburg) 42 % of the passengers use adult season tickets (abonnement, monthly tickets, Annual passes, company tickets, VBB abonnement 65+), 35 % use cash tariffs (Single tickets, multi-ride tickets (also trainees), daily and group tickets), 14 % use season tickets for trainees or students and 9 % the other (see VBB 2015, p. 7).

The ticket prices for the Berlin public transport were equalized step by step after the reunification (see Figure 4-6).

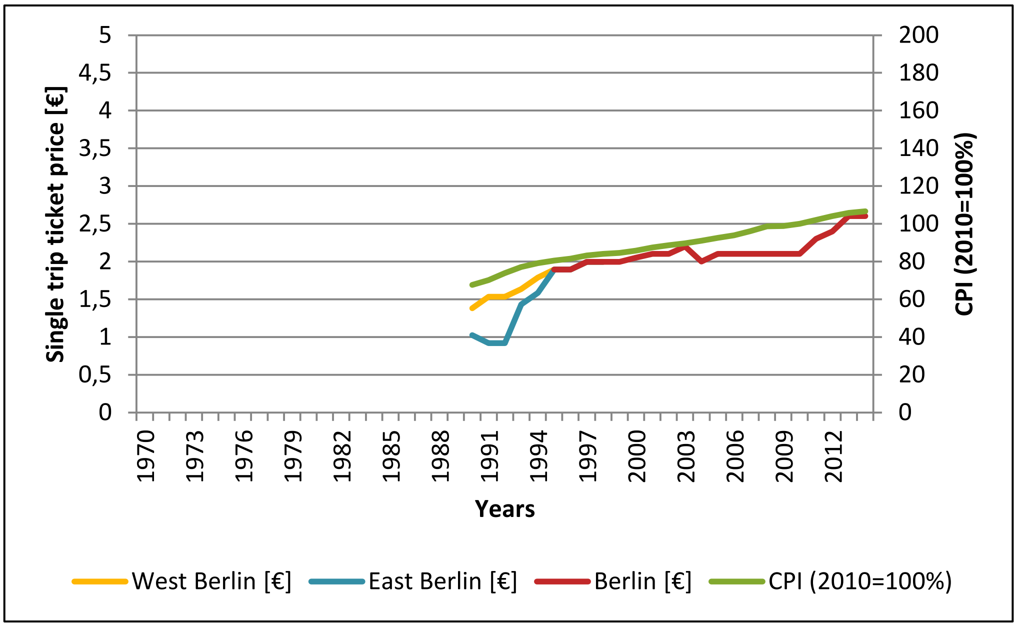

Figure 4-6: Development of the price for a PT single trip ticket (central zone) [€], not inflation-adjusted
Source: SenStadtUm based on SenStadtUm 2001-2014; CNB 2016b , Destatis 2016

From 1990 to 1992 the price of a single ticket in East Berlin was converted to EURO and set at € 1. In West Berlin, on the other hand, the single ticket already cost € 1.50. From 1995, the single ticket in the entire city was on average € 1.90. By 2010, the price remained almost constant at € 2.00 with a slight increase to € 2.10. The price then increased up to € 2.60 by 2013.

Until the mid-90s, the prices for a PT annual ticket were largely different in the former eastern and western parts. From 1997 onwards, the price increased significantly from € 475.50 to € 722.00 in 2014 (see Figure 4-7).

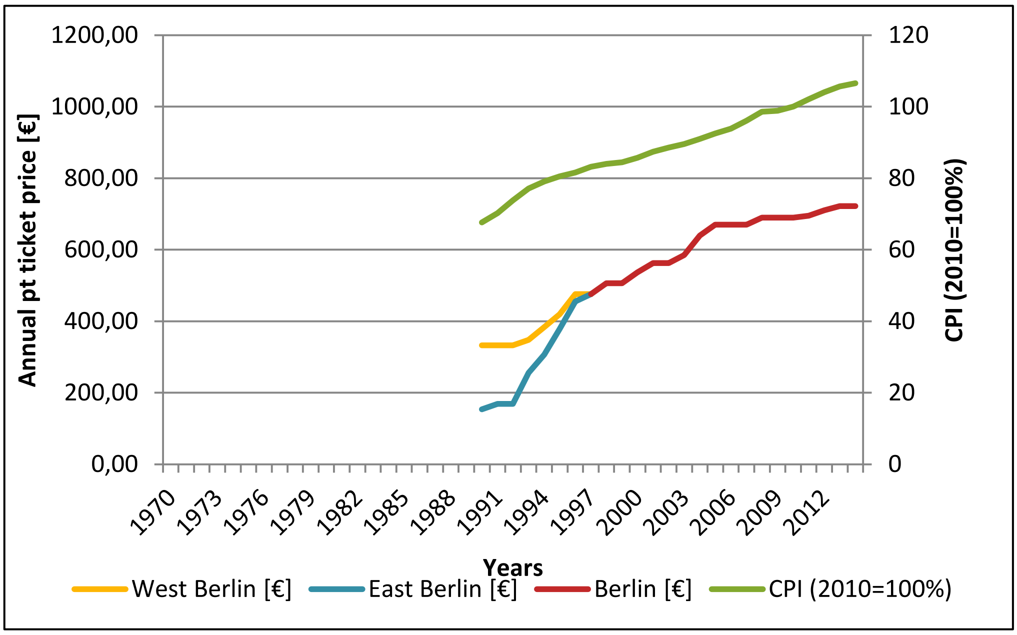

Figure 4-7: Development of the price for a PT annual PT ticket price (central zone) [€], not inflation-adjusted

Source: SenStadtUm based on SenStadtUm 2001-2014; CNB 2016b , Destatis 2016

Both the BVG and the S-Bahn provide real-time information for almost all operating vehicles through personal trip planners on their websites and smartphone applications (see BVG 2016c; S-Bahn Berlin 2016b). Both the VBB and the traffic management centre (VMZ) provide the same services on their independent platforms (see VIZ Berlin 2016).

4.3 Cycling

It must first be noted that the length of the bicycle facilities initially reveals nothing about the density of the bicycle network nor the bicycle friendliness of a city. At best it gives a rough idea of the process for completing the main roads with cycling facilities. Since 1990, the bicycle network in Berlin was increased gradually. Around 50 % of Berlin's urban area is now covered by cycling infrastructure.

Since 2012, there is a new way of measuring and counting the bicycle paths in Berlin as a result of administrative changes and changes in monitoring. According to the official new census there are currently 1,470 km of streets with accompanying bicycle facilities available in Berlin: 285.8 km of on-street bicycle lanes and protective lanes, 968.4 km of structural cycle paths on the side walk, and 216.1 km shared foot and cycle paths. Additionally, there is the Berlin Bike Main Route network for long distance cycling. The most important places of the city are linked by bike through the Berlin Bike Main Route network. Sign-posted cycle routes run primarily through quiet side streets, but also via green areas and boardwalks. Routes on major roads have safe road accompanying bicycle facilities (see SenStadtUm 2016e).

Main routes (300 km)

The current extended main route network will consist of 12 radial routes (star-shaped running routes between the city centre and the outskirts of Berlin) and 8 tangential routes. Ten of these routes were completed by 2015.

Supplementary routes

There is also the network of complementary routes that covers approximately 880 km.

Long distance bike paths (about 180 km)

Numerous Long distance bike paths such as the R1 European cycle route, the Long distance bike paths Berlin-Usedom, Berlin and Copenhagen and Berlin-Leipzig, and the Havel bike trail, Spree bike trail and the Dahme bike trail run through Berlin (see SenStadtUm 2016e).

Since 2012, the length of the bicycle network increased gradually due to investment programs for bicycle infrastructure since 2012. By 2015, the length of structural cycle paths on sidewalks increased by 4 km since 2012. During the same time, the length of the on-street bicycle lanes and protective lanes increased by more than 30 km from 253 km to 285.8 km (see SenStadtUm 2016e & Figure 4-8).

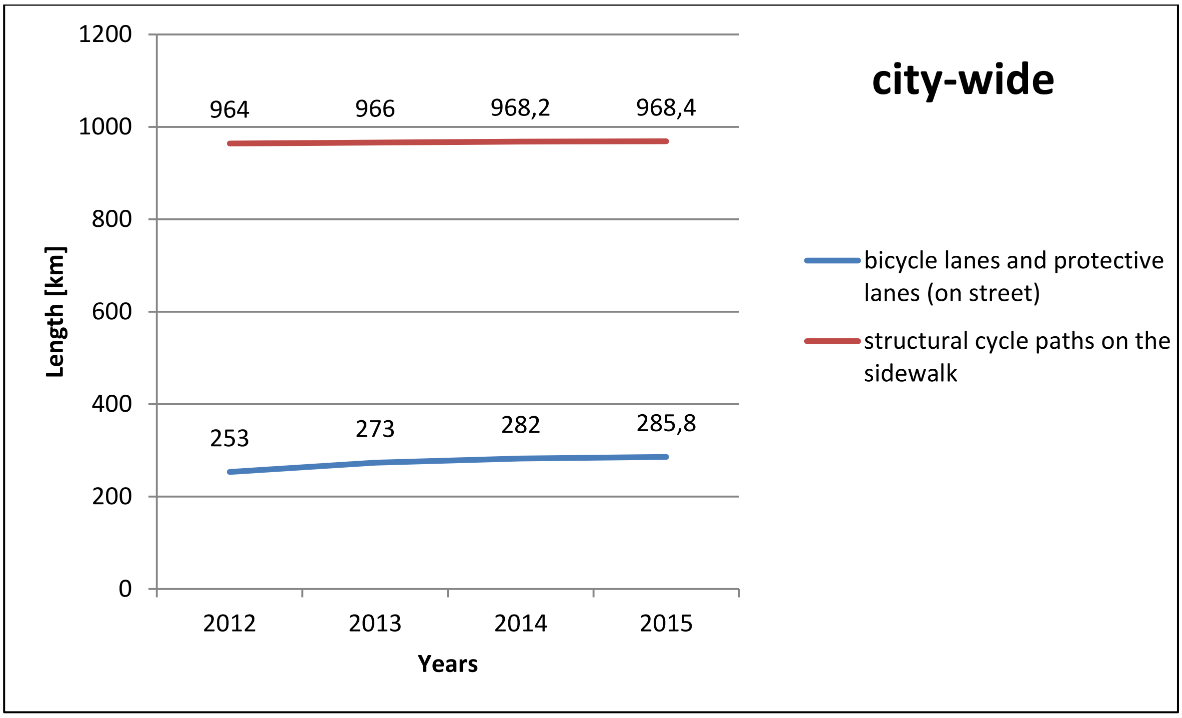

Figure 4-8: Development of the length of the city-wide bicycle lanes and structural cycle paths (2012-2015)
Source: SenStadtUm based on SenStadtUm 2016e

For a long time, no projects directed toward the optimization of bicycle transportation at crossing and traffic lights have not been a priority. In 2014 a small project with two traffic lights each per direction was installed as a small-scale test. Currently the first project has been evaluated, and tests at another location are been considered.

Until 2016, the DB Rent GmbH operates a public bicycle rental system with the system "Call a Bike - city bike for Berlin". The system is the result of a project funded by the Federal Republic of Germany in

2012. In 2013 and 2014, the State of Berlin supported the system. In addition, other Bikes system operators as well as local competitors offer rental bikes in Berlin, but not in the sense form of a developed public bicycle system. The current public bicycle rental system has established rental and drop-off locations with a high density of stations in the downtown area. Spatially, the system is concentrated in an area of approximately 88 km² inside the S-Bahn-ring to create the necessary service density with a couple of exceptions. The result is a system of 150 stations and 1,750 bikes (as of the end of 2014) in six districts of Berlin. From 2012 to 2015 the number of users increased by 10 to 40 % per year, with more than 330,000 rides and around 90,000 customers. Here, in particular, the expansion of the station network and the simplified use of processes (e.g. quick access to the bikes via a RFID customer card) did show effect.

Currently Berlin is finishing a tender for a new public supported bike sharing system with at least 175 Stations and 1,750 bikes. Within the next few years the system will be increased to 700 stations and 5,000 bikes (see Abgeordnetenhaus von Berlin 2013, 2014, 2016; SenStadtUm 06.06.2016).

4.4 Walking

There are numerous pedestrian zones in Berlin usually located in historical districts and along local shopping miles. Most of these zones were introduced in order to improve the quality of stay in district centers, to introduce local shopping miles and to reduce the negative effects of car traffic for these central areas (see SenStadtUm 2016c; Senatsverwaltung für Verkehr und Betriebe Berlin 1995, F6-F9).

4.5 Taxi supply

The change in the number of licensed taxis in Berlin can be analysed from 1995 up to 2015 (see Figure 4-9).

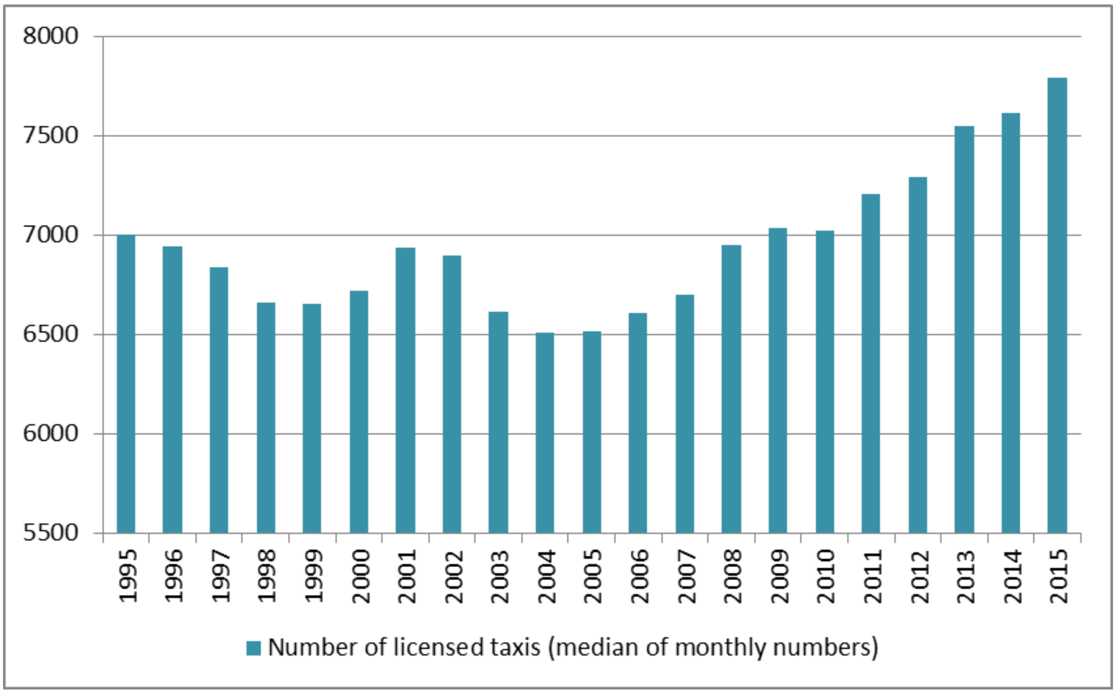

Figure 4-9: Development of the number of licensed taxis (citywide)
Source: SenStadtUm based on Landesamt für Bürger- und Ordnungsangelegenheiten (LABO), Berlin, 2016

Aside from a peek between 2000 and 2002, the number of licensed taxis decreased until 2004 from about 7,000 to 6,500 taxis. Since 2006 the numbers have been increasing to almost 7,800 taxis (as of 2015). During this period, the number of inhabitants, especially, of tourists also increased (see Figure 3-6, Figure 3-13 & Figure 4-8).

4.6 Car sharing

Berlin is the city in Europe with the most available car sharing vehicles. Additionally, all currently available car sharing systems are operating in Berlin. Therefore, Berlin is sometimes referred to as the car sharing capital of Europe. From 2012 forward, the traditional station-based car sharing systems have been complemented by free-floating car sharing systems, which have reached an enormous increase in importance ever since (see Fiechtner 2016, pp. 18-20 & Table 4-5).

Table 4-5: Current car sharing operators in Berlin 2015

Operators	Type	Description
Cambio	Station-based	30 stations, mainly on public accessible private ground (small cars to vans)
car2go	Free-floating	1,100 cars (SmartForTwo, Mercedes-Benz A-class, GLA, CLA, B-class)
DriveNow	Free-floating	1,040 cars (BMW & Mini, 40 BMW i3 fully electric)
Drivy	Private cars, Station-based	Providing private cars for short-term rental (small cars, vans, luxury cars)
eMio	Free-floating	150 e-Scooter (scooter-sharing)
Flinkster	Station-based (partly hybrid)	64 stations, mainly on public accessible private ground, some stations on public ground (small cars, vans, luxury cars), 20 hybrid parking zones
Greenwheels	Station-based	50 stations, mainly on public accessible private ground (small cars to vans)
Multicity	Free-floating	currently 250 e-cars
Hertz 24/7	Station-based	4 stations (3 at IKEA furniture stores), service reduced on furniture transport + service for Lufthansa customers at Berlin-Tegel airport
Stadtmobil	Station-based	50 stations, mainly on public accessible private ground (small cars to vans)
Tamyca	Private cars, Station-based	Providing private cars for short-term rental (small cars, vans, luxury cars)

Source: SenStadtUm based on Fiechtner 2016, pp. 19–20; Carsharing-News.de 2016

The number of cars in free-floating systems was enlarged to almost 2,500 cars in 2015. Additionally, new web platform operators provide private cars for short-term rental (see Table 4-5). A hybrid type of car sharing was introduced by a traditional station-based operator with currently 20 hybrid parking zones. The parking zones are treated as flexible station, were the dedicated cars can be parked and re-lent at public on-street parking lots. In addition, 150 e-scooters can be used during the summer half of the year (see Fiechtner 2016, pp. 18–20; LHM & SenStadtUm 2015, p. 14).

5 Transport policies

5.1 Private motorized transport

Description of the current situation and history of private car transport access restrictions (e.g. access management, ramp metering)

Berlin does not have a typical means of restricting o private-car transport access. Since 2008, an environmental zone (low emission zone) for the inner-city prohibits vehicles with a European emission standard label of below EURO 2 to enter the city centre. The environmental zone serves as a form of health protection. In densely populated areas, in the centre of Berlin, the limit values for particulate matter (PM10) and nitrogen dioxide (NO2) are exceeded on many major roads. Road traffic is the important source of these pollutants in Berlin. Before the introduction of the environmental zone, road traffic contributed nearly 40 % of the particulate matter pollution and 80 % of the nitrogen dioxide pollution. In order to improve the health of the people living in Berlin, traffic emissions had to be reduced. With the introduction of the environmental zone, the number of people living at streets with high pollution has been reduced by approximately one quarter. Even residential areas that are not directly on busy streets benefit from this development. In 2010, the restriction was extended, and since then, only vehicles with EURO 4 or higher are allowed to enter the inner-city (see SenStadtUm 2016f).

Description of the current situation and history of road pricing system

There is no road pricing system in Berlin and there currently are no future plans for introducing one.

Description of the current situation and history of dynamic traffic light controls (e.g. coordination of traffic lights, prioritisation)

The traffic control (VLB) keeps the streets of Berlin in motion. Modern traffic control systems (VBA) make an important contribution to a safer and more fluid moving traffic; in addition to improving the flow of traffic, it also reduces emissions. The traffic control systems are controlled and monitored, according to the current traffic demands, by the Traffic Control Centre (VKRZ) of the Berlin Traffic Control. The Berlin Traffic Control Centre is one of the largest and most modern traffic management and information centres in Europe. In the Traffic Control Centre, the traffic situation is observed across more than 1,500 km of roads. In Berlin, there are traffic lights (also "traffic signals" – according to the LSA) on more than 2,000 intersections as well as nine traffic control systems (VBA) (particularly on the Berlin motorway) which are monitored and switched manually when necessary. The Traffic Control Centre is particularly important for the work of the Berlin Traffic Control. Through the combination of all traffic-related information in one place, the Berlin Traffic Control is able to selectively engage in the Berlin traffic in order to minimize interference or even to prevent it completely. The staff of VKRZ checks the Berlin light-signalling and traffic-control systems around the clock, allowing for the immediate elimination of errors and so ensuring the functionality of the equipment.

Thus, the VKRZ is able to engage in critical traffic situations as well as dangerous circumstances, particularly in the tunnel sections, by placing warnings, reducing speed limits or disabling access to tunnels all together. Integrated into the VKRZ, the Country Registration Office for the Traffic Information Service sends current information about special events such as traffic jams, roadwork and construction, or demonstrations to the affiliated broadcasters, printed media and navigation devices via the TMC method (Traffic Message Channel) (see SenStadtUm 2016i).

Description of the current situation and history of other traffic demand management (TDM) (considering public transport, cycling and walking network, parking and pricing management etc.)

Urban transportation development plans (years 2000-2013)

Around 2000, work started on the **'Urban Transportation Development Plan'** (Stadtentwicklungsplan Verkehr, StEP Verkehr) "mobil 2010", the strategic masterplan for Berlin's transport policy. The initial concern was to establish a sense of ownership within different spheres of society and within different departments of the Senate's administration; this was integral for the acceptance and implementation of the plan. However, agreeing over these measures was a hard task. Therefore, a round table, aimed to inform and educate stakeholders, was initiated.

Berlin established the *Runder Tisch Verkehr (*Transport Round Table), a committee set up to support this development, and invited, among others, representatives from political parties, businesses, environmental and automobile associations, and transportation companies to take part. The integrated plan outlines around 100 measures, spanning from infrastructure investments and land-use planning to sector organisation. The intensive discussions in this committee and the work of the administration led to the first 'Urban Transportation Development Plan', which was approved by the Berlin Senate in 2003.

The plan unequivocally set out the qualitative and quantitative objectives of a sustainable mobility policy (aiming horizon 2025):

- Reducing car traffic in favour of eco mobility - public transport, cycling and walking.
- Cutting traffic-related pollution caused by airborne pollutants, noise and CO2
- Increasing road safety

Though including some infrastructure improvements for the closing of gaps in the road and rail networks, the measures primarily addressed new priorities for the non-motorised traffic, traffic avoidance and a more reconcilable handling of road traffic. This policy was supported by key framework planning in other policy fields, such as in environmental policy. For example:

- Berlin, supported by the cycle strategy and comprehensive network planning, has modernised and extended the infrastructure for cyclists on a large scale. This does not only apply to the network of routes, but to the crucial topic of bicycle parking.
- Traffic speed is not only a vital issue in 'city-friendly traffic', but also for road safety and the environment. This is why nearly all the minor roads in Berlin (over 70% of the road network) have a 30 km/h speed limit. Moreover, Berlin has also imposed a maximum speed of 30 km/h on a series of stretches of main roads. For example, as part of a special programme, over 60 sections of the main roads have a 30 km/h limit between 10 pm and 6 am to reduce traffic noise.
- In 2008, in accordance with the EU Commission proposals on limiting carbon emissions, Berlin established a low-emission zone (LEZ) in the Berlin inner-city. Only vehicles meeting set standards on exhaust emission technologies (since 2010 at least the EURO 4 emission standard) are allowed in this green zone - which is, after all, home to one million residents.
- In addition, Berlin has made substantial investments to advance the public transport infrastructure, trough establishing new tram lines and construction new S-Bahn stations with improved barrier-free mobility (see SenStadtUm 2016k).

Second Urban Transportation Development Plan (StEP Verkehr 2025)

Eight years after the first Urban Transportation Development Plan was passed, the mobility policy commenced from a decisively different point. Despite the ambitious goals and challenging programme of measures, the first Urban Transportation Development Plan in 2003 assumed that motor vehicle traffic and the associated pollution would continue to rise until 2015. However, through the supporting measures and general developments, the turnaround was achieved in 2008/2009. And the change is apparent in the city. When it comes to modes of transport, Berlin has seen a clear growth in green transport. For instance, Berlin residents took 11 % of all journeys by bike. The amount of daily journeys doubled within 8 years. The public transport share was over 26 %, with pedestrian traffic accounting for nearly 29 %. The car was only used for (just under) a third of all journeys, and, after 1998, that percentage had dropped from 38 % to 32 %. The lower levels of car use also have a noticeable effect on the stress on Berlin's road network, which carried 5 % -10 % less traffic as opposed to a few years ago. Growing numbers of people are utilizing as well as combining the eco-friendly bike and public transport. On some days, for instance, up to 50,000 people take their bike with them on the S-Bahn. The LEZ has resulted in significantly shorter usage of older vehicles with high pollutant levels which are now being replaced sooner with more eco-friendly cars.

Led by the guidelines of the first Urban Transportation Development Plan, the second StEP Verkehr developed 12 goals that evaluate the economic, social, ecological and institutional dimensions. With 7 partial strategies, 44 goals of action, and a numerous set of concrete measures for Berlin 2025 was created to stabilise and pursue the positive path of development (see SenStadt 2011b).

Low-emission zone (LEZ)/"Umweltzone"

In 2008, Berlin started a low emission zone to protect public health. Vehicles with particularly high emissions are not allowed to drive within the low emission zone. Thus, the air quality in Berlin has been improved. In 2010, the second stage of the environmental zone regulation took effect. Limited to only a few exceptions, the low emission zone covers the entire inner Berlin S-Bahn-ring. Here the concentration of pollutants in the air is particularly high due to the concentration of traffic as well as the close proximity of buildings to one another. With the implementation of the first stage, numerous old vehicles with particularly high pollution levels have been disposed and replaced with cleaner vehicles. The low emission zone applies to all motor vehicles except motorcycles. Motorists who wish to enter the low emission zone must have vehicles that satisfy the minimum standards of pollutant emissions and that have an official sticker on the vehicle indication its level of pollutant emissions. This sticker, marked with the colors red, yellow or green, an "environmental badge" placed visibly in the winds marking is carried out by groups of pollutants according to the European emission standard label (EURO 1 to 4 or higher) (see SenStadtUm 2016j, 2016f).

Strategy on Pedestrian Traffic (Fußverkehrsstrategie)

The Strategy for Pedestrian Traffic in Berlin is a long term plan which aims, together with the cycling strategy, to maintain and improve the quality of life in the city. The strategy deepens the statements of the Urban Traffic Development Plan in order to promote non-motorized transport modes and it implements objectives, measures, and pilot projects for pedestrian traffic. It is also a guide to the boroughs where to implement essential measures. The advisory board "Berlin on Foot" ("Berlin zu Fuß") has contributed significantly to the development of the Senate's Strategy for Pedestrian Traffic. The Strategy on Pedestrian Traffic has the overall objective of urban, socially and environmentally sustainable, healthy, safe and cost effective mobility. In order to make tangible progress, it defines verifiable objectives, such as increasing user satisfaction, reducing accidents, and creating accessible public spaces.

In the framework, ten pilot projects were named with measures promoting foot traffic. One important project deals with the theme of "encounter zones". In such zones, all modes of transport are respected. In this case, better cooperation and mutual consideration do not have to be "arranged", but rather, in an ideal situation, result from the road design itself. The projects aim for developing a city-wide "modular tool box" with possible solutions. The results are intended to act as a driving force for the districts and as a long-term stabilisation for the promotion of Pedestrian Traffic. Considering Berlin's budgetary situation, complete conversions are hardly possible. Therefore, ways are sought how the situation can be improved by relatively simple means. After a thorough inventory, existing conflicts are analysed by willing participants, concerned citizens and businesses to identify possibilities for dividing the roadway, sidewalks and recreational areas. Children and young people from the project areas are specifically integrated in the investment process. The design takes into account the specifics of each street and endeavours to parallel the distinctive characteristics of these new "encounter zones". The streets are signposted as "low traffic divisions" with a 20 km/h speed limit (see SenStadtUm 2016d).

Cycling strategy

The cycling strategy should contribute to maintaining quality of life in Berlin in the long term and to improving it gradually, together with the Strategy on Pedestrian Traffic. The strategy deepens the statements of the Urban Transportation Development Plan to promote non-motorized transport modes and illustrate them with goals and guidelines, measures and model projects for bicycle traffic. It also is a guide for the implementation of measures in the districts.

The cycling strategy is framed by the overall objective of urban, socially and environmentally sustainable, healthy, safe and cost effective mobility. To make achievements as well as shortcomings in the implementation understandable, it set itself the objective to increase the bicycle traffic share to 18-20 % of all journeys, to establish cycling on longer routes as well as links with public transport, to reduce accidents, and to implement an adequate funding scheme.

Measures to promote cycling in Berlin are comparatively inexpensive and cost-effective, especially since existing traffic areas can often be converted. Nevertheless, the implementation of the cycling strategy requires a number of measures for which funding must be secured. The strategy therefore continues upholds the perspective that the bicycle planning needs a share of the resources available for the financing of urban transport appropriate to its importance for sustainable mobility in the city of Berlin. The National Cycling Plan (NRVP) by the federal government provides a lower limit of 5 € per inhabitant per year of investments for bicycle traffic. The aim is to gradually achieve this magnitude with measures to promote cycling with the investment means spent for road construction by 2017. According to multiple survey points throughout the city, there was an average of 40% more bikes on the roads in 2012 compared to 2004.

Through the promotion of building programmes of the S-Bahn Berlin GmbH (since 1999) and BVG (since 2006) the construction of

- 8,500 parking spaces for bicycles at the Berlin S-Bahn stations and
- 3,000 parking spaces for bicycles at underground stations, tram and bus stops of the BVG

were realised. Overall there are more than 27,000 Bike & Ride spaces available at public transport stations and stops (see SenStadtUm 2013; SenStadt 2011a).

Traffic safety

Every year 17,000 people are involved in accidents on Berlin streets. The accident victims are mostly children, teenagers, young adults and seniors. Two-thirds of which were on foot or by bicycle. The aim of the Berlin traffic safety programme is to enhance safety for all road users through a range of different measures:

- The Road Safety Programme "Berlin Safe Mobile" 2020 ("Berlin Sicher Mobil 2020") is a comprehensive strategy for action to further reduce the traffic accidents in which people come to harm.
- Since 1992, the annual number of traffic accidents in Berlin has declined significantly according to the annual Road Safety Report.
- An important part of Berlin's work in improving road safety is the realisation of projects and programmes for mobility and traffic education. They should help to ensure that care and consideration characterise the traffic behaviour. One part of this are the children city map projects, where children in selected primary schools explore the geographical environment of their school and create a map of their school neighbourhood for other kids.
- An important aspect for the safety of all road users is the speed limit on the streets of Berlin, since motor vehicles are involved in most accidents. Therefore, among other things, low speed zones (30 km/h) were enlarged in the city of Berlin, especially in front of facilities for children and places of higher risk in traffic safety. Currently more than 70 % of Berlin's road network has a maximum speed limit of 30 km/h.
- Another reason for the decrease in the speed limit to 30 km/h is for noise reduction at night. Noise directly disturbs the quality of sleep; and 30 km/h regulations are designed to protect sleep. Now, for some sections of road which are highly utilized at night, the speed limit has been set to 30 km/h from 22:00-06:00.
- After evaluating the contributions from an online dialog with a focus on turning street corners the conflicts between cars and bicycles are nearly resolved (see SenStadtUm 2016l, 2014a).

Parking regulations

The parking management is an important measure. It aims to ensure efficient parking, to be compatible for the city and the environment, and to simultaneously satisfy residents and local businesses. Berlin introduced parking management in 1995 in parts of the eastern and western inner-city. From 9 am to 6 pm/9 am to 10 pm and popular shopping hours during the week as well as on Saturdays, each driver must retrieve a time-stamped ticket stub for the vehicle, for which a minute ore hourly rate for parking is issued.. This originally started with DM 2 /h, approximately € 1/h. Some residential streets are reserved specifically for residents and require an issued resident parking card.

Each borough is in charge of the implementation of parking management areas within its boundaries. Since the first Urban Traffic Development Plan, the Senate Department coordinates the implementation of parking management areas and is in charge of the higher parking strategy. There are approximately 103,210 parking spaces within the parking management areas of Berlin, located on public roads within currently 40 parking zones (2014). The total area of parking zones is 2,980 hectares. Residents living in a parking zone can register for a "resident parking permit". This allows the owner to park in their home area (current cost for 2 years is approximately € 20.40). In contrast to other countries, the cost for a "resident parking permit" is raised based on an administration fee and not on a parking fee. The maximum possible fee is € 30.70 per year in Germany based on a federal regulation in the "Gebührenordnung für Maßnahmen im Straßenverkehr (GebOSt)" (see GebOSt Nr. 265). Craftsmen who generally rely on using a motor vehicle, can request a business parking card in areas with parking management (currently € 200.00 per year, + 40.00 € for every addition car, not more than 3). This card works as a remission of the regular parking fees (see SenStadt 2011a; SenStadtUm 2016h).

Description of development of the annual average fuel prices (diesel and petrol)

Figure 5-1 shows the development of annual average fuel prices distinguished by net values and taxes for diesel as well as for petrol. The values show the nominal prices in Euro per litre and do not consider the customer price development. The numbers refer to the average in Germany as a whole because city specific data are not available. It can be assumed that the city of Berlin shows the same tendencies as seen in the countrywide numbers. Both the petrol net price and the taxes are increasing over time in a general trend. However, upon closer examination, it can be seen that taxes, in particular, rose continuously, with a sharp increase in the late 1980s. In contrast, until 2000, the net prices for petrol and diesel show only slight movements up and down. The increase of the gross prices, between the late 1980s and the millennium year, were mainly driven by rising taxes. From 2000 until the economic crises in 2008, net prises for fuel visibly increased. This, together with the rising of taxes, led to significantly higher gross costs for car drivers. During this period the proportion of diesel engines in production grew drastically. The lower consumption of this type of engine was a main determinant for this development. Since 2008, there has been a lot of movement within fuel prices. First, coupled with the economic crises, fuel prices declined considerably; whereas from 2009 until 2012, fuel prices sharply increased. From 2012 until present there has been, once again, a declining trend in the price of fuel, accompanied by a slight decline in taxes per litre due to the VAT proportion within the fuel price.

Taking in consideration the population’s costumer price development over the last few decades it should be pointed out that the fuel costs for car drivers were oriented according to the Costumer Price Index (CPI) until the end of the 1970s. After an increase in the early 1980s, were the customer prices inclined more smoothly than the fuel prices, the gross prices for petrol and particularly for diesel stayed relatively cheap (Figure 5-3) until the mid-2000s.

From the mid-2000s, there was a sharp increase of gross fuel prices until the economic crises in 2008. After a short drop, prices visibly rose again until 2012. From 2012 onwards, a sharp drop can be once again observed. The gross fuel prices show a very volatile development over the last 10 years.

For the last decade, the perception of car drivers, in terms of fuel expenditures, might be relatively inelastic because car engines are also becoming more efficient (particularly gasoline-powered engines).

This development is especially interesting in light of PT usage costs. For decades, the costs for annual PT tickets have been increasing steadily (Chapter 4.2.2, Figure 4-7). Since 2010, even single PT ticket prices were increasing sharply in Berlin (Chapter 4.2.2, Figure 4-6). Investigations about the subjective perception of these opposing developments and their effect regarding mode choice are unknown. The last Berlin HTS survey of 2013 does not show negative effects on PT mode choice or on the increase in car driver patterns (see chapter 6.2.5). However, it is a logical consequence that fuel prices may affect car use patterns in the near future under ceteris paribus conditions.

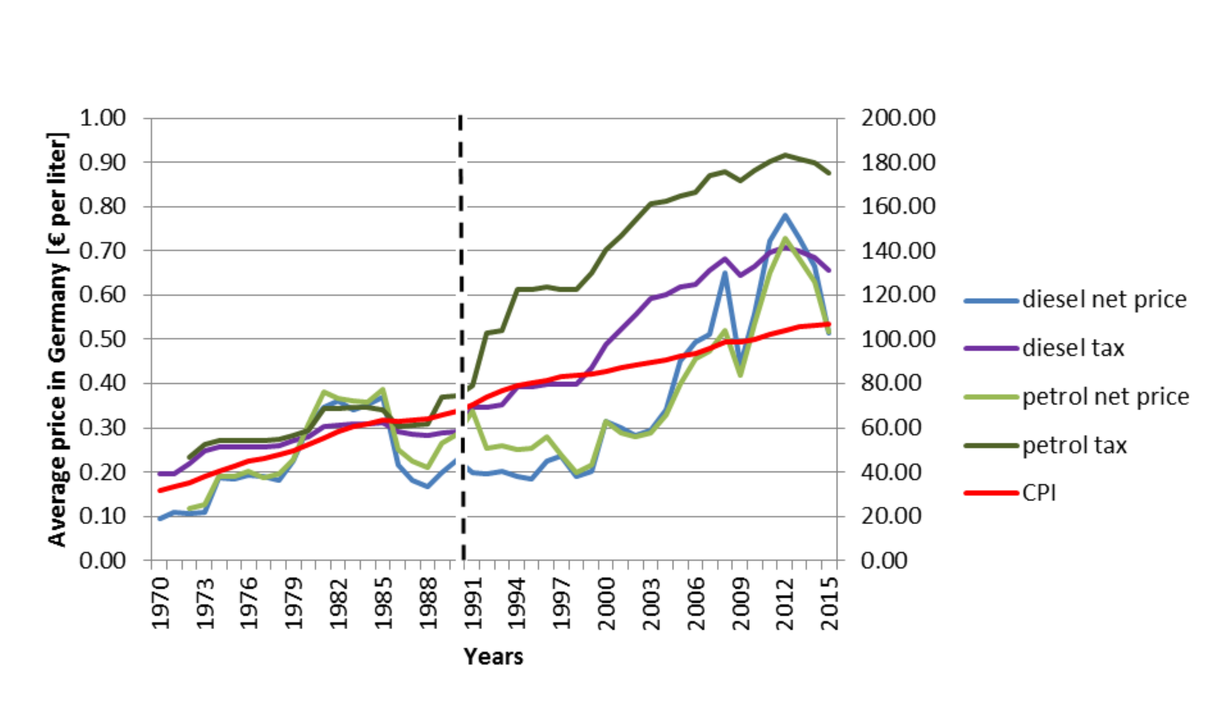

Figure 5-1: Development of annual average fuel prices (diesel and petrol) in Germany distinguished between net values and taxes [€ per litre]

Source: MWV. (n.a.). Durchschnittlicher Preis für Dieselkraftstoff in Deutschland in den Jahren 1950 bis 2016* (Cent per liter). In Statista - Das Statistik-Portal. Access: May 10 2016, http://de.statista.com/statistik/daten/studie/779/umfrage/durchschnittspreis-fuer-dieselkraftstoff-seit-dem-jahr-1950/, Destatis 2016.

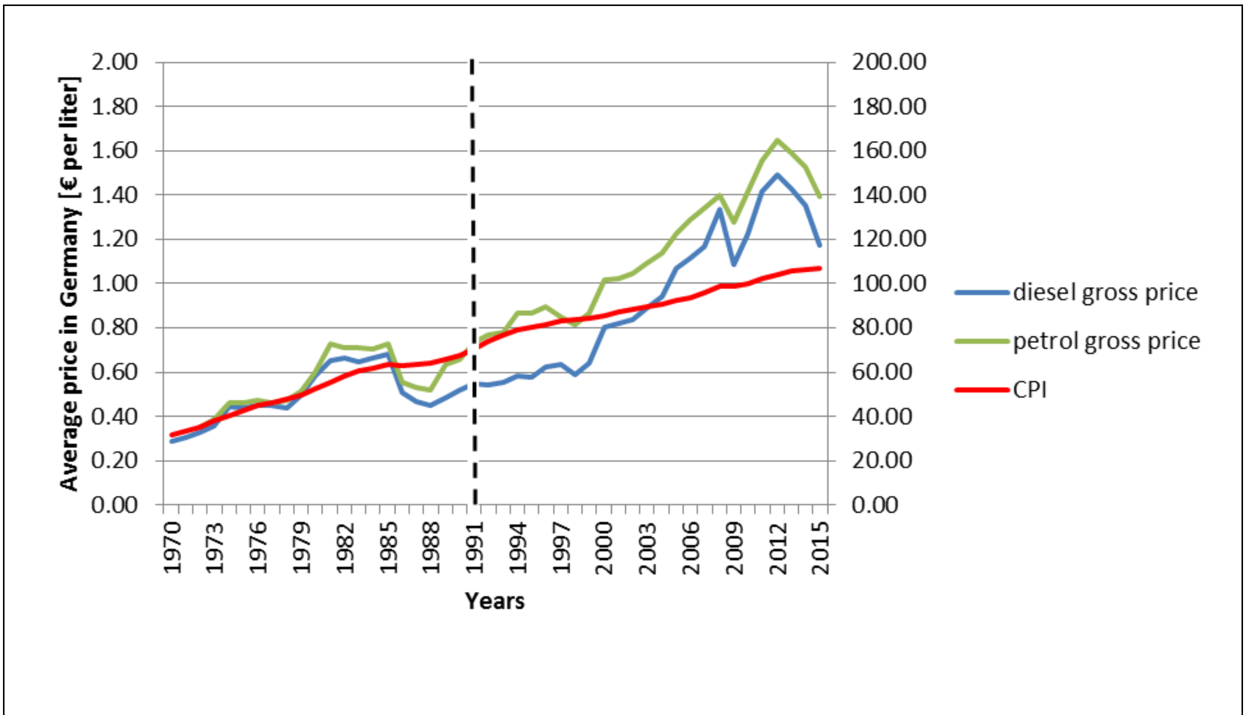

Figure 5-2: Development of annual average gross fuel prices in Germany[€ per litre]

Source: MWV. (n.a.). Durchschnittlicher Preis für Dieselkraftstoff in Deutschland in den Jahren 1950 bis 2016* (Cent per liter). In Statista - Das Statistik-Portal. Access: May 10 2016, http://de.statista.com/statistik/daten/studie/779/umfrage/durchschnittspreis-fuer-dieselkraftstoff-seit-dem-jahr-1950/, Destatis 2016.

Average costs for private car

The average costs for a private car vary according to the different licensed car brands, models and usage. The German Automobile Club (ADAC) offers calculations of fixed costs, variable costs and average costs per km for almost all car brands and models. The calculations consider a 4-years usage with a 15,000 km per year mileage including loss of value (see ADAC 2016a, p. 1, 2016b).

For the five best-selling models in 2015, a brief overview of the average costs of a private car is derived using an example modification for each model type (see statista 2016). On average, there are € 99.60 fixed costs, € 55.80 costs for repair, € 107.60 operating costs and € 359.80 loss of value per month for a private car. In total, a private car in Germany costs about € 622.80 per month and about € 0.50 per km (based to this approximation).

5.2 Public transport

Current situation and history of priority for public transport (at intersections with traffic lights)

For the prioritization of public transport at traffic signals, two investment programmes are available in Berlin for financing the upgrade of equipment: the tram investment programme (since 1999) and the bus investment programme (since 2006). As of October 2012, about 926 of the nearly 2,100 traffic signals in Berlin (= 58 % of about 1,400 for public transport related systems) have been converted. The aim is that public transport can pass by without stopping at nodes. If this is not feasible, then the maximum waiting times are not to be exceeded. It is the requirement of the transport modes of the environmental network to adapt to the increasing importance of cycling and walking. Here, it is important to note that, unlike the ever-flowing private transport, public transport only occasionally engages in the traffic-signals programming at nodes. These interactions take place, according to the timing sequence of public transport, a few times per hour, and the public transport is favoured due to its large carrying capacity as opposed to private vehicles. Currently there are 987 prioritised traffic lights at intersections as of 2015 (see Emmerich und Grätz 2016, pp. 21–22; SenStadtUm 2014c, pp. 110–112).

Current situation and history of subsidising to the public transport operators for service and investments

Mobility and transport infrastructure cost money. Therefore, Berlin spends over €300 million on investments related to road construction, as well as on maintenance and energy costs for the Berlin road network per year. Costs for operation and maintenance thereby exceed the spending on road construction. Public spending for the public transportation system can be divided into passenger transportation subsidies for the main operators (BVG, S-Bahn, DB regional trains, ODEG, NEB) and mainly infrastructure investments/capital expenditures for public transport. In addition, the subsidies are divided into a basic remuneration plan based on traffic contracts and the actual granted subsidies (actual compensation), which is calculated according to the actual performance and quality of the service (see SenStadtUm 2016g, pp. 11–13).

In 2012, main operators (BVG, S-Bahn, DB regional trains, ODEG, NEB) received subsidies with a total amount of €545.9 million. The BVG received about €267 million, the S-Bahn €232 million and DB Region (regional train) €41 million. The two smaller regional train operators ODEG (Ostdeutsche Eisenbahn GmbH) and NEB (Niederbarnimer Eisenbahn AG) were subsidised with €2.1 and €1.5 million in 2012. From 1997 to 2009, the total amount of subsidies decreased by more than €200 million due to a reorganisation of PT-funding in Germany and Berlin. Also due to the positive development in inhabitants and tourists, the traffic volume in PT and therefore, the amount of subsidies increased since 2010 (see Figure 5-3).

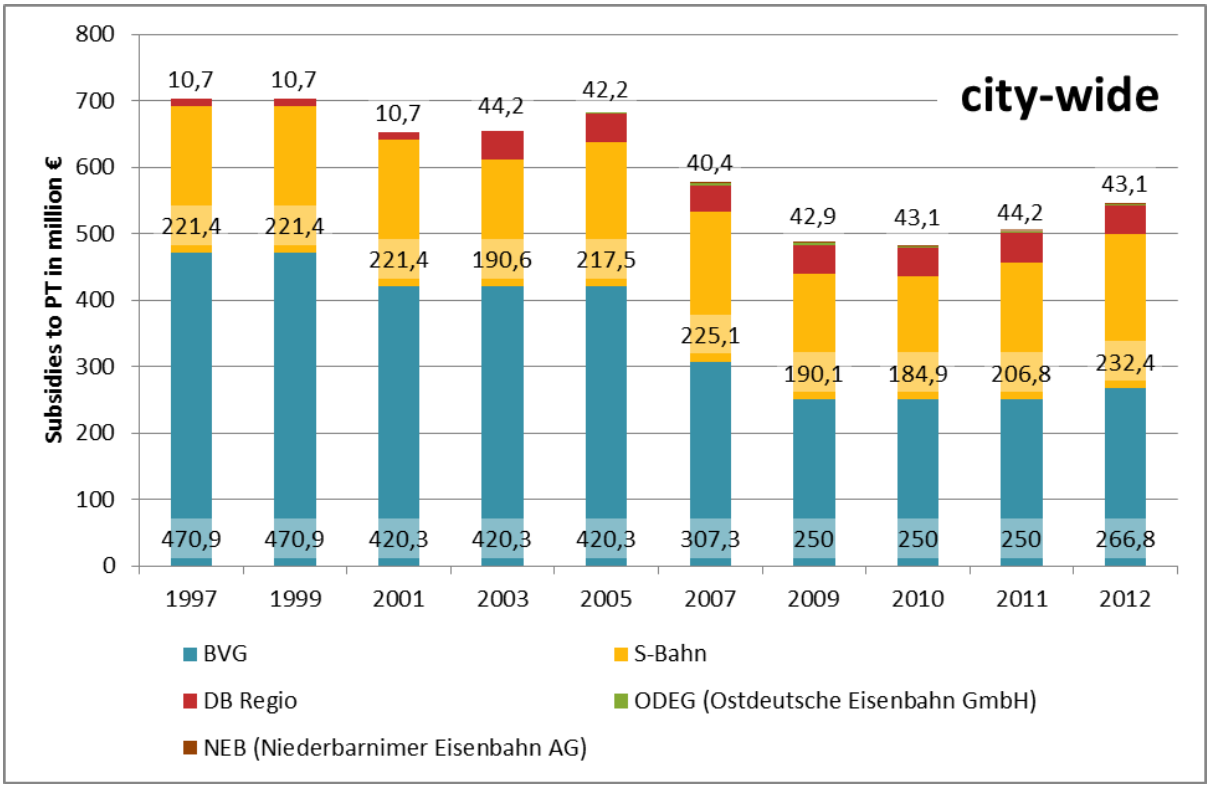

Figure 5-3: Subsidies to PT in million €
Source: SenStadtUm based on SenStadtUm 2014b, p. 110

A comparable amount was spent on infrastructure investments/capital expenditures for public transport (see Table 5-1). Roughly € 311.8 million were invested in the local rail infrastructure of the S-Bahn, U-Bahn and trams. About €162.4 million were paid for the overhaul and new construction of the U-Bahn and € 81.6 million for investments in the S-Bahn. The overhaul and new construction on the tramway network cost about € 67.8 million. Costs for repair, maintenance, and rolling stock procurement are not included in these numbers (see SenStadtUm 2014b, pp. 106–110).

Table 5-1: Capital expenditure on public transport

	1995	1997	1999	2001	2003	2005	2007	2009	2011	2012
Capital expenditure, total (in million euros)	751.6	907.8	639.4	452.8	499.2	553.9	259.4	465.2	375.6	511.8
S-Bahn	172.3	230.2	104.5	110.9	132.6	84.5	40.8	90.1	91.1	81.6
U-Bahn, total	130.1	102.4	78.2	55.5	51.6	59.7	76.2	84.2	129.8	162.4
Major repairs	101.3	79.1	59.0	43.2	44.4	42.2	55.7	68.6	103.6	112.0
New construction	28.8	23.3	19.2	12.3	7.2	17.5	20.5	15.6	26.2	50.4
Tramways, total	83.8	54.2	78.7	23.1	24.5	30.5	26.2	24.8	40.1	67.8
Major repairs	53.7	41.6	59.5	20.0	20.9	23.4	18.7	22.1	37.8	63.1
New construction	30.1	12.6	19.2	3.1	3.6	7.1	7.5	2.7	2.3	4.7
Subtotal	386.2	386.8	261.4	189.5	208.7	174.7	143.2	199.1	261.0	311.8
Long-distance rail and regional rail transport	365.4	521.0	378.0	263.3	290.5	379.2	116.2	266.1	114.6	200.0

Source: SenStadtUm based on SenStadtUm 2014b, p. 109

Subsidies for public transport tickets

In Berlin, there are three major forms of subsidising public transport use for specific groups of people. First, (non-university) students and apprentices/trainees can buy special student or apprentice/trainee tickets. A monthly (non-university) student ticket currently cost € 29.50 per month, and a apprentice/trainee ticket € 57.00 per month for Berlin tariff zone (A+B) (see BVG 2016a). Second, seriously disabled persons and, in some cases, chaperons can use the public transport for free with a handicap ID. Third, mostly unemployed individual, people on welfare, and some applicants for asylum are allowed to buy a special Berlin-Ticket S. The VBB offers the Berlin-Ticket S as a monthly ticket for Berlin tariff zone (A+B) with up to 50 % off. Currently the ticket costs € 36.00 per month (see S-Bahn Berlin 2016a).

These three special offers are currently subsidised by the State of Berlin in a way illustrated in Table 5-2.

Table 5-2: Current compensatory payments for transport operators in Berlin (million €)

Year	2014	2015
Pupils- or apprentices/trainees-tickets (§ 45a PBefG)	64.7	64.7
Free ride for seriously disabled persons (SGB IX)	30.3	31.2
Berlin-Ticket S e.g. for unemployed people, people on welfare & applicants for asylum	11.9	13.1

Source: SenStadtUm based on SenStadtUm 2014c, p. 18

University student tickets are not separately subsidised by the State of Berlin. As a result, the students of Berlin's universities voted for a compulsory student ticket for all enrolled students. Each university may negotiate the price of the compulsory semester ticket separately. On average, the semester ticket costs around € 190 € per 6 months for the Berlin tariff zone and the surrounding suburbs (A+B+C)[6].

Other means of transport

With the implementation of the bicycle strategy, the amount spent on cycling has increased. The aim is to gradually reach an amount of investments in Bicycle Traffic Promotion of 5 € per inhabitant per year until 2017 (see SenStadtUm 2013, p. 4).

[6] The regular ABC annual ticket currently costs € 986.00 (see BVG 2016b).

6 Transport demand and access to transport modes

6.1 Access to transport modes

6.1.1 Private car ownership and driving licence possession

The level of motorisation differed greatly between East and West Berlin from the 1970s until the reunification. In East Berlin, 77.5 cars were registered per 1,000 inhabitants in 1970; whereas, in the western part of the city, the level of motorisation was 175.4 per 1,000 inhabitants (almost 100 vehicles more). In 1995, as a result of the reunification, the numbers came much closer than before: In East Berlin, 302 cars were registered per 1,000 inhabitants, and in West Berlin, 346 cars. No statements can be made about the level of motorization for the eastern part of the city for the period from 1991-1993, due to the changeover of license plates for all vehicles (see Figure 6-1).

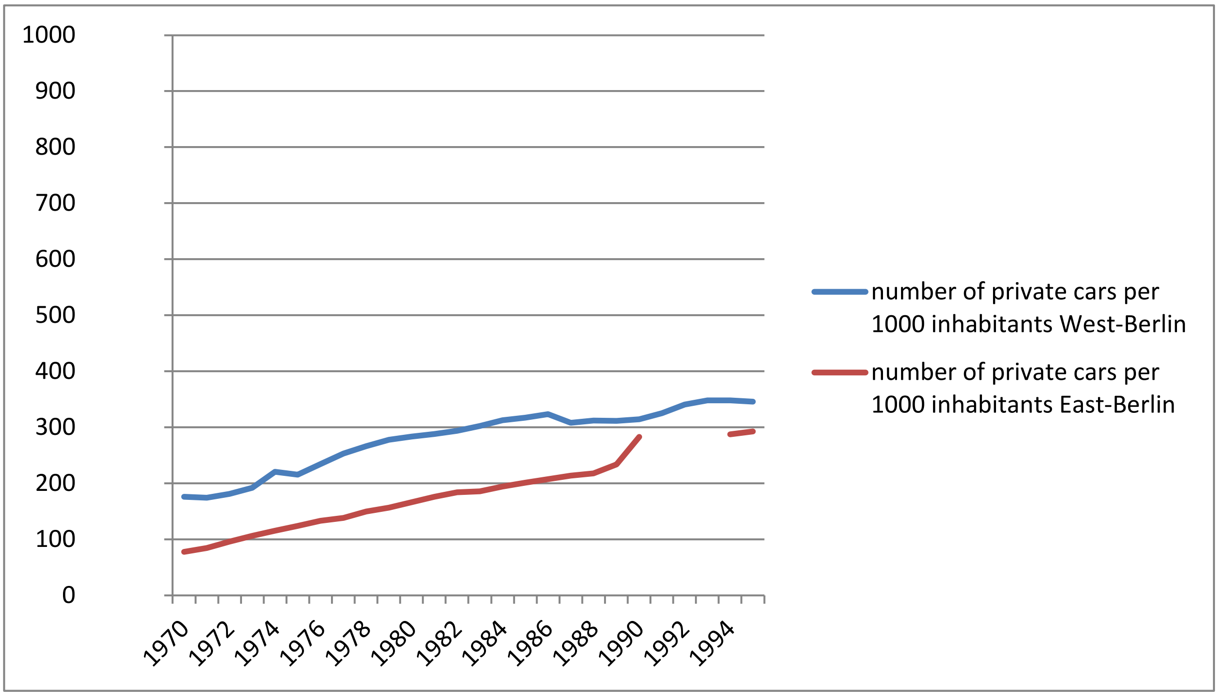

Figure 6-1: Level of motorization in Berlin 1970 - 1995 (according to the country Registry Office Berlin, the State Statistical Office and the Berlin Senate Department for Economics)
Source: SenStadtUm based on SenStadtUm 2011

Figure 6-2 shows the development in private cars from 1994 until 2014 and the number of driving licenses per 1,000 inhabitants from 2004 until 2014, based on the population register and data from the Federal Motor Transport Authority (KBA).

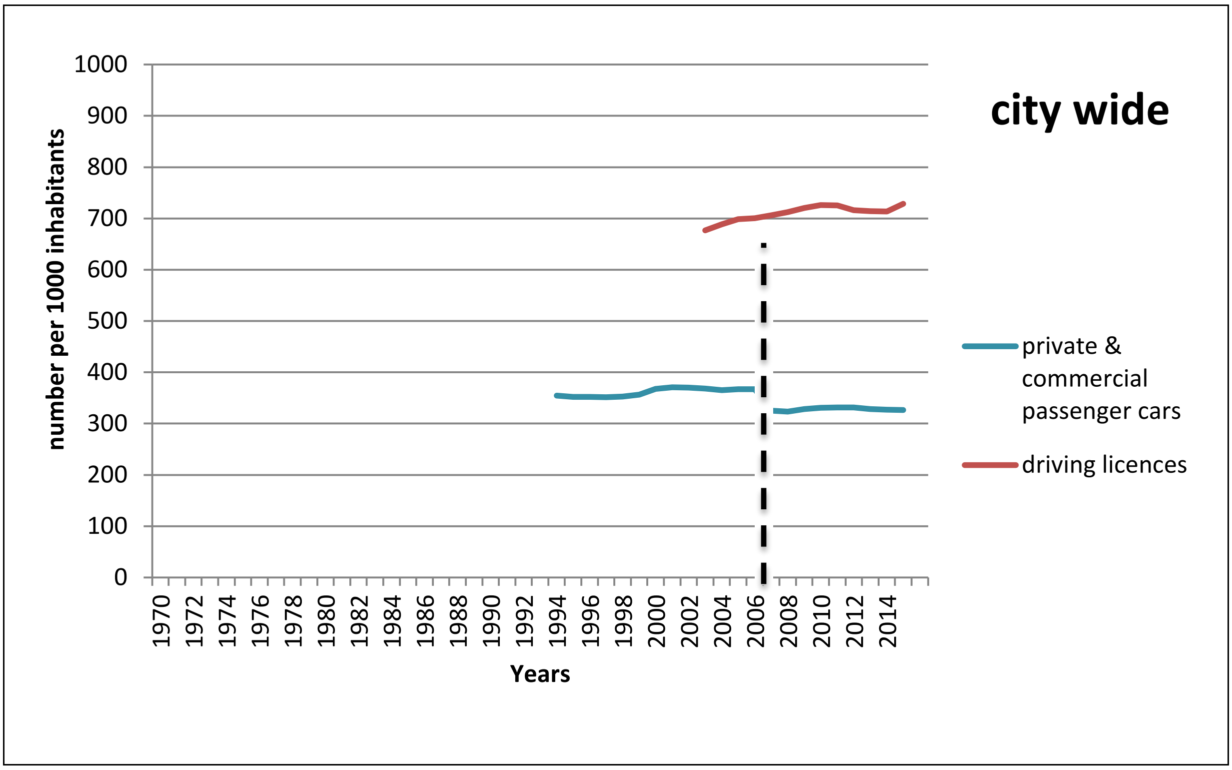

Figure 6-2: Development of the number of passenger cars and number of driving licences per 1000 inhabitants [number per 1000 inhabitants]

Source: SenStadtUm based on © Amt für Statistik Berlin-Brandenburg, Potsdam, 2016 & Landesamt für Bürger- und Ordnungsangelegenheiten (LABO), Berlin, 2016

Until the end of the 20th century, the share of passenger cars per 1,000 inhabitants remained around 350 cars, until it increased to about 370 cars from 2000 until 2006. Between 2006 and 2007, there was a dramatic change (dashed line). This change was not due to a decrease in the number of cars or an increase in the number of inhabitants, but rather to the method in which total number of registered cars was recorded. Prior to 2007, temporary shutdowns of cars were included in the inventory. From 2007 onward, only permanently registered vehicles (meaning the "flowing car traffic") were taken into account. From 2007 to 2015, the share fluctuated between 324 and 331 cars per 1,000 inhabitants with no clear tendency to increase or decrease. However, the number of passenger cars per 1,000 inhabitants in Berlin has been slightly decreasing since 2012 (see Figure 6-2).

Expectedly, the number of driving licences per 1,000 inhabitants (slowly) increased during this observed period, because licenses do not expire. As demonstrated in Figure 6-2, there are more than twice as much licenses than passenger cars. Company cars or commercial passenger cars in private use are included in the number in Figure 6-2 but are not clearly distinguishable within the statistic (see Figure 6-2). It should be mentioned, that a long term analysis of private passenger cars only was not possible. In 2014, about 295 private passenger cars were registered per 1,000 inhabitants.

Figure 6-3 shows the proportion of persons by age that have a car in a household. The proportion of young adults (18-29 years of age) with a car in a household has clearly decreased. Persons between 20 and 44 years of age show a very similar tendency. Middle aged people (45-64) show almost constant car accessibility since 1998. Three out of four persons have a car in their household. This number is currently only peaked by the age group of 65-74; the share of people with a car has increased sharply from 58 % to 76 %. A similar increase can also be observed by people 75+, but at a lower level. The overall level of car access in households in Berlin has decreased slightly from 74 % to 68 % within 15 years.

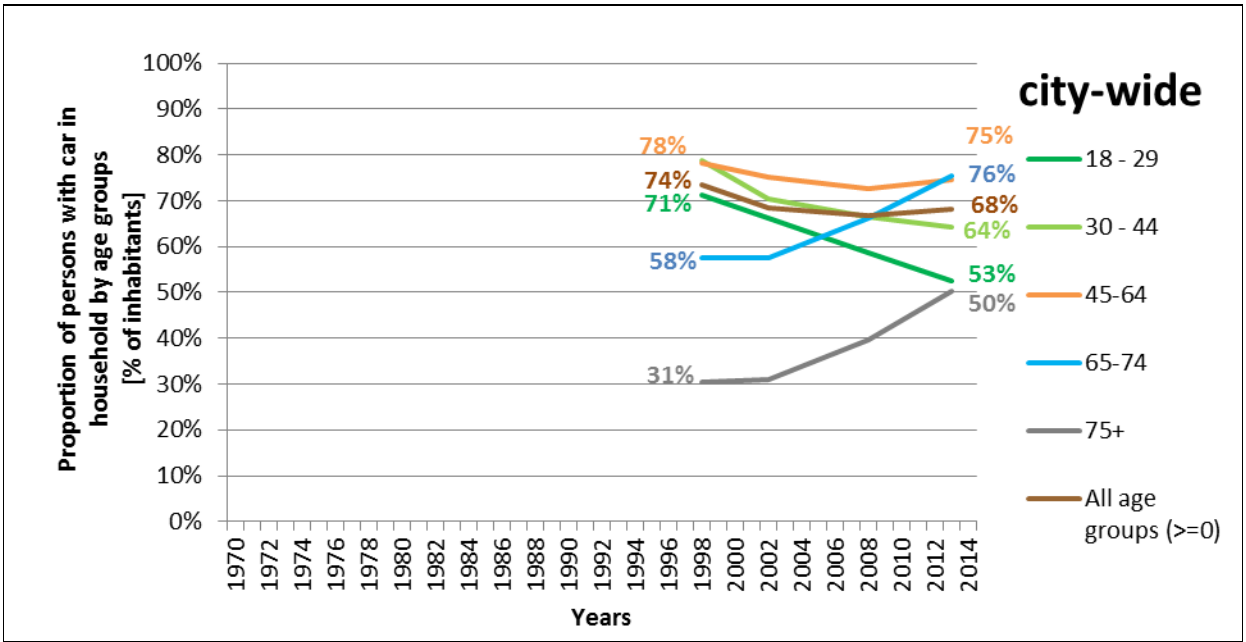

Figure 6-3: Proportion of persons with car in household by age groups [% of inhabitants]
Sources: BVG 1998, MID 2002, SrV 2008, SrV 2013 (HTS)

6.1.2 PT yearly season pass ownership

Two data sources have been found which describe the development of yearly PT season pass ownership in the city of Berlin. HTS data are available from 1998 until 2013. Operator statistics (BVG and S-Bahn) are available from 2007 until 2014 (S-Bahn: 2008). Both data sources show the same tendencies: PT season pass ownership increases. The HTS number in 2013, including monthly season passes, almost doubles the number of 1998. Statistically, more than four out of ten people living in Berlin have a flexible access to PT due to owning PT season passes.

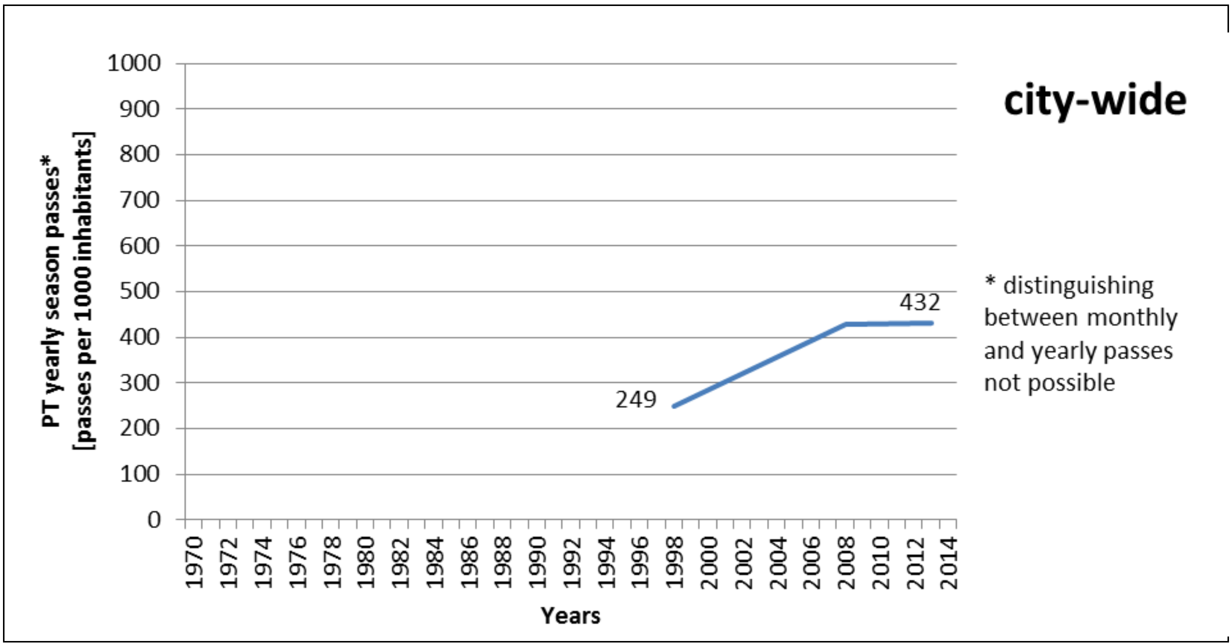

Figure 6-4: Development of number of people with PT season pass [passes per 1,000 inhabitants]
Sources: BVG 1998, MID 2002 (value not available), SrV 2008, SrV 2013 (HTS)

There are no official surveys or lists regarding the number of people with PT annual season tickets. Nevertheless, the two operators, BVG and S-Bahn, irregularly publish the number of PT annual season tickets. Since all passengers may use the services of both operators, the number of PT annual season tickets can be calculated. Since 2007, the number of purchased annual season tickets gradually increased from more than 100 passes per 1,000 inhabitants to over 170 annual season tickets by 2014. Figure 6-5 also shows that the BVG has almost twice the number of purchased annual season tickets as compared to the S-Bahn.

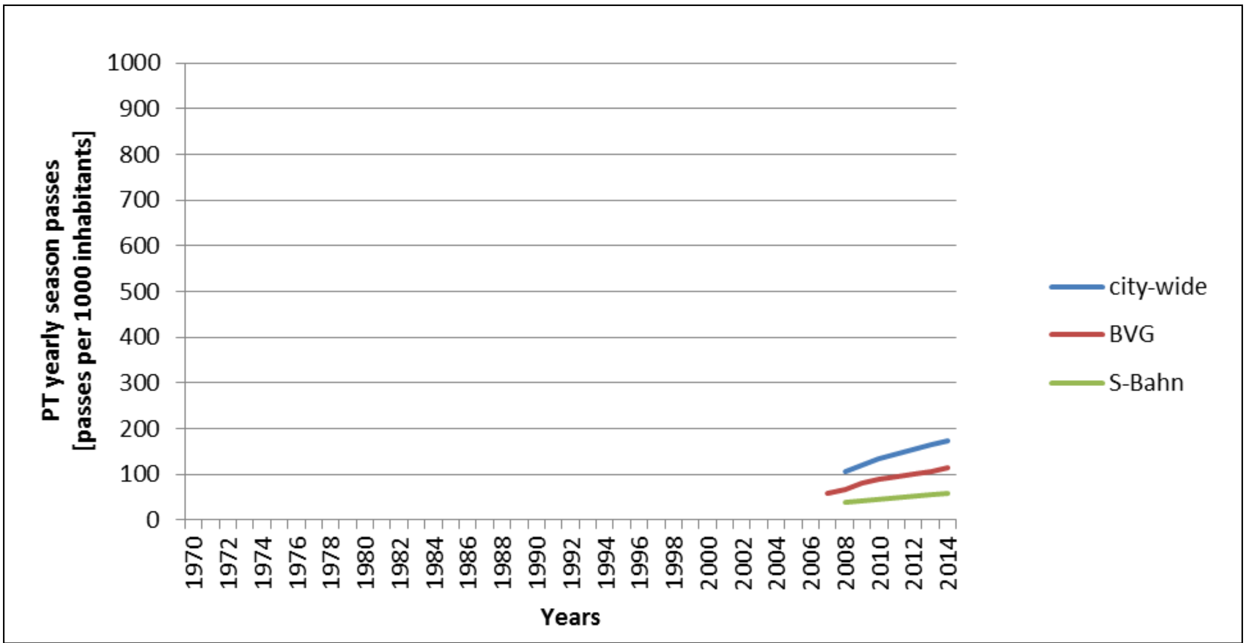

Figure 6-5: Development of number of people with PT yearly season pass [passes per 1,000 inhabitants]
Source: SenStadtUm based on SenStadtUm 2001-2014; CNB 2016b

6.1.3 Bicycles ownership

Figure 6-6 shows a statistic of bicycle ownership, resulting from HTS data and describing the development of the number of bicycles per 1,000 inhabitants from 1998 until 2013. Obviously, there is a slight increase from 1,034 bicycles (in 1998) to 1,079 bicycles (in 2013) per 1,000 inhabitants. Overall, the data show a high accessibility to bicycles in Berlin per capita. Statistically, every citizen has a bicycle available. This high access rate, together with good cycling conditions (particularly topography conditions), show further potentials to be developed.

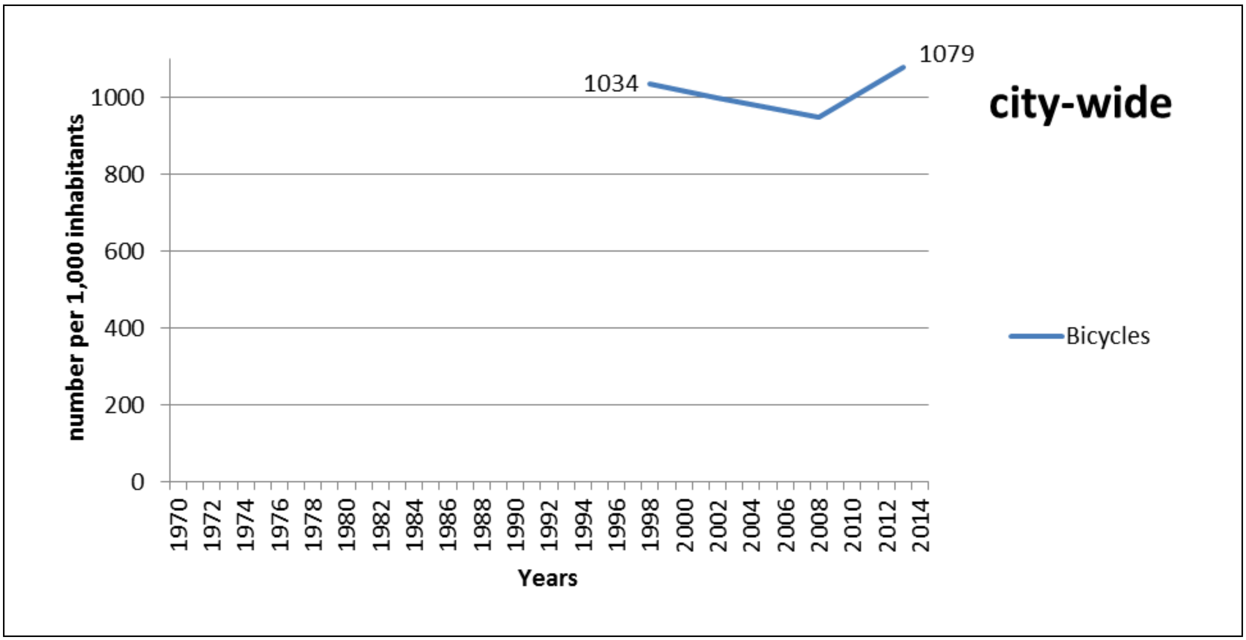

Figure 6-6: Development of the number of bicycles per inhabitants [bicycle per 1,000 inhabitants]
Sources: BVG 1998, MID 2002, SrV 2008, SrV 2013 (HTS)

6.1.4 Car sharing membership

Carsharing has gained wide public awareness over last few years. Many providers, including the automotive industry, have gathered experience in this business area. Particularly inhabitants, living in large towns, experience carsharing in their everyday mobility or, at the very least, are exposed to the carsharing infrastructure present in their neighbourhoods. Carsharing is an important part of the Berlin mobility culture. Provider data concerning the membership of carsharing organisations exist, but only at the provider level, and sometimes these data are not public. Nevertheless, local household travel surveys did not ask for the usage of carsharing on a personal level until 2013. In 2013, Berlin's HTS provided the first representative information at population level (Figure 6-7). Almost 7 % of all inhabitants were using carsharing (this number refers to % of all inhabitants, including people < 18 years of age). The proportion of person within the main target group (particularly young adults without household obligations) was higher. Taking into consideration only adults with a driving license, 8.2 % used carsharing. Within the inner-city, the share was even higher at 15.7 %. Comparing the amount of carsharing trips within the travel survey, far less than 1 % of all trips were by car sharing vehicles (see Fiechtner 2016, pp. 43 & 61).

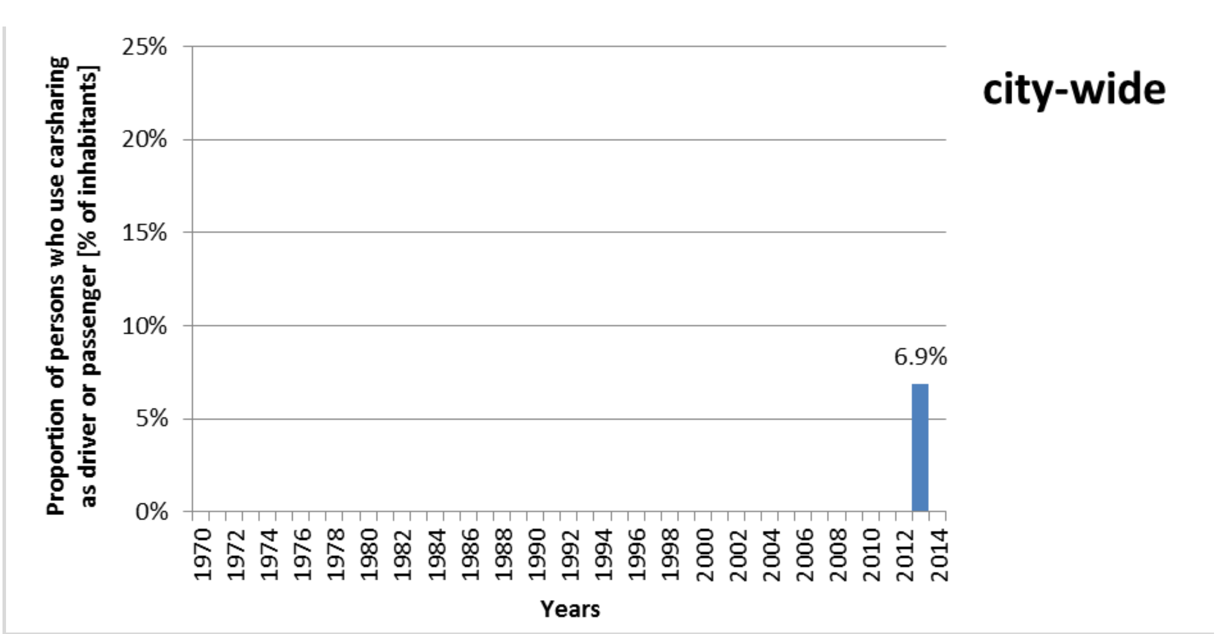

Figure 6-7: Development of the proportion of persons who use carsharing as driver or passenger [% of inhabitants]
(Source: HTS, SrV 2013)

6.2 Individual travel behaviour

6.2.1 Average number of trips (per tripmaker and day)

The average number of trips per tripmaker and per day is one of the most important indicators for evaluating the quality of household travel surveys. It is widely accepted that activity needs do not change fundamentally within only few years. Figure 6-8 contains these numbers provided by Berlin's HTS. The number of trips, per tripmaker and day, varies only within a small range, as mentioned above. If a person indicates out-of-home activities on the reporting day, the average of daily trips re relatively constant across time and the value is just below four trips per tripmaker and day.

Young adults and elderly people show dynamic changes in travel behaviour within the last decades. Figure 6-9 shows the development of the elder generation, which is of particular interest for analysing population travel behaviour. Various life experiences lead to the development of habits (e.g., in travel behaviour) over time. Therefore, elderly people have very strong attitudes und perceptions concerning travel. Travel practices in the past were very important for the establishment of behaviour patterns in their current life stage.

Regarding trip rates, Figure 6-9 shows a tendency: The number of trips per workday, referred to tripmakers, has increased. Access to a car has a strong impact on daily trip rates. At the personal level, both age groups have more trips per tripmaker and day when there exists a direct access to a car within the household

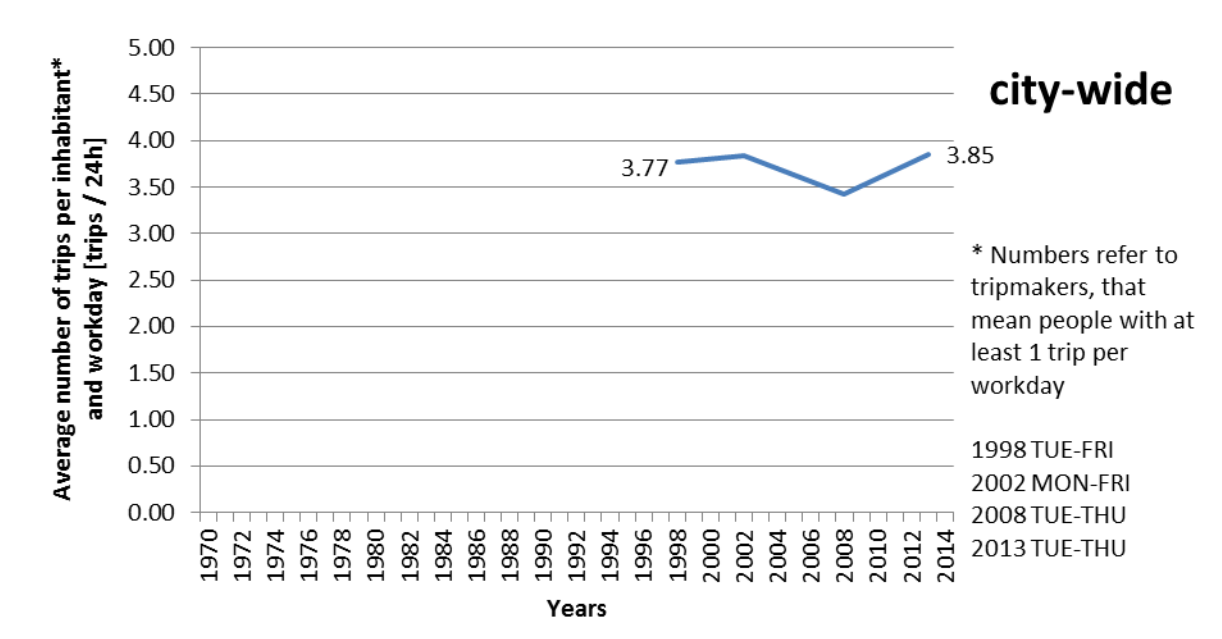

Figure 6-8: Development of the average number of trips per inhabitant and workday (only tripmakers, excluding non-mobile persons) [trips / 24h]

Sources: BVG 1998, MID 2002, SrV 2008, SrV 2013 (HTS)

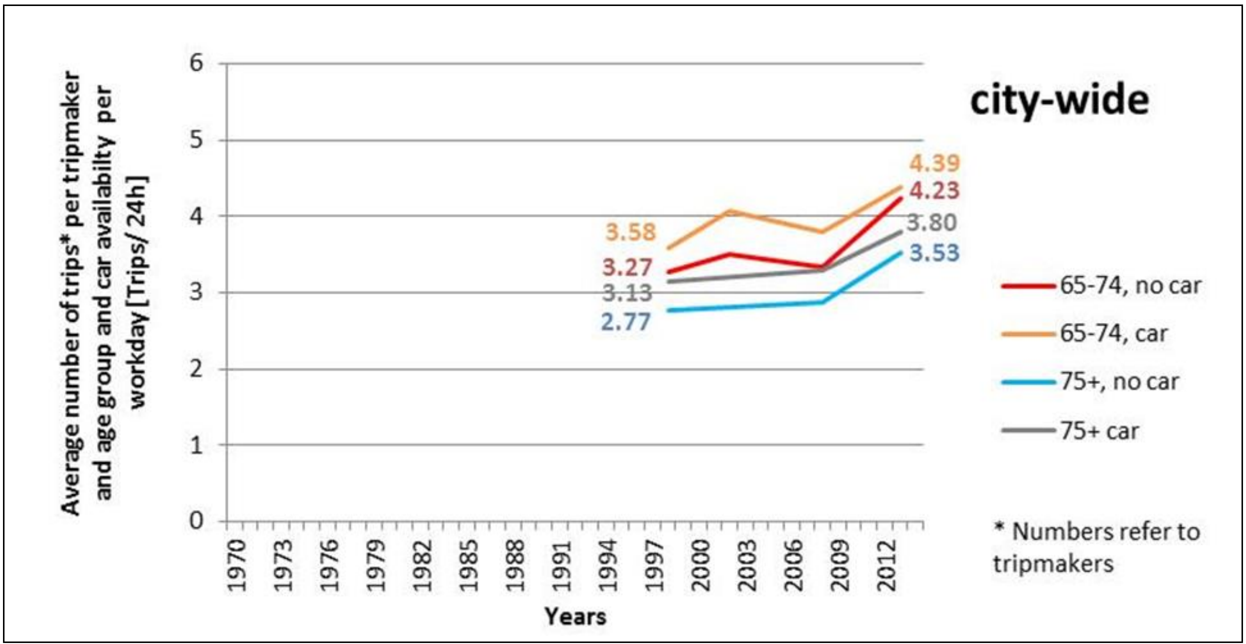

Figure 6-9: Development of the average number of trips of elderly people by age group, car availability and workday (only tripmakers, excluding non-mobile persons) [trips / 24h]

Sources: BVG 1998, MID 2002, SrV 2008, SrV 2013 (HTS)

6.2.2 Distribution of trips per peak hour

Figure 6-10 shows the average number of trips per tripmaker and day within the peak hour period (6 am to 9 am). After a drop between the survey years 1998-2002, the number of trips (mostly for work purposes), within the three morning peak hours, stays constant at nearly 0.8 trips per tripmaker and day. The drop between the first two survey years seems to be quite large; this could be the result of analysis inferences but also indicates a well-known phenomenon: The daily employment time-table changed, particularly during the 1990s, thus leading to less peak-hour work travel in many cities. The HTS numbers underscore this phenomenon even if earlier numbers are not available for Berlin.

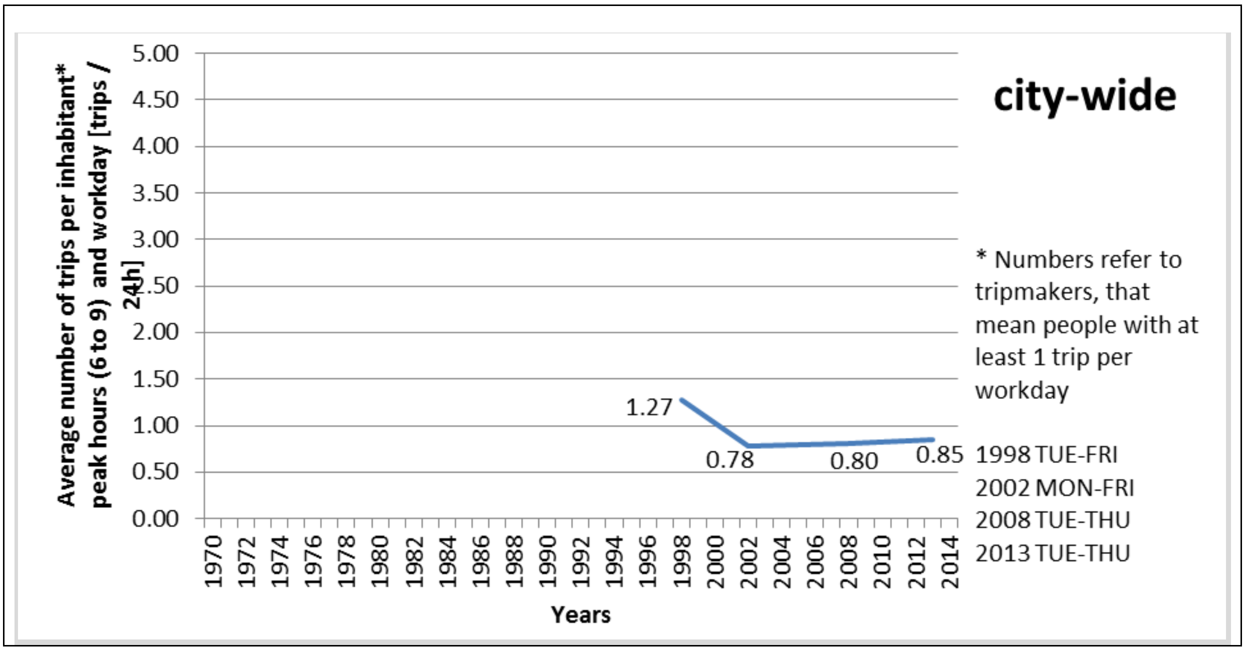

Figure 6-10: Development of the average number of trips per inhabitant and peak hour (on the aver 6 to 9 hours) [trips per inhabitants within the 3 hour period per day]
Sources: BVG 1998, MID 2002, SrV 2008, SrV 2013 (HTS)

6.2.3 Average milelage (per tripmaker and day)

The total mileage driven (including kilometres as pedestrian) during a workday is one of the most interesting parameters of daily mobility. Mileage is a performance indicator which also includes the choice of activity as well as its specific location (trip rate and trip destination choice). Figure 6-14 indicates that these numbers for valid trips (valid duration, length, and speed) are <100 kilometres for Berlin. Obviously, mileage per tripmaker and workday declined significantly between 1998 and 2013. The 2013 value is more than 10 % below the value of 1998 and decreased continuously across all four survey years.

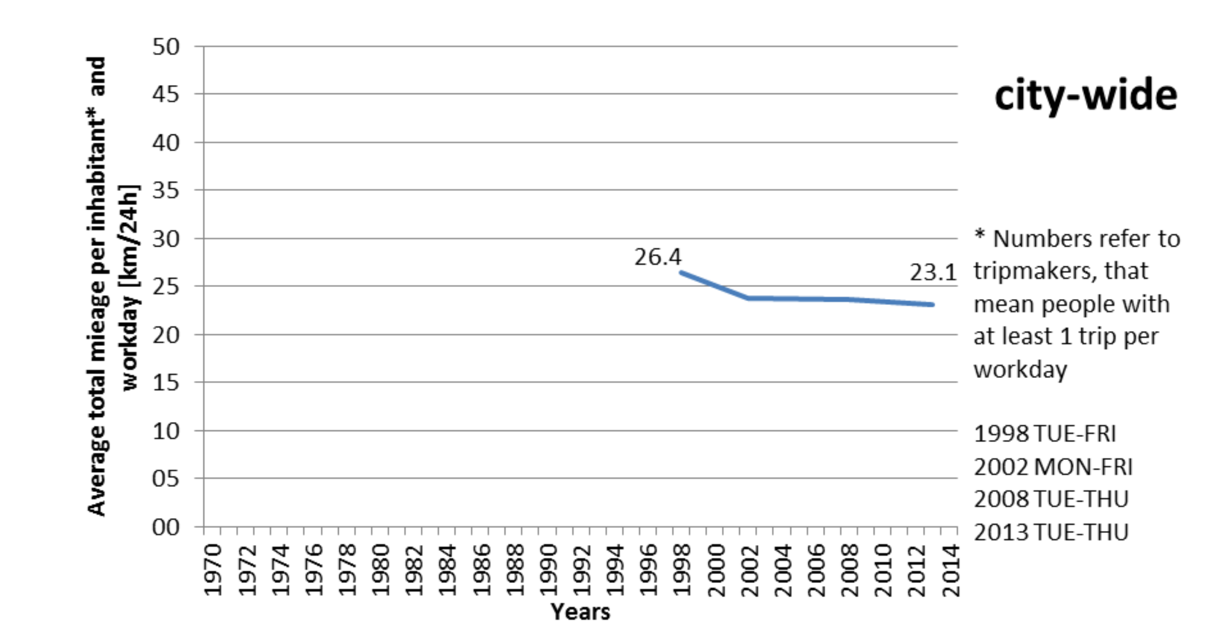

Figure 6-11: Development of the average total mileage per inhabitant and workday [km / 24h, only valid trips < 100 km]

Sources: BVG 1998, MID 2002, SrV 2008, SrV 2013 (HTS)

Figure 6-12 distinguishes the mileage driven per inhabitant by main modes. The main goal of this graph is to show that the relation of mileage driven by inhabitants has changed fundamentally between PT users and car-drivers. While car-driver mileage was more than twice as high as the mileage driven by PT users in 1998, in 2013, values were much closer, and PT mileage had even overtaken the car-driver value.

Following the HTS data, there was a sharp drop of car-driver mileage, particularly between 1998 and 2002. Methodological influences cannot be ruled out completely. Nevertheless, the general development of the numbers seems to be logical and consistent. This can also be reasoned by the fact, that only car-driver mileage shows a sharp drop. All other modes of transport show rather smooth developments.

Two other changes should be highlighted: Kilometres driven by car passengers also declined within the observation period and cyclist mileage increased constantly by one kilometre per day in 1998 to almost 1.8 kilometres per day in 2013.

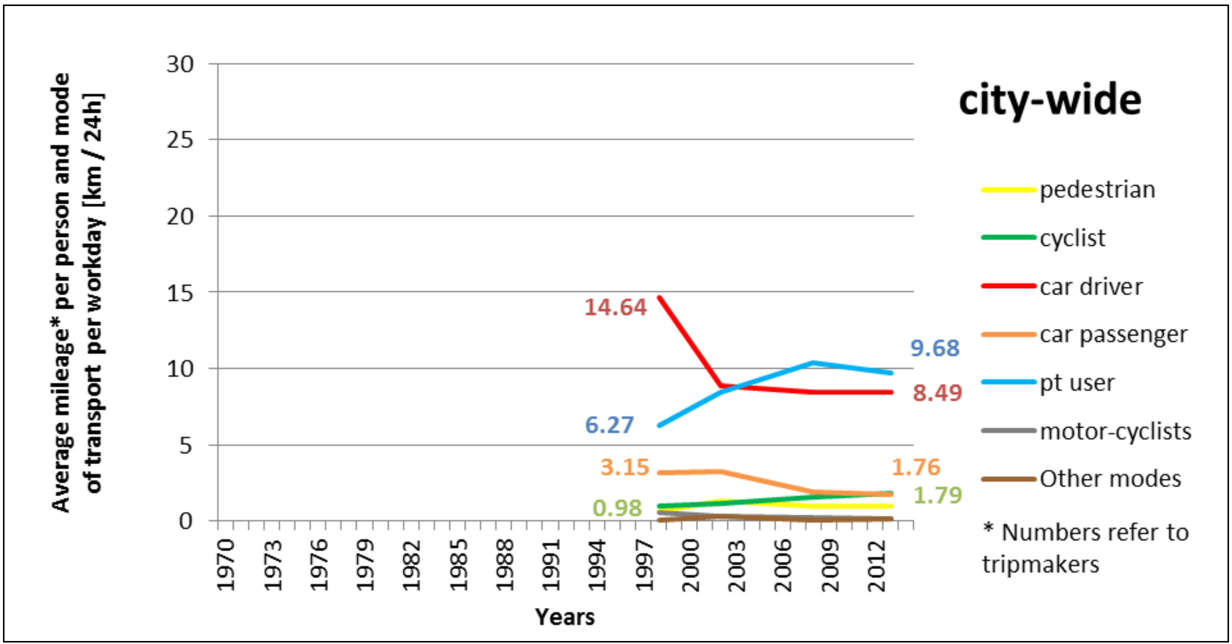

Figure 6-12: Development of the average total mileage by main mode per inhabitant and workday [km / 24h]

Sources: BVG 1998, MID 2002, SrV 2008, SrV 2013 (HTS)

6.2.4 Average trip length

The average trip length by main mode is another indicator for better understanding mobility patterns. Figure 6-13 shows the development of trip lengths within the observation period from 1998 until 2013. These numbers underscore the already mentioned link between activity choice and destination choice. Kilometres per car trip declined both for car-drivers and for car passengers while PT trip lengths increased. Trip lengths for motor-cyclists also declined, while the average trip length for bicyclists increased clearly from 2.2 to 3.4 kilometres per trip. Trip lengths for pedestrians remain almost constant at one kilometre per tripmaker and day across the timeline.

The data show that the slump in car-driver mileage between 1998 and 2002 is not only a result of trip length but also of a declining number of trips per day by car-drivers.

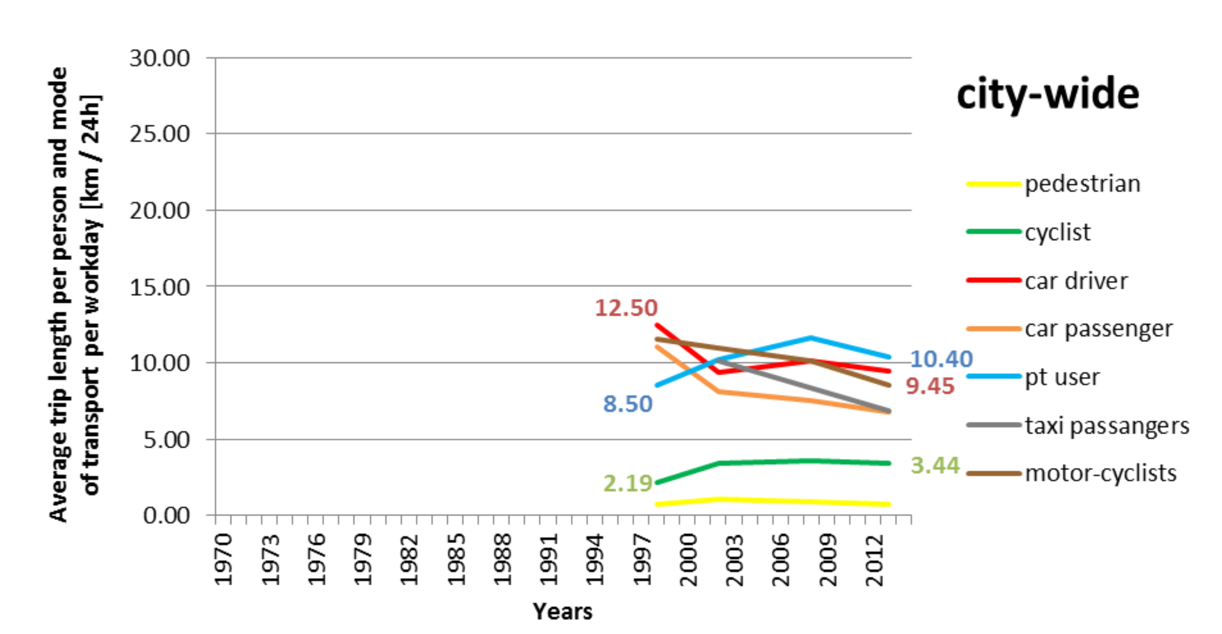

Figure 6-13: Development of average trip length per mobile person and mode of travel per workday [km / 24h]

Sources: BVG 1998, MID 2002, SrV 2008, SrV 2013 (HTS)

6.2.5 Modal split of the inhabitants

The modal split is one of the most common indicators for evaluating the perception of different transport modes and the mode choice at an individual level within a city. This indicator is widely accepted, although the share of trips by transport mode only indicates the relative relation between means of transport and does not always offer a direct interpretation of total transport demand. However, in the case of Berlin, the overall mobility rate between 1998 and 2013 remained nearly constant. This gives a good impression of the modal choice and overall travel demand of inhabitants.

Figure 6-14 shows the proportions of different transport modes at the modal split on workdays. Trips by car-drivers have declined impressively from 30 % to 22 % since 1998. The share of car-passenger trips has also been decreasing as well as the proportion of trips by motor-cyclists. All in all, it is clearly visible that that all individual motorised transport modes lost importance within mode-choice behaviour. Non-motorized trips have increased most (e.g. walking and cycle trips) whereas the share of PT trips has remained, more or less, at the same level in 2013 as in 1998. In other words, the growth of public transport mileage (addressed above) mainly resulted from the extension of trip lengths by public transport. Today, environmentally-friendly transport modes (non-motorised or public transport modes) have a proportion of more than 71 % on the modal split.

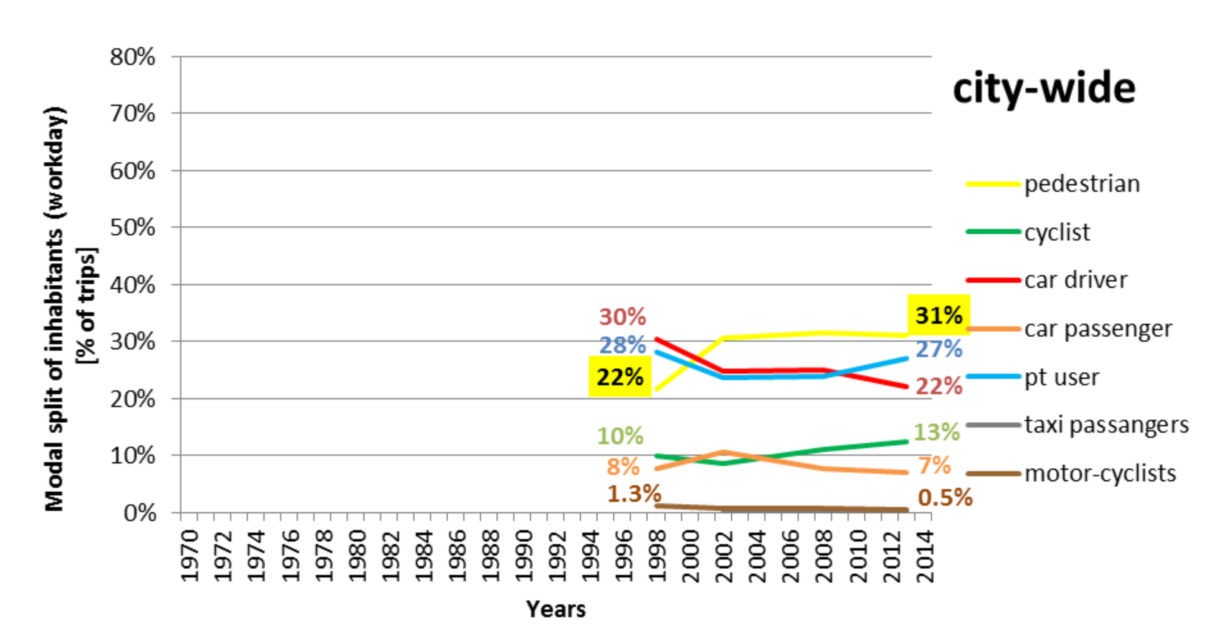

Figure 6-14: Development of modal split of inhabitants (workday) [% of trips]
Sources: BVG 1998, MID 2002, SrV 2008, SrV 2013 (HTS)

The number of elderly people has increased in the city of Berlin within the last decade. Persons with 65 years of age or more are more mobile in terms of their number of trips. This population group plays an important role in everyday car traffic as they also show a growth in car access. The following pictures contain the development of elderly persons' modal split distinguished by age group and access to a car (car within the household and a car driving license). Figure 6-15 shows the modal split of people between 65-74 years of age without car within the household. Cycling and car trips have a very low level, because mobility needs were mainly satisfied by public transport and walking. The figure shows an interesting development: Public transport and walking shares have nearly reversed. While, in 1998, almost four out of ten trips were done by PT, by 2013, the PT share had clearly declined, and walking had become the most important transport mode within this group.

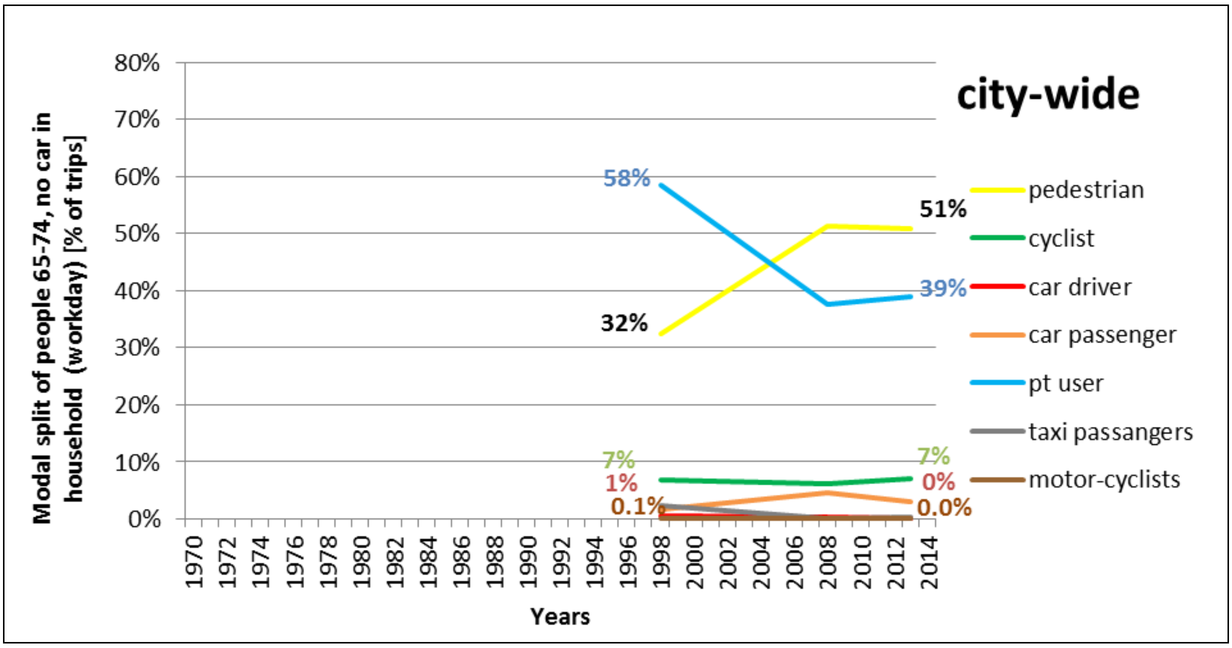

Figure 6-15: Development of modal split of people 65-74 years of age, no car in the household (workday) [% of trips]

Sources: BVG 1998, MID 2002 (value not shown because of too few cases), SrV 2008, SrV 2013 (HTS)

Figure 6-16 contains the modal split of people between 65-74 years of age with car access. As opposed to the group before, everyday travel behaviour is characterised by car trips and walking. Since 1998, walking has increased while car driver trips have declined slightly. Once again, cycling does not play a very important role for this group. The share of PT transport on modal split has decreased.

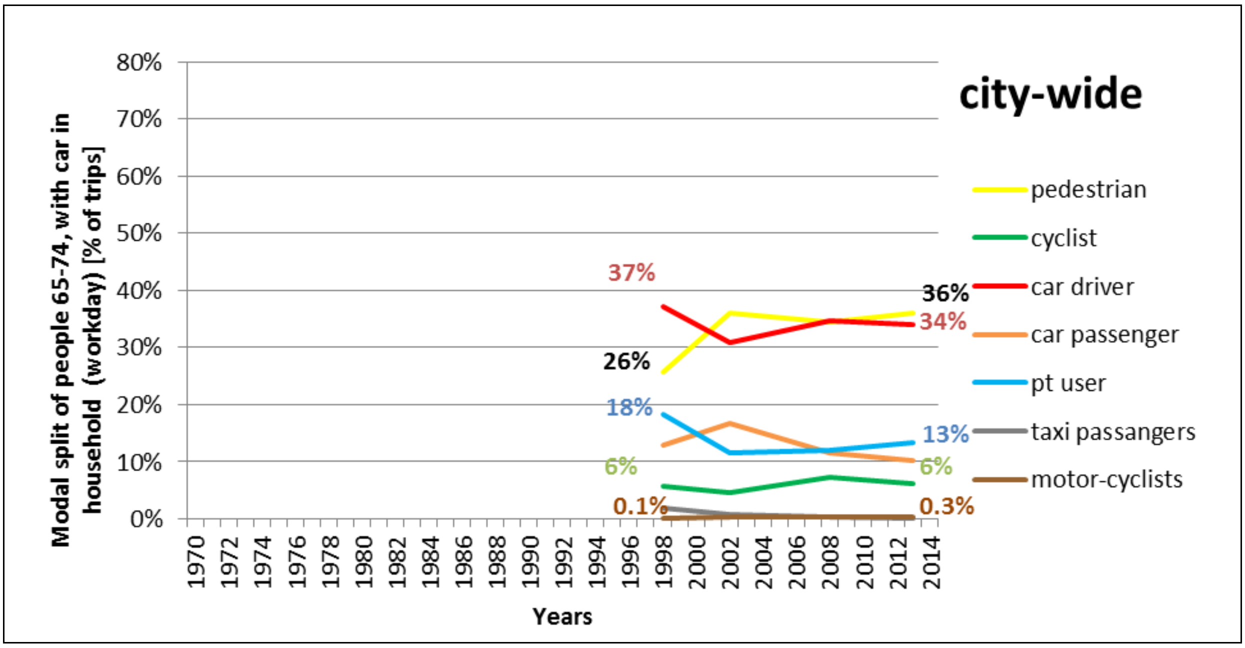

Figure 6-16: Development of modal split of people 65-74 years of age, with car in the household (workday) [% of trips]

Sources: BVG 1998, MID 2002, SrV 2008, SrV 2013 (HTS)

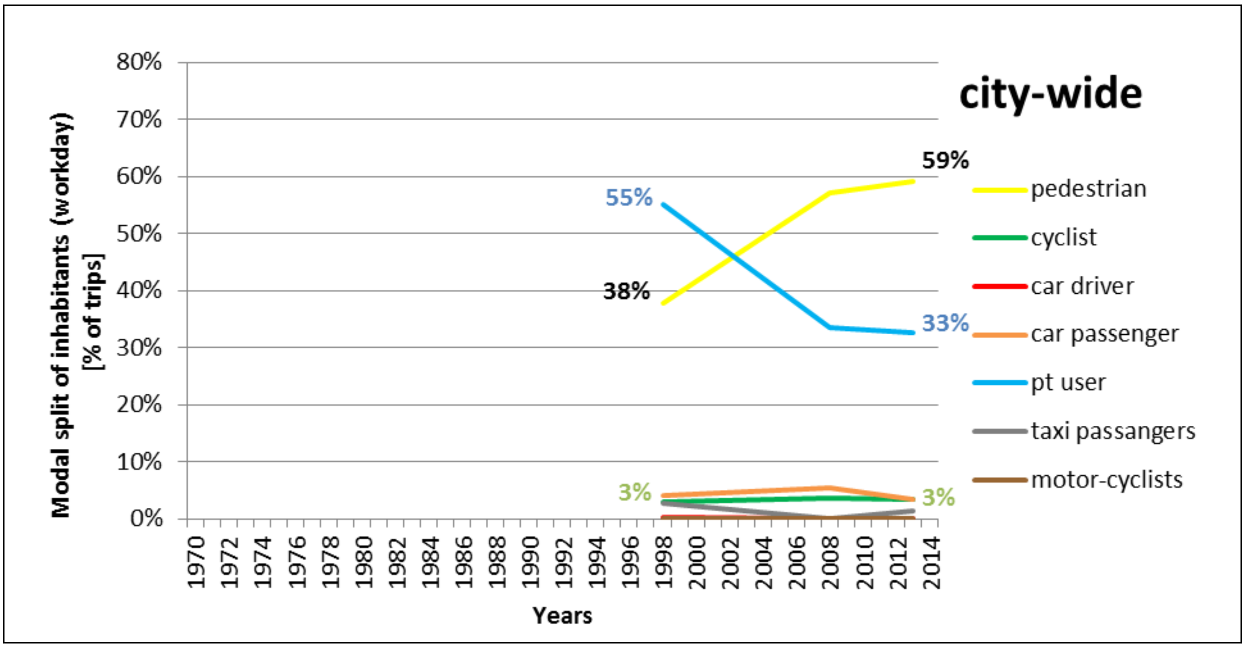

Figure 6-17: Development of modal split of people 75+ years of age, no car in the household (workday) [% of trips]

Sources: BVG 1998, MID 2002 (value not shown because of too few cases), SrV 2008, SrV 2013 (HTS)

The modal split of people 75+ years of age without access to a car is visualised in Figure 6-17. These people show similar tendencies to the younger group of seniors: PT and walking are the dominating transport modes. The share of cycling is already at a very low level and the other transport modes do not play any role. People without car access and over 75 years of age have the lowest trip rate of all elderly people. They suffer the most mobility restrictions in comparison with the other groups.

The last group, people 75+ with car access, again have similar travel behaviour patterns to the younger seniors (Figure 6-18): Car trips, together with walking, are the most important transport modes. Compared to people of the same age group without car access, an interesting detail can be observed: Persons with car access are not only more active regarding their number of trips but also still have cycling trips within their model split. Moreover, this value has increased by two percentage points, since 1998, to 8 %. Walking has also increased, while car trips have kept constant.

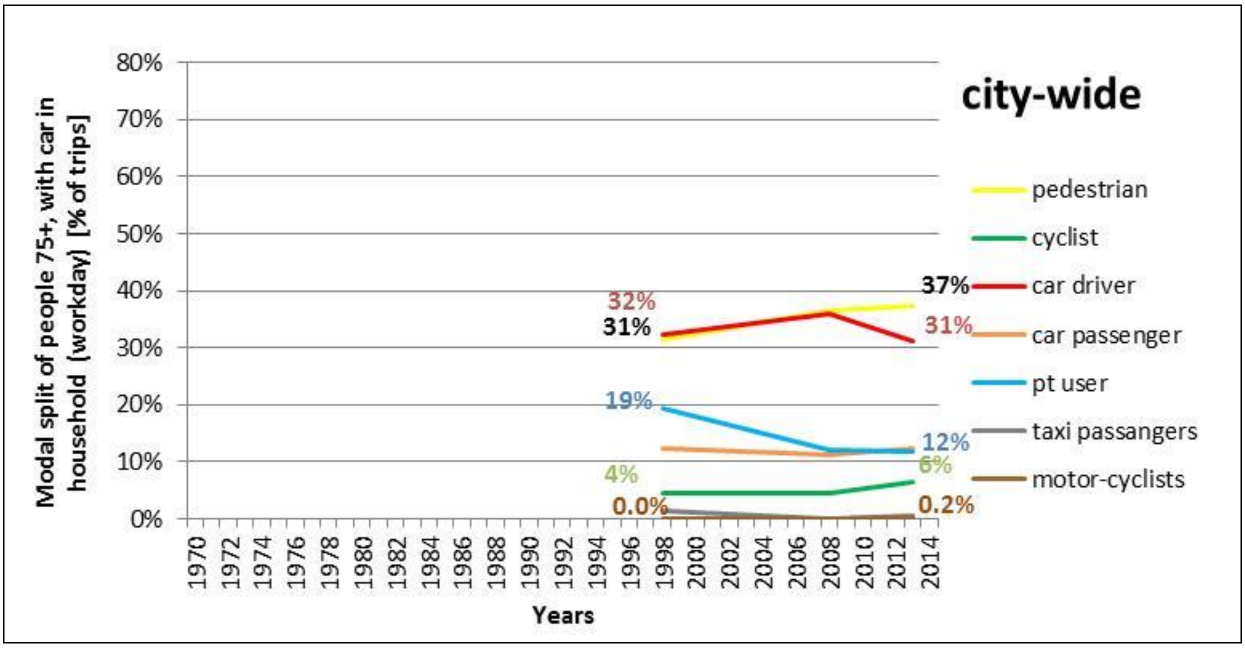

Figure 6-18: Development of modal split of people 75+ years of age, car in household (workday) [% of trips]

Sources: BVG 1998, MID 2002 (value not shown because of too few cases), SrV 2008, SrV 2013 (HTS)

6.2.6 Trip purpose

Figure 6-19 provides an overview of the kind of activities performed by inhabitants on workdays. While home-based trips and leisure activities keep more or less constant, an interesting development of work/education-related trips and shopping/errand related trips has been found. Despite of some consistency issues that seem to be within data points, a well-known tendency can be observed: The share of work-related trips decline while shopping/errand activities rise.

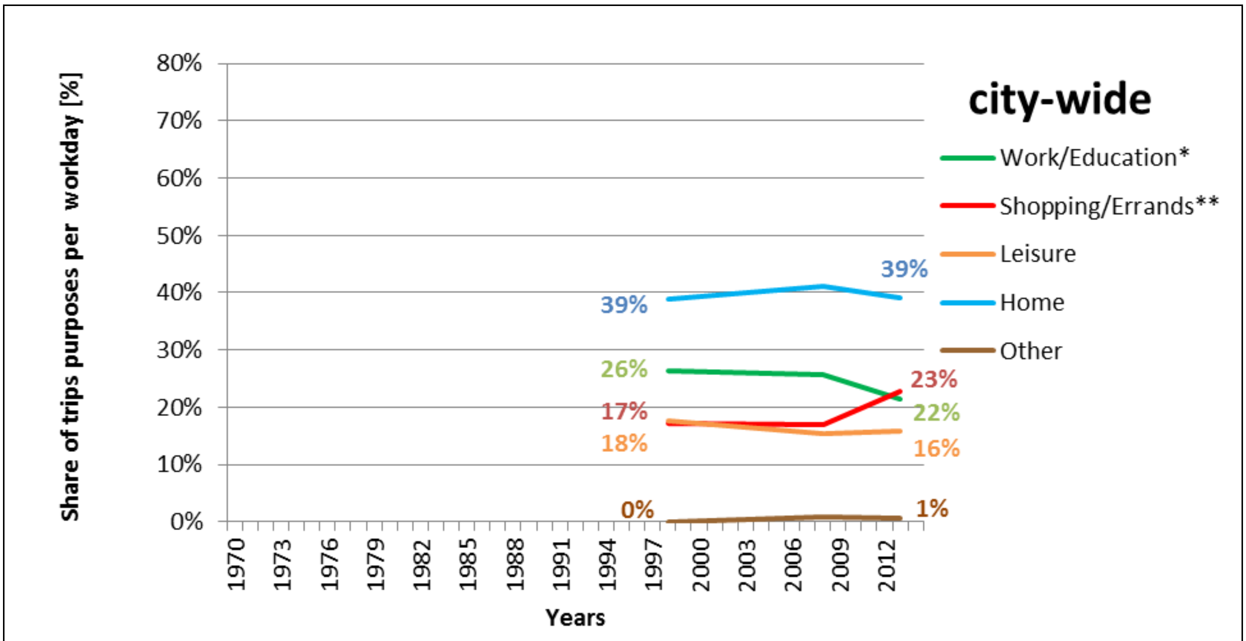

Figure 6-19: Development of the trip purpose according to 5 groups

Sources: BVG 1998, MID 2002 (value not shown because inconsistent), SrV 2008, SrV 2013 (HTS)

6.2.7 Car occupancy rate

Several factors relates to the development of car occupancy on workdays. Figure 6-20 contains the numbers for the timeline from 1998 until 2013. The numbers were calculated using the information for car-driver trips and car-passenger trips because direct car occupancy values were only surveyed for the years 2008 and 2013. However, this approach is frequently used to approximate real car occupancy.

The data shows that car occupancy only differed slightly within the 15 year time period. It should not be counted as a clear tendency of increasing value, for only a very little development could be supposed.

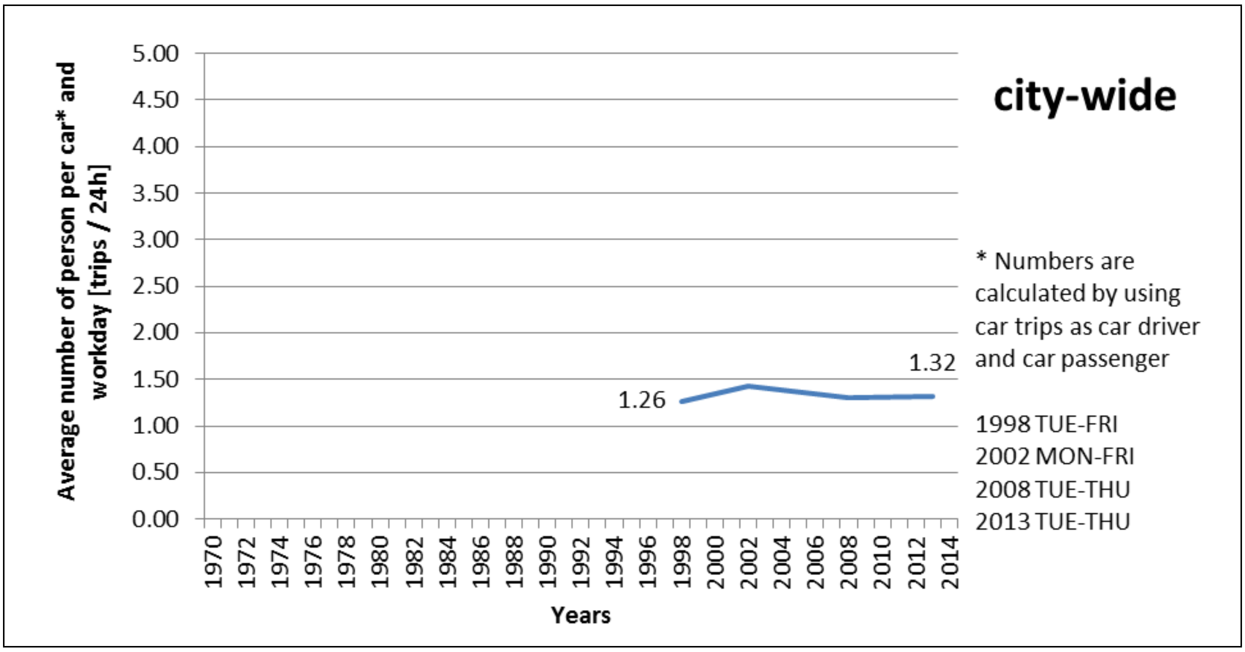

Figure 6-20: Development of the car occupancy rate [persons per car], workday
Sources: BVG 1998, MID 2002, SrV 2008, SrV 2013 (HTS)

6.2.8 Average total mileage by age group

A better understanding of the influences behind the developments described above is only possible by analysing additional explanatory variables. One of the most meaningful explanatory variables at the individual level is age. Due to the different sample sizes of the four survey years, seven age groups were established for classification.

Figure 6-21 indicates the development of total mileage by age group and workday. The graphic shows interesting developments among age groups. Since 1998, the total mileage has decreased for people younger than 12 years and people between 18-44 years of age. The development is not as clear for the age group of 45-64 years. The age group of seniors (65 years and more) and teenagers (12 to 17 years of age) are the only groups were mileage increases. In the case of seniors, a significant increase in mileage can be observed.

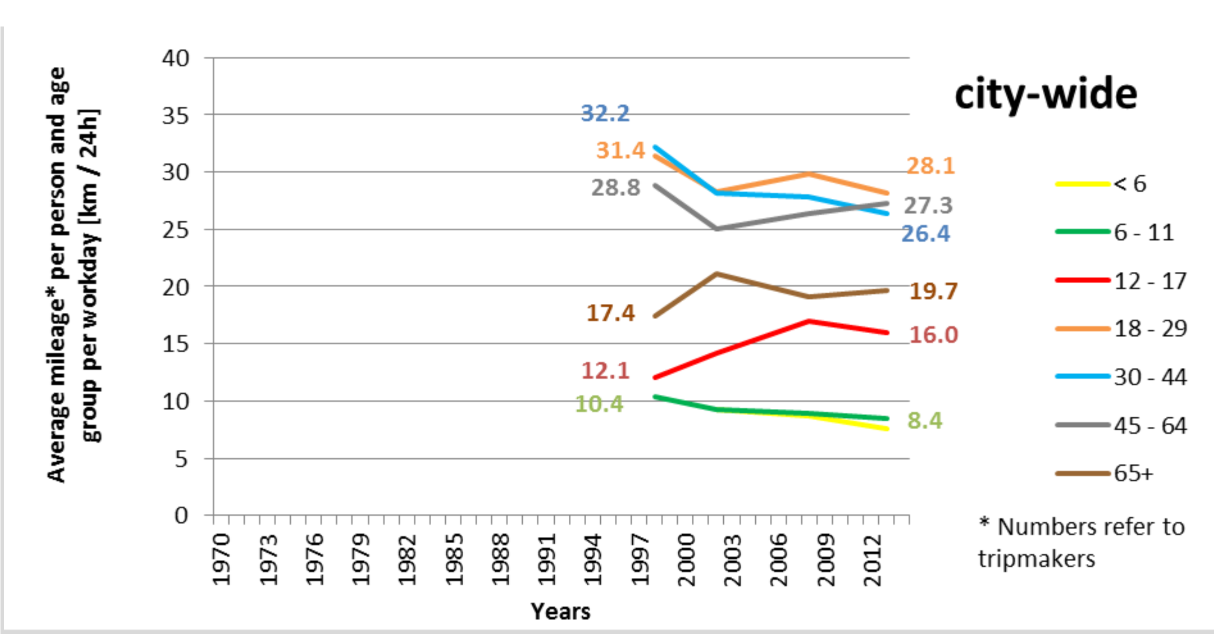

Figure 6-21: Average total mileage according to age group per workday
Sources: BVG 1998, MID 2002, SrV 2008, SrV 2013 (HTS)

6.2.9 Average car mileage by age group

The mileage, according to transport mode and differentiated by age group, gives another meaningful insight into changes in travel behaviour of Berlin's inhabitants. For the sake of clarity, to the transport modes have been separated.

First, the average car mileage per driver and workday according to age group is shown in Figure 6-22. Despite the fact that car mileage has declined generally in Berlin, some interesting statements for age groups exist. The age groups 18-29 and 30-44 have very clearly reduced their daily mileage as car drivers. Particularly the age group of young adults (18-29) decreased its car-driver mileage from 16 kilometres per day to 6 kilometres. Seniors (65+) are the only group that has increased their car driver mileage. While this group drove an average of 7 kilometres per workday in 1998, this value reached 8 kilometres per workday in 2013. Most kilometres are driven from people aged 30-64, extending over all survey years.

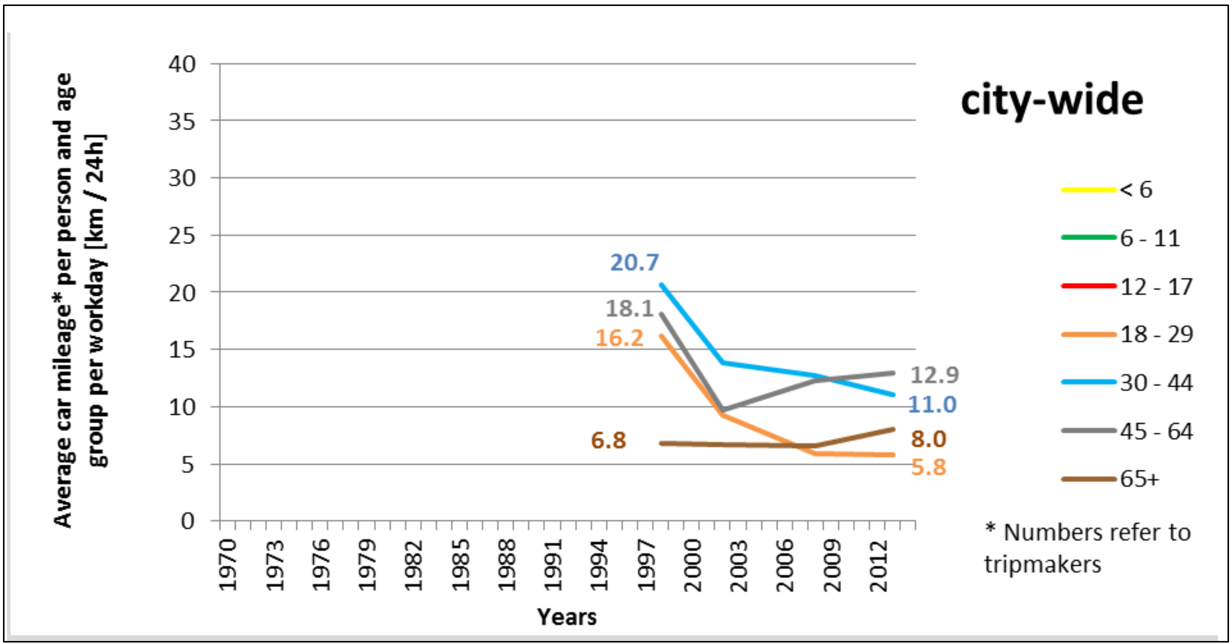

Figure 6-22: Average car mileage (by driver) according to age group per workday
Sources: BVG 1998, MID 2002, SrV 2008, SrV 2013 (HTS)

Almost the exact opposite of development is shown in Figure 6-23, which displays the PT mileage per age group and workday. Within the 15 year period, young adults have dramatically increased their PT mileage from 9 kilometres up to 18 kilometres per workday. Similar tendencies exist for the other age groups but with less intensity than for young adults. The only group who reduced their PT mileage slightly is the group of elderly people (65+). Public transport is increasingly becoming the backbone of Berlin's daily mobility for inhabitants as well as for longer distances within the city.

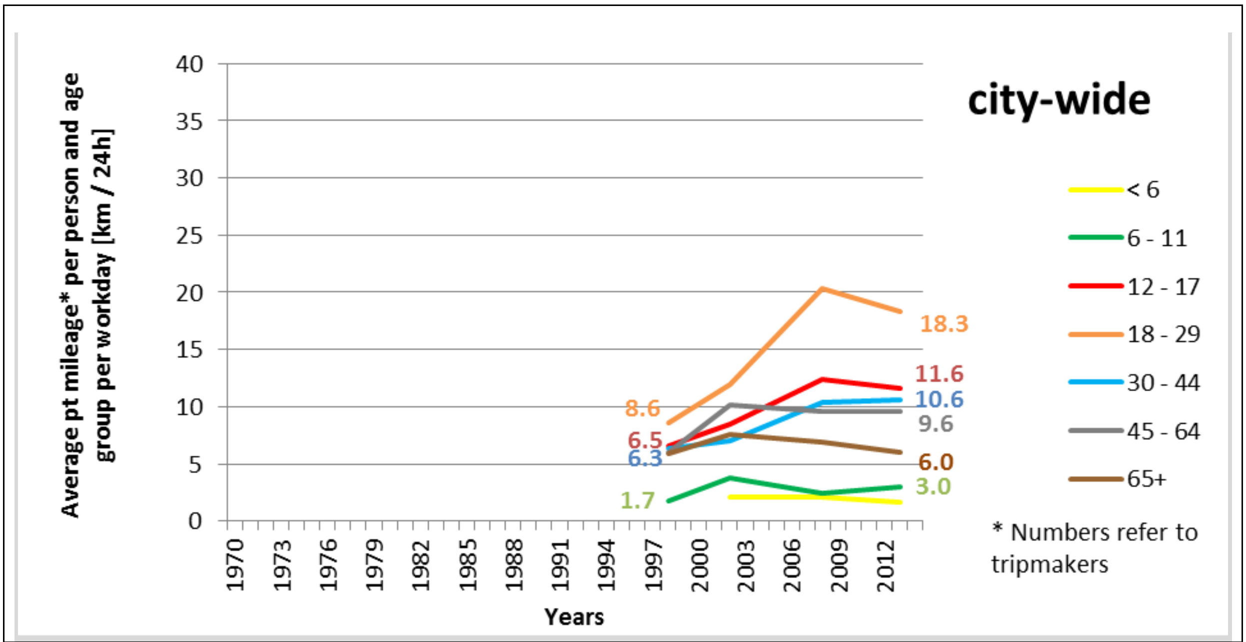

Figure 6-23: Average PT mileage according to age group per workday
Sources: BVG 1998, MID 2002, SrV 2008, SrV 2013 (HTS)

6.2.10 Share of car driver trips by age groups

The following analyses show the share of trips separated by transport modes by age group. Since the trip-related modal split is one of the most discussed values in planning, the age as an explanatory variable should provide a wider scope for interpretation. Nevertheless, it should be kept in mind that each relative number within the model split depends on the number of trips by other transport modes and should not be interpreted completely separately.

Figure 6-24 contains the share of car-driver trips within the modal split by age group. As already mentioned young adults (18-29) are the group with the largest reduction compared to all other groups (from 29 % to 13 %). Significant reductions can also be observed for people between 30-44 years of age (40 % to 26 %). Only the group of elderly people (65+) has clearly gained car-driver modal shares from 18 % in 1998 to 23 % in 2013.

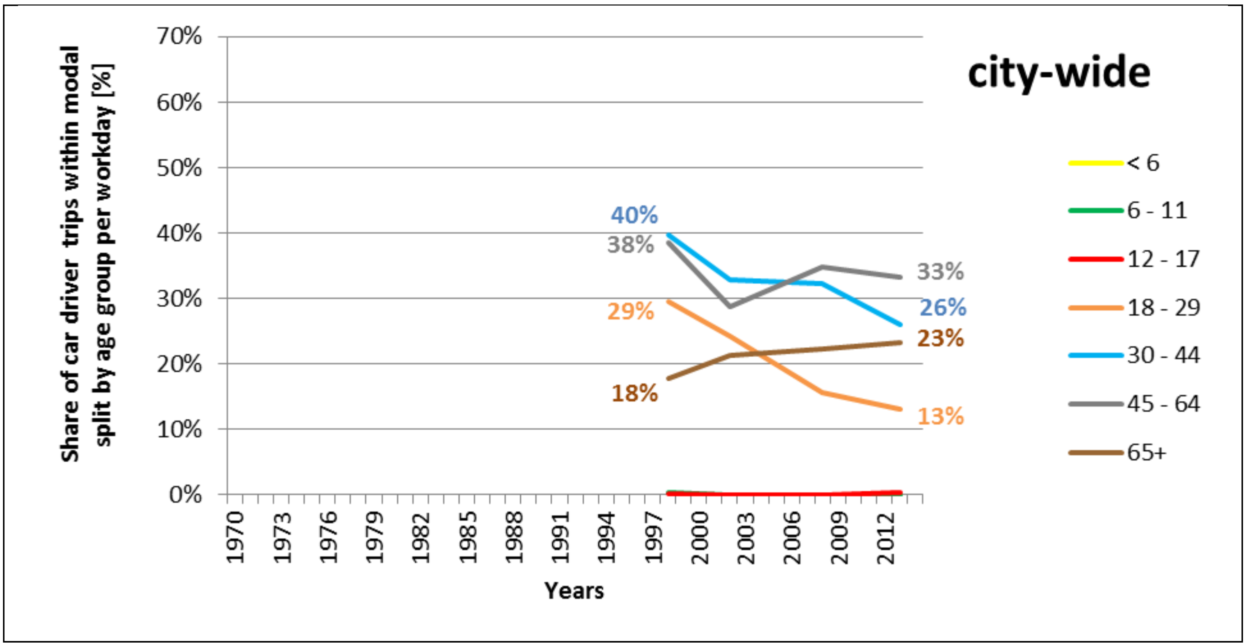

Figure 6-24: Share of car driver trips within model split (all modes) by age group
Sources: BVG 1998, MID 2002, SrV 2008, SrV 2013 (HTS)

6.2.11 Share of PT trips by age group

Figure 6-25 indicates the numbers for PT trips within modal split by age group. Most PT trips are by teenagers. That is a well-known phenomenon, due to mobility obligations and requirements to education. Regardless, particularly the group of 12 until 17 years of age rises sharply. Today more than a half of all trips within that age group are performed with public transport modes. A nearly parallel development occurs with the group of young adults from 18 to 29 years of age. Elderly people (65+) again show a particularly interesting development. The share of PT trips within the modal split decreased very clearly from 38 % (1998) to 20 % (2013), as shown by the numbers in Figure 6-25. This development corresponds with the vaulting car-driver share of elderly people and an increasing number of driving licences (especially of women) within this age group over time.

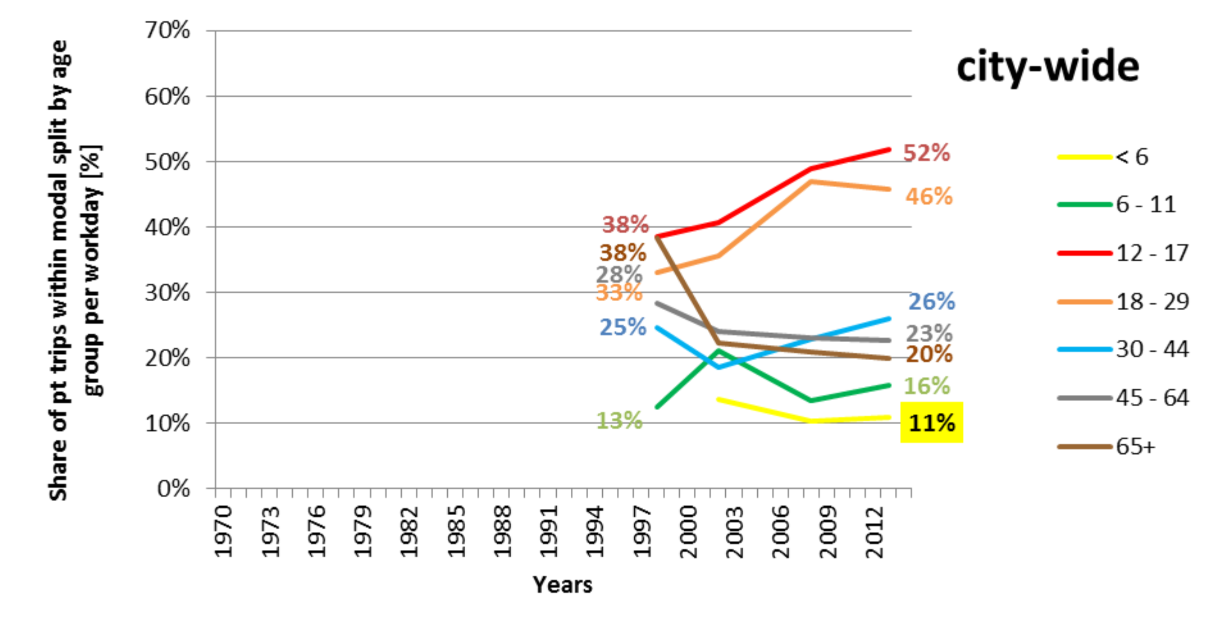

Figure 6-25: Share of PT trips within model split by age group
Sources: BVG 1998, MID 2002, SrV 2008, SrV 2013 (HTS)

6.2.12 Share of cycle trips by age group

Figure 6-26 includes the numbers for the proportion of cycle trips within modal split distinguished by age group. The numbers show smoother developments compared with the already-discussed results for trips as a car driver or as a PT user. Increasing bicycle use can be observed for the youngest age groups (up to 11 years of age) and for middle aged people (30 to 64 years of age). Changes move only in a minor single-digit percentage.

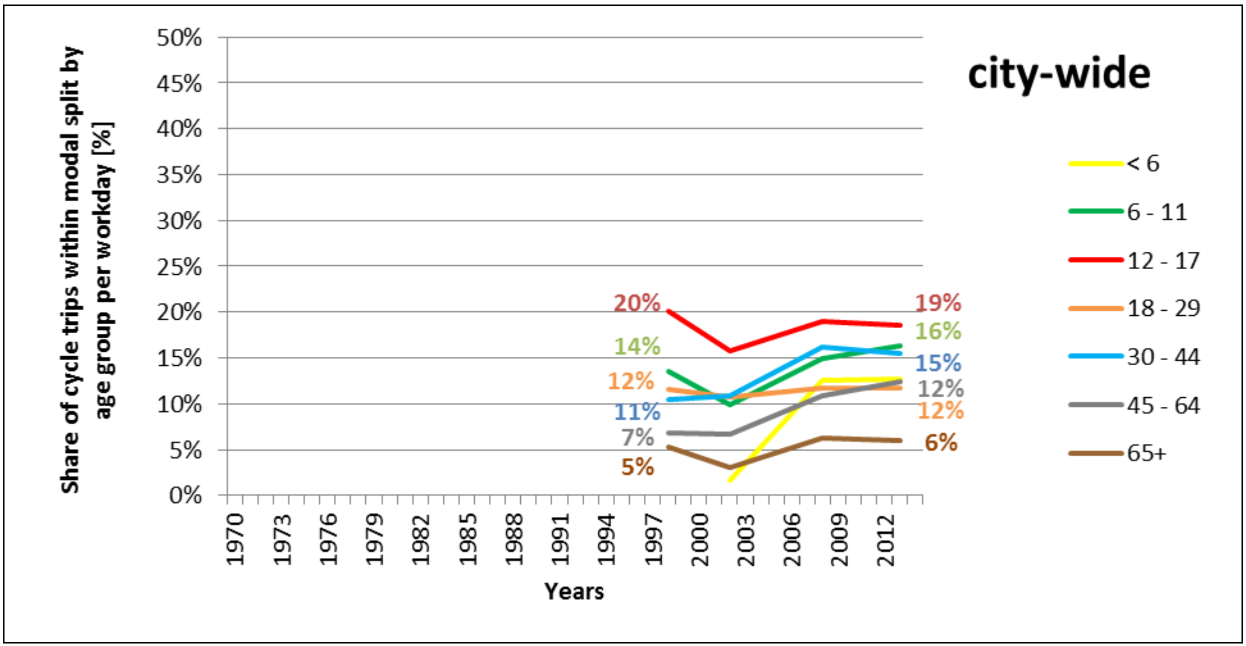

Figure 6-26: Share of cycle trips within model split by age group
Sources: BVG 1998, MID 2002, SrV 2008, SrV 2013 (HTS)

6.2.13 Share of walking trips by age group

As walking is one of the most flexible forms of mobility, particularly for short distances, it is relevant explore these numbers more in detail. Figure 6-27 shows these values according to age group for Berlin's population. It is interesting to highlight that for the age groups of 6-11 and 12-17 years, the share of walking reduced at a constant rate. On the other hand, the walking share for young adults (18-29) as well as for middle-aged people (30-44) and seniors has grown clearly within the 15 year observation period. This reveal some different developments beneath the surface, while, globally, the share of walking for the whole population appears to barely change at all. In general, it can be pointed out that seniors (65+) seem to prefer more individual transport modes (including walking) than collective ones.

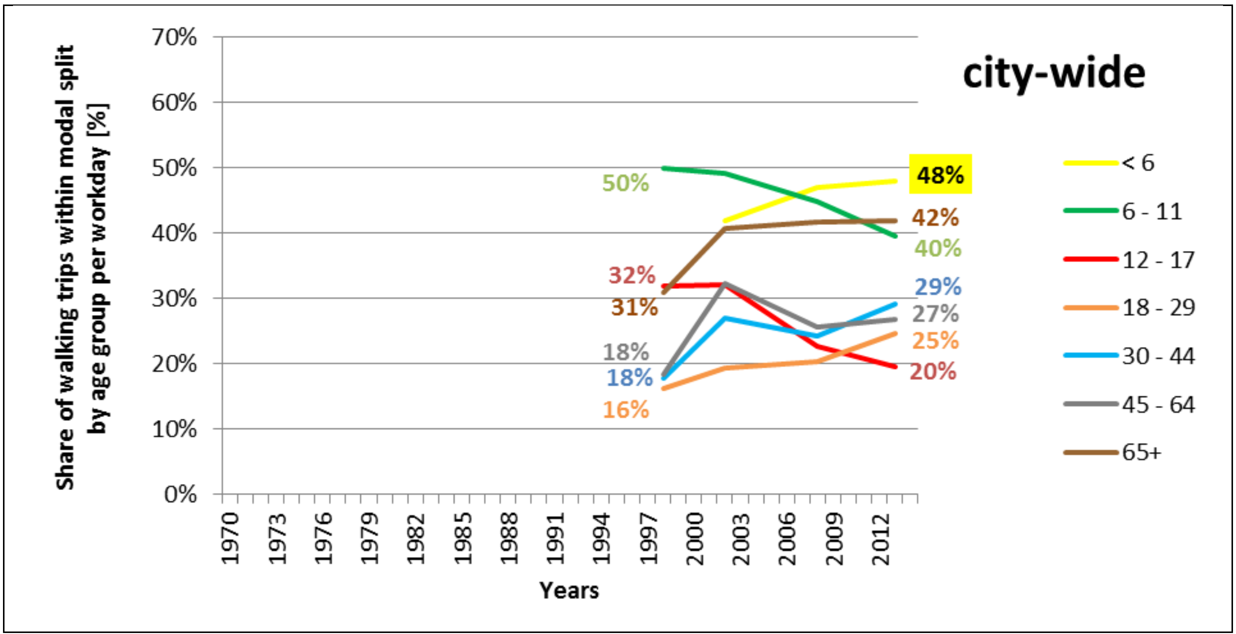

Figure 6-27: Share of walking trips within model split by age group
Sources: BVG 1998, MID 2002, SrV 2008, SrV 2013 (HTS)

6.3 Aggregated travel behaviour

6.3.1 Annual road traffic volume

The average cross-sectional road traffic volume per workday and road type is not monitored in Berlin. The indicator is considered to be of little significance, since even an average traffic load over road types oversimplifies the situation. Hence, the local situation for the different types of streets has to be considered if analysing traffic volume.

Instead, in Berlin, the classified average cross-sectional road-traffic volume per day is analysed. Together. the length of the different parts of road (total and in %) and their mileage are documented (see Table 6-1).

A comparison of the volume of traffic on the road in 1971, 1980, 1985 and 1993 in West Berlin shows a 74 % increase of traffic volumes in 1993 compared to 1971.

The following summaries are based on the characteristic route lengths and performance on traffic-load classes between 1993 and 2009. The total annual mileage has increased by approximately 413 million km per year (approx. 1.1 million km per day) to 2005.

Table 6-1: Traffic volume (DTV), distance (km) and mileage (km / day) in the main road network in 1993, 1998/99, 2005, 2009

Traffic volume (DTV), distance (km) and mileage (km / day) in the main road network in 1993						
DTV	**km distance**	**%**	**% - cumulated**	**mileage**	**%**	**% - cumulated**
less than 2,500	12.2	1.00%	1.00%	25.988	0.10%	0.10%
>2,500 to 5,000	32.2	2.70%	3.80%	132.554	0.50%	0.60%
>5,000 to 7,500	78.3	6.70%	10.50%	509.774	1.80%	2.40%
>7,500 to 10,000	92.6	7.90%	18.30%	834.669	3.00%	5.30%
>10,000 to 20,000	424.4	36.20%	54.50%	6.191.964	22.00%	27.40%
>20,000 to 30,000	235.4	20.10%	74.60%	5.824.114	20.70%	48.10%
>30,000 to 50,000	205	17.50%	92.00%	7.768.120	27.60%	75.70%
>50,000	93.6	8.00%	100.00%	6.818.144	24.30%	100.00%
total	**1,173.70**	**100.00%**		**28,105,326**	**100.00%**	

Traffic volume (DTV), distance (km) and mileage (km / day) in the main road network in 1998/99						
DTV	**km distance**	**%**	**% - cumulated**	**mileage**	**%**	**% - cumulated**
less than 2,500	3.2	0.30%	0.30%	5.338	0.02%	0.02%
>2,500 to 5,000	26.3	2.20%	2.50%	107.525	0.40%	0.40%
>5,000 to 7,500	58.4	4.90%	7.40%	363.374	1.30%	1.60%
>7,500 to 10,000	108.2	9.10%	16.50%	937.553	3.20%	4.90%
>10,000 to 20,000	451.4	37.90%	54.40%	6.573.078	22.70%	27.50%
>20,000 to 30,000	237.4	19.90%	74.30%	5.771.406	19.90%	47.40%
>30,000 to 50,000	213.5	17.90%	92.30%	8.141.383	28.10%	75.50%
>50,000	92.3	7.70%	100.00%	7.098.841	24.50%	100.00%
total	**1,190.80**	**100.00%**		**28,998,497**	**100.00%**	

Traffic volume (DTV), distance (km) and mileage (km / day) in the main road network in 2005						
DTV	**km distance**	**%**	**% - cumulated**	**mileage**	**%**	**% - cumulated**
less than 2,500	32.1	2.39%	2.39%	68,865	0.24%	0.24%
>2,500 to 5,000	56.7	4.23%	6.62%	232,407	0.79%	1.03%
>5,000 to 7,500	132.8	9.91%	16.53%	828,848	2.83%	3.87%
>7,500 to 10,000	136.0	10.14%	26.67%	1,186,683	4.06%	7.92%
>10,000 to 20,000	484.2	36.13%	62.80%	6,986,687	23.90%	31.82%
>20,000 to 30,000	237.2	17.70%	80.50%	5,805,277	19.86%	51.68%
>30,000 to 50,000	162.5	12.13%	92.63%	6,105,699	20.88%	72.56%
>50,000	98.8	7.37%	100.00%	8,022,697	27.44%	100.00%
total	**1,340.2**	**100.00%**		**29,237,163**	**100.00%**	

Traffic volume (DTV), distance (km) and mileage (km / day) in the main road network in 2009						
DTV	**km distance**	**%**	**% - cumulated**	**mileage**	**%**	**% - cumulated**
less than 2,500	50.6	3.21%	3.21%	73,647	0.26%	0.26%
>2,500 to 5,000	117.4	7.45%	10.67%	469,683	1.69%	1.96%
>5,000 to 7,500	173.8	11.03%	21.70%	1,104,039	3.97%	5.93%
>7,500 to 10,000	202.8	12.88%	34.58%	1,847,354	6.65%	12.57%
>10,000 to 20,000	523.0	33.21%	67.78%	7,486,173	26.94%	39.51%
>20,000 to 30,000	278.6	17.69%	85.47%	6,782,343	24.40%	63.92%
>30,000 to 50,000	176.0	11.17%	96.64%	6,685,888	24.06%	87.97%
>50,000	52.9	3.36%	100.00%	3,342,355	12.03%	100.00%
total	**1,575.1**	**100.00%**		**27,791,482**	**100.00%**	

Source: SenStadtUm 2011

Among other things, through the changes in the detected network, the increase in the shares of small to medium-loaded traffic routes in 2005 can be explained over the earlier detection times. The reduction of total mileage is striking and accounts for nearly 1.5 million kilometers of lines, which is particularly noticeable in the highest class with more than 50,000 motor vehicles. One cause is certainly the allocation of lanes on the city motorways, causing sections to fall into the lower DTV classes (where an increase in performance can be observed). Overall, the decline in the driven distances in Berlin corresponds well with the decrease in the vehicle fleet in the city (including private cars of which the numbers stayed generally the same, mirroring the total decrease in inhabitants).

Compared to the numbers in 2005, several road completions had to be taken into account, analysing the 2009 data. This includes the approximately 10.5 km-long section of the A100 / A113, which is the connection of the motorway A100 with the Berliner Ring A10 (in May 2008), and which directly connects to the future international airport Berlin Brandenburg (BER) in Schönefeld. Another example is the opening to traffic of the B96 to the road tunnel around the Tiergarten on 26/03/2006.

Based on the Berlin traffic control, VLB conducted and evaluated traffic surveys is the main road network defined in the Urban Development Plan Traffic (StEP) network. Based on a survey conducted in 2009, this network extends around 1,315 km to 1,575 km in length. The following numbers are from the working Traffic-Model for the whole city area, which only covers the first 2-3 road types almost completely. Stage 1 roads include important motorways and arterial roads; Stage 2 roads include main roads and motorways; Stage 3 is comprised of local and regional roads; and Stage 4 consists of supplementary roads. Approximately 30,000 to 35,000 cars, per day and direction, use Stage 1 road. The section of the motorway interchange called *Funkturm* represents the busiest stretch of motorway in Germany. About 186,100 vehicles every 24 hours (both directions together, mostly heading north) drive per day on the A100 (see Bast 04.01.2012). From 10,000 to 12,000 cars per day drive on Stage 2 roads on workdays (per direction). The most occupied Stage 2 road is the section of the A100 between the interchanges Jakob-Kaiserplatz and Beusselstraße, reaching nearly 37,500 cars every 24 hours on working days (per direction). On average, around 5,000-6,000 cars every 24 hours use a Stage 3 road on working days (per direction). About 16,250 cars per day drive on Konstanzer Straße north to Hohenzollerndamm on working days (per direction). A smaller supplementary Stage road has 3,000-4,000 cars every 24 hours on working days (per direction). The busiest one in Berlin is the Lindenstraße north of Gitschiner Straße with around 13,350 cars per day on working days (per direction).

6.3.2 Average speed level

The average speed of motorised transport for the main road network has only been monitored and analysed since 2014, using floating car data provided by a large navigation system service (anonymised sample). Until then, mostly static sensors and test drivers were used. Using the analysis of the floating car data, a weighted mean (weighted by mileage) of the average speed level in September 2014 (no holidays, representative for a standard year) was calculated for the morning and afternoon peak. For speed levels close to the local average speed level, an estimation procedure was used to adjust unreported deviations. This was supported and adjusted by static sensor data and test drives. Figure 6-28 illustrates that both the motorway and the main road network show, as expected, a higher speed level during the morning peak than during the afternoon peak.

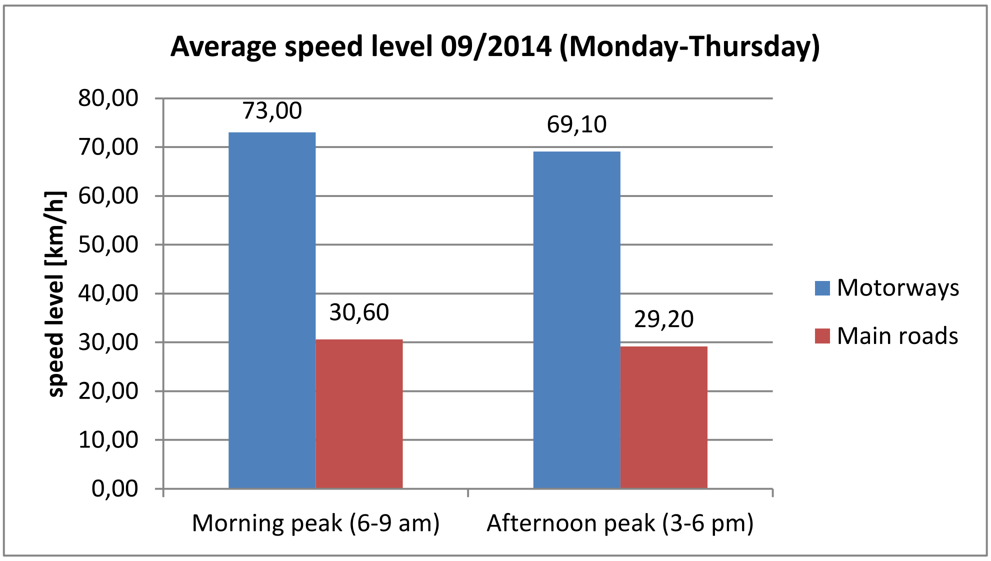

Figure 6-28: Average speed level higher main road network, weighted (September 2014, Monday-Thursday)

Source: SenStadtUm based on VMZ Berlin 2016

During morning peak, the average speed level on motorways with 73 km/h is close to the set speed limit, this indicates a good traffic flow. On main roads, the speed level was 50 km/h, which is much lower than the set speed limit. In the afternoon, both speed levels decreased from 73 to 69.1 km/h on motorways and 30.6 to 29.2 km/h on main roads.

For the main road network, a distinguished analysis for the inner-city and outer-city is possible (see Figure 6-29).

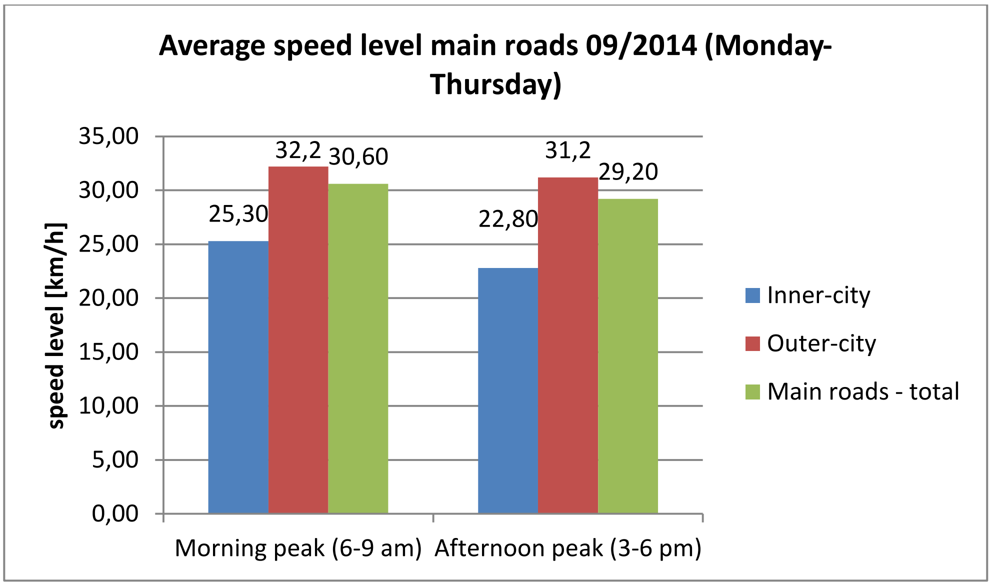

Figure 6-29: Average speed level main road network by city area, weighted by mileage (September 2014, Monday-Thursday)

Source: SenStadtUm based on VMZ Berlin 2016

The inner-city main roads show a much lower average speed level then the outer-city network due to congestions caused by high traffic volume, narrow streets, tram and bus-traffic, and extensive bicycle riding. In the outer-city, the speed level is slightly higher than the total average due to less PT service volume, a less dense PT network, larger distances between stops, and a different traffic flow.

6.3.3 Annual PT passenger trips

Similar to the service supply, a representation of passenger the number of passenger trips has only been available since 2007. However, the growth of passengers identified by the S-Bahn and BVG companies has already been accessible since 1991. After the reunification, ridership increased to around 1,250 million passengers per year until 1993 before falling to barely more than 1,000 million passengers per year in 1998 (see Figure 6-30).

From 2002 until 2007, the number of total passengers rose in the Berlin transport to 1,274 million. The number of passengers traveling by train climbed steadily since the renewed acquisition of the entire S-Bahn network in 1994, increasing by 240 million to 388 million passengers per year (2008).

Despite difficult years with strikes and the S-Bahn-crisis (2009–2011), which led to significant travel restrictions, the ridership of transport companies has had a visibly positive trend: In 2014, nearly 978 million passengers (UBF) used BVG buses and trains. Almost 414 million passengers in Berlin and Brandenburg used the S-Bahn in 2014, after a drop to 376 Million passengers during the S-Bahn crisis (2009–2011). Manufacturer-related vehicle defects and poor company management led to the Berlin S-Bahn crisis in 2009, which considerably reduced transport quality for passengers. Because of wheel defects, almost 400 of the required 550 double coaches had to remain in the depot. The number of available vehicles only (and gradually) increased back to the regular amount by 2011. Between 2009 and 2011, S-Bahn services had to be reduced to an emergency timetable (see VBB 2006-2015).

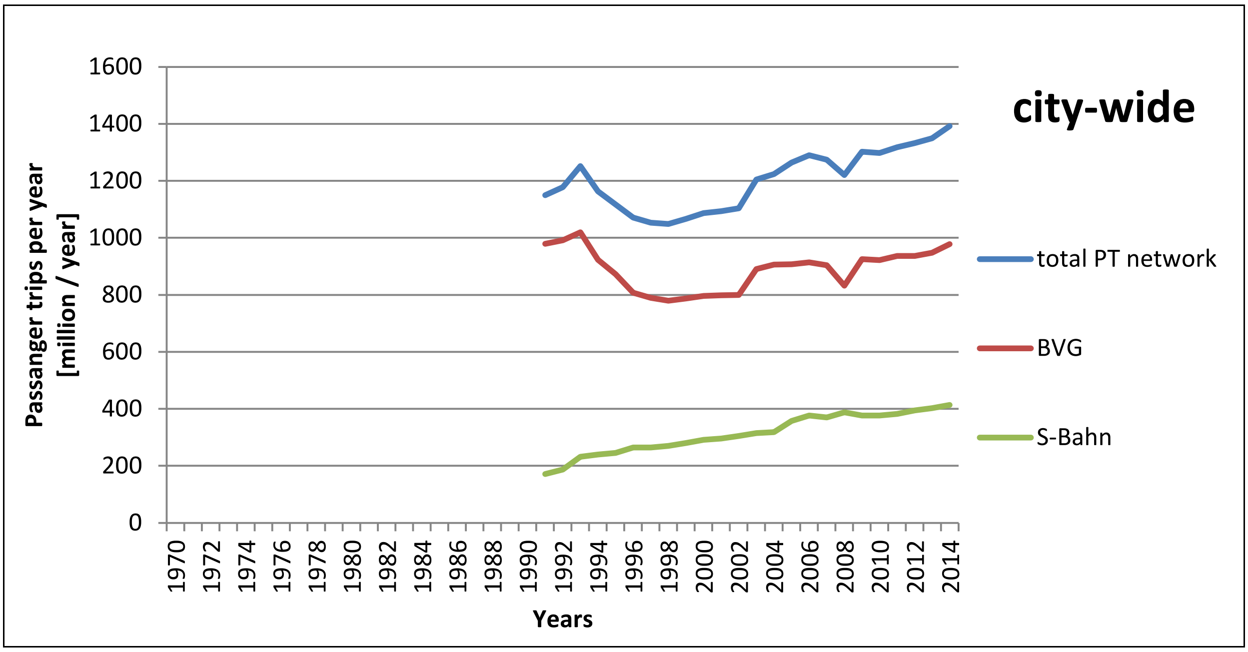

Figure 6-30: Development of the number of PT passengers by company [million trips / year]
Source: SenStadtUm based on SenStadtUm 2001-2014; CNB 2016b

In relation to the different modes of transport, the number of passengers increases: In combined paths with transport from 1 provider (here BVG) a combined trip by bus and U-Bahn is counted as 1 passenger per company but as 1 per passenger per U-Bahn and bus each with the separation in modes of transport. Therefore, in 2014 over 151 million passenger journeys per year were counted in Berlin, differentiated by mode (see Figure 6-30). It is noticeable that the curves reflect the same development as the diagram above (see Figure 6-31). In addition, it is clear that with around 517 million passenger trips in 2014 most passengers were traveling with the U-Bahn. Bus ridership and S-Bahn ridership were roughly the same with 405 million (bus) and 413.9 million passengers (S-Bahn). Just over 180 million passengers used the tram in 2014. The S-Bahn crisis is not clearly reflected in the ridership development. This might be caused by the high number of commuter passengers of the S-Bahn, who normally could not easily witch to U-Bahn, tram or bus and often had to use private modes instead or had to rely on the reduced S-Bahn service for parts of their journey.

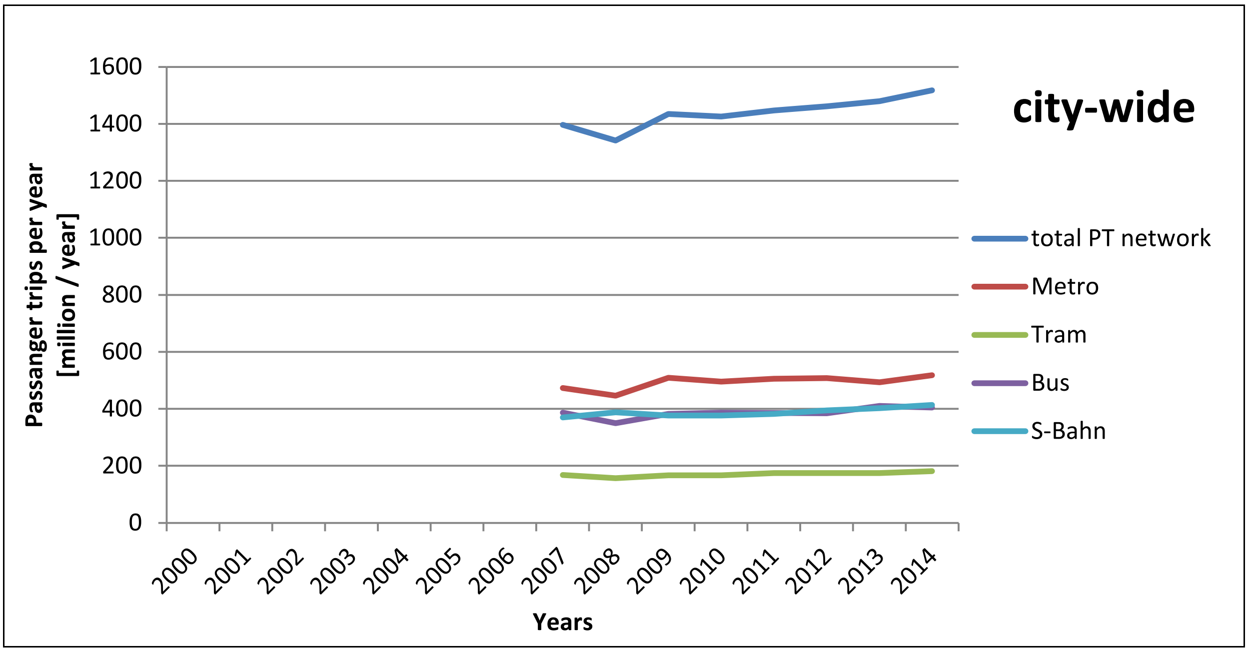

Figure 6-31: Development of the number of PT passengers by mode [million trips / year]
Source: SenStadtUm based on SenStadtUm 2001-2014; CNB 2016b

6.3.4 Annual PT passenger kilometres

The development of annual PT passenger kilometres has been continuously documented since 2006. In contrast to the development of ridership, both the S-Bahn crisis and the BVG-strike were clearly reflected in the development of the annual PT passenger kilometres (see Figure 6-32). This might have been caused by the high number of commuter passengers of the S-Bahn, who normally could not switch to U-Bahn, tram or bus that easily and often had to use private modes for parts of theirs journeys instead. Overall, the transport performance in the Berlin public transport system has increased by 11 % from 7,644,022 passenger kilometres in 2006 to 8,521,966 passenger kilometres in 2014. Both the BVG strike of 2008 and the S-Bahn crisis of 2009-2011 are clearly distinguishable from the overall development. Nevertheless, the transport services again grew strongly from 2012 onwards. Above all, this was due to the re-establishment of regular S-Bahn service. After a better performance during the BVG strike and declines during the S-Bahn crisis, the transport service increased greatly after 2011. With subways and trams, the transport service stabilized after the strike-year, with between approximately 2,850,000 and 2,900,000 passenger kilometres. The transport performance of the bus system on the other hand increased moderately after a very small decrease in 2008 to approximately 1,350,000 passenger kilometres in 2014.

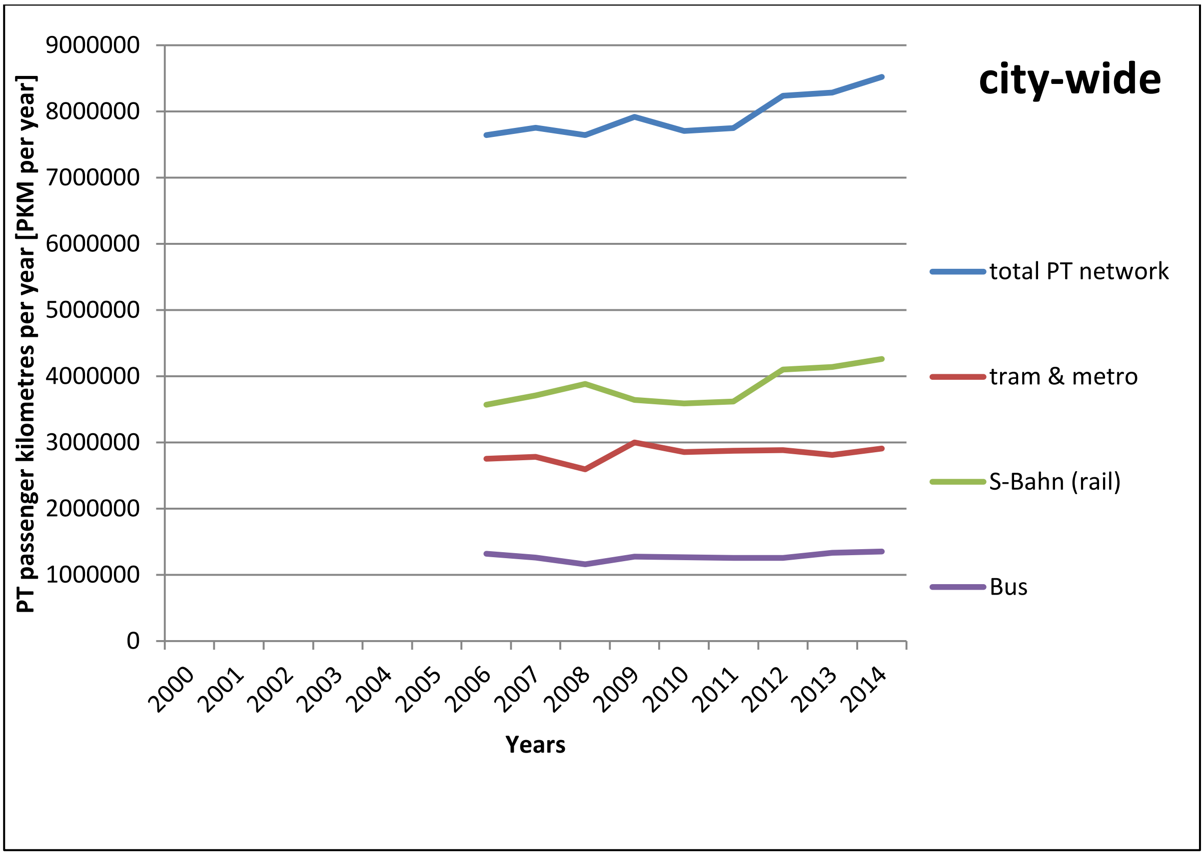

Figure 6-32: Development of the PT passenger kilometres per year
Source: SenStadtUm based on SenStadtUm 2001-2014; CNB 2016b

6.3.5 Trips entering the city

The number of trips entering the city is not measured on a continual basis. Two alternative sources of information are available: first, the number commuters based on the number of people in paid work at place of work (here Berlin) and place of residence (outside Berlin) (see Figure 6-33). Second, the number of cars entering every 24 hours on a working day, both directions combined (see Figure 6-34).

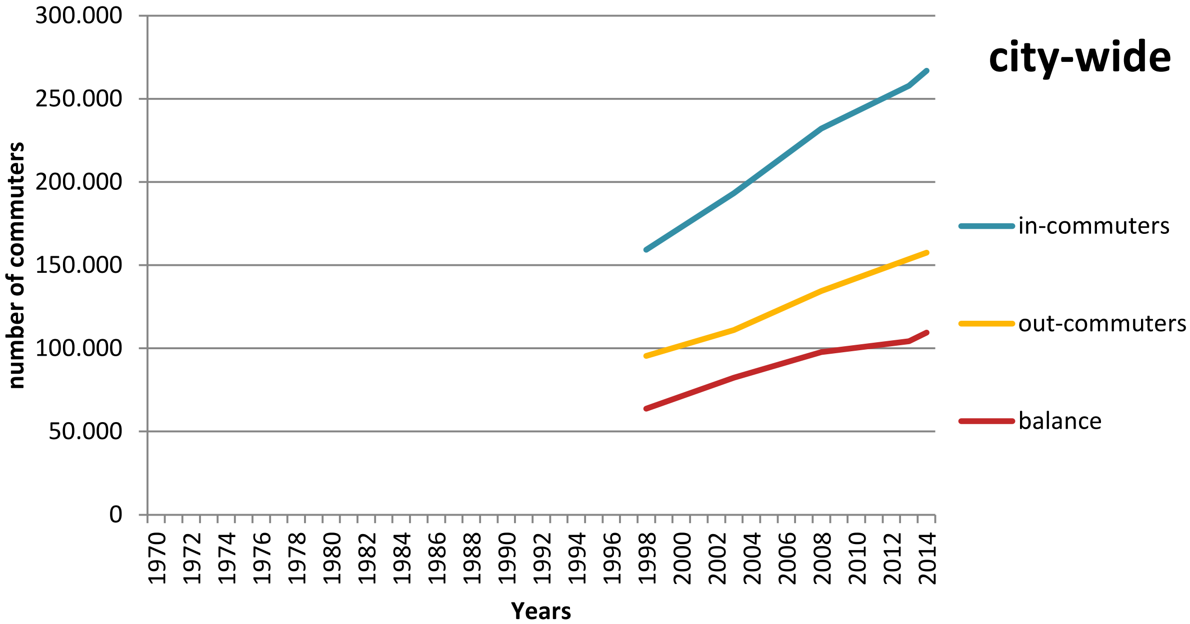

Figure 6-33: Development of the total number of commuters entering and leaving the city (based on the number of people in paid work at place of work)
Source: SenStadtUm based on Regionaldatenbank Deutschland 2015

The figures above indicate that the links between Berlin and Brandenburg have increased significantly since 1998. From 2008 to 2014, the values rose less than in previous years. Nonetheless, the number of commuters entering the city almost doubled within the monitored 16 years, based on the number of people in paid work at their place of work. The number of commuters leaving the city faced an increase as well, but less intense. To better interpret the number of commuters in Berlin, the current commuter statistics can be compared to other German major cities (see Table 6-2).

Table 6-2: Number of commuters for major cities in Germany (2014)

	In-commuters	**Out-commuter**	**Balance**
Berlin	257,894	153,703	104,191
Hamburg	325,527	104,308	221,219
Munich	341,312	146,842	194,470
Frankfurt a. M.	336,050	77,052	258,998

Source: SenStadtUm based on Regionaldatenbank Deutschland 2015

The analyses shows that Berlin has considerably lower commuting figures than other German cities even without considering the total population of the different metropolitan areas. The number of commuters for major cities in Germany turns out to be comparatively higher. The number of commuters leaving the city is comparatively higher than for other major cities. This indicates a sufficient number of jobs within in the Peri-urban I and II areas, which is also reflected in the still comparatively low number of commuters entering the city (see Table 6-2). The strong increase in commuters entering the city also points out the results of the strong suburbanisation of the late 20th century and currently again since about 2013 (see Figure 6-33 & Table 6-2).

Figure 6-34 illustrates the relative development of cars entering and leaving Berlin.

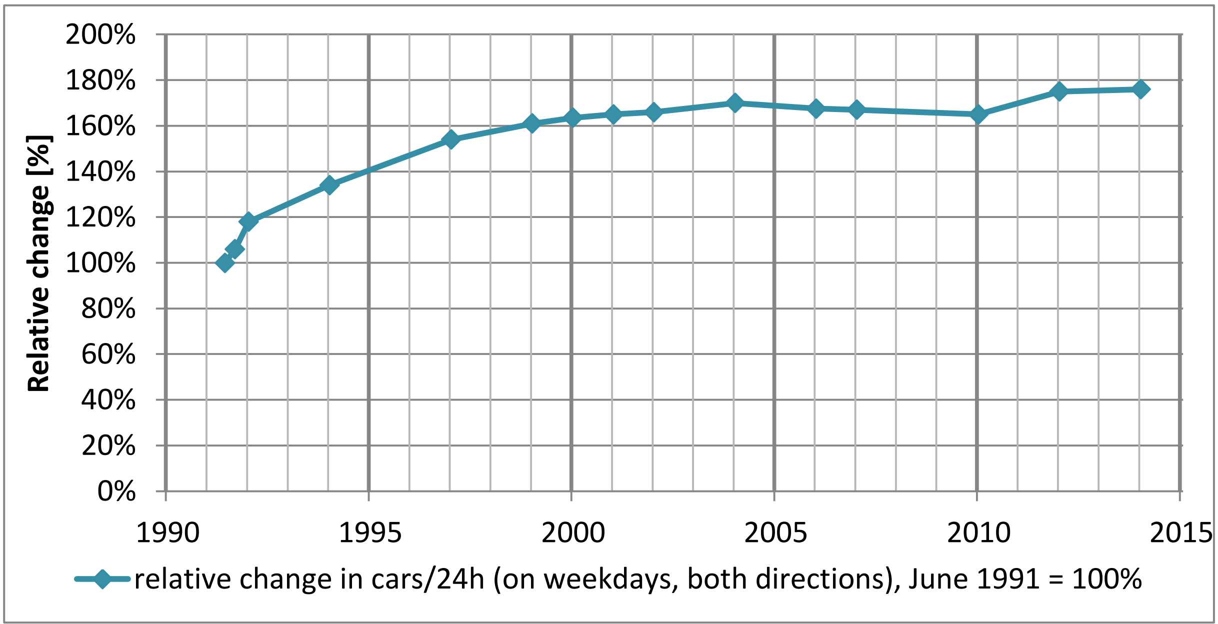

Figure 6-34: Relative change of cars entering and leaving Berlin in cars/24h (on weekdays, both directions), 1991-2014
Source: SenStadtUm based on statplan 2015

The amount of cars entering and leaving the city has increased dramatically since the reunification, rising to a peak in 2004, with about 170 % of the cars entering and leaving. Until 2010, the amount of cars, crossing the cordon, deceased to a relative volume of 165 % compared to 1991. The volume of cars rose to a relative amount of 176 % of the cars entering and leaving the city in 2014. Altogether, Figure 6-34 mirrors the increase of the overall number of commuters. It also shows that although the number of commuters almost doubled from 1998 until 2014, the relative change in trips leaving and entering the city by motorized transport was negligible (see Figure 6-33 & Figure 6-34). This underscore the huge importance of the metropolitan PT system, especially with the S-Bahn and the local/regional passenger transport.

6.4 Mind-sets, attitudes, mobility cultures

There no official surveys on mind-sets, attitudes or mobility cultures for Berlin.

6.5 Travel behaviour and policies

6.5.1 Share of car trips per inhabitant indicated by policy action

Until the reunification, a small-scale, yet continuous increase in the care use occurred. Nevertheless, due to relatively high costs and hindrances in vehicle production, only a few people had a private car in former East Berlin (see Kalender 2012, pp. 458–461). That changed with the fall of the Berlin Wall and the subsequent reunification in 1989/90. Many citizens of the former eastern part of the city took the chance and bought vehicles from western manufacturers. Additionally, the West Berliners were able to drive through the open borders into the countryside to Brandenburg for the first time, which increased the appeal and, thus, demand for car transport. Following 1990, many gaps in the road network had to be closed. The parallel investment in the public transport system did not provide a decrease in the share of motorised transport in the short term perspective. Partly because of this catch-up development and investment in infrastructure, the share of car trips increased the modal split from 22 % before reunification to approximately 38 % at the end of the 20th century. The amount of car traffic rose until 2000, followed by either increasing or decreasing traffic volume in different areas.

In the early 21st century the construction of the inner-city motorway A 100 (2000 & 2004) south to the inner-city area was continued. In addition, a large portion of the Teltow Canal Highway (A113) was built. However, the total car traffic volume did not increase but mostly shifted towards the motorway section.

With the introduction of the environmental zone (low emission zone) in 2008 and the second stage in 2010, many older vehicles were prohibited to enter the city centre.

During the financial crisis, it was decided in 2008 by the federal government to reward the purchase of climate-friendly cars by discarding old climate-unfriendly vehicles. After all, this did not lead to an increase of the share of motorised transport (see Figure 6-35).

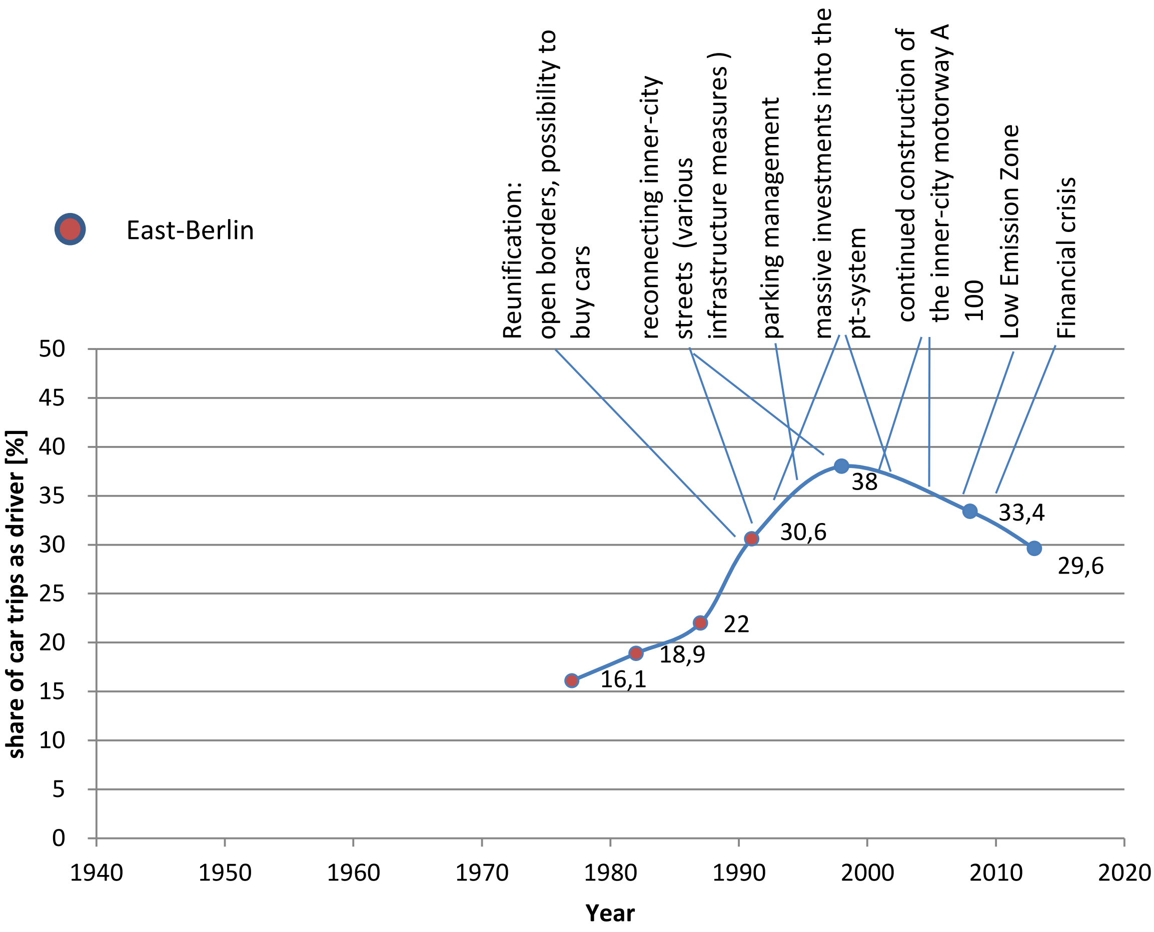

Figure 6-35: Share of car trips indicated by policy action

Source: SenStadtUm based on SrV 77, 82, 87, 91, 08, 13, BVG 98 & Senatsverwaltung für Bauen, Wohnen und Verkehr Berlin 1999, pp. 12–45; SenStadt 2011a

6.5.1 Share of PT trips per inhabitant indicated by policy action

In 1971, East Berlin approved a large housing program. Public transport such as the S-Bahn and tram were to be integrated into the program via the establishment of new lines. Although the first housing estates in Marzahn could not be opened for living until 1979, the S-Bahn had already been operating for three years in order to bring the workers to the construction site. The subsequent years were marked in East Berlin by residential construction (large housing estates). In addition to Marzahn housing estates alsp emerged in the satellite towns Hohenschönhausen and Hellersdorf. By the end of 1984, the S-Bahn connection was completed to Hohenschönhausen. From Tierpark up to Hönow, instead of an S-Bahn route, the U-Bahn line E (later U5) was extended in three stages until 1989 (see Kalender 2012, pp. 469–479).

After reunification the separate systems of the subway and S-Bahn network had to be joined together again. From 1990 until after 2000 the PT system was characterised by massive investment in the public transport infrastructure. In former East Berlin, the S-Bahn-ring with circular rail was gradually closed until 2002 again. Broken lines between the former West part and Brandenburg were reopened. In addition to the opening of the subway line U8, which was started before reunification, there were large investments in the tram network in the eastern centre. For the first time since the building of the Wall, the tram network was extended again to former West Berlin. In the end of 2014 the railway station was finally connected to the tram network (see Senatsverwaltung für Bauen, Wohnen und Verkehr Berlin 1999, pp. 12–24; Senatsverwaltung für Verkehr und Betriebe Berlin 1995, Ö1-Ö79; SenStadtUm 2016a).

Prior to the 2006 World Cup, important rail infrastructure projects were finished, such as the north-south tunnel, the new railway stations at the Berlin Hauptbahnhof (central railway station), Südkreuz, Gesundbrunnen Spandau, and the expansion of the railway line between Berlin and Leipzig to 200 km/h. In many instances, the travel times between Berlin and neighbouring cities, as well as between Berlin and central and regional centres could be shortened in Brandenburg by 20-25 minutes (see SenStadt 2011b).

In 2005, a night public transportation service was introduced. Since then, the bus service has gradually become more frequent and extended, by demand, to the evenings, and on weekends. Moreover, the use of a night-bus doorstep service network was tested in the outer areas of the city.

The Metro buses run on a high-demand system and are designed to supplement the subway and railway network together with the corresponding MetroTram lines (also operating with a tighter timetable and during the night). Metro services run every ten minutes during the day (some mor frequent), and operate 24 hours, and in the outer branches normally 20 hours a day (during the week and on weekends). At night, the operating buses or trams come every 30 minutes (see Figure 6-36 & SenStadtUm 2016a, pp. 12–17; SenStadt 2007, pp. 22–26). Moreover, the expanded accessibility at the stops and adjustments to the traffic signals made the public transport system more suitable for disabled people (see SenStadtUm 2014c, pp. 74–75).

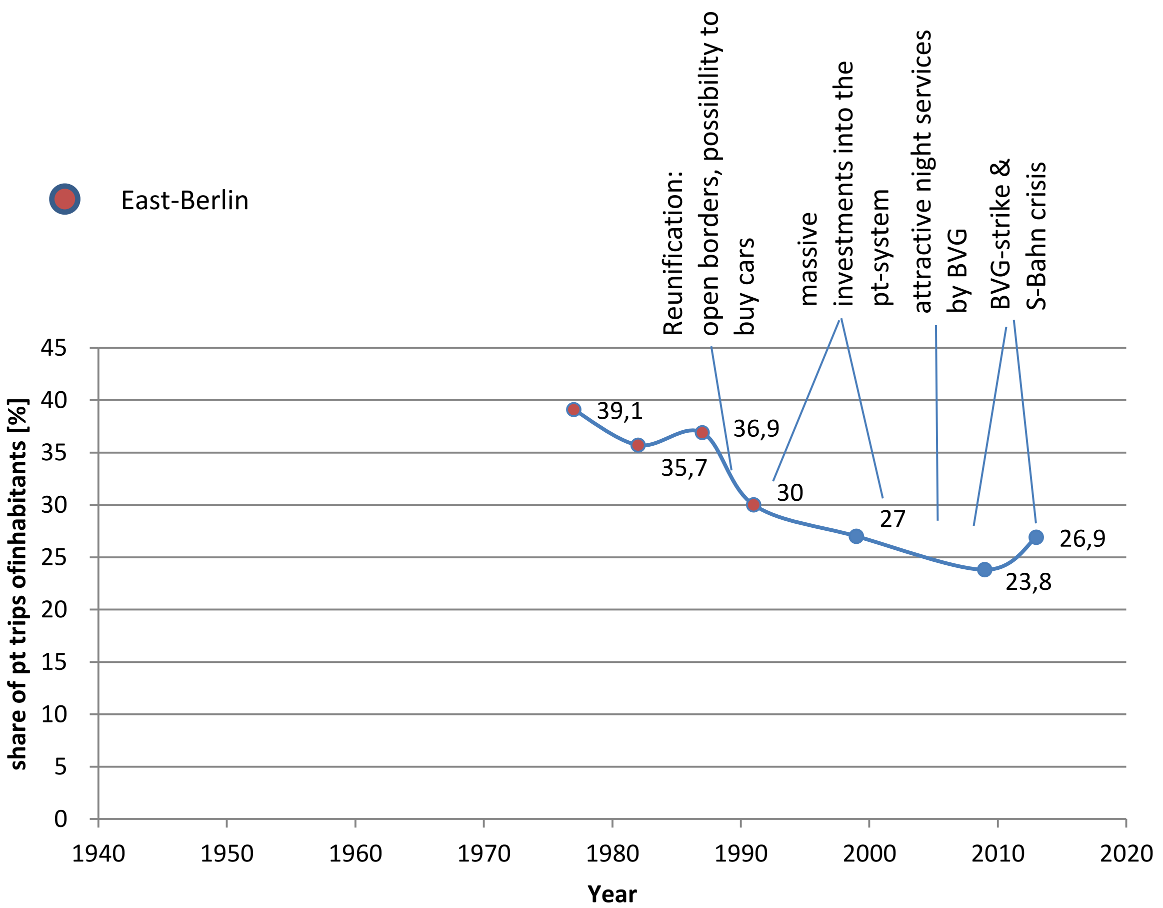

Figure 6-36: Share of PT trips indicated by policy action on the time line

Source: SenStadtUm based on SrV 77, 82, 87, 91, 08, 13, BVG 98 & Senatsverwaltung für Bauen, Wohnen und Verkehr Berlin 1999, pp. 12–24; SenStadt 2011a

6.5.2 Share of cycle trips indicated by policy action

Cycling was the main mode of transport in Berlin (West) by the end of the 1950's. With the increased proliferation of private cars, the bike significantly lessened in importance. Since the mid-1970s, bicycle traffic has slowly increased once again on the roads and paths in West Berlin (see Figure 6-37).

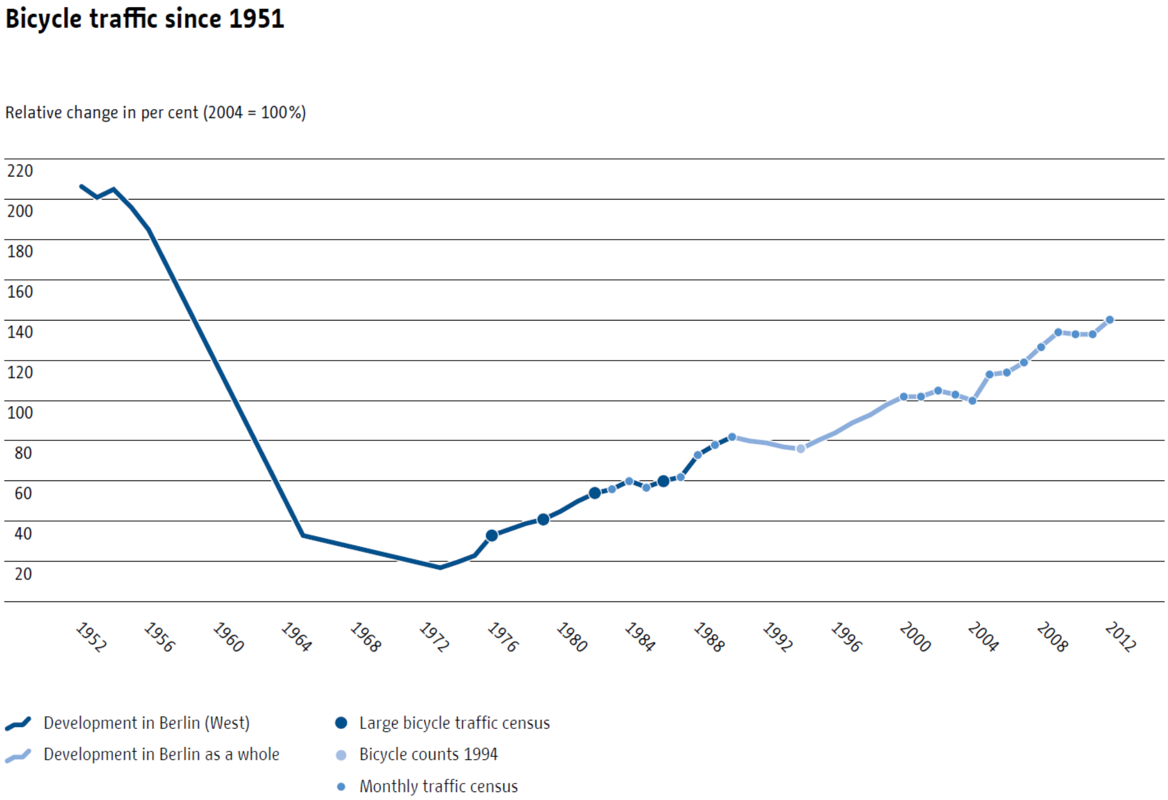

Figure 6-37: Relative change in bicycle traffic in Berlin since 1951
Source: SenStadtUm 2014b, p. 41

In East Berlin, the bike lessened in importance upon the fall of the Berlin Wall. The modal split share went down to 2 %. At the time of the reunification, the bike played only a minor role in the two city sections (slightly higher in West Berlin). By the end of the 20th century, the bike share increased steadily, due to the investment in the expansion of the cycling infrastructure.

Since 1997, nearly all 100 km bus lanes were allowed to be used by bicycle traffic. The transport of bicycles on trains of the BVG and S-Bahn came to uniformly possible (with a corresponding ticket).

Little by little, cycling became an urban trend in Berlin in the 21st century. The share in modal split increased until 2013 from 10 % up to 13 %. Most of the additional bicycle trips were located in the inner-city boroughs of Mitte, Friedrichshain-Kreuzberg and Prenzlauer Berg (see Figure 6-38).

Bicycle traffic at selected counting points[1)]

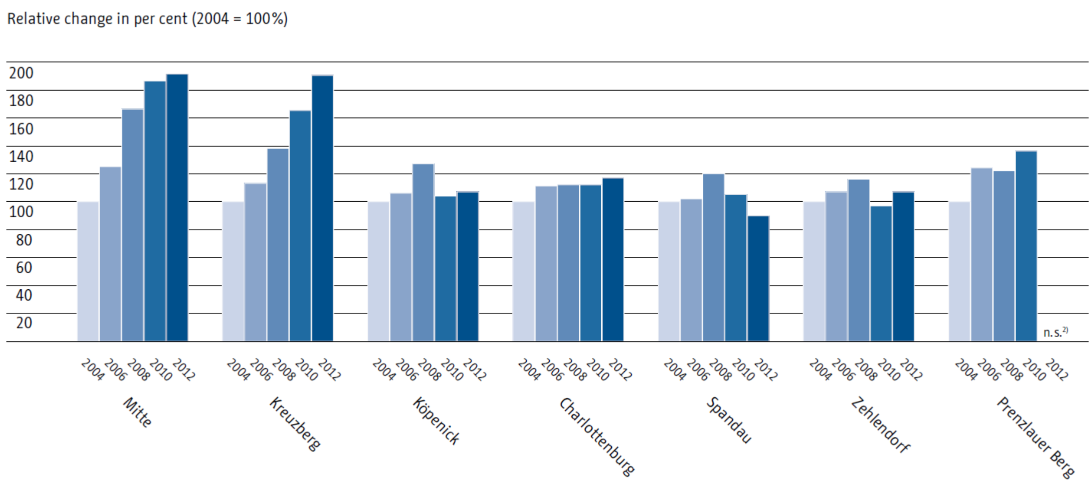

Figure 6-38: Relative changes in bicycle traffic in different boroughs of Berlin
Source: SenStadtUm 2014b, p. 41

In recent years, the number of conflicts between cyclists and motorists has increased sharply. In 2012, the Road Traffic Safety Campaign began in order to improve interaction between motorists, cyclists and pedestrians. The number of injured and killed cyclists decreased progressively after the fall of the Berlin Wall. However, partly due an increase in the number of cyclists, the number of killed or injured cyclists increased once again in 2012.

By 2013, the cycling strategy was enacted. It included a program for expanding bicycle facilities (about 15 to 20 km of marked annually structural cycle paths on the sidewalk & bicycle lanes and protective on-street lanes), for improving bicycle parking at railway stations, shopping malls and residential complexes, for creating of numerous bike-and-ride facilities, and increasing the re-dedication of small roads into bicycle roads (see Figure 6-39).

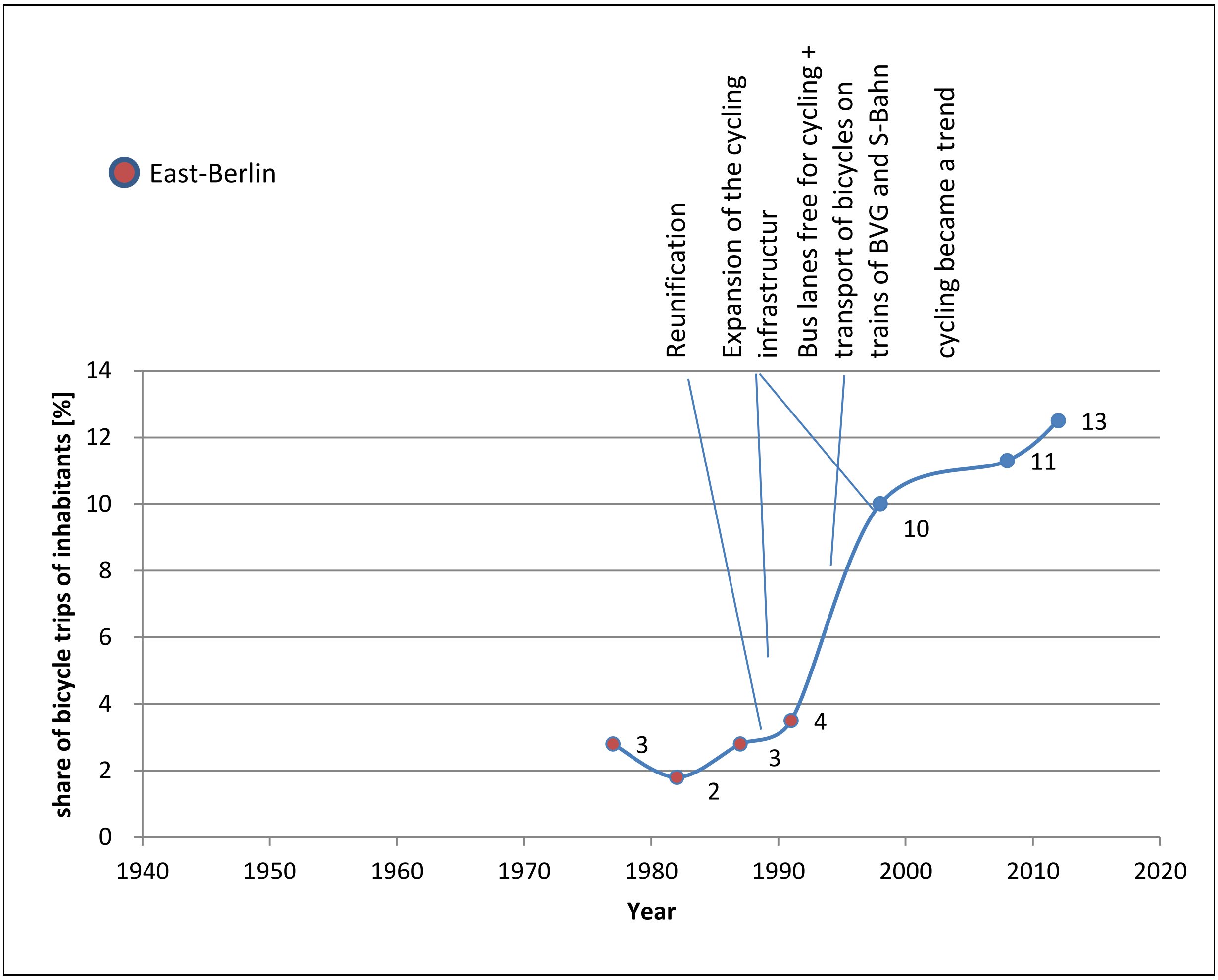

Figure 6-39: Share of cycle trips indicated by policy action on the time line
Source: SenStadtUm based on SrV 77, 82, 87, 91, 08, 13, BVG 98 & Senatsverwaltung für Bauen, Wohnen und Verkehr Berlin 1999, pp. 12–45; SenStadt 2011a

6.5.3 Share of walking trips indicated by policy action

Foot traffic was the main mode of transport in East Berlin leading up to the reunification. With the reunification and the sharp increase of motorized traffic, the importance of foot traffic initially increased. One of the first infrastructural measures to promote pedestrian traffic included programs to increase the number of crosswalks ('zebra crossings'). Because each trip by bike, car or via public transport always includes walking, the importance of foot traffic for the transport policy was re-evaluated with the StEP 2003 and has been a focus of transport policy ever since. As of 2012, the Strategy on Pedestrian Traffic had been accepted and implemented.

The Strategy on Pedestrian Traffic for Berlin coupled with the cycling strategy, aims to maintain and improve quality of life in the city in the long term. The strategy deepens the statements of the Urban Traffic Development Plan to promote non-motorized transport modes and enforces objectives, measures, and pilot projects for pedestrian traffic. It is also a guide to the districts where essential measures should be implemented. The advisory board "Berlin on foot" ("Berlin zu Fuß") has contributed significantly to the development of the Strategy on Pedestrian Traffic. This strategy has the overall objective of an urban, socially and environmentally sustainable, healthy, safe and cost effective mobility.

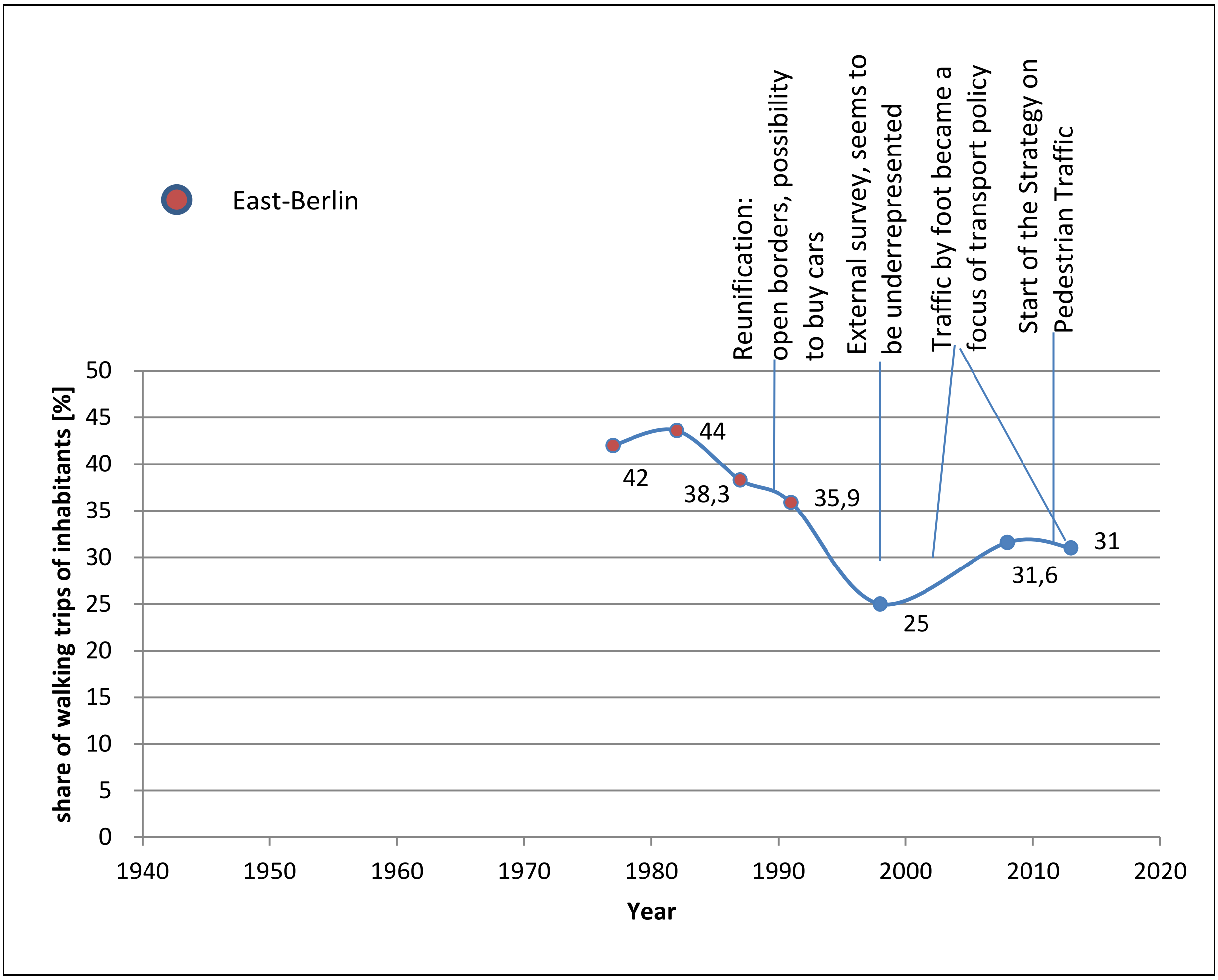

Figure 6-40: Share of walking trips indicated by policy action on the time line

Source: SenStadtUm based on SrV 77, 82, 87, 91, 08, 13, BVG 98 & Senatsverwaltung für Bauen, Wohnen und Verkehr Berlin 1999, pp. 12–45; SenStadt 2011a

7 Freight Transport

Until the end of the 20th century, indicators for freight transport had not been surveyed continuously due to the separation and reunification of Germany and Berlin.

Nevertheless, freight transport has an important yet two-edged role in the younger history of Berlin. On one hand, the access to freight networks by rail, road, air and inland waterways was crucial for rebuilding the inner-city after the reunification. Generally, it is essential for supplying Berlin and for the disposal of waste.

On the other hand, large amounts of noise and air pollution and the increase in expenditure on maintenance are caused by freight transport. Therefore, freight transport by rail and inland waterways, as well as environmentally friendly heavy-duty road traffic are promoted (see Menge 2013, pp. 98–109; SenStadtUm 2014b, pp. 62–63).

This development of freight transport reflects the younger history: the huge increase in freight transport due to major construction projects until the end of the 20th century; and the decrease caused by the completion of the main construction projects and structural changes in the economy with the Germany-wide stagnation of economy and the growth of Berlin's economy since 2007 (see Menge 2013, pp. 98–109; SenStadtUm 2014b, pp. 62–63).

Figure 7-1 illustrates the development of the building site of the Regierungsviertel and the new central station from 1995 to 2006 as an example of one major inner-city building site after the reunification.

Figure 7-1: Development of building site of the Regierungsviertel and the new central station (above: 1995, 1998; below: 2006)
Source: DSK 2013, pp. 36–37

The newly-introduced construction boom is many concentrated on housing and recreation and much less focused on large building sites (see SenStadtUm 2016b).

The larges freight volume in tonne is, by far, still transported on the road. In contrast to rail and freight via inland navigation, the economic revival is not reflected in the development of road freight transport. Compared to Berlin, more than twice the volume has been transported by the road and rail networks in Brandenburg. Air freight has (at least concerning the tons transported) no real relevance to the freight transport in Berlin and Brandenburg (see Figure 7-2, Figure 7-3 & Figure 7-4).

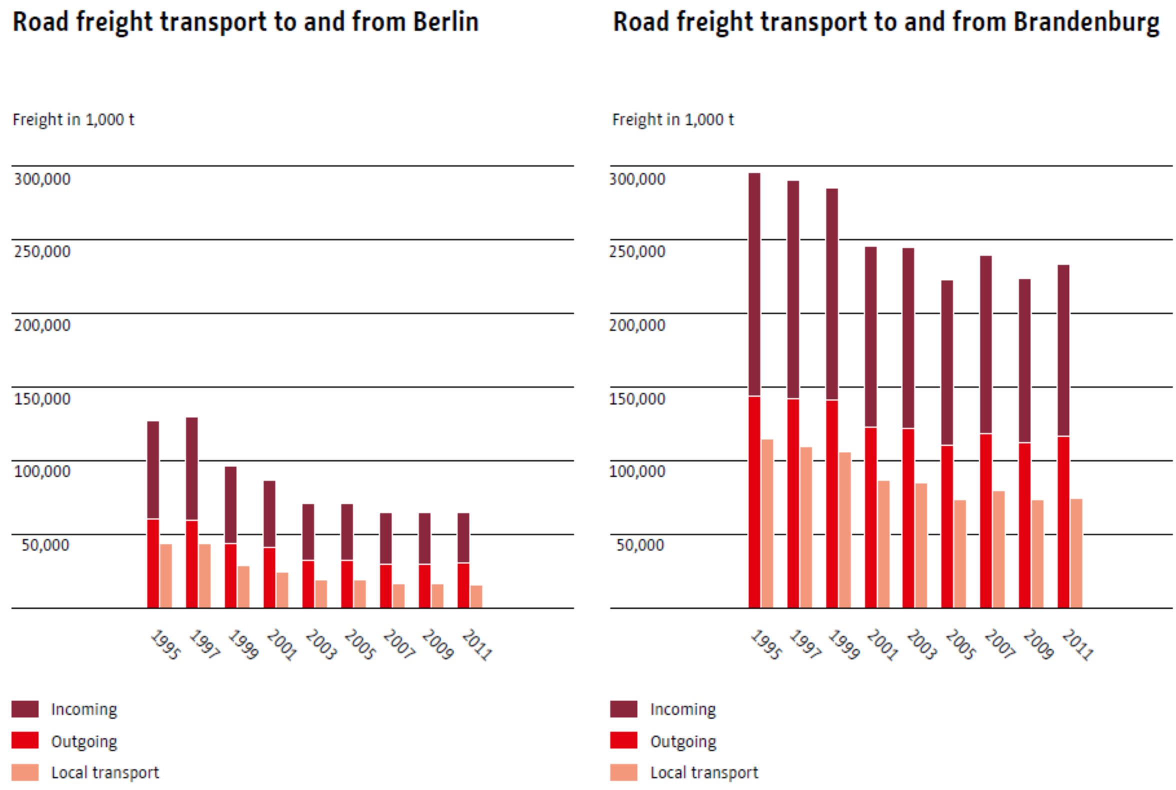

Figure 7-2: Road freight transport to and from Berlin/Brandenburg
Source: Federal Motor Transport Authority (KBA) in SenStadtUm 2014b, p. 70

Figure 7-3: Rail freight transport to and from Berlin/Brandenburg
Source: Federal Statistics office in SenStadtUm 2014b, p. 67

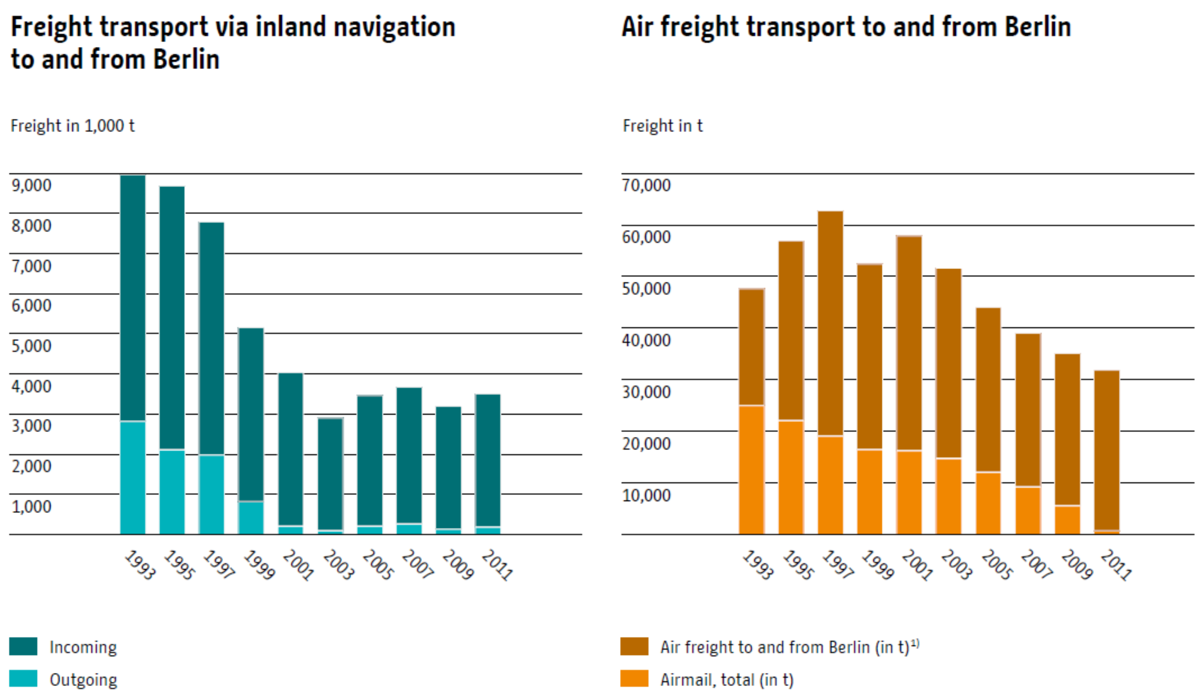

Figure 7-4: freight transport via inland navigation and air to and from Berlin
Source: Joint Statistics Office of the States of Berlin and Brandenburg (AfS BB) and Flughafen Berlin Brandenburg GmbH, traffic statistics in SenStadtUm 2014b, p. 69

Planning policies

To fulfil general planning objectives, different approaches for urban commercial transport were applied in Berlin. One focus was to ensure the development or maintenance of the city's infrastructure, such as inner-city harbours, railroad infrastructure, and potential locations, to develop freight-related facilities. Another objective for land-use planning was to keep potential sites available.

Additionally, efficient freight networks were necessary. One key tool for implementing an informal network was the so-called “Platforms for Commercial Transport” (“Plattformen Wirtschaftsverkehr”). From 1996 to 2002, different stakeholder groups, such as transport service providers, retail, the chamber of commerce, the city boroughs, and SenStadtUm discussed how difficulties in supplying major shopping areas had to be managed.

The only real regulatory framework for commercial freight in Berlin was the Environmental Zone (“Umweltzone”) with a low-emission zone (LEZ). The LEZ effected commercial transport significantly and led to a rapid modernisation of the truck fleet (see Menge 2013, pp. 98–109).

8 Summary, Conclusions

The analysed indicators have been strongly influenced by the reunification and are, at the most, only available from 1991 onward. Even so, trends could be derived from the available data. Important highlights of the analyses are:

Supply-side indicators

- The number of inhabitants reflects several factors: the suburbanisation process after the reunification, the strong increase in urban inhabitants for Berlin since 2010, the overall decreasing number of inhabitants in the entire Federal state of Brandenburg/Peri-urban II area, and, in contrast to that, the enhanced importance of the Peri-urban I area.
- The difficult and irregular economic situation within the study area during the monitored period are reflected in the GDP, the employment status and the number of people with paying jobs. Only within the last 5 to 10 years, is a positive trend recognisable.
- The increasing number of university students and tourists has gained significant importance for the traffic systems in Berlin. Both have become central customer groups for the PT systems.
- The biggest amount building projects was realised until 2000. Intense building activities are barely reflected in the development of the different land-use categories, which did not change significantly within the last 10 years.

Traffic system indictors

- The figures on motorisation show the strong increase in car ownership until 1994, with (still) almost twice as many cars per 1,000 inhabitants in former West Berlin than in the East and moderate to steady development from 1995 until 2014 (despite the recent increase in total inhabitants). Interestingly, the share of young adults (18-29) and middle-aged people (30-44), with at least one car in their household, has constantly declined since reunification, whereas the share of people older than 65 within a car household drastically increased during the same period. Though the share of car trips within that age group did not change considerably, in total, the share of people older than 65 increased.
- Shortly after reunification, Berlin's traffic system was strongly characterised by building projects aimed to re-establish the broken links in the PT and road infrastructure and thereby re-connecting the formerly separated traffic networks. Thought not fully documented, the bicycle network was also enlarged with a focus on measures to direct bicycle traffic onto the street.
- Although influenced by several strikes and the S-Bahn crisis from 2009-2011, the number of passenger trips and kilometres per passenger rose since reunification with a huge growth from 2003 onwards.
- Compared to other German metropolitan regions, Berlin has relatively few commuters entering the city and a moderate amount of commuters leaving the city. Nonetheless, the intense suburbanisation in the end of the 20th century and the rise in the total population within the Peri-urban I area led to a considerably high amount of total commuters. Fortunately, the increase in counted private motorised traffic, leaving and entering the city, is much less intense.
- Thus, Berlin is sometimes referred to as the Carsharing capital of Europe, with about 8 % of the possible costumer group generally using Carsharing and, more than 2,400 available cars, Carsharing has little to no impact on the daily traffic volume.

In the modal split, a clear increasing trend of the importance for environmental friendly transport modes, with a decreasing share of trips by car, is visible. Especially teenagers (12-17), young adults

(18-29) and middle-aged people (30-44) currently use PT systems more frequently than in the mid-90s. The share of bicycle trips increased for almost every age group.

The growth in the total number of inhabitants, visitors and total traffic volume affects every transport mode and is one of the biggest challenges for the current transport policy in Berlin.

Conclusion

The 3-stage model of a transport policy evolution cycle is generally difficult to apply directly to the real development of a city. All described developments are based on different processes, which are drawn-out, ongoing and often run in parallel. In addition, there are always numerous supporting and inhibiting factors with a push or pull effect. For Berlin in particular, the development of travel behaviour, transport policy, and of important supply-side indicators has been heavily shaped by the World War II, the division of Germany as well as Berlin, and the subsequent reunification.

Berlin started its spatial development in the end of the 19th and beginning of the 20th century with political focus on the development of a railway-orientated city. These policies were aiming for a railway-based urban and regional network, transport planning as a strategic tool for urban planning, and a public-led urban transport system. Until the beginning of World War II, Berlin developed into one of the biggest cities worldwide, with a strong focus on a complementary rail-based rapid transport system with electric-powered tram lines. However, since the 1920s, a more car-oriented policy has been gradually introduced. Due to the division of Germany and Berlin after World War II, since the late 1950s, both sides of the city have turned towards a more positive economic development, with an increase in car ownership through the rebuilding of the destroyed city centres. Due to differing financial resources, the development in West Berlin was much faster and more ambitious, while East Berlin had to focus solely on public transport because of the shortages in East German automobile production. Regardless, by the end of the 1980s, both parts of Berlin had established traffic mitigation policies as well as sound, separately running PT systems. During this period, both cities had, more or less, reached a Stage 2 city phase. After the reunification, catching up on city development (such as suburbanisation and intense motorisation) shaped the traffic development. Thus, important broken links in the road network were closed and long-planned extensions of the southern inner-city highway were completed. Despite the massive investments in public transport, Berlin's PT travel behaviour regressed through an increase in both inhabitants (very short) and in motorised transport. Followed by the decrease in the number of residents since around 1995, public spending on transport was reduced by the end of the 20th century. This led to a reconstruction of the bus and tram network of the BVG and a reduction of service in some areas. With the task of reuniting the two parts of Berlin and their completely separate transport networks, the main focus of Berlin's transport policy until the end of the 20th century was mainly to build, or rebuild, the city into a united capital city. Nevertheless, important political decisions to re-focus on the promotion of environmentally-friendly traffic modes were made. In 1991 and 1992, the first parking-management policies were introduced. In 1999, the introduction of the common public transport tariff, run by the Verkehrsverbund Berlin-Brandenburg (VBB), was a huge step toward an integrated and easy-to-use PT System. All these developments, including the reunion and re-establishment of the PT network, became the foundation and framework for a change in travel behaviour and transport policy. In the beginning of the 21st century, the usage of environmental-friendly modes increased considerably, and Berlin became a Stage 3 city after 2000/2001. Enabled by the work after the reunification, the policy focus shifted from (re-)building to regulating the transport systems. This clear shift in transport policy was institutionalised by the first Urban Transportation Development Plan (StEP Verkehr) which focused on promoting public transport and non-motorised traffic and on regulating motorised traffic, aiming for a more resendable use.

The numerous changes in politics, administration and spatial attribution make the 3 stage model/policy evolution cycle difficult to adapt for Berlin. Local differences and opposite trends to the meta-level development are typical for heterogenic or polycentric cities like Berlin. Nonetheless, the model can still be adapted for Berlin (with some limitations). Instead of a step-by-step evolution with one stage consecutively after the other, Berlin's development is better represented by a wave. The shift toward a new stage with a less car-orientated policy and travel behaviour was only possible through the promotion of high capacity alternatives (like the investments into the PT network and the improvement in quality) and non-motorised modes.

Concerning the development of the 3-stage model, the modal split is one of the prominent indicators that could show necessary changes for a transition to another stage. Possible push-factors for this transition in Berlin might be the introduction of and, later, the combined planning of areas with parking management as well as other such measures which aim to reduce on-street parking. The re-establishment of one of the biggest and densest public transport networks, the promotion of non-motorised modes, and the common public transport tariff for the metropolitan region can all be considered important pull-factors.

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Project acronym: **CREATE**

Project title: **Congestion Reduction in Europe - Advancing Transport Efficiency**

D3.2 - Technical report for Stage 3 city

Copenhagen

Work Package 3 "Quantitative Analysis of Travel"

Date of preparation:	**October 2016**
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Prepared by: **Annette Kayser and Helene Søgaard, Copenhagen City. Henrik Grell, Peter Ravn, Svend Torp Jespersen and Jesper Kristensen, COWI**

Checked by: **Roman Klementschitz, BOKU**

Verified by: **Peter Jones, UCL**

Status: **Final**

Dissemination level: **Public (PU)**

Table of Contents

1 CREATE project

CREATE's work is based on 3 main challenges/activities:

- to establish which policies were most effective at controlling congestion, reducing car use and promoting sustainable transport,
- whether such policies are transferable to other cities,
- how cities are going to respond to the challenges of rapid population growth and new transport technologies in the future.

In other words, and more specifically, CREATE aims to help five cities from Eastern Europe and the Euro-Med countries to decouple traffic from economic growth, with the support of five Western European cities that have already passed the critical phase of rapid increase in car ownership, and are now moving towards a sustainable transport system. CREATE sets out to study and look at options to further improve network efficiency and reduce the overall need to travel in those advanced cities.

CREATE uses knowledge gained from stakeholder interviews, data analysis, detailed research and historical studies in order to develop tools, guidance and teaching packages, providing capacity building and opportunities to enable less advanced cities to accelerate their shift towards a more sustainable mobility system.

This in-depth investigation, supported by leading analysts and a major provider of real-time traffic data will permit CREATE to investigate changing patterns of road traffic and car use, success factors behind decreasing car usage and lessons learnt.

1.1 Concept and approach

The CREATE project is based on four central innovative ideas or assumptions:

1. The way in which the "congestion" debate is framed in a city underlies how transport system performance is measured.
2. The existence of a 3-stage "Transport Policy Evolution Cycle" spread over 40+ years, which gradually shifts the policy emphasis and investments priorities from catering for road traffic growth to building up a liveable city.
3. The examination of future mobility options given a rapidly growing urban population (and a mobility densification), with policy measures which can achieve congestion reduction, promote sustainable mobility, while meeting wider policy goals.
4. Promoting the "policy transfer" of understanding gained from investigating the above mentioned ideas, to those cities which are coping with rapid growth in car ownership and promoting "pro-car" policies. This would provide them with insights into how to short-circuit the 3-stage historical "Transport Policy Evolution Cycle".

1.2 Objectives

The CREATE project is based on achieving four high-level objectives:

1. To explore the nature and the causes of urban road traffic congestion, developing and applying a set of policy relevant and practical indicators of urban road congestion and transport network performance. This will provide network managers and policy makers with metrics to establish the degree to which efficient and sustainable urban mobility is being delivered in the CREATE cities.
2. To work with five economically advanced Western European capital cities, which have already passed through the "peak car" phenomenon, examining how they have succeeded in

decoupling economic growth from traffic growth. It will be particularly interesting to discern which transport and non-transport factors have been most effective in reducing car use, thus encouraging greater use of sustainable modes.

3. To develop specific guidance and promote capacity-building for professionals in the group of cities (Eastern European and Euro-Med) which are at the earlier stages in their economic development, with a view to help them to adopt policies based on sustainable mobility, rather than becoming car dependant cities.
4. To address the serious future issues starting to emerge in many of the CREATE cities due to rapid increases in population and employment, thus potentially overwhelming all modes of transport. Via the investigation of the potential for new technologies, and the changes in business and social habits, there are chances for better managing the transport systems and reducing the overall need to travel as well.

2 About this document

The primary aim of WP3 is to analyse the transport policy evolution cycle as described in Deliverable 2.1 for the five stage 3 cities, from their stage 1 condition to their current status as stage 3 city. The development of relevant travel indicators is mapped over time in order to quantify this trajectory and to identify the various factors which have contributed to observed changes in behaviour – particularly the observed reductions in car driver modal shares.

This deliverable documents the analysis of the data to provide an overview of city development and characteristics as input for further analysis. Trends in congestion and travel behaviour (by purpose, mode, etc.) are measured, charting the emergence of "peak car" and the growth in the use of sustainable modes of travel in different parts of the urban and peri-urban areas. A descriptive analysis for each stage 3 city is conducted across the years. Indicators of changes in conditions in each city are analysed, including traffic volumes, speed, congestion, public, transport patronage, modal shares of different modes depending on data availability.

Indicators of possible causes of changed travel patterns are covering demographic changes, economic developments, car ownership, labour-market, land use, or government policies. Analysis is distinguished between different segments of population in different parts of the cities over time. Data are mainly based on any kind of statistical sources available as well as household travel surveys and are to be documented for the longest possible period of time in each city. Most of data, but in particular household travel survey data, should be available in all stage 3 cities at least 20 years back from 2014, in some cases from the 1970s, and should provide information of the stage 1 situation in the particular city.

The contents of this deliverable are based on the analysis scheme provided in Deliverable 3.1. Technical internal report, detailed analysis scheme for WP3 to ensure the generation of comparable figures over time for all stage 3 cities. The list of indicators to be documented is subdivided into 2 levels: (1) "must-have-indicators" which all stage 3 cities should have to provide and (2) "nice-to-have-indicators" representing additional analyses of specific data available in case these data are easy to access. Additionally, any other documentation of data or further cross analysis of data of interest in a particular stage 3 city are highly appreciated and should be added accordingly.

This deliverable is organised as follows: The city specific framework as the basis for the analysis is presented in chapter 2. Chapter 3 and 4 are dealing with transport supply data and policies influencing travel demand in the city documented in chapter 6. Freight transport is described in chapter 7. Summary and conclusions are documented in Section 8.

3 City specific framework conditions

3.1 Spatial characteristics

3.1.1 Area definitions

This section is to provide basic information and a description of each area type according to the definition as proposed in Deliverable 3.1:

- Inner-city: City centre
- Outer-city: City area beyond inner-city but within the city boundary
- Peri-urban I: Area bordering the city, fulfilling the criteria of high population density, high density of workplaces, high number of commuters to or from the city
- Peri-urban II: Wider commuting catchment area to the city.

City of Copenhagen is the capital city of Denmark. It is one of 98 municipalities with local self-governments having the obligation of collecting municipal taxes. For historical reasons, the City of Frederiksberg is a municipality geographically totally surrounded by the City of Copenhagen. The two municipalities are together often called "the two central cities". In this report, City of Copenhagen is used as a term embracing also Frederiksberg Municipality when presenting statistics etc – if nothing else is mentioned, see also Figure 3-1 and Table 3-1.

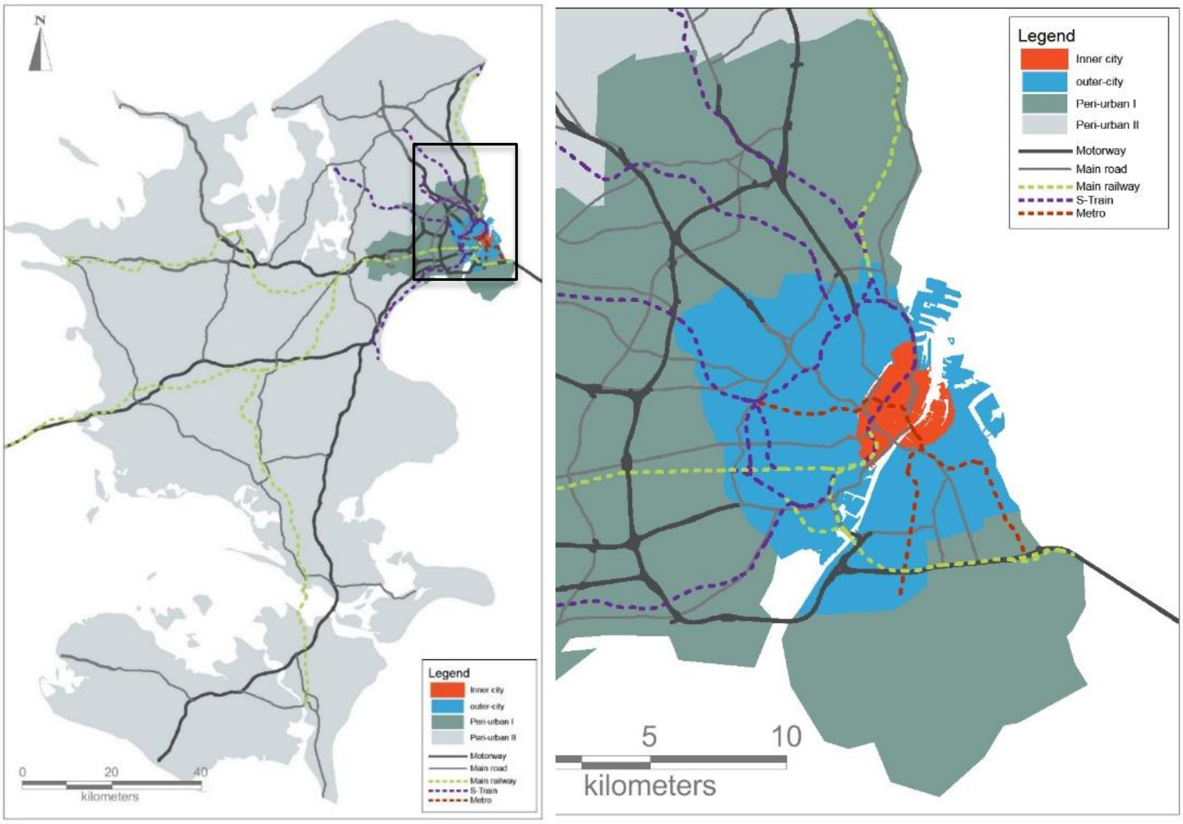

Figure 3-1: Area types of the stage 3 city Copenhagen and main transport infrastructure 2016.
Sources: COWI, own GIS production.

Table 3-1: Size of study area [km²]

Area type	Total surface area [km²] (2016)
Inner-city	9
Outer city	88
Peri-urban I	406
Peri-urban II	8784
Total area	9287

Sources: COWI, own GIS production.

City of Copenhagen is in this report divided in an inner city and an outer city. The inner city has a fairly natural boundary to the rest of the city as it is surrounded by the sea / harbour to the east and a chain of three artificial lakes to the West. City of Frederiksberg is located in the outer city together with other quarters of City of Copenhagen. The Inner cty covers approx. 9 km^2 and the outer city covers approx. 88 km^2.

The nearest peri-urban area (I) consists of 12 municipalities surrounding City of Copenhagen. They all have a fairly high densitiy and they have a vast number of commuting to and from City of Copenhagen. The Peri-urban area I covers approx. 406 km^2.

Peri-urban area II surrounds peri-urban area I, and it consists geographically of the rest of the island Zealand. The area includes 31 municipalities and covers an area of approx. 8784 km^2. Peri-urban area II is to a certain degree a commuter hinterland to City of Copenhagen and Peri-urban area I, but the area has also major towns with their own commuter hinterlands.

City of Copenhagen, Peri-urban area I and the inner part of Peri-urban area II is located in the administrative region "Capital Region of Denmark", whereas the outer part of peri-urban area II is located in the administrative region "Region Zealand". Denmark is in total divided in to five regions mainly having responsibility for parts of the health care system, especially the hospitals. However, the regions also have some functions on environmental protection, on research and on regional development. The regions were formed in 2007 by a national administrative reform. Before 2007, Denmark was divided in to more than 270 municipalities and 14 counties with directly elected councils and the obligation to collect taxes. Both municipalities and counties also had the obligation to prepare spatial plans and the counties were owners of regional roads.

After 2007, spatial planning is only the responsibility of the municipalities supplemented with a few national directives within the overall planning framework. One of the national directives is a regional planning directive for the capital agglomeration which is more or less equal to the area of the Capital Region of Denmark. The planning directive aim is to ensure coherency on crucial spatial planning principles across municipal borders on e.g. urban development and major transport infrastructure planning. Former county owned roads are now either state or municipal owned.

The national and regional transport infrastructure in the capital agglomeration area is still characterized by the structure developed as part of the "Fingerplan" in 1947. In principle, one can find five main radial corridors ("fingers") and a number of ring corridors as illustrated in Figure 3-2. Each of the original five fingers has a railway line (main railway or S-train) and a high class main road (mostly motorways). Furthermore, two major ring roads exist as motorways and another two main ring roads are located in City of Copenhagen.

In 2023 / 2024, a light rail line is expected to open and will run along one of the main ring roads (Ring 3) outside City of Copenhagen. In the City of Copenhagen, a supplementing circle metroline is going to open in 2019.

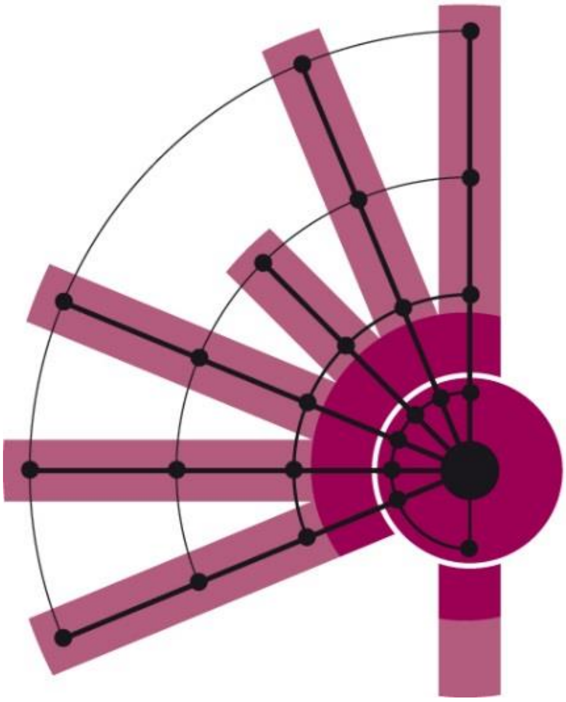

Figure 3-2: The overall structure of urban development and main transport corridors in the greater Copenhagen area. Originally with five "fingers" in 1947, but later supplemented with two more fingers. Sources: (Environment, Danish Ministry of, 2015).

3.1.2 Land use

City of Copenhagen

In City of Copenhagen, changes in land use has for many years first and foremost consisted of brown field development converting mainly industrial areas into more liveable urban space.

This is the case for the quarters surrounding the two harbour areas "Sydhavnen" and "Nordhavnen" just outside the Inner City. These quarters were developed mainly with heavy industry having a close link to harbour activities. However, the general international trend with heavy industries moving out of the central parts of the city and the falling importance of shipping as a main mode for transport of goods has also influenced these quarters. A large part of these quarters along the harbour have been changed in to residential areas integrated with service industries and small innovative start-ups. The harbour has changed accordingly creating new recreational areas. In Copenhagen these changes - together with improved sewage systems leading to good water quality – makes it now common for people to swim in the harbour.

Furthermore, some of the new harbour areas are a result of land reclamation enlargening the total area of the city. This is especially evident in Nordhavnen, see also Figure 3-3.

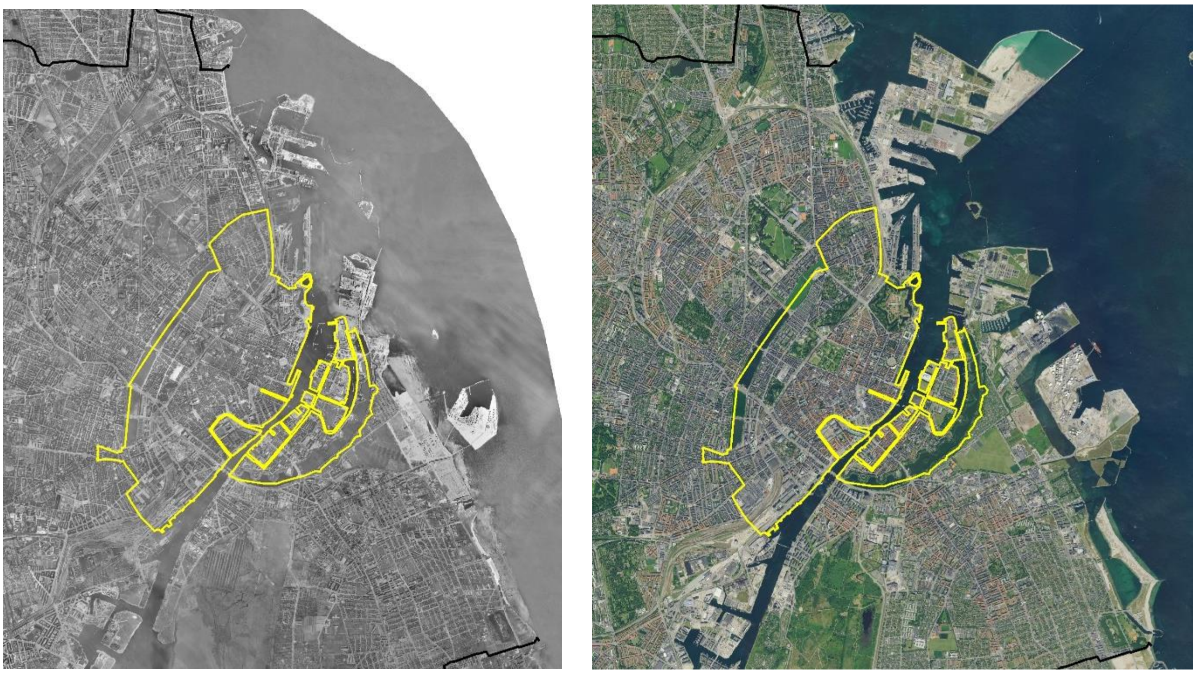

Figure 3-3 Aerial photos from 1954 (left) and 2016 (right) illustrating the size of land reclamation in the harbour areas both south and north of the Inner City (yellow line).
Sources: DDOland, copyright COWI.

One major green field development was decided in the beginning of 1990's for "Ørestaden", an area with a size of 310 ha (3.1 km²) south of the Inner City. The zoning status of the area prior to the development was unbuilt city area, mostly functioning as a recreational area. The area has been developed during the last two decades, and the centre of Ørestaden is supposed to function as a new central business district serviced by the metro and a main railway line. The income generated from selling the land was invested in the construction of the metro. The area is now built up area with the zoning status of mixed use for residential purposes and service industries. The infrastructure including the high rail metro, takes up a relatively large part of the area.

A new park, Amager Strand Park, was inaugurated in 2006 in the southern part of the City. The park is the result of land reclamation and is now a large recreational beach area. The size of the park is approximately 60 ha. It was created by investments amounting to 250 million DKK.

Furthermore, large investments in recent years have resulted in new developments of small scale urban recreational areas (called "pocket parks") without changing the zoning status. Accompanying the development of recreational areas is a coherent network of bike tracks and lanes well integrated with the blue and green urban areas. These developments have primarily been driven by public investments.

Another major change is the extensive renovations of backyards mainly in the densely built up dwelling quarters ("bridge" quarters surrounding the Inner City (the medieval part) from the early days of industrialisation with a massive migration to the city. Previously, the backyards were characterized by asphalt, garbage sheds and toilets and filled with a large number of back buildings. The renovations were a precondition for making younger people, newly established and more resourceful families stay in the city. These renovations started already in the 1960s; but the extensive and larger reconstructions in Nørrebro (one of the bridge quarters) were made in the 1980s, whereas the renovations in Vesterbro started in the 1990s.

City of Copenhagen has for decades not had any agricultural production or forest areas.

In short, the development of land use in City of Copenhagen from the 1970s can be characterized by the following:

- City of Copenhagen was already before 1970 a full developed urban area with no forests or agricultural land. However, a former large recreational area at Amager (Ørestaden) is today a built up area functioning as a commercial district.
- Major changes since 1970s have been transformation of former industrial areas in to dwelling areas, office areas and new recreational areas
- Especially the harbour areas have undergone a major change leading to more liveable quarters in the city with attractive dwelling areas as well as recreational access to and use of the water.
- The clearance of very densely built backyards in dwelling quarters from the start of the industrialisation giving more local recreational space is also an important part of the overall trend towards a more liveable city being attractive for families with children
- Finaly, the change of e.g. streets for car traffic as well as not accessible small local municipal owned areas (e.g. squares with old air-raid shelters from World War II) in to public accessible recreational areas has also supported the overall trend towards a more liveable city.

Peri urban areas

The development of land use in the peri urban areas is more diversified. The inner part consists of municipalities originally being villages, but with a rapid urban development especially after Second World War. Large industrial areas, dwelling areas and new suburban city centres were built on former agricultural land during the 1960s continuing up to present time. The urban development has been accompanied by a growing road infrastructure both at the municipal level and at the regional / national level including major radial routes linking the peri urban areas with City of Copenhagen as well as ring roads and motorways linking the major urban areas in the peri urban areas.

Peri urban area I has a lower degree of settlement area than the City as can be seen in Table 3-2. The area has compared to the city a fairly low percentage of urban fabric with high density and industry and transport infrastructure compared to the city. The development has not been mapped historically and thus only an overview based on a mapping from around 2005 is shown in the table.

For the Peri urban area II no such mapping has been identified. In qualitative terms, Peri Urban area II consists of major towns, minor towns and villages as well as rural areas. Each of the major towns have most likely experienced a development of land use more or less like the City of Copenhagen and the municipalities in the Peri Urban area I. This development has led to a growth in size and the development of larger dwelling and industrial areas. However, each of the towns are still surrounded by rural agricultural areas and have smaller towns and villages in their hinterland.

Table 3-2 Segregation of land use in City of Copenhagen and Peri Urban Area I. Data are collected approximately 2004 – 2006. Data are based on an EU financed study creating an Urban Atlas and may differ from other national or local sources of information.

Area type	Inner city	Outer city	Peri urban Area I
Settlement area	5	50	170
Transport infrastructure area	2	15	42
Semi-natural area	0	1	6
Recreational area	1	18	38
Water area	1	2	9
Forest area	0	1	38
Agricultural area*	0	0	104
Total	9	88	406

* Based on visual review of the Urban Atlas, it is evaluated that the source has defined a too large agricultural area in Peri Urban Area I. The visual review leads to an estimate that more than 30% of the area of 104 km² could be either semi-natural area or recreational area. This change has not been made in the table.
Sources: COWI based on (European Environmental Agency, 2016).

3.2 Demographics and economy

3.2.1 Population development

The population development shows a fairly high growth in the peri urban II area especially in the 1970s growing to approx. 1.27 million persons. The peri urban I area increased in population in the beginning of the 1970s. From 1976 to 1990, the population in the peri urban I area declined, after which it has experienced a small growth to approx. 0.6 million persons, see Figure 3-4.

The population in the city experienced a decline in the 1970s and 1980s, but has grown since 1990. The population in the city (the sum of Inner and Outer City) is close to 0.7 million persons in 2014. These numbers include Frederiksberg Municipality with approx. 100,000 inhabitants. The population in the City constitutes approx. 12 per cent of the total Danish population of 5.7 million persons.

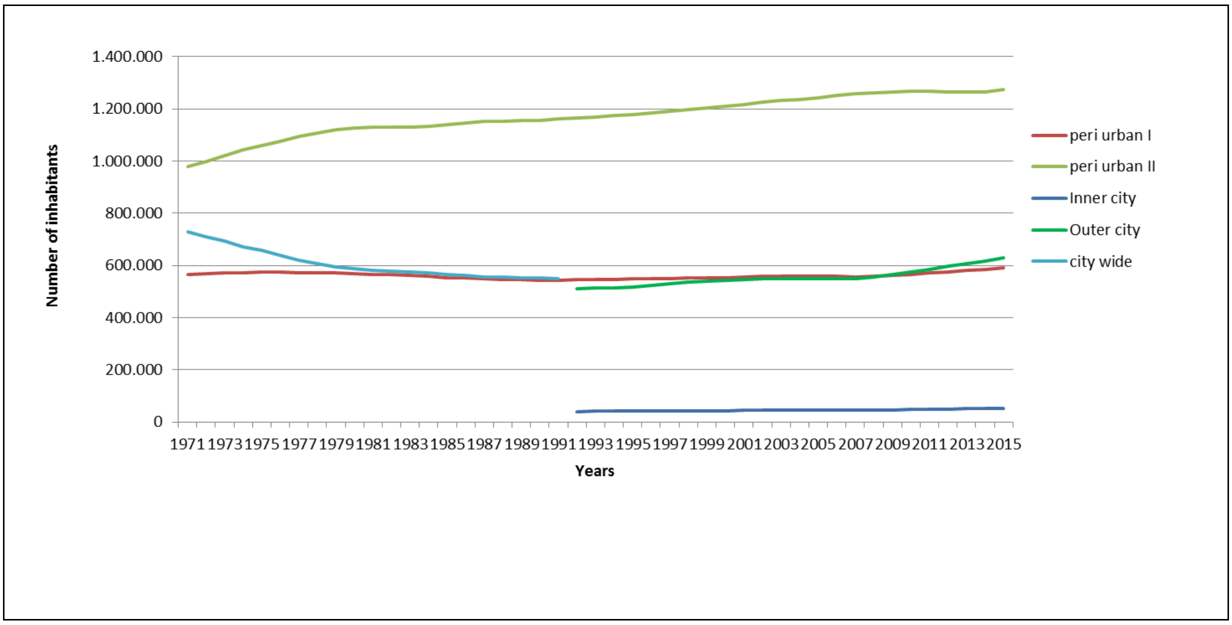

Figure 3-4: Development of the total number of inhabitants by area types [number]. No data available for segregation of inhabitants in Inner and Outer City before 1992.

Sources: COWI, based on (Statistics Denmark, 2016a) and (City of Copenhagen, 2016a).

3.2.2 Household size

The average household size is defined as the population divided by the number of households. A household is a group of persons living at the same address[1]. The development in household size clearly shows an increase in the number of persons in each household in the city (sum of Inner and Outer city) from the late 1980s until now, see Figure 3-5.

In 1986 there were on average 1.76 persons per household, but in 2015 the number was 1.99. The direct cause of this is that the population has increased faster than the number of households. In the period 1986-2015 the population in the city increased by 21 per cent (from 561 to 681 thousand) while the number of households increased by 7 percent (from 319 to 346 thousand). A main reason is that the city deliberately has focused on urban development (primarily renewal) with dwellings targeted at families with children. This targeted policy and planning aimed at attracting a more diversified population to increase the overall tax paying ability among the citizens enabling to finance a growth in welfare services incluing better urban spaces to make the City more liveable.

In the peri urban areas, the average household size decrased from 1986 to 2015. In the peri urban I area, average household size was 2.28 in 1986, and in 2015 it was 2.2. This is because the number of households increased by 11 per cent, while the population only increased by 7 per cent over the period. In the peri urban II area, average household size was 2.49 in 1986 and 2.21 in 2015. This reflects an increase in the number of households by 25 per cent (from 460 to 580 thousand) over the period, while the population grew by 11 per cent. The development in the peri urban areas is more similar to the trend in the rest of the country, where the falling number of children per family, rise in number of divorces and hence more single parents have led to an average lower household size.

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[1] This implies that e.g. two students sharing an appartment will be classified as one household – more specifically a household of the type 'Households consisting of several families'.

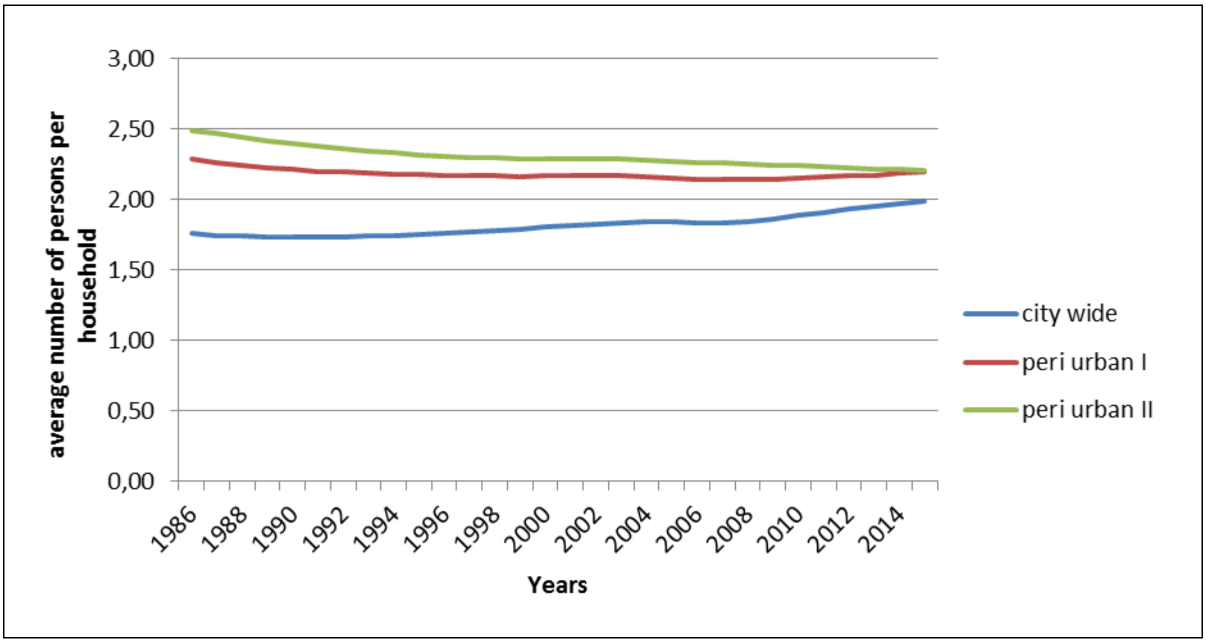

Figure 3-5: Development of the average household size by area type (average number of persons per household).

Sources: COWI, based on (Statistics Denmark, 2016b).

3.2.3 Gender balance and age class distribution

Figure 3-6 illustrates both the age and gender distributions for the city, peri urban I and peri urban II for two years: 1980 and 2016. The results reflect the cohort size and lifetime expectancy, but also population movements between different parts of Denmark.

From a pure demographic point of view one would expect a surplus of males among young persons and a surplus of females among old persons due to a biologically determined birth surplus of males, which for every subsequent age is offset by females' higher lifetime expectancy. This shows up clearly in 2016 for both peri urban I and peri urban II areas.

For the city, the gender differences are small for children and older persons, whereas there is a large surplus of young women in the agegroup 20-30 years. This surplus of young women cannot be found in peri urban I and peri urban II areas. One direct cause of the surplus is the number of women in the higher education system. For Denmark, the number of 18-28 year old women enrolled in ISCED 2011 level 7 studies is approx. 20-25 per cent higher than the number of men (depending on whether one divides by the number of women or by the number of men). For ISCED 2011 level 6 studies, there are approx. 11 per cent more women than men enrolled among the 18-28 year old.[2] As Copenhagen is a major city of study for tertiary education, the greater number of women in the tertiary education system can be expected to show up in the population statistics.

In Denmark, the population pyramid shows some large cohorts born in 1992-2002, 1962-1977 and 1947-1952. This pattern is also visible in 2016 for peri urban II area, and to a lesser degree for peri urban I area. However, the city has a different pattern. For the city, the age structure is dominated by

[2] COWI based on data from (Statistics Denmark, 2016c).

young persons aged 20-30 years, and the population share steadily declines for the age groups older than 30 years, and the size of birth cohorts seem to play only a minor role.

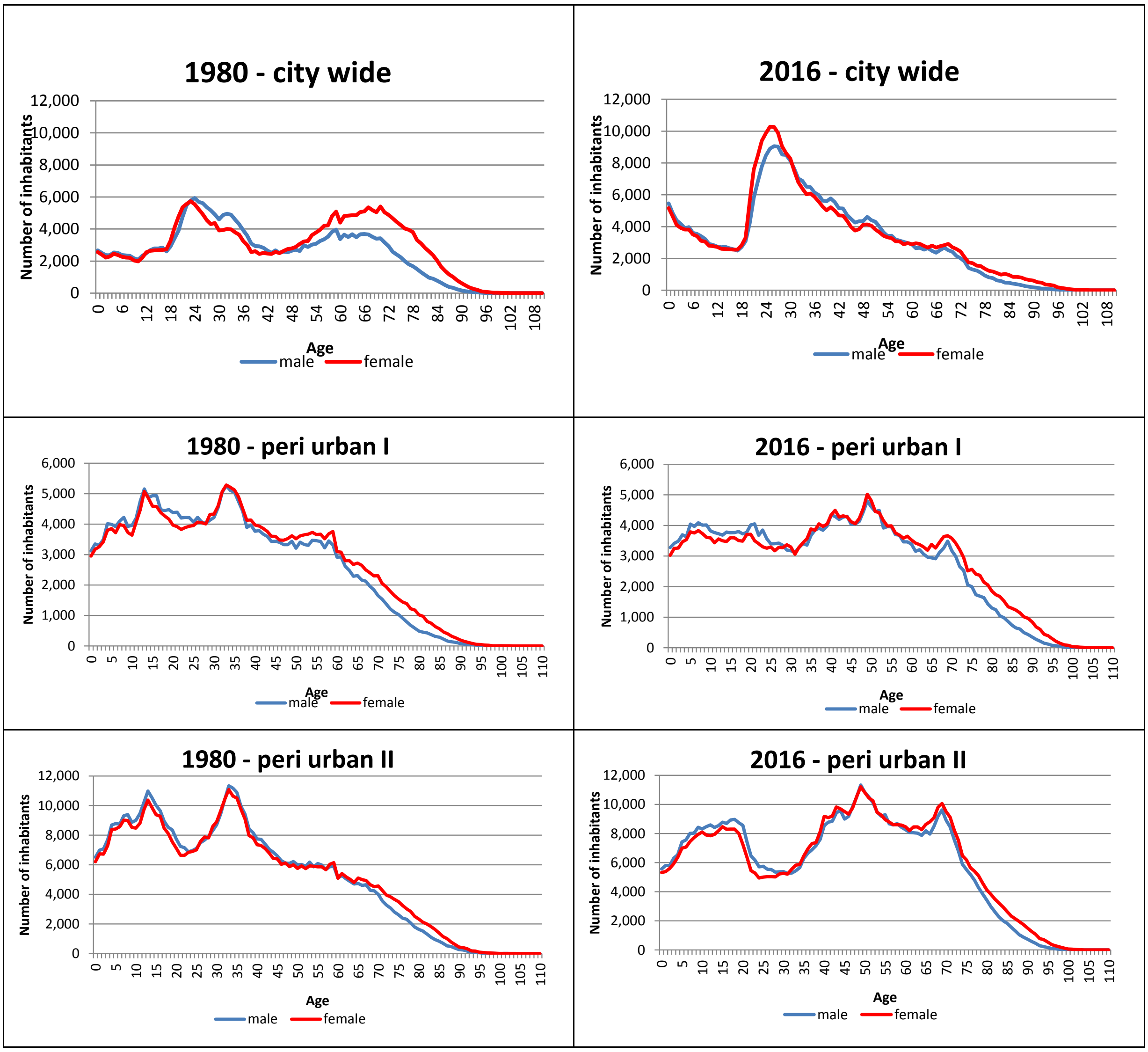

Figure 3-6: Comparison of gender balance of population between 1980 and 2015 (Total number of residents per gender)

Sources: COWI, based on (Statistics Denmark, 2016d).

3.2.4 Ownership of driving licence by age class

Statistics on ownership of driving licence can be based on the national survey on travel habits (see further explanation in subchapter 6.2). At city level the most significant historic development is that the share of persons older than 65 years having a driving license has grown substantially. , see Figure 3-7. This is the case both among women and men. However, men still have the highest percentage of ownership of driving license. Figures from 1975 indicate an ownership share of 31 percent for men and 4 percent for women, whereas figures for 2015 indicate 84 percent and 50 percent.

In other age groups, a significant growth has occurred in the city from 1975. During the last 10 – 20 years, the growth has been fairly small, but noticeable.

For the peri urban areas, the sample sizes for interviews in some of the age groups are too small to get a valid picture of the development. For the sum of all age groups, the data for the peri urban areas illustrate a smaller growth in ownership of driving licences than in the City. However, the starting point in 1975 was also higher for the peri urban areas, and figures for 2015 illustrate that more than 80 percent of the inhabitants in the peri urban areas have a driving license whereas the figure for the City is 75 percent.

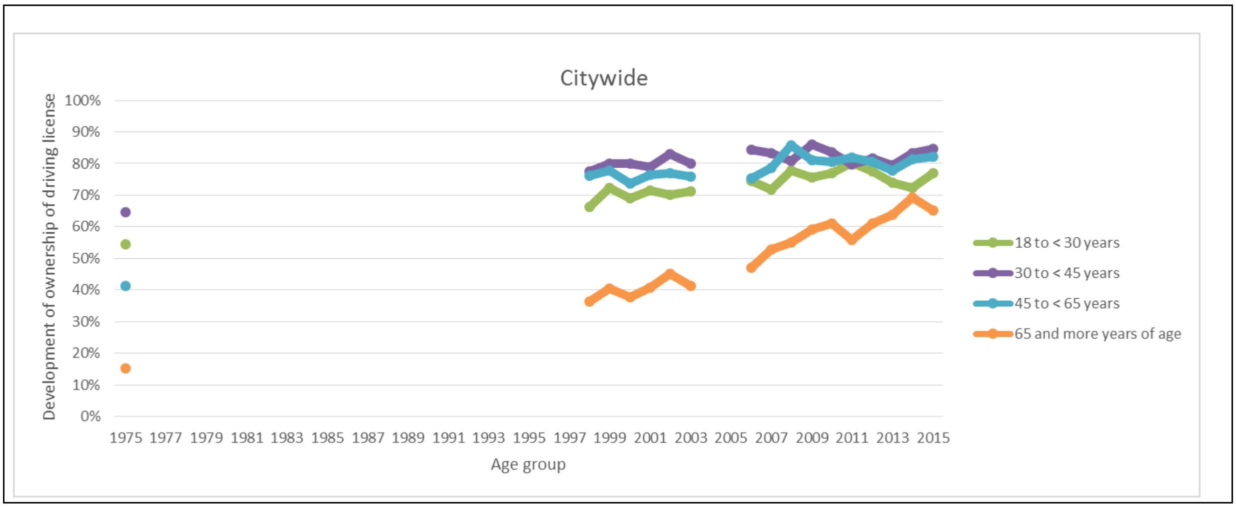

Figure 3-7: City-wide data of the development of ownership of driving licence and age class.
Source: (DTU Transport, 2016)

3.2.5 Education level of residents

The share of the adult population having completed an education level higher than primary education has increased from 1991 to 2015. In the city, the share of persons aged 18-69 with secondary education as the highest achieved education level grew from approx 62 per cent to approx 80 per cent. In the peri urban I area, the increase was approx 11 percentage points, from 61 per cent to 71 per cent. In the peri urban II area the increase was approx 15 percentage points, from 55 per cent to 70 per cent, see Figure 3-8. This follows the national tendency in Denmark where the share of adults with education greater than primary level has increased from 55 per cent in 1991 to 73 per cent in 2016.[3]

The national tendency reflects several developments. Firstly, the registration of education has improved for persons born in Denmark. When the registration of persons' education started, there was much doubt concerning the education level of older persons. Statistically, such problems were resolved by classifying persons as unskilled if no credible information could be obtained. Over time, the share of old persons with poor education data has decreased, which is reflected in a higher general level of education. Second, the share of immigrants in the Danish population has increased, and the problems of classifying immigrants by education level have not been resolved, and immigrants are often classified as unskilled.[4] This by itself would tend to give an impression of a decreasing general level of education. Third, the share of young persons who complete an education higher than primary, has increased.[5]

The education level among residents has developed in to a situation where the number of persons with a tertiary education now exceeds the number of persons with a primary and a secondary education in the city. The same trend can be seen in the peri urban areas, but the number of persons with only a primary education still exceeds the number of persons with a tertiary education in peri urban area II.

[3] (Statistics Denmark, 2016e).

[4] (Statistics Denmark, 2016f).

[5] (Statistics Denmark, 2016g).

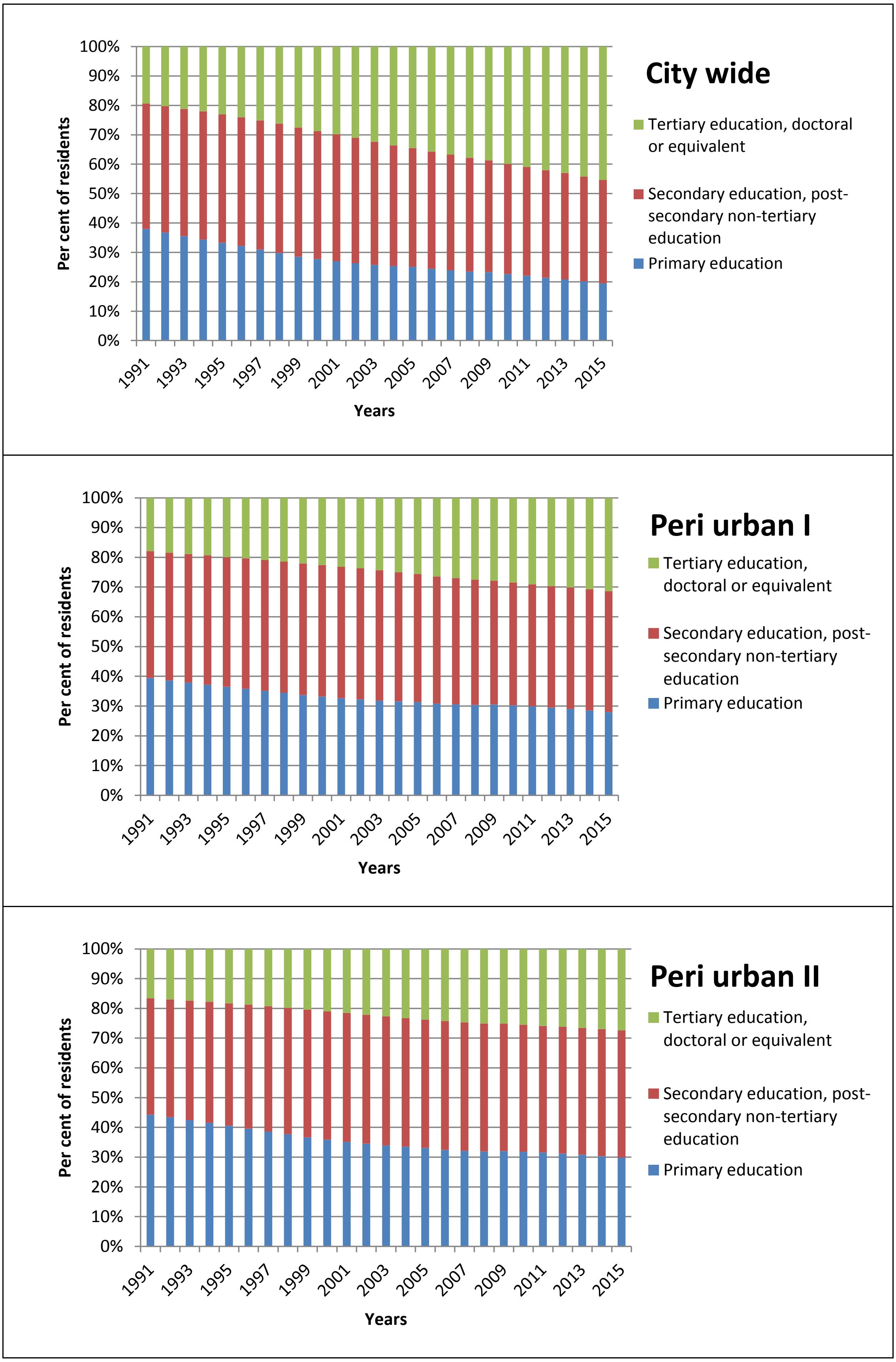

Figure 3-8: Development of the distribution of residents by education level and area type

Sources: COWI based on (Statistics Denmark, 2016h).

3.2.6 Employment status of residents

The composition of population by socio-economic status has changed a little in the city over the period 2008-2013. Figure 3-9 illustrates the main development being that retired persons constitute a declining share, whereas students constitute an increasing share. Some reasons why retired persons have moved out of the city may be that house prices have increased, which gives an economic incentive to reap a capital gain by moving to cheaper areas. Secondly, property taxes have increased, which have made it difficult for some low-income earners without the prospect of long-run income increases to afford to own a house.

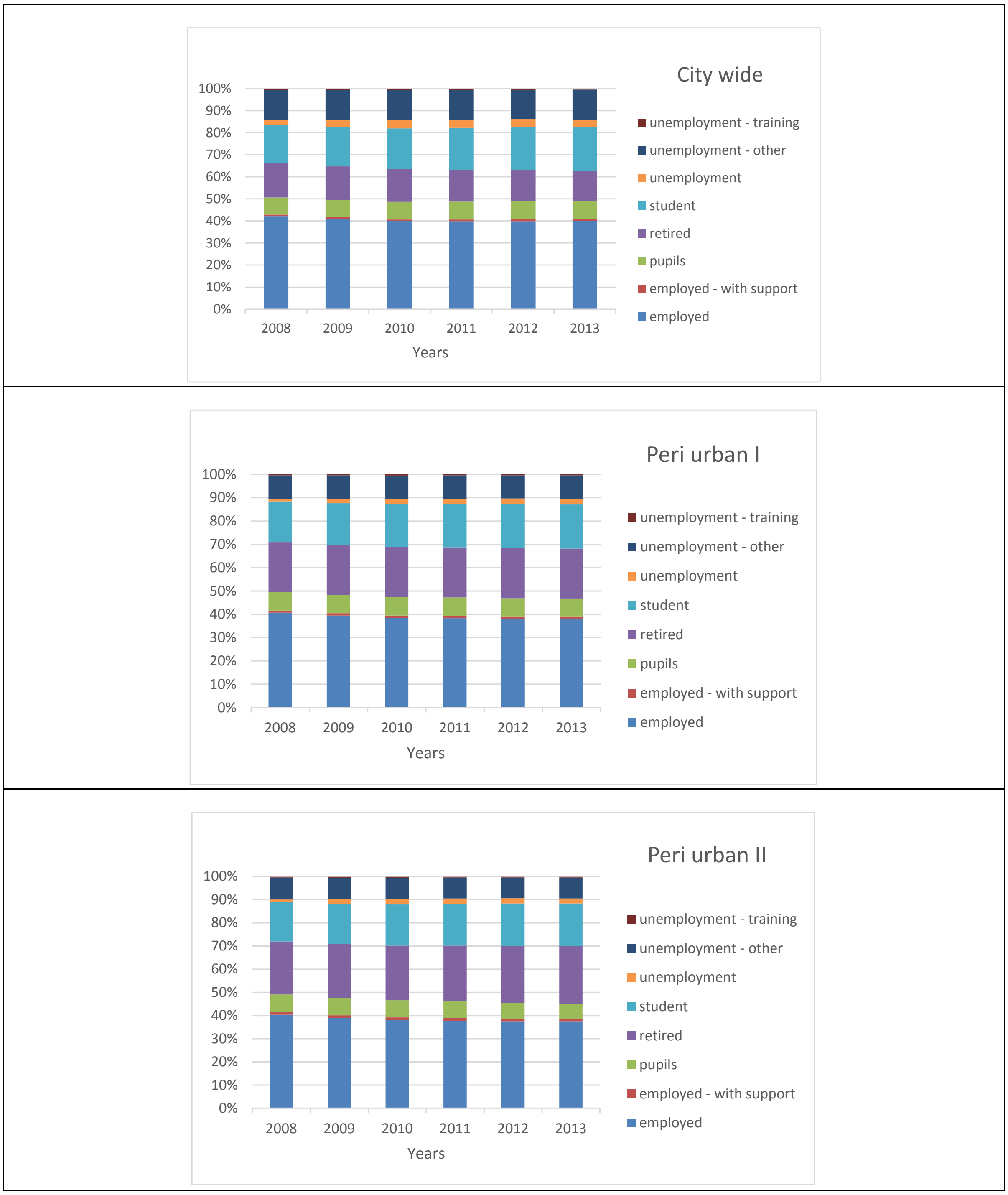

Figure 3-9: Development of the distribution of residents by employment status and area type.
Sources: COWI based on (Statistics Denmark, 2016i).

Number of jobs and workplaces

The development in number of jobs has varied across areas over the period 1997-2014 for which data is available segregated in Inner and Outer City, see Figure 3-10[6]. In the City, the number of jobs has grown from approx. 350,000 to approx 400,000. The growth was interrupted by the 2001-2004 'growth pause' related to the dot-com crisis and by the financial crisis. The latter had effect from 2008 to 2010. A similar development can be seen in the Peri Urban Area I, though the financial crisis has been more persistent here. Focusing on the peri urban II area, the number of jobs is the same in 2014 as in 1997, approx. 500,000. This reflects a movement of jobs from other parts of Zealand (Peri Urban Area II) to the City and Peri Urban Area I. Looking at the period 1982 – 1996, the numbers show a significant reduction, most likely caused by the closure of many industrial workplaces moving out of the City.

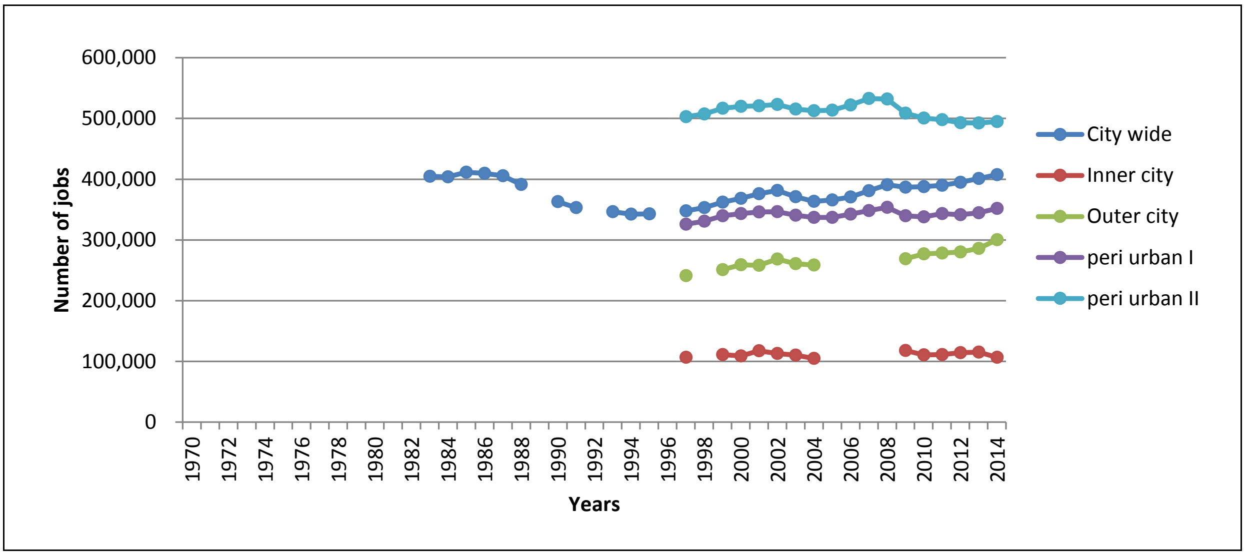

Figure 3-10: Development of the total number of jobs by area type

Sources: COWI based on (Statistics Denmark, 2016j) and (City of Copenhagen, 2016b) and (City of Copenhagen, 2016c). Data before 1996 only available for City of Copenhagen, "city wide".

The number of workplaces (addresses with a company registration), has changed over the period 1990-2014, but the relative importance of the different areas of the city remains more or less constant. The number of workplaces in the city stays between 30,000 and 36,000 throughout the period. The number of workplaces in the Peri Urban Area I stays between 27,000 and 30,000 in the period, and the number of workplaces in the Peri Urban Area II stays between 63,000 and 69,000, see Figure 3-11.

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[6] A job in a geographical area is defined as a person working at a workplace in the area. The information is identified by reports/filings from the workplace to the tax authorities as part of the Danish withholding tax scheme (kildeskat), where employers state their own address (workplace) as well as the name, address and personal identification number of all employees.

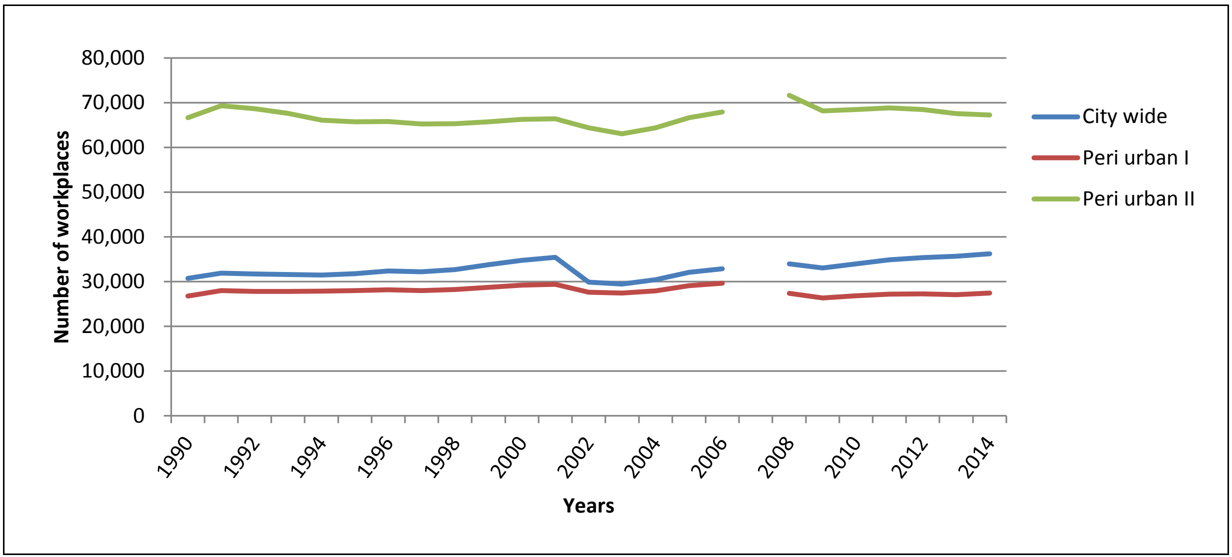


Figure 3-11 Number of workplaces.
Sources: COWI based on (Statistics Denmark, 2016k).

All areas are characterized by an increase in the importance of the tertiary sector and a decline for the secondary sector over the period 1997-2014 for which data is available, see Figure 3-12. Focusing first on the City, there is no primary sector of economic importance at any time in the period. However, the secondary sector has been reduced over the period to less than half its size in 1997. In 1997, the secondary sector made up 12 per cent of all jobs in the City – in 2015 it was 5 per cent. This reflects a national tendency of a declining secondary sector – the number of persons employed in manufacturing in Denmark has declined by approx. 31 per cent, and the share of all employed persons who work in manufacturing has declined from 16 per cent to 10 per cent. This decline is generally ascribed to globalization and offshoring of manufacturing jobs. The size of the decline of the secondary sector in the City cannot be wholly explained by the national decline of the secondary sector, but manufacturing appears to have moved out of the City, making room for dwellings and the tertiary sector.

The sectoral shifts are also apparent in the peri urban areas, though they have a different magnitude than in the City. In the peri urban I area, the share of manufacturing of the total number of workplaces has declined from 22 per cent to 17 per cent, and in the peri urban II area, the decline is from 23 per cent to 18 per cent. A less visible, but still remarkable, development is that the primary sector in the peri urban II area has been reduced to about half its 1997-size over the period.

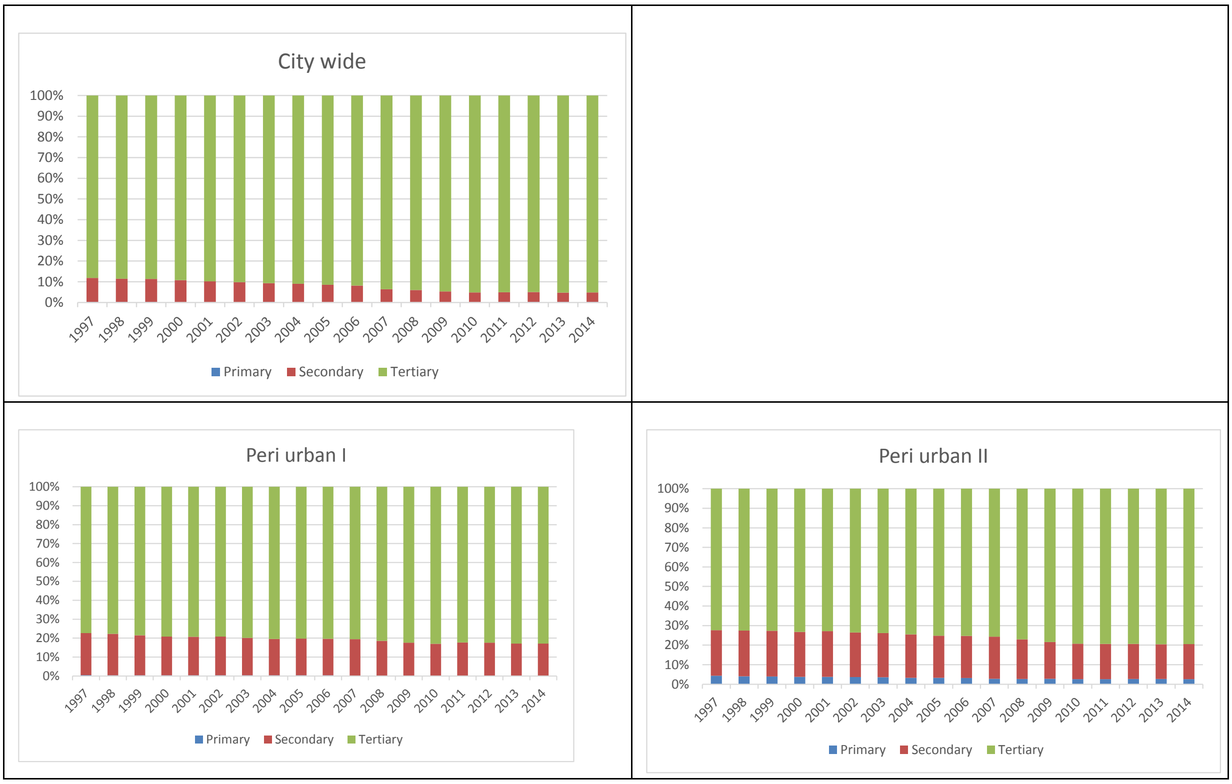


Figure 3-12: Development of the distribution of jobs by area type distinguished between economy sectors
Sources: COWI, based on (Statistics Denmark, 2016j).

3.2.7 GDP and income per capita

This subsection describes GDP per capita and income in the areas. GDP per capita can be an indicator of productivity or standard of living, depending on the context. In the present context, it will be interpreted as a productivity indicator. A note of caution is, however, that GDP per capita is GDP divided by the number of inhabitants, not by the number of employees, and at the regional level there can be a major difference between the two. This problem also applies if GDP per capita is intented to be an indicator of standard of living.

A first thing to note from Figure 3-13 and Figure 3-14 is that geographical productivity differentials have widened while income differentials have narrowed. This reflects the tendency for the peri urban II area to be a commuting area for the City, where earlier on, the City's commuting area was smaller. This indicates that people can live more or less anywhere in the peri urban II area and still take advantage of the high productivity in the City.[7]

A second thing to note is that the increase of productivity in the City and the peri urban I area exceed the increase in the peri urban II area. This is driven by an increase in GDP, because the population in the City has experienced a relatively higher increase than the population in the peri urban II area in the period 1993-2014. In this period, the population in the City increased by 21 per cent, while the population in peri urban I increased by 7 per cent and the population in peri urban II increased by 8

[7] Income is not the same as consumption possibilities. Firstly, the incomes shown are before taxes. Secondly, property price differentials mean that a given available income after tax payment does not give rise to the same consumption possibilities in the City as in e.g. peri urban II areas.

per cent. A third thing to note is the general higher level of productivity in the City and the peri urban I area compared to the peri urban II area. GDP per capita is roughly 70 per cent to 90 per cent higher in the City and peri urban I than in peri urban II.

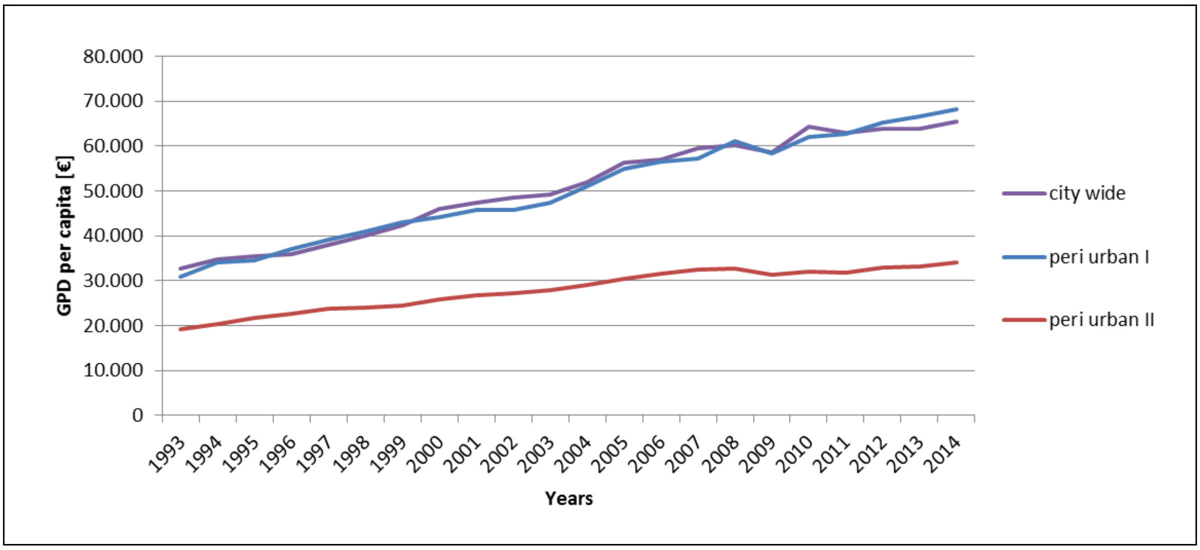


Figure 3-13: Development of the GDP per capita [€/capita], current prices

Sources: COWI, based on (Statistics Denmark, 2016l).

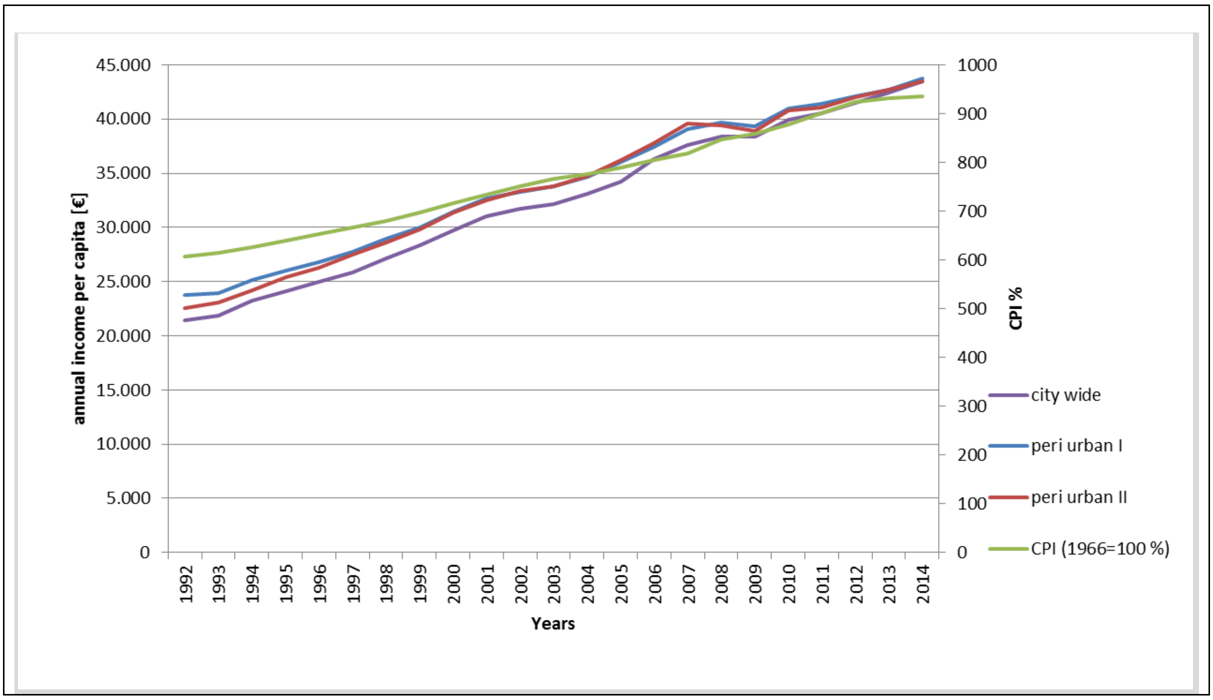


Figure 3-14: Comparison between peri-urban and city-wide data of the development of annual income per capita (gross), current prices and the national consumer price index (CPI).

Source: COWI based on (Statistics Denmark, 2016m).

4 Transport supply

4.1 Road infrastructure and parking

4.1.1 Road network

City of Copenhagen

City of Copenhagen (not exactly the same classification can be found in City of Frederiksberg) has roads and streets divided into five different road types as opposed to the four types of infrastructure given in table 4-1. The five types defined in the municipal plan 2015 are given as follows:

- Regional roads are major roads connecting Copenhagen with the whole region, Greater Copenhagen. These roads are planned for the car traffic, and the major parts of heavy traffic are concentrated on these roads. However, more of these roadss are also planned for giving main access for bicycle traffic with bicycletracks along the road and specific safety measures at intersections. These roads correspond more or less to main roads in the typology of table 4-1, since there are very few motorways. The few motorways are included in the regional road network.
- Distributional roads (Danish: fordelingsgader) ensure the connection between districts. Therefore they are organized to facilitate both car traffic, public transport and bicycle traffic. However, in some areas the public transport is favoured at the expense of car traffic. Some of these roads cross through sensitive city environments with schools and shopping centres. In these areas, road sections are developed also bearing in mind facilities for pedestrians. The type can be characterized as a subgroup of the main roads
- City district streets (Danish: bydelsgader) support the traffic within the districts. Therefore, the car traffic passing through is sought minimized by initiatives of traffic calming including dedicated bus streets. The accessibility for busses and bicycles is prioritized higher than for the car traffic. The streets can be characterized as minor roads.
- The City of Copenhagen also plans for shopping sheets (in Danish Strøggader). These streets are developed with specific attention to business and shopping with a high density of cafés and restaurants. Thus these streets require good opportunities to hang out in the street and to cross the street as a pedestrian to connect the two sides of the street. The safety of the pedestrians and the cyclists are main prioritities. Car traffic is calmed. These streets can be characterized as a subtype of the minor roads and low-speed zones.
- The local streets are the remaining group of streets, also those situated in residential areas. The car traffic is calmed and there is mostly shown consideration to the pedestrians and cyclists. In a number of dwelling zones, a general speed limit is set to 40 km/hour. Through going car traffic is prevented through traffic calming measures. These streets can be characterized as a subtype of the minor roads and low-speed zones.

Furthermore, special conditions apply for the traffic zone in the medieval part of the inner city. Here the car traffic is handled as in the shopping streets.

Other areas

The Danish road network is owned by the municipalities (here including City of Copenhagen) and the state.

The state roads are administrated by the Danish Road Directorate and consist mainly of motorways with some supplementing main roads. All Danish motorways are state roads.

The municipal roads in Denmark are divided in different road classes, but not necessarily using the same terminology across municipal borders. However, the main distinction is between

- Traffic roads serving car traffic between towns / urban areas and between areas / districts in towns and urban areas. Typically these roads are planned, designed and maintained for keeping a good traffic flow. The majority of these roads have separate bicycle facilities (often bicycle tracks separated from the carriageways at least with a kerbstone) along the roads. However, many subcategories of roads and streets exist and can include streets with speed calming measures, bus lanes etc.
- Local roads only serving local traffic in between the network consisting of traffic roads.

Table 4-1 indicates the speed limits defined by legislation.

Table 4-1: Speed limits by types of infrastructure

Type of infrastructure	Speed limit (max. allowed speed) [km/h]
Motorways	130 km/h, but restricted to 110 km/h or lower in all sections in peri urban area I and City of Copenhagen.
Main roads (except motorways)	80 km/h outside urban areas, 50 – 70 km/h in urban areas – with some examples of lower speeds on short sections
Minor roads (within urban borders)	50 km/h, but restricted to 30 – 40 km/h on many sections
Low-speed zones	30 or 40 km/h speed limit zones as well as individual streets with lower speed limits

The total network of public owned roads in City of Copenhagen was approx. 429 kilometres in 1971 and grew with 6% up to 1998 to a total of approx. 455 kilometres. The statistics does not make it possible to segregate the development in road types before 2007.

In 2007, the length of public owned roads in City of Copenhagen had grown to approx. 496 kilometres and in 2016, the number is approx. 562 kilometres giving a growth of approx. 24% from 1998. The main growth has been on minor roads and is most likely due to three main reasons. First, the reclamation of new land and the transformation of large industrial areas to residential areas has led to a denser network of minor roads in these areas. Second, in the period after year 2000, the City has changed the status of some minor roads from private owned to city owned roads due to legal reasons. Third, the methodology for providing statistics on road length has changed due to changes in road database systems.

The road network in the city consists of both public owned and priate owned roads / streets. However, the overall statistics on private owned roads is not available or is inconsistent. The private owned roads / streets are minor roads, primarily in residential areas, and do not have the same influence on overall traffic flow as other roads. Therefore, the numbers in Figure 4-1 only include public owned roads.

The private owned roads constitute nevertheless a large part of the total network of roads, adding more than 400 kilometres to the total road length. Even though these roads are private owned, public users have acces to them. The question of deciding the ownership is mostly a question of financing of construction and maintemance costs as well as legal issues on parking regulations. It is not a decision made from a traffic point of view. Furthermore, the policy on private owned roads and thus, the resulting share of private owned roads differs quite a lot among Danish municipalities.

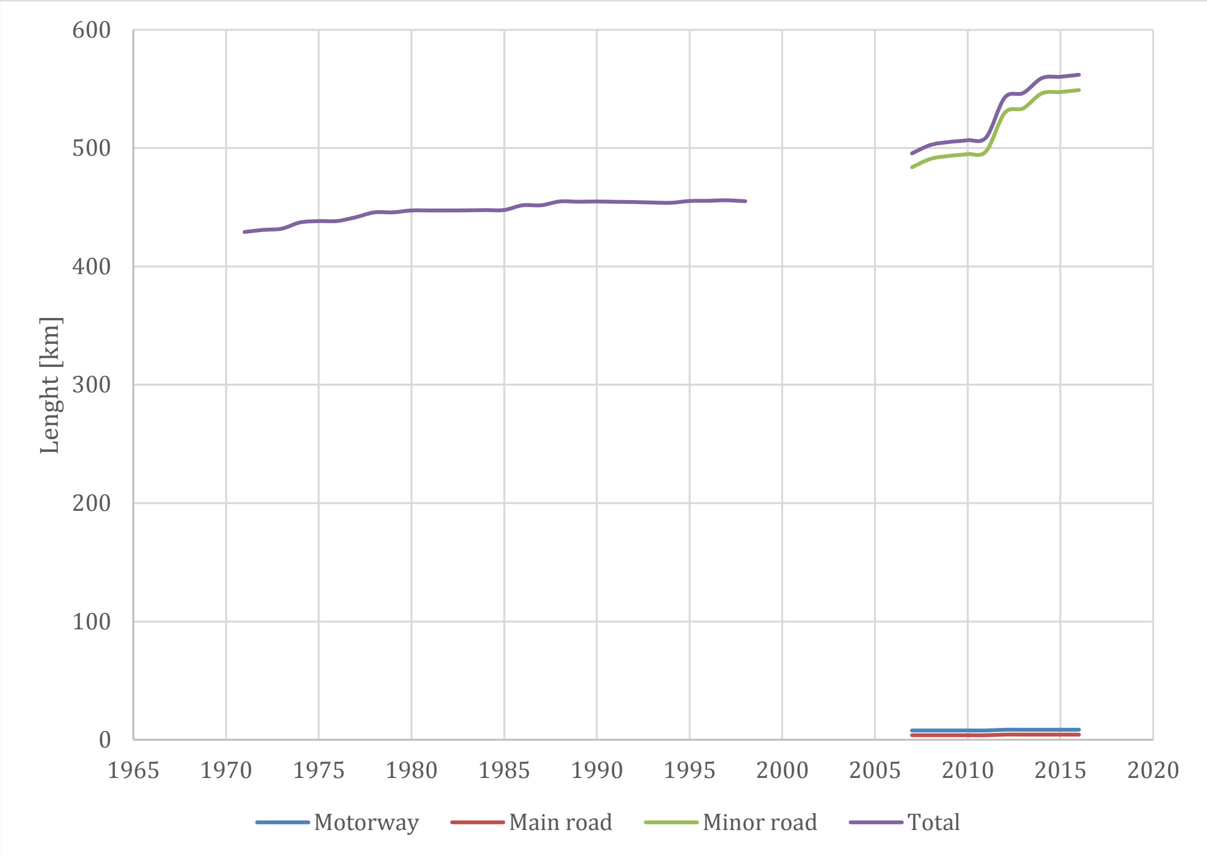


Figure 4-1 City wide development of length of public road network (not considering multiple lanes). [km]
Notes: No data available for the years 1999 – 2006.
Sources: (City of Copenhagen, 2016d) and (Vejdirektoratet, 2016b)

Local streets account for more than 70% of the total length of the road network in the City of Copenhagen, see Figure 4-2.

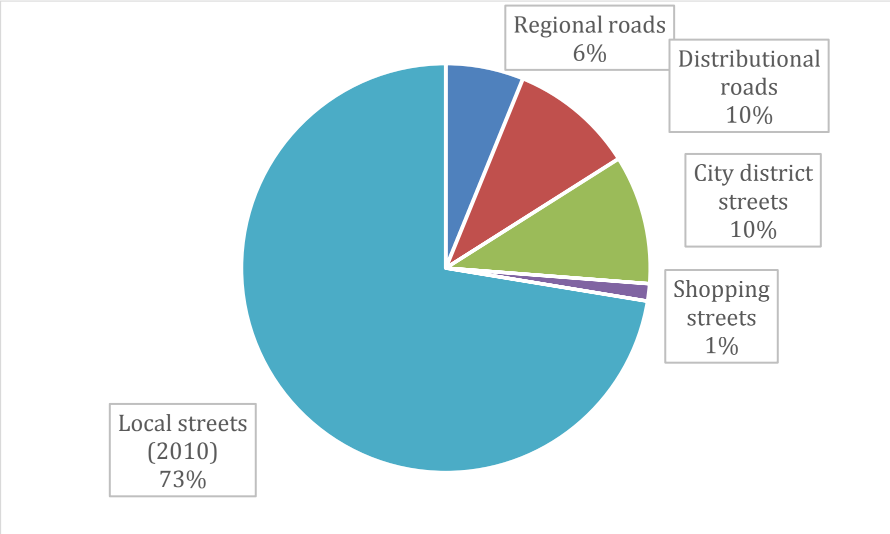


Figure 4-2 Distribution of road network length on road types in City of Copenhagen (not including City of Frederiksberg)
Source: (City of Copenhagen, 2015a).

An overview of the development of the road network in the Peri urban areas does not exist. However, numbers for the length of the road network in 2016 makes it possible to compare the sizes of road networks between the areas, see Table 4-2.

Table 4-2 Total road network in 2016, not including private owned minor roads [km]

2016	State roads, motorways	State roads, other major roads	Municipal roads	Total
City of Copenhagen	9	4	549	562
Peri Urban area I	118	11	1,833	1,962
Peri Urban area II	305	568	14,682	15,555

Sources: (Vejdirektoratet, 2016b).

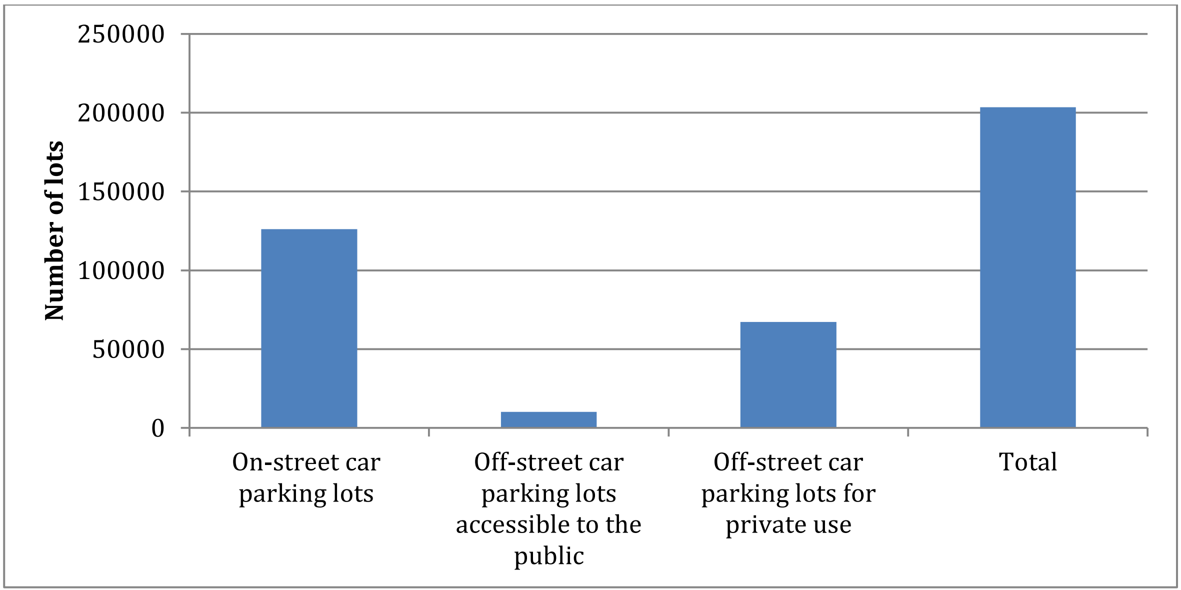
4.1.2 Parking space

For this study, numbers have only been identified for the City of Copenhagen and not including City of Frederiksberg.

The supply of car parking lots in City of Copenhagen is provided within the categories:

- On street car parking lots: Parking on the streets both within the parking payment areas and outside
- Off-street car parking lots accessible to the public: Parking lots in constructions incl. underground
- Off-street car parking lots for private use: Parking lots on private ground (next to villa houses), municipally owned parking lots and private parking facilities reserved for the companies and residents using the premises.

The total counting of parking lots in City of Copenhagen was carried out for the first time in 2016 using the categories described, but not divided in geographical areas. However, the number of public on street parking lots has been almost constant the last 10 years with approximately 126,000 lots, see also Figure 4-3.



Note. Private owned but public accessible parking at some shopping centres are not included in the statistics. An estimate is that the total amount of this parking is smaller than the included off-street car parking lots accessible to the public.

Figure 4-3: Number of parking lots by category in City of Copenhagen in 2016
Sources: (City of Copenhagen, 2016e)

The bicycle parking data includes dedicated public accessible parking lots for bicycles on roads and sidewalks but cannot be divided in inner and outer city, see Figure 4-4. The numbers are based on estimates using Geographical Information System (GIS) combined with actual countings of existing and currently constructed bicycle parking facilities. However, the real number might be higher since not all parking facilities are registered in the GIS. Data concerning parking space for bicycles are rather scarce, especially prior to 2006.

The increasing number since 2006, however, shows the results of a consistent policy and effort to promote bicycle traffic. City of Copenhagen has traditionally constructed conventional bicycle parking facilities whereever relevant and possible.

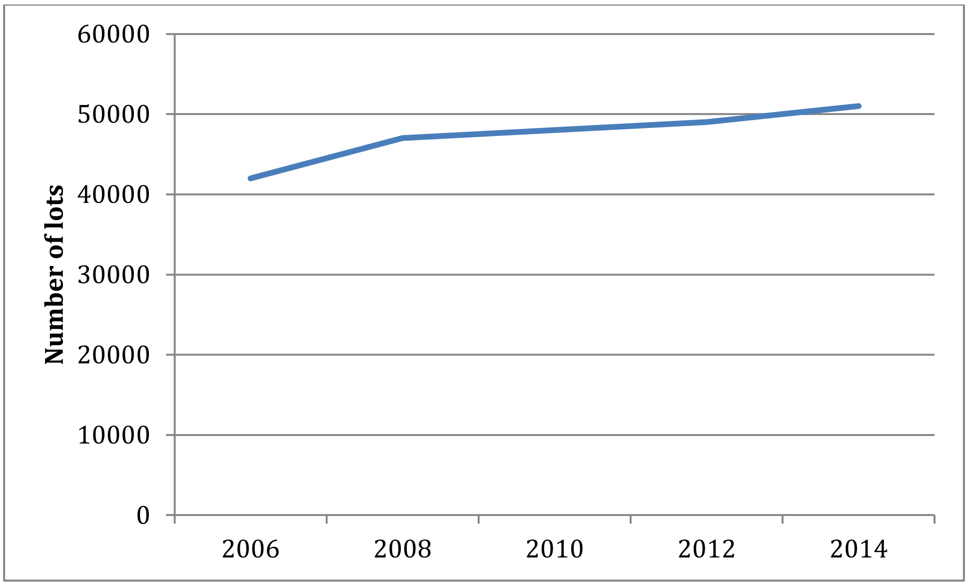


Figure 4-4: Development of the number of dedicated cycle parking lots in City of Copenhagen, not including City of Frederiksberg.
Source: (City of Copenhagen, 2015b).

4.2 Public transport and taxi supply, car-sharing

4.2.1 Public transport network

The main changes in the length of the public transport network since 1970 can in short be described as follows, see also Figure 4-5:

- Copenhagen had tram lines, but they were gradually closed from the end of the 1950s. The last line closed in the beginning of 1972. The tram lines were partly replaced by bus lines.
- A new S-train line in the southernmost "finger" following a major new urban development scheme covering municipalities in both peri urban areas. The line was opened in stages from 1972 to 1983.
- The extension of the northwest going S-train line in 1989 in peri urban area II.
- Extension of the S-train line, "Ring line", more or less replacing a rail line giving some minor changes in the actual extension of the line newtwork. Construction works on the lines were carried out around year 2000. The line improved connections between the radial lines
- Harbour busses by ferry were established in year 2000 with six stops connecting the two sides of the harbour area
- The introduction of metro lines in City of Copenhagen (extending partly in to peri urban area I) from 2002 to 2007 with a total length of approx. 20 km. The metro also replaced an S-train appendix line to the Ring line.

No overall statistics exists for the total number of km roads serving bus lines.

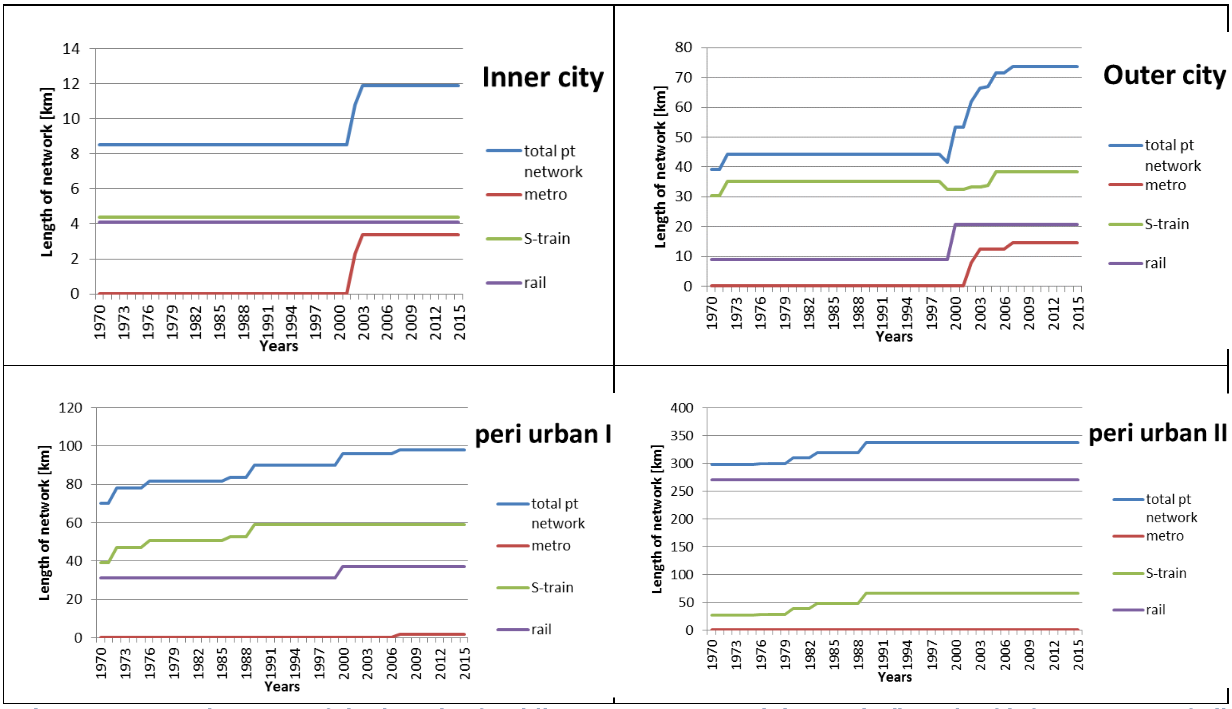


Figure 4-5: Development of the length of public transport network by mode (length of infrastructure of all urban lines in regular service on weekdays) [km]. Only public transport by rail is shown. The last tram line was closed in 1972 and is not shown either.

Sources: COWI based on GIS maps.

The first bus lane in City of Copenhagen was inaugurated in 1973 in one street, Fredensgade, and since then the overall trend has been a growing number of bus lanes. However, no systematic statistics exist on the development and length of bus lanes. From various sources it is possible to see a development from approx. 26 km in 2003 to approx. 30 km in 2012, see Figure 4-6.

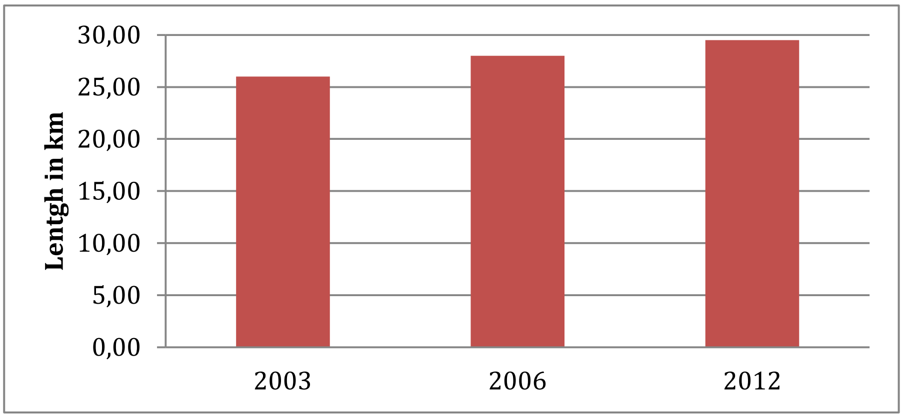


Figure 4-6: Development of the length of separate bus lanes per direction (length of infrastructure) [km] in City of Copenhagen.

Sources: Various documentation from archives, City of Copenhagen.

4.2.2 Public transport supply

Figure 4-7 illustrates the development in the supply of public transport expressed in terms of number of train km. The statistics does not provide numbers on the development of "seat km". However, the extension of the S-train net (see paragraph below on "Service frequency of public transport") and renewal of the vehicle fleet has given an increase in the total number of seat km. The newest generation of S-trains introduced gradually from 1998 to 2006 has approx. 30 percent more seats than previous generations with an average of approx. 336 seats per train. The metro has approx 96 seats per train.

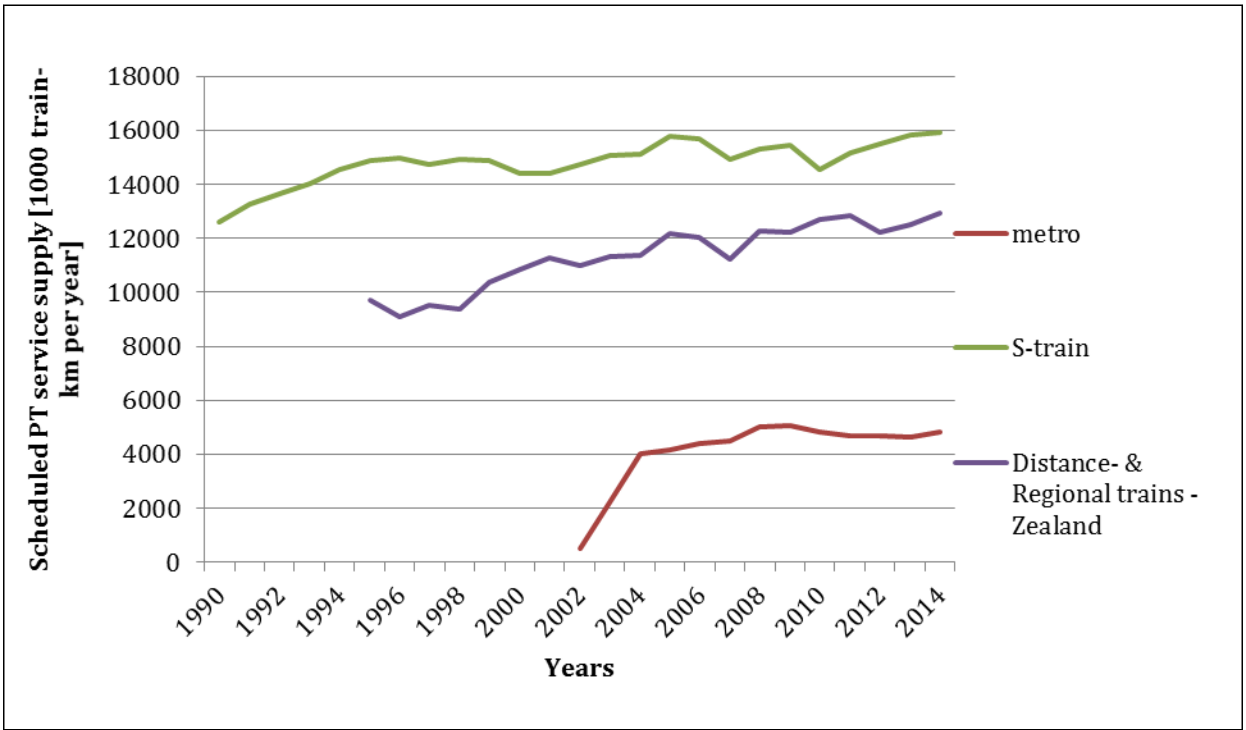


Figure 4-7: Development of the scheduled (offered) public transport service supply, all types [1000 train-km per year] for all areas in the study area.
Sources: (Statistics Denmark, 2016p)

One can also argue that the development of seat km does not fully or correctly illustrate the development of passenger capacity. The newest generation of S-trains has another fitting up of seats than earlier generations. This includes more narrow seating's providing more seats but at the same time more space for e.g. bicyclists giving less seats. The metro has – as is the case in most cities – less seats per unit area than the S-trains and more space for standing up giving a larger total passenger capacity.

Service frequency of public transport

The first S-train lines were established in 1934 and have gradually been developed to the present number of lines. Until year 2000, the trains ran with a frequency of 20 minutes, but on some lines supplemented during peak hours giving a frequency of 10 minutes. From year 2000, the timetables were adjusted and all S-train lines now have a frequency of 10 minutes during daytime, 20 or 30 minutes frequency evening and nights.

The number of bus lines have gradually been expanded in the Greater Copenhagen area (all areas including City of Copenhagen and peri urban area I) following the urban development. Until 1970, City of Copenhagen also had trams running with a frequency of approx. 6 – 7 minutes. They were replaced by bus lines running with a frequency of 3 – 4 minutes. However, the frequency and the number of bus lines in the City of Copenhagen were hereafter gradually reduced due to a falling number of passengers leading to the need of reducing the costs. Furthermore, a growing need for expanding the services in the peri urban areas also influenced the need to reduce the costs in the central areas.

Gradually, the frequency of the bus services the last approx. 10 – 20 years have decreased due to reduction in the number of passengers. However, the total number of lines were maintained. This was an unstable situation and around year 2000 discussions took place on making more radical changes on the bus network. This was also facilitated by the introduction of the metro.

The introduction of the metro in 2002 therefore lead to an adjustment of the bus service in City of Copenhagen leading to a natural reduction in the bus service. This lead to a new concept of "A-busses" running with a frequency of 3-4 minutes – more or less on some of the former lines served by trams. The metro has a frequency of 2-3 minutes during daytime and up 15 minutes during night time. A similar development with fewer bus lines but with high frequencies can be seen in many Danish and other European cities.

Public transport operators

Up to 1974 public transport (busses and trams) in the Inner and Outer city was provided by one company. Outside these areas, the services were run by a number of both private and public operators and not always coordinated.

In 1974 a public transport operator HT ("Hovedstadsområdets Trafikselskab", which more or less can be translated to the public transport company of the capital region) was created. HT was a partnership amongst the municipalities, the City of Copenhagen and the regional authority. DSB (the Danish Railways) still operated trains including the S-trains which they still operate today. Furthermore, some private operators were still to be found in the peri urban areas.

However, a very significant change in 1974 was the introduction of a common fare system among all bus operators in the region including approximately the present peri urban area I. In 1979, trains and S-trains were included in the common fare system.

The next major change appeared in 2007, when a new transport company MOVIA was created covering two administrative regions equal to the whole study area of this report including peri urban area I and II.

The public transport company has in the period from 1990 to 1996 gradually changed from a transport operator owing their own vehicle fleet to a transport company buying transport through public service contracts.

Description of delays in the public transport system

Public available information on delays is only to be found for trains, as part of the service contracts with the national Government. The contracts include e.g. targets for reliability and arrivals within the scheduled time. Such information is not available for bus operations. The delays for trains are described with two parameters:

- Reliability (percentage of all trains not cancelled)
- Percentage of trains arrived within a gap specified in service contracts.

In 2003, the average delay for long distance and regional trains was 120 seconds, while in 2004 the average increased to 158 seconds. In 2011, the railway operator DSB made a traffic agreement which obliges DSB to deliver an average delay of maximum 190 seconds for all long distance- and regional trains, see Figure 4-8.

The threshold for when to define a train as delayed has changed throughout the years and differ between the train systems, ranging from 2 min 29 sec to 5 min 59 sec.

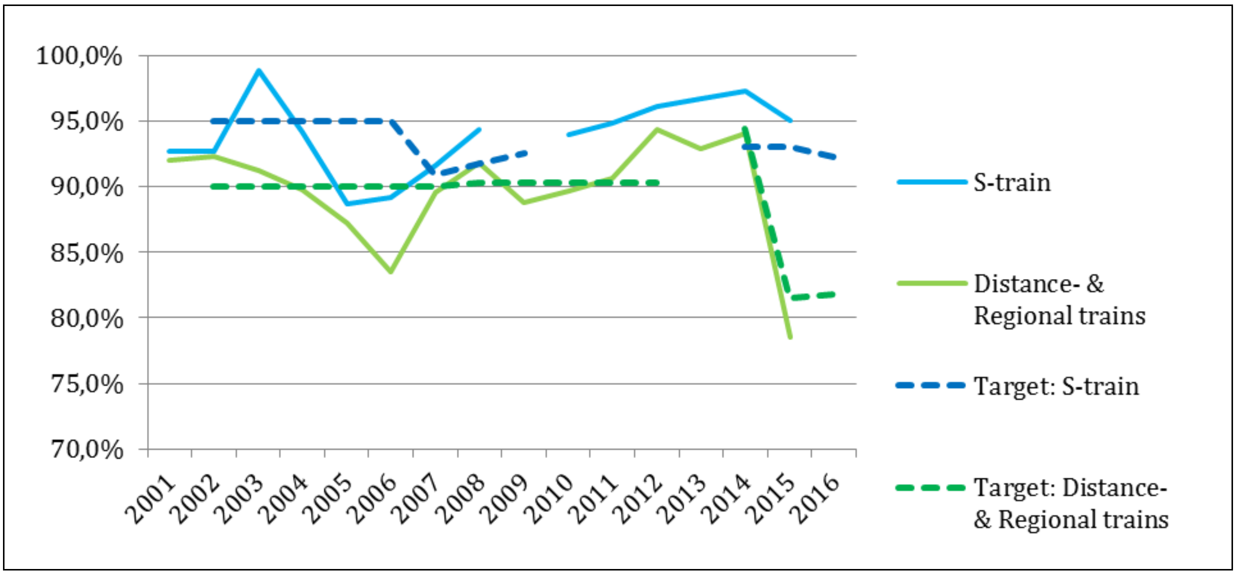


Figure 4-8 Development of delays in public transport (percentage arrived on time).
Source: COWI, based on (DSB, 2001 - 2015).

In 2015, the definitions were changed to make them more comparable. The target value is now 2 min 59 sec for all types. Furthermore, before 2015 the delay was calculated for each train, while from 2015 and onwards it is calculated for each costumer. Therefore, delayed evening trains with very few passengers do not count as much as morning trains with many passengers.

For reliability, the target has been difficult to reach for the operators, see Figure 4-9.

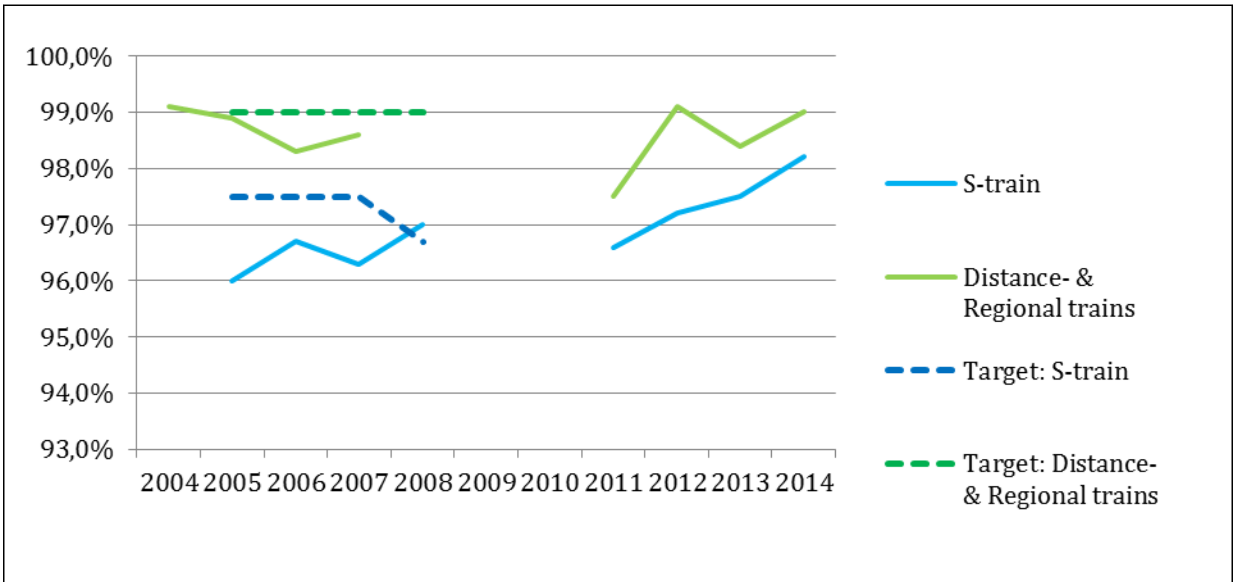


Figure 4-9 Development of the reliability in public transport [% not cancelled]
Source: COWI, based on (DSB, 2001 - 2015).

Pricing policy and tarrifs

The most important change was implemented in 1974 with the introduction of the common fare system. With the introduction, a new ticket system was also introduced; namely a 10 trip ticket giving fairly big discounts compared to single trip tickets. The system resulted in more passengers. The common fare structure was developed gradually and has covered the whole peri urban area for some years.

From 2010, the national "Rejsekortet" was introduced and gradually implemented. It is a travel pass based on a contactless card covering all Denmark and all public transport – with a few exceptions in some regions outside the study area.

The pricing structure is decided in the boards of the public transport companies. The policy is more or less to cover a certain percentage of the yearly expenses. The present objective is to reach an average level of approx. 50 percent. The national Government has sat a limit for the average growth of ticket prices to 2 – 3 percent per year.

The pricing policy for the common fare system has for many years been to give frequent users with e.g. monthly passes price reductions compared to e.g. single trip ticket users. The price for single trip tickets has grown more than consumer prices in general. In particular after 2000, the rate of increase of the prices of single trip tickets has exceeded the rate of increase of consumer prices. See Figure 4-10.

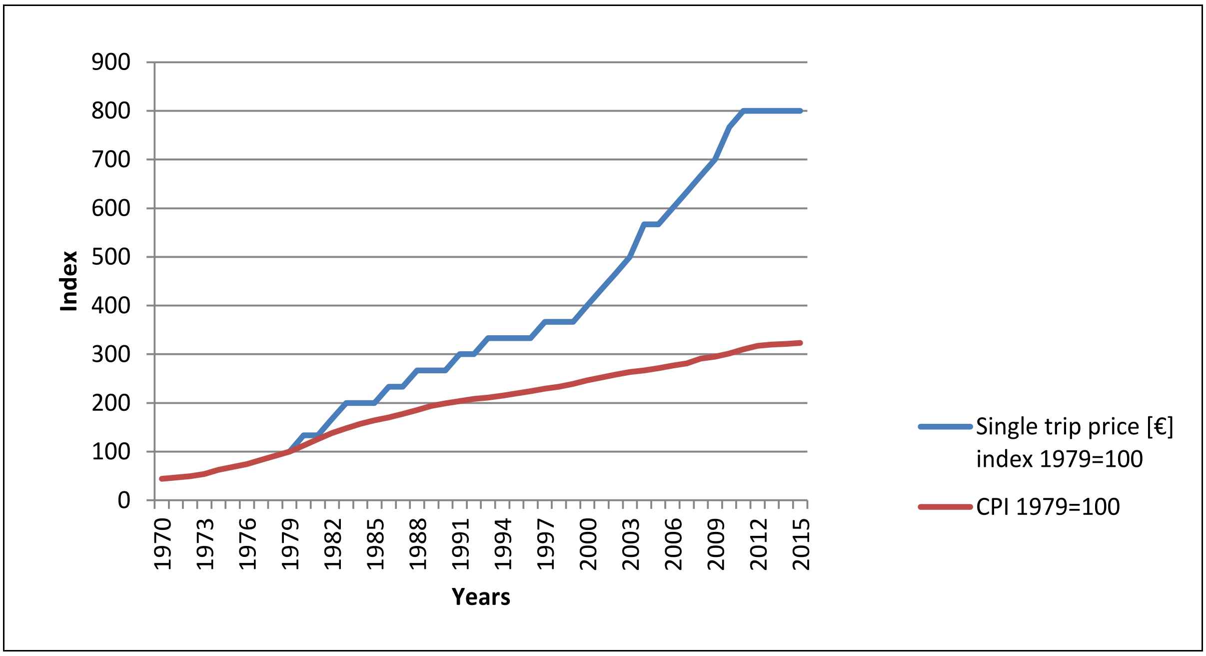


Figure 4-10: Development of the price for a PT single trip ticket covering two fare zones (the sum of Inner and Outer city covers approx. two fare zones) and of the national consumer price index (CPI) [%].
Source: COWI based on (Din offentlige transport, 2016) and (Statistics Denmark, 2016n).

The price of a monthly ticket in public transport has also increased more than consumer prices in general. An exception is the period 1992-1998, where ticket prices fell, while general consumer prices increased. After 2000, monthly ticket prices have outgrown the general consumer prices. See Figure 4-11.

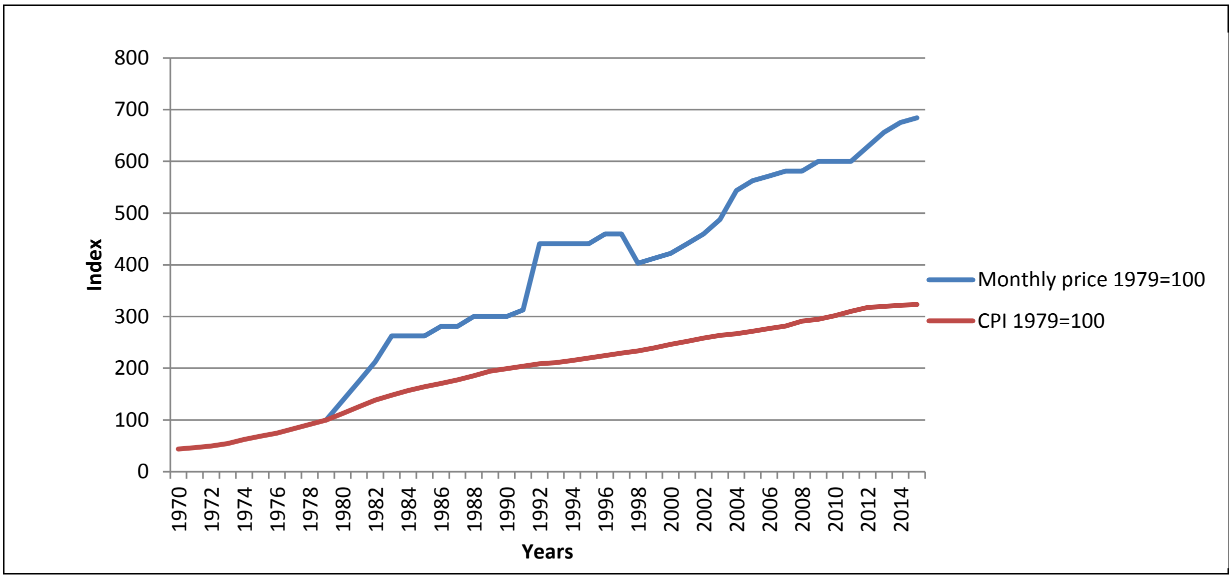


Figure 4-11: Development of the price for a PT monthly ticket covering two fare zones (the sum of Inner and Outer city covers approx. two fare zones) and development of consumer prices. Some variations during the years in the possibility of buying "zone" tickets covering precisely the City. Own calculations have therefore been used for 1979-1991.

Source: COWI based on (Din offentlige transport, 2016) and (Statistics Denmark, 2016n).

The prices of annual tickets for public transport has also outgrown general consumer prices. There are two exceptions, the periods 1992-1998 and 2010-2012. See Figure 4-12.

Summarizing across the different ticket types, the price of single tickets has increased most, by a factor 7, since 1979. Prices of annual and monthly tickets have increased by a factor 6 in the period. In the same period, consumer prices have tripled.

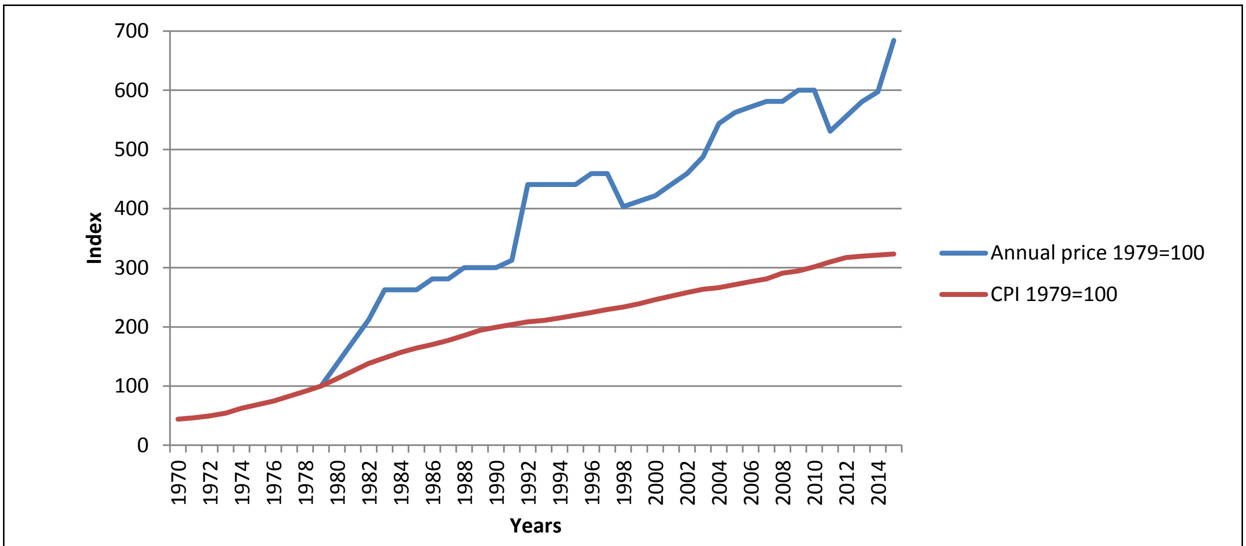


Figure 4-12: Development of the price for a PT annual ticket covering two fare zones (the sum of Inner and Outer city covers approx. two fare zones) and development of the national consumer price index. Only for the years 2011-2014 a discount on 11.5 percent was given if buying a seasonal pass for a year. For the other years, the price is calculated as 12 * monthly pass.

Source: COWI based on (Din offentlige transport, 2016) and (Statistics Denmark, 2016n).

Real time information for public transport

Real time information has gradually been implemented for all busses since 2004. It is now possible for passengers to get information at some bus stops and on board the busses and on various Internet and mobile platforms.

The S-trains started providing real time information in the 80ties.

Step free acces to public transport

Low floor busses were introduced as pilot projects in the 90ties and have gradually been implemented in most busses. The present service contracts include demands for low floor busses.

The S-trains do not include low floor entries. However, the present generation of S-trains have on board ramps for wheelchairs that have to be operated by the driver. The metro trains all have low floor entries.

Furthermore, all S-train and metro stations have lifts giving acces to the platforms.

Surveys of public transport customer satisfaction

Surveys on customer satisfaction were sporadic until the 1990s but have gradually been developed. Today, the public service contracts with the operators include that customer satisfaction is measured. From year 2000 tenders' the topic is integrated in the payment system to the operators.

Recently, a new independent organisation titled "Passagerpulsen" (the pulse of the passenger) was established. It calls itself a consumer watchdog in connection with the use of bus, train and metro nationwide and it runs as a part of the Danish Consumer Council. It is sponsored by the Danish Ministry of Transport and the public transport companies but is independent of the operators. Passagerpulsen has started the work to systematically collect data on passenger satisfaction, but the very first results have only been published in June 2016. Therefore no historic development can be described yet.

Accessibility to public transport

In 2002, before all the present metro lines were in operation, 42.0% of all housing, workplaces and student places in the city of Copenhagen and the city of Frederiksberg were able to reach the S-train or regional train within 600 meters walking distance. The 42% is a total for all three groups, while the number is 38.1% of all inhabitants, 42.1% of all workplaces and 61.8% of all student places.

After the first 3 stages of metro, in 2004, the coverage expanded to 57,1% to reach the metro, the S-train or regional train within 600 meters walking distance for all inhabitants, 64,2% of all workplaces, 65,0% of all student places, which gives a total of 60.6%

In 2019, with the opening of a stage 4 of the metro, 86,2% of all inhabitants will be able to reach either the metro, S-train or regional train within 600 meters walking distance, 83.8% of all workplaces, 85,8% of all student places, which gives a total of 85.2%.

These numbers cover the city of Copenhagen and the city of Frederiksberg[8].

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[8] Source: (Øystein Leonardsen, 2004).

4.3 Cycling

Shortly after 1900, City of Copenhagen began constructing one-way bicycle tracks on each side along streets. The tracks were 2.5 m wide and separated from the carriageway (car traffic) and the sidewalks (pedestrians) by curbstones. From 1950 – 1970 (almost from 1910 up until today) such bicycle tracks have been constructed along a major part of all "not" local streets.

The large coherent network of bicycle tracks has most likely been among the decisive parameters for maintaining the bicycle tradition even during the growth in car traffic in the 1960s and 1970s and thus giving good preconditions for the city's sustainable traffic development from the 1990s. Figure 4-13 illustrates the development. Before 1989, no solid statistics exist on the differentiation between bicycle lanes (painted lanes on the carriageway) and bicycle tracks, but as can be seen after 1989, the majority of the network consists of tracks.

In the beginning of 1990s, the city started the planning and implementation of a supplementing network of green cycle paths decoupled from the roads. Some of them utilize abandoned old railway alignments.

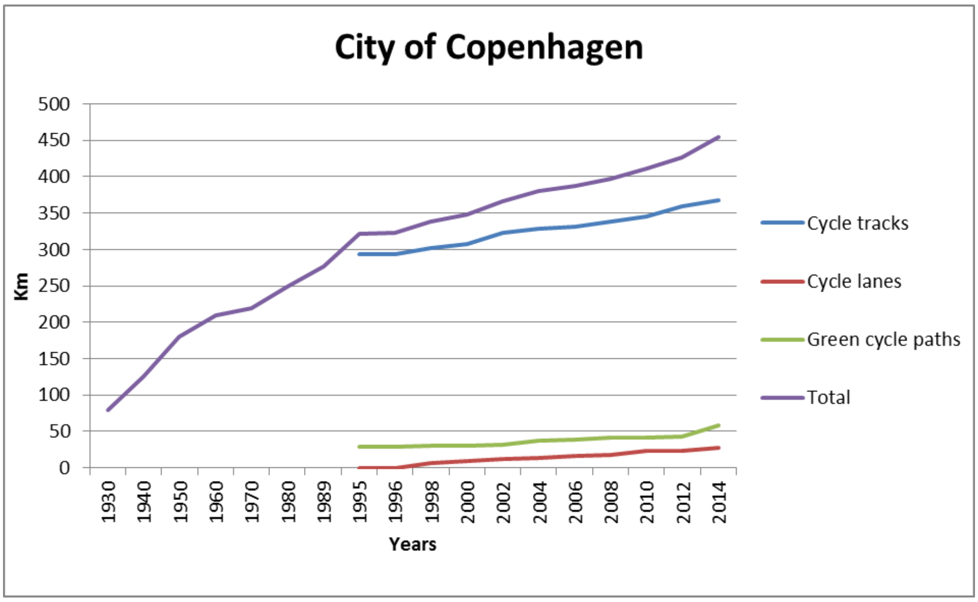

Figure 4-13: Development of the length of cycling network, in total and distinguished by type of infrastructure. Cycle tracks = separated from the sidewalks and the road by kerbstones. Lanes = separated from the car lanes by road markings. Green cycle paths = bicycle network decoupled from the rest of the road network. Data does not include City of Frederiksberg.

Source: (City of Copenhagen, 2016f).

Green waves for cyclists

Green waves for cyclists started as a test in one of Copenhagen's busiest streets for cycling traffic; Nørrebrogade. The green wave consisted of 13 traffic signals. The results from the test were a 12 per cent increase in travel speed and a reduction of the amount of stops for red lights from 6 to 0 when cycling 20 km/h. In 2006 a permanent green wave was established at Nørrebrogade. Since then the green wave network has expanded and now includes the following streets: Østerbrogade, Amagerbrogade and Nørre Farimagsgade, approx. 6.5 km in total.

The effort provides good passability and a minimum of stops. Especially the reduction in the number of stops is considered important by the cyclists. For parts of the cycling network it is challenging to create a coherent priority due to the distance between the signals and the variation in cyclists speeds. The City of Copenhagen is planning to expand the network with green waves for cyclists.

Bicycles in public transport

The possibility of bringing bicycle in the public transport is an ongoing topic in Copenhagen. In short, the development can be described as follows:

Trains:

- Before 1980 it was illegal to have bicycles in trains, one could put them in freight carriages, but there was no protection
- After 1983, bicycles could be transported with trains – first only on fast trains, in weekends and not during rush hour, then all trains.
- In 1998, a new generation of S-trains were introduced. They have carriages with room specially designed for bicycles
- In 2006, a change in rules was applied. It was now possible to take bicycles also during rush hour on S-trains – except for boarding on the busiest underground station, Nørreport station in the Inner City.
- In 2010, a change in tariffs was made. It was now possible to bring bicycles on S-trains free. This lead to a growth from 2.1 million to 7.3 million bicycles on S-trains by 2012
- In 2013, the S-trains were rebuilt with bigger bicycle carriages.

Busses:

- It is legal to get the bike on the bus on lines in some parts of the outer peri urban areas, but restricted depending on space available in each bus
- In 2011, a new rule was applied for S-busses (fast and frequent busses in peri urban area I and the city supplementing S-trains) and for R-busses (a concept with regional busses in peri urban area II giving good connections to e.g. trains). They can now accept bicycles, but not during rush hour for the same price as for a person ticket.
- Only normal bicycles are allowed in busses
- It is for free to take a bicycle on water busses crossing the harbour
- It is not allowed to take bicycles on busses in the City

Metro

- Bicycles have been allowed since the opening in 2002, but only normal bicycles and not during rush hours

Taxis

- Since 1999, taxis have obliged to carry bicycle racks and accept bicycles to be transported.

Cycling and walking guidance system

As the number of travelled km on bicycles per day in Copenhagen is increasing and the bicycle infrastructure has been extended, the need for improved cycle guidance has become more evident. Furthermore, City of Copenhagen cooperates with the surrounding municipalities establishing a network of Cycle Superhighways in order to improve the bicycling conditions for commuters across administrative borders. As these highways get inaugurated, the need for more guidance for commuters is growing.

Overall there are three initiatives improving the cycling guidance system:

- Bicycle (and walking) signs
- Route planner
- Dynamic bike signs

The bicycle (and walking) signs are placed at major intersections and indicate well known distant and adjacent locations. The signs indicate the distances to the locations measured in km with 1 decimal and the average travel time by bike measured in minutes.

There are two relevant bicycle route planners both in the form of an app:

- 'The Bicycle Plan' (Cykelplanen), which was launched 16 October 2013 and developed by the Capital Region of Copenhagen
- 'I BIKE CPH' was launched 4 August 2014 by City of Copenhagen

The apps cover the same geographical area; namely the whole country of Denmark and the Swedish region 'Skåne' and show the fastest route from A to B. 'The Bicycle Plan' combines trips with the S-train network via the web-platform and app 'Rejseplanen', which is a national travel planner covering all public transport. Rejseplanen combines all public transport modes, walking and the use of private bicycles. However, it does not include the bike sharing system (see below), use of private car or carsharing systems. Initial steps towards a more integrated approach for mobility such as a MaaS-platform (Mobility as a Service) have been made. However, it is in its very early phase of ideation.

I BIKE CPH', however, make special routes for cargo bikes, and in the future it will also be possible to choose and plan more recreational routes crossing through green/blue areas.

The Dynamic bike signs are not yet in operation. A pilot study is expected to be implemented in January 2017. At five locations, a variable sign will be able to give the bicyclists various information. The signs are planned to show: (1) congestion on specific cycling tracks and lanes, (2) distances to specific destinations and time savings and (3) general safety messages on the bike net. Data for the evaluation will be collected during 4-5 months, and an evaluation report is expected to be published ultimo July 2017. The information will be based on radar detection of number of bicyclists.

These three initiatives supplement each other, e.g. the route planners can be used prior to the bicycle trip in order for the bicyclist to gain an overview of the route, whereas the bicycle signs are preferable during the bike ride.

Bike sharing system

The history of the bike sharing system in Copenhagen can be divided into three generations. The first generation of bike sharing systems started in 1996 initiated by activists and financed by sponsorships. Therefore, Copenhagen was one of the first cities in the world to have a bike sharing system. This first generation of bikes were later on financed by outdoor advertisement, but the bikes were never developed in to a so called second generation of bike sharing systems, which was an international trend and a huge industry during the first decade of the 21st century.

The present bike sharing system is a third generation of bike sharing system seen as a part of the public transport network and not bound by contracts with outdoor-advertisement similar to systems in London, Holland and Germany, where public transport agencies have invested in the bike system. The work with the third generation of bike sharing system was initiated in 2008 by the City of Copenhagen in collaboration with the City of Frederiksberg and DSB (the Danish Railway Network). Unfortunately, the implementation of the third generation of the bike sharing system was postponed mainly due to a binding contract with the outdoor-advertising company. In 2011 an agreement was made between four partners, DSB, The Metro Company, the City of Copenhagen and the City of Frederiksberg, to implement the third generation of the bike sharing system. The organisational set-up is a commercial foundation financed by the municipalities and DSB who runs the contract with GoBike, which serves as the supplier and operator. Newest information from GOBike shows that more than 2,000 bicycles are in operation and they can use more than 100 docking stations, see Table 4-3.

The system was fully deployed in 2015 and the City of Copenhagen has contributed with 40 mio. DKK. The bicycles are electrical and have tablets with GPS information. The bike sharing system is integrated with Rejsekortet (electronic traveller pass for public transport) to identify you as a user. It is not yet possible to pay for the bicycles with Rejsekortet but work is in progress on that topic. As a special feature it is possible to book a bicycle in advance and the bicycle serves you with information about connecting public transport. The current assessment shows that the system is economically viable. However, the system is based on a certain level of public co-funding to ensure that the system has the right volume and service level to support public transportation.

Table 4-3 Present bike sharing system in City of Copenhagen and Frederiksberg.

	Numbers
Bicycles in operation	2,232
Docking stations	120
Docking points	3,348

Source: (GoBike, 2016)

4.4 Walking

Before 1962, the streets in the old medieval city centre were dominated by car traffic, and every square was used for car parking. After the WWII the overall car traffic increased rapidly deteriorating conditions for pedestrians in the city centre.

On 17 November 1962, Copenhagen's main street, Strøget, was turned into a pedestrian street. The conversion was strongly debated at the time. Newspapers made statements like: "We are Danes, not Italians", and "Using public space is contrary to Nordic mentality". However, the new car free zone proved extremely popular among Copenhageners from the very first day. Since then the pedestrian area has been extended gradually year by year. Car traffic has been moved or slowed down in order to calm the streets.

In the 1960s and the 1970s the pedestrian streets were dominated by shopping opportunities. However, in the 1970s small cafés opened and political and cultural happenings started to make use of the car free urban space, which was previously used as parking lots. The outdoor season is extended gradually to include the entire year making room for recreational activities such as cultural events, exhibitions and most recently also physical exercises.

According to Jan Gehl and Lars Gemzøe ('Det nye byliv' 2005), the key to success for the transformation has been the incremental and small gradual conversion of streets. People had the opportunity to gradually adjust their habits accordingly.

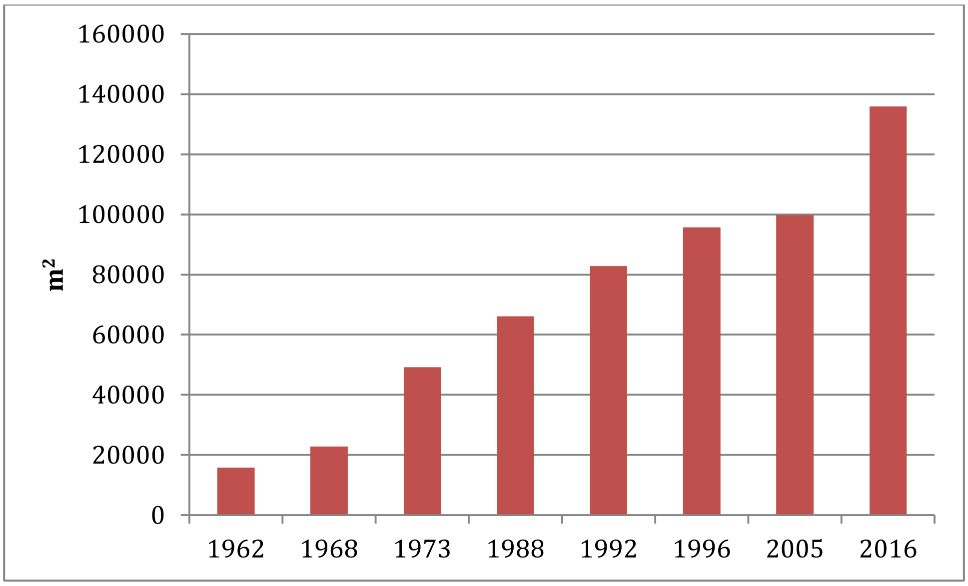

Figure 4-14: Development of car-free zones (Pedestrian zones) [km²] in the central part of the Inner City of Copenhagen.
Source: (Gehl, 2006) and (City of Copenhagen, 2016g).

Figure 4-14 illustrates the development of the pedestrian area in the Inner City of Copenhagen. In the rest of the city, however, a slightly different alteration of urban space has taken place.

In the Outer City (the Bridge Quarters) the changes have focused mostly on improving urban space for pedestrians rather than constructing entirely car free areas. In overall terms, two approaches can be identified.

The first approach is similar to the development in the inner city, where focus has been to create public space inviting pedestrians to halt and enjoy city life. New examples are: Regnbuepladsen, Tåsinge Plads, Husum Bypark, Guldbergs Plads, Skotlands Plads, Valby Storbyhave and Tove Ditlevsens Plads.

The other approach, however, is the construction of the so-called ‘transit spaces’, where the physical surroundings are reconstructed for the benefit of pedestrians, these areas cannot be characterized as exclusively car free zones, however, they support the pedestrians in their travel from A to B. Of new examples can be mentioned Vester Voldgade, Vesterbro Passage, Istedgade and Nørrebrogade.

4.5 Taxi supply

All numbers on taxi supply derive from "Taxinævnet", which is an organisation covering 28 municipalities (Inner and Outer City, Peri Urban I and a smaller part of Peri Urban II) and with four booking offices.

Currently, 1,098 hauliers cover the 1,900 licensed taxi vehicles. The hauliers have between 1 and 35 licensed taxi vehicles, and at the end of 2015 there were 7,472 taxi drivers with a valid driver card for taxi and limousine in the area of "Taxinævnet". The number of licensed taxi vehicles have decresed since 2007, see also Figure 4-15 - Figure 4-17.

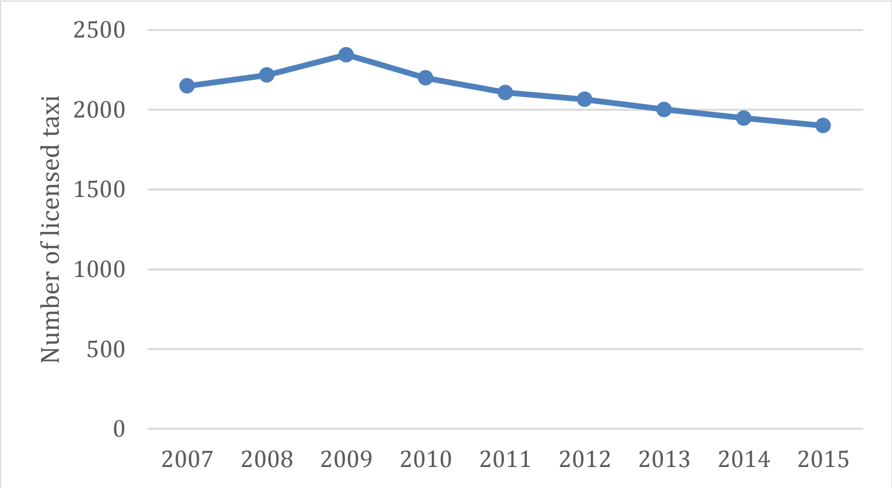

Figure 4-15: Development of the number of licensed taxis
Sources: (Taxinævnet i Region Hovedstaden, 2016)

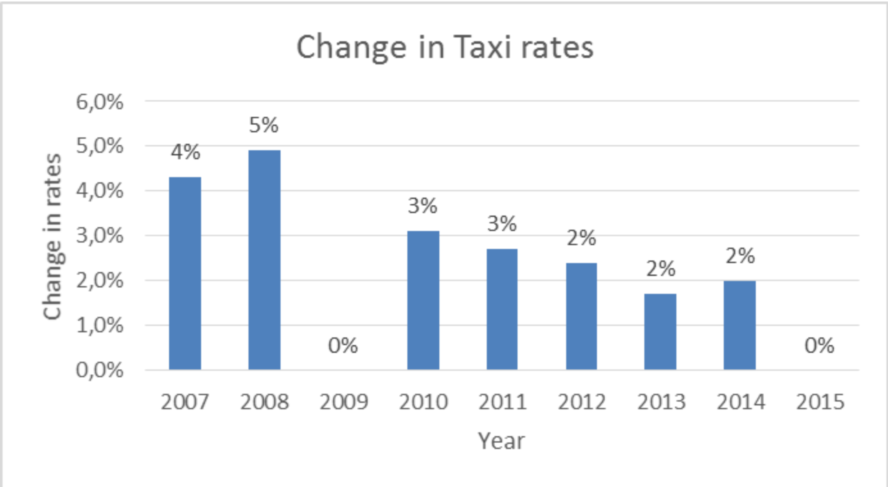

Figure 4-16: Development of the Taxi rates
Sources: (Taxinævnet i Region Hovedstaden, 2016).

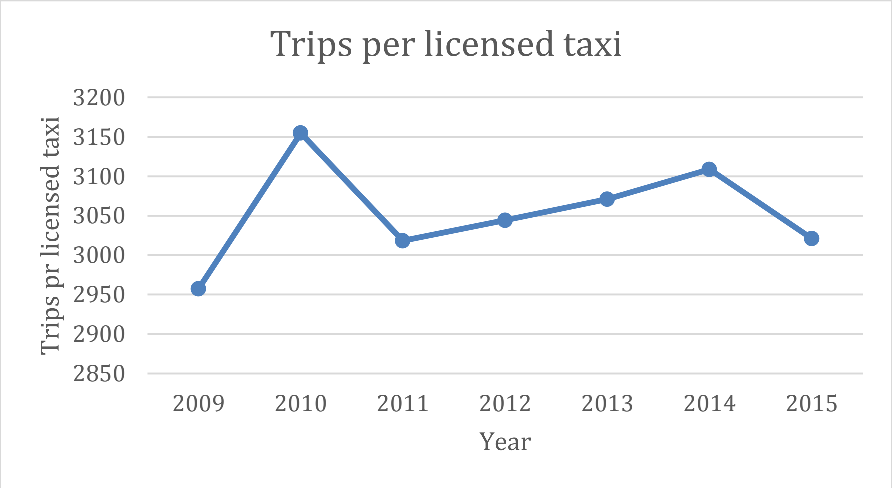

Figure 4-17: Development of the number of taxi trips per licensed taxi
Sources: (Taxinævnet i Region Hovedstaden, 2016).

4.6 Car sharing

The first organised car sharing in Denmark was established in 1997 in Odense. A year after, in 1998, car sharing was established in Copenhagen offered by Hertz Car Rental at the request of City of Copenhagen. A number of car sharing organisations have been established afterwards typically as a local association such as Københavns Delebiler (Copenhagen Car Sharing), which started in 2004. In 2012 Københavns Delebiler and Århus Delebilklub (Århus Car Sharing Club) among others merged into LetsGo. Hertz Car Sharing and LetsGo are the biggest suppliers of car sharing in Copenhagen with approx. 5,000 members among citi, but there exists five additional suppliers.

Free-floating car sharing was introduced in Copenhagen by Car2Go in 2014 and in 2015 DriveNow was introduced, which is a company with electric free-floating car sharing. In 2016 Car2Go withdrew.

In 2005 City of Copenhagen decided that 150 parking lots in the payment zones should be reserved for car sharing. The first 85 parking lots were established in 2006 and the number has increased since then. In 2012 the number of parking lots reserved for car sharing was expanded to 300 parking lots.

Halfway through 2015, 232 parking lots were reserved for car sharing in Copenhagen, see Figure 4-18.

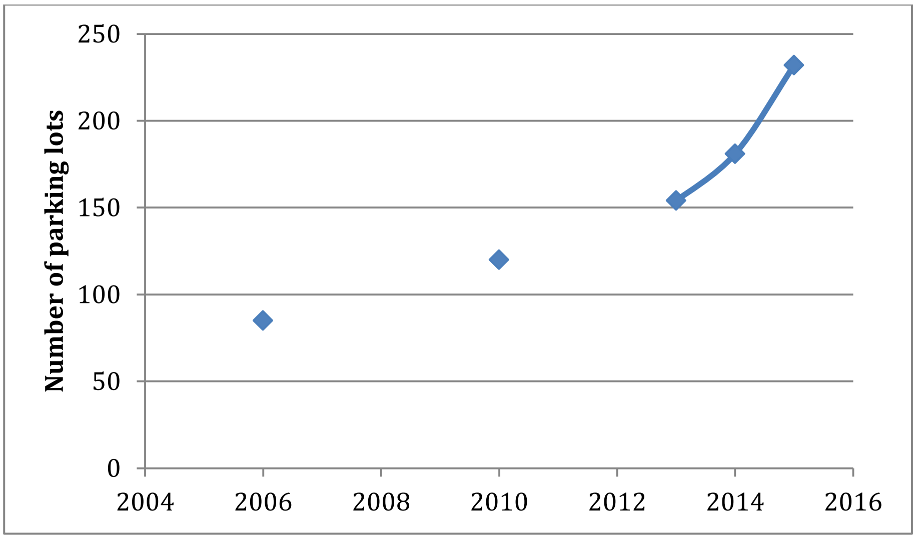

Figure 4-18 Development in the number of parking lots reserved for vehicles included in car sharing organisations

Sources: (City of Copenhagen, 2016h).

Currently free floating car sharing does not have prioritised parking conditions. At present one supplier of free floating car sharing is operating in Copenhagen offering 400 cars to the approx 30,000 members in Copenhagen.

The possibility for private car owners to rent out their cars as car sharing among neighbours started in 2013 and in 2014 a new taxi-like system was offered, where chauffeurs drive in their own cars (Über). Besides, there exists car-pooling which can be considered as a form of car sharing. Organised car-pooling is primarily used as a mode of transportation between cities and other long distance trips. The most known of these organisations, Gomore, had by the end of 2015 approx. 320,000 users nationwide – approx. a twofold increase compared to 2014..

All kinds of car sharing exist on initiatives by a fund or by a private actor, usually without the municipality playing a particular role. The actual volume of vehicle-km with these different types of car sharings arrangements is not known.

5 Transport policies

5.1 Private motorized transport

Access restrictions for private car transport

No general access restrictions exist in Copenhagen, but the central part of the inner city is a pedestrian area with no car access, except for delivery of goods in the morning. Furthermore, traffic calmed streets with low speed limits are to be found in the residential areas.

A Low Emission Zone (titled Environment Zone) was introduced in 2008 covering the Inner and Outer city. In this zone heavy goods vehicles and busses over 3,500 tons must live up to at least Euro norm 4. A dispensation can be made for older vehicles it they install particulate filters.

Road pricing system

In the period 2008 – 2012, plans for a road pricing system in Copenhagen were under discussion initiated both by City of Copenhagen and national authorities. The plans were dropped by the national Government and no similar initiatives have been taken since then.

Dynamic traffic light controls

The main motorways and other main national roads leading to and through the city change to roads owned by the city at the city border (regional roads). Thus City of Copenhagen has the possibility to control the traffic flow and especially doze the number of vehicles entering the city borders by adjusting the green lights at the first traffic signals after crossing the city border. This way the vehicles queue up during morning peak hour at the motorways with high capacity (more lanes) just outside the city borders in less densely built up areas. This facilitates that vehicles entering the city can be guided through in a more smooth flow. This system has worked since the 1970s and worked well as the morning traffic mainly was in the direction towards the city. However, the system has been challenged the latter years as traffic flows seem to less one way directed.

In general, traffic light control in the city is used to give priority to busses, especially where bus lanes lead up to a signal and the busses are given green light priority in front of other vehicles.

Furthermore, some provisions exist with specific traffic lights for bicycles, which give green light to cyclists before cars. This provision is especially relevant for safety reasons with right turning vehicles. The city also has - as previously mentioned in Chapter **Fehler! Verweisquelle konnte nicht efunden werden.**- green waves for cyclists at especially busy cycling routes.

Parking regulations

The parking regulations in Copenhagen include payment parking zones and zones with time restrictions. In City of Copenhagen there are currently (2016) three payment parking zones; green, red and blue. The red zones are the most expensive, whereas the blue zones are the cheapest. In these areas the residents have to buy a residential parking permit. Business related parking needs special parking permits. Visitors need to pay per hour for parking. The City of Copenhagen issues fees if it is registered that the payment requirements are not fulfilled. The payment system was digitalised in the spring of 2016. The payment area is going to be extended in 2017 with a new yellow zone (see Figure 5-1).

The payment parking in Copenhagen was introduced in 1990/1991 with four different parking zones varying in the payment per hour, see Table 5-1.

Table 5-1 Development of parking fees in City of Copenhagen [dkk/Euros]

Zone	1991	1996	2000	2008	2013	2015	2017*
Red zone	15/2.02	20/2.69	20/2.69	26/3.49	30/4.03	31/4.17	35/4.70
Green zone	6/0.81	9/1.21	12/1.61	16/2.15	18/2.42	18/2.42	19/2.55
Blue zone	4/0.54	5/0.67	7/0.94	9/1.21	11/1.48	11/1.48	11/1.48
Yellow zone	-	-	-	-	-	-	9/1.21
Evening charge: red, blue, green zone	-	-	-	9/1.21	11/1.48	11/1.48	13/1.75
Night charge: red, blue and green zone	-	-	-	3/0.40	3/0.40	3/0.40	5/0.67
Evening and night charge: yellow zone	-	-	-	-	-	-	2/0.27

* Preliminary numbers for 2017 as they will be finally decided later in 2016.
Sources: (City of Copenhagen, 2016e).

In addition to the payment, parking zones with time restrictions can be found in some neighbourhoods; in Outer City (Vanløse, Hellerup, Grønjord and along the Metrostation Lergravsparken). In these zones the parking is restricted to three hours parking between 8am – 7pm on weekdays. Residents have free parking in these zones, however, it is not possible to buy extra parking time, season cards or anything similar.

The following map shows the payment zones as well as the new yellow zone and the time restricted parking zones including a not yet planned / agreed extension of the red payment zone.

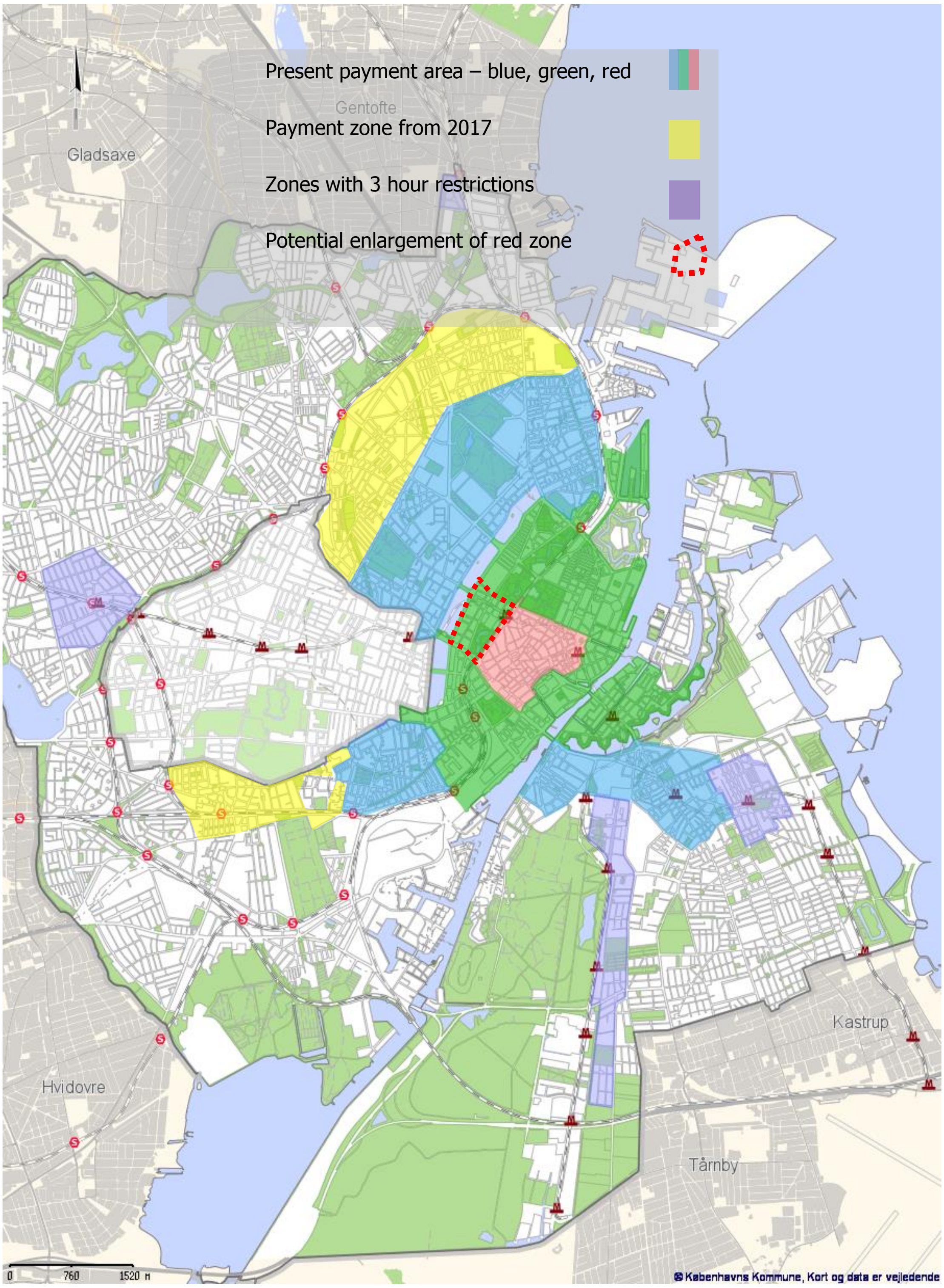

Figure 5-1 Parking zones in City of Copenhagen – not including City of Frederiksberg
Sources: (City of Copenhagen, 2016e).

Development of fuel prices

Figure 5-2 and Figure 5-3 illustrate the car fuel prices for the period 1989 - 2016. The development follows roughly the international oil price development, though there are differences in the absolute magnitude of the changes over time, primarily because of changes in the DKK - USD exchange rate. The taxes on petrol and diesel are a mixture of ad valorem taxes (VAT) and taxes linked to the quantity consumed (energy tax and CO_2 tax). The ad valorem taxes constitute the minor part of the taxes, which is why price fluctuations do not vary that much together with the taxes. All tax rates have been increased gradually over time from 1989 to now.

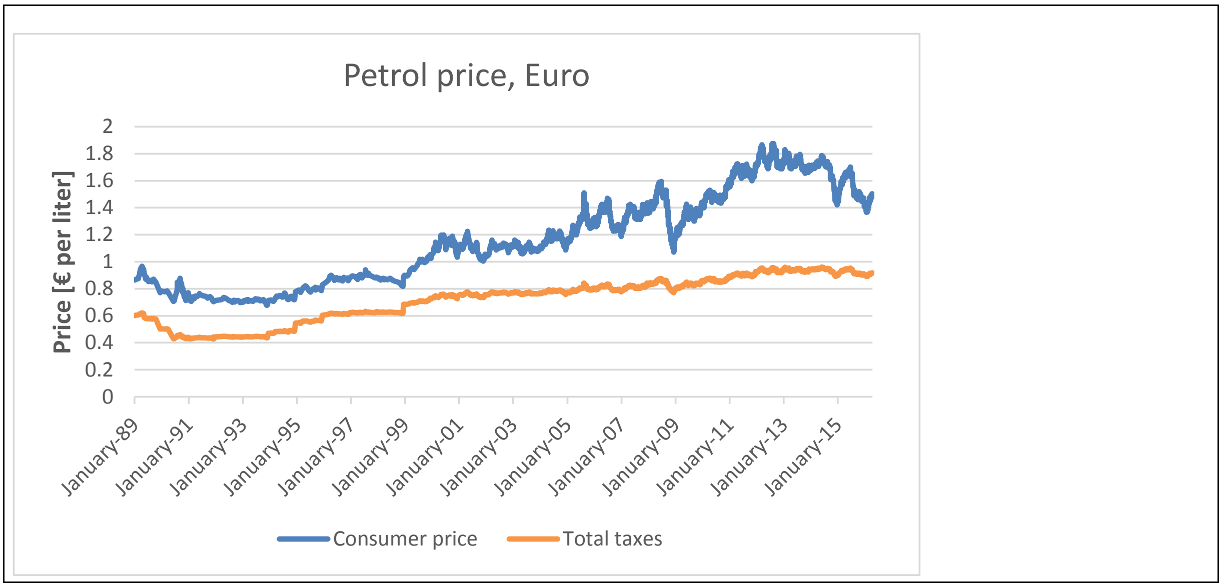

Figure 5-2: Development of fuel prices (petrol) distinguished between net values and taxes [€ per litre]

Sources: (Energi- og Olieforum, 2016). Note: The consumer price is the 'at petrol station price' including product price before taxes, energy taxes, CO_2 taxes and VAT. Total taxes is the sum of energy taxes, CO_2 taxes and VAT.

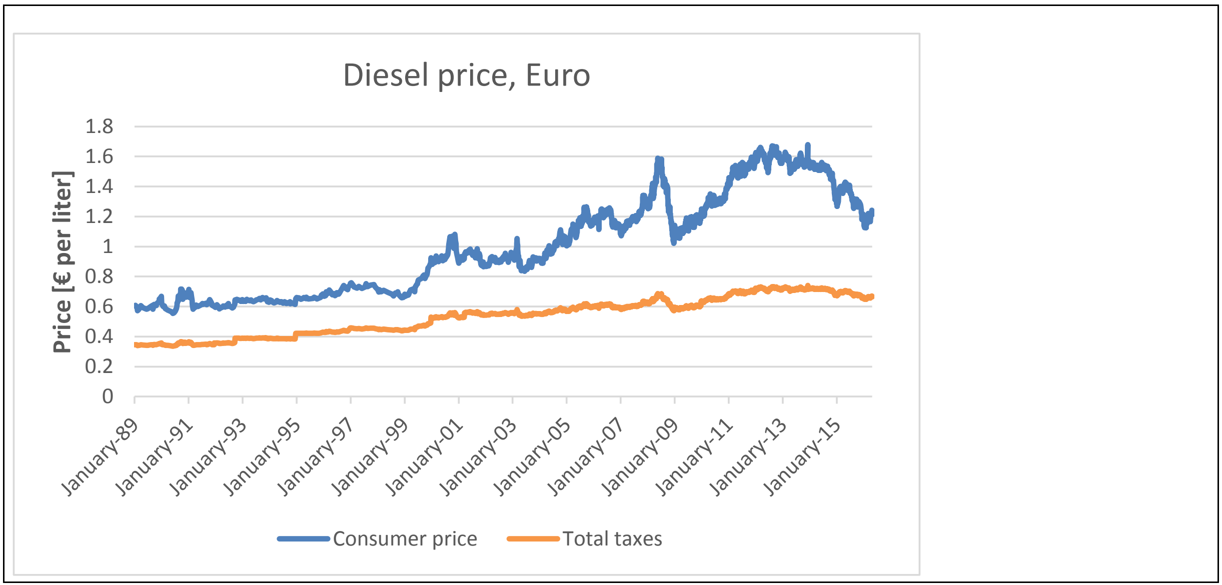

Figure 5-3: Development of fuel prices (diesel) distinguished between net values and taxes [€ per litre]

Sources: (Energi- og Olieforum, 2016). Note: The consumer price is the 'at petrol station price' including product price before taxes, energy taxes, CO_2 taxes and VAT. Total taxes is the sum of energy taxes, CO_2 taxes and VAT.

Development of average costs of a private car

Data for the private costs of driving a private car are only available for 2016. The variable costs encompass fuel, oil, battery, tyre consumption, repairs and maintenance and a mileage-dependent depreciation. The fixed costs encompass mileage-independent repairs and maintenance and depreciation, insurance and the vehicle-ownership tax. The vehicle-ownership tax does not depend on usage, but on price and the emission-class of the vehicle. The fixed costs of private car usage are greater than the variable costs in Denmark, as can be seen in Figure 5-4. The fixed costs per 100 km amount to on average 21 Euro, whereas the variable costs are 17 Euro per 100 km.

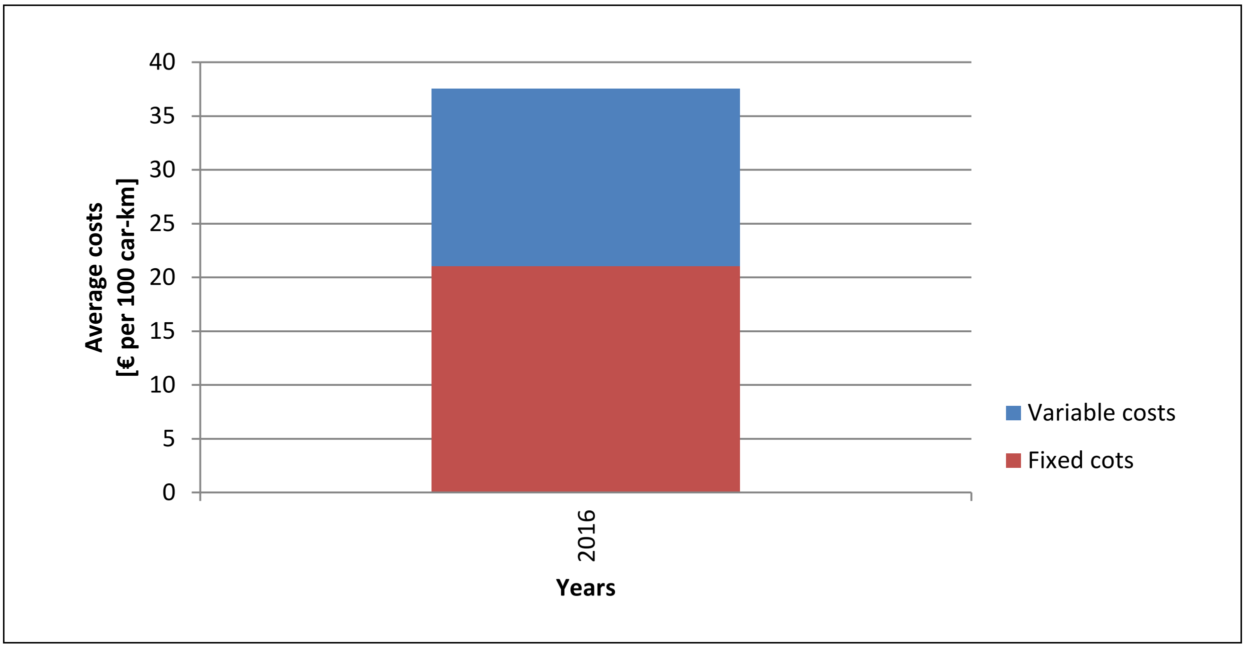

Figure 5-4: Development of the average variable and fixed costs of private car [€ per 100 car-km], including taxes

Sources: COWI based on (DTU, 2016) and (FDM (Forenede Danske Motorejere), 2016).

5.2 Public transport

Priority for busses

The first examples of giving priority to busses in signalised intersections were introduced in the 1970s, but only in the 1980s a more systematic development started and it has gradually led to an increasing number of such intersections. No total overview exists, but Figure 5-5 illustrates the length of bus lanes up to 2011. In total, approx. 50 km bus lanes were established and hereof approx. 30 km in City of Copenhagen.

Furthermore, a number of bus priority schemes have been established especially in City of Copenhagen but also in the peri urban areas, giving priority for busses through signalised intersections. The development is ongoing and includes e.g. the first BRT system in City of Copenhagen opened in 2015 with a line of approx. 6 km length.

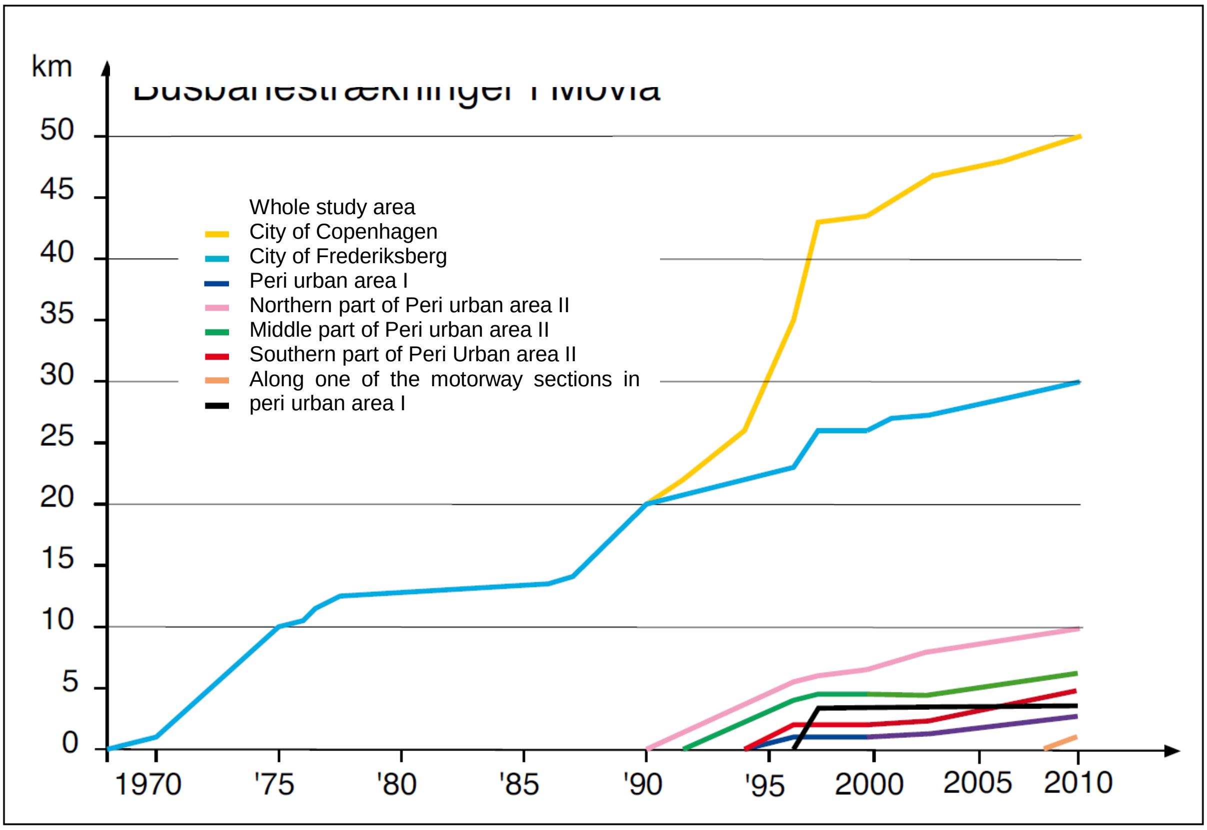

Figure 5-5: Overview of the development of bus lanes in the study area [km].
Sources: (MOVIA, 2011).

Subsidies for public transport

National law decides the highest possible annual increase in ticket prices for public transport since 2008 and it has varied between 0 % and 4.8 %. The trend so far has been that the public transport companies increase the prices accordingly.

Concerning the subsidizing of public transport, the direct financing can broadly be described as follows:

- The busses are financed (through the many different organizational forms) by ticket sales and municipal taxes, supplemented a bit by regional taxes. In 2014 Movia, the bus company covering the study area, received approximately € 360 million in total from the municipalities and the Capital Region of Copenhagen, of which City of Copenhagen paid approx. € 47 million. This has been relatively constant the last five years amounting to a yearly sum of € 47 – 53 millions.
- The metro is financed by ticket sales and building rights in the urban development area served by one of the metro lines
- S-trains and other trains are financed by ticket sales and national taxes. In 2015, DSB (the train operator) was paid € 395 million for long-distance and regional trains, whereas DSB S-train was paid € 155 million for the S-train traffic.

These numbers cover the present situation. Previous accountings are not available due to major changes in the organizational structure of public transport and consequently, large changes in payment structures. This makes the comparison to previous years somewhat pointless.

Subsidising public transport use for specific customer groups

The following user groups have traditionally been subsidised specifically:

- School children
- Senior citizens over 65 years can get a discount of approx 50% of normal price
- Various student and youth discounts
- Free access for blind persons
- Free access for conscripted soldiers.

5.3 Parking

Parking guidance

For a period, signs were provided showing the number of available parking lots in bigger parking garages. As studies showed they had no significant effect, the signs were removed; though a few private parking garages still provide the service.

There is currently no coordinated parking guidance system, however, it is under development.

6 Transport demand and access to transport modes

6.1 Acces to transport modes

6.1.1 Private car ownership and driving licence possession

The car ownership in Denmark is relatively low compared to many other Western European countries. In 1970 there were around 200 private cars per 1,000 inhabitants growing fairly steady to 300 in 1993 and to approx. 400 in 2014, see Figure 6-1. The main reason for this is most likely the high level of vehicle registration taxation. The vehicle registration tax is between 105 and 150 per cent of the price before tax, depending on the price before tax, c.f. Danish Customs and Tax Administration.The vehicle registration taxes were reduced by the end of 2015. The high rate, which is now 150 per cent, used to be 180 percent and covers more or less all cars from middle sized cars (e.g. a standard Skoda Octavia 1.4 TSI) and upward. The low rate was introduced in 2007 for the most energy efficient cars. This has most likely been one of the main reasons for a relative increase in market share – and in total volume – in Denmark of especially small and relatively cheap cars as well as diesel-cars.

For the City of Copenhagen, the numbers have always been and are still lower, but after a stagnation up to the middle of the 1990s, the numbers are slowly increasing. The number was approx. 175 in 1993 and is now approx. 235 (2014 numbers). The Peri Urban Area I follows the national development, but has a level a bit under the average national level. The development in Peri Urban Area II is also fairly similar to the average national level, but has a slightly higher level with a number of approx. 420 in 2014.

The statistics used for Figure 6-1 can have a bias resulting in too high numbers for the City of Copenhagen due to the national registration system. If a car is bought by a major company having head office in the city centre, but is used by a person living in another part of the region, the car is registered as if it belongs to an inhabitant in the City of Copenhagen. Therefore, City of Copenhagen makes their own statistics attempting to only include numbers for cars actually being used by citizens in the City. Hereby, the numbers tend to be approx. 5 percent lower.

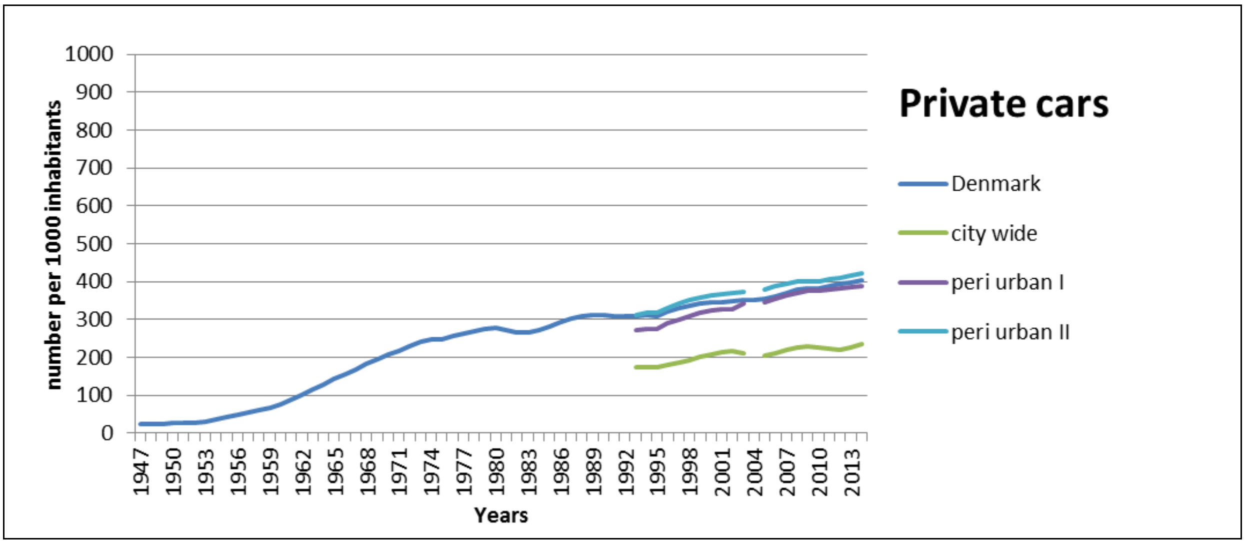

Figure 6-1: Development of the fleet of private cars [number per 1000 inhabitants]
Sources: COWI based on (Vejdirektoratet, 2016a) and (Statistics Denmark, 2016o).

6.1.2 PT yearly season pass ownership

No PT yearly season pass exists in the Copenhagen area. An indicator on the number of period pass holders can be found in the statistics of sold monthly PT passes, see Figure 6-2. Numbers indicate a significant growth since 1992. It is not possible to distinguish between inhabitants in the different areas within the overall Copenhagen area.

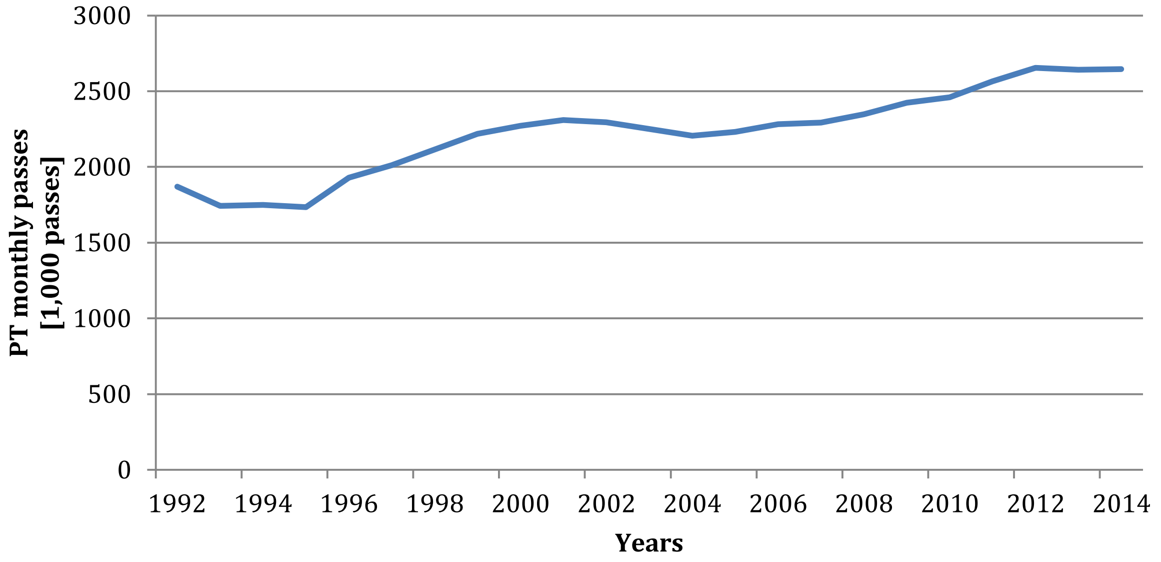

Figure 6-2: Development of number of sold PT monthly passes for public transport in the total study area [number of sold passes]

Sources: COWI based on (MOVIA, 2016).

6.1.3 Bicycles ownership

City of Copenhagen has carried out surveys among a sample of citizens every second year since 2008 as input for the "Bicycle account". Numbers from here on bicycle ownership show no significant development but some fluctuations that may be caused by the sample size. The numbers show that on average each citizen has a bit more than one bicycle, see Figure 6-3.

The survey also reveals the percentage of bicycles on different types – as here shown for 2014 (numbers have to be taken as indicative numbers due to a fairly small sample size of the survey)[9]:

- Normal bicycles : 87.5%
- Children bicycles: 9.8%
- Cargo bicycles: 2.3%
- Electric bicycles: 0.4%

[9] Source: (City of Copenhagen, 2015b)

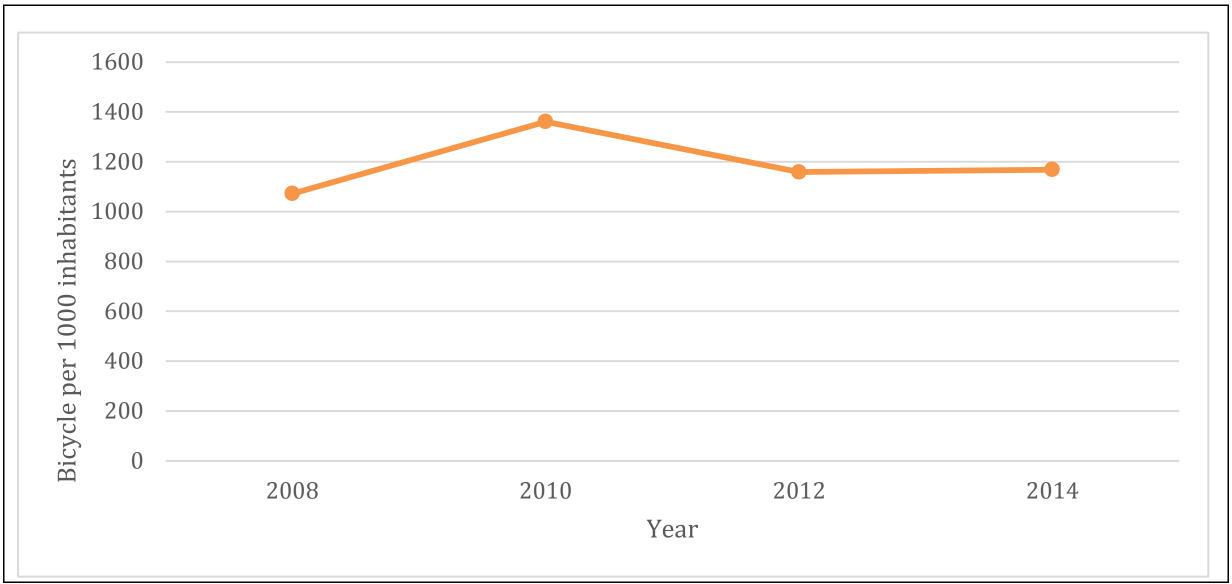

Figure 6-3: Development of the number of bicycles per inhabitant. Data does not include City of Frederiksberg [bicycles per 1,000 inhabitants].

Sources: (City of Copenhagen, 2015b).

6.2 Individual travel behaviour

The first comprehensive survey of travel habits in Denmark was made in 1975. Such a survey has taken place on a fairly regularly basis over the years up to now. The survey is national and thus covers citizens for the whole country. However, a number of changes in the methodology of carrying out interviews, the sample sizes of the interviews, variations in questions etc makes it difficult to use all the surveys for the purpose of this study. The surveys from 1975, the period 1998 – 2003 and the period after 2006 include geographical information making it possible to identify and segregate numbers for inhabitants in City of Copenhagen. For the period between 1975 and 1998, the surveys do not include geographical information on the individual trips, not even at municipal level. Thus, these surveys are not used in this study.

Even though the survey methods may vary between 1975, the period 1998 – 2003 and the period from 2006, the results are useful as indicators on the development of travel behaviour in the Copenhagen capital area. The immobility rate (proportion of persons without any reported trip on the reporting day) in the surveys has been between 8 percent and 14 percent in the period 1998 – 2015.

The following subchapters use results mainly from these surveys.

6.2.1 Average number of trips (per trip maker and day)

The development in the average number of trips per trip maker and day does not appear to show a very clear tendency, see Figure 6-4. However, apparently the number of trips seems to be decreasing a bit the last approx. 10 years. This seems to be the case in both the city and in the peri urban areas. The significant decrease from 1975 is not possible to explain but can most likely be caused by differences in the data collection methodology, too small sample sizes and real changes in travel behaviour.

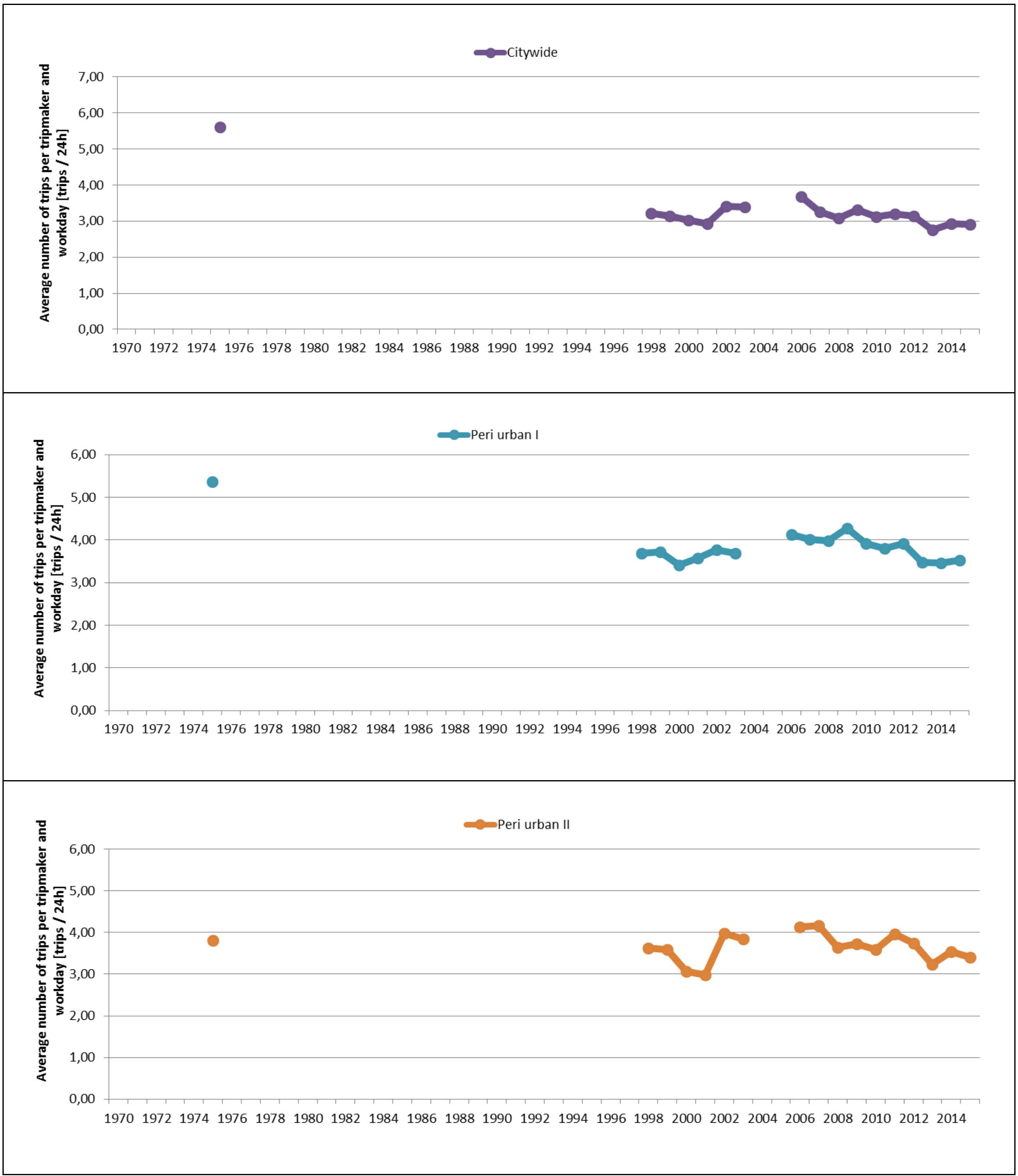

Figure 6-4: Development of the average number of trips per trip maker and workday [trips / 24h]. Data derives from three different "survey series" (1975; 1998 – 2003; 2006 – 2015) that may lead to some inconsistencies when looking across the whole period.

Source: COWI based on (DTU Transport, 2016).

6.2.1 Distribution of trips per peak hour

The development in the average number of trips per inhabitant during the morning peak hours does not appear to show any significant changes the last 10 – 20 years, see Figure 6-5.

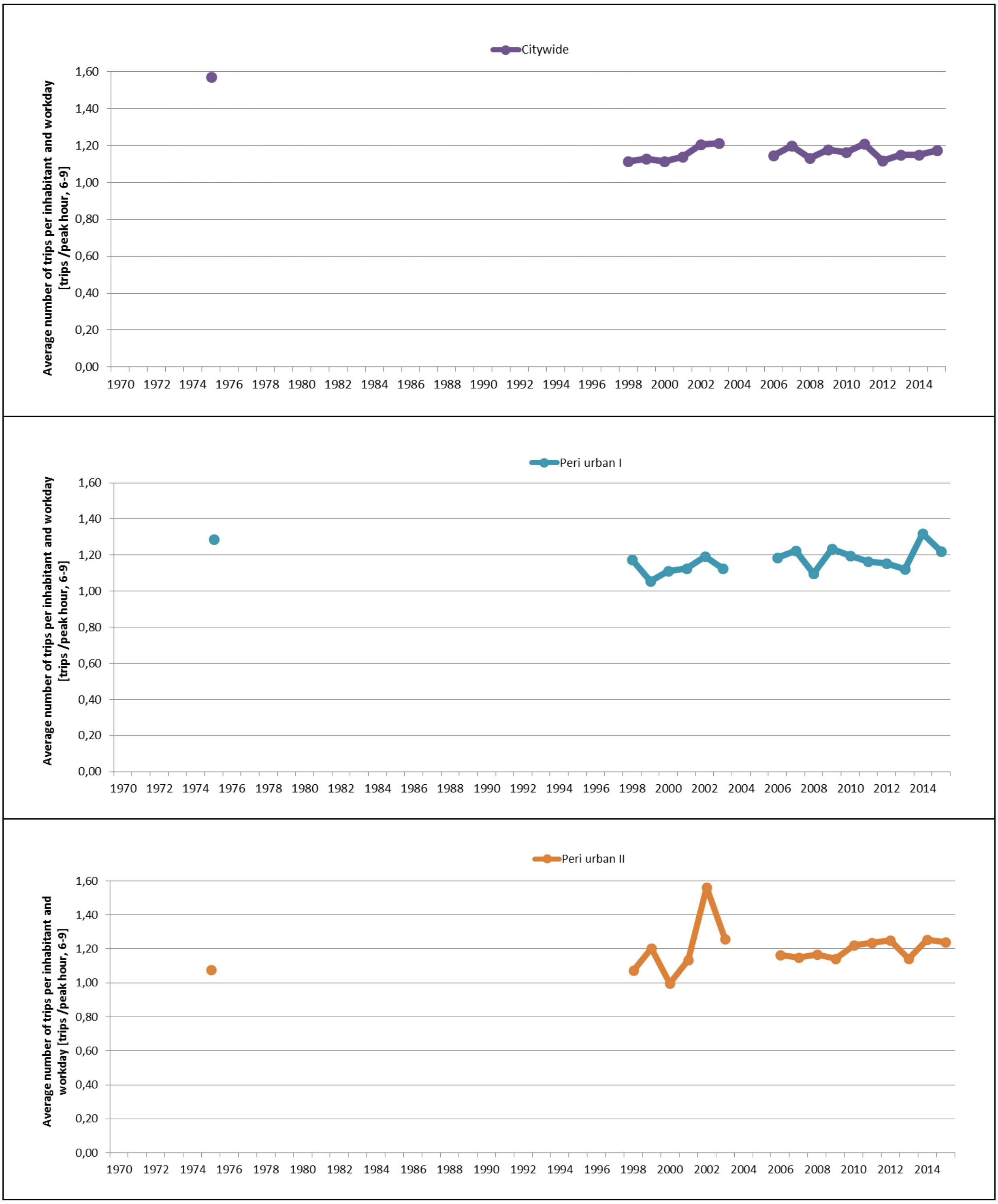

Figure 6-5: Development of the average number of trips per inhabitant and peak hour (trips starting *and* ending between 6 and 9 in the morning) [trips per inhabitants and hour] Data derives from three different "survey series" (1975; 1998 – 2003; 2006 – 2015) that may lead to some inconsistencies when looking across the whole period.

Source: COWI based on (DTU Transport, 2016).

6.2.2 Average mileage (per trip maker and day)

The total average mileage per trip maker per day for inhabitants in Copenhagen City shows a trend with a decrease from 2006 until 2014 with total daily distances between approx 23 and 29 km. For 2015, the survey results show a surprising increase, mainly caused by an increase in car traffic. It is still too early to judge if this is a persistent trend, see Figure 6-6.

Furthermore, it is noticeable that the average total mileage as a cyclist is significant. It covers approx. 15% of the total average mileage – or approx 3 – 4 km - carried out by inhabitants in the city per day.

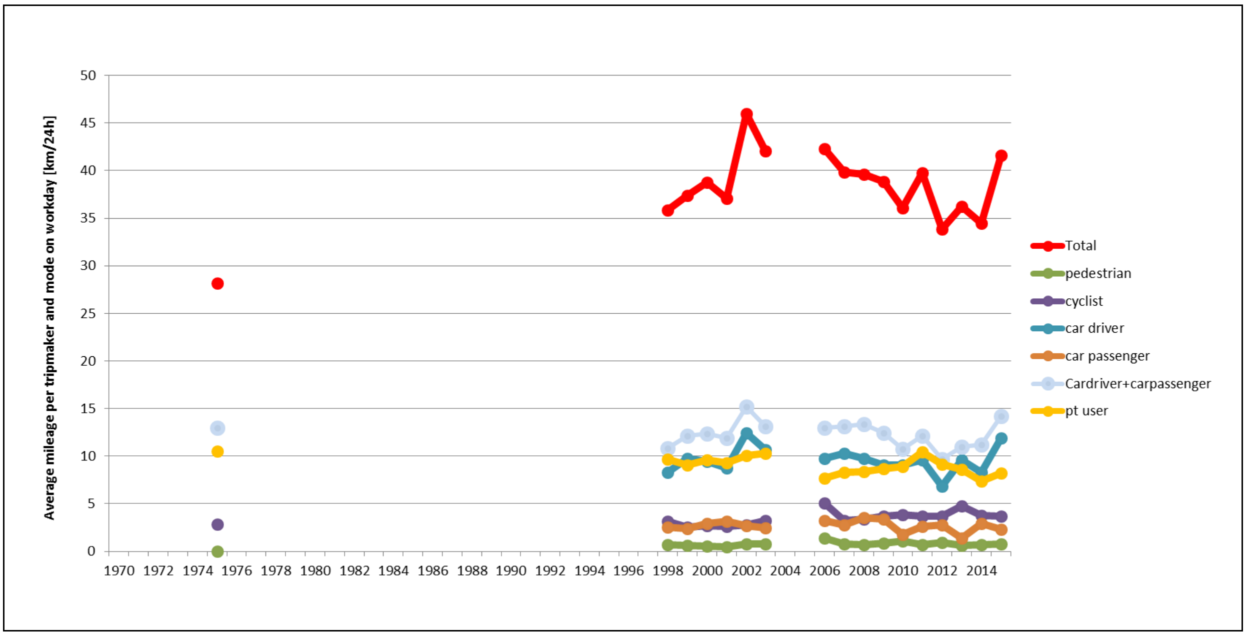

Figure 6-6: City wide development of the average total mileage per trip maker and workday [km / 24h]. Data derives from three different "survey series" (1975; 1998 – 2003; 2006 – 2015) that may lead to some inconsistencies when looking across the whole period. 1975 data do not segregate in car drivers and car passengers.

Source: COWI based on (DTU Transport, 2016).

6.2.3 Average trip length

The average trip length per trip for each of the transportmodes has not changed significantly in the survey periods for public transport, bicyclists and pedestrians. Variations can be found from year to year – most likely caused by the sample size of the survey, but the overall trend is a development without major changes, see Figure 6-7. A pedestrian trip is on average approx. 1 km; an average cycle trip is between 3.5 and 5 km; an average car trip and PT trip is approx. between 15 and 20 km.

For car drivers, the results show an increase in trip length among the inhabitants in the City.

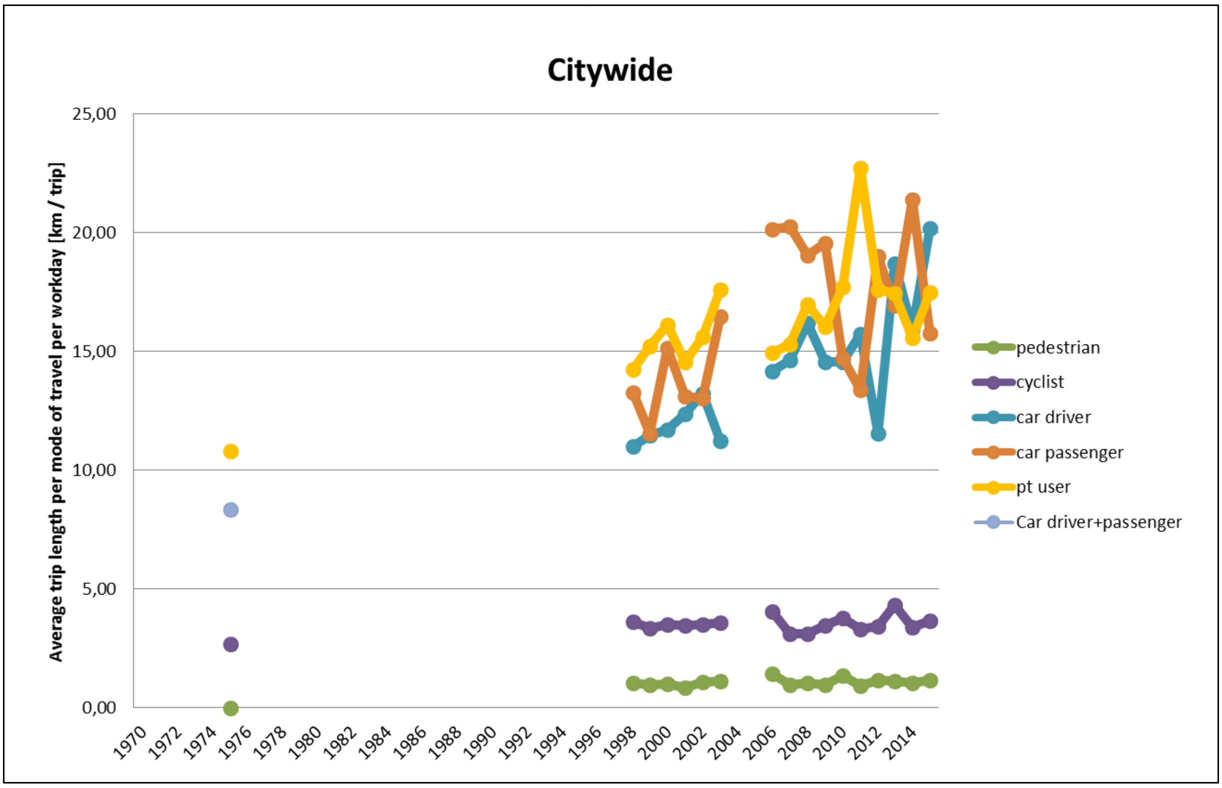

Figure 6-7: City wide development of average trip length per mode of travel per workday [km / trip]. Data derives from three different "survey series" (1975; 1998 – 2003; 2006 – 2015) that may lead to some inconsistencies when looking across the whole period.
Source: COWI based on (DTU Transport, 2016).

6.2.4 Modal split of the inhabitants

The development in modal split among the inhabitants in Copenhagen City shows a significant increase for cyclists – being the largest contributor to the number of trips - from approx. 28% in 1975 to 35% - 40% in 2013 - 2015 and a similar decrease in the share of car trips (sum of passenger and driver trips), see Figure 6-8. Apparently, the last two years show a tendency to a small decrease in cycle share, whereas the share of pedestrian trips and car trips seem to have a similar increase.

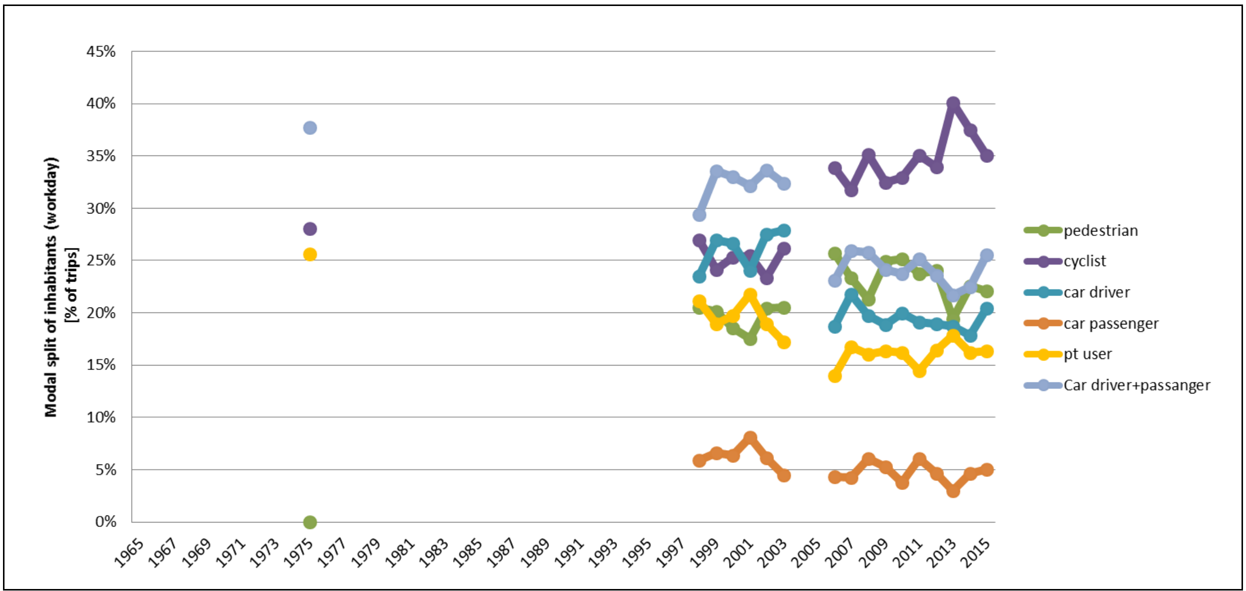

Figure 6-8: Development of modal split of inhabitants in City of Copenhagen, "citywide" (workday) [% of trips]. Data derives from three different "survey series" (1975; 1998 – 2003; 2006 – 2015) that may lead to some inconsistencies when looking across the whole period.

Source: COWI based on (DTU Transport, 2016).

6.2.5 Trip purpose

In 1975, trips to work or education counted for 44% of all trips among inhabitants in the City, whereas shopping, errand and leisure trips counted for 53%. The latest numbers for 2015 show that work and educations trips now only count for 30%, whereas leisure trips count for 39% and shopping/errand trips count for 31%. A similar trend can be found for inhabitants in the peri urban areas.

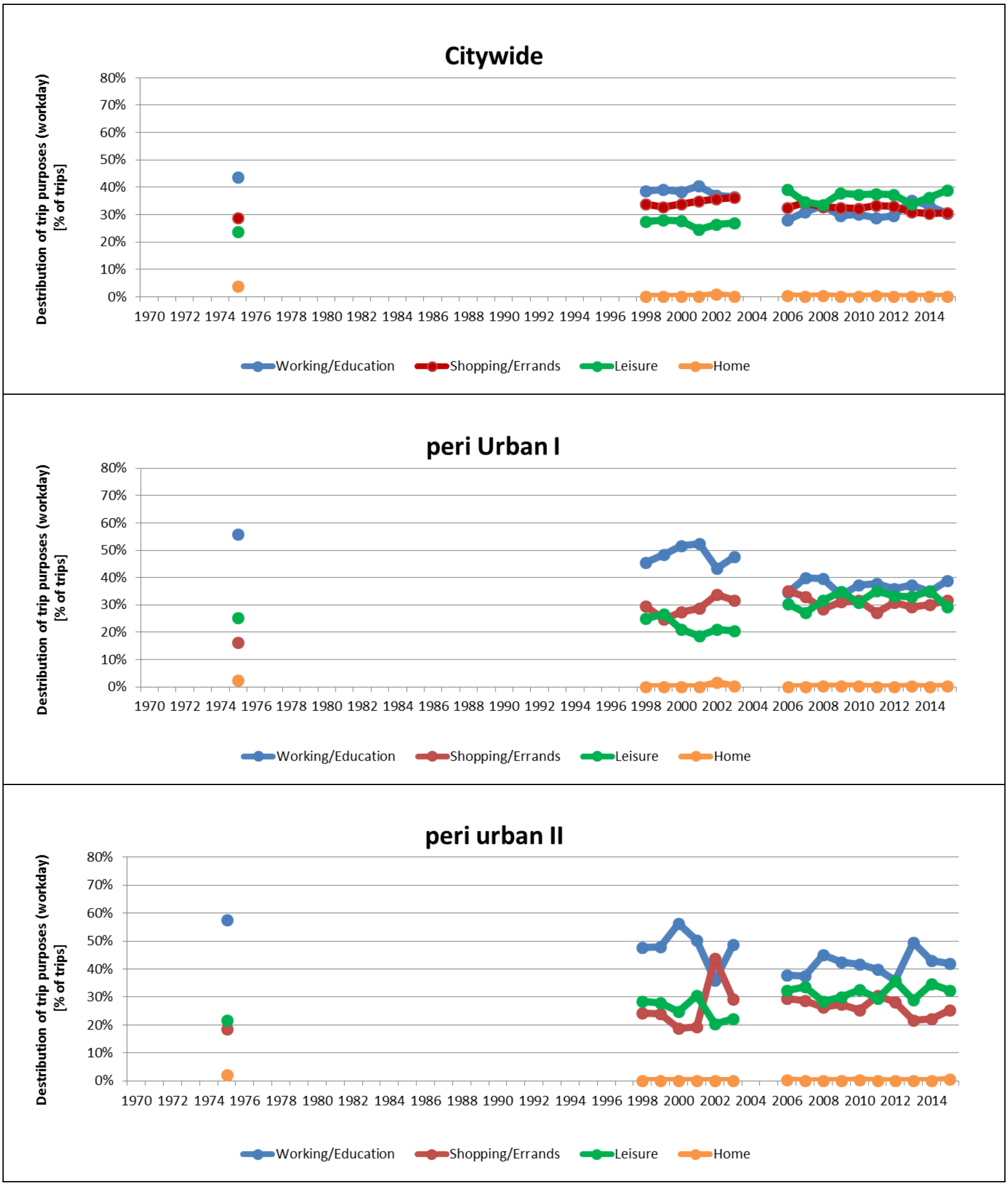

Figure 6-9: Development of the trip purpose. Data derives from three different "survey series" (1975; 1998 – 2003; 2006 – 2015) that may lead to some inconsistencies when looking across the whole period. "Home" trips are between two different addresses both defined as home by a person.
Source: COWI based on (DTU Transport, 2016).

6.2.6 Car occupancy rate

The car occupancy rate can only be described from year 2000 up to now, see Figure 6-10. The development does not show significant changes in this approx. 15 year long period for any of the areas.

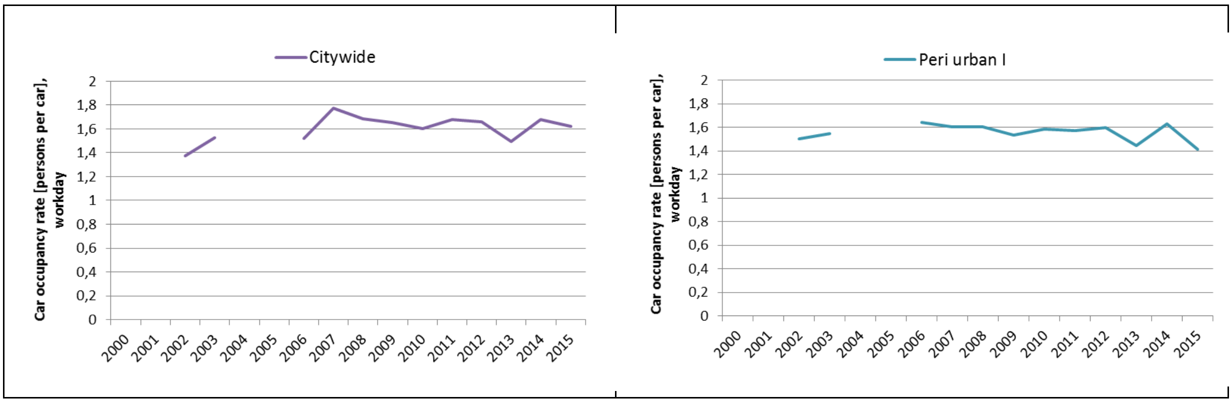

Figure 6-10: Development of the car occupancy rate [persons per car], workday. Data derives from two different "survey series" (1998 – 2003; 2006 – 2015) that may lead to some inconsistencies when looking across the whole period.
Source: COWI based on (DTU Transport, 2016).

Looking only at the car occupancy rate during the morning peak hours does not show any significant changes over time either, see Figure 6-11. The rate is lower than for all trips during a work day – from approx. 1.4 – 1.6 for the whole work day and 1.2 – 1.4 during peak hours. The occupancy rate does not vary between the areas either.

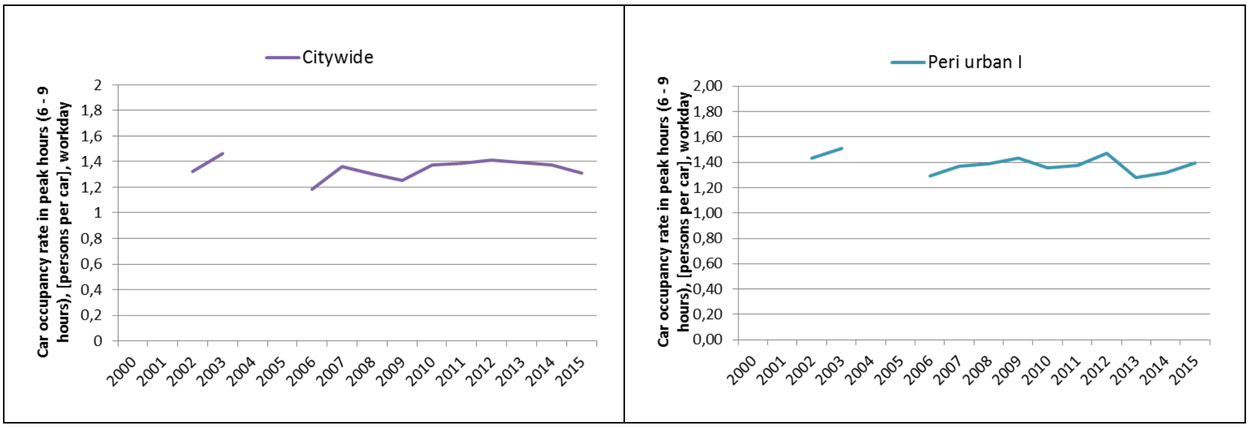

Figure 6-11: Development of the car occupancy rate in peak hours (6 – 9 hours), [persons per car]. Data derives from two different "survey series" (1998 – 2003; 2006 – 2015) that may lead to some inconsistencies when looking across the whole period.
Source: COWI based on (DTU Transport, 2016).

The numbers for trips between home and work illustrates more or less the same situation, see Figure 6-12. However, it is clear that the occupancy rate is lower for home to work trips (approx. 1.2) than for other trips.

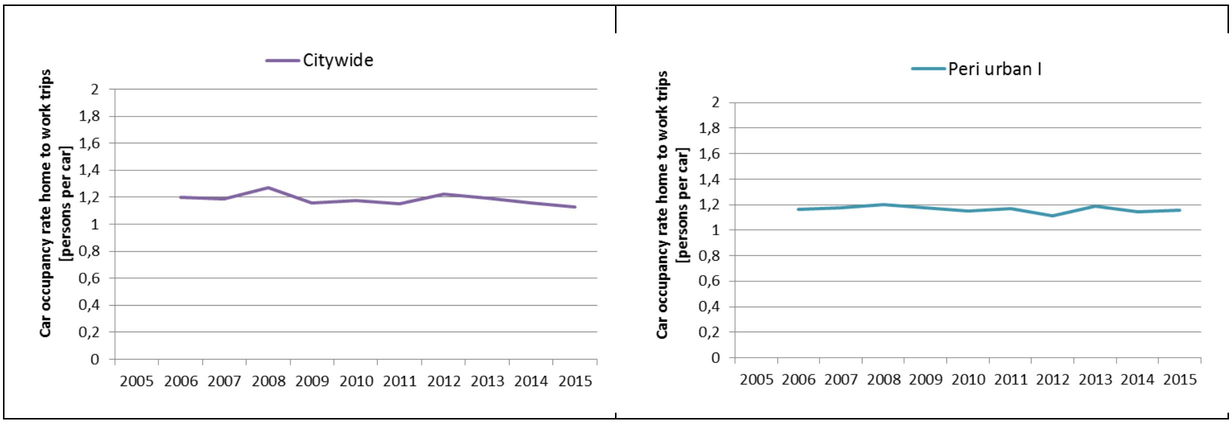

Figure 6-12: Development of the car occupancy rate for home to work trips [persons per car]. Data derives from two different "survey series" (1998 – 2003; 2006 – 2015) that may lead to some inconsistencies when looking across the whole period.

Source: COWI based on (DTU Transport, 2016).

A segregation of the car occupancy rate on trips with different purposes emphasizes the difference in car occupancy rate between commuter trips and other trips. For leisure trips, the rate is approx. 2 even though significant variations occur over time, see Figure 6-13.

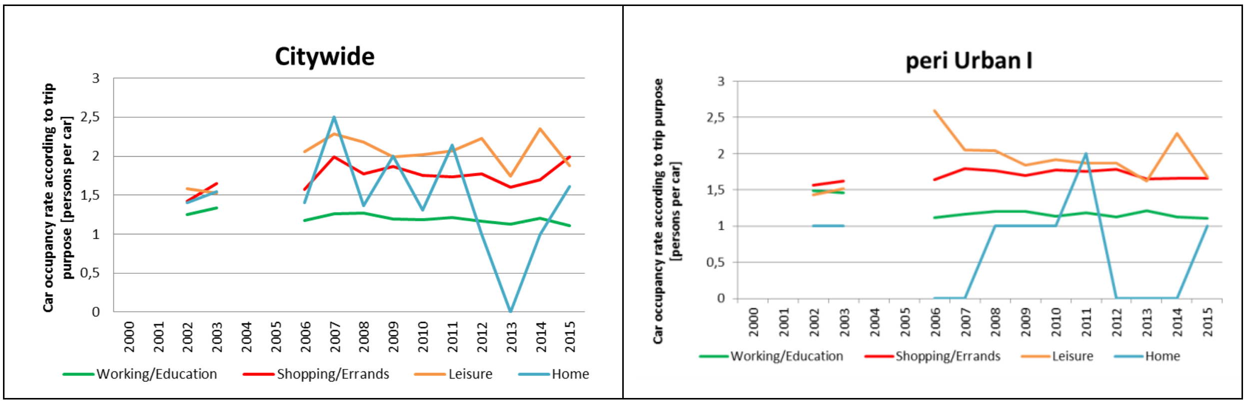

Figure 6-13: Development of the car occupancy rate according to trip purpose [persons per car]. Data derives from two different "survey series" (1998 – 2003; 2006 – 2015) that may lead to some inconsistencies when looking across the whole period.

Source: COWI based on (DTU Transport, 2016).

6.3 Aggregated travel behaviour

6.3.1 Annual road traffic volume

The overall number of vehicles passing the outer city border and passing the inner city border on a working day between 07 and 19 hours is counted regularly every year. The numbers show a general increase in car traffic to and from the city (outer city border) from the beginning of 1980's and until approx. 2007. From 2008, the car traffic has decreased even though a slight increase seemed to occur in 2014. The numbers give an overall picture of the development but numbers can vary significantly between neighbourhoods and roads, see Figure 6-14.

Car traffic crossing the inner city border shows a different development. Even though fluctuations can be seen, the overall picture is that the car traffic has decreased significantly since 1970.

Just for comparison, the figure also illustrates the development of bicycle traffic showing that for 2014, the number of bicycles passing the inner city border nearly is equal to the number of cars.

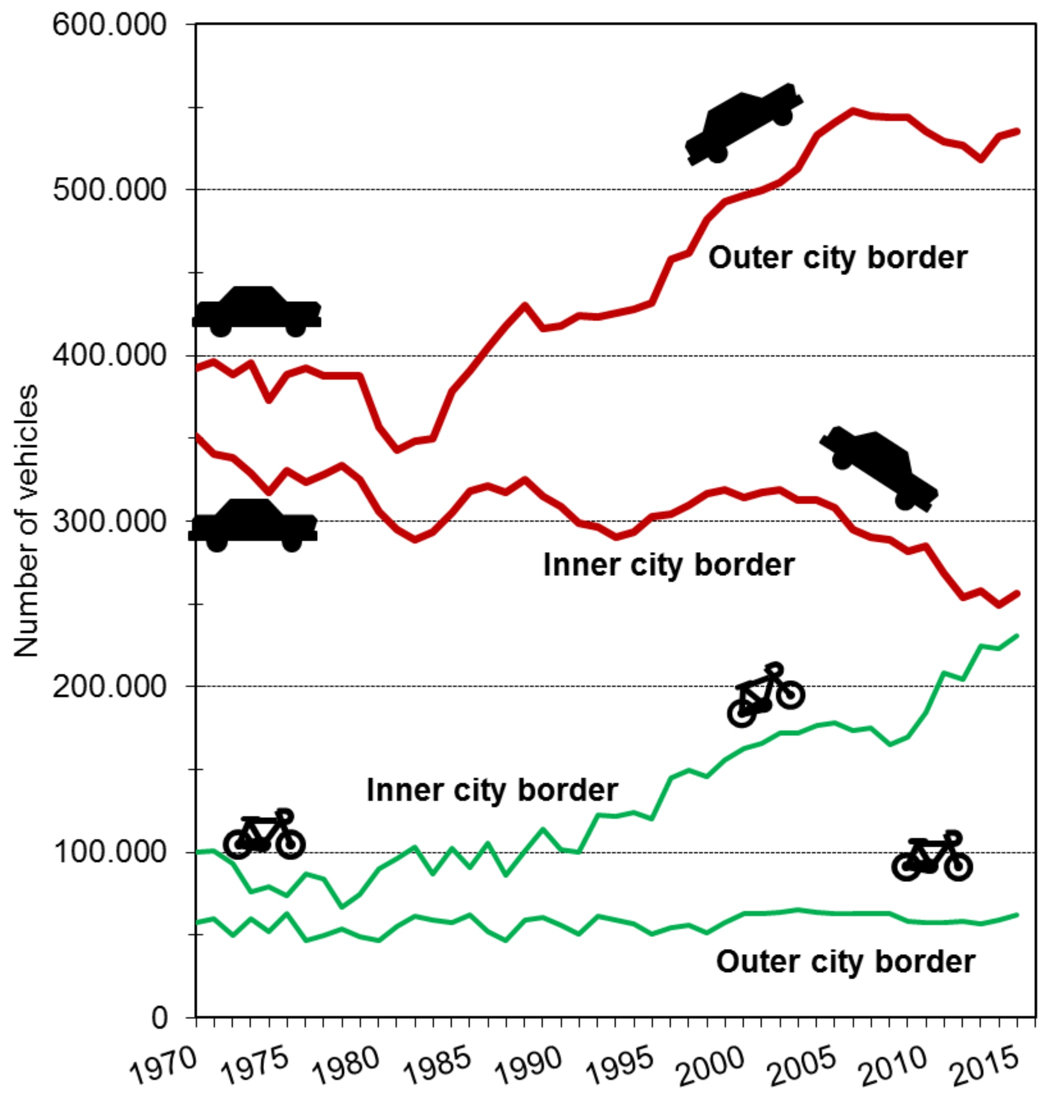

Figure 6-14: Development of average cross sectional road traffic volume (all motor vehicles) per workday between 07 and 18 hours. [Number of vehicles]
Sources: (City of Copenhagen, 2016h).

Looking at the development of the total volume of vehicle-km on the road network, numbers show nearly the same development as seen for the cross sectional road traffic, but with differences depending on road classes. For the overall road network (except local streets for which only estimated numbers exist – and only from 2003 and forward), an increase in volume of vehicle-km can be seen until approx. 2007 – 2008. The increase occurs primarily on the highest road category, regional roads.

For the other main road types having relatively more local traffic, the numbers show a decrease or no change during the years, see Figure 6-15.

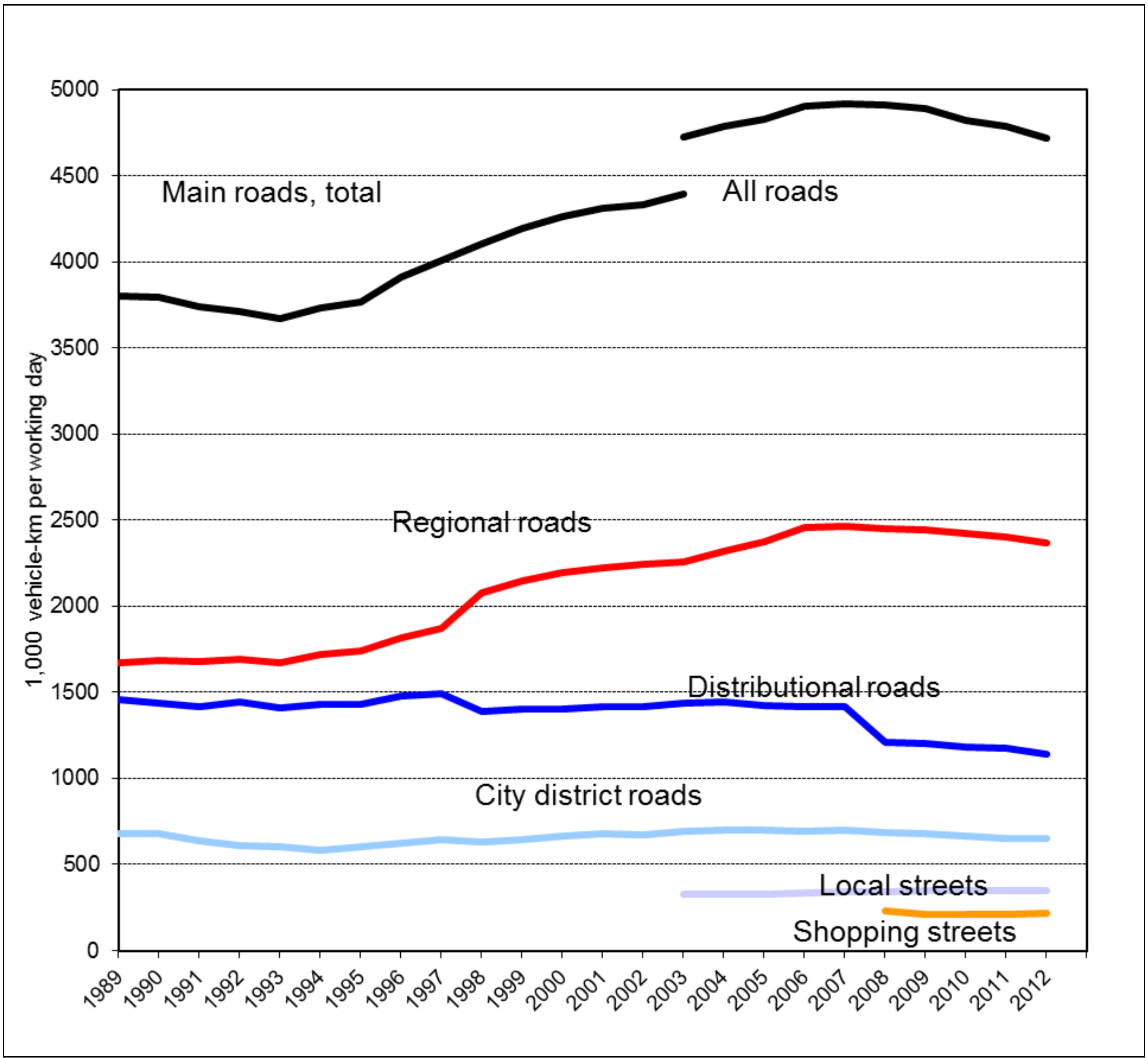

Figure 6-15 Development of total number of vehicle-km per working day in City of Copenhagen, not including Frederikberg. Numbers for Local streets only exist from 2003[10].
Sources: (City of Copenhagen, 2016h).

6.3.2 Average speed level

City of Copenhagen has since 1980 regularly measured average travel speed during morning and afternoon peak hour traffic on six selected regional road sections. The results show a decrease in

[10] The calculation is based on the city's road database giving road lengths per road section combined with the city's data on daily traffic volume from traffic counts at a selection of representative roads and assumptions for traffic volumes on the remaining roads.

speed level over the years up to 2010, see Figure 6-16. No newer data are available. The development appears to follow the development in overall vehicle-km on the road network shown in Figure 6-15. In the period from 1989 up to approx 1995, the average travel speed was more or less constant as was also the total volume of vehicle-km. After 1995, the average travel speed appeared to decrease and most likely this can be caused by the similar increase in volume of vehicle-km.

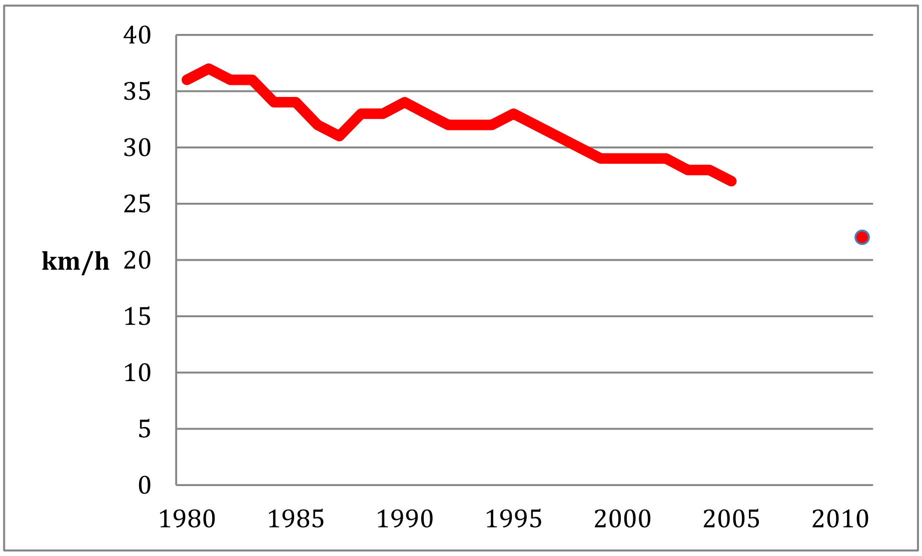

Figure 6-16: Development of the average speed level (peak hours) measured at the same six main road sections in City of Copenhagen each year.
Sources: (City of Copenhagen, 2016h).

6.3.3 Annual PT passenger trips

The yearly number of passengers with public transport in the whole study area is monitored by the public transport operators in the area. The latest status is from June 2016 including numbers up to 2015. The development in the total number of passengers over the last 20 years show an increase of approx. 15% from 1993 to 2015, see Figure 6-17. The increase can be seen both on the S-trains operating in the whole region and on the Metro operating primarily in the city. The decrease in number of passengers with bus is mainly caused by the introduction of the metro.

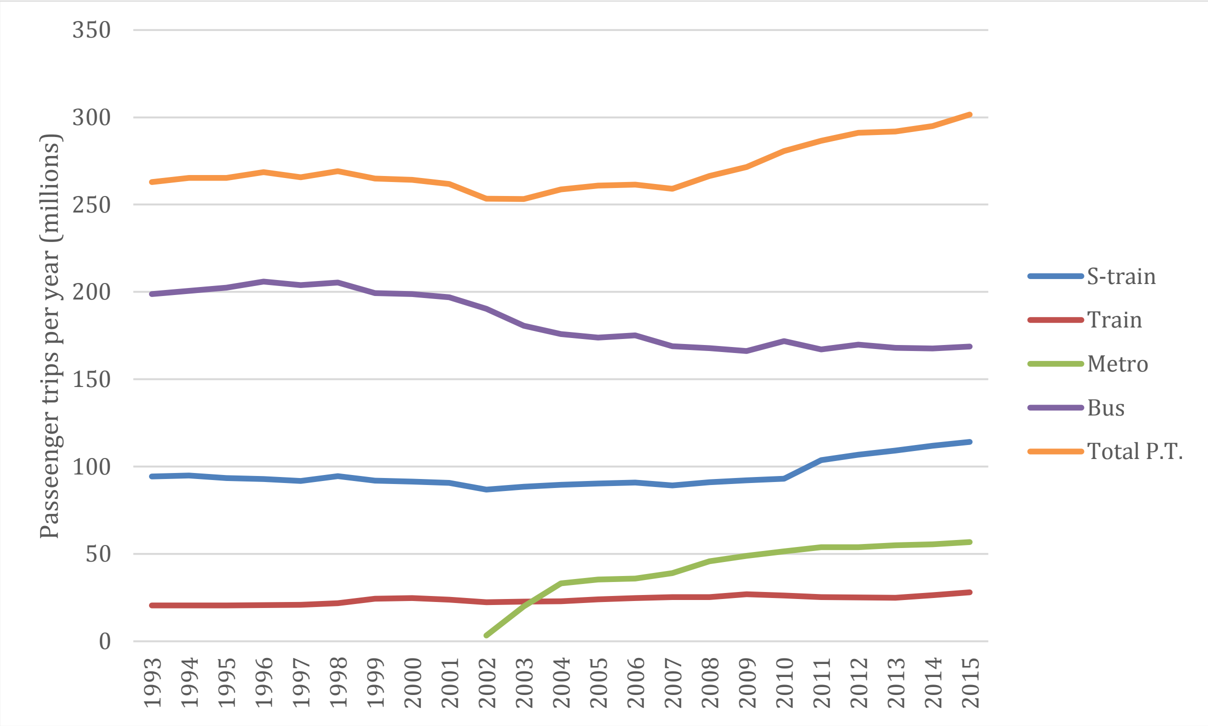

Figure 6-17: Development of the number of PT passengers in the greater Copenhagen area* I [thousand trips / year].

* This area includes City of Copenhagen, Peri Urban Area I and a few municipalities in the inner part of Per Urban Area II. This area was from 1974 a common public transport area (see subchapter 4.2.2).

Source: (MOVIA, 2016).

The yearly number of passengers with public transport in City of Copenhagen was fairly stable in the 1990s. The introduction of the metro in 2002 created a growth in the total number of PT passengers. The loss of passengers in busses is due to the fact that bus lines were closed in 2002 as the metro replaced the service on these lines, see Figure 6-18.

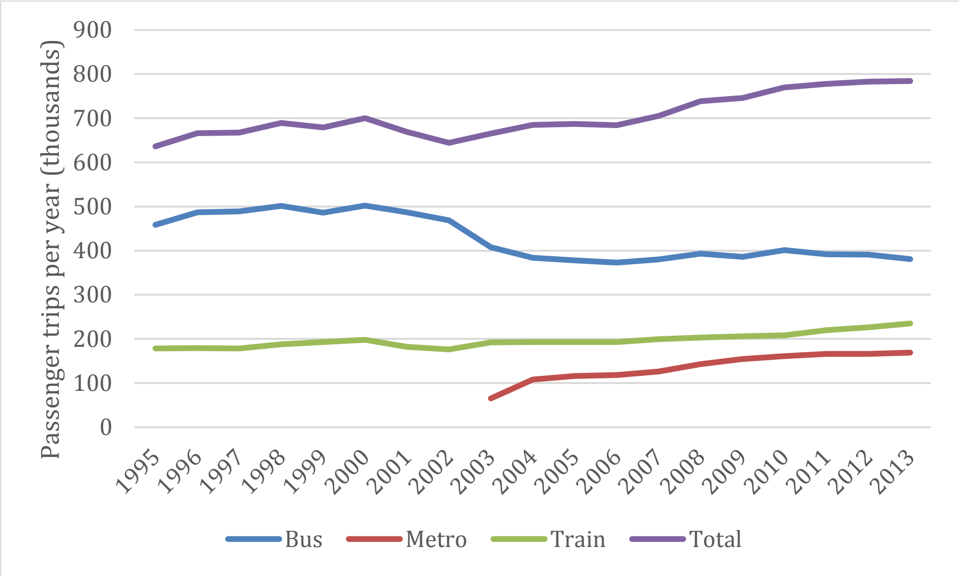

Figure 6-18 Development of the number of PT passengers in the City of Copenhagen [thousand trips / year]

Source: (City of Copenhagen, 2014).

6.3.4 PT patronage

No overall statistics exist for the public transport patronage understood as the number of passengers in relation to the actual vehicle capacity. Figure 6-19 illustrates cases for S-trains and metro for the period 2006 – 2013 (only from 2008 for the metro). The numbers illustrate a significant growth for the metro, reaching an average 64% use of the vehicle capacity in 2013. For the S-trains, a minor growth can be seen from approx. 21% in 2006 to approx. 24% in 2013. The numbers are based on average passenger volumes per year and they do therefore not give any indications on the actual situation during peak hours or differences depending on area. However, the metro covers nearly only the city, whereas the S-train primarily covers the city and the Peri Urban Area I.

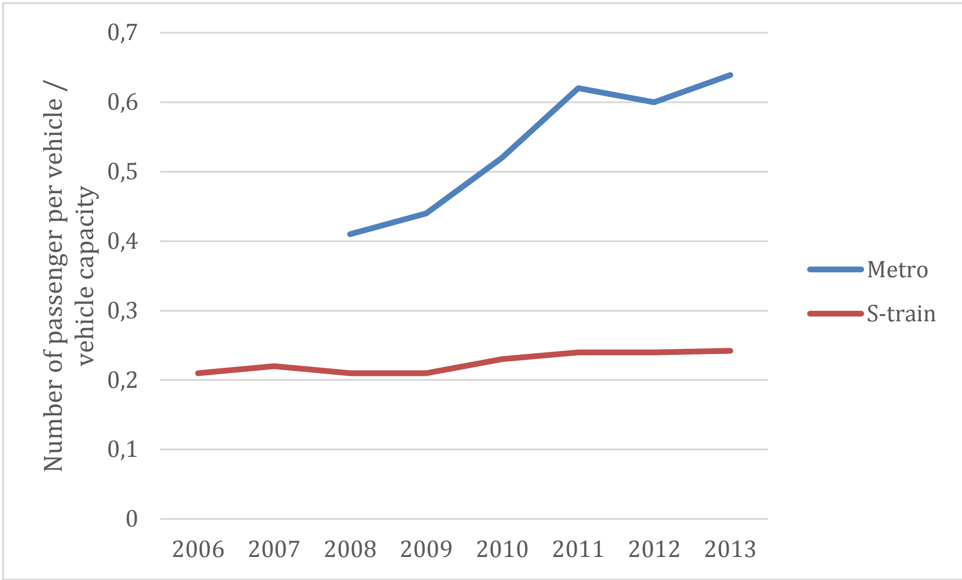

Figure 6-19: Development of the PT patronage (average number of passenger per vehicle over vehicle capacity)[11].

Sources: COWI based on (COWI, 2015).

6.3.5 Trips entering the city

The number of trips entering the city can be derived from the counts of vehicles passing the outer city and inner city border described in subchapter 6.3.1. The counts also provide numbers for the traffic during peak hours. Figure 6-20 shows the development, clearly indicating a significant decrease in car traffic and a similar increase in bicycle traffic passing the inner city border during peak hours. The development is very similar to the one illustrated for traffic during the whole working day in Figure 6-14. However, it is noticeable that the number of bicycles in the morning peak hour now is much larger than the number of cars.

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[11] The source has used publicly available statistics on total number of passengerkm and trainkm per year to calculate number of passengers per vehicle, and has furthermore used own assumptions on passenger capacity per average S-train and metro (vehicle capacity).

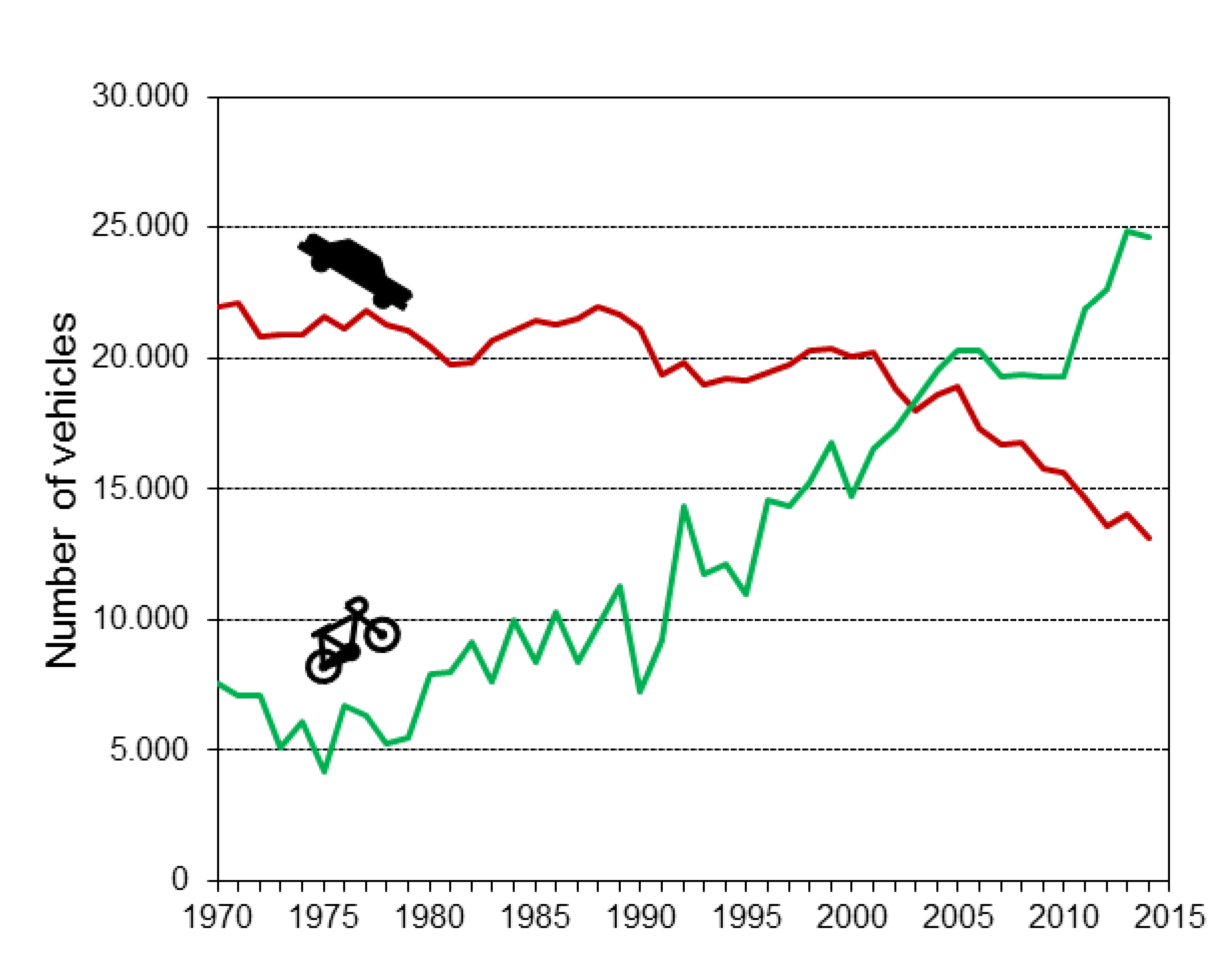

Figure 6-20: Development of the number of cars and bicycles entering the Inner City during peak hour, between 8 and 9 in the morning.
Sources: (City of Copenhagen, 2016h).

6.4 Mindsets, attitudes, mobility cultures

In the beginning of the 1970s, the bicycle traffic reached the lowest level after the Second World War. However, during the next decades, more Copenhageners realized that it is not only cheap to bike; it is also easier, faster and healthier. Various informal information on such changes in attitudes exists, but is not described very consistent.

However, from 2004 City of Copenhagen has developed a "Bicycle Account" including questionnaires on the satisfaction with cycling in the city. Figure 6-21 illustrates results from the survey.

COPENHAGENERS' SATISFACTION WITH THE CYCLING CITY *

'04	'06	'08	'10	'12	'14	
83	83	85	93	95	94	**Copenhagen as a bicycle-friendly city**
54	58	49	55	60	60	**Integration of cycling and public transport**
64	65	65	68	76	80	**Amount of cycle tracks**
50	48	43	47	50	53	**Cycle track width**
50	48	54	50	61	63	**Cycle track maintenance**
27	28	26	31	32	36	**Road maintenance**
30	26	26	27	29	33	**Bicycle parking, generally**

*Percentage who answered "satisfied" or "very satisfied". The answers are based on interviews with 704 respondents who either use the bicycle as the preferred transport mode or who use the bicycle at least once a week.

Figure 6-21 Satisfaction with cycling in City of Copenhagen, not including Frederiksberg.
Source: (City of Copenhagen, 2015b).

The surveys are carried out every other year among the cyclists in Copenhagen in order to identify the level of satisfaction with the City's efforts to improve the bicycle conditions.

The trend is, especially during the last two years, that the Copenhageners are becoming more and more satisfied with the bicycling conditions in Copenhagen. However, it is worth noticing that the road maintenance and bicycle parking conditions could be improved in the opinion of the Copenhagen cyclists.

In 2013, two other specific analyses were carried out. They uncovered the trends and attitudes of Copenhageners in order to achieve the goal of an even larger share of cyclists in Copenhagen. The analyses found three major changes of attitude that underpin more sustainable mobility behaviour among the Copenhageners[12]:

1) The car is no longer the most important symbol of status:
   In the 2000s, a house, a car and TV were the important status symbols; today, however, it has changed in the direction of health, time, children, technology and art/culture. This is a shift in the general culture that can underpin a lower car-dependency
2) Renting instead of owning:
   Collaborative consumption is a growing new sustainable trend. The younger generations no longer have the same needs for owning everything themselves, partly due to the fact that they can create a digital image of themselves. Such development can support the growth of car sharing schemes
3) The city as facilitating human endeavour:
   There is a growing focus of having cities being built for human beings, human endeavour and creating a liveable city with local anchoring of activities. This is a growing trend of attitudes among the public that can support further restriction of car use within the city borders.

[12] Source: (Is it a bird, 2013)

6.5 Travel behaviour and policies

In the following, figures on travel behaviour development (number of trips etc.) are discussed in relation to policy actions. The development in travel behaviour among citizens of City of Copenhagen naturally depends on many entangled factors that cannot be separated. In this subchapter, mainly local and regional policy actions are sat in relation to the development. When found possible and important, other factors such as overall economic development, changes in national taxation systems etc are also mentioned. As the results in travel behaviour of a specific policy action most likely first will show gradually, the policy actions are illustrated with timelines starting from the implementation.

6.5.1 Share of car trips per inhabitants indicated by policy action

The share of car trips per inhabitant in the City of Copenhagen decreased according the travel survey data especially up to the end of the 1990s. The decreasing car share among the inhabitants was only partly seen on total road traffic volume in the City (see Figure 6-15) and on the daily number of cars passing the border of the City (see Figure 6-14). These numbers show a stagnation in the number of cars.

The decrease in the share of car use in this period can most probably be explained mainly by the growing percentage of older and younger citizens in the City. These groups did not have the same access to a private car as families with adults in the 30ties to 50ties moving out to new bigger apartments or houses in the growing suburbs.

As the overall car traffic in the City includes commuters and other visitors to the City, their contribution can probably explain the overall stagnation in the overall car traffic and not only a decline caused alone by the inhabitants.

The correlation to local policy actions does not appear to be very clear. The structural changes in location of new dwelling areas and industry moving out of the city parallel to the economic crises most likely had a great influence. These structural changes were also part of a regional spatial planning policy especially in the stat of the 1970's, e.g. with the establishment of two new regional "mega"-centres in the Peri Urban area. One also has to remember that the national taxation on private cars and fuel always has been fairly high in Denmark, which especially during economic crises can motivate people not to invest in or to use a car.

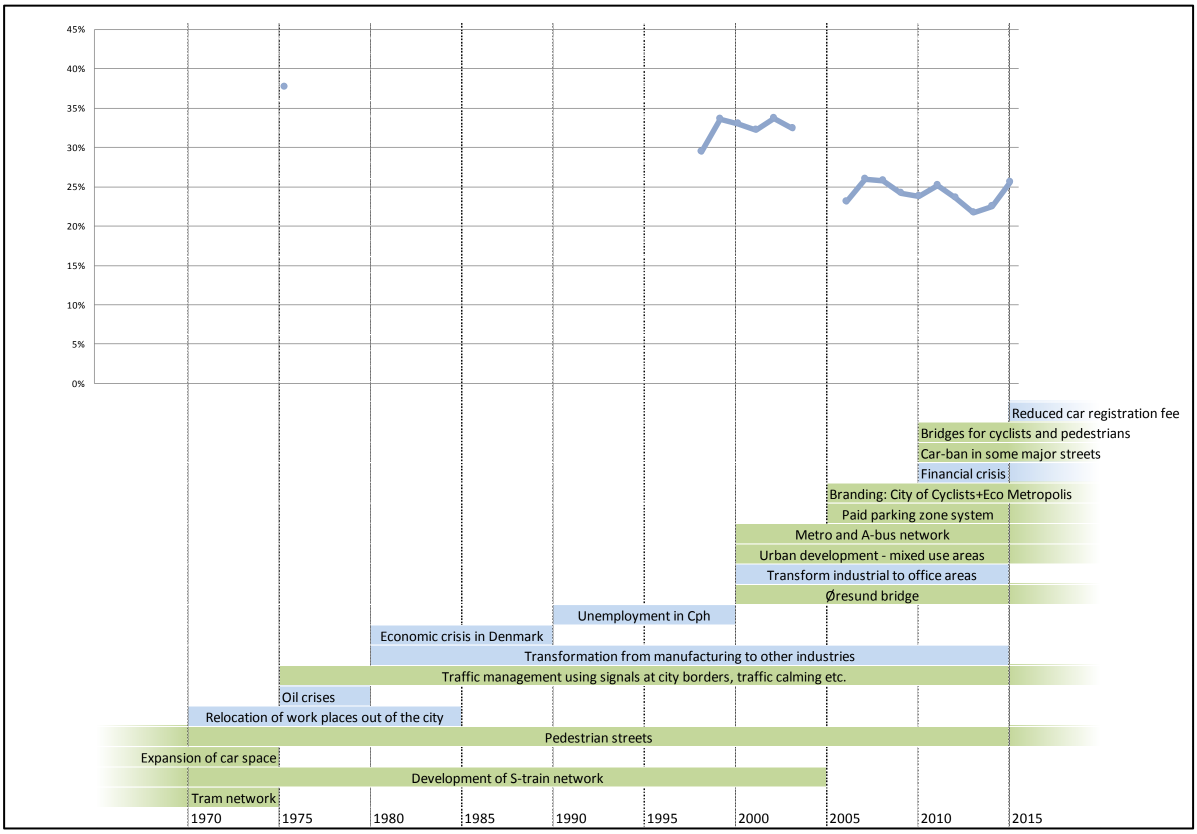

Figure 6-22: Share of car trips indicated by policy action

From the end of the 1990s, the share of car traffic seem to grow reaching a certain stabilisation between 15% and 20%. Bearing in mind that the income level among inhabitants in the City has grown significantly from the 1990s, and still is growing, it is noticeable that the share of car traffic has not the same increase. Most likely, a number of factors can be used to explain this. Without attempting to give a full picture, significant factors seem to be:

- *Cultural changes among the inhabitants*. The awareness of and attitudes toward traffic safety, air pollution, climate, health / exercise and general liveability has changed in general. Overall, these changes seem to increase the motivation for not using the car.
- *City policy and actions towards less car traffic– towards the 1990s.* Starting in the beginning of the 1970ties and continuing up in the 1990s, the political tendencies and demands from inhabitants were to mitigate negative impacts from the growing car traffic. Furthermore, the deliberate change in urban policy (especially during the last part of the period) to motivate families with children to stay in or move to the city led to e.g. clearance of densely built backyards in dwelling quarters giving more urban space for leisure purposes. The traffic / urban policy can be described by a number of actions (not necessarily giving a total picture):
    - Major traffic calming schemes moving car traffic from many local streets to the major streets, see Figure 6-15 illustrating a significant increase in traffic volume on major roads compared to more local streets.
    - Progressive regulation of car traffic entering the city by using traffic signals to hold back cars at the city border especially during morning peak hours leading to a fairly smooth flowing traffic in the Inner City compared with many other cities.
    - A growing supply of pedestrian areas taking space from cars

- Ensuring a limited supply of car parking especially in the Inner City. The number of jobs in the Inner City has for the last approx 15 years been approx 100,000, whereas the number of all-day available parking for employees has been much lower (approx. 15,000 lots)[13]
    - The construction of bicycle facilities began shortly after 1900 and has actually never stopped. Even during the peak period for making space for new major roads in the 1960s, bicycle tracks were included along the major roads. The resulting bicycle network has most likely assisted significantly in maintaining the bicycling tradition, giving a good starting point for the later (see below) more deliberate strategic focus on Copenhagen as a bicycle city.
- *City policy actions towards a more liveable city – from the 1990ties.* From the middle of the 1990ties, the City experienced optimism and growth based among other issues on a better city economy (more inhabitants and especially more people with fairly high incomes). National investments like the new bridge connecting Denmark and Sweden, support to a new major urban development plan including the introduction of metro lines were also part of this development. A side effect was an increased car ownership rate and a rise in the car traffic volume, even though this was not very visible on the car share rate. New traffic / urban policy actions, supplementing the already described actions, are the following (not necessarily giving a total picture):
    - Major improvements of public transport by introducing the Metro, priority schemes and lanes for busses and a system with new frequent "A-bus" lines
    - A change in urban planning policy leading to a high intensive urban development close to the stations (providing more hinterland for public transport) and including restrictions on max. number of car parking lots near stations
    - A strategic focus on improving the image of bicycle traffic both by infrastructure investments, restrictions for car traffic and focused marketing (using "the carrot, the stick and the tambourine" as described by City planners)
    - An overall focus on creating a "liveable city" with more urban space for pedestrians and bicyclists and branding of Copenhagen as an Eco Metropolis.
    - Implementation of major innovative and very visible infrastructure projects for environmental friendly transport. E.g. new significant visual important land marks in the form of bridges for pedestrians and bicyclists and closure for individual car traffic on a major former arterial street giving more space to bicyclists, pedestrians and busses.

6.5.2 Share of pt trips per inhabitants indicated by policy action

The share of public transport use has declined from approx 25 percent in the 1970s to a more stable situation from the end of the 1990s on approx. 16 percent. Major policy actions for this development (supplementing description to subchapter 6.5.1) may be these:

- Bus supply in the City was under financial pressure up to the 1990s and reductions were politically decided and implemented.
- Increased focus on public transport from the end of the 1990s as described in previous subchapter gave a "boost" to the public transport
- Especially the introduction of the Metro has increased the share of trips by public transport.

[13] The number of available parking lots cannot be verified precisely, but is based on indicative numbers available at the City of Copenhagen administration. Source: (City of Copenhagen, 2016e).

The decline from the 1970s was also part of the overall increase in car ownership and the growth in bicycle traffic.

Sociological studies on travel behaviour and preferences from the 1980s and forward also indicates that car drivers and bicyclists often have more in common on preferences for mode choice (e.g. freedom of choice, flexibility, and travel speed) than users of public transport – if they have alternatives to choose from.[14]

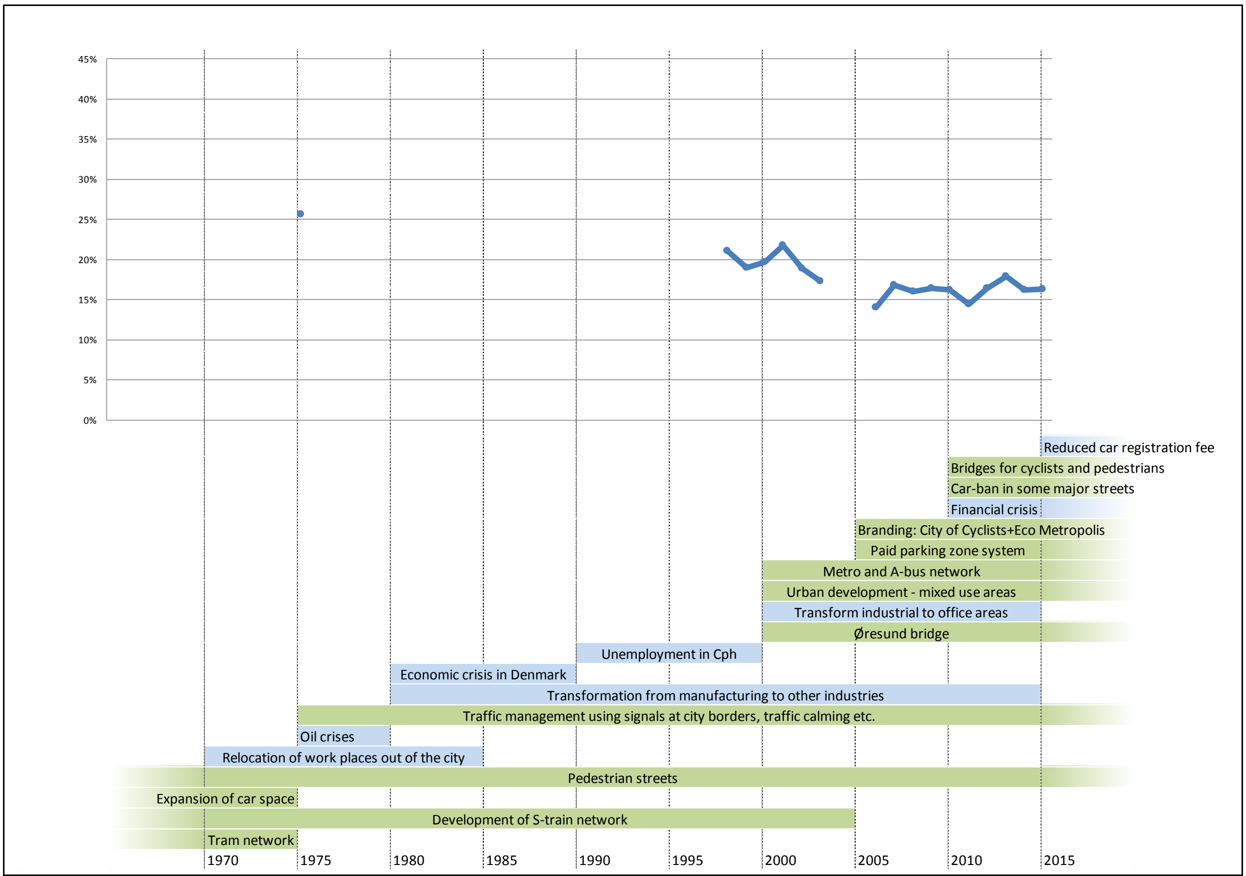

Figure 6-23: Share of pt trips indicated by policy action on the time line

6.5.3 Share of cycle trips indicated by policy action

The share of cycle trips has increased from approx 28 percent in the 1970s to approx. 40 percent in 2013 and declining a bit the latest two years. The increase seems to have happened especially after the beginning of the 2000s. Major policy actions for this development (supplementing description to subchapter 6.5.1) may be these:

- Introduction of "Bicycle packages" in the Copenhagen City budgets dedicating budget for specific measures as e.g. new green bicycle routes, safety improvements, bicycle parking, filling out gaps in the bicycle network etc.

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[14] Various sociological studies and surveys indicate such preferences, but the description here is solely the responsibility of the authors.

- Introduction of bicycle route schemes for commuters to and from the City together with neighbouring municipalities (Super cycle highways)
- Supplementing "soft" measures (the carrot and the tambourine) with campaigns, support to projects supporting the use of bicycles in kindergartens, among elderlys, among non-ethnic Danes etc.

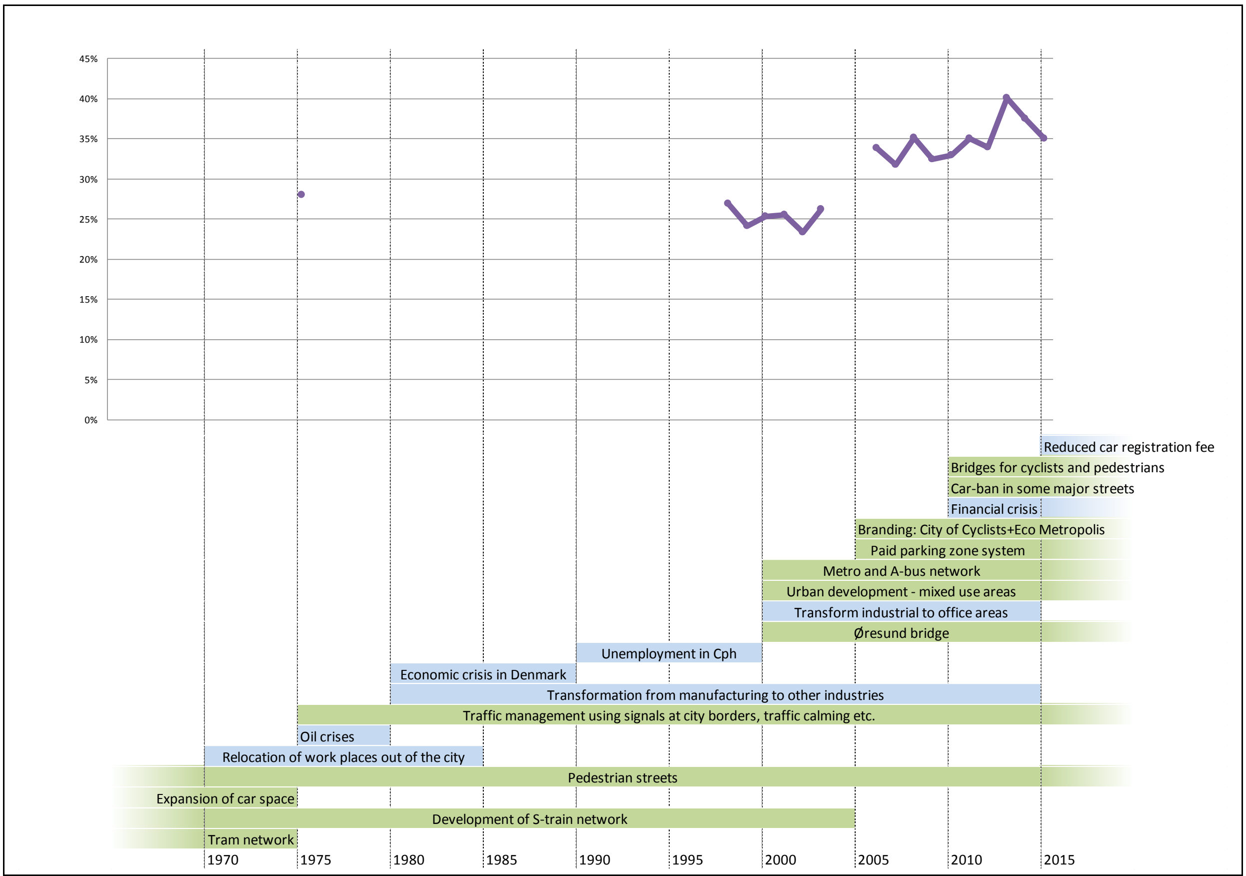

Figure 6-24: Share of cycle trips indicated by policy action on the time line

6.5.4 Share of walking trips indicated by policy action

The share of walking trips can only be seen in the travel surveys from 1998 up to now. The share is above the level of public transport trips and seems to be over 20 percent. The development is not very clear, but the share today appears to be higher than the level 10 to 15 years ago.

Major policy actions for this development (supplementing description to subchapter 6.5.1) may be the increased focus on development of liveable urban spaces making it more safe, comfortable and eventful to walk.

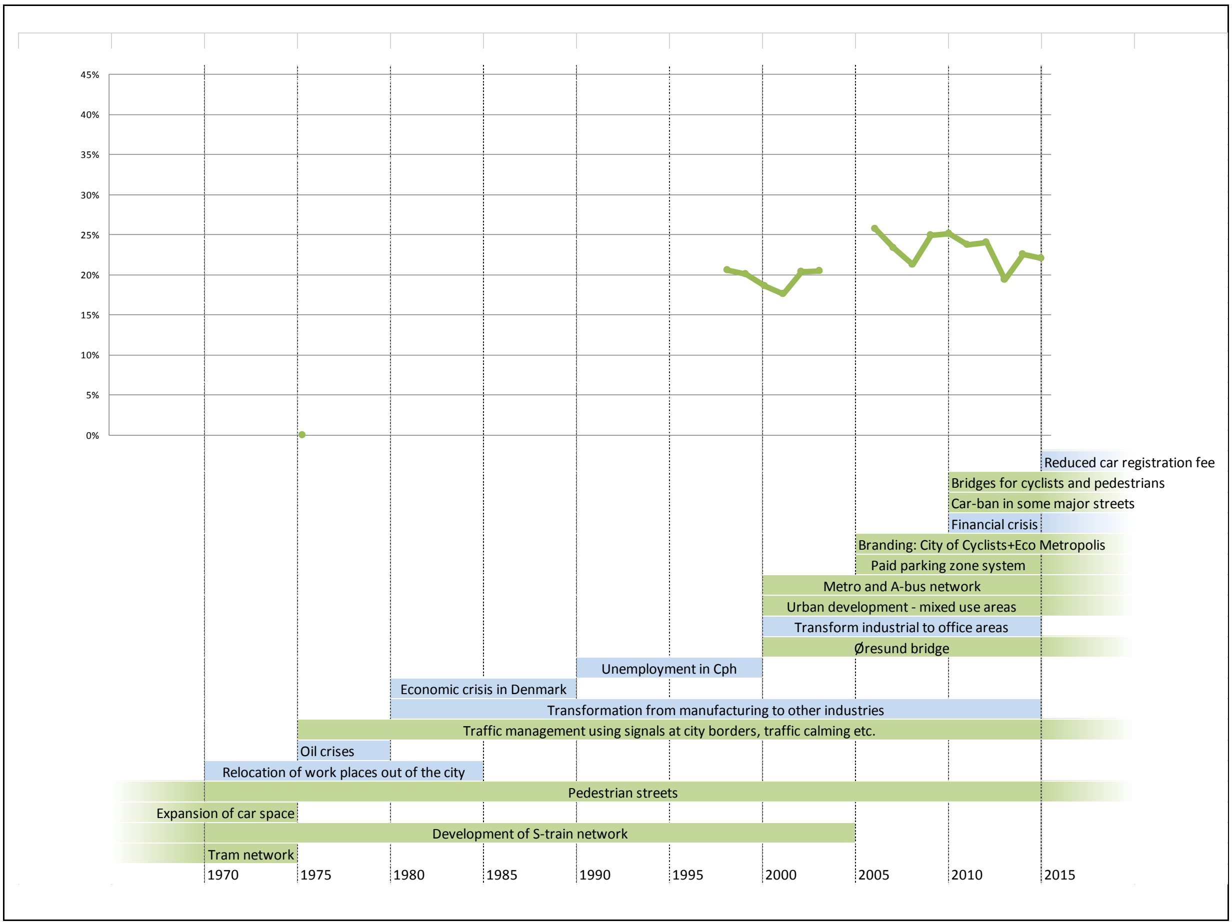

Figure 6-25: Share of walking trips indicated by policy action on the time line

7 Freight Transport

Freight transport has not been investigated during this study. For the purpose of illustrating the development in the City of Copenhagen, it can be seen that the number of Heavy Goods Vehicles (HGV) entering the city has been reduced significantly since year 2000, see Figure 7-1.

From January 2008, City of Copenhagen together with Frederiksberg Municipality introduced a regulation on limited acces for diesel engine HGV without a filter for particulate matter in an "Environmental zone" covering the whole area of Inner and Outer City. The introduction aimed at improving the air quality. Howwever, the introduction also lead to a significant decrease in the number of HGV passing the city border in 2008.

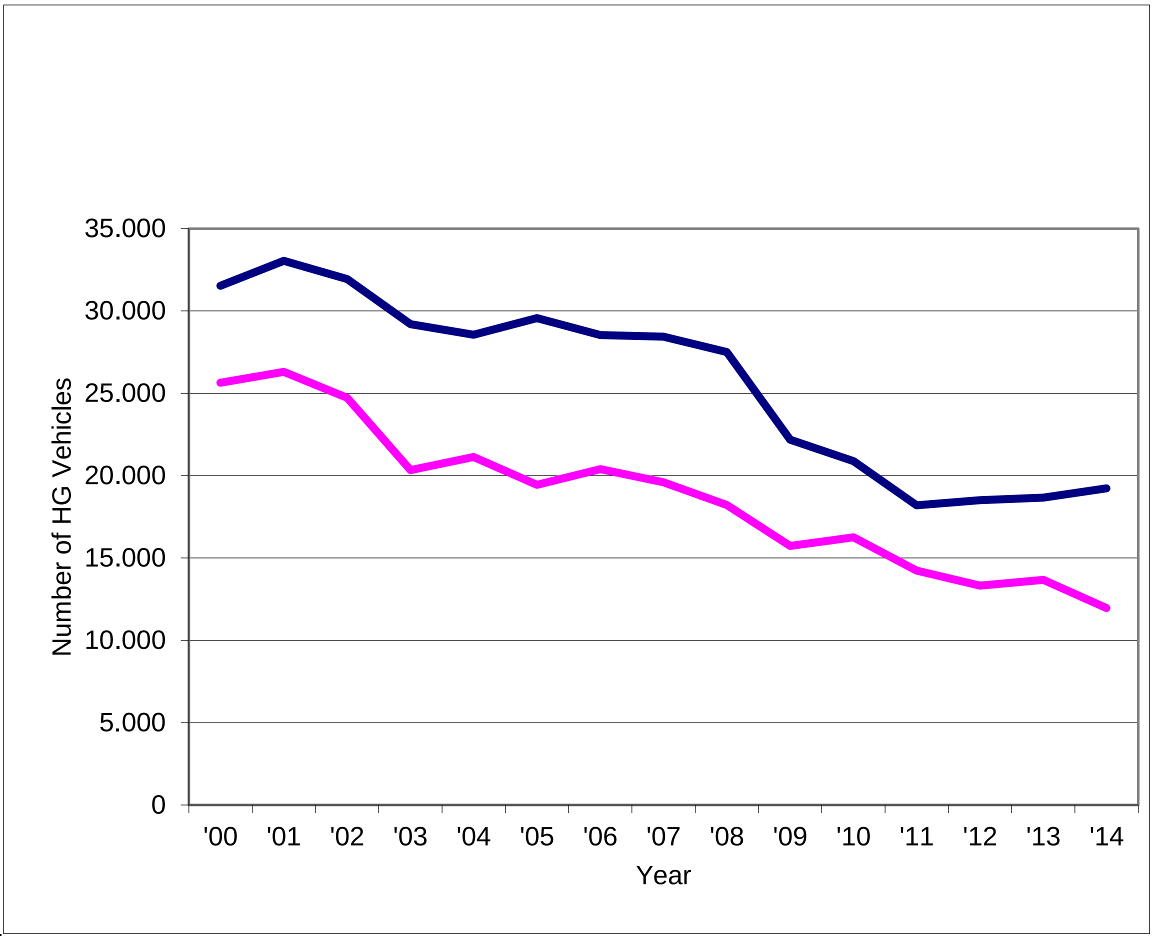

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Figure 7-1: Development of average cross sectional road traffic volume by HGV per workday between 07 and 18 hours (number of vehicles). Blue = Outer city border. Red = Inner city border.

Sources: (City of Copenhagen, 2016h).

8 Summary, Conclusions

The development of the traffic situation in the City of Copenhagen over the period 1970-2015 is interesting, because despite significant growth of the population and of the average income of citizens, car traffic in central Copenhagen has declined. Generally, at least among traffic planners, there is an expectation that car traffic increases when population and incomes increase.

There are two types of potential explanations for the development: The first is structural changes in the population and the economy, the second is policy measures undertaken by the City of Copenhagen and the national government.

There has been a significant change in age structure of the population of the City of Copenhagen. Over the period 1980-2015, a change has taken place so that young persons has become the dominant age group. Young persons tend to be less car-dependent - and younger persons today may even be less car-dependent that young persons 20 years ago - than other age groups, which may have contributed to the decline in car traffic in the Inner City. On the other hand, the incomes among inhabitants in the City have increased. Remarkably, the average income now equals those of the rest of Denmark, despite the population of Copenhagen being dominated by young persons. Increasing incomes can generally be expected to lead to more car traffic.

The City of Copenhagen together with regional and national authorities have undertaken a range of policy actions towards traffic in Copenhagen. Major improvements have been made to public transport by introducing the Metro, priority schemes and lanes for busses and a system with new frequent "A-bus" lines. Parallel to this, a change has been made in urban planning policy leading to a high intensive urban development close to the train stations and thus motivating for more use of public transport.

Furthermore, there has been a strategic focus the last approx 20 years on improving the image of bicycle traffic. Actions have included infrastructure investments, restrictions for car traffic and focused marketing and communication on branding bicycle traffic.

The focus can in short be said to be on creating a "liveable city" with more urban space for pedestrians and bicyclists and branding of Copenhagen as an Eco Metropolis. Major "visual landmark" projects for environmental friendly transport have been implemented. E.g. new innocative bridges for pedestrians and bicyclists and closure for individual car traffic on a major former arterial street providing more space to bicyclists, pedestrians and busses.

These potential explanations are supported by simple correlations, but not by sophisticated statistical analyses. Gaps in the available transport data makes it challenging to catch the decisive indicators and policy actions. A simple answer could also be that the complex interaction of structural changes and deliberate policy actions is the best explanation. No single measures or indicators seem to be decisive.

It should also be noted that the traffic development in City of Copenhagen differs markedly from that of the other parts of the Copenhagen agglomeration (per urban areas), where car use has increased more or less in accordance with the growth of incomes.

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10 List of Figures

11 List of Tables

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Project acronym: **CREATE**

Project title: **Congestion Reduction in Europe - Advancing Transport Efficiency**

D3.2 - Technical report for Stage 3 city

London

Work Package 3 "Quantitative Analysis of Travel"

Date of preparation: **November 2016**

Start date of project: **1st June 2015**

Duration: **36 month**

Version: **3**

Prepared by: **Charles Buckingham and colleagues, TfL**

Checked by: **Oliver Roider, BOKU**

Verified by: **Peter Jones, UCL**

Status: **Final**

Dissemination level: **Public (PU)**

Table of Contents

1 CREATE project

CREATE's work is based on 3 main challenges/activities:

- to establish which policies were most effective at controlling congestion, reducing car use and promoting sustainable transport,
- whether such policies are transferable to other cities,
- how cities are going to respond to the challenges of rapid population growth and new transport technologies in the future.

In other words, and more specifically, CREATE aims to help five cities from Eastern Europe and the Euro-Med countries to decouple traffic from economic growth, with the support of five Western European cities that have already passed the critical phase of rapid increase in car ownership, and are now moving towards a sustainable transport system. CREATE sets out to study and look at options to further improve network efficiency and reduce the overall need to travel in those advanced cities.

CREATE uses knowledge gained from stakeholder interviews, data analysis, detailed research and historical studies in order to develop tools, guidance and teaching packages, providing capacity building and opportunities to enable less advanced cities to accelerate their shift towards a more sustainable mobility system.

This in-depth investigation, supported by leading analysts and a major provider of real-time traffic data will permit CREATE to investigate changing patterns of road traffic and car use, success factors behind decreasing car usage and lessons learnt.

1.1 Concept and approach

The CREATE project is based on four central innovative ideas or assumptions:

1. The way in which the "congestion" debate is framed in a city underlies how transport system performance is measured.
2. The existence of a 3-stage "Transport Policy Evolution Cycle" spread over 40+ years, which gradually shifts the policy emphasis and investments priorities from catering for road traffic growth to building up a liveable city.
3. The examination of future mobility options given a rapidly growing urban population (and a mobility densification), with policy measures which can achieve congestion reduction, promote sustainable mobility, while meeting wider policy goals.
4. Promoting the "policy transfer" of understanding gained from investigating the above mentioned ideas, to those cities which are coping with rapid growth in car ownership and promoting "pro-car" policies. This would provide them with insights into how to short-circuit the 3-stage historical "Transport Policy Evolution Cycle".

1.2 Objectives

The CREATE project is based on achieving four high-level objectives:

1. To explore the nature and the causes of urban road traffic congestion, developing and applying a set of policy relevant and practical indicators of urban road congestion and transport network performance. This will provide network managers and policy makers with metrics to establish the degree to which efficient and sustainable urban mobility is being delivered in the CREATE cities.
2. To work with five economically advanced Western European capital cities, which have already passed through the "peak car" phenomenon, examining how they have succeeded in

decoupling economic growth from traffic growth. It will be particularly interesting to discern which transport and non-transport factors have been most effective in reducing car use, thus encouraging greater use of sustainable modes.

3. To develop specific guidance and promote capacity-building for professionals in the group of cities (Eastern European and Euro-Med) which are at the earlier stages in their economic development, with a view to help them to adopt policies based on sustainable mobility, rather than becoming car dependant cities.
4. To address the serious future issues starting to emerge in many of the CREATE cities due to rapid increases in population and employment, thus potentially overwhelming all modes of transport. Via the investigation of the potential for new technologies, and the changes in business and social habits, there are chances for better managing the transport systems and reducing the overall need to travel as well.

2 About this document

The primary aim of WP3 is to analyse the transport policy evolution cycle as described in Deliverable 2.1 for the five stage 3 cities, from their stage 1 condition to their current status as stage 3 city. The development of relevant travel indicators is mapped over time in order to quantify this trajectory and to identify the various factors which have contributed to observed changes in behaviour – particularly the observed reductions in car driver modal shares.

This deliverable documents the analysis of the data to provide an overview of city development and characteristics as input for further analysis. Trends in congestion and travel behaviour (by purpose, mode, etc.) are measured, charting the emergence of “peak car” and the growth in the use of sustainable modes of travel, in different parts of the urban and peri-urban areas. A descriptive analysis for each stage 3 city is conducted across the years. Indicators of changes in conditions in each city are analysed, including traffic volumes, speed, congestion, public, transport patronage, modal shares of different modes depending on data availability.

Indicators of possible causes of changed travel patterns are covering demographic changes, economic developments, car ownership, labour-market, land use, or government policies. Analysis is distinguished between different segments of population in different parts of the cities over time. Data are mainly based on any kind of statistical sources available as well as household travel surveys and are to be documented for the longest possible period of time in each city. Most of data, but in particular household travel survey data, should be available in all stage 3 cities at least 20 years back from 2014, in some cases from the 1970s, and should provide information of the stage 1 situation in the particular city.

The contents of this deliverable are based on the analysis scheme provided in Deliverable 3.1. Technical internal report, detailed analysis scheme for WP3 to ensure the generation of comparable figures over time for all stage 3 cities. The list of indicators to be documented is subdivided into 2 levels: (1) “must-have-indicators” which all stage 3 cities should have to provide and (2) “nice-to-have-indicators” representing additional analyses of specific data available in case these data are easy to access. Additionally, any other documentation of data or further cross analysis of data of interest in a particular stage 3 city are highly appreciated and should be added accordingly.

This deliverable is organised as follows: The city specific framework as the basis for the analysis is presented in chapter 2. Chapter 3 and 4 are dealing with transport supply data and policies influencing travel demand in the city documented in chapter 6. Freight transport is described in chapter 7. Summary and conclusions are documented in Section 8.

Disclaimer

This is a summary descriptive report setting out and describing key travel trends and their influences for London. The function of this report is to provide key data and high-level interpretations for London to feed into the wider cross-city analysis of trends being undertaken for Work Package 3 of the CREATE project. It is not of itself therefore a definitive synthesis of travel trends and their causes in London, but rather a compendium of resources, with some basic interpretation, to feed into this further analysis.

Where opinions are expressed about the causes of change or the significance of specific aspects, these are with the sole intention of guiding further analysis under the CREATE programme and to act as a starting point for that further quantitative analysis. They therefore have the status of ‘exploratory hypotheses’, and do not necessarily reflect the fully formulated views of Transport for London (TfL).

The report has been compiled by Transport for London (TfL), London's integrated transport authority (www.tfl.gov.uk).

Conventions adopted in this report

This report presents resources (quantitative trends and simple interpretations) relevant to the cross-city quantitative analysis of trends being undertaken as part of CREATE Work Package 3.

The structure of the report follows that recommended for this work package, but the report also contains additional material where this is believed to be of particular significance for London. As is to be expected, not all of the required material is available. Historic data, particularly for the pre-internet era, is difficult or impossible to obtain, and over any lengthy analysis period numerous changes of definition, arising in particular in London from changes in ownership or governance of transport networks and associated datasets, will seriously affect the comparability of time-series data. These limitations are highlighted throughout the report.

This report is accompanied by an Excel workbook, which contains data behind many of the figures cited in the report. Web references to third party material are frequently given in the text, so as not to repeat extensive material that is already available and in the public domain. Reference should be made to these sources for further detail as required. The interpretative content of this report is, however, original. In some cases, detailed data (eg Mapinfo layers) are available from TfL on request. Datasets relating to the key travel surveys have also been provided. All data in this report are comprehensively sourced.

The material should be read in conjunction with outputs from Work Package 4 of the CREATE project. This work package considers many 'qualitative' aspects of change in London, such as changes to governance, political change and social factors – aspects that are crucial to fully explaining the quantitative trends presented in this report.

A key general resource for travel data and trends relating to London are the 'Travel in London' reports, published annually by Transport for London. These can be found at: https://tfl.gov.uk/corporate/publications-and-reports/travel-in-london-reports

3 City specific framework conditions

3.1 Spatial characteristics

3.1.1 Area definitions

This section summarises the spatial zoning used for the CREATE analysis in London. This is based on three concentric 'Zones':

- Inner London (including central London) – CREATE Zone 1 (319 square km).
- Outer London – CREATE Zone 2 (1,253 square kilometres). Note that CREATE Zones 1 and 2 comprise the administrative unit of 'Greater London' (1,572 square km).
- A peri-urban area of contiguous local authorities having a defined functional relationship to Greater London – CREATE Zone 3. To reflect data availability, this zone is considered in two parts – an 'inner' and an 'outer' peri-urban area (see also below).

The Greater London area (CREATE Zones 1 and 2) covers 1,572 square kilometres in the south east of England. This area has been administratively stable for the last five decades, and currently forms the administrative unit corresponding to the Greater London Authority/Mayor of London (see: https://www.london.gov.uk/). At the level below Greater London, there are 33 local authorities, known as the London Boroughs (see: http://data.london.gov.uk/dataset/london-borough-profiles). Transport for London (TfL) is the administrative unit responsible for most aspects of transport in London (see: www.tfl.gov.uk), and has, through predecessor organisations, been largely stable over the CREATE period of interest. There has been no equivalent transport authority for the peri-urban area.

Greater London is conventionally regarded as being divisible into three concentric 'functional areas'. These are:

- Central London. An area of high-density commercial land use comprising around 2 per cent of the Greater London land area.
- Inner London. An area of generally high-density residential and commercial development.
- Outer London. An area of lower-density residential and commercial development, distinguished by significant areas of open space and a close functional relationship with major satellite towns within the Greater London area – for example Kingston and Croydon.

There are several different definitions of these areas in common use, particularly relating to the definition of central London. However, for CREATE purposes, and given that central London is completely contained within CREATE Zone 1, the definition of inner London based on boroughs is used (see Appendix 1). CREATE Zone 1 therefore includes both central and inner London boroughs (319 square kilometres). CREATE Zone 2 is identical to the administrative unit of Outer London, again based on boroughs (1,253 square kilometres).

The 'inner' peri-urban area (CRAETE Zone 3) is comprised of a selection of local authorities surrounding London, defined by local government districts (having many of the characteristics of London boroughs) in which at least 10 per cent of residents commute to Greater London (based on the UK Census of Population). This is therefore a 'functional' definition and is identical to that used for the Four World Cities Transport Study (*Focas et al, London Research Centre, 1999).* A map of these areas is shown below (Figure 3.1.1 (a)).

The 'outer' peri-urban area comprises the administrative unit known as the South East of England. This is defined on the basis of English counties (Berkshire, Buckinghamshire, East and West Sussex, Hampshire, Isle of Wight, Kent, Oxfordshire and Surrey). This is a bigger area, and is included to reflect the available level of resolution of certain data. The local authorities comprising the peri-urban area are tabulated in Appendix 1. The total size of the peri-urban area is 19,096 square kilometres, which includes the land area for CREATE Zones 1 and 2 (above).

Figure 3.1.1 (a): CREATE study areas for London.

Practical implications of CREATE zoning structure for analysis

The zonal definition described above is most suitable for CREATE purposes, as it reflects the key structural, administrative and functional differences between the key areas. In practice, however, there are no 'hard' boundaries and therefore one area grades gradually into another. The peri-urban area in addition contains some substantial towns in their own right – many of which have above the defined threshold of residents commuting to London.

A key practical implication is the difference in data availability. Since 2000, most transport within CREATE zones 1 and 2 have been managed by TfL, and consistent data are generally available for this period (the key exception to this is National (surface) Rail. In particular, TfL has operated, since 2005, a rolling household-based travel behaviour survey of London residents (the London Travel Demand Survey – LTDS). Data are less good relating to the administrative structure before 2000, although historic equivalent data are available for many of the aspects considered by this report.

Data for the peri-urban area are however poor – particularly relating to transport supply and economic conditions. This reflects the historic lack of a central unified authority covering transport in these areas. The only practical source of consistent travel behaviour data for this area arises from the UK's National Travel Survey (NTS) – a diary-based survey of the travel behaviour of households. This provides a consistent view of trends over the last 20 years or so. It is however limited in terms of the available sample size (generally, three-year moving average values are used to overcome this), as well as some methodological inconsistencies with the equivalent survey in Greater London. Furthermore, the heterogeneity of the peri-urban area (mixed urban and rural) means that average values across this area are of limited use analytically.

Relevance to travel trends

Although the above details are mainly offered for descriptive context, it is important at this stage to highlight some key dimensions of their influence on travel patterns in London.

- The first point is the pattern of lower densities with increasing distance from central London. Associated patterns of lower public transport provision, and higher car ownership and use, are highly relevant to explaining travel trends and are illustrated throughout this report.
- A second point is the influence of the 'Green Belt' (a zone in which development is strictly controlled) immediately surrounding Greater London. This has limited the scope of London to 'sprawl', and has favoured secondary development well outside the GLA in a series of 'satellite' towns, such as Reading, which characteristically have high levels of commuting into London. The M25 orbital motorway, completed in the late 1980s, passes generally on the inside of the Green belt, and is a key structural feature affecting road traffic patterns.
- A third point is the administrative discontinuity between Greater London and the peri-urban area. Whilst, for most of the period considered by CREATE, London has had a strong centralised transport authority, able to plan initiatives on a city-wide basis (TfL currently, and the Greater London Authority/London Transport before that), this has never been the case for the peri-urban area. Combined with the lower densities and primarily radial orientation of the key transport networks, this has meant that transport provision, travel behaviour and the perception of 'need' for transport developments has been fundamentally different to that applying in the GLA area itself. A key policy difference has been the deregulation of the bus network outside London, effective from the early 1980s, compared to the essentially 'regulated' situation within London (the growth of the bus network in London has been a significant factor contributing to changes in mode share).
- A fourth point is that the distinctions of central, inner and outer London are not very significant in terms of city administration and transport policy within CREATE Zones 1 and 2. They are formed of relatively loose groupings of boroughs. To the extent that transport provision and travel trends differ, this is much more a reflection of structural factors such as density, which in turn influences transport provision, than of administrative boundaries or of general London transport policy.

3.1.2 Land use

General comments

London is an established capital city and land use patterns and the relatively slow pace of change reflect that. These land use distinctions provide the basic backdrop in terms of trip 'productions' and 'attractions', with prevailing commuter movements towards the centre, and outwards again, in the weekday peak periods. The basic city structure is therefore fundamental to explaining travel patterns and trends. However, change is relatively slow overall, although locally significant, and therefore land use change is very much a secondary explanatory factor of change at the London wide scale.

Land use structure and change

Whilst sophisticated GIS datasets describing and mapping land use exist for the contemporary situation, the available historic data is very limited. For the purpose of this analysis, we compare the situation in 1971 (a year for which there is good data) with that of 2016. Equivalent data for the peri-urban area are not available. Figure 3.1.2 (a) below gives a 'top-level' comparison of the main land use categories (both columns add to 100 per cent of all land uses). This is because the definitions used are not identical between 1971 and 2016. A more disaggregate breakdown of these categories is given in Appendix 2.

Table 3.1.2 (a). Top-level comparison of land use in Greater London – 1971 and 2016 compared

Land use type	1971 hectares	1971 per cent	2016 hectares	2016 per cent
Settlement – residential	54,119	33.8	58,512	36.5
Settlement – commercial/industrial/services	22,989	14.4	21,790	13.7
Recreation, leisure, agricultural, semi natural, forest and water	59,189	36.3	54,409	33.9
Transport infrastructure	24,795	15.5	25,525	15.9
Total all land uses	**160,092**	**100.0**	**160,236**	**100.0**

Source: Annual Abstract of Greater London Statistics (1971) and GLA London Datastore (2016: http://data.london.gov.uk/.

This aggregate breakdown is however quite adequate to illustrate the main trends:

- The proportions of the key land uses have changed little over this 45 year comparison period.
- There has been a modest increase in the proportion of the land area occupied by residences. There has been a largely-corresponding reduction in the amount of open space, natural or non-commercial land uses.
- The amount of land covered by transport infrastructure is, effectively, identical between the two surveys.

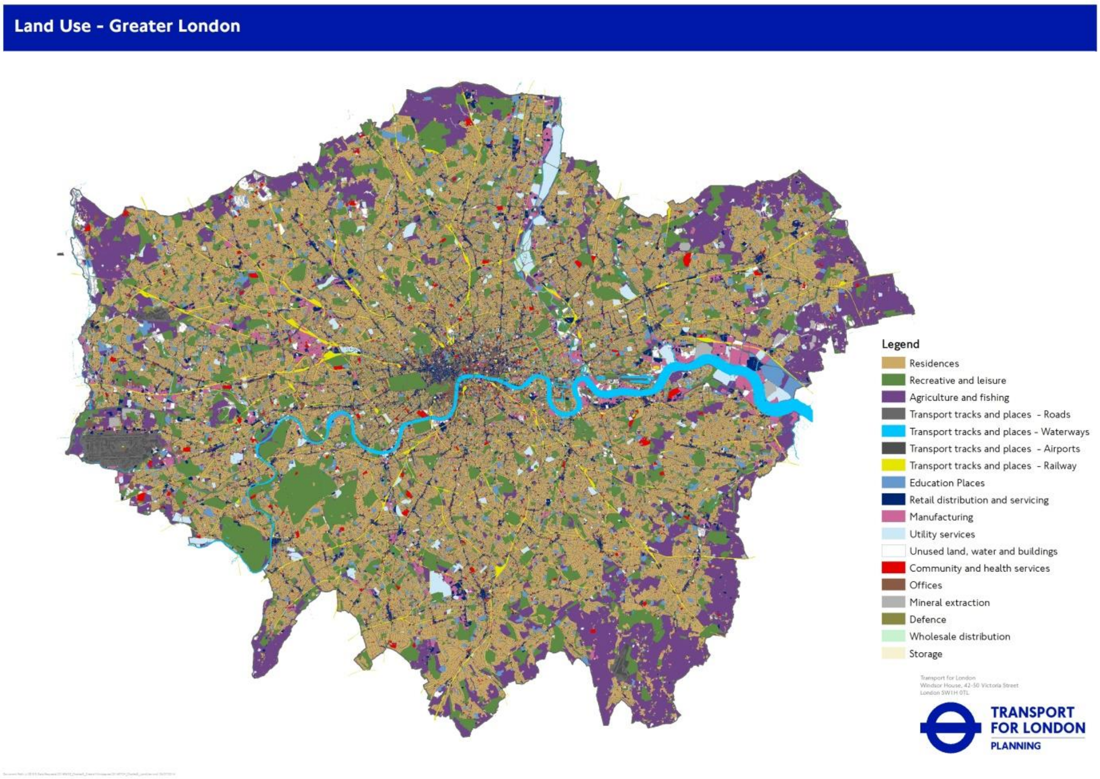
Relevance to travel trends

These top-level trends are intuitive, and reflect the development of London over this period, in the context of an already well-established city structure. However, at the top level they seem to offer little in terms of potential explanatory power. As will be illustrated in other parts of this report, it is not the top-level land use category changes themselves that are important in determining travel behaviour change; rather it is wider economic and cultural change that have affected the way these land uses generate and attract trips that are more important.

For example, the rise of home working depends little on the absolute number of homes, but on how they are used. Similarly for retail – there was no Internet in the 1970s ! The importance of the land use mix is therefore much more relevant to explaining changes of scale between the CREATE cities than explaining change within each city, Locally, however, land use change has been very significant. The complete transformation of the London Docklands from the late 1980s is the most obvious example, although this would be hard to specifically detect in any 'London-wide' (ie CREATE Zones 1 and 2 combined) trends. Whilst very significant locally in land use terms, and much more widely in terms of trip generation and attraction, the areas involved are very small in the context of the overall land area of Greater London.

Figure 3.1.2 (b) below shows the pattern of land use cover for Greater London in 2016. The image itself is of little practical use, but the GIS dataset underlying it is available for more detailed analysis if required. There are, unfortunately, no historic data of comparable detail for London, and data for the peri-urban area are not readily available.

Figure 3.1.2 (b): Overall pattern of land use in Greater London in 2016.



Source: GLA London Datastore.

3.2 Demographics and economy

3.2.1 Population development

General points

Demographic trends have been a very important factor influencing travel patterns in London over the CREATE period. There are several distinct types of demographic trend that would be regarded as important:

- Absolute numbers of people.
- Population composition (age, gender, ethnicity) and, crucially, wider cultural and societal factors that differentially affect particular groups within the population.
- Arrangement of population spatially and in households.

Each of these is addressed in turn below.

Change in absolute level of population – CREATE Zones 1 and 2

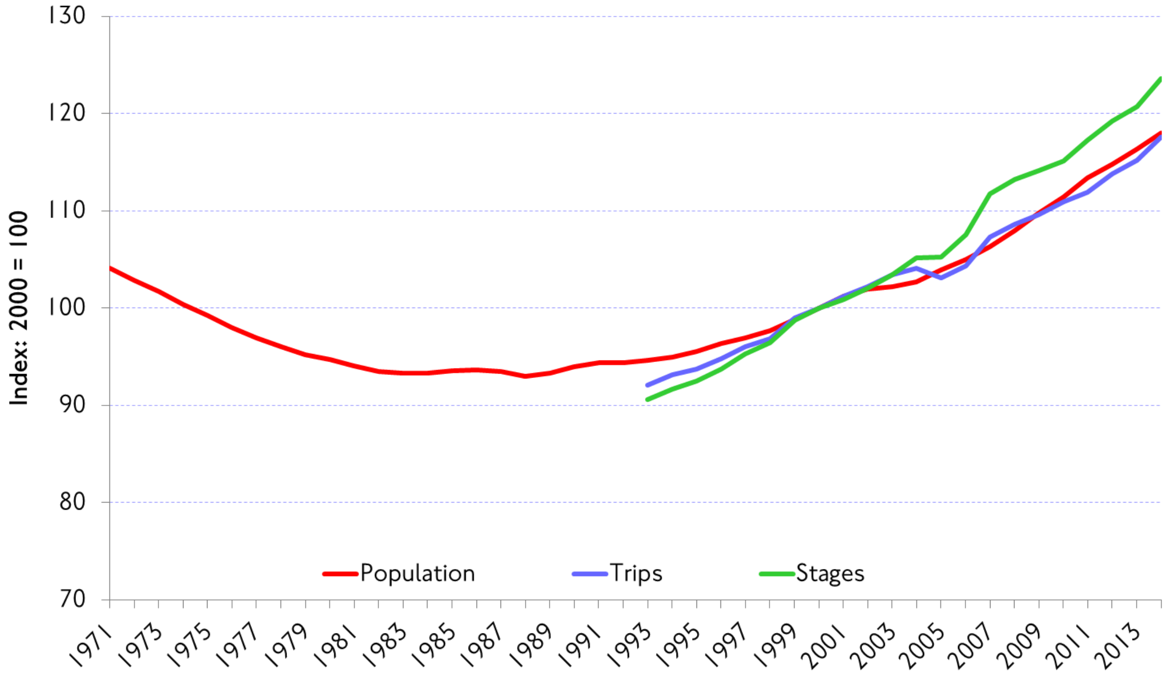
Looking first at Greater London (CREATE Zones 1 and 2 combined), Figure 3.2.1 (a) shows the trend in resident population since 1971. The basic pattern is that of a ‘U’ shaped curve – population declined for much of the period up to the mid-1980s, primarily a result of decentralisation policies and the ‘decline’ of the established inner city areas. This process was reversed – regeneration initiatives coupled with the increasing economic success of London, making it more attractive to migrants, have resulted in a sustained increase from the mid-1980s to date. This trend is projected to continue – at least up to 2041 – at a broadly similar rate. Accommodating the growth in travel demand that will arise from this population increase is a major current policy preoccupation in London (highly relevant to potential CREATE Stage 4 conditions). In terms of basic numbers (CREATE Zones 1 and 2 combined):

- The historic 'high point' for London's population was 1939, at 8.60 million people.
- The recent 'low point' was in 1988, at 6.75 million people
- The current (2015) population is also 8.60 million - comparable to the historic high point.
- Projections of London's population to 2041 suggest around 10.4 million people. This growth is equivalent to adding the population of two substantial UK regional cities – Birmingham and Glasgow – to London between now and 2041. Such population growth would lead to around 5.5 million additional trips per day by London residents. This graphically illustrates the scale of the transport challenge that this growth implies.

Basic relationship of population to travel demand – CREATE Zones 1 and 2

At a simplistic level it is possible to look at the relationship between population and basic travel demand, over the period since the early 1990s for which comparable data is available. This is a crude comparison, because total travel demand reflects trips by non-London residents and it takes no account of changes to the structure and characteristics of the population, which have been significant (see section also below), but it is of value, particularly as, by including different views of total travel (ie trips and journey stages), it illustrates some interesting trends in terms of the structure of trips (Figure 3.2.1 (a)).

Figure 3.2.1 (a): Basic population trend for Greater London, showing relationship to indicators of total travel demand.



Source: Transport for London

The generally close relationship between resident population and travel demand since the early 1990s suggests, as would be expected, that the size of the resident population has been a major explanatory factor affecting the volume of travel demand over the CREATE period. In connection with this, it is notable, as shown in section 6 below, that overall trip rates and time spent travelling have been relatively stable over the limited period for which comparable data are available. By increasing the supply of public transport, London has been able to accommodate this population growth whilst simultaneously achieving a substantial shift in mode share away from the private car.

In terms of the distinction between trips and journey stages (a trip is a one-way movement to achieve a specific purpose, a journey stage is a component of that trip, relating to a specific transport mode), it is seen that the number of journey stages have increased at a faster proportionate rate compared to the number of trips. This is primarily a function of the change in mode share towards more trips being made by public transport. Car-based trips are almost always single-stage, whereas public transport trips are almost always multi-stage.

Table 3.2.1 (b) shows absolute population numbers for CREATE Zones 1 and 2 since 1971 at decennial intervals. More detailed breakdowns of population by area are available on request.

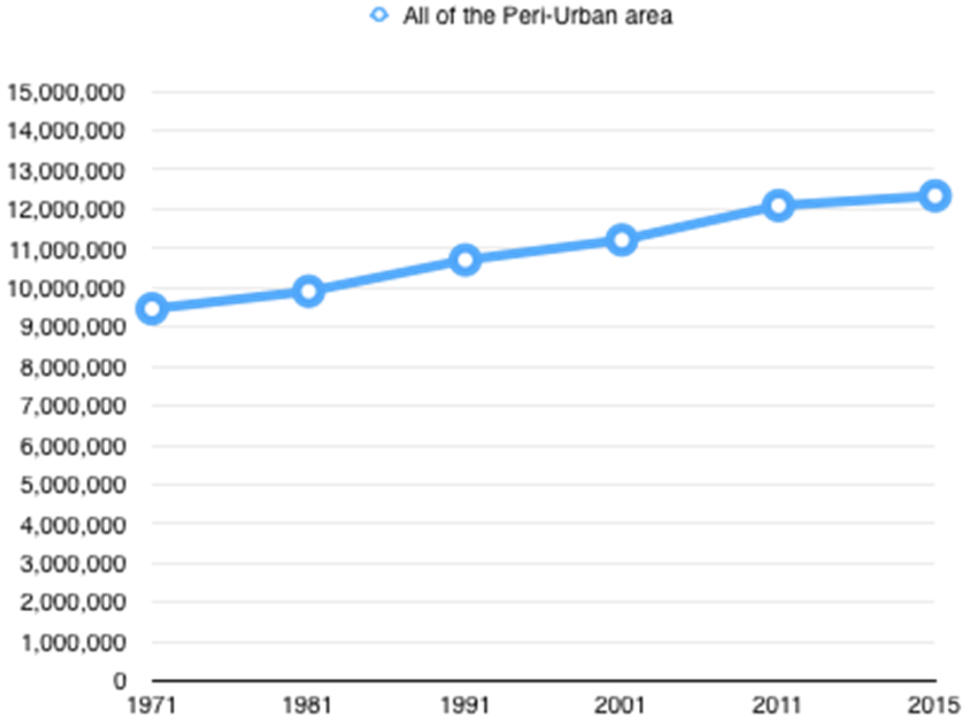
Table 3.2.1 (b): Absolute population trend for CREATE Zones 1 and 2. 1971 to 2014.

Year	Zone 1	Zone 2
1971	3,059,700	4,469,700
1981	2,550,100	4,255,400
1991	2,599,300	4,230,000
2001	2,859,400	4,463,000
2011	3,241,100	4,963,300
2012	3,285,000	5,023,400
2013	3,335,400	5,081,100
2014	3,395,700	5,143,000

Peri-urban area

The population of the peri-urban area (in this case both inner and outer peri-urban areas combined) has grown continuously over the CREATE period (Figure 3.2.1 (c)). It is reasonable to assume that future population growth in this area will be on a similar trend to that for CREATE Zones 1 and 2.

Figure 3.2.1 (c). Total resident population of the peri-urban area (inner and outer peri-urban areas combined).



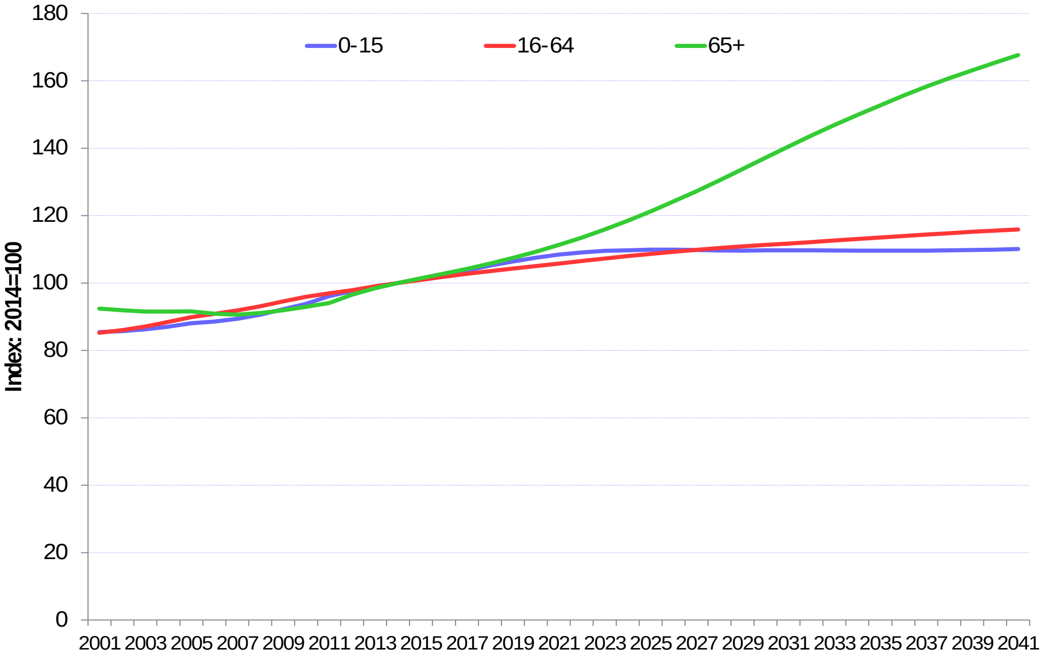
Source: UK Census of Population.

<u>Looking to the future</u>

Looking to the future, 'reducing the need to travel', for example through co-location of residential and employment land-uses, and initiatives such as home-working, are likely to be major features of policy as London seeks to accommodate the expected future population growth. Although it is not yet clear in the available survey data, future conditions in London might see significant reductions in trip rates per person, as the city becomes increasingly dense, as co-location of developments act to reduce the need to travel. Increasing leisure time and factors such as increasing use of home delivery services (eg for internet shopping) would however be factors tending to act in the opposite direction.

The following two figures illustrate TfL's latest thinking on population and travel demand growth to 2031. Briefly, in Figure 3.2.1 (d), London's total population is expected to continue to grow steadily – reaching an expected 10.4 million people by 2041. The components of this increase are not equal however. Growth will disproportionately occur in the older age groups, partly as the 'baby boom' generation ages. The number of London residents aged 65 and over is expected to be 68 per cent higher in 2041 than in 2014 – a major shift that has significant implications for future transport provision in terms of factors such as total travel demand, mode share, and the times of day that people travel.

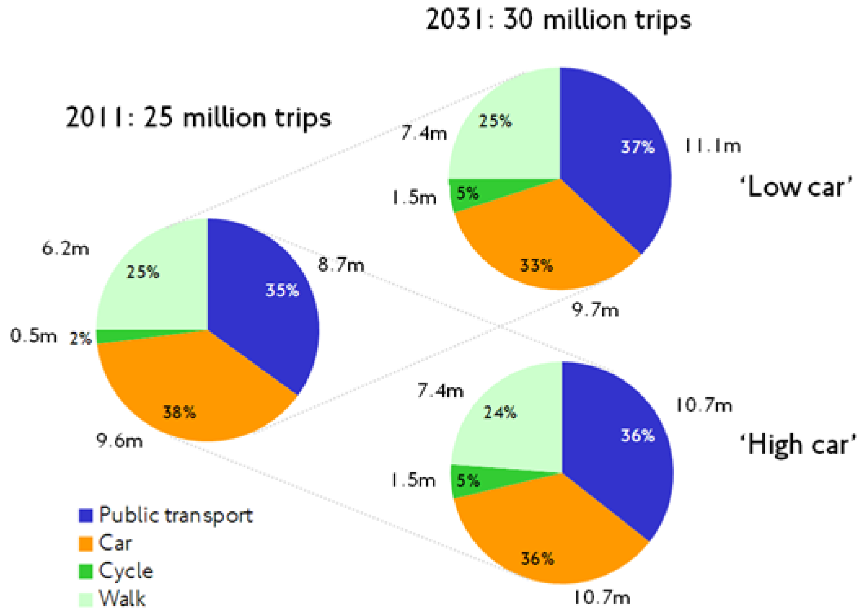
Figure 3.2.1 (d). Population change by age group 2001-2041. TfL/GLA projections (index based on 2014).



Source: Transport for London.

In terms of how this population change is expected to affect travel demand, Figure 3.2.1 (e) shows two complementary scenarios. An expected 30 million trips per day is common to both (up from 25 million in 2011). However, to reflect uncertainty around future car demand trends, TfL has developed scenarios based on differing assumptions – a ‘high car’ scenario, where growth in car use is assumed to broadly follow national projected trends, and a ‘low car’ scenario, where growth is based on actual historic trends observed in London. The idea is that potential future infrastructure schemes can be assessed against both scenarios to give a more informed basis for decision. As would be expected, the mode share of car trips is lower in the ‘low car’ scenario – but, importantly, both scenarios have a lower car mode share than 2011.

Figure 3.2.1 (e). Projected trip growth to 2031 – 'high' and 'low' car scenarios compared. CREATE Zones 1 and 2 combined.



Source: Transport for London, Strategic Analysis.

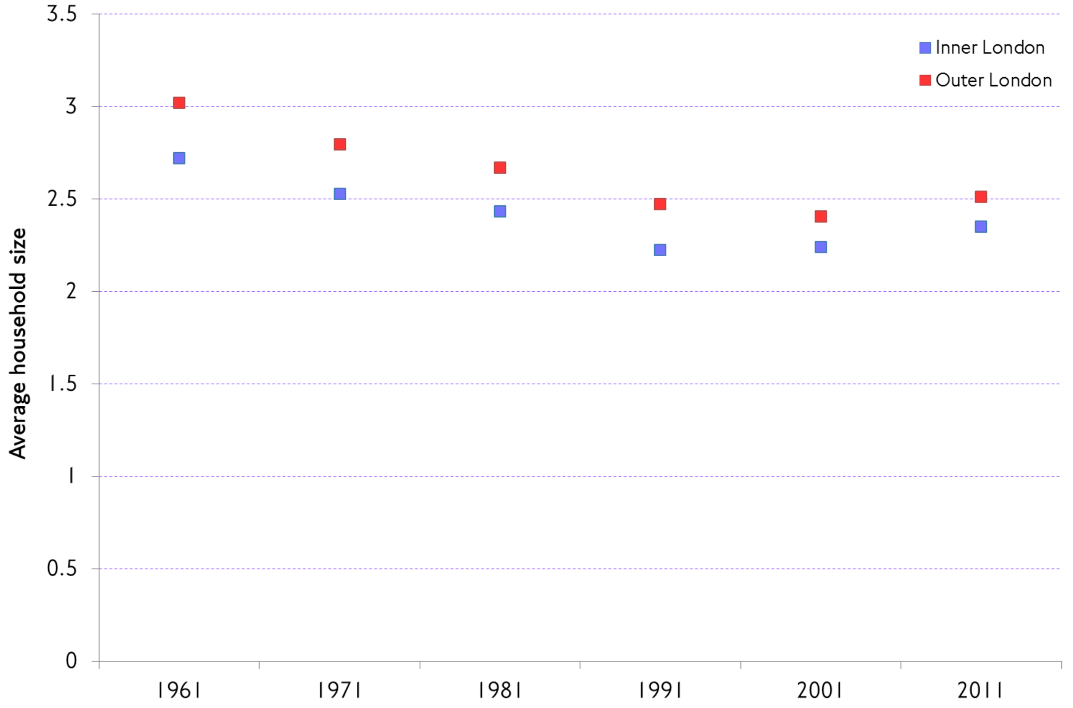
3.2.2 Household size

<u>Household size in CREATE Zones 1 and 2</u>

The trend for household size in CREATE Zones 1 and 2 is one of a steady decline over the early part of the period covered by CREATE, with a recent increase in average household size. The early decline reflects factors such as increasing affluence and wider social changes such as delayed marriage and increased labour mobility leading to the formation of more single-person households. Although there is a persistent difference in scale between inner and outer London, the overall trend has been very similar in both areas.

The more recent trend towards larger average household size is primarily thought to reflect the substantially increased cost of housing, an increase in migration with different family structures, and the tendency of younger people to remain living in the family home for longer than previously, reflecting housing cost increase. A further factor to be taken into account – perhaps more significant for the future – is the decreasing actual size of houses (in terms of space provision), which in the figure would tend to dampen the rate of increase in household size. This is an important consideration for potential explanatory variables – such as car ownership and income, which are traditionally enumerated on a per household basis, and suggests that overall population density is the more relevant indicator. This can be addressed in a quantitative analysis through normalisation against the household size variable. Figure 3.2.2 (a) shows the equivalent distribution of household sizes for inner and outer London.

Figure 3.2.2 (a): Average household size in inner and outer London (CREATE Zones 1 and 2).



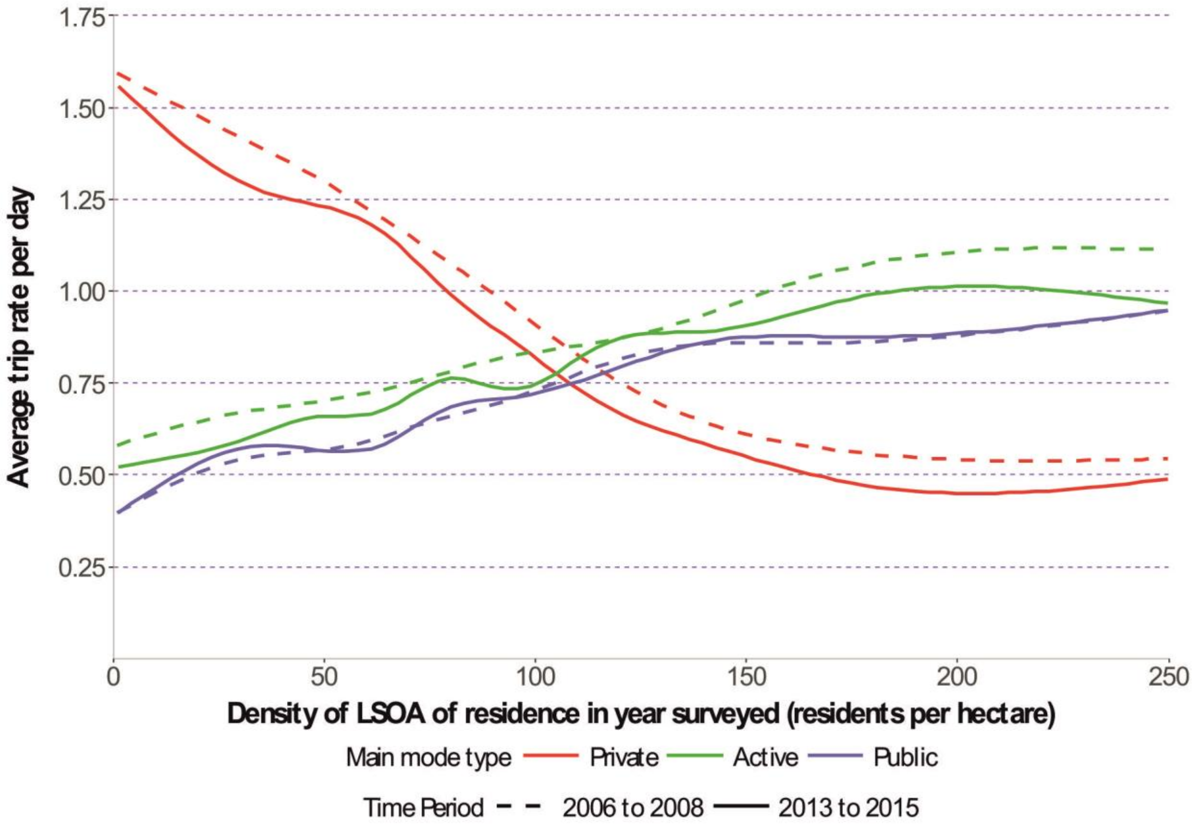
Source: United Kingdom Census of Population.

<u>Population density is a better explanator of travel trends</u>

Another way of looking at this is the relationship between population density and travel. However, density is correlated with many other aspects that also influence travel, for example, lower car ownership, greater public transport supply, and so any quantitative analysis of density needs to take these correlated variables into account.

Figure 3.2.2 (b) shows the relationship between density (in terms of persons per hectare) and share of trips made by the main travel modes. Clearly, density and all of its correlates (such as public transport provision and availability of parking space) are powerful factors influencing travel behaviour.

Figure 3.2.2 (b): Relationship of density (persons per hectare) to average trip rate by the principal travel modes. CREATE Zones 1 and 2 combined.



Source: Transport for London Strategic Analysis.

Future impacts of increasing densification in CREATE Zones 1 and 2

In simple terms, therefore, population density (and its correlates) is closely related to rates of travel demand by car. As London's population continues to increase, levels of density will also continue to increase. Assuming that the provision of public transport continues to broadly keep pace with population growth, and that other factors, such as increased co-location of home and workplaces, act to moderate travel demand, increasing density should act as a good predictor – at a spatially disaggregate level - of car travel rates per head in the future. TfL can provide further details of its work on this aspect if required. For most of the peri-urban area, however, density *per se* does not act as a significant constraint on car ownership and use.

3.2.3 Population characteristics – gender, age and ethnicity

General considerations

Within the broader context of overall population trends as described above, the population of London has also undergone several significant 'structural' changes over the CREATE period that have influenced travel patterns. It is not the change in population composition itself that is significant. Rather, it is that different groups have different travel demand patterns. Therefore, to the extent that the representation of particular groups changes, so will the associated travel patterns. There are at least three subtly different manifestations of this phenomenon, as illustrated below.

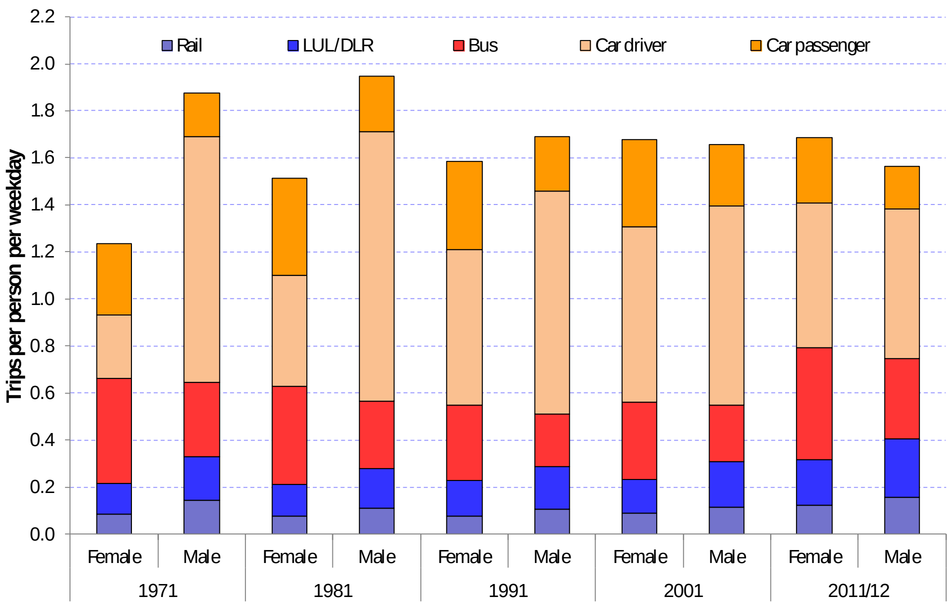
- For example, increasing numbers of older people would tend to lead to lower per capita travel demand and a general absence of work-related trips, which are usually made in the peak hours for example. This is an illustration of a 'direct' effect and reflects the fact that, due primarily to lower economic participation, older people tend to travel less than the average for the general population.
- A more 'indirect' effect is illustrated by the impact of increasing numbers of young people. So, the recent trend of increasing migration of younger people to London, reflecting economic opportunity, has been focused on the inner, denser, areas of the city. This, in turn, reflects housing availability and cost and also the availability of cultural attractions. In turn, close proximity to work/leisure and lifestyles increasingly dominated by technology might be expected to lead to lower overall trip rates and, in particular, car ownership per person. So, younger people tend to have higher trip rates, but their socio-economic situation means that these trips are structurally distinct from that of the overall population.
- A third type of effect, perhaps best characterised as a 'static' effect, is illustrated by the increasing economic participation of women over the CREATE period. The proportion of women in the population has of course been broadly stable – but average trip rates among women have grown substantially owing to wider societal changes affecting this group.

In this way, the basic relationship between total population and travel demand illustrated above is seen to be a considerable simplification of reality. The material below explores several dimensions of these relationships, in terms of developments relating to CREATE Zones 1 and 2.

<u>Gender and travel</u>

Over the CREATE period, the trip rate of women has markedly increased, particularly over the period 1971-1991, as participation of women in the workforce increased. Interestingly, the amount of travel undertaken by men decreased, to a largely corresponding degree (Figure 3.2.3 (a)). There have been related changes in mode share, with, for example, the proportion of car trips made by males decreasing, with an initial growth in relative car use by women, which then decreased over the more recent decades.

Figure 3.2.3 (a). Trips per person per day (average trip rate) by gender and main mode. Decennial London travel surveys 1971-2011. CREATE Zones 1 and 2 only.

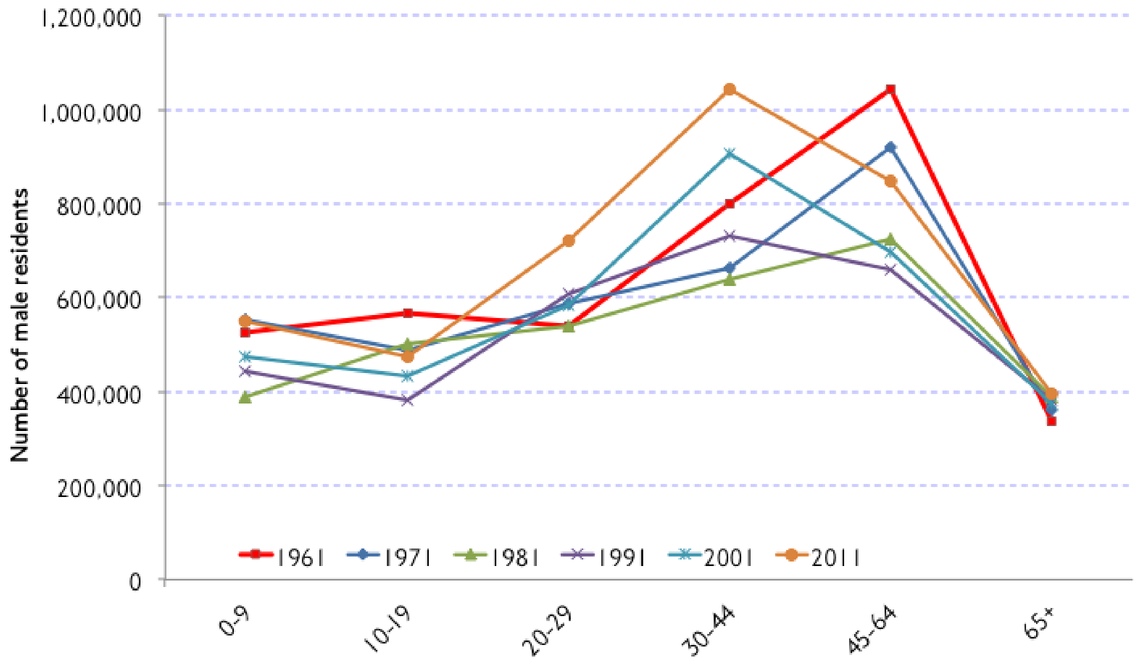


Source: Transport for London. LTDS and predecessor travel surveys.

Age distribution of population

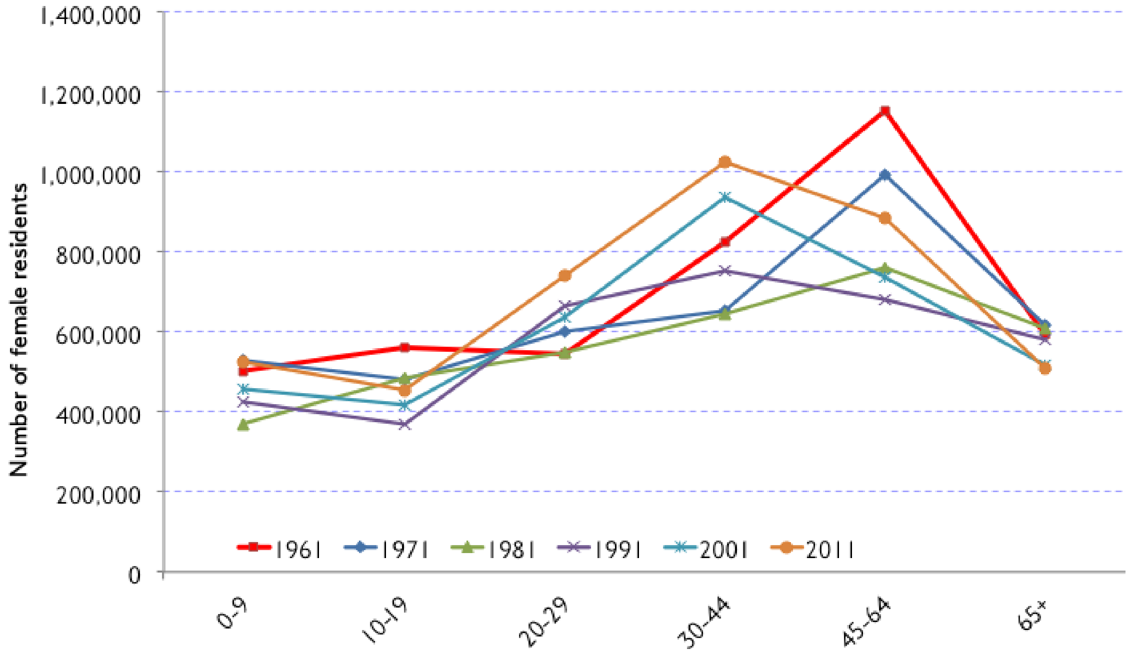
Looking at the age distribution of the population historically, the overall trend was for a progressively younger overall population over the early part of the CREATE period. This has reversed more recently with the population of London becoming increasingly older on average. However, the number of very old people has not increased. These changes in the relative structure of the population need to be seen in the context of the overall population trend, which declined over the early part of the CREATE period. These age-related patterns have been broadly similar for men and women (Figures 3.2.3 (b) and 3.2.3 (c)).

Figure 3.2.3 (b): Greater London population – age distribution for men. CREATE Zones 1 and 2 only combined.



Source: United Kingdom Census of Population.

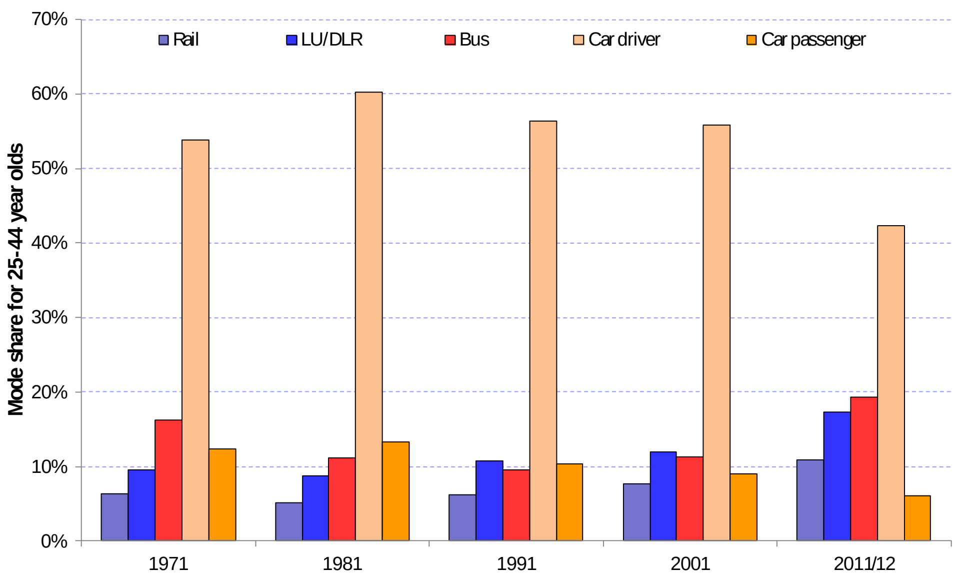
Figure 3.2.3 (c): Greater London population – age distribution for women. CREATE Zones 1 and 2 only combined.

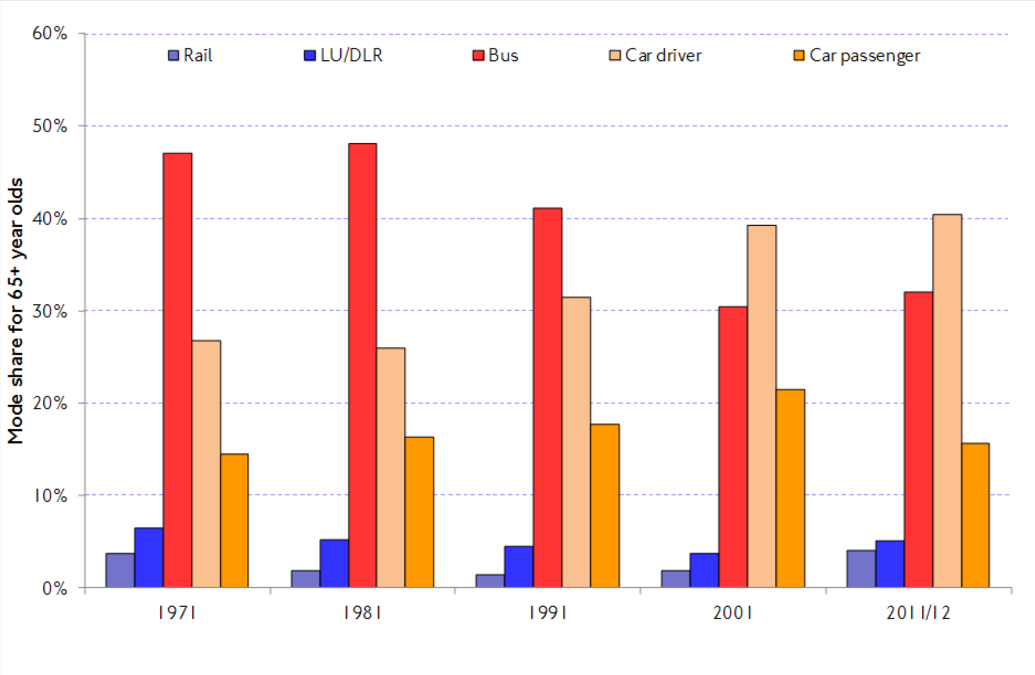


Source: United Kingdom Census of Population.

Figure 3.2.3 (d) shows relative mode shares for two distinct age groups. There are clear distinctions between the groups, for example with older people much more likely to use the bus. This illustrates how changes to the relative prevalence of different age groups can affect overall travel patterns.

Figure 3.2.3 (d). An illustration of the implications of changes to the age structure of the population for travel behaviour. Mode share trends for persons of younger working age and mode shares for people aged 65+. London residents. CREATE Zones 1 and 2 only combined.





Source: Transport for London. LTDS and predecessor travel surveys.

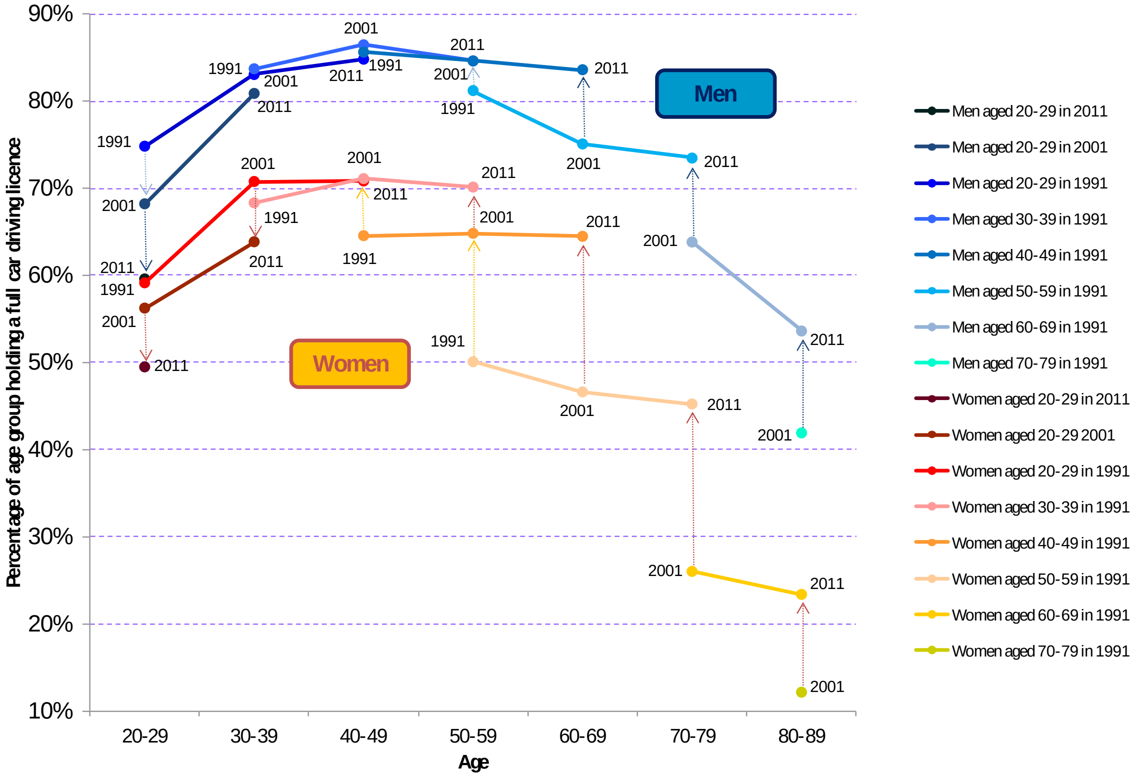
Longitudinal or 'cohort-based' change – the example of driving licence holding

A different approach to looking at age-related change in travel behaviour is to consider the same particular group of people, for example those born in the 1980s, and observe how their behaviour changes 'longitudinally' over their lifetimes. Figure 3.2.3 (e) shows both cross-sectional and longitudinal trends for car driver licence holding amongst London residents, with the lines joining points that represent the same cohort over time, and the arrows indicating the change in cross-sectional behaviour between one cohort and the next.

The section on the right of the chart shows that licence holding increased from one cohort to the next for Londoners who were in the 50-59 age group or older in 1991. This represents car use becoming more prevalent over the decades in the post-war period. There is then a period where each cohort behaves similarly to its predecessor, with little difference in the cross-sectional points for Londoners who were aged between 20 and 40 in 1991. Licence holding had therefore stabilised by this time, suggesting the process of car use becoming 'normal' had finished. Finally, on the left side of the chart, the trend of increasing licence holding from one cohort to the next is reversed. Since 1991, each successive cohort of Londoners has had a lower rate of licence holding while in their 20s.

The decline in licence holding amongst the youngest generations of Londoners potentially has significant implications for future travel demand. If these groups maintain their lower level of licence holding as they age, car trip rates per person could fall in future, resulting in a continuation of the divergence between population growth and the volume of car travel. This aspect of travel behaviour change in London (by cohort) is explored fully in http://content.tfl.gov.uk/long-term-trends-in-travel-behaviour-cross-sectional-cohort-analysis.pdf.

Figure 3.2.3 (e): Car driver licence holding by age-cohort groups (1991, 2001 and 2011). CREATE Zones 1 and 2 only combined.



Source: Transport for London. LTDS and predecessor travel surveys.

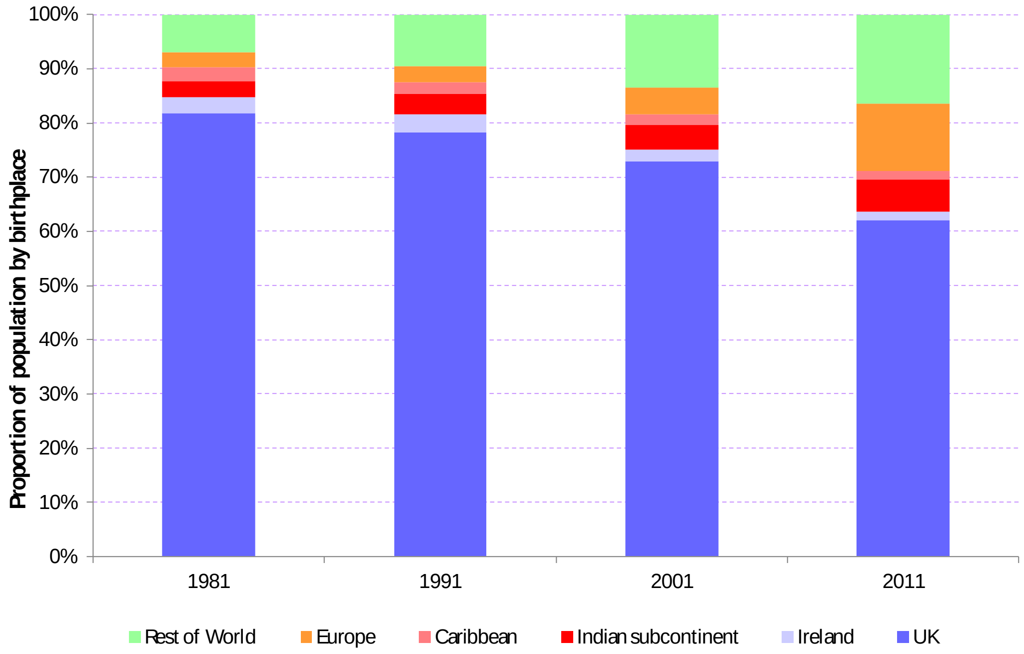
Further TfL assessment of the implications of these changes to London's population composition, and future expectation of how London's population will evolve in this respect, are considered in more detail in our Travel in London reports (volumes 6 and 8, see: https://tfl.gov.uk/corporate/publications-and-reports/travel-in-london-reports).

Ethnicity

There are recognised differences in travel behaviour between different ethnic groups, and the hypothesis has been advanced that changes to international migration patterns over recent decades underlie some of the trends seen in the aggregate travel demand data. For example, it is believed that more recent, younger migrants from the European Union are less likely to own and use cars than average for the total resident population. It is probable that these differences are not so much intrinsic properties of the ethnic groups themselves; rather that they reflect distinctive socio-demographic/socio-economic biases characteristic of these groups - such as distinctive age profiles, preferred residential locations, length of 'establishment' in the UK and types of employment undertaken.

Available data on place of birth and length of UK residence are insufficient to allow this to be analysed in detail. However, as Figure 3.2.3 (f) shows, recent decades have seen substantial increases in the proportion of London residents who were not UK born, with 38 per cent of residents born outside the UK in 2011, compared with 27 per cent in 2001 and 18 per cent in 1981.

Figure 3.2.3 (f). Proportion of London residents by country of birth, 1981-2011. CREATE Zones 1 and 2 only combined.

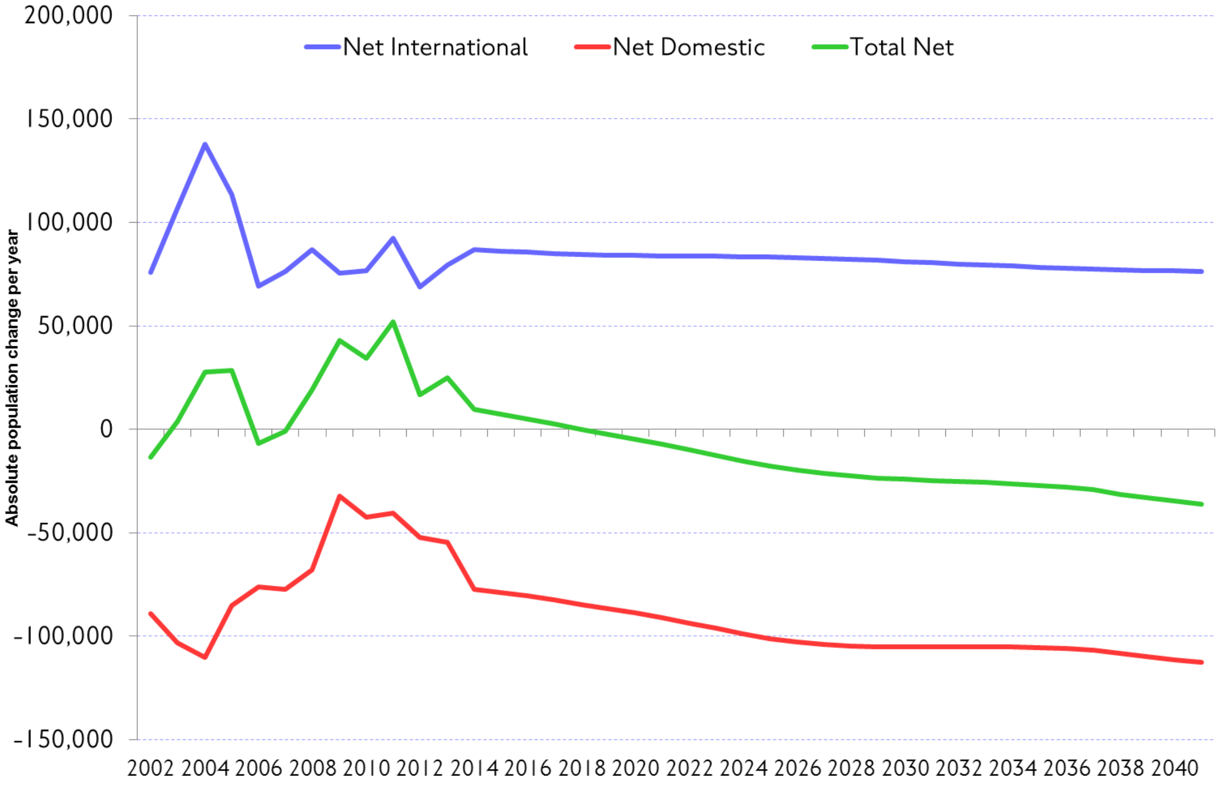


Source: United Kingdom Census of Population.

<u>The future</u>

Figure 3.2.3 (g) shows how this is expected to develop in the future in CREATE Zones 1 and 2. It shows that natural population change is forecast to overtake migration as a net contributor to overall growth. In other words, migration (both international and internal) will become relatively less significant as a driver of overall population change, and therefore the extent to which travel behaviour differences associated with migrants affect overall travel trends will diminish correspondingly.

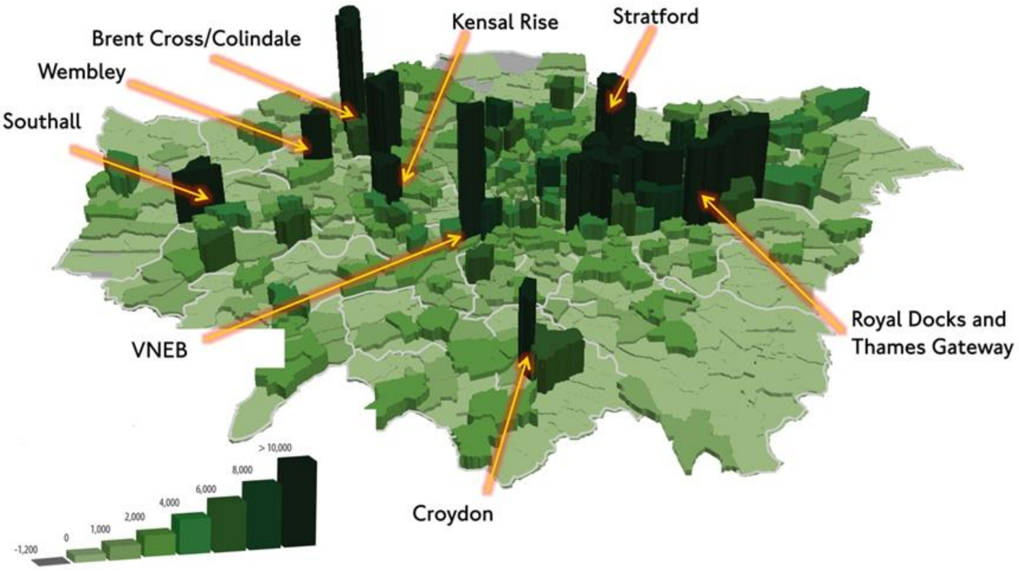
Figure 3.2.3 (g). Contribution of migration to population growth – 2002 to 2041 – absolute change. CREATE Zones 1 and 2 only combined.



Source: Greater London Authority.

Importantly, the large scale growth in London's population which is expected in the next three decades will be focused spatially on Opportunity and Intensification areas. These are areas of rapid and intense development, usually fulfilling a primarily 'regenerative' function. In these areas, a close mix of workplaces and residences, with excellent public transport links built in from the start, should help overall to minimise the need for car ownership and more general travel among the population that lives there (Figure 3.2.3 (h)).

Figure 3.2.3 (h). Projected population change to 2031 – biggest changes in London's Opportunity and Growth Areas. CREATE Zones 1 and 2.



Source: TfL Planning Strategic Analysis.

3.2.4 Education level of residents

Figure 3.2.4 (a) shows the highest qualification level for London's resident population of working age for a recent year. Half of London's working population is educated to degree level, whereas an additional 14 per cent are educated to A level/NVQ (National Vocation Qualification) level 3 – the minimum required for enrolment in a degree course. Historic data for this aspect are not readily available.

Table 3.2.4 (a): Highest qualification of working age population (aged 16-64), 2015. CREATE Zones 1 and 2 combined.

Degree level or above (NVQ level 4+)	50%
2 A Levels or equivalent (NVQ level 3)	14%
5+ GCSEs or equivalent (NVQ2)	11%
1-4 GCSEs or equivalent (NVQ1)	8%
Trade apprenticeships	1%
Vocational/work-related qualifications	9%
No qualifications	7%

Source: London Datastore (Greater London Authority).

Relevance to travel trends

It is not considered that this aspect has had a substantial impact on travel behaviour change *per se*. However, wider factors that are correlated with it, such as increasing affluence and changes to industrial structure, have been significant over the CREATE period and are dealt with elsewhere in this report.

3.2.5 Number of work places

Basic considerations and relevance to explaining travel trends

Employment is a key driver of travel demand – and as a successful and growing capital city, travel patterns in London are heavily influenced by the daily commute inwards/outwards to/from workplaces. In much the same way as it relates to overall population, the overall number of jobs will relate closely to the trend in aggregate travel demand. Business-related travel is also an important factor, both for employees in London, but also in terms of London's international relationships. London's role as a key employment centre has not fundamentally changed over the CREATE period, and therefore at the aggregate level change in these variables is not a good explanator of some of the more subtle trends in travel demand. Local changes in land-use and employment, for example as has been seen in the London Docklands area, have however been a very significant local-scale factor influencing travel demand, but are difficult to discern at the London-wide scale.

Workplace jobs in Greater London

Data are available for the total number of jobs within the Greater London area – CREATE Zones 1 and 2 (Figure 3.2.5 (a)). This is only available on a consistent basis since 1996. Data are not available for the peri-urban area (CREATE Zone 3), or separately for inner and outer London (CREATE Zones 1 and 2).

Some data for intermediate years only is available for the period before 1996. It is not known whether these earlier data are compatible with that for later years. The impact of the early 1990s recession is however clearly visible.

Figure 3.2.5 (a): Workplace jobs in Greater London – longer term trend. CREATE Zones 1 and 2 combined.

Source: London Datastore (Greater London Authority).

The future

Along with increasing and changing population, changes to the number and type of jobs in London are important factors to be taken into account in developing forecasts of future travel demand. It is estimated that there were 4.9 million jobs in London in 2011, with 3.0 million jobs located in central and inner London, and 1.9 million in outer London. Furthermore, there were 6.7 million workplaces in the East and South East Government Regions surrounding London.

Between 1992 and 2014 the number of jobs in London grew by over 1.6 million, and is currently estimated as 5.5 million. This has included several distinct growth periods, punctuated by economic slowdowns. Following the recession of the early 1990s, the number of jobs in London grew by 750,000 between 1992 and 2001. There was another slowdown in 2002, followed by a period of growth, until a further economic decline and fall in jobs in 2008 and 2009. Since then, job growth has been exceptionally strong. Between 2011 and 2014 the number of jobs in London grew by 640,000, an annual average of 4.2 per cent or more than 200,000 jobs per year. This recent strong growth compares with an average growth rate of 0.7 per cent or 29,000 jobs per year between 1984 and 2011.

The large increase in the number of jobs has been accompanied by a significant change in the structure of London's economy since the 1980s. The number of manufacturing jobs halved between the mid-1980s and mid mid-1990s, and then halved again by 2011. In contrast, the professional, real estate, scientific and technical services sector grew over this period, with jobs in this sector doubling between the 1980s and 2011. Since 2011 growth in this sector has been higher than other major sectors and much higher than the longer-term trend, growing by annual average rate of 7.3 per cent compared with an annual average of 3.0 per cent between 1984 and 2011.

Figure 3.2.5 (b): Projected growth in employment in London, 2011-2041. CREATE Zones 1 and 2 combined.

Source: TfL Planning, Strategic Analysis.

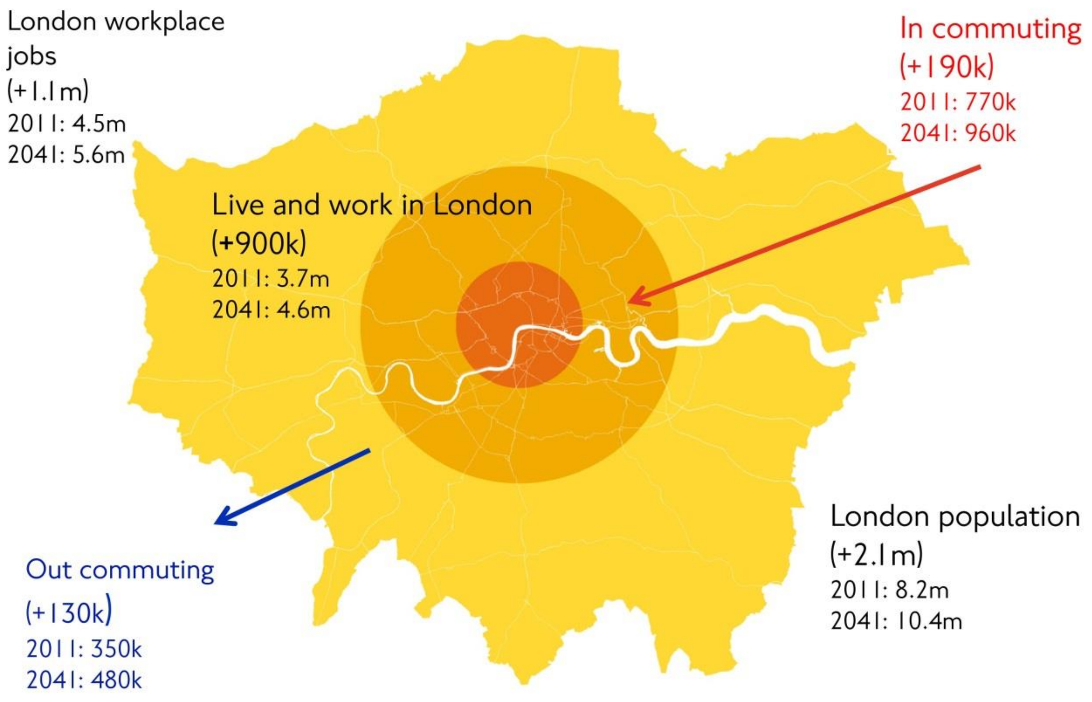
Projecting forward to 2041 (Figure 3.2.5(b)), the largest growth in employment will be in central and inner London. Narrowing the focus to 2031, London's Opportunity and Growth areas are expected to play a key role in supporting London's growth, with potential capacity to support nearly 600,000 jobs. In the east the Opportunity areas in the Isle of Dogs, Lower Lea Valley and the Royal Docks have total capacity for 200,000 jobs.

London's labour market balance

Jobs in London are taken up by London residents and by in-commuters from the areas around London. In turn, some London residents travel to jobs outside Greater London. It was estimated that, in 2011, about 800,000 people commuted into London on an average day from areas outside. Out-commuting was much less, at an estimated 350,000 people per day. The remaining 3.7 million workplace jobs in London were filled by those who also lived in London.

Relative changes in these components to 2031 will also affect future travel patterns in London, although the overall pattern is expected to remain similar to the present (Figure 3.2.5(c)). In-commuting is expected to increase in proportion to employment growth, with 900,000 in-commuters expected daily in 2031 (an increase of 17 per cent over 2011). Although the major share of new jobs will be taken up by London residents, it is clear that longer-distance commuting will continue to present capacity challenges that extend beyond the GLA area and particularly affect the National Rail network.

Figure 3.2.5 (c): London's changing labour market balance.



Source: Greater London Authority.

Potential alternative source of data

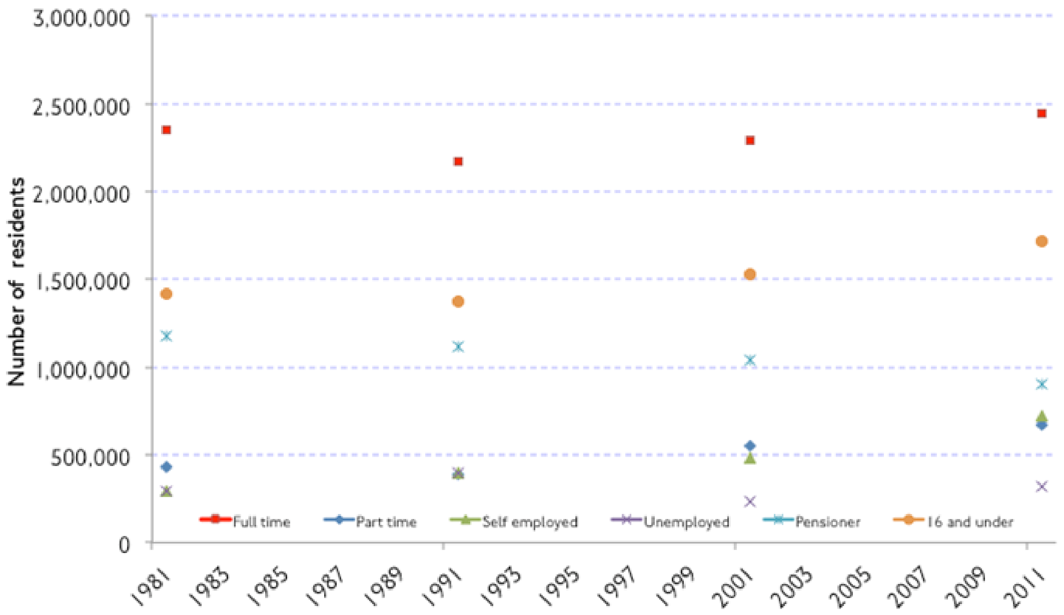
A more reliable and spatially-disaggregate source of these data, for 2001, 2011 and for various future projection scenarios, can be provided from TfL's strategic transport models. These related to trip productions and attractions, as well as trip origins and destinations. They are available in matrix format covering a system of approximately 1,000 zones. Importantly, these give indicative (synthetic) data for the peri-urban area (CREATE Zone 3) surrounding London, and also give future projection horizons. These can be provided on request.

3.2.6 Employment status of residents

Basic considerations

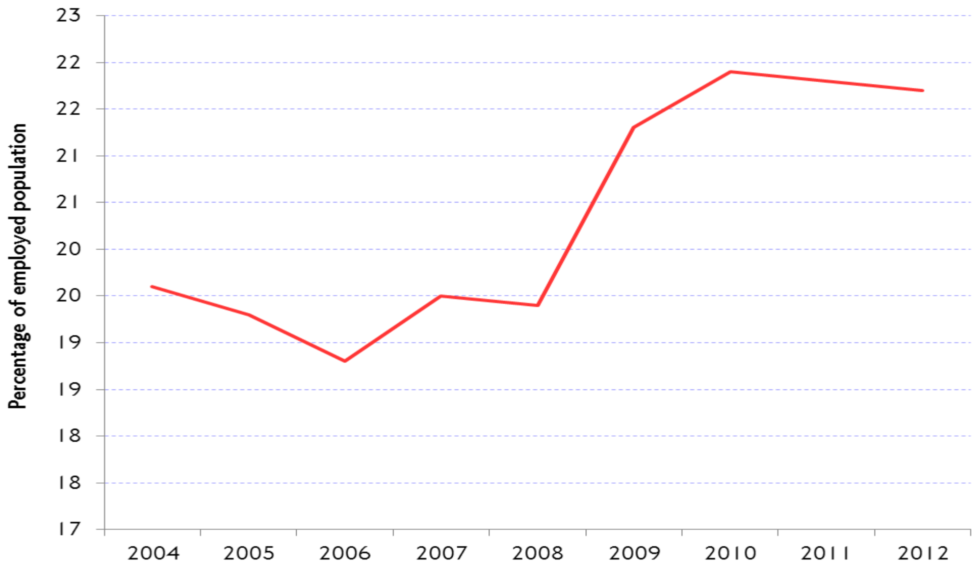
Figure 3.2.6 (a) shows the trend for the working status of London residents since 1981. The overall shape of the trend follows the trend for the resident population. Short-term deviations were caused but economic downturns – but the overall relationship is consistent. In terms of the significance for explaining travel trends, this statistic is of limited use. More recent data are available that may be analytically associated with shorter-term trends, making use of the discontinuity in the established trends caused by the 'financial' crisis from 2008. There are (a) the proportion of the population in full-time employment, which shows a progressive trend towards greater part-time employment (Figure 3.2.6 (b)) and (b) the trend of economic inactivity, which shows a fairly consistent decline in this indicator over the available review period (Figure 3.2.6 (c)).

Figure 3.2.6 (a): Working status of Greater London residents. CREATE Zones 1 and 2 combined.



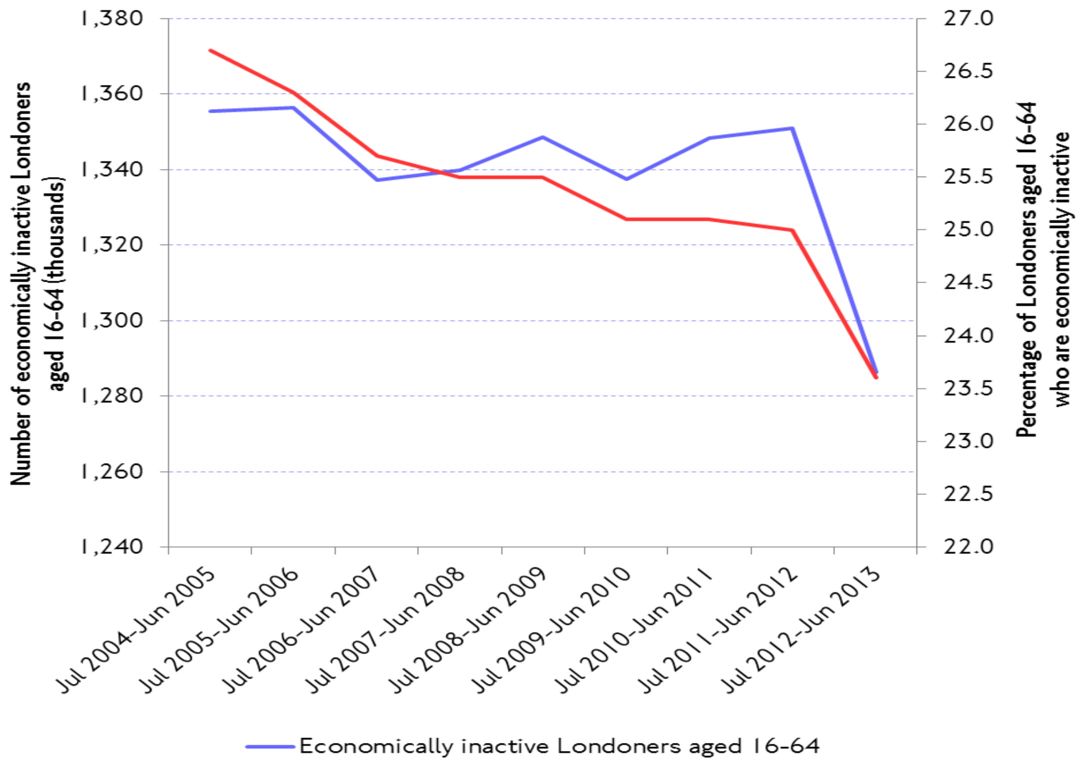
Source: United Kingdom Census of Population.

Figure 3.2.6 (b): Proportion of employed population in part-time employment for Greater London – CREATE Zones 1 and 2 combined.



Source: United Kingdom Office for National Statistics.

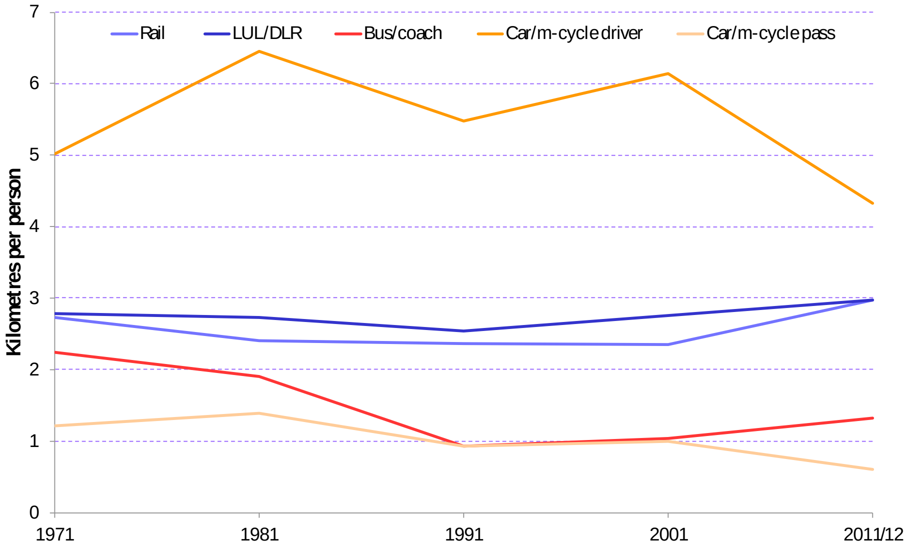
Figure 3.2.6 (c): Economic inactivity in London, 2005 – 2013. CREATE Zones 1 and 2 combined.



Source: United Kingdom Office for National Statistics.

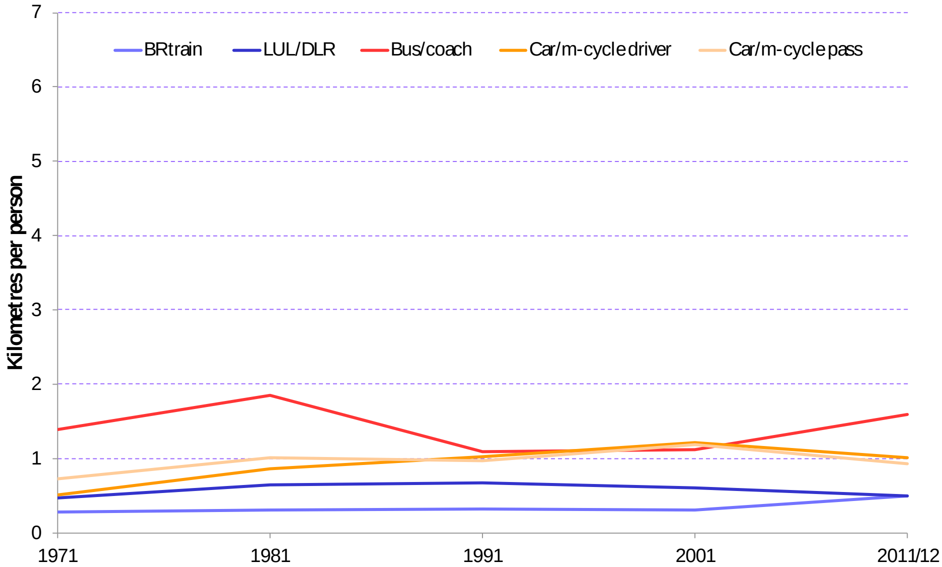
The impact of employment status on travel behaviour can be gauged from Figures 3.2.6 (d) and 3.2.6 (e) below. They show, for Greater London area residents (CREATE Zones 1 and 2 combined), how the average distance travelled relates to employment status, with clear distinctions between persons in employment and persons unemployed. They also show the historical development of this aspect. Note that (a) the travel distances relate to all trips, not just commute trips and (b) the nature of 'full time' work in London has changed significantly over the CREATE period, with a greater degree of home and informal working in the later years.

Figure 3.2.6 (d): Average distance travelled per person by mode (persons in full-time employment). CREATE Zones 1 and 2 combined.



Source: Transport for London. LTDS and predecessor travel surveys.

Figure 3.2.6 (e): Average distance travelled per person by mode (persons not in full-time employment). CREATE Zones 1 and 2 combined.

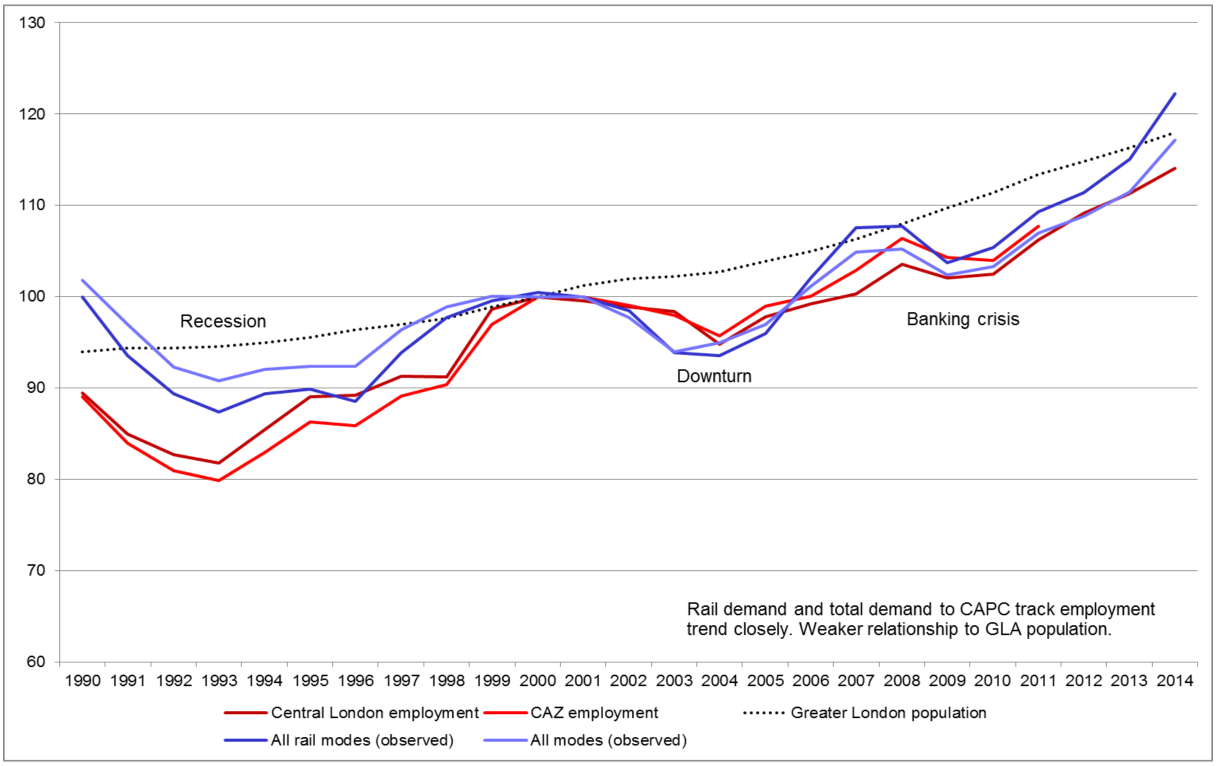


Source: Transport for London. LTDS and predecessor travel surveys.

Relevance to explaining travel trends

Within the overall context of London's established and continuing role as a major employer, and levels of travel demand that reflect that, short-term fluctuations in travel demand have been repeatedly observed relating to the economic cycle. Figure 3.2.6 (f) below illustrates the relationship between morning peak demand for travel to central London and the number of jobs in central London – a good example of the scale and nature of these short-run fluctuations in travel demand that reflect changing economic conditions.

Figure 3.2.6 (f): Relationship of demand for travel to central London in the weekday morning peak and the number of jobs in central London.

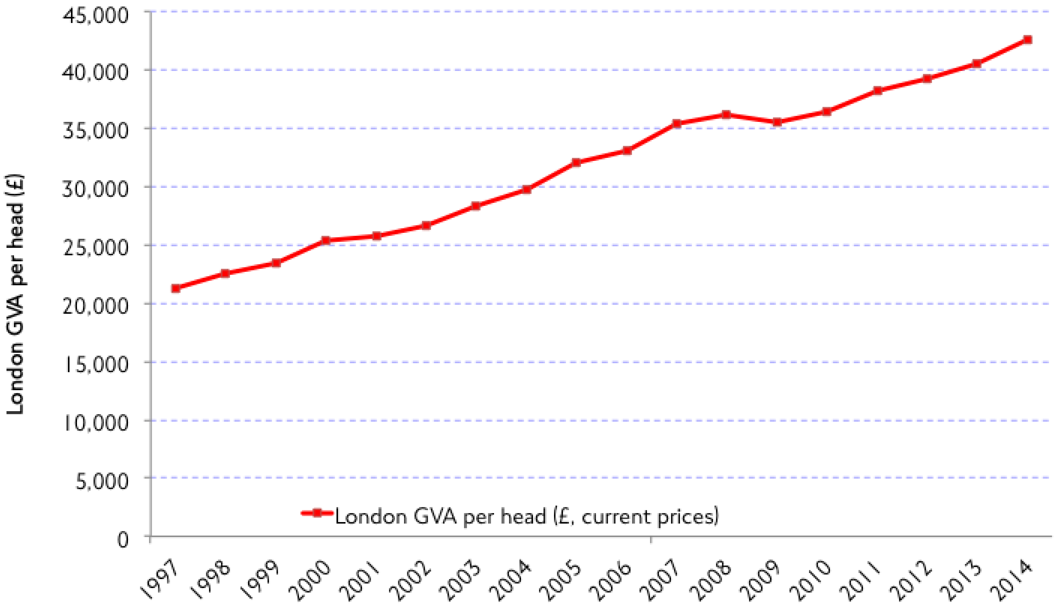


Source: Transport for London, Strategic Analysis.

3.2.7 GDP and income per capita

With the exception of a slight slowing reflecting the recent financial crisis, average London GVA (Gross Value Added) has grown at a fairly steady rate since the mid-1990s (Figure 3.2.7 (a). This suggests a trend of steadily growing affluence, which would be typical of comparable cities. Data are not unfortunately available for the earlier period, for the peri-urban area or for inner and outer London separately.

Figure 3.2.7 (a): Trend in Gross Value added (GVA) for Greater London (CREATE Zones 1 and 2 combined).

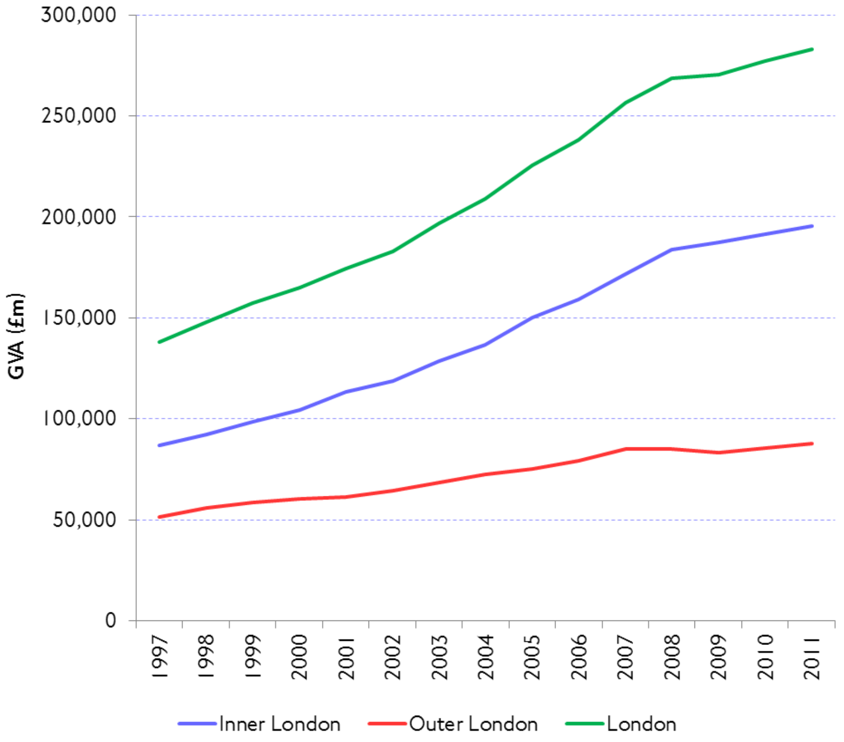


Source: London Datastore (Greater London Authority).

The productivity of London's economy, measured in Gross Value Added (GVA), increased steadily from 1997 through to 2007. The majority of the growth in productivity in London as a whole over this period was down to strong growth in inner London. Inner London's already larger output more than doubled, while outer London added 70 per cent.

From 2007 onwards, the difference in economic performance between inner and outer London became even more marked. While growth in inner London slowed from the rate it had been growing at prior to the recession, in outer London GVA barely increased at all, adding just 3 per cent from 2007 to 2011. The growth seen in inner and outer London's economies during the recession following the 'credit crunch' in 2007 was in part due to the continued growth in population in both regions. Taking the growing population into account and looking at production per capita, it becomes apparent that inner London became less productive after 2007 and remained so until 2011 (Figure 3.2.7 (b)).

Figure 3.2.7 (b): GVA growth in inner (CREATE Zone 1) and Outer (CREATE Zone 2) London compared.

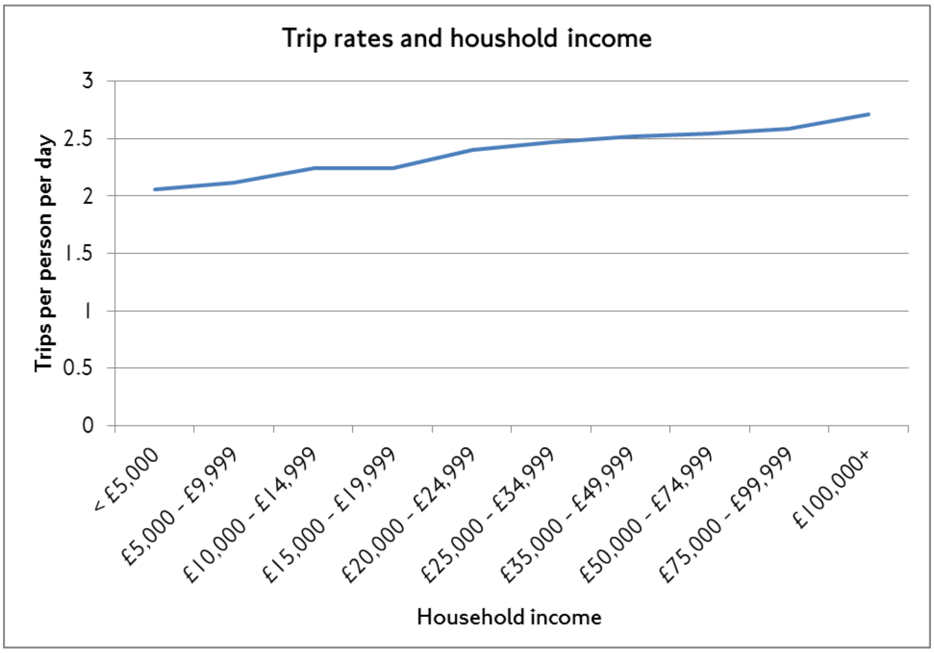


Source: United Kingdom Office for National Statistics.

Household income

Perhaps more relevant as a potential explanator for travel behaviour is average household incomes, although the available data only permit a short-term recent view of trends. First, Figure 3.2.7 (c) shows the relationship between household incomes and trip rates – a reflection of 'total travel demand'. It is seen, as would be expected, that the trip rate per person increases steadily with increasing income of the household in which they live. This reflects things like increased economic participation of higher-income households.

Figure 3.2.7 (c): Relationship of overall trip rates to household income. CREATE Zones 1 and 2 combined.



Source: Transport for London - London Travel Demand Survey (LTDS).

Trip rates (the number of trips made per person per day) by all modes rise with household income (Figure 3.2.7 (c)). Londoners living in households with incomes above £100,000 make 32 per cent more trips per day than those living in households with an income below £5,000 which, while significant, suggests there is a minimum amount of 'necessary' travel at around 2 trips per day on average amongst those with the lowest household incomes, and that there is an upper bound to the amount of travel that is considered desirable regardless of income

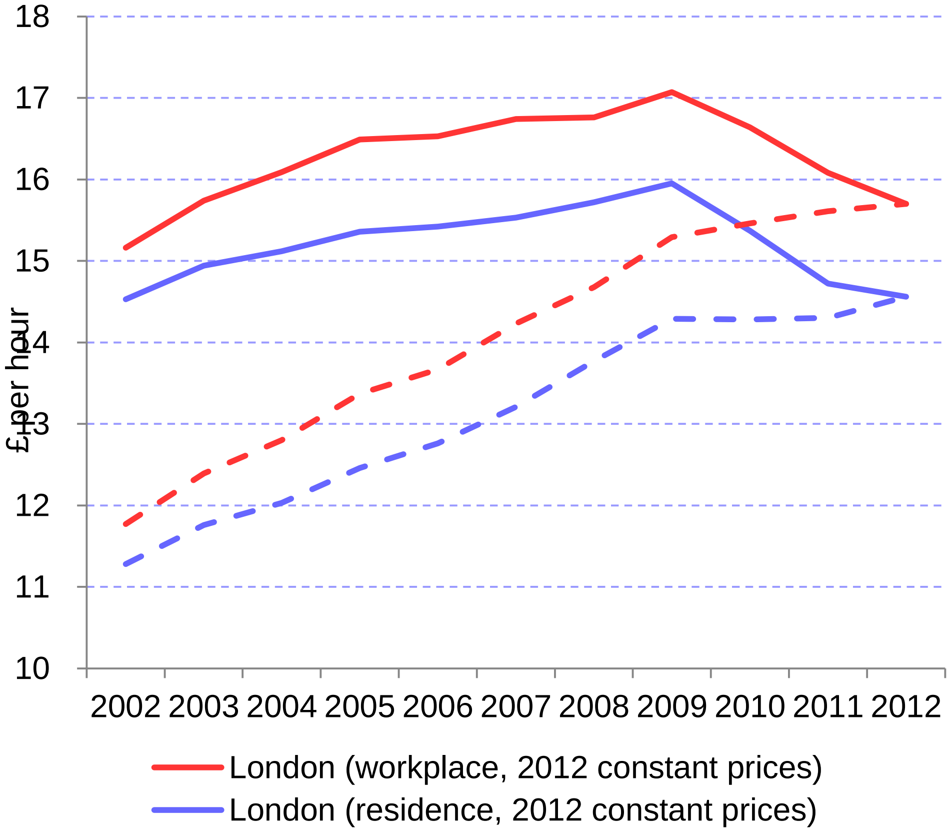
Different patterns emerge when looking at the link between household incomes and trip rates by individual modes. For those with household incomes below the £35-50k band car trip rates rise in line with income in approximately the same way as trip rates by all modes do, but there is a structural break in the relationship beyond this point and people with higher household incomes cease to make more car trips. Use of London Underground and National Rail services rises as household incomes rise. In both cases the elasticity with respect to income is greater than the income elasticity of demand for travel in general, meaning that people's desire to travel by rail modes rises with income at a faster rate than their desire for travel of all types. Travel by rail is particularly strongly linked to household income. The relationship between income and trip rates is reversed when looking at bus travel: as household income rises people make fewer trips by bus, with those in the top income band making just 35 per cent the number of bus trips of those in the bottom income band.

Wages/Earnings

On a short-term view, the wages of people working in London saw real-terms growth of 13 per cent between 2002 and 2009 although the wages of London residents saw lower growth of 7 per cent over the same period. The median wage for those working in London was also 7 per cent higher than that of London residents in 2009, reflecting the fact that those commuting longer distances from outside London are travelling to higher value jobs (Figure 3.2.7 (d)).

After 2009, wages declined in real terms both for those working in London and for London residents. In the case of London residents', this decline meant that wages were back to 2002 levels by 2012, while the 9 per cent drop from the 2009 peak in wages for London workplaces took them back to 2003 levels.

Figure 3.2.7 (d): Median hourly earnings excluding overtime of all employees in London. Employees working in CREATE Zones 1 and 2 combined.

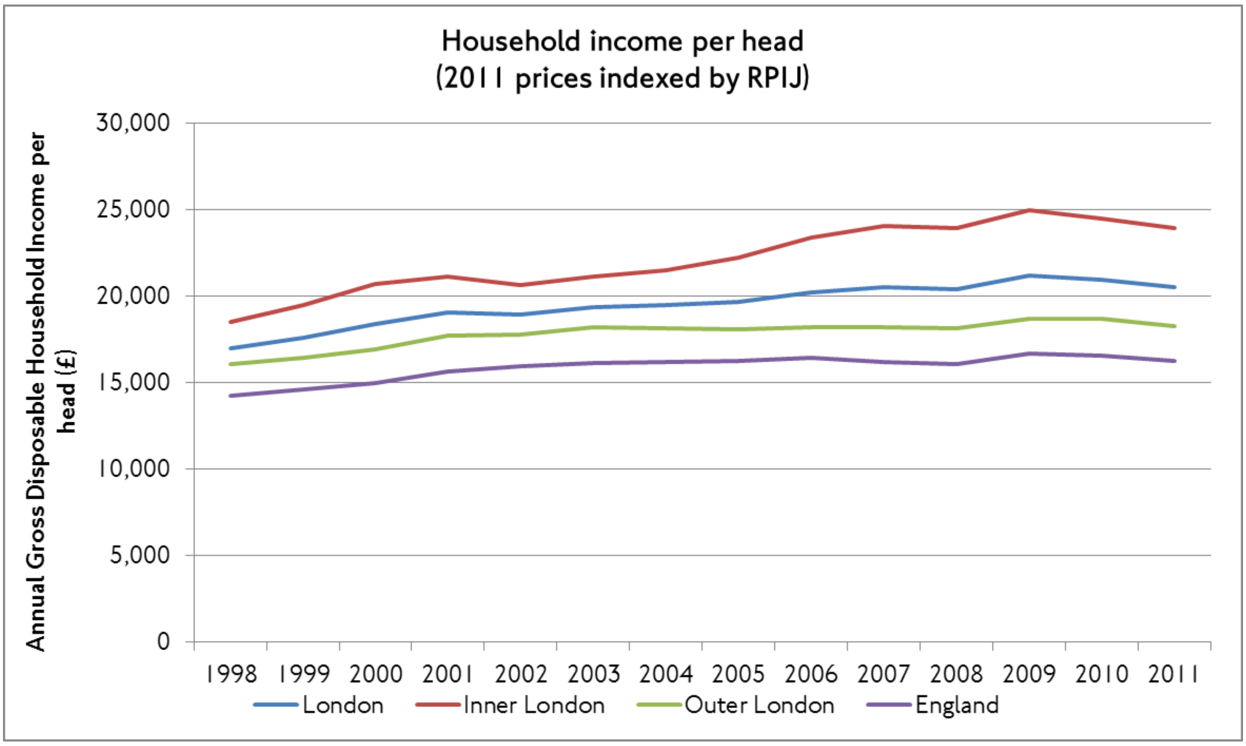


Source: United Kingdom Office for National Statistics.

Further exploring trends in income broken down by inner and outer London (CREATE Zones 1 and 2), a similar pattern to that seen in economic output in the two regions becomes apparent. Real incomes per capita declined both in inner London and in outer London from a 2009 peak, but there were very different scales of growth in the period before this. From 2003 to 2009 inner London incomes rose by 18 per cent before falling back to a cumulative 14 per cent by 2011. In contrast, outer London incomes increased by just 3 per cent between 2003 and 2009, and from 2009 to 2011even this growth was eroded, meaning by 2011 income per person in outer London was back to 2003 levels (Figure 3.2.7 (e)).

This phenomenon is an important explanatory factor in the trend in car travel that has been observed at the London-wide level. Since car ownership and use are linked to higher incomes, the fact that outer London incomes have not increased for almost 10 years means that the upward pressure on ownership and use of cars in outer London that was present until the early 2000s (while incomes were increasing) has been removed. Without any upward influence on the quantity of car travel from growth in household incomes, the downward influence of the supply factors detailed elsewhere appears to have led to a decrease in the volume traffic in outer London, where around 70 per cent of car trips in London occur.

Figure 3.2.7 (e): Household income per head (2011 prices, indexed by Retail Price Index). CREATE Zones 1 and 2, with England comparator.



Source: United Kingdom Office for National Statistics.

4 Transport Supply

4.1 Road infrastructure and parking

General introduction

Changes in the effective level of service offered by the road network in London are thought to have been a major factor in explaining travel trends in Greater London over the CREATE period. It is not the case that the extent of the road network has changed significantly – London is an established, dense capital city and the scope for new road infrastructure (and the public appetite for it) has been extremely limited. Work Package 4 includes a full review of the 'politics' of London's roads over the CREATE period. Rather, it is the way that the available road capacity has been used that is important. This comment relates to all aspects of road capacity – including the availability of parking.

For the purposes of CREATE work package 3, the basic trends are that:

- Up until the mid-1980s, demand for car travel grew. This was in line with rising affluence and car ownership and the relative decline of the public transport network. For example, in the late 1970s, the closure of several rail lines (that are now very significant parts of London's transport infrastructure) was being seriously discussed. In this period, the road network was able to accommodate more demand, and the focus of road network development was to facilitate this. Congestion levels rose over this period. There was little focus on aspects of the urban realm and things like road safety or public transport priority.
- At about the mid/late 1980s two significant things happened. First, congestion levels rose to what was perceived to be an 'intolerable' level, and, second, the political debate shifted from an emphasis on accommodating the car towards other priorities around road safety, liveability and developing the public transport network. As well as being reflective of conditions reflecting the transition from CREATE Stage 1 to CREATE Stage 3 conditions, the development of all of these non-traffic priorities required the reallocation of road capacity.
- In the period since, the effective capacity provided by the road network for general traffic has consistently and significantly reduced. Meanwhile, the capacity and level of service provided by the public transport networks has been substantially increased. There are thus both 'push' and 'pull' factors affecting demand for road travel.
- In the context of continuing economic and population growth, and the availability of good public transport alternatives, the expressed demand for travel by car has fallen. Congestion remains at high, although not extreme levels, and the marginal motorist has opted to travel by a different mode. This has resulted in the situation observed in London where congestion remains high, but the volume of road traffic has declined, alongside rapid growth in the patronage of public transport.
- The focus of road network management in London over the last decade has been to manage the road network as efficiently as possible so as to minimise congestion. Because 'background' levels of congestion are so high, problems arise from short-term disruption, for example through accidents or poorly-timed emergency infrastructure works (leading to 'gridlock' conditions). It has not been the focus of roads policy in London to provide new infrastructure – experience largely supports the contention that to do so would induce 'suppressed' demand – and that any new infrastructure would rapidly fill up in the absence of measures to prioritise the use of such new infrastructure.
- The main aspects that have affected the available road network capacity in London are identified as follows (in no particular order):
    - Increased emphasis on road safety – through engineering and other measures, for example carriageway 'calming', speed limits and speed enforcement, and

pedestrian/cycling priority. London's roads are now some of the safest of any capital city.

- Increased emphasis on the quality of the urban realm. Many small roads have been blocked off to prevent 'rat running' through residential areas. Some town centres have been pedestrianised. There has been a general emphasis on 'traffic calming'. Space has been reclaimed from roads to create high-quality public space, for example the 'World Squares' project involving Trafalgar Square in central London (see, for example: http://www.fosterandpartners.com/projects/trafalgar-square-redevelopment/).
- Development of the public transport networks – particularly the buses. The near-doubling of the service provided by the bus network over the last decade and the widespread introduction of bus priority.
- Increased general development of London. London's economic success has led to a building boom and much road space is taken up, perhaps on a long-term but temporary basis, by construction activities and the materials to support them.
- Utility renewal – major programmes of water/sewage and electronic communications infrastructure renewal have taken up significant road space on a long-term temporary basis.
- The availability of parking has substantially reduced, reflecting the high value of land and the competition from other potential users of road space. Although detailed data on this aspect are not readily available, difficulties and high costs associated with parking are known to be a major deterrent to car travel – particularly in the inner/central areas. Much former parking land (primarily private non-residential parking) has been given over to other higher-value land uses, such as residential/commercial development. Parking is regulated by the 33 London boroughs, and high parking charges are also a major deterrent to car travel (for an overview of current parking regulation in CREATE Zones 1 and 2 see: http://www.londoncouncils.gov.uk/services/parking-services/parking-and-traffic/parking-advice-members-public/parking-your-car-london).
- The emphasis of road network management over the last decade or so has been on how to best manage London's limited road capacity to ensure the optimal economic use of the roads. Policies like Congestion Charging in central London from 2003 illustrate this 'prioritisation', although this specific policy is not very significant in determining traffic levels at the London-wide scale as only about 2 per cent of London's traffic is directly affected. Much emphasis has been given over recent years to better managing the road network. Initiatives to better control utility works – such as TfL's Lane Rental scheme, the progressive roll-out of the SCOOT traffic signal control system, and an emphasis on 'real time dynamic traffic management, with rapid responses to disruptions, are three aspects of these initiatives.

In many ways, therefore, London demonstrates the archetypal 'progression' through CREATE Stages 1 to 3. Some key references that explain this evolution and the current policy context are:

(1) TfL's Travel in London reports, which give an overview of recent trends. Available at: https://tfl.gov.uk/corporate/publications-and-reports/travel-in-london-reports

(2) TfL's Drivers of Demand for Travel in London report – which gives a conspectus of the factors underlying travel behaviour change since 2000. Available at: http://content.tfl.gov.uk/drivers-of-demand-for-travel-in-london.pdf

(3) The Roads Task Force Report – which, although specifically reflecting the thinking of mayor Johnson, outlines an approach to management of road space which is very reflective of current views (and CREATE Stage 3 city thinking). Available at: https://tfl.gov.uk/corporate/publications-and-reports/roads-task-force

The following sections consider specific aspects of road network capacity in more detail.

4.1.1 Speed limits by infrastructure

Basic situation in London and its significance

The general trend in London over the CREATE period has been:

- Speed limits have got slower overall, mainly reflecting Stage 3 city type policies and a particular emphasis on road safety.
- Many more roads have been brought under specific speed limit control, instead of the 'default' UK National Speed Limit of 60 miles per hour for non-motorway roads.
- There has been a growing emphasis on the enforcement of speed limits, through devices such as speed enforcement cameras.

Because congestion is defined in terms of the difference between night-time and daytime speeds, where speed limits have been lowered, this should also be reflected in a reduced night time speed. Therefore, reduced speed limits should not be a primary contributor to congestion. However, because (a) compliance with speed limits is likely to be less at night than during the day time and (b) drivers will experience slower journeys, this trend is thought to have been a significant contributor to reductions to the effective highway network capacity provided in London and lower journey speeds overall.

Detailed information regarding the current situation for speed limits is available via a Mapinfo layer, which can be provided separately. The following is a summary of the historic position. It should be related to the road length statistics shown below.

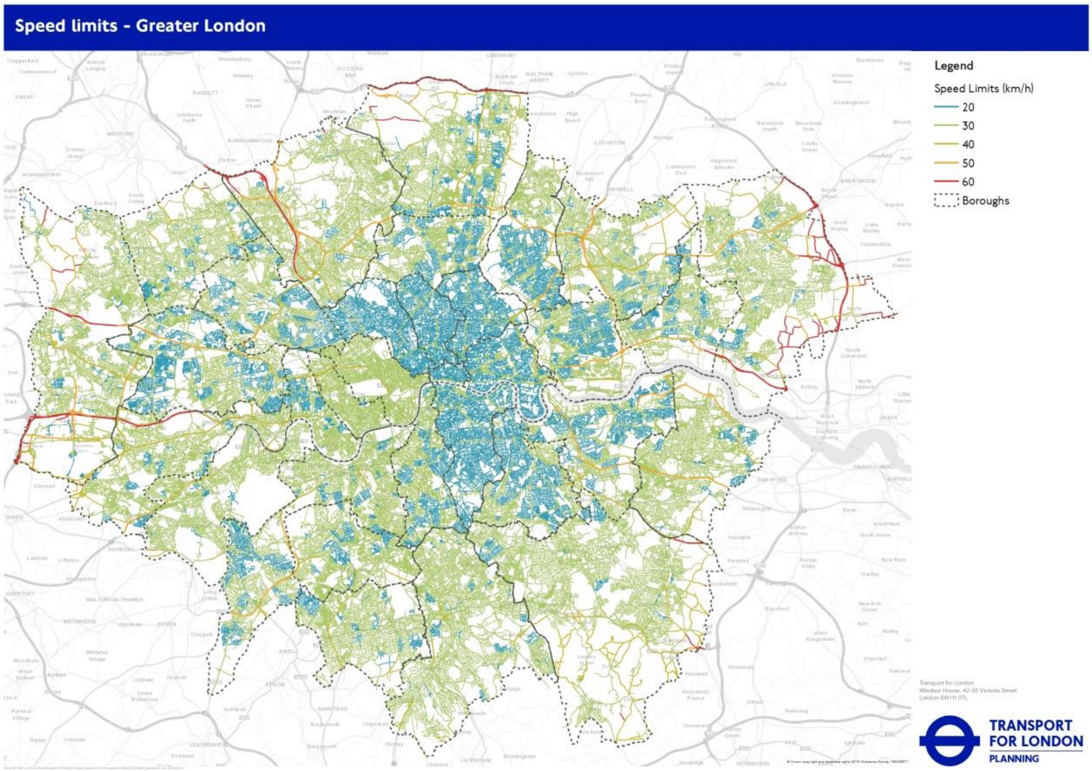
For many years the default speed limits in the UK have been:

- Motorways – 70 miles per hour
- Trunk roads/ rural roads – 60 miles per hour (default 'National' speed limit)
- Urban and residential roads – 40 or 30 miles per hour

Therefore, for most of the period covered by CREATE, the prevailing speed limit has been 40 miles per hour for major roads, and 30 miles per hour for residential roads (Figure 4.1.2 (a)). It should be noted that roads that carry large volumes of traffic 'trunk roads' generally have higher speed limits – an important factor when considering total vehicle throughput.

Since about year 2000, however, there has been an increasing move to lower the speed limit on residential roads to 20 miles per hour. This now applies to much of inner London. At the same time, there has been a large increase in the introduction of speed limits locally that are below the national maximum. For example, on the London section of the M4 motorway the speed limit has been reduced to 60 miles per hour (since about year 2000). Major roads through town centres are now routinely restricted to 30 miles per hour, the use of 20 miles per hour limits in dense residential areas is widespread, and there are moves also to introduce 20 miles per hour zones on some of the major roads. The primary motivation for this has been to improve road safety. However, certainly within the built up area, the actual impact of this during daytime hours has been minimal. Average speeds achieved on typical trips are usually much lower than the maximum permitted speed limits (see data on average vehicle speed trends).

Figure 4.1.1 (a): Map of speed limits in Greater London – 2016. CREATE Zones 1 and 2.



Source: Transport for London.

Table 4.1.1 (b): Percentage of network covered by different speed limits. CREATE Zones 1 and 2 combined.

Speed limit (miles per hour)	Percentage of road network in Greater London
20	27.5
30	66.2
40	3.2
50	1.9
60	1.2

Source: Transport for London.

Note that, for motorways within Greater London, a speed limit of 60 miles per hour or less applies. The National UK speed limit for motorways outside London is 70 miles per hour,

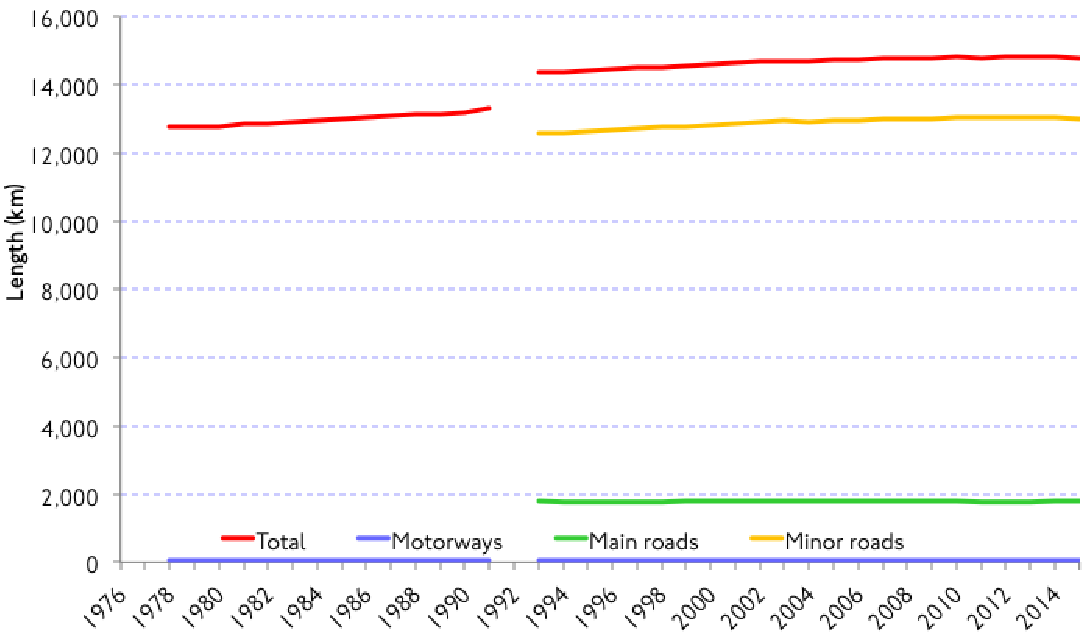
In much of inner London, for most of the day, speed limits are somewhat 'academic', in that congestion often prevents travelling at the posted maximum speed, and the frequency of junctions and the delays associated with them are a much more important factor in determining the 'level of service' experienced on the road network (which, in turn, affects the perceived attractiveness of journeys by road in relation to the alternatives).

For the peri-urban area the same broad conventions of speed limit by road type apply. However, there has not yet been the widespread recent introduction of 20 mph zones here.

4.1.2 Development of the length of the road network

Figure 4.1.2 (a) shows the length of the road network in Greater London (CREATE Zones 1 and 2). The earlier data is not directly comparable to the later data – there is a series break in the data as it would not be correct that the total length of road has increased in the way that the graph suggests. The best long-term view would be that the length of the road network in London has been effectively stable or only marginally increased over the study period, although the amount of motorway-type roads in the Greater London area has indeed increased, with the construction of a small number of major motorways during the period 1970-1990.

Figure 4.1.2 (a): Length of road network in Greater London. CREATE Zones 1 and 2 combined).



Source: Transport for London.

<u>Relevance to explaining travel trends</u>

The length of road is of very limited value as a potential explanatory variable of either traffic or road journey speed trends. This is for a range of good reasons – for example the roads are radically different in type – over 80 per cent of roads in London are minor roads, yet these carry much less than 20 per cent of the traffic by kilometrage. Secondly, the efficiency with which the available capacity provided by the network is used is a much more potent factor. As is explained above, trends in highway engineering design, road safety considerations and the wider 'policy' need to accommodate competing demands on the available road space, have led to significant reductions to the effective capacity of the road network. So, although there has been a marginal increase in the extent of the road network over the CREATE period, the volume of traffic that can be carried has generally been reducing, and the level of service offered to that traffic (most simply reflected in congestion levels) has fallen. These are 'contrary' trends and are explored elsewhere in this document. Given the (broadly) stable provision over the CREATE period, the view would be that the extent of London's road network per se is largely a constant factor and is not (of itself) a major factor explaining trends.

A word about the M25 orbital motorway.

This major piece of new infrastructure was completed in the 1980s. It is a high capacity motorway that completely encircles the Greater London area (most of it is located just outside the administrative boundary and is therefore in CREATE Zone 3). It's impact on traffic levels was mixed. On the one hand, it increased general levels of traffic in outer London, since many new journey opportunities were provided. On the other, it worked to reduce levels of traffic in outer London, as trips that formerly travelled through outer London could now 'bypass' London and travel on the motorway instead. The net impacts are visible in the traffic trend graphs considered below.

4.1.3 Average traffic speeds and congestion

In any consideration of the causes of traffic trends in London, it is necessary to consider trends in road traffic congestion. TfL has published much in the way of interpretative material on this topic – and so the following is a summary only.

Definition

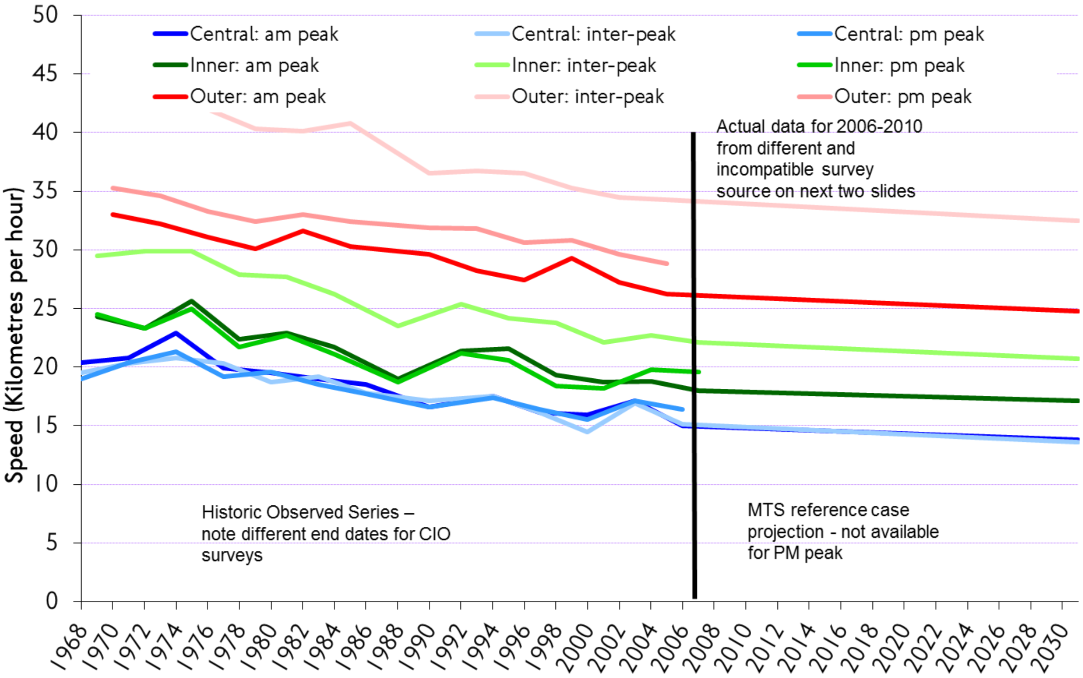
'Congestion' is defined as the time taken for a journey by road over and above that which would be required if there were no congestion. In practical terms, it is defined as the difference between the time taken to travel a unit distance in the overnight (uncongested) period and that taken to travel the same unit distance during the daytime (congested) period. The units in which congestion is expressed are minutes per kilometre, which is mathematically the inverse of speed. Congestion is therefore defined as a measure of 'slowness'. As a quantity, it is indirectly related to average speed, since changes to the latter are partially subsumed into the baseline measurement used to define congestion (the overnight speed or travel rate). It is also notionally independent of journey time reliability, although it is known that journey time reliability tends to deteriorate as congestion increases.

Because of data comparability issues, historic congestion in London is however best considered in terms of overall average traffic speed.

Long term trends in London

The long-term trend for average traffic speeds in London is instructive (Figure 4.1.3 (a)). Note that the measurement methodology for congestion changed between 2006 and 2009. Newer measurements are not directly comparable with the historic measurements. Note also that the translation of these speeds into congestion measurements is explained in detail in TfL sources referenced elsewhere.

Figure 4.1.3 (a): Historic trend for road network congestion in London. Average London traffic speeds. Moving car observer periodic surveys. CREATE Zones 1 and 2.

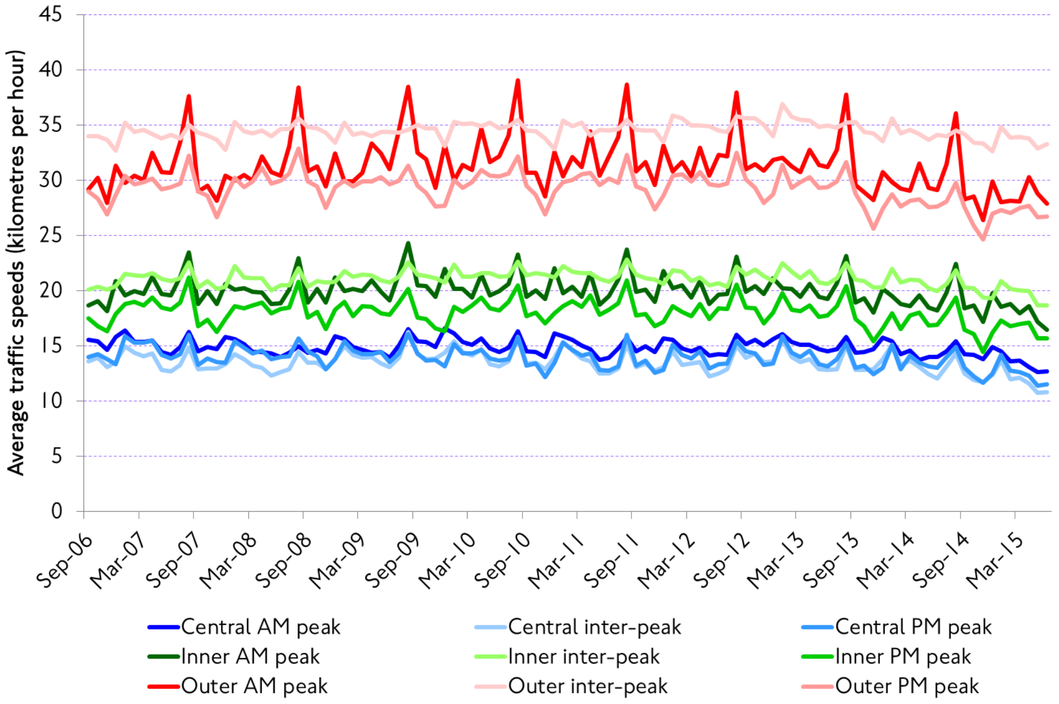


Source: Transport for London. Strategic Analysis.

The basic trend revealed by the figure is that there was a long-term trend of reductions in average traffic speeds over most of the historic CREATE period. This affected all parts of London. Over the early part of this period, it is believed that the primary cause of the trend towards slower average traffic speeds was increased levels of traffic (ie demand). This is conventionally regarded as the main 'cause' of increased congestion. However, it is also believed that, over the later part of this period, the primary cause of continued reductions in average speed was the removal of effective road network capacity in favour of a range of other policy priorities. Importantly, because baseline night-time speeds would also have been affected by this change in capacity (but would not have been affected by increases in daytime traffic levels), the actual deteriorating impact on congestion would be greater than is implied by the figure.

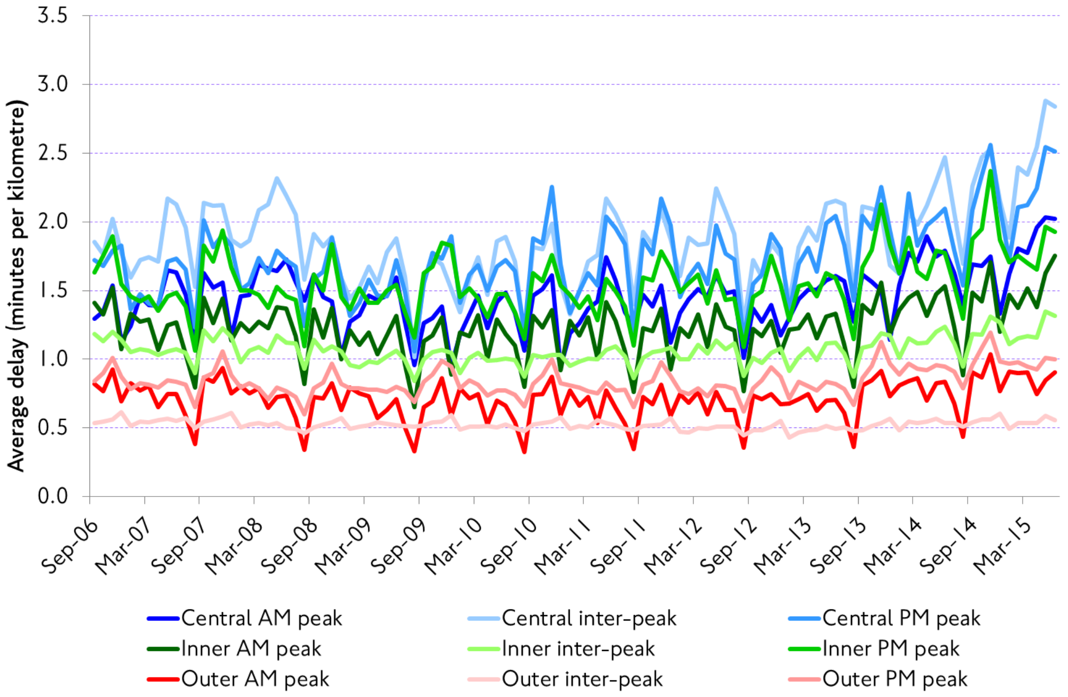
More recently, TfL has moved to use GPS data to measure traffic speeds and congestion. This has resulted in an apparently 'flat' trend for both speeds and congestion in recent years. In part, this reflects falling traffic levels and a very much-increased emphasis by TfL on the effective management of the road network. However, it is also partly illusory. Because the new GPS measurement takes a wider definition of /night-time' speeds, covering the period 22:00 to 06:00 when there are significant traffic flows in London, and because some elements of capacity removal affect night-time speeds, it is probably the case that the GPS trend in measured night-time speeds are partly 'masking' the continued removal of capacity from the road network. This was considered in Travel in London report 6, pages 128-130. Figure 4.1.3 (b) below shows the recent trend in average traffic speeds in London, whilst Figure 4.1.3 (c) shows the equivalent congestion trend.

Figure 4.1.3 (b): Recent trend in average road traffic speeds in Greater London. GPS based continuous measurements. CREATE Zones 1 and 2.



Source: Transport for London.

Figure 4.1.3 (c): Recent trend in road network congestion in Greater London. GPS based continuous measurements. CREATE Zones 1 and 2.



Source: Transport for London.

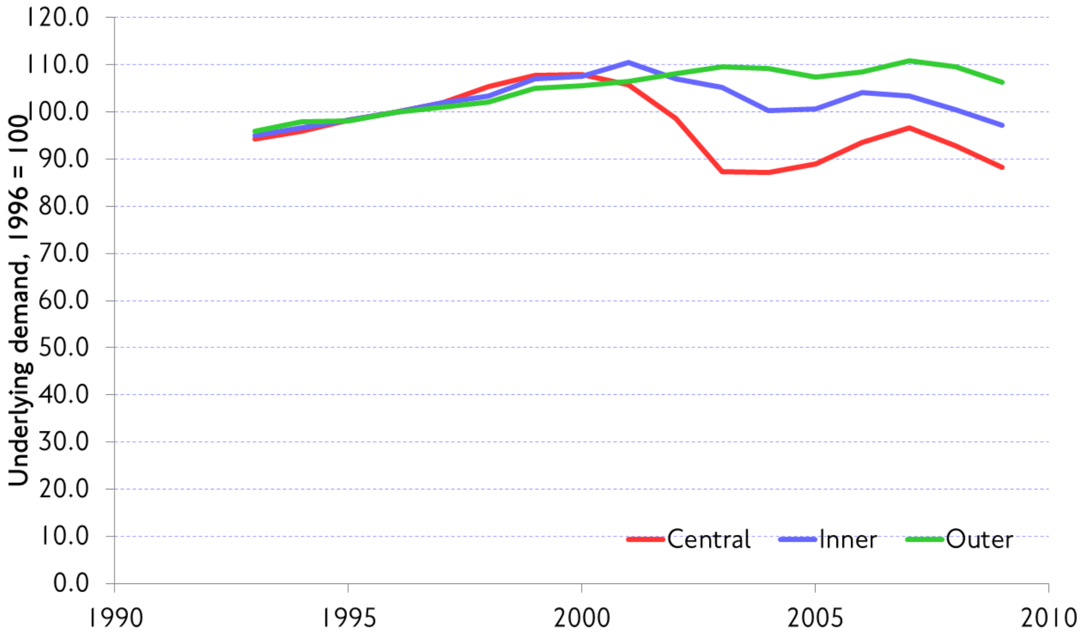
Interpretation – the removal of effective road network capacity in London

In simple terms, therefore:

- In the early part of the CREATE period, traffic demand was increasing. As demand increased, so average speeds reduced and congestion increased.
- From about the early 1990s, firstly in central London but also observed later in both inner and outer London, traffic demand ceased to grow and started to fall. Meanwhile, congestion continued to increase.
- This change in the nature of the relationship between traffic volumes and congestion is thought to be reflective of a situation where (a) the carrying capacity of the network in critical locations and at times of peak demand was reached (b) the increase of other policy demands on the available road network capacity removed capacity for general traffic and resulted in further increased congestion/a reduced level of service for motorists (c) in the context of more attractive public transport alternatives, the 'generalised cost' of making trips by road exceeded that of using public transport for an increasing minority of car drivers.
- Therefore, expressed demand fell, as people chose non-road modes in preference, and traffic levels also fell.
- Congestion however did not respond to falling demand, as capacity was further removed in support of policies that reflect CREATE Stage 3 city conditions. The emphasis of TfL over this period was on better management of the available road space, in the context of all of the competing priorities, rather than on providing new road space (which is NOT the same as increasing network capacity).

This hypothesis was elaborated at length in our Travel in London 4 report (see pages 100-105). In particular, using simple relationships, TfL was able to estimate the loss of available road network capacity over the period. The resulting trends are shown in Figure 4.1.3 (d). It is seen from the figure that the effect has been quite dramatic. Over the period 1996-2009, TfL estimated that around 25 per cent of the road network capacity for general traffic in central London was lost. This corresponds to a traffic reduction of a similar magnitude (the role of Congestion Charging in these trends is considered below). Inner London lost around 15 per cent of its road capacity over the same period, alongside similarly reduced traffic volumes. It is important to recognise that this was only very marginally reflected in terms of the length of the road network in these areas.

Figure 4.1.3 (d): inferred change in available road network capacity in Greater London. CREATE Zones 1 and 2.



Source: Transport for London. Strategic Analysis.

A suggestion here is that this type of analysis is extended to the other CREATE Stage 3 cities. All that is required are comparable historic trends for average traffic speed and traffic volumes, together with an empirically derived value for the elasticity of speed with respect to flow, as observed in each city. London is happy to help develop this idea further.

Peri urban area

Whilst no specific data are available for the peri-urban area, it would be reasonable to assume that similar trends to those seen in CREATE Zone 2 are developing. However, road traffic and road network capacity are in better balance, and so this phenomenon would largely be expected to be confined to urban areas within the peri-urban area, and at a much earlier stage than seen in CREATE Zone 2.

4.2 Public transport and taxi supply, car sharing

4.2.1 Public transport network in London – general orientation

General introduction

Public transport supply has played a major role in determining travel demand trends in Greater London over the CREATE period. However, this role has not always acted in the same direction. The level of service provided by the public transport networks has followed an evolutionary cycle, with a broad picture of decline up until the mid-1980s, followed by a period of strong growth, investment and improved quality, which continues to date. Therefore, in the early part of the CREATE period, public transport supply, or rather the general deterioration of the public transport networks, was a significant factor acting in favour of greater car use.

More recently however, better public transport has been a major factor attracting travellers away from the private car, where the level of service provided by the road networks has simultaneously been in decline. Also, the fortunes of public transport in London have largely followed the population trend – as

London's population fell during the 1960s and 1970s the focus was on 'managed decline' of these networks – the service offering in many cases failed to keep pace with contemporary expectations, and there was a large backlog of maintenance and improvement. More recently, with rapid population growth, public transport is seen as the main way in which this growth can be accommodated. There is therefore an important policy dimension to this that fits very well with the CREATE 'Stages' model.

Brief history of London's public transport networks relevant to CREATE

Public buses

London's bus network grew rapidly in the early years of the last century with patronage reaching a high point in the 1950s. From this date, however, both the level of service supplied and the levels of patronage fell, reaching a low point in the 1980s. This reflected a number of factors such as the growth of car use. More recently, starting with the 'fares fair' policy of the Greater London Council (see WP4), patronage began to grow, and this was shortly followed by a large-scale programme of service and quality enhancement that continues to this day. Bus patronage has now returned to the high point of the last century. Innovations particularly affecting bus patronage trends in the more recent period have included: zonal fares and other integrated ticketing technologies, bus priority on the road network, extensive development of the Night Bus network and quality improvements in terms of the service offered (punctuality, information, etc.). The emphasis on developing the bus network in the years immediately after 2000 reflected the perceived need for more capacity over a short timescale – it was recognised that new rail capacity could not be delivered quickly enough to keep pace with capacity shortages caused by London's (then) rapid population growth. Although buses will continue to play a very significant role in London's transport over the coming two decades, the scope for further expansion is considered to be limited, as buses still suffer from extensive road congestion, and in some respects also contribute to it, and the coverage of the network is now so extensive that few areas of London are without a local bus service. One significant aspect is that bus services in London (CREATE Zones 1 and 2) are 'regulated' – that is that the service levels are specified by TfL and private operators compete via tender for contracts to operate groups of bus routes, with TfL taking the revenue risk. This means that TfL can specify levels and quality of service that it considers most appropriate to meet London's needs. In the peri-urban area, and in the rest of the UK, bus services are 'deregulated', where private operators operate services on a commercial basis, although often with subsidy for 'socially necessary' services. This has meant that, whilst bus mileage and levels of service and patronage have grown very significantly in CREATE Zones 1 and 2, this has not been the case in the peri-urban area.

Underground

London's Underground is a well-established 'metro' style heavy rail system that is almost entirely contained within the Greater London area (CREATE zones 1 and 2). The main elements of the network were all in place by 1960, although, as with the buses, both patronage and level of service were on a downward trajectory in the immediate post-war decades. Nevertheless, the Victoria line was a major addition to the network during the 1960s, a small extension to Heathrow airport of the Piccadilly line in the 1970s, and the Jubilee line extension (in fact, only the eastern portion of the line from Baker Street was new) followed during the 1990s. As with the buses, patronage and levels of service started on an upwards trajectory in the late 1980s, again reflecting the fact that London's population had started to grow again, and integrated transport initiatives, most notably zonal ticketing and 'Fares Fair' were put in place. Today, the Underground regularly records new 'record' levels of patronage. Although there have been no other additions to the network in recent decades, the focus of the 'Tube Upgrade' programme has been on squeezing maximum capacity out of the existing network, through the introduction of new rolling stock and signalling technologies that allow closer operational headways. For the future, the emphasis is on new 'heavy rail' infrastructure (see 'Crossrail' below) rather than new Underground lines per se, reflecting the capacity arrangements inherent in such a network, although the whole would operate as a single fully-integrated network. The London

Underground network penetrates the peri-urban area in two minor respects – at the northern extremities of the Metropolitan and Central lines, although these are relatively minor in terms of determining travel patterns in the peri-urban area. Note also that the coverage of the Underground network is dense to the north of the river Thames. Metro-style rail services in south London are predominantly provided by National Rail operators.

National (surface) Rail

During the 1800s the UK developed an extensive national rail network focused on London. Twelve 'main line' terminal stations were developed in London, located in a ring around the periphery of the central area. These still remain today, and are connected into the Underground network at strategic points. London's National Rail network was overwhelmingly 'radial' in orientation, and as the residential hinterland around London became developed, so daily commuting from the suburbs and further afield became a characteristic feature of travel in London. As with most aspects of public transport in London, patronage and levels of service were in decline in the early part of the CREATE period, but both have experienced a sharp turnaround with rapid growth over the period since the mid-1980s. Britain's railways have undergone some complex changes of ownership since 1990. Although many aspects of the quality of service, in particular frequency and capacity, have improved, this is thought to largely reflect the overall change in UK and London transport policy towards enhancing the role of public transport and increasing population.

Light rail, trams and trolleybuses

Historically, London had extensive tram and some trolleybus networks. These were however all closed during the 1950s, as they were seen as an inefficient use of road space. More recently, however, London has developed two extensive but largely self-contained light rail networks. The Docklands Light Railway, based around the London Docklands, has been incrementally added to since its initial development in the 1980s. It is not a very significant travel mode locally in East London, but is totally segregated and does not involve any 'street running'. A new tram network was also established in south London, based around Croydon. Again, this is an important part of the public transport network locally. Importantly, both networks are fully integrated into London's wider public transport networks in terms of ticketing etc.

Indicators of service supply for the main public transport networks

There are several possible indicators for the level of service provided by London's public transport networks.

Length of networks

The section below details measures of the length of the key public transport networks in London and how they have developed over the CREATE period. Note that definitions are crucial here, as the structure of the networks, and the changes that they have undergone over the CREATE period are not always straightforward. In particular, many 'lines of route' are shared between several different National Rail or Underground lines, and many lengths of road have multiple bus routes which operate over them. In addition, the historical data relating to these aspects is limited and imperfect. Wikipedia-based references are the most suitable resource to help understand some of these complexities and are given where appropriate below.

- The length of the **Underground** network in 2016 was 402 km (250 miles). There are currently 11 lines with 270 stations. Approximately 22 miles (35kms) of this network are outside the Greater London boundary and are located in CREATE Zone 3. In terms of how this has developed historically, incremental additions since 1960 have included: Victoria Line (21 km/13.3 miles – from 1968); Heathrow airport extension to the Piccadilly line (4 miles/6km) from 1975); Waterloo and City Line (transfer of ownership from National Rail in 1996) (1.5

miles/2.5 km); Jubilee Line Extension, completed 1999, 10 miles (6 km). Full details of the structure and development of this network can be found at: https://en.wikipedia.org/wiki/London_Underground.

- The total length of the **London Bus** route network in 2016 was 10,163 km. This value is for one-way routes (so, bidirectional routes are counted twice) and includes (ie multiple counts) lengths of road served by more than one route. The recent history of this statistic is as follows: 2014 (10,168 km); 2013 (10.178 km); 2012 (10,165 km). This is not an ideal statistic, as it is not available historically and does not give a balanced representation of the extent and coverage of the bus network. The total 'route length', where no routes are double counted, was 4,138 kms in 2015. This literally means that there are 4,138 kms of road in CREATE Zones 1 and 2 that have at least one bus route. Full details of the structure and development of this network can be found at: https://en.wikipedia.org/wiki/London_Buses.
- There approximate length of the **National Rail** network in London in 2016 was 798.2 km. There are no historical data available for this indicator. The extent of the network has however remained relatively stable over the CREATE period, with some minor additions (in terms of length) being counterbalanced by some losses (mainly the transfer of ownership of a small number of lines to London Overground (see also below). Note that London Overground branded trains operate in parallel with other National Rail trains on substantial parts of the rail network in London. See also: https://en.wikipedia.org/wiki/National_Rail.
- **London Overground**. The London Overground surface rail network was created by TfL in 2007. It comprises a developing network which has largely grown through the transfer of ownership of a small number of existing National Rail lines to create a more intensive 'metro' style service. On many of these lines, London Overground trains operate alongside National Rail trains. Only a very small proportion of the current London Overground network route length (104 miles/167 km) therefore comprise 'new' infrastructure. The development of this network is summarised at: https://en.wikipedia.org/wiki/London_Overground.
- The Docklands Light Railway was first opened in 1987 and has been progressively extended in the period since. The current network length is 37.4 km. Details of the development of this network can be found here: https://en.wikipedia.org/wiki/Docklands_Light_Railway.
- Croydon Tramlink was opened in 2000. The current network length is 28.1 km. Details of the development of this network can be found here: https://en.wikipedia.org/wiki/Tramlink

We question the utility of indicators of transport supply based on network lengths. These are a poor proxy for the relative levels of service provided, and the relative attractiveness of the networks as travel choices. Within the context of an infrastructure of rail routes that cannot be changed or added to in the short term, the focus of efforts in London over the last two decades has been very much on extracting the maximum utility from the networks that exist, for example through our 'Tube Upgrade' programme (see: https://tfl.gov.uk/campaign/tube-improvements). We strongly recommend metrics based on actual capacity provided, and London is able to provide several of these over the required time period.

Peri urban area

In the peri-urban area the extent of the public transport networks has remained more stable – there has been little new infrastructure development over the CREATE review period. However, in common with much of the rest of the UK, service frequencies on National Rail services have increased over the last 15 years, as has rail patronage. Bus deregulation, applicable to all English counties outside London, has in general resulted in a fall in the level of bus services operated and an increase in the fares levels in the peri-urban area, applicable from the mid-1980s.

4.2.2 Public transport supply – services operated

Appropriate metrics

The most appropriate indicator of the extent of public transport supply in London is one based on place-kilometres scheduled or operated (in practice there is little difference between the two). This is more meaningful than the physical length of the public transport networks. However, it is only meaningful at the level of the individual mode, because the characteristics of the vehicles differ between the modes. A bus, for example, can typically accommodate about 60 people. Some of the longer surface rail trains in London can now accommodate over 1,500 people. Clearly, one bus does not equal one train etc. Also to be taken into account in making comparisons based on aggregate numbers across the public transport modes are (a) speed of vehicles – faster moving vehicles such as trains cover more vehicle kilometres than slower moving ones such as buses and (b) actual average occupancy. In terms of occupancy, the average London bus carries about 18 people. Occupancy on the train networks varies greatly according to time of day. This means that the places provided statistic is a poor measure of actual relative usage. These factors all relate to, and partly explain, the public transport patronage trends shown elsewhere in this report.

Data sources and known limitations

This is a complex area, owing to the many changes in definition and ownership over the CREATE review period. The data shown below is assembled from a range of sources. The key things to know for each mode are as follows:

- **Bus**. Data are in terms of bus kilometres scheduled (vehicles). They cover the entire London bus network which, broadly, corresponds to the Greater London boundary (CREATE zones 1 and 2). The data are a consistent time series assembled from various internal TfL sources over the time period back to 1978. Data prior to 1978 are not readily available. Although the data are consistent in terms of reflecting vehicles, there have been a number of structural changes to the bus network over the period. The most significant of these has been a move towards smaller buses since about year 1990, and also the rapid development of the night bus network. This means that the recent increase in bus vehicle kilometres overstates the actual capacity increase, although this is not a huge problem and the general strong upward trend since year 2000 is valid.
- **Underground.** This is a relatively consistent indicator over the period since 1978 and has been assembled from internal TfL sources. Data are not readily available prior to 1978. As with buses, the vehicle-based trend is affected by a general trend towards higher capacity trains over the period. In contrast to buses, however, this means that the vehicle-based trend marginally under-states the scale of the capacity increase over time.
- **Surface Rail**. There are two series here. There is no direct measure of train kilometres operated within the Greater London area as this measure/boundary has no relevance for the National Rail Operators. Before 1978, the former British Rail operated on a national-scale and no London area specific data was kept. After 1978, vehicle-based statistics are available for an operating region that was created in 1981 – known as 'Network South East'. This covered an area bounded by Kings Lynn, Huntingdon, Bedford, Northampton, Banbury, Oxford, Bedwyn, Exeter and then the coast back to Kings Lynn. This is very much larger than CREATE zones 1 and 2. The statistic relates to services that were operated under the Network South East brand. It is not a complete measure of train service in this area because services operated under the 'Inter City' brand also served stations within the area, albeit as part of longer-distance journeys. It is however a fairly good proxy for the change in National Rail services relevant to London, as most Network South East services served London at some point in their journey. British Rail was broken up in the early 1990s. The data for the later years of the Network South East operation and early years running up to the privatisation of the UK rail network are not available. However, from 2001 a new measure is available

based on train kilometres operated by those franchisees classified as ‘London and South East’ operators. This is not the same as the former Network South East (it is an even larger area). The approach recommended here is therefore to join the two series using simple linear interpolation. Note that the dip in train kilometres operated around 2004 is genuine and reflected the ‘collapse’ of Railtrack, the privatised railway infrastructure operator, in that year.

- **Light rail and trams – Docklands Light Railway and Croydon Tramlink.** These are relatively new networks operating in specific parts of London. They have grown incrementally over the period since opening. Comparable data is available from 2000/2001. These are relatively small contributors to the overall PT offer in London, but they are locally important.

<u>Approach to deriving a composite indicator of public transport supply</u>

The various incompatibilities with these series mean that we would not normally recommend attempting to derive a composite indicator of public transport supply. For the purposes of CREATE however it is necessary to make an attempt at this. This has been done according to the methodology described below. These data should be regarded as <u>indicative only</u> in all uses and publications arising from CREATE. The data do not represent an authoritative statement of the trend or overall capacity provided by the public transport networks in London. Given that an overall measure of capacity across the whole system does not reflect the huge range of differences between supply and demand across specific parts of the network, we also express serious reservations about the extent to which this measure is actually informative. The method adopted is as follows:

- For **bus**, we multiply the vehicle kilometres by an average bus capacity value of 60 people per bus. This is a ‘representative’ value in terms of the planning capacity of bus vehicles over the last 15 years. It includes both seated and standing passengers. We assume that all bus kilometres (100%) are operated within the Greater London area (CREATE zones 1 and 2).
- For **Underground**, we multiply the vehicle (train) kilometres by an average train capacity value of 850 people per train. This again is a representative value for the whole London Underground network over the review period. It includes both seated and standing passengers. We assume that 95 per cent of all Underground vehicle kilometres are operated within the Greater London area (CREATE zones 1 and 2).
- For **Surface Rail**, we multiply the vehicle (train) km by a representative value of 1,300 passengers per train. The majority of vehicle kilometres here are actually operated outside the Greater London Authority area. The exact value is not known. A ‘best guess’ value of 30 per cent has been used for the Network South East series and 20 per cent for the London and South East operators series (the latter operator group covers a geographically bigger area than Network South East. It includes trains between London and Penzance, for example, and those running on branch lines in the county of Cornwall!).
- For **Docklands Light Railway**, we multiply the vehicle kilometres by the representative value of 500 passengers per train. All vehicle kilometres are operated within the Greater London Authority area (CREATE zones 1 and 2).
- For **Croydon Tramlink**, we multiply the vehicle kilometres by the representative value of 209 passengers per tram. All vehicle kilometres are operated within the Greater London Authority area (CREATE zones 1 and 2).

So, to derive an overall proxy measure of capacity, in terms of passenger places provided by the public transport networks in London per year within CREATE Zones 1 and 2, we use the equation:

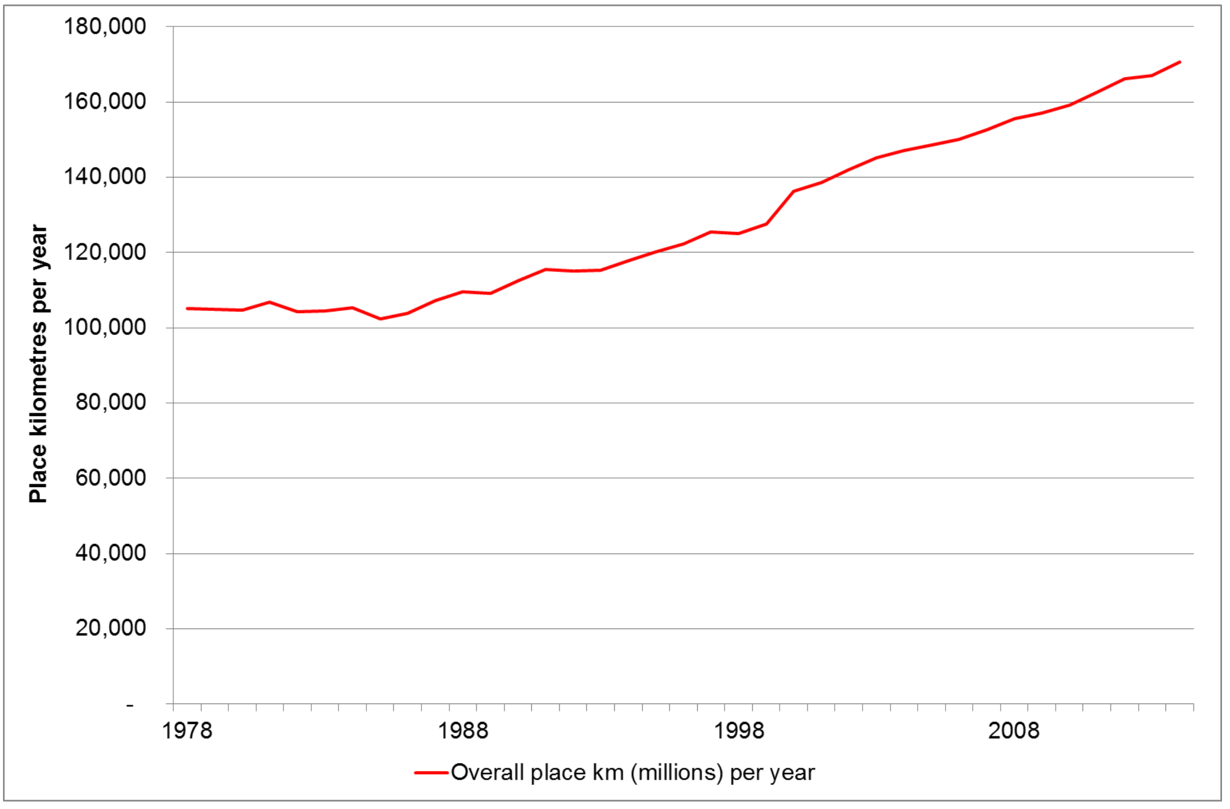
*((bus*100)*60)+((surfacerail*0.25)*1,300)+((underground*0.95)*800)+((DLR*100)*500)+((Tramlink*100)*209) = indicative capacity provided (passenger kilometres within CREATE zones 1 and 2 (Greater London only)).*

Note that these are place kilometres (not seat kilometres) and assume maximum occupancy levels of all vehicles (including standing passengers at maximum planned levels of vehicle occupancy). In absolute terms, therefore, they are a gross over-estimate of public transport demand. Because of the incompatibility of the numbers used to compile this series, it is recommended that absolute numbers are not used as part of the CREATE analysis, but that it is presented as an indexed trend.

Consolidated data is only available from years since 1978. However, data going back to 1971 is provided for bus and Underground networks. Note also that individual trips frequently use more than one mode. Therefore, a single trip may use capacity on all of the modes considered by this graphic.

Figure 4.2.2 (a) shows the composite measure adjusted as described above. This reflects the overall picture of relative stagnation during the early part of the CREATE review period, with steady and consistent growth in the latter part of the period.

Figure 4.2.2 (a): Total places provided across the public transport networks. CREATE Zones 1 and 2 only. Indicative trend only.



Source: Transport for London. Strategic Analysis.

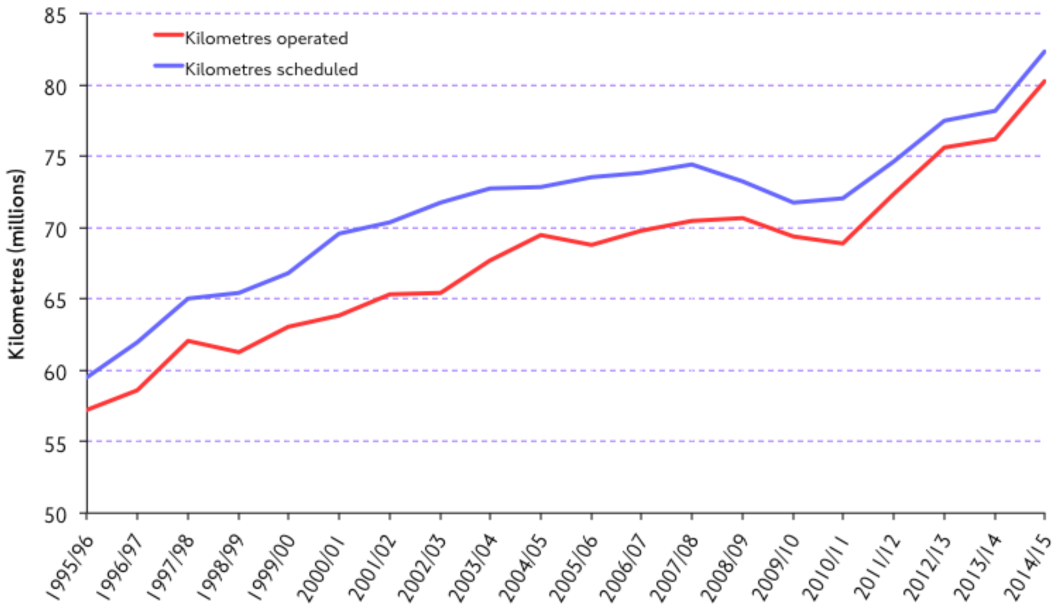
<u>Recent-period modal service supply indicators for the key public transport networks in CREATE Zones 1 and 2</u>

The following are a series of public transport modal supply indicators for the more recent period, taken from TfL's Travel in London reports. The overall picture is one of a progressive and substantial increase over the period covered by the figures – typically from the mid-1990s.

London Underground

Within the context of a generally fixed network (in terms of network extent), recent growth largely reflects incremental upgrades to individual tube lines to increase their capacity (Figure 4.2.2 (b)). This has typically involved the purchase of new rolling stock with higher capacities, and upgrades to the infrastructure so that service frequencies can be increased. This has been on-going over the period, but started to bear particular fruit from about 2010. Note that, in the period immediately before this, there was a slight dip in the trend owing to temporary closures on certain lines to allow engineering works connected with the upgrade programme. As a historical comparator, there were 48.8 million train kilometres operated in 1981 and 48.3 in 1977.

Figure 4.2.2 (b): Public transport capacity – London Underground. Train kilometres operated and scheduled. CREATE Zones 1 and 2 combined.

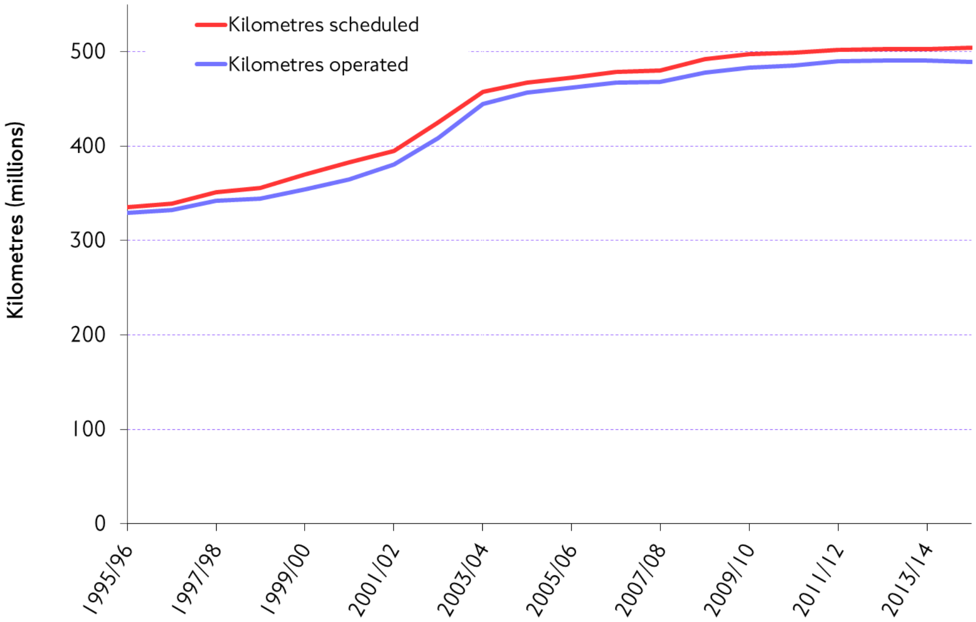


Source: Transport for London.

London Bus network

The trend here is similar to that described above for London Underground, reflecting the resurgence in public transport in the latter part of the period of interest for CREATE (Figure 4.2.2 (c)). The increase in bus service provision in London was particularly rapid in the period immediately after 2000, with the first Mayor of London making improving bus services a priority, to provide a capacity boost to public transport in London that could be implemented quickly. As a historical comparator, the number of bus kilometres operated in 1981 was 280 million, whilst in 1977 it was 288 million.

Figure 4.2.2 (c): Public transport capacity – Bus vehicle kilometres operated and scheduled. CREATE Zones 1 and 2 combined.



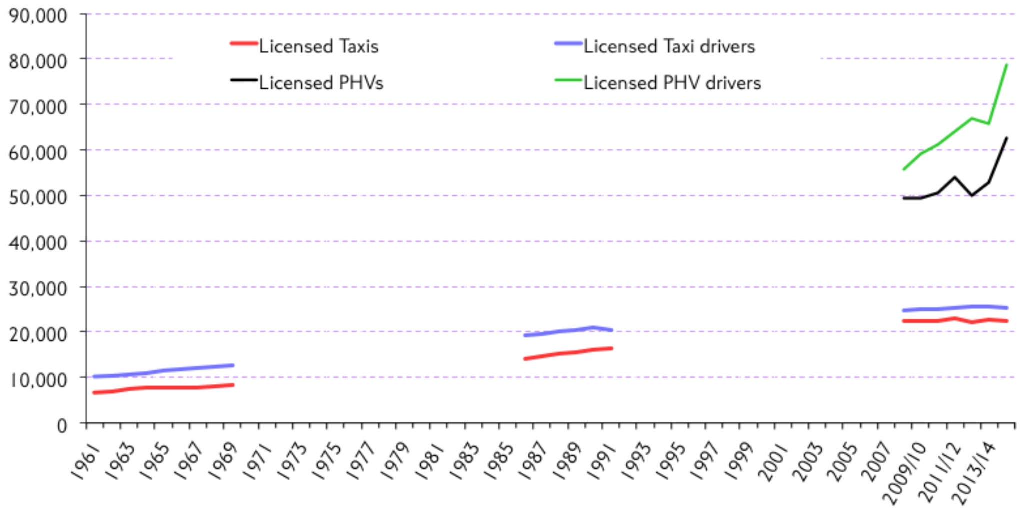
Source: Transport for London.

London Licensed Taxis and Private Hire

London has two types of taxis. The first type, known as London Licensed (Black) taxis, are regulated by Transport for London. These can be hired on street. These vehicles have to comply with strict 'conditions of fitness' and operating conditions, and fares are set by TfL (although the driver keeps these). There are two types of licence – 'green' badges, where the driver is able to operate London-wide, and 'yellow' badges, where the driver is only allowed to operate in outer London. Drivers of black taxis have to pass a test known as 'The Knowledge', which is a test of knowledge of the road network in London so that, in theory, they are competent to navigate across the entire London network.

Since 2003, Private Hire Vehicles have also been licensed by TfL. These can be hired for journeys that are pre-booked only (ie they cannot be 'hailed' on street in the same way that licenced taxis can. However, there are much fewer regulations relating to vehicle and driver fitness, and fares are not set by TfL. Recently, mobility options such as 'Uber' have become available in the Private Hire Market. These affect things like the operation of individual Private Hire businesses, but are not a matter for TfL, as this is a 'commercial' sector, albeit one that is subject to TfL regulation.

Figure 4.2.2 (d): Public transport capacity – Licensed taxi and Private Hire Vehicles. CREATE Zones 1 and 2 combined.



Source: Transport for London.

With reference to igure 4.2.2 (d), for which only limited historical data are available, the number of licensed taxis in London has grown steadily over the CREATE period. No information is available about the prevalence of private hire vehicles in London prior to their licensing in 2007. Since this date however their numbers have grown rapidly, in part reflecting initiatives such as Uber (see also https://www.uber.com/).

Full details of TfL's current arrangements for licensed taxis and private hire can be found at: https://tfl.gov.uk/info-for/taxis-and-private-hire/.

Public transport place kilometres

The above measures are vehicle-based. Different types of public transport vehicle have different capacities. Since 2007, TfL has developed a measure of the total capacity provided by the main public transport networks (bus, Underground and Light Rail (Docklands Light Railway and Croydon Tramlink). This relates to CREATE Zones 1 and 2 combined. The available time series reflects the contemporary trend of growing public transport provision in London (Figure 4.2.2 (e)).

Table 4.2.2 (e). Recent trend in capacity (place-kilometres) provided by the main public transport networks in London. CREATE Zones 1 and 2 combined.

Mode	2008/09	2013/14	2014/15	Percentage change 2008/09 to 2014/15	Percentage change 2013/14 to 2014/15
Underground	64,193	67,328	70,493	9.8	4.7
Bus	28,817	29,605	30,057	4.3	1.5
DLR	1,715	3,234	3,291	91.9	1.8
London Tramlink	556	632	629	13.1	-0.5

Source: Transport for London.

The London Overground surface rail network

A significant development of the last decade has been the creation of the London Overground rail network. This has progressively assumed responsibility for several former National Rail corridors in London. The idea has been to create high-frequency/high quality metro-style rail services. In its first year (2008), London Overground operated 3.3 million train-kilometres. By 2014, this had grown to 8.1 million. However, much of this growth relates to lines formerly operated by National Rail, albeit at a lower level of frequency. Small, but operationally key, pieces of new infrastructure have been added to facilitate the new service pattern. Further information on the development of this network can be found here: https://en.wikipedia.org/wiki/London_Overground.

4.2.3 Public transport cost (fares) levels

General considerations

The fares structure for public transport in London has undergone some very significant changes over the CREATE period. This means that time series of representative fares, even if indexed to take account of inflation etc. are not generally possible to construct. The key historical features of public transport fares in London are described below. Third party references are given which provide historical detail on these developments. A full description of current arrangements can be found on the TfL website (see: www.tfl.gov.uk)

- In the early part of the CREATE period, fares were distance-based. On the Underground, fares were priced on a station-to-station basis, as were fares on National Rail. Bus fares were similarly structured, based on bus 'fare stages', which were specific stops at which the price changed according to distance. Season tickets of various kinds were available, as were one-day passes valid on the entire bus network, but there were no 'fare zones' or Travelcards of the type available today.
- This structure lasted until the mid-1980s, when the concept of Fares Zones was introduced. This greatly simplified the fares structure, so fares were now available based on the zones travelled in, the fare being the same for the zonal combination used irrespective of actual distance. At the simplest level, there are six concentric fares zones in Greater London (CREATE Zones 1 and 2), although the precise structure has undergone many detailed changes over the period since the mid1980s (see: https://en.wikipedia.org/wiki/London_fare_zones).
- With the introduction of fare zones, the types of fares that were available also changed. A major development was the introduction of zonal-based Travelcards, which allow unlimited daily travel inside the particular zonal combination that is paid for (see: https://en.wikipedia.org/wiki/Travelcard). Travelcards and the fares are generally interchangeable between bus, Underground and other TfL services, although again this aspect has undergone many detailed changes in the period since introduction.
- The latest significant development has been the adoption of 'Smartcard' payments using the Oyster Card 'pay as you go' (see: https://en.wikipedia.org/wiki/Oyster_card). This works with the zonal fares structure described above, but allows elements of 'smart' pricing, the most relevant being that, to encourage adoption of Oyster, discounted fares have been set for Oyster use that are cheaper than the 'non-Oyster' fare (which very few people actually pay). A more recent development to this has been the introduction of 'contactless' payment, whereby mainstream debit and credit-cards can be used to pay for journeys, in all fundamentals in the same way as Oyster cards (see: https://en.wikipedia.org/wiki/Contactless_payment).
- Developments to concessionary fares (many different types) have also affected the profile of actual fares paid over the CREATE period (see, for example: https://en.wikipedia.org/wiki/Freedom_Pass).
- National Rail services in London are not operated by TfL and, whilst they have generally followed a similar path to TfL services in terms of the fare structure, this has not yet been

developed to the same extent. Generally, the current position is that fares are zonally-based, Travelcards and Freedom Pass concessions are available (integrated with the rest of TfL services), but Oystercards and contactless payment are only available on certain National Rail lines.

Pricing trend for representative tickets

Year-on-year prices from 2000 for a selection of 'representative' public transport tickets can be found at: http://londonist.com/2011/11/london-transport-fares-2000-2012. A summary comparison, between 2000 and 2016, is shown in Figure 4.2.3 (a) below. It is necessary to bear in mind that inflation will need to be taken into account in order that 'real' fares can be compared between the years and that there has been a growing differential over the period between 'Oyster' and non-Oyster fares. This is to incentivise the use of Oyster. For many years only a very small proportion of fares have been non-Oyster – the very large majority of fares are paid under the Oyster pricing structure.

Table 4.2.3 (a): Comparison of actual prices for selected 'representative' public transport fares in London (£ actual). CREATE Zones 1 and 2 combined only.

Ticket	2000	2004	2012	2014	2016
Underground single zones 1-4 cash	2.60	3.00	5.30	5.70	5.90
Ungerground single zones 1-4 Oyster	n/a	2.80	3.60	3.80	3.90
Bus single fare incl. zone 1 cash	1.00	1.00	2.30	2.40	n/a
Bus single fare Oyster (peak)	n/a	0.70	1.35	1.45	1.50
Seven Day Travelcard Zones 1-4	26.80	29.20	41.80	45.00	46.50
Seven day bus and tram pass	11.50	9.50	18.80	20.20	21.20

Source: http://londonist.com/2011/11/london-transport-fares-2000-2012.

Because of the many changes in fares structure and the lack of comparable historic information, it is preferable to look at indices that compare 'baskets' of fares that more appropriately reflect the cost of travelling by public transport in London. These are described below.

Real fares levels

Since 2009/10, TfL has developed a composite indicator of real public transport fares levels (Table 4.2.3 (b)). This is expressed in terms of pence per kilometre. The series is shown below. It is a composite measure, covering bus and Underground only, calculated as the total actual fares revenue for passengers paying full adult fares, adjusted for inflation and divided by corresponding actual bus and Underground passenger kilometres.

Table 4.2.3 (b): Real fares levels public transport (pence, 2013 prices). CREATE Zones 1 and 2 combined.

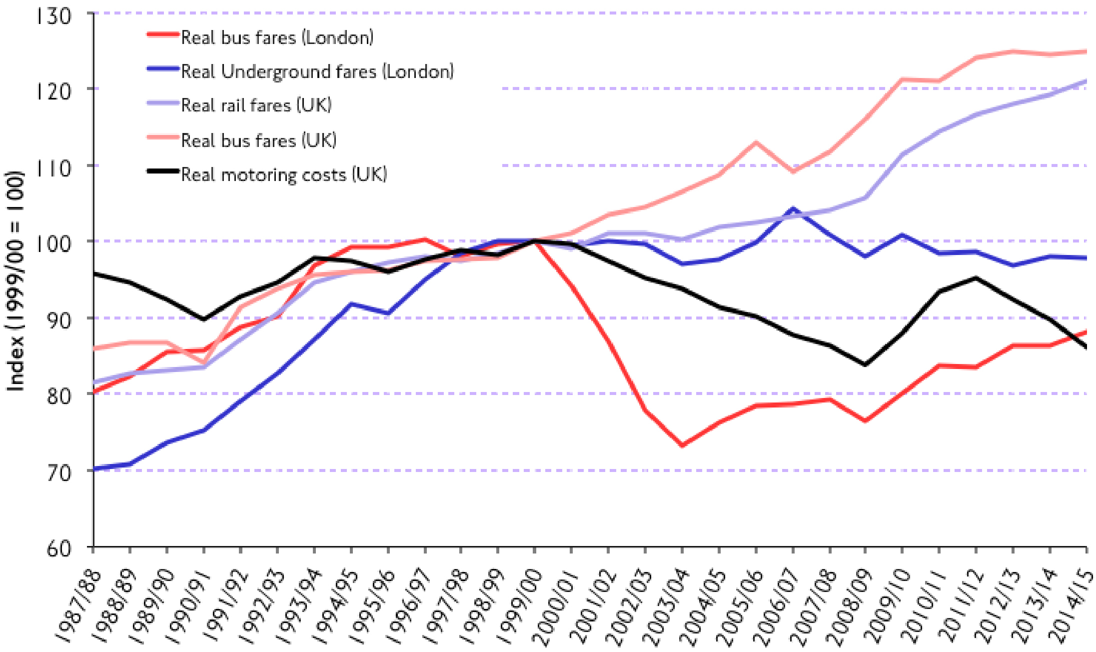
2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16
20.3	20.4	20.5	20.6	20.7	20.7	20.9

Source: Transport for London.

Comparative cost of public transport fares and motoring in London

Several more historic indicators are however also available. Figure 4.2.3 (c) below shows a longer term trend for public transport fares by main mode alongside the equivalent trend for the cost of motoring. It also gives a London-rest of UK comparison. Over this period it is seen that public transport fares in London have been relatively stable, yet those in the rest of the UK have increased in comparison. This largely affects legislative differences, most notably bus deregulation in the rest of the UK outside of London. Real motoring costs, only available at the UK level, have fallen in recent years, but the overall trend is not dissimilar to that for public transport fares in London. It should be noted that costs for motoring in London will probably have risen by a greater amount than those nationally. This is because high parking charges and policies like the congestion charge have imposed additional motoring costs that are specific to London.

Figure 4.2.3 (c): Trend in real public transport fares and motoring costs comparison. London trends relate to CREATE Zones 1 and 2 combined only.

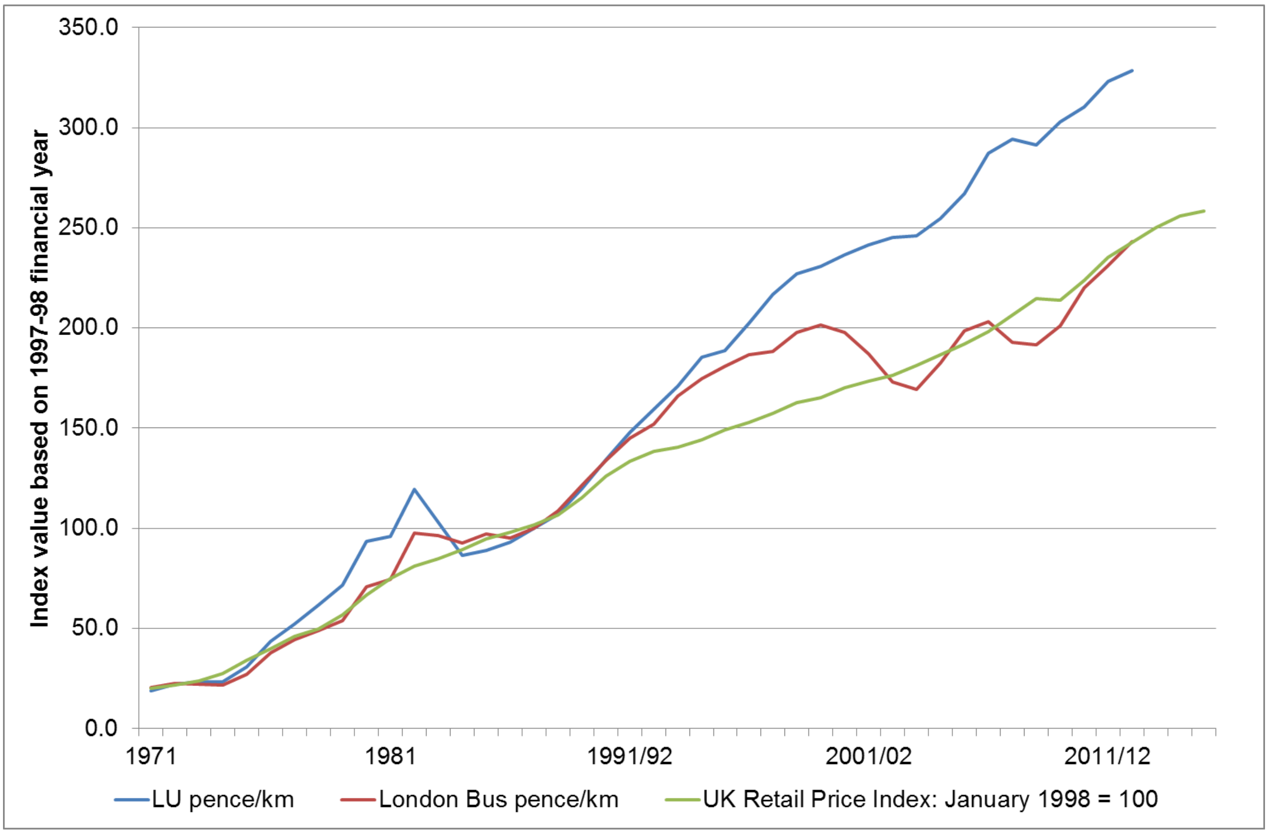


Source: Transport for London.

Average fare paid

For an even longer historic perspective, Figure 4.2.3 (d) shows the long-term trend in average absolute fares since 1971 for bus and underground. This index reflects changes to factors such as concessionary fares - so different proportions of travellers receive the various concessions over the years of interest. The RPI index (retail price index – a measure of inflation) is also given for comparison. Basically, bus fares have broadly matched the RPI over the long term, but were notably higher, in terms of the RPI during the 1980s and 1990s. The recent reduction in relative price of buses reflects the large-scale investment in the bus network since 2000, and the corresponding rationalisation of the ticketing structure. The introduction of fare zones and Travelcards, with a daily fares cap, effectively means that the marginal cost of additional bus journeys is zero. Whilst the 'headline single fare' remains high, very few people actually pay it. On the other hand, fares on London Underground have consistently outpaced the RPI over the period.

Figure 4.2.3 (d): Long-term trend in average fares paid, with RPI deflator. CREATE Zones 1 and 2 combined.



Source: Transport for London.

<u>Peri-urban area</u>

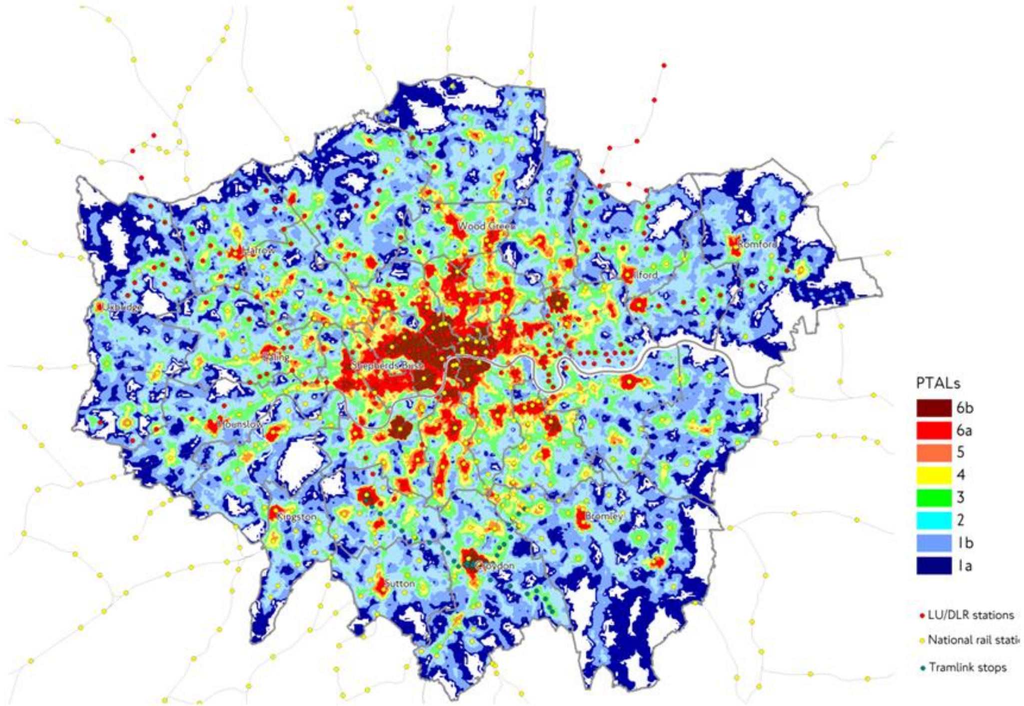
No consistent data for this indicator are available for the peri-urban area,

4.2.4 Public transport access of inhabitants

TfL measures the public transport access of Greater London residents in terms of our 'PTAL' measure (Public Transport Access in London). Note that this is primarily a measure of connectivity to the transport networks. This measure does <u>not</u> reflect physical accessibility, in terms of Londoners with disabilities. As would be expected, the overall pattern is, and has been for many years, a progressively greater level of access for locations closer to central London.

TfL has developed a sophisticated website from which interactive maps can be obtained and bespoke queries made - our 'Webcat' system (available via: https://tfl.gov.uk/info-for/urban-planning-and-construction/planning-with-webcat/webcat?lat=&lon=&type=Ptal&locationId=&input=&scenario=2011+%28Base+year%29). Figure 4.2.4 (a) below gives a London-wide overview for 2015. Whilst very useful in terms of the planning process for specific developments, for CREATE purposes this indicator has several limitations. Access to the public transport networks does not necessarily mean that they provide services to locations that people want to reach, and the indicator takes no account of change in terms of enhanced service levels and quality on the networks that exist. In terms of historic change, although not available from this source, the radical expansion of the bus network in London during the first half of the decade beginning in 2000 would have been expected to significantly improve general PTAL levels, particularly in outer London where connections in some areas were previously relatively sparse.

Figure 4.2.4 (a): Overview of Public Transport Accessibility Levels (PTALS) in Greater London (CREATE Zones 1 and 2 combined).



Source: Transport for London. Strategic Analysis. WEBCAT tool.

PTAL is a measure of connectivity. A high PTAL in a specific location indicates good connectivity to the public transport network. PTAL values are influenced by the walking distance to nearby stations and stops, and by the frequency of services at these stations and stops. It is not directly a measure of distance from any location to the nearest public transport access point. Full details of the PTAL methodology can be found in the following report: https://tfl.gov.uk/info-for/urban-planning-and-construction/planning-with-webcat.

Peri-urban area

No data on this aspect are available for the peri-urban area, or in terms of a significant historical time-series.

4.3 Cyclist/pedestrian priority

At the city-wide scale the degree of cyclist and pedestrian priority on the road network is relatively small. However, it has increased progressively over the CREATE analysis period and, in particular, at a rapid rate in more recent years.

The main historical developments have been:

- A trend towards pedestrianisation of town centres. This improves the retail and urban environment (eg to encourage shopping).
- An early trend towards delineation and signage of semi- or un-segregated cycle routes (the London Cycle Network of the 1990s).
- More recently, the 'legible London' scheme which focuses on improving signage and promoting short walk trips and,
- The previous Mayor of London's Vision for Cycling.

Source material describing each of these is available via the Internet (see, especially, https://www.london.gov.uk/sites/default/files/cycling_vision_gla_template_final.pdf, which describes the Mayor of London's Vision for Cycling, and https://tfl.gov.uk/modes/walking/, which illustrates TfL's contemporary approach to encouraging and facilitating walking as a transport mode in London.

Peri-urban area

No data on this aspect are available for the peri-urban area.

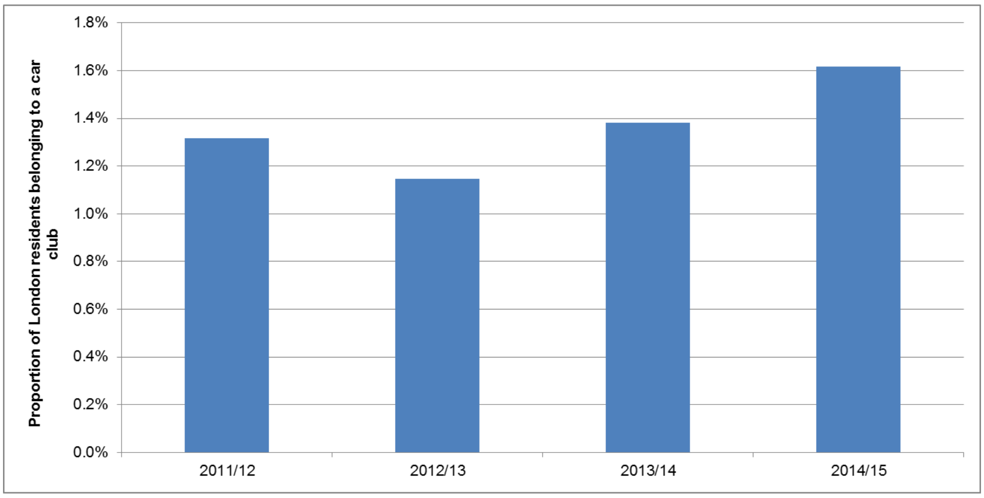
4.4 Car sharing systems

London is the largest market in Europe for car clubs (known as car sharing outside of the United Kingdom) and the second largest globally. Over recent years there has been sustained growth in both car club membership and the geographical coverage of car clubs across London. During 2015 further progress has been made in terms of member numbers, network coverage and sector innovation. Member numbers grew to almost 186,000 using a network of almost 2,500 cars across the capital. Most boroughs are now served by more than one operator.

Flexible models are expanding their coverage across the city through the public launch of GoDrive and continued growth of services offered by DriveNow. In flexible car clubs, cars may be located on-street (but not in designated bays) or off-street and do not necessarily need to be returned to the same location where they were picked up. Car clubs are no longer seen as an 'alternative' option in policy terms, but rather an attractive part of a modern mobility mix alongside public transport, taxis, walking & cycling.

Although growing significantly, and seen as a possible preferential model for the future, the number of Londoners who are members of a car club is between 1 and 2 per cent. Although, in theory, the car club model can 'take a number of cars off the road', as people only use them when they need a car rather than bearing the whole cost of ownership, there is undoubtedly also an element of 'self-selection' among car club members – that is that members are more likely to be those who have occasion to use cars on only an infrequent basis. In addition, this is a relatively new innovation in London and is not significant in terms of explaining long-term travel trends.

Figure 4.4.1 (a): Car Club membership in London (CREATE Zones 1 and 2 combined).



Source: Transport for London.

Peri-urban area

No data on this aspect are available for the peri-urban area. However, it is not thought that car clubs are yet significant in this area.

5 Transport policies

5.1 Private car transport access restrictions

These have been of some significance in London, in so far as they have contributed to the reduction in effective road network capacity for general traffic.

There have been a few examples of pedestrianisation of some town centres, such as Kingston – in this case dating back to the late 1970s. The Mayor's Roads Task Force sees an increasing use of access restrictions of this type to better manage traffic and improve the urban environment.

However, a more significant effect has been the closing off of a lot of minor residential roads, where they join the major road network, to discourage through traffic or 'rat running'. This has been particularly prevalent in inner London. The roads still permit vehicular access, for example for residents, but do not allow through traffic. This is to improve safety and the urban environment. But is has meant that traffic is compelled to use the more major roads, arguably leading to greater congestion on these roads and the need for longer, more 'round about' journeys.

Peri-urban area

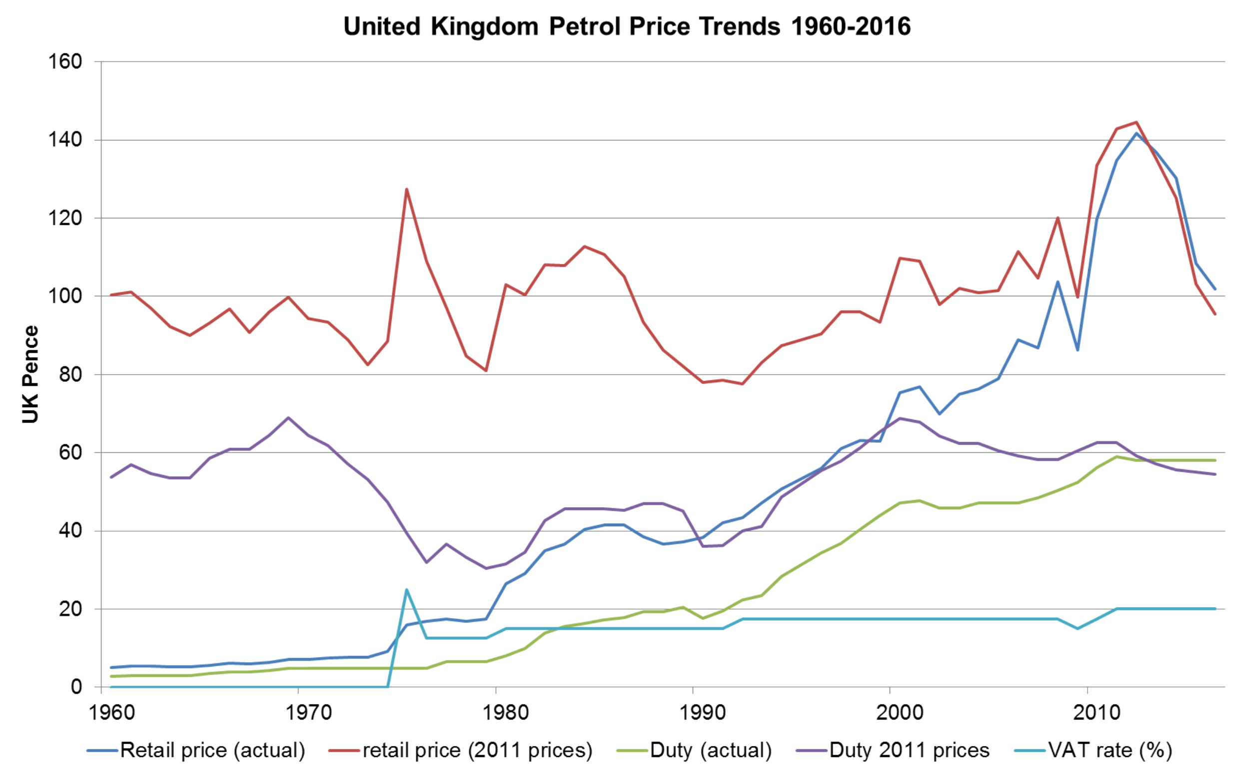
No data on this aspect are available for the peri-urban area, although similar general policies to London are thought to have been pursued in some of the larger towns.

5.1.1 Fuel prices

Fuel prices are conventionally regarded as being related to the demand for road travel with a long-run elasticity of about -0.3 (see, for example, http://www.sciencedirect.com/science/article/pii/S2352146514000192). However, this effect is considered in isolation from the wide range of other variables that affect demand for road travel.

Figure 5.1.1 (a) shows indicators relating to the price of fuel for road vehicles in the UK (London does not differ significantly from the rest of the UK in this respect). In terms of the total 'pump' price, which is indexed to 2011 prices, the 'real' cost in 2016 is effectively identical to that of 1960. However, the effect of the oil crisis of the mid 1970s, together with recent oil price highs, are visible in the trend. It is also notable that absolute levels of duty on fuel in 2016 are effectively the same as in 1960. However, an additional duty, in the form of Value Added Tax, has been levied since 1974.

Figure 5.1.1 (a): Indicators of road fuel costs – United Kingdom.

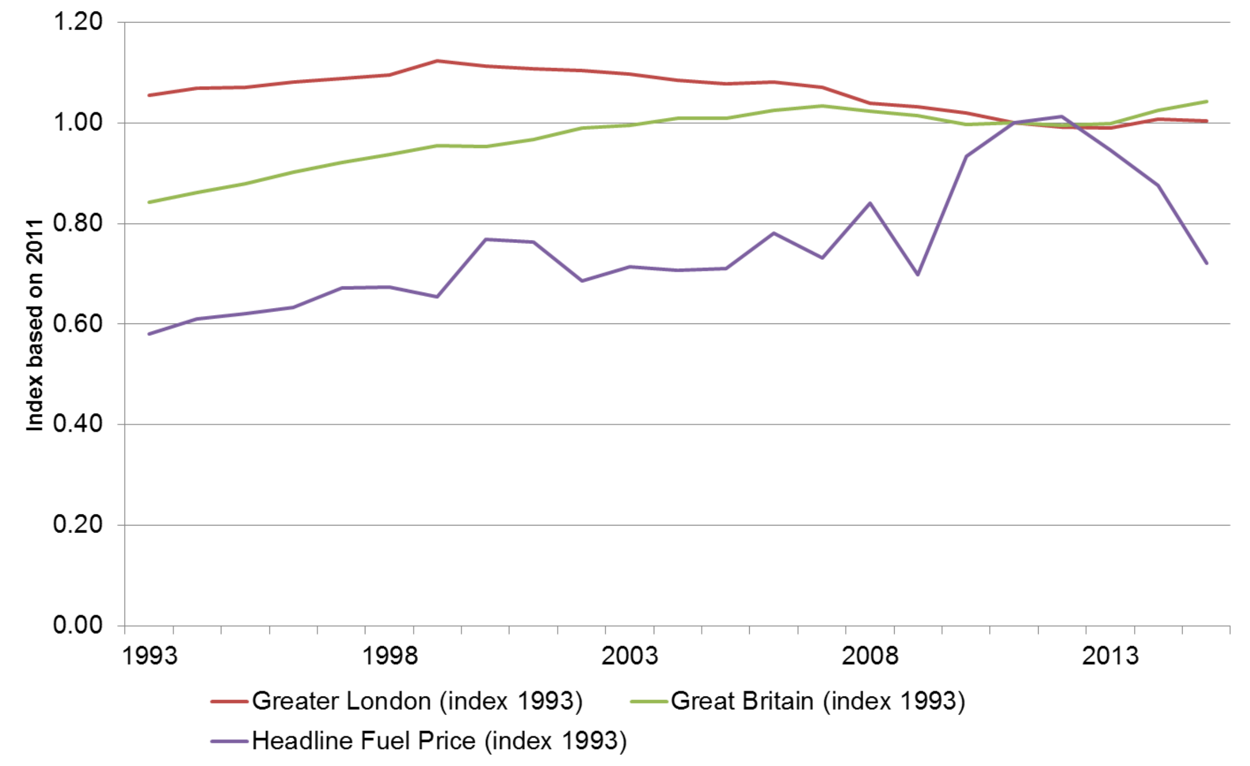


Source: United Kingdom Department for Transport.

<u>Relevance to explaining travel trends</u>

The long-run trend in the total cost of road fuel has been relatively stable, despite short-period fluctuations. Of itself, therefore, it is not thought that changes have been a major factor in explaining long-term travel trends over the CREATE period. In considering road fuel price trends, it is also important to consider the public transport counterpart (see below). Furthermore, because it is believed that there have been specific factors applying to London that have affected traffic trends, it is informative to set UK and London traffic levels against one another in the context of the 'headline' total fuel price (the red line on the above figure). This is done in Figure 5.1.1 (b) below, where it is seen that London and national traffic trends diverged for much of the CREATE period. The fuel price spike around 2011 did have a perceptible effect on traffic demand at a national level, but it should also be remembered that the aftermath of the banking crisis was also felt for much of the latter years of the last decade.

Figure 5.1.1 (b): Relationship of London and UK traffic trends to headline fuel price. 'London' refers to CREATE Zones 1 and 2 combined.



Source: Transport for London. Strategic Analysis.

5.2 History of a road pricing system

The Central London Congestion Charging scheme is described extensively in the literature. The impacts, during the early years of the scheme, are described in detail in TfL's Congestion Charing: Impacts Monitoring Reports, the series of which can be found at: https://tfl.gov.uk/corporate/publications-and-reports/congestion-charge. This TfL web page also contains extensive details relating to the design of the scheme and its current operation (see: https://tfl.gov.uk/modes/driving/congestion-charge). The Congestion Charge only affects central London, a relatively small part of CREATE Zone 1.

For CREATE purposes, the following are the key points:

- The Congestion Charge was developed as a concept as far back as 1961 (see Smeed, R, 1961). However, political circumstances were such that it was not adopted as a policy for some four decades after this original report. Several technical feasibility studies were however completed over the period 1960-2000, the most recent of which, the Road User Charging Options for London (RoCOL) report (Government Office for London, 2000), provided the effective blueprint for the current scheme.
- With the creation of the Greater London Authority (GLA) in 2000, and election of a Mayor (Ken Livingstone), who included the introduction of congestion charging in his manifesto, it became possible and the scheme was implemented in February 2003.
- As has been elaborated in WP4, however, the key thing is that changes in London government and the worsening of congestion over the previous 30 years had given rise to a groundswell of opinion that some form of charging scheme should be introduced to tackle the problem of congestion in central London. The administrative and political changes around year

2000 allowed this to happen, but the circumstances that gave rise to the perception that is was an appropriate response to congestion have much deeper routes and go back much further in time.

- Although the scheme was very high profile, it only directly affected about 2 per cent of London's road traffic. In terms of overall London traffic trends, therefore, it is very small in scale. Also, these effects only apply during weekday charging hours, again diminishing the actual impact on annual trends.
- Within the charging zone, traffic volumes during charging hours fell by 15 per cent and congestion, measure4d as excess delay, by 30 per cent.
- During subsequent years there was a continued incremental reduction in traffic volumes of about 1 per cent per year. This is thought mostly to reflect continued removal of road capacity, then any significant effect of changes to the charging scheme itself. In 2006, there was a 60 per cent increase in the charge, from £5 to £8. But the traffic response was equivalent to about 1 per cent additional incremental reduction on the established trend of continuing slow decline. We concluded that the remaining traffic after the impact of the original charge, plus the already high 'generalised cost' of driving in the charging zone, was very inelastic. Very little further traffic reduction would therefore be achieved by further increases to the charge.
- There was a western extension to the central zone introduced in 2007 and removed in 2011. This had general impacts proportionate to those of the original central area.
- There are no current plans or proposals to further extend road user charging in London.

Charging other than in central London

There are no other significant road charging or toll arrangements in London. In the peri-urban area, the Dartford (motorway M25) crossing is a tolled piece of infrastructure, However, tolling along similar lines is increasingly being explored as a way to fund new road infrastructure, for example new river crossings to the east of London.

London's Low Emission Zones are not road user charging schemes, although they have been enacted under road user charging legislation. They have the characteristics of emissions regulation schemes. A penalty charge is only payable if vehicles do not comply with the specified regulation, which is very much the exception. They do not produce overall net revenues. Further details of London's Low Emission Zone can be found at: https://tfl.gov.uk/modes/driving/low-emission-zone. There are developing plans to further extend low emission zones in Greater London – primarily to bring forward compliance with EU Air Quality regulations.

5.3 Dynamic traffic light controls

SCOOT – a form of dynamic traffic signal control – has been in operation in London since 1984. **Split Cycle Offset Optimisation Technique** (**SCOOT**) is an adaptive traffic control system for controlled road crossings originally developed by the UK Transport Research Laboratory. It has been progressively extended over these years, and continues to be extended today, with an eventual aspiration to cover all of London's signalised junctions. See below for a link that explains the operation, benefits and current status of SCOOT in London. http://www.scoot-utc.com/London.php?menu=Results

It is important to bear in mind that decongestion benefits quoted in connection with SCOOT are local, confined to the junction to which it is applied. There are no reliable statistics that quantify network-level effects, where numerous SCOOT junctions act semi-independently. It is likely, however, that the network level benefits are of a substantially lower order of magnitude than the junction-specific benefits. In London, SCOOT is seen primarily as a way of mitigating existing congestion problems, rather than proactively increasing the throughput of the road network.

Peri-urban area

There is no data on the application of SCOOT in the peri-urban area, although it is not thought to be in widespread use.

5.4 Travel demand management

Until the London 2012 Olympic Games, there was little recognised practice of formal Travel Demand Management in London. Of course, there were information and demand management strategies put in place for major events and closures historically, but these did not have the objective of influencing travel on a large scale on a permanent basis. The Games required this, so that the exceptional demand associated with the Games themselves could be accommodated on the networks, whilst London could also be kept 'open for business'.

The Travel Demand Management strategy put in pace for the games was both ground-breaking and very successful. The strategy and the outcomes are described at length in TfL's Travel in London report 5 and are not repeated here (see, in particular, Figure 10.69 of that report): https://www.google.co.uk/search?q=travel+in+London+report+5&ie=utf-8&oe=utf-8&gws_rd=cr&ei=FznNV6u2FYaNgAbe2oIY.

TfL's calculations showed that 'background' travel demand was reduced by about 5 per cent during the Olympic Games, and by about 3 per cent during the Paralympic Games. This was almost equal to the additional Games-related demand. Furthermore, in terms of time and place, the reductions achieved were almost precisely in the optimal time/locations to give the required relief for Games-related travel demand.

However, it was also the case that this changed travel demand did not endure after the Games. Within a very short space of time demand levels were back to those before the Games. Nevertheless the success of the Games did influence TfL to look into applying these tools and strategies both in connection with major events and closures after the Games, and more generally to influence travel demand away from very crowded parts of the networks, although there are few significant examples of where this is currently in action. The text below describes how TfL currently formulates the idea of travel demand management as part of its work.

TDM supports travel in London by offering customers the ability to make better informed decisions and enabling and encouraging them to avoid times and locations where demand exceeds, or will exceed, transport capacity and where regular travel will be significantly affected by planned events, maintenance or network changes.

TfL works collaboratively with other transport operators to positively influence customers' travel experiences in London. This includes actively seeking to achieve targeted changes in travel behaviour where there is a direct customer and business/operational benefit and developing an open relationship with customers by giving them useful information and advice presented consistently.

There are three strands to TDM in London:

- 'Everyday Hotspots' which relate to areas of recurring congestion.
- Major events, which include regular mass participation events including the London Marathon and Prudential Ride London as well as one-off events such as the 2014 Rugby World Cup and 2015 World Athletics Championships.
- Major works, such as the development of Thameslink, form the final strand of TDM.

Information is passed to customers through a range of channels including advertising, direct emails, social media and TfL Online.

Peri-urban area

There is no information available about the prevalence of these initiatives in the peri-urban area, although it is not thought to have been developed to the same extent as in London.

5.5 Priority for public transport at intersections

There are several kinds of bus priority in London. The most prevalent are segregated bus lanes. However, there are also examples of vehicle-activated traffic signal priority control. These have been rolled out progressively over the past 25 years and are now widespread in central London and in congested town centre areas in inner and outer London. The following is a paper that describes the situation in London: http://abstracts.aetransport.org/paper/download/id/2379. It is important to note that initiatives to give priority to public transport on the road network also have the effect of removing capacity for general traffic. Alongside many other types of intervention, and whilst improving the reliability of public transport, and thereby encouraging its use, these interventions are thought to be of significance in explaining the overall reductions to effective road network capacity in Greater London.

Peri-urban area

There is no information available about the prevalence of these initiatives in the peri-urban area, although it is not thought to have been developed to the same extent as in London.

5.6 Public transport subsidy

This is currently being dealt with as part of the response to WP4 and is not elaborated in detail here.

5.7 Public transport subsidy

The evolution of parking regulations in London is both complex and varied, since parking is primarily the responsibility of the 33 London local authorities (boroughs). It is not attempted to explain the full details here. However, reference should be made to the following website, which explains the current status of parking in London: http://www.londoncouncils.gov.uk/services/parking-services/parking-and-traffic/parking-advice-members-public/parking-your-car-london

In summary: Parking has become a major constraint on both car ownership and the relative attractiveness of car use over the CREATE period. There is limited road space available for parking, and as car ownership increased during the early part of the CREATE review period the available space quickly became over-subscribed. The general response to this was to introduce controlled parking zones in residential areas, where only residents were able to obtain a permit, together with charges for more general parking ‘on street’. These charges are set by local authorities and regulations differ between them. Parking on-street in central London is now very expensive and adds a major additional cost to the ‘generalised cost’ of a car trip. Alongside this, the general hassle of finding a parking space etc. is known to be a major deterrent to driving in central and parts of inner London. A further factor that has been important is that the supply of off-street (private non-residential) parking as declined sharply, particularly in central London. Furthermore, parking charges (from on-street parking places or, in some cases, residential permits, are now a major part of local authority revenues (income) stream.

6 Transport demand and car ownership

Essential background

There are many aspects of travel demand patterns that will be of interest to CREATE, Material on many of these has been produced by TfL and is in the public domain – primarily through our Travel in London reports series. This section presents a selection of the more relevant indicators, together with some brief interpretation in each case.

The travel data presented in this section is drawn from comprehensive household-interview based travel diary surveys. In London (CREATE Zones 1 and 2), large-scale exercises were conducted every decade from 1971 until 2001. From 2005/06, the survey moved to an annual rolling (continuous) survey, with a correspondingly smaller sample size. The data from each of the surveys is broadly, although not completely, compatible across the time series, although the range of variables that are available from the older surveys is rather more limited than that allowed by the current survey. The second source is from data collected 'on system' relating to patronage on each of the key travel modes. These are typically things like traffic counts and 'ticket' (ie Oyster) 'events.

The travel diary surveys only cover residents of CREATE Zones 1 and 2 – the total travel in London is of course influenced by a range of categories of non-London residents (eg commuters, tourists) – these thought to account for between 15 and 20 per cent of all travel at the Greater London level (although more locally). The on-mode data provides nominally 100 per cent coverage of all travellers, regardless of their residential location. Both sources used in combination can therefore give a comprehensive picture of total travel patterns and, for residents, the socio-demographic basis underlying their travel behaviour.

For the peri-urban area (CREATE Zone 3), the only source is the United Kingdom National Travel Survey (NTS). This is a national-level travel diary based survey. Although it is similar in concept to the travel diary survey in London, there are a number of key methodological and definitional differences that mean that data are not usually directly comparable with equivalent data from the within London survey. Consistent data from this source are available back to the early 2000s. Apart from the methodological incompatibilities, a further limitation on the use of NTS data is the small available sample size (in the context of a national survey) for the selected local authorities that comprise CREATE Zone 3. Where possible, three-year moving average values are used to partially overcome this limitation. Nevertheless, it should be borne in mind when making comparisons between trends inside and outside Greater London.

As with most 'query-able' databases, a very wide selection of tabulations can be produced. Those reproduced below are perhaps the most representative – but many other tabulations and/or variations to tabulations can be produced from the basic datasets – which have already been made available to the CREATE consortium.

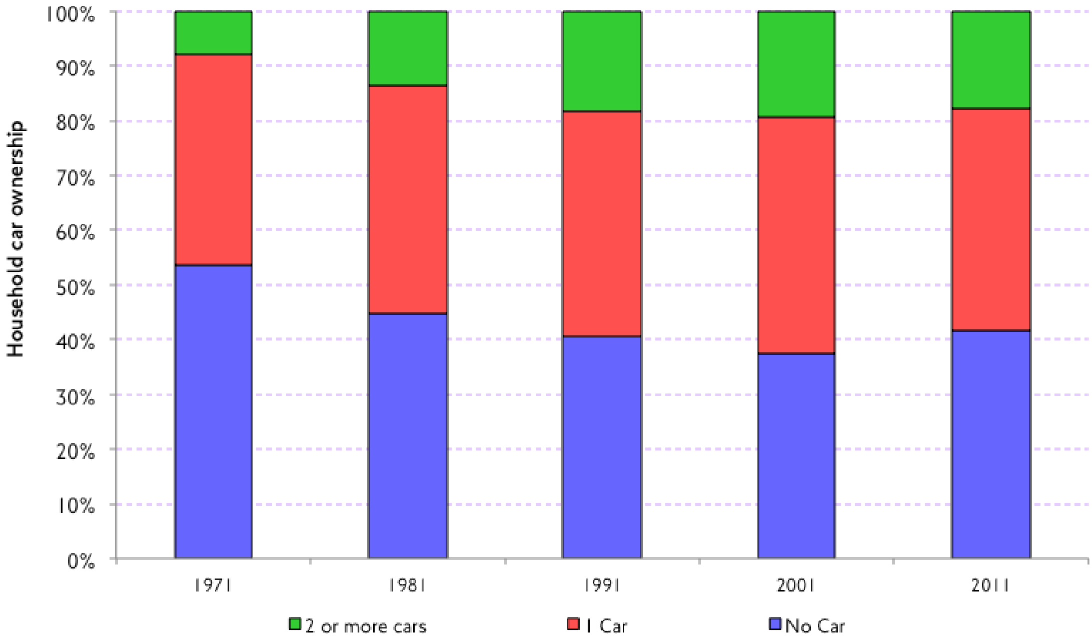
6.1 Car ownership

6.1.1 Private car ownership and driving licence holding

The five figures that follow show various aspects of car ownership and use in London, from TfL's travel survey data. They all relate to CREATE Zones 1 and 2.

Figure 6.1.1 (a) shows the long term trend in household car ownership in London. The trend to 1991 is of increasing car ownership – reflective of CREATE Stage 1 and 2 conditions. 2001 however is an inflexion point in the graph, with 2011 showing a net decrease. The distinction between households in terms of the number of cars is of interest, bearing in mind that household size changes also need to be taken into account in interpreting these.

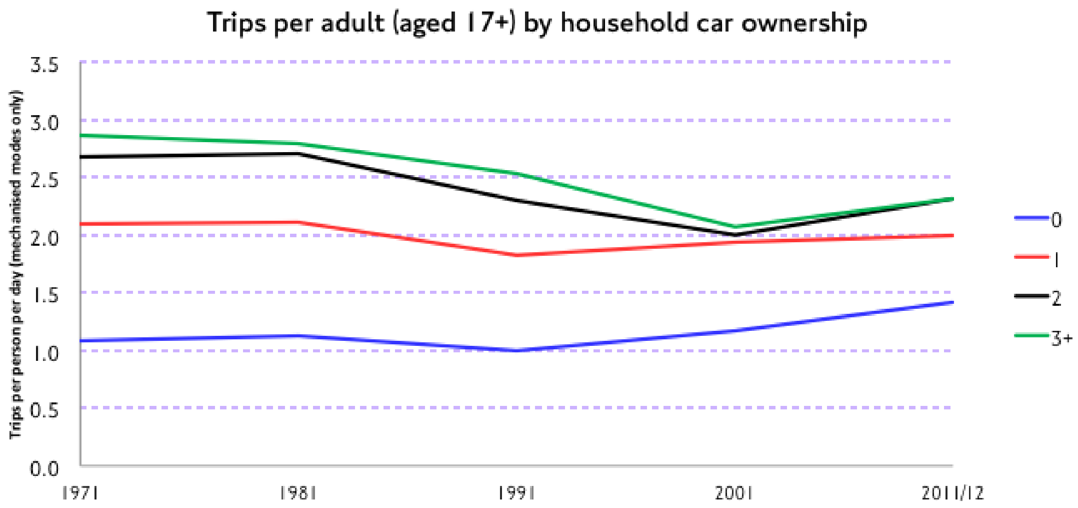
Figure 6.1.1 (a): Long term trend in household car ownership in London. CREATE Zones 1 and 2 combined.



Source: Transport for London.

Figure 6.1.1 (b) shows person trip rates by car ownership (household level). It therefore shows how the household car ownership changes described above relate to and affect the travel behaviour of those living in the households. Note that the trip rates (average number of trips per person per day) relate to travel by all modes (not just car). In terms of observations from the graph, firstly there is the expected relationship between car ownership and general mobility – persons living in households with more cars tend to be more 'mobile' than those living in households with fewer or no cars. However, this is almost certainly not a simple cause/effect relationship – for example wealthier residents tend to lead lifestyles that require higher levels of mobility, as do people in larger households – which in turn means that they are likely to have a higher degree of car dependence. Of particular note from the figure is the near 50 per cent rise in mobility levels among those living in households with no car. On the one hand this probably reflects the large-scale enhancements to public transport in London over the last decade or so. However, it probably also reflects a 'substitution' effect, in that the increase in non-car households in London seen in recent years does not always reflect 'travel poverty' – the 'non-car' lifestyle in London is increasingly preferred by affluent people, who lead more mobile lives.

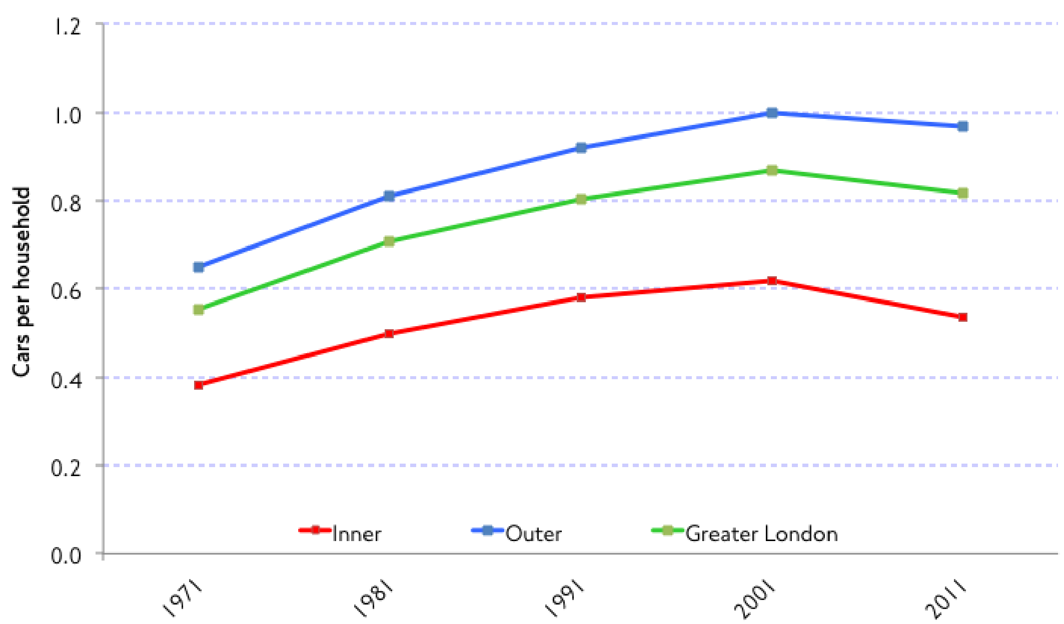
Figure 6.1.1 (b): person trip rates by household car ownership (all mechanised modes only (mechanised: mechanical, excluding walking and cycling but including all other modes) – a measure of 'total mobility' as it relates to car ownership).



Source: Transport for London.

In terms of geographical breakdown between CREATE Zones 1 and 2, the Figure 6.1.1 (c) below shows the average number of cars per household in Greater London on a consistent basis since 1971. The general pattern is of an increase to 2001, followed by a decline. In interpreting this trend, it is necessary to bear in mind that car ownership is not consistently related to mobility (see also below), and that household size is also a factor.

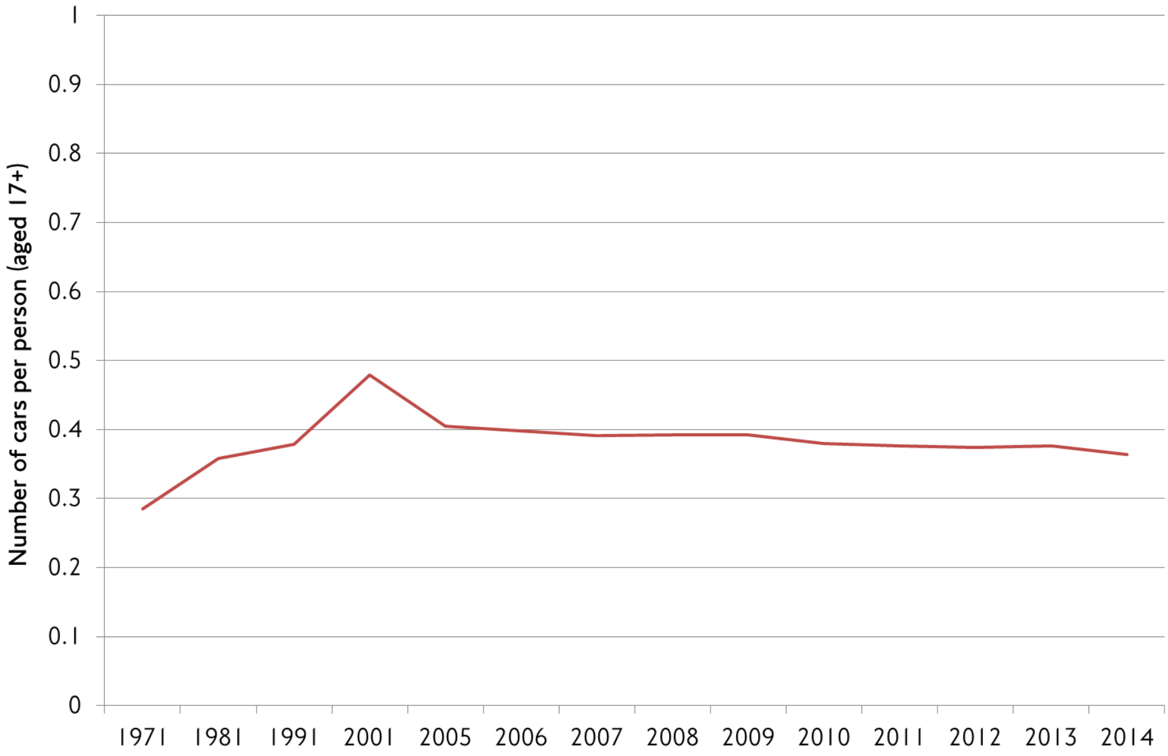
Figure 6.1.1 (c): Cars per household – Greater London. CREATE Zones 1 and 2 separately.



Source: Transport for London.

A related indicator is number of cars per head (Figure 6.1.1. (d). This is calculable using the census data for population and the travel survey data for car ownership. This is distinct from vehicle licensing based data, which may include vehicles registered to company headquarters in London. It shows a broadly intuitive trend of a historic increase, followed by a later fall. Note the compressed timescale on the graphic in order to accommodate the earlier decennial travel surveys.

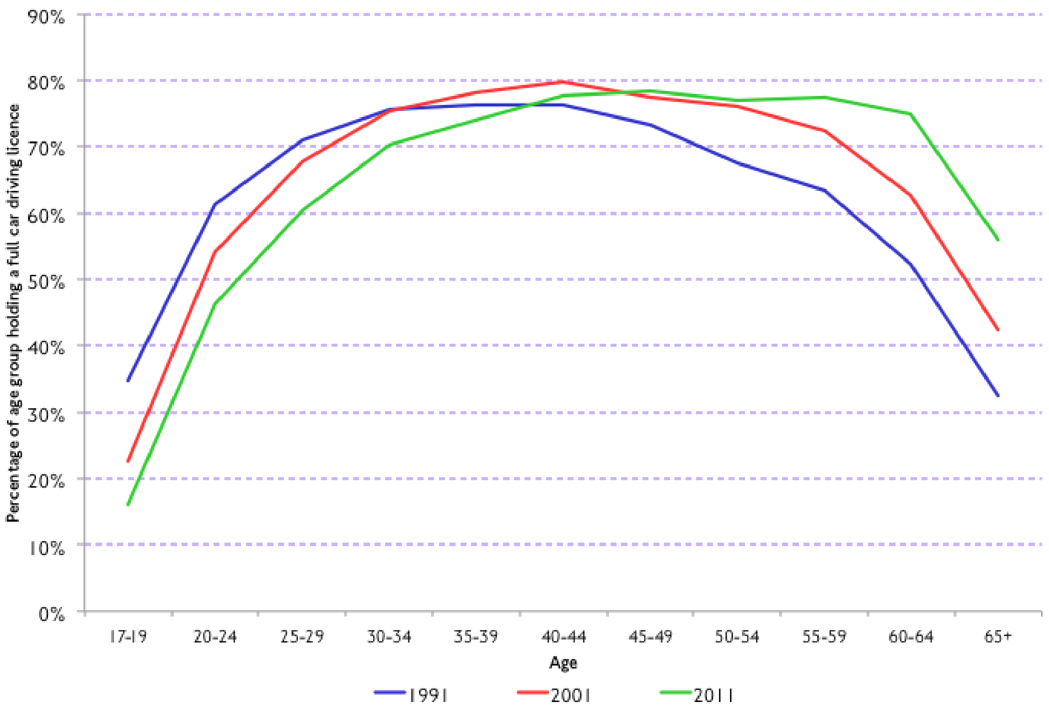
Figure 6.1.1. (d): Trend in cars per head in CREATE Zones 1 and 2.



Source: Transport for London. LTDS and predecessor surveys.

Figure 6.1.1. (e) shows the trend in driving licence holding for greater London residents (CREATE Zones 1 and 2 combined) since 1991. Data for earlier years is not available. The overall trend, as has been documented elsewhere, is for a right-wards shift in the age distribution of licence holders, as older people retain licences previously held as they age, and fewer younger people take up driving. For further description about this phenomenon, see http://www.racfoundation.org/research/mobility/on-the-move-main-research-page. This is a manifestation of the 'cohort' effect described above – whereby different generations 'carry their travel behaviour traits with them' as they age. The extent to which contemporary younger people carry their relatively lower driving licence holding with them as they age, or the extent to which they 'catch up' at a later date, is a largely unknown question – but one of crucial relevance to planning for future travel demand on horizons up to 40 years hence http://content.tfl.gov.uk/long-term-trends-in-travel-behaviour-cross-sectional-cohort-analysis.pdf

Figure 6.1.1. (e): Trend in driving licence holding for Greater London residents. CREATE Zones 1 and 2 combined.

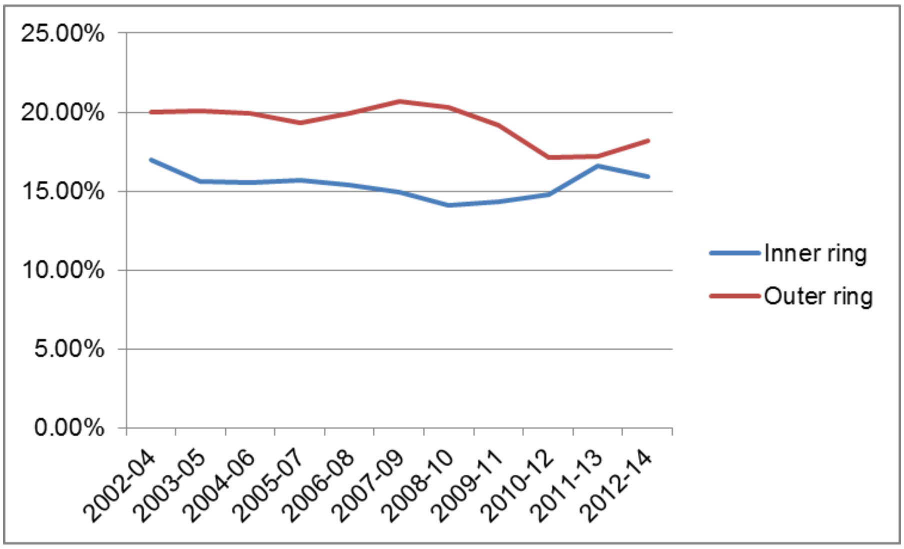


Source: Transport for London. LTDS and predecessor surveys.

Peri urban area

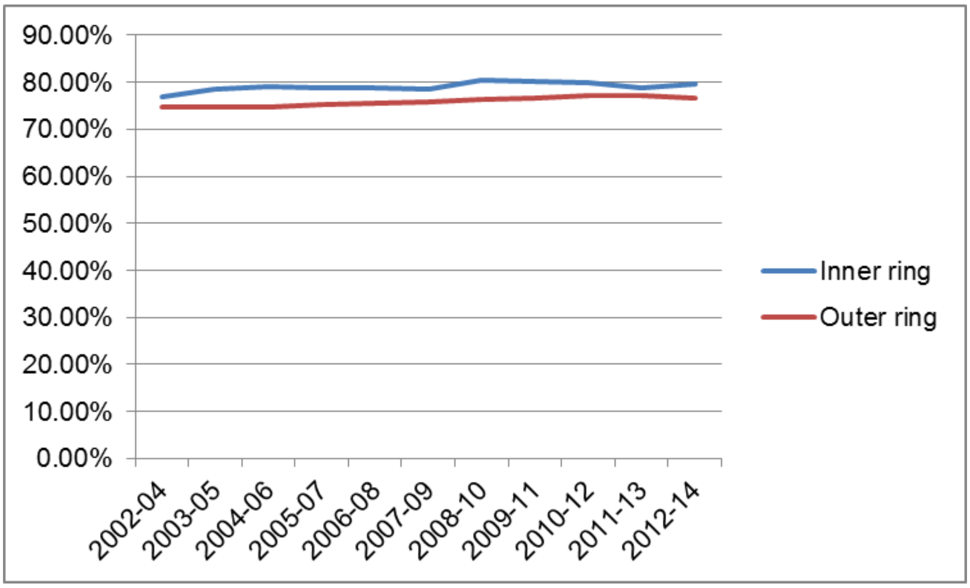
Car ownership rates have increased slightly in both London's inner and outer peri-urban areas since 2002, whilst driving licence holding amongst adults has increased slightly in both London's inner and outer peri-urban areas since 2002 (Figures 6.1.1 (f) and (g)).

Figure 6.1.1 (f). Three-year moving average of households not owning a car in London's Inner and Outer Peri-urban areas.



Source: UK National Transport Survey (NTS).

Figure 6.1.1 (g). Three-year moving average of adults holding a full driving licence in London's Inner and Outer Peri-Urban areas.



Source: UK National Transport Survey (NTS).

6.1.2 Ownership of yearly public transport season tickets

General considerations

These data are not available on a consistent basis for London. Furthermore, changes to the fares and ticketing structure mean that they would, in any case, not be meaningful in a comparative sense.

There were developments during the 1980s that integrated fares across the main public transport modes, which had previously been organised and charged on a separate basis. In particular, this brought together surface rail, underground rail and bus into one unified ticketing structure, under the brand 'Travelcard' (initially from 1981 with the creation of fares zones). At around the same time, persons over 65 years were given a free annual 'Travelcard'. More recently, from about 2000, the roll-out of Oyster-based (Smartcard) ticketing, with the associated daily fares cap, mean that conventional season tickets for bus and underground rail networks are effectively being phased out. This trend is also now progressively spreading to surface rail in and around Greater London. These developments are described in more detail above.

The table below shows the situation as recorded by the 1991 household travel survey for Greater London residents. A second table gives the equivalent position in 2014/15. Annual Travelcards are not specifically identified in the survey.

A factor to bear in mind when interpreting these trends is the equalisation of eligibility age between genders for the Freedom Pass between the surveys and the more recent general deferral of eligibility reflecting an increase in the state pension age – meaning that the prevalence of this type of pass over the years is not a direct reflection of 'retired persons' travel'. The reduction in Travelcard holding between the surveys is also probably a reflection of various alternative pricing strategies made available through Oystercards. There is, for example, a daily cap applied on spend. This functions in a very similar way to a Travelcard as far as the customer is concerned, in that they can travel 'for free' above a pre-set level of spend (the same concept as a Travelcard, but not marketed as such). Full details of the fares structure in London can be found on TfL's webpage: https://tfl.gov.uk/fares-and-payments/fares. There is therefore less need to purchase a daily Travelcard or, if use of not made of public transport on all five days of the working week, to purchase a 'period' Travelcard.

Table 6.1.2 (a): ownership of Travelcards, Railcards and Concessionary passes. Greater London residents 1991.

Type of ticket	Number of people	% of population
Period Travelcard (within London – 1 week+)	764,000	11.1
Travelcard with extension to outside London	16,000	0.2
Station to station season ticket (National Rail)	33,000	0.6
Local authority 60+ concession pass (free)	954,000	13.8
Local authority disabled concession pass (free)	57,000	0.8
Local authority scholars pass	48,000	0.7
Staff/Police free pass	112,000	1.6

Source: Travel in London: 1991 London Area Transport Survey. London Research Centre.

Table 6.1.2 (b): ownership of Travelcards, Railcards and Concessionary passes. Greater London residents 2014/15.

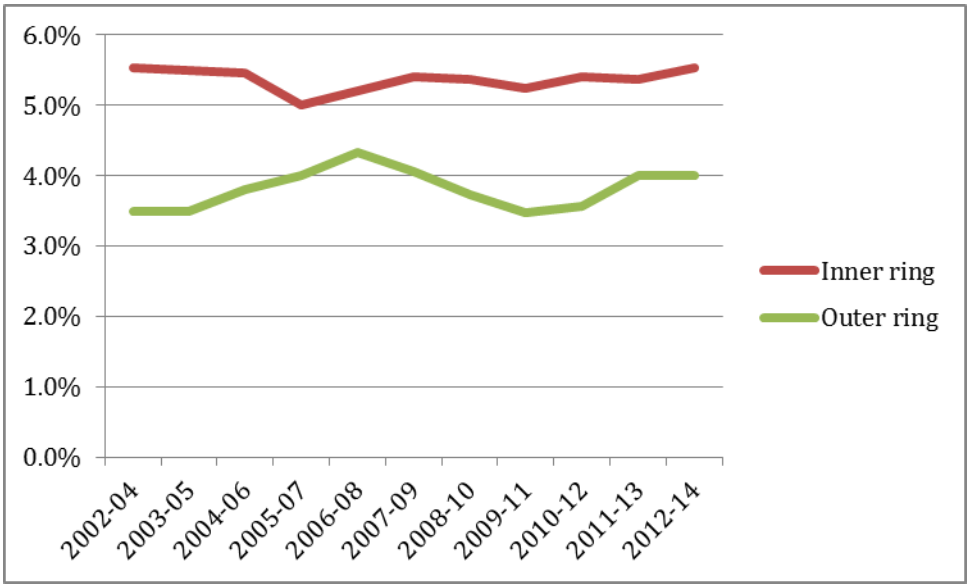
Type of ticket	Number of people	% of population
Period Travelcard (London)	714,000	9.0
Station to station season ticket (National Rail)	53,000	0.7
Local authority OAP concession pass	1,198,000	15.1
Local authority disabled concession pass	147,000	1.8
Staff/Police free pass	105,000	1.3

Source: London Travel Demand Survey (LTDS) 2014/15.

Peri-urban area

Public transport season pass rates have stayed largely stable in both London's Inner and Outer Peri-Urban areas since 2002. These figures exclude season passes given to the elderly and other types of passes, such as school or work passes (Figure 6.1.2 (c)).

Figure 6.1.2 (c): ownership of Travelcards, Railcards and Concessionary passes. Inner and outer peri-urban area.



Source: UK National Transport Survey (NTS).

6.1.3 Car sharing membership

See also above. Currently, between 1 and 2 per cent of the resident population of CREATE Zones 1 and 2 are members of a car club. Although this is expected to grow, it is not a significant explanator for long-term trends.

6.2 Individual travel behaviour

6.2.1 Personal trip rates

Essential background

The 'trip rate' is conventionally defined as the number of trips undertaken (by all modes or by a specific mode) divided by the number of people who are 'in scope' for the survey. In London, the conventional measure is defined as an average across all people, irrespective of whether or not they make any trips on the travel day. Conventionally, 'all people' is defined as persons aged 5 years or over, for the simple reason that persons of less than five years are not included in the travel diary survey (the assumption is that all travel by people in this group is accompanied by an adult).

It is however possible to define trip rate in terms of only those who make at least 1 trip on the survey day (the preferred CREATE definition). This is problematic from a London point of view, in that changes affecting travel behaviour have tended to lead to more people undertaking no trips on any one day. This is a manifestation, for example, of developments like the increase in 'informal' working arrangements – factors which are known to partly underlie the emergence of CREATE Stage 3 conditions, and the encouragement of which is likely to be a major plank of future transport policy (through things like co-location of homes and workplaces). To confine consideration only to those who travel, therefore, is to ignore a key factor influencing travel behaviour change at the aggregate level.

The data below are presented according to both definitions, although the use of the former is strongly recommended. The prevalence of non-travel amongst Londoners was examined in Travel in London report 8, section 11.6. It is strongly recommended that reference is made to this source when interpreting the data in this section: https://tfl.gov.uk/corporate/publications-and-reports/travel-in-london-reports.

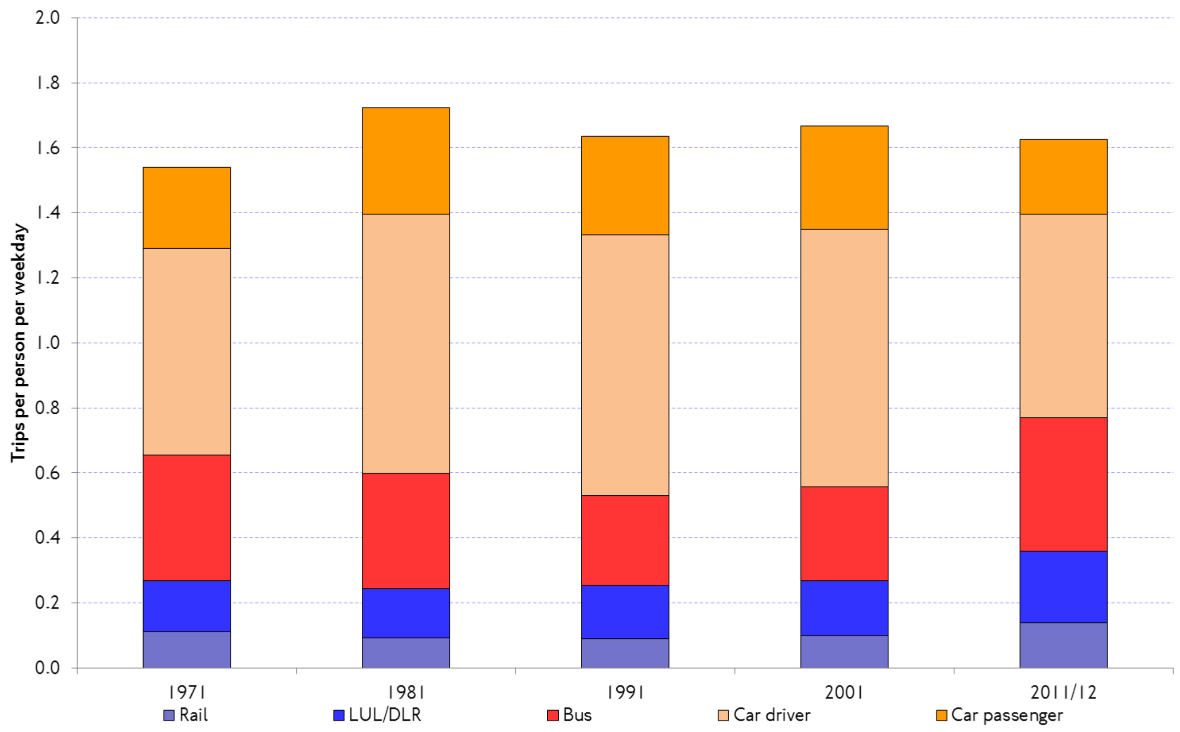
All trip rates in this section relate to weekdays only, and to 'mechanised modes' (ie excluding walking and cycling). This latter is because data for these modes was not collected on a consistent basis across the available surveys. Changes in the relationship between travel on weekdays and at weekends is also a feature of interest for CREATE, which can potentially also be examined with the London data.

Basic trip rates – CREATE Zones 1 and 2

The historic trend in this and other similar indicators of travel were described in TfL's Travel in London report 6 (chapter 7). Figure 6.2.1 (a) below is an example of the content of this material. It shows trip rates, differentiated by main mode and gender, for Greater London residents (CREATE zones 1 and 2 combined) between 1971 and 2011/12. The definition is: trips on weekdays by all in-scope people aged 5 years or over. Note that walking and cycling trips are not included in this figure.

The figure largely speaks for itself – with a generally stable overall trip rate of around 1.6 trips per person per day on average. The reducing share of car trips is clearly visible in the more recent years.

Figure 6.2.1 (a): Historic trend in person trip rates by main mode – Greater London residents. All people aged 5+, weekdays only.

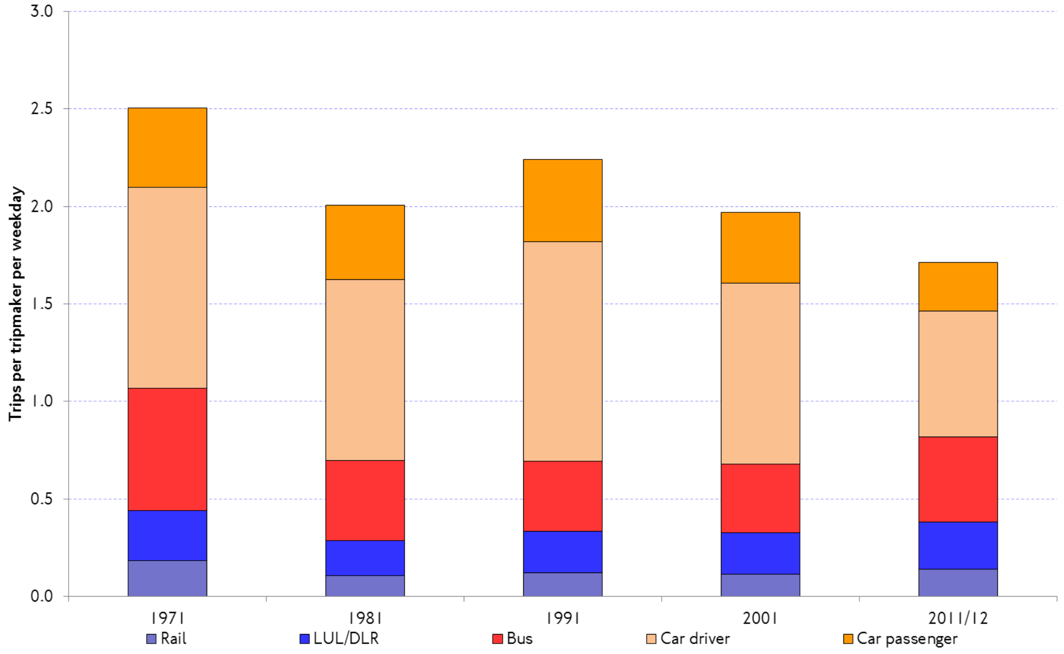


Source: Transport for London. LTDS and predecessor surveys.

Looking at this only in terms of those who make at least 1 trip on the survey day however presents a different and misleading picture (Figure 6.2.1 (b and c)). The definition here is Greater London residents (CREATE Zones 1 and 2 combined), weekdays only, for persons 5 years of age or over, including only residents who make at least one trip on the survey day.

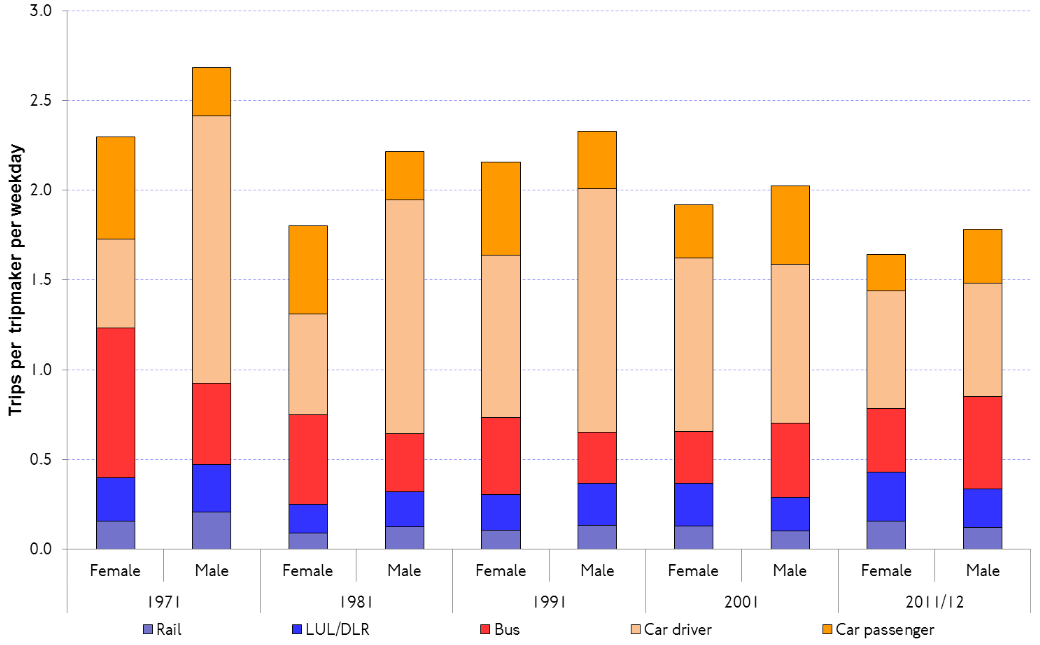
Taken at face value, this shows a sharp drop in trip making per person. This should strictly be interpreted as a reduction in the trip rate of (only) those who make at least one trip on the survey day. To understand the causes and implications of this, it is necessary to look at parallel changes to the non-travelling population. Changes to the absolute population in CREATE Zones 1 and 2 are also an important factor.

Figure 6.2.1 (b): Historic trend in person trip rates by main mode and gender – Greater London residents (CREATE Zones 1 and 2 combined). Persons aged 5+ years who make at least one trip on the survey day.



Source: Transport for London. LTDS and predecessor surveys.

Figure 6.2.1 (c): Historic trend in person trip rates by main mode and gender – Greater London residents (CREATE Zones 1 and 2 combined). Persons aged 5+ years who make at least one trip on the survey day. By gender.



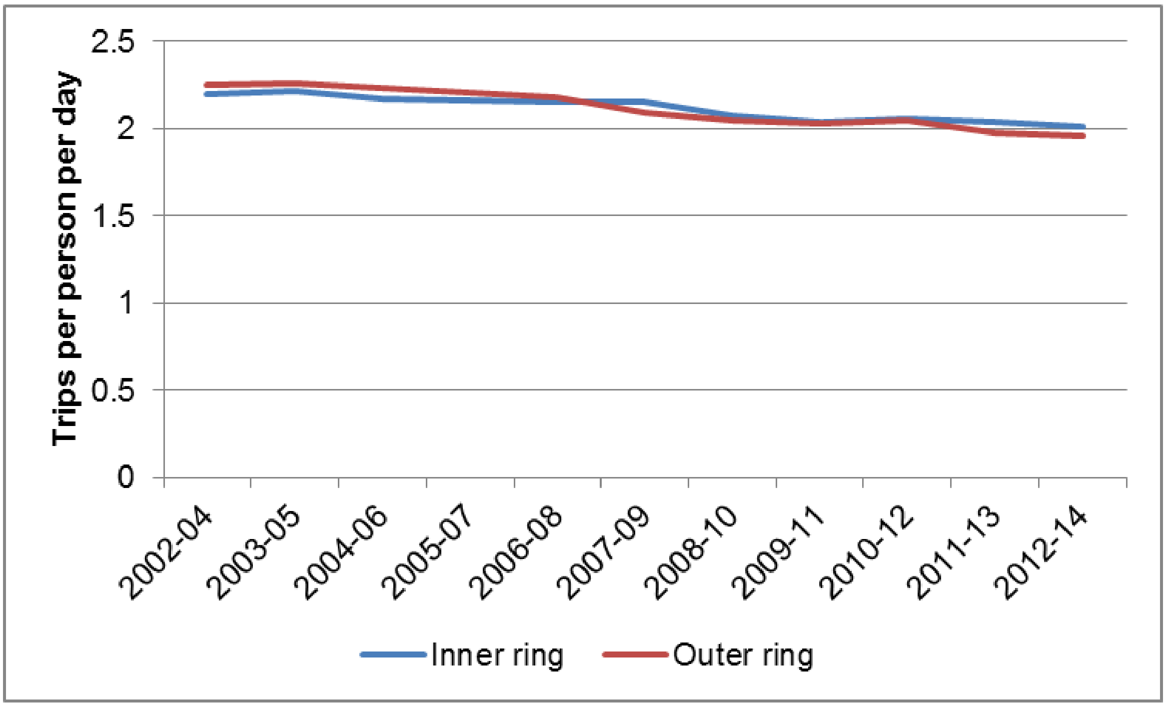
Source: Transport for London. LTDS and predecessor surveys.

Peri-urban area

The data on trips is only for those who made a trip on the "travel day" and the "travel day" happened to be a weekday. The NTS includes a seven day travel diary. However only on the last day are respondents asked to complete all travel trips including short walks. Thus the data analysed for trips, in this and all the following sections, is solely based on the last day of the travel diary.

Trip rates in the peri-urban area have been falling (Figure 6.2.1 (d)). This is consistent with national figures in England (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/457752/nts2014-01.pdf).

Figure 6.2.1 (d). Three-year moving average of trip rates (average number of trips per person per day – for weekdays only and excludes those that made no trips on survey day) for residents of London's Inner and Outer Peri-Urban areas.

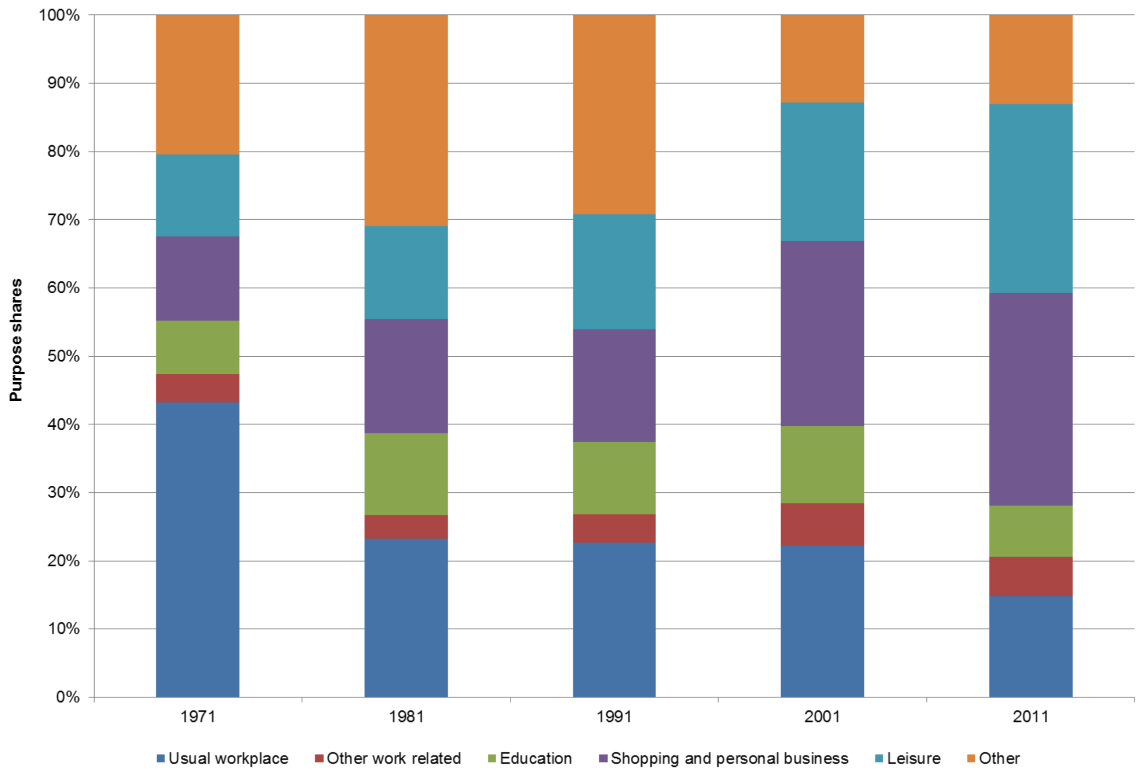


Source: UK National Transport Survey (NTS).

Journey purpose shares

In CREATE Zones 1 and 2 there has been a general trend towards work-related journeys making up a lesser share of people's daily travel over the CREATE period. The proportion of journeys made for the purposes of shopping and personal business has grown (Figure 6.2.1 (e)). Figure 6.2.1 (f) shows the equivalent values in terms of trip rates (weekdays only, excluding those who do not make any trips on the survey day).

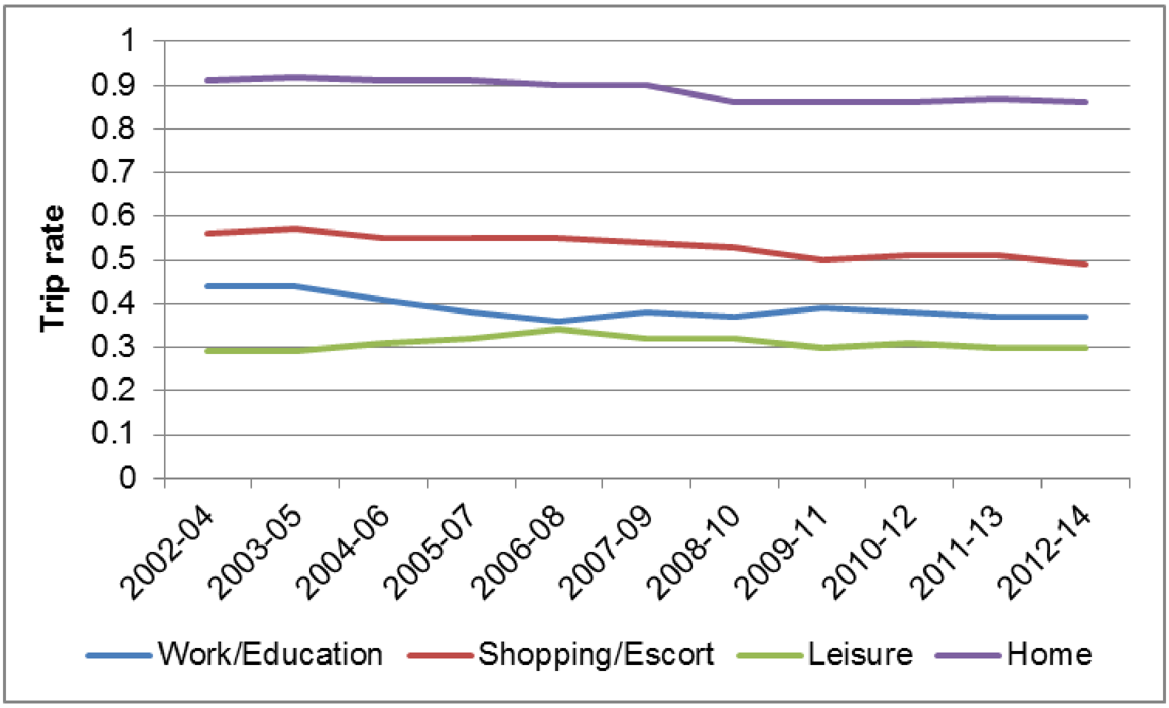
Figure 6.2.1 (e): Journey purpose shares for residents of CREATE Zones 1 and 2 combined.



Source: Transport for London. LTDS and predecessor surveys.

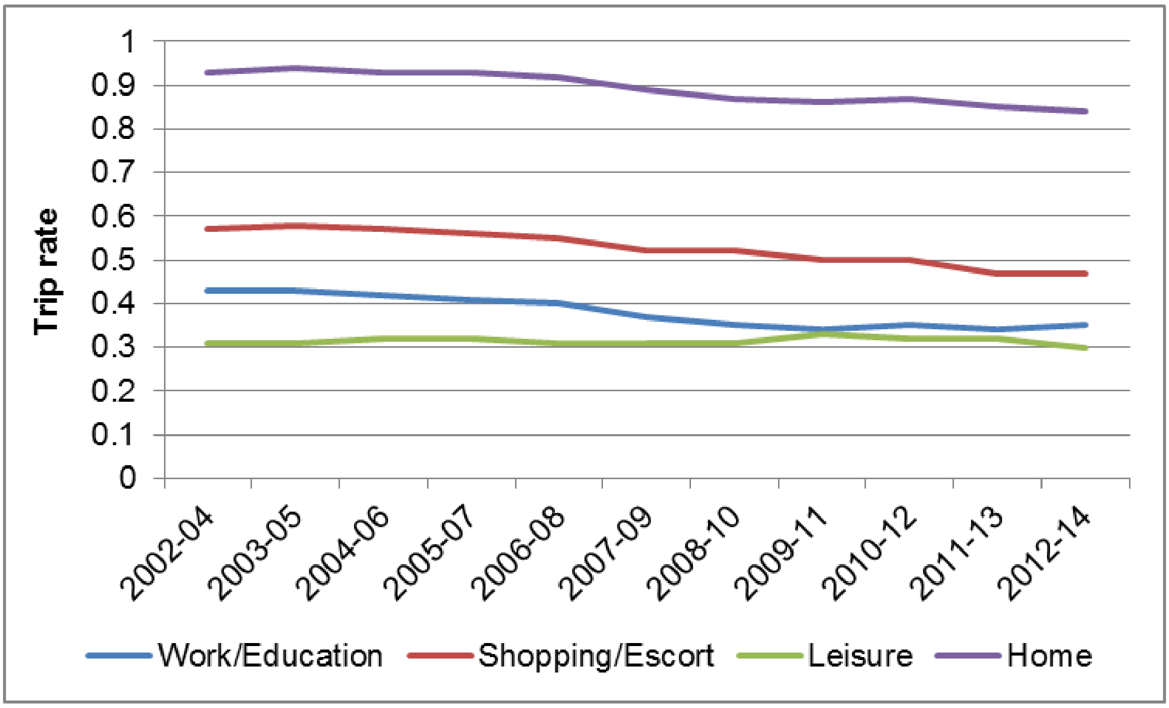
For the peri-urban area, and over the shorter timescale permitted by the available data, Figures 6.2.1 (f) and 6.2.1 (g) show the equivalent trip rates by journey purpose. Again these are for weekdays only and exclude those who do not make any trips on the survey day. They are for trips with at least one end in the peri-urban area.

Figure 6.2.1 (f): Trip rates by journey purpose for residents of CREATE Zone 3 (inner peri urban area).



Source: UK National Travel Survey (NTS).

Figure 6.2.1 (g): Trip rates by journey purpose for residents of CREATE Zone 3 (outer peri urban area).

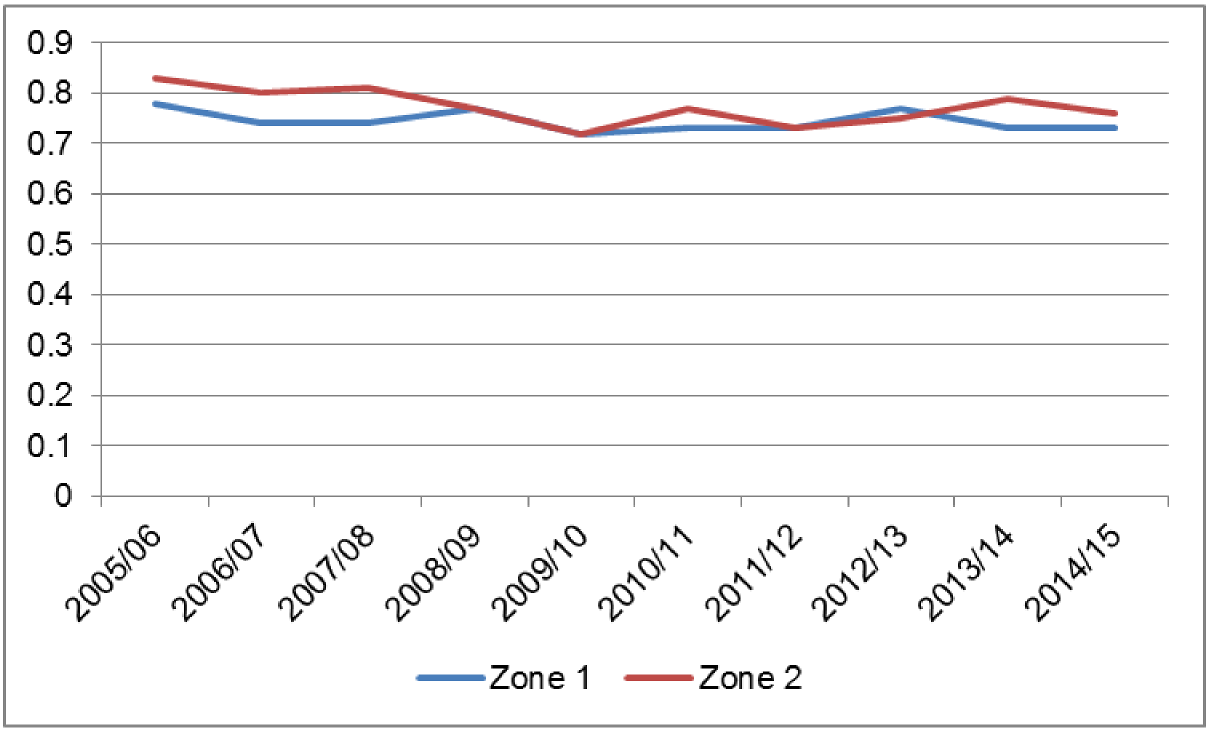


Source: UK National Travel Survey (NTS).

Figure 6.2.1 (h) shows, for CREATE Zones 1 and 2 separately, trip rates for residents within the weekday AM peak three-hour period. This is trips that start between 07:00 and 09:59 AM that have at least one origin or destination within Greater London (CREATE Zones 1 and 2 combined). Figure

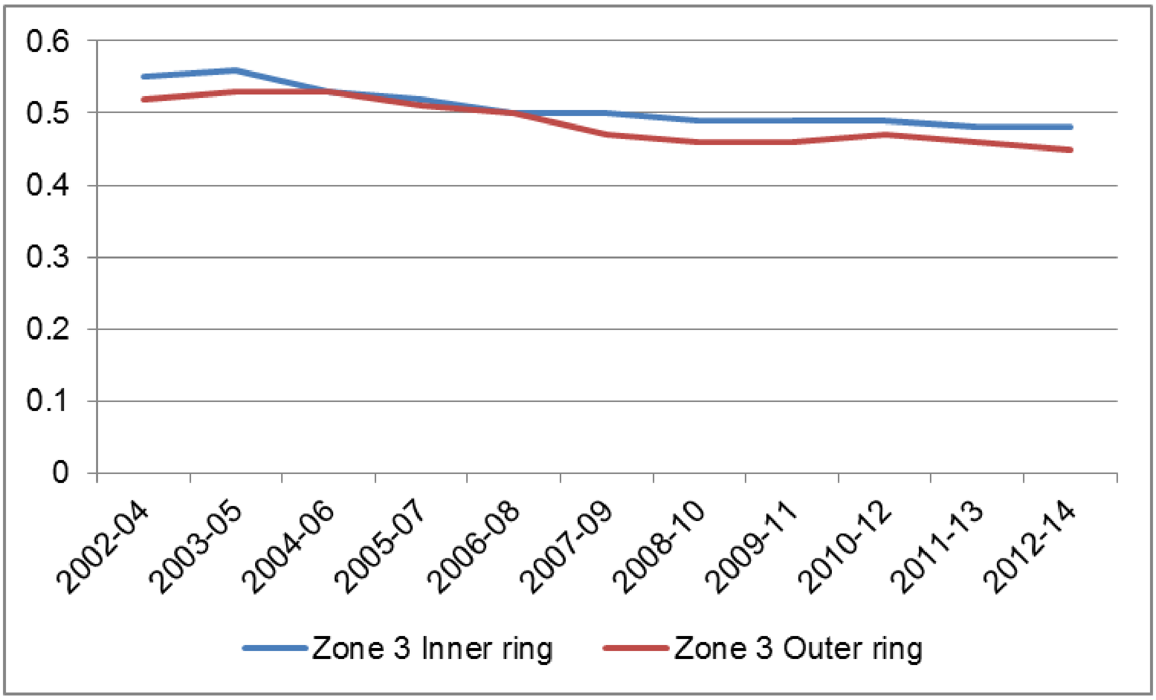
6.2.1 (i) shows equivalent data for the peri-urban area. For a more extensive treatment of changes to the time of day of trips over the CREATE period, the reader is referred to Travel in London report 6, Chapter 7.

Figure 6.2.1 (h): Trip rates for trips starting within the three hour weekday AM peak period. CREATE Zone 1 and 2 residents who make at least 1 trip, trips with at least one end in CREATE Zones 1 or 2.



Source: TfL London Travel Demand Survey (LTDS)

Figure 6.2.1 (i): Trip rates for trips starting within the three hour weekday AM peak period. CREATE Zone 3 and residents who make at least 1 trip, trips with at least one end in CREATE Zone 3.



Source: UK National Travel Survey (NTS).

6.2.2 Average daily travel time and distance

General considerations

The average travel times and travel distances of residents are good indicators of the total 'intensity' of travel. However, they are averages and averages may conceal many changes at the more detailed level. Furthermore, because the travel surveys from which these statistics arise only consider (in this case) residents of an area (CREATE Zones 1 and 2), travel to areas outside of the region and occasional long-distance travel can distort the averages in terms of the scale of the city to which they apply. Furthermore, there is also a view in the academic literature that average total time spent travelling and total distance are inert-related and self-limiting (see, for example: https://en.wikipedia.org/wiki/Marchetti's_constant). This is based on the idea that individuals have a notional 'travel time budget' that is unlikely to be exceeded (on average). Furthermore, as transport improvements bring the possibility of faster journeys, it is possible to travel further within the same time.

This phenomenon has been seen to underlie some changes in travel behaviour, for example the increase in longer-distance commuting into London from CREATE Zone 3 and further afield, but in this case there are also other powerful drivers influencing change, most notably the rapid increase in house prices in London. In this scenario the traveller is a 'victim of circumstance', in that the additional cost of commuting is offset by cheaper accommodation, yet the total volume of travel, and related factors such as CO_2 emissions, increase. To the extent that these 'longer distance' travellers relocate outside London, they are not visible in the London survey, and therefore it is not possible to discern this effect in the material presented below.

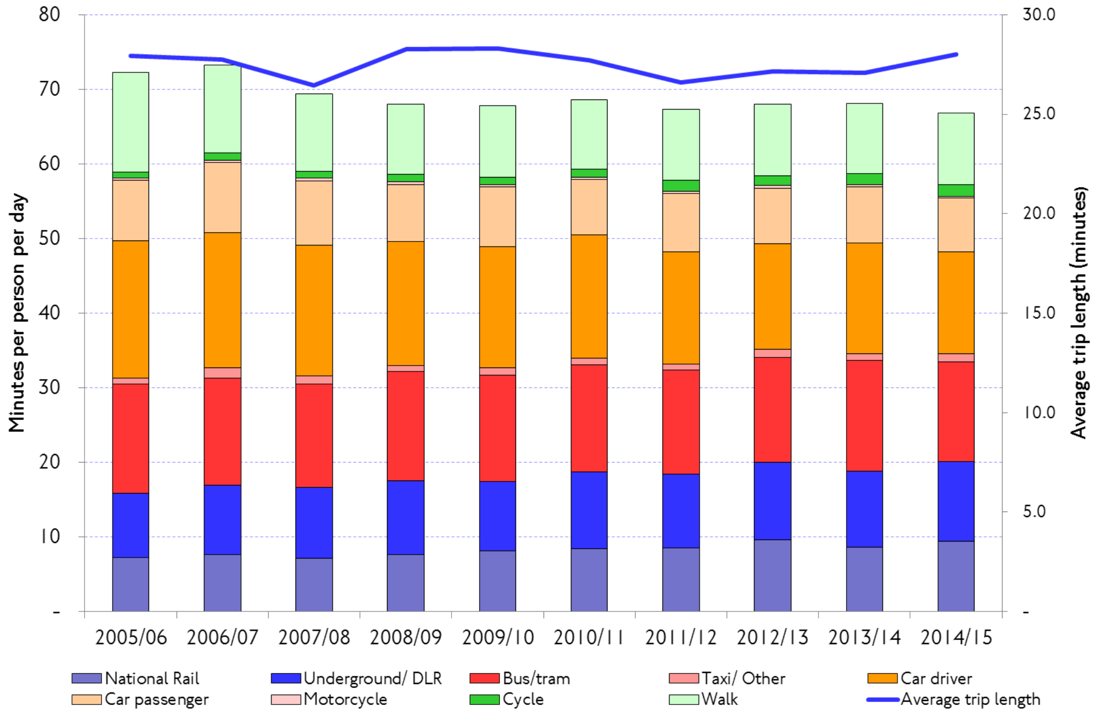
Average time spent travelling

As with trip rates, the statistics below are presented for all travellers aged 5+ years (weekday) and for only those travellers who make at least one trip on the survey day.

Figures 6.2.2 (a) and (b) are from TfL's Travel in London report 8. They show the recent trend in terms of average time and distance spent travelling by London residents, distinguished by mode. The bars relate to averages across all people. The line, however, only relates to trips actually made.

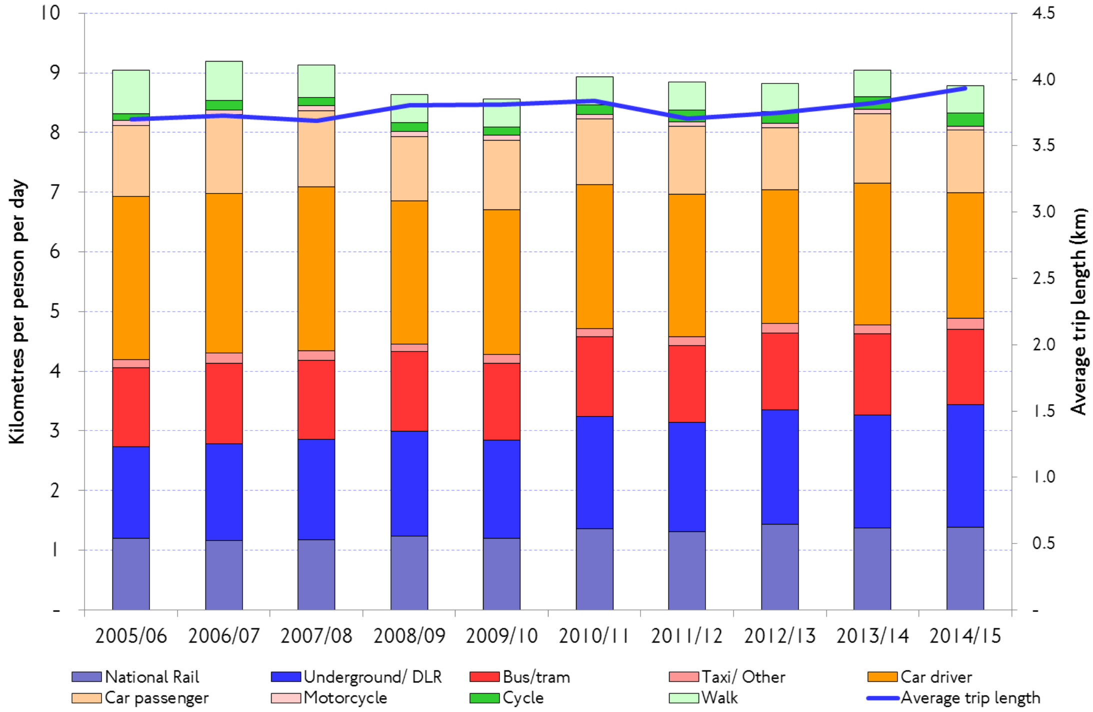
For distance, the overall trend has been gently downwards over the review period. For time, the pattern is more stable. The impact of the economic crisis, which led to lower levels of mobility, is visible in the figures. Note that the trips in-scope for the following four figures are trips with both origin and destination inside Greater London (CRAETE Zones 1 and 2).

Figure 6.2.2 (a): Average daily travel time – London residents (7 day week). CREATE Zones 1 and 2 combined.



Source: Transport for London. LTDS and predecessor surveys.

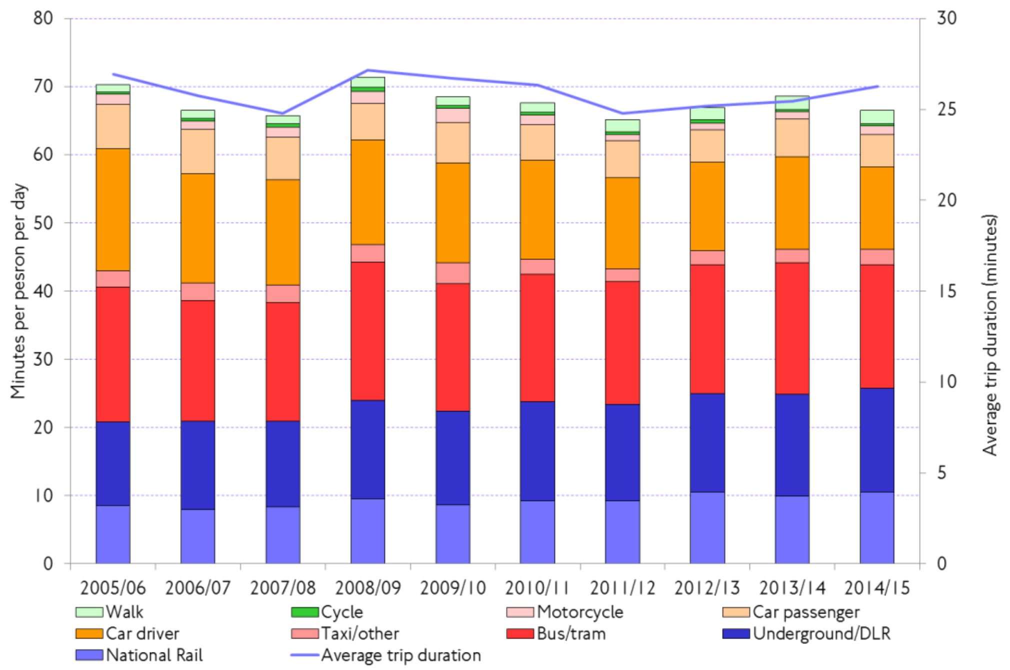
Figure 6.2.2 (b): Average daily travel distance – London residents (7 day week). CREATE Zones 1 and 2 combined.



Source: Transport for London. LTDS Survey.

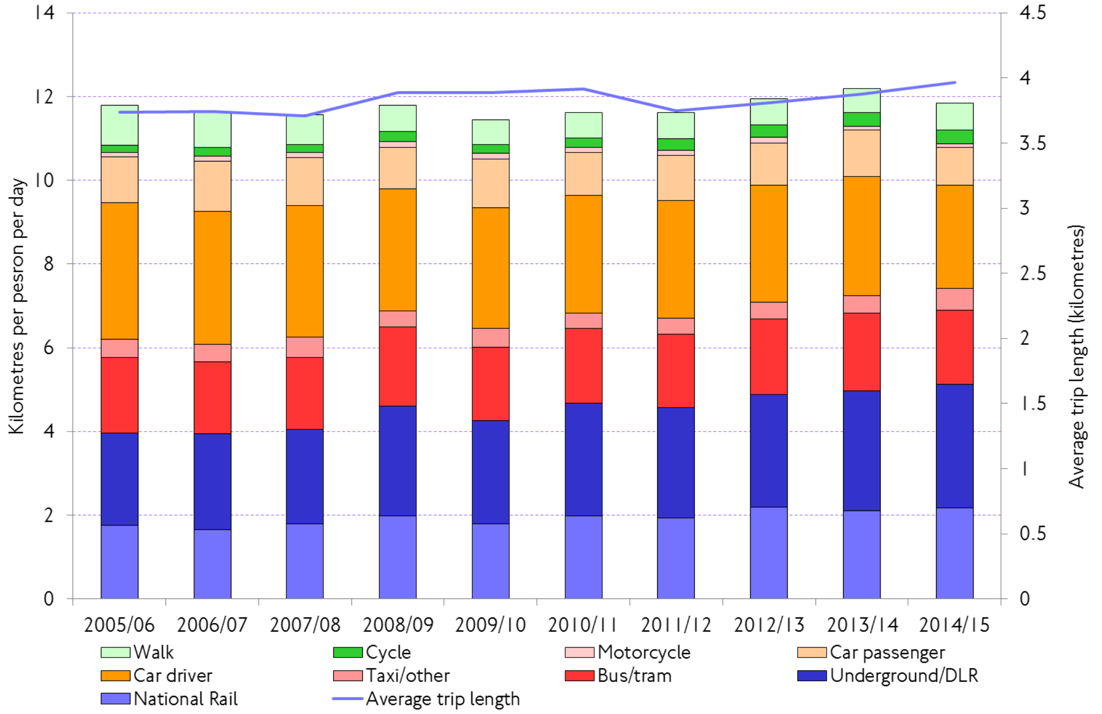
Figures 6.2.2 (c) and 6.2.2 (d) show the equivalent data for weekdays only.

Figure 6.2.2 (c): Average daily travel time – London residents (weekdays only). CREATE Zones 1 and 2 combined.



Source: Transport for London. LTDS Survey.

Figure 6.2.2 (d): Average daily travel distance – London residents (weekdays only). CREATE Zones 1 and 2 combined.

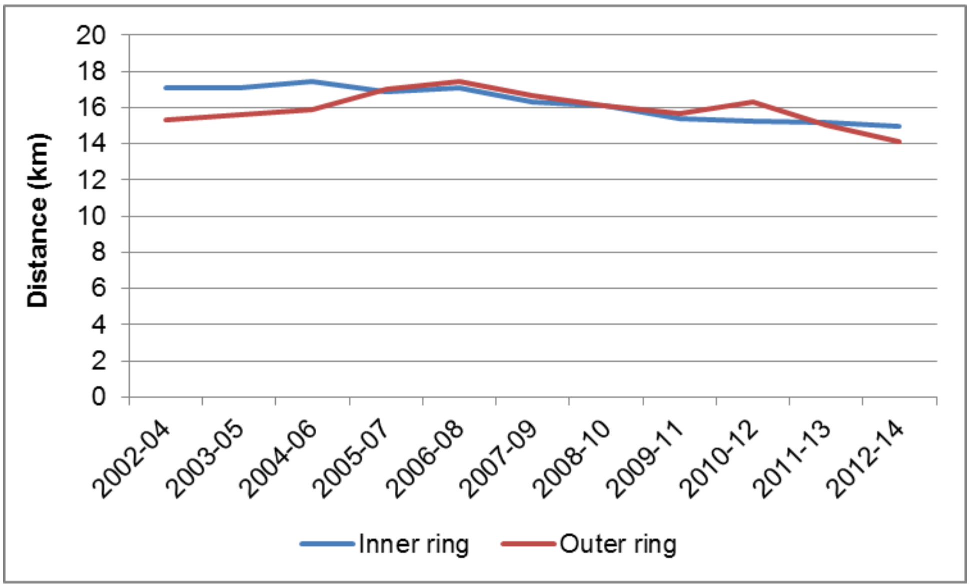


Source: Transport for London. LTDS Survey.

Peri-urban area

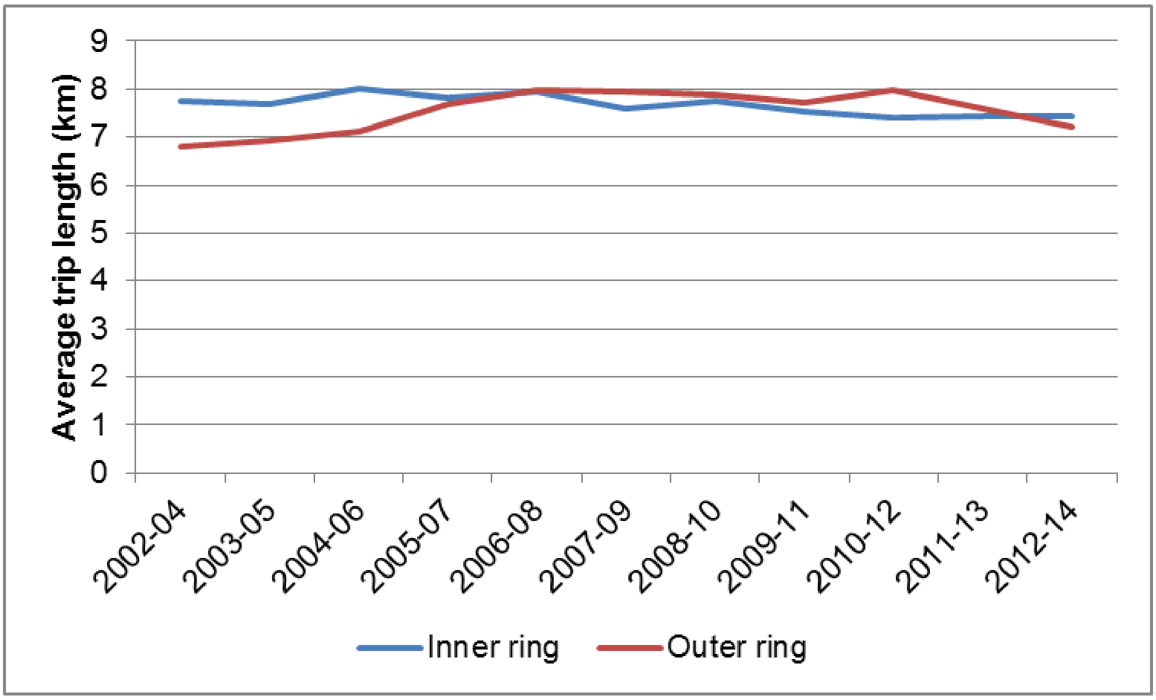
Figures 6.2.2 (e and f) show the trend in person trip distances and trip lengths for the peri-urban area, based only on those who make at least one trip on the survey day.

Figure 6.2.2 (e). Three-year moving average of trip distances (average distance travelled in kilometres per person per day – for weekdays only and excludes those that made no trips on survey day) for residents of London's Inner and Outer Peri-Urban areas.



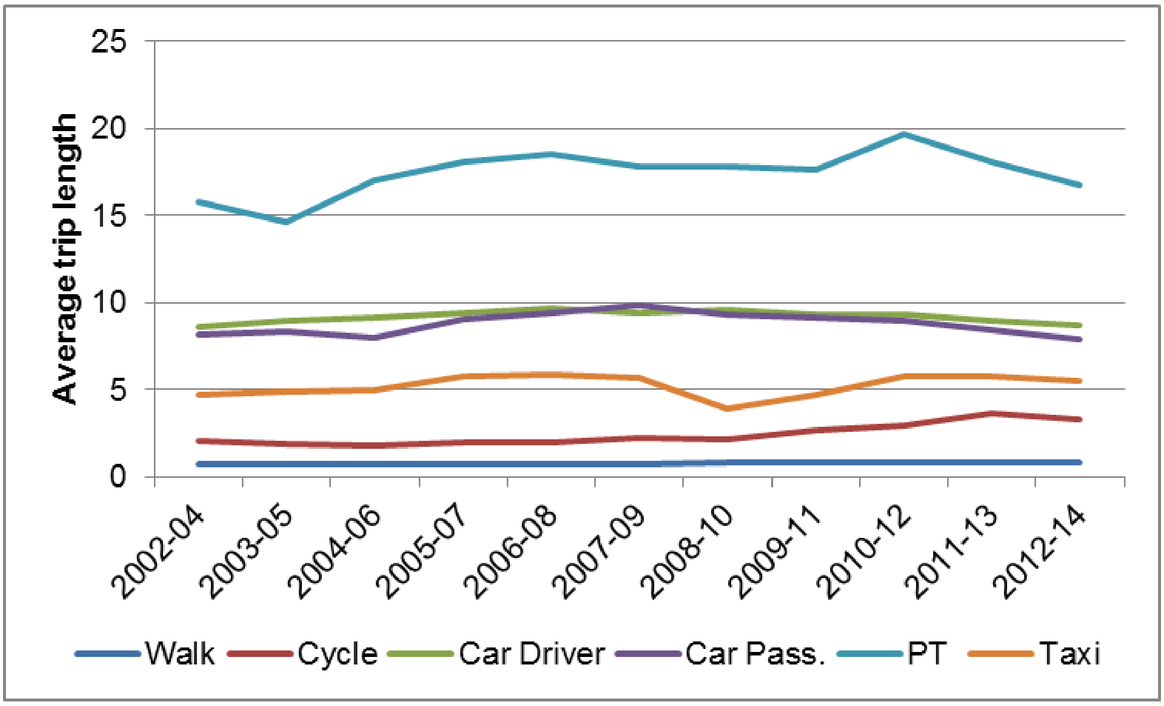
Source: UK National Transport Survey (NTS).

Figure 6.2.2. (f). Three-year moving average of average trip length for all modes (average distance travelled in kilometres per person per day – for weekdays only and excludes those that made no trips on survey day) for residents of London's Inner and Outer Peri-Urban areas.



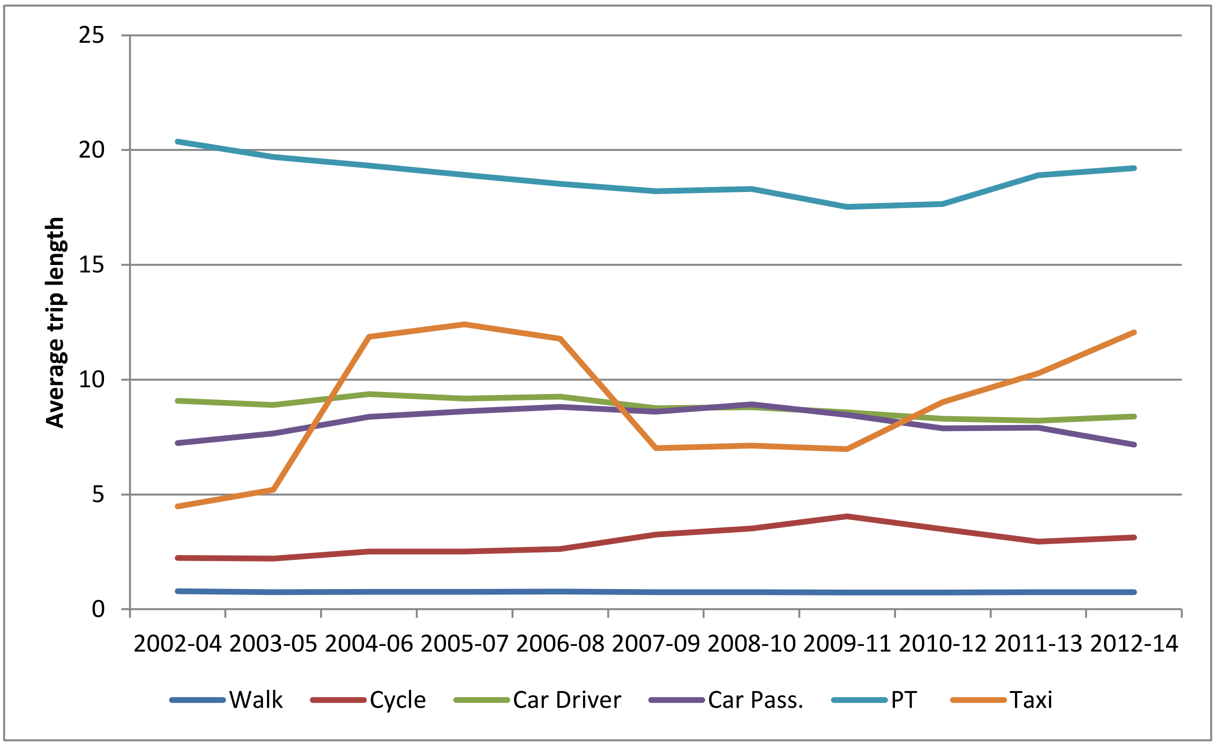
Source: UK National Transport Survey (NTS).

Figure 6.2.2 (g). Three-year moving average of average trip length by mode (average distance travelled in kilometres per person per day – for weekdays only and excludes those that made no trips on survey day) for residents of London's Outer Peri-Urban area.



Source: UK National Transport Survey (NTS).

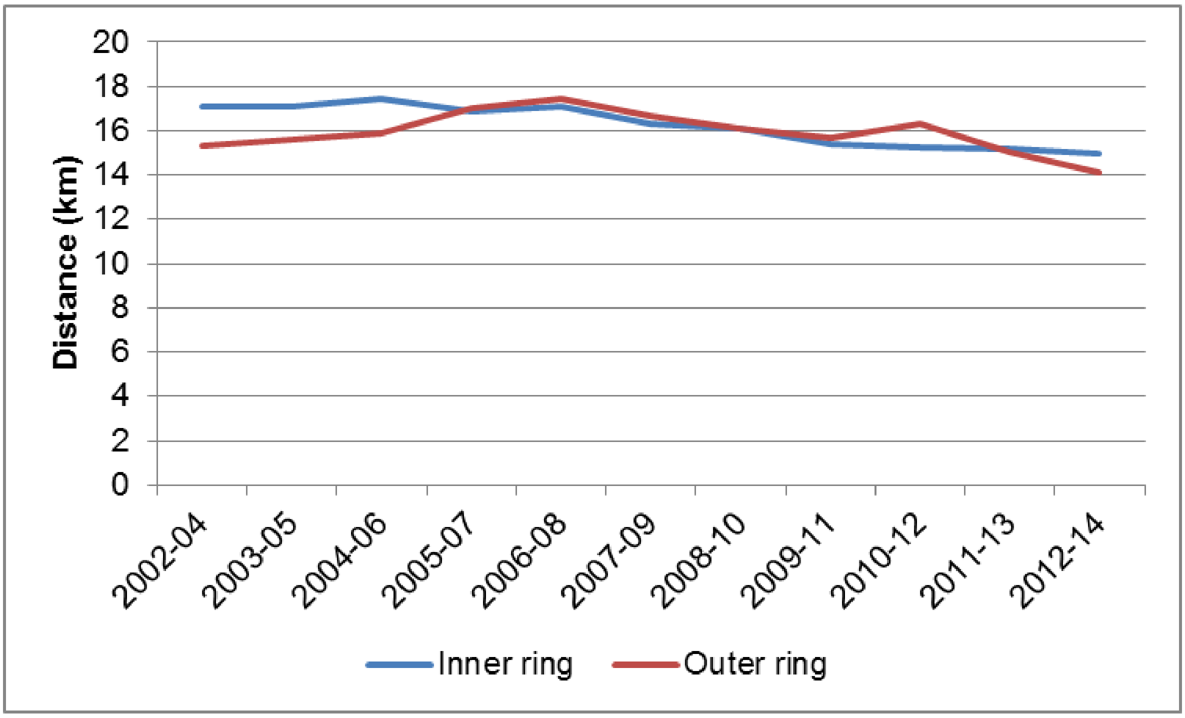
Figure 6.2.2 (h). Three-year moving average of average trip length by mode (average distance travelled in kilometres per person per day – for weekdays only and excludes those that made no trips on survey day) for residents of London's Inner Peri-Urban area.



Source: UK National Transport Survey (NTS).

Figure 6.2.2 (i) below gives summary data for the peri-urban area.

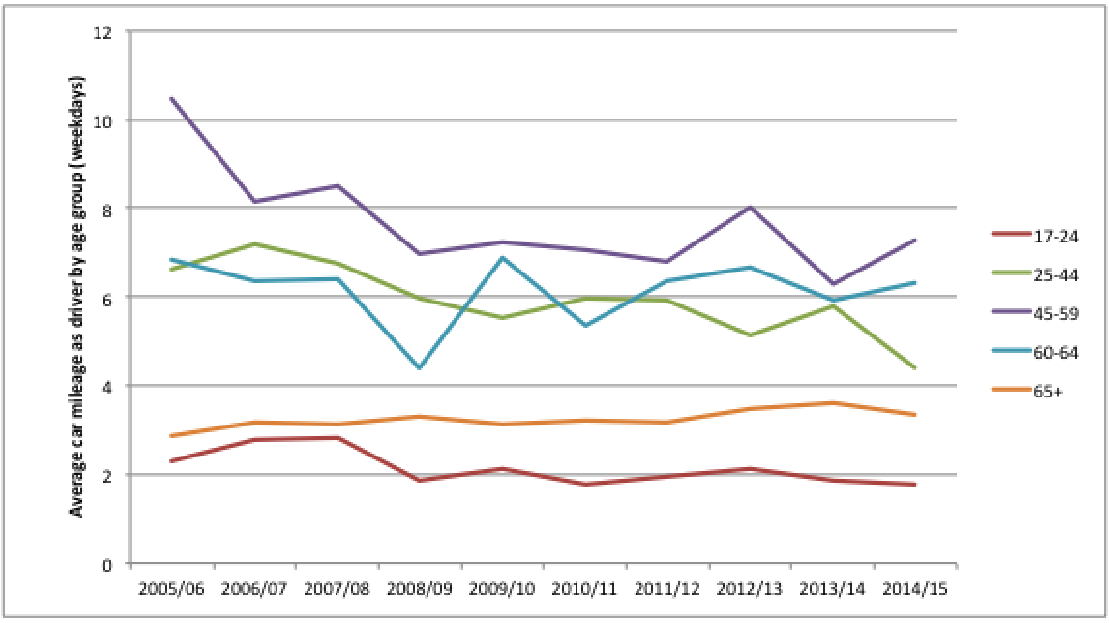
Figure 6.2.2 (i): Three-year moving average of trip distances (average distance travelled in kilometres per person per day – for weekdays only and excludes those that made no trips on survey day) for residents of London's Inner and Outer Peri-Urban areas.



6.2.3 Average car mileage

Figure 6.2.3 (a) shows the average car mileage driven per day by residents of Greater London – CREATE Zones 1 and 2 combined. It has trended downwards slowly over the period covered by the figure.

Figure 6.2.3 (a): Average car mileage per day driven by London residents. CREATE Zones 1 and 2 combined. Seven day week.

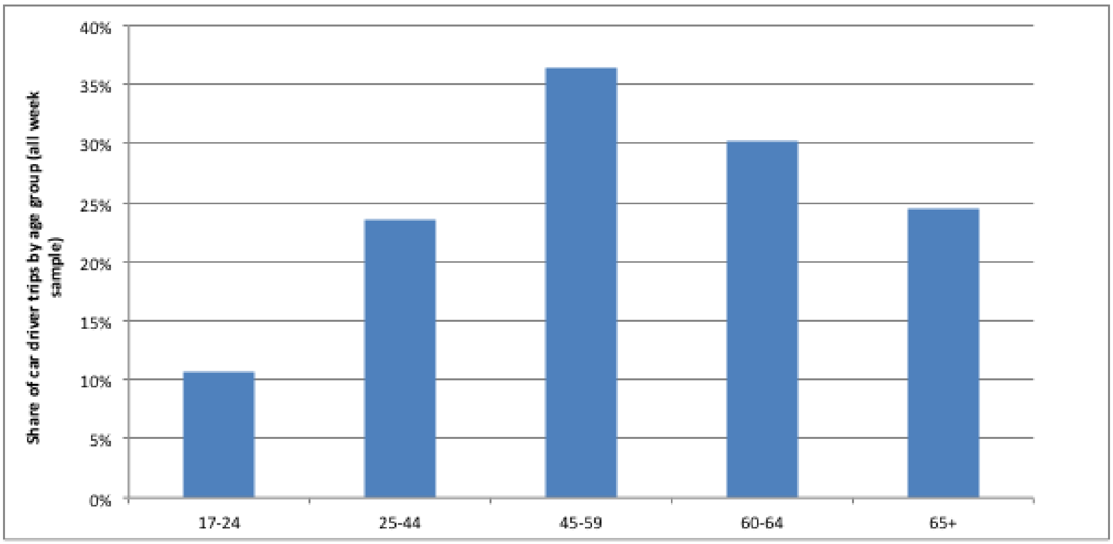


Source: Transport for London.

6.2.4 Share of car driver trips by age group

Figure 6.2.3 (a) illustrates these age differences in driving behaviour by age for 2015. This is a cross-sectional indicator and it is known that this profile has changed over time and that it has also been a significant factor underlying travel behaviour change in London. Reference should be made to two external reports to explore this aspect in more detail – TfL's cohort analysis report: and the 'On The Move' study by the RAC Foundation (Jones et al): http://www.racfoundation.org/research/mobility/on-the-move-main-research-page.

Figure 6.2.3 (a): Age distribution of car driver trips, Greater London residents. CREATE Zones 1 and 2 combined.

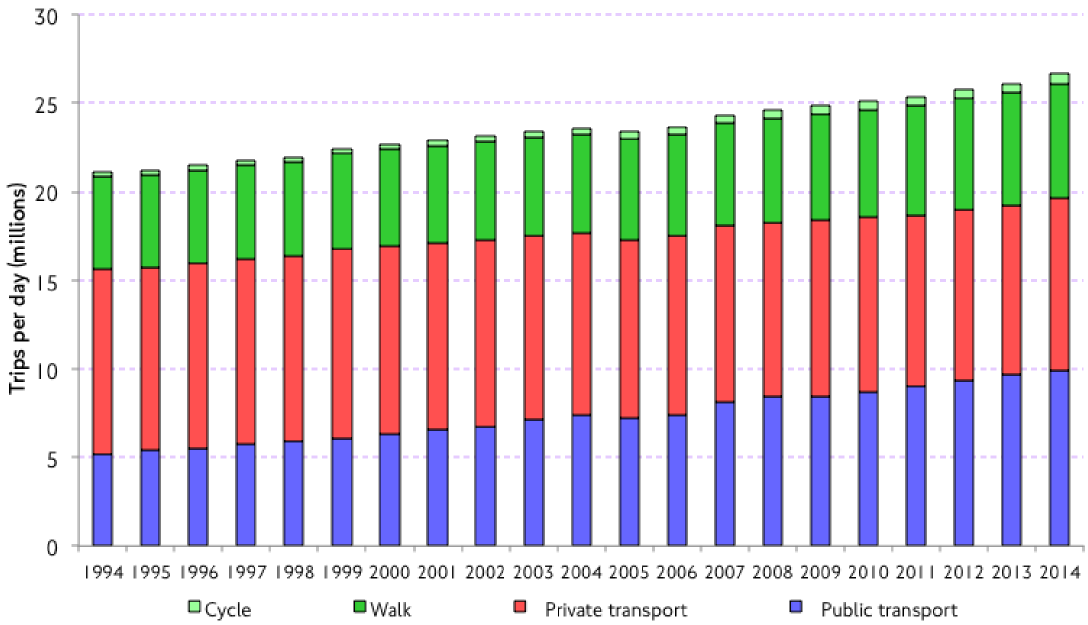


Source: Transport for London

6.2.5 Modal split

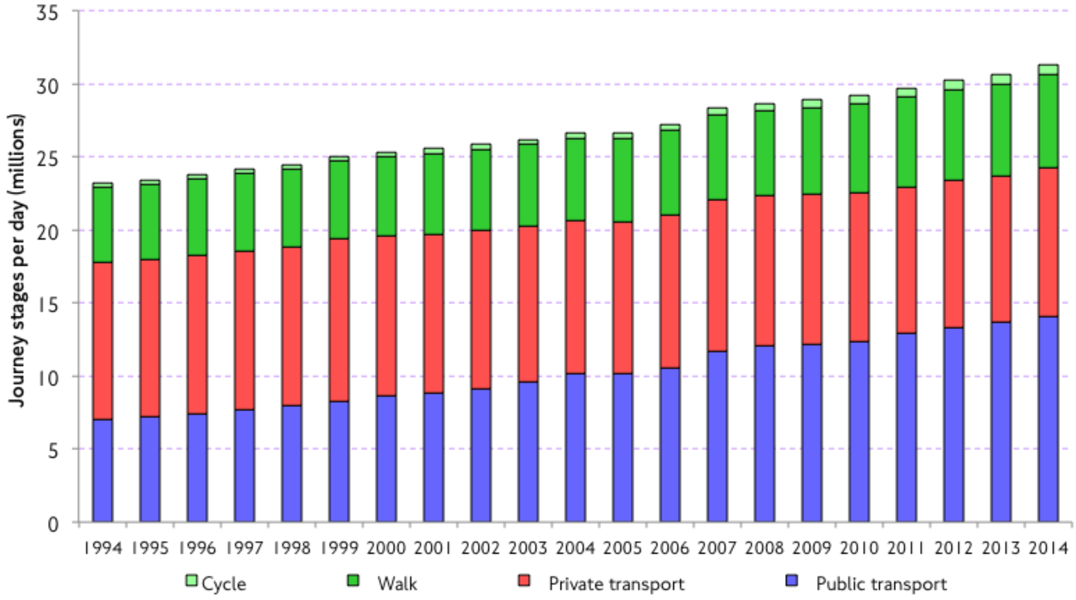
Figures 6.2.4 (a) and 6.2.4 (b) below show total travel volumes in the Greater London area (CREATE Zones 1 and 2 combined) by mode of travel. They are composite measures developed by using both household survey and 'on mode' (ie count) data. They show a steady and consistent rise in total demand (volumes of travel), as well as a steady and progressive change in mode share away from the private car towards public transport, walking and cycling. The first graphic is in terms of trips, for which a 'main mode' is defined, typically the mode used for the longest-distance 'stage' of the trip, and the second is in terms of journey stages. As an indicator of relative volumes of travel across the networks, the use of the journey stage based indicator is recommended.

Figure 6.2.4 (a): Total number of trips in London and basic mode share. Average day (7 day week). Trips with at least one trip end in CREATE Zones 1 and 2.



Source: Transport for London.

Figure 6.2.4 (b): Total journey stages in London and basic mode share. Average day (7 day week). Trips with at least one trip end in CREATE Zones 1 and 2.

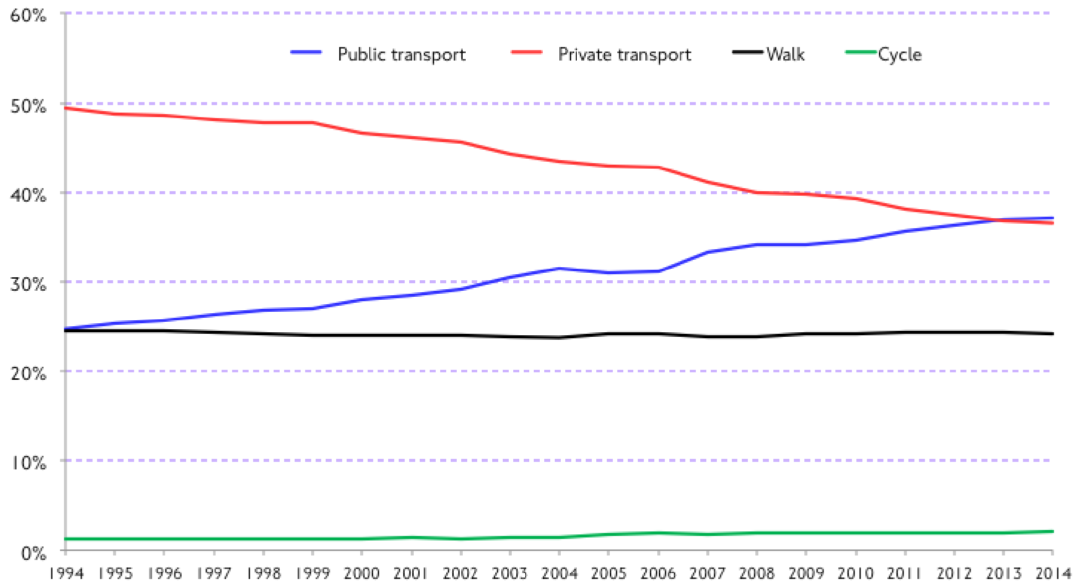


Source: Transport for London.

The above two figures show a pattern of (a) consistent growth in travel volumes, primarily reflecting increases to the population of London, and (b) a progressive shift in mode share away from the car towards public transport, walking and cycling. The net shift, at the journey stage level, away from car was 11 percentage points over the period 2000 to 2015 – a major 'structural' change in the way that people travel in London and fully demonstrating CREATE Stage 3 city characteristics.

Figure 6.2.4 (c) is a time-series graphic of trends in mode share by principal modes of transport, based on the preceding two figures.

Figure 6.2.4 (c): Mode share for trips in London. All travellers, 7 day week. [y axis label]



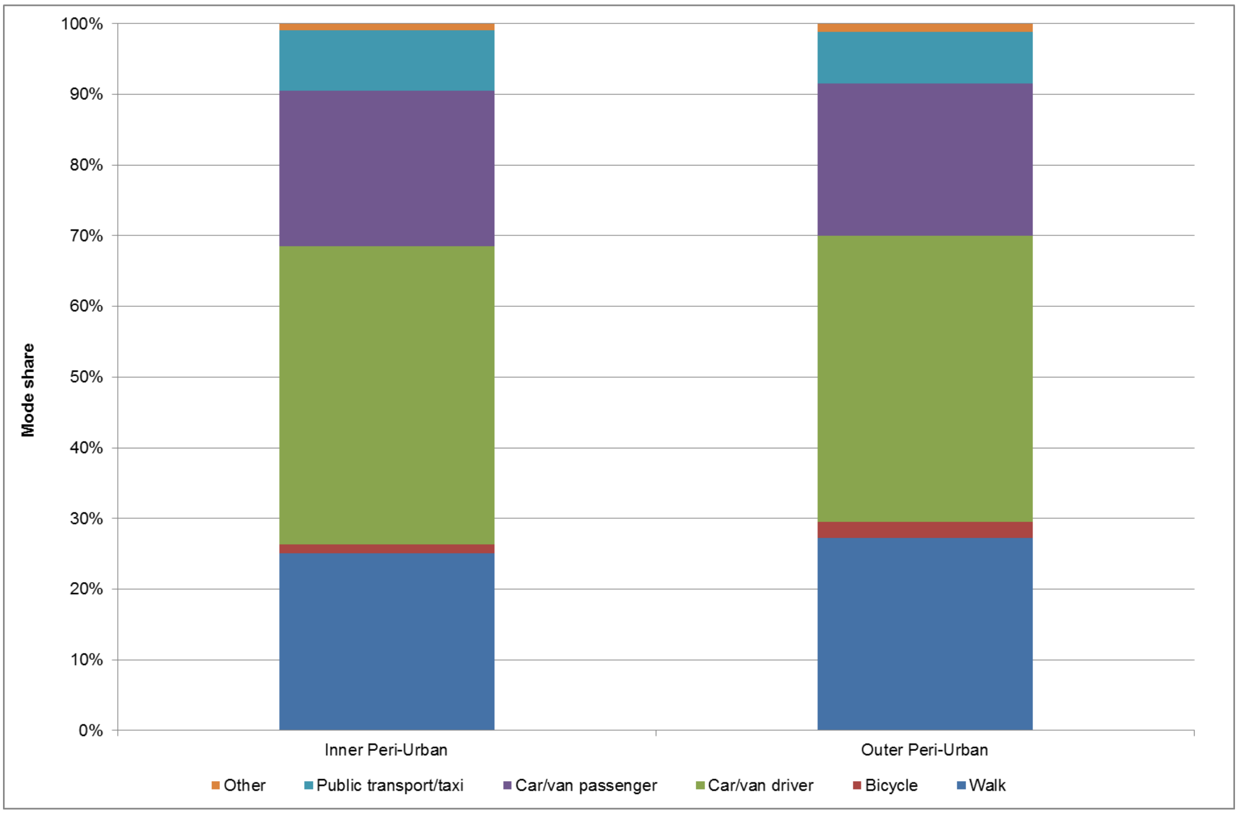
Source: Transport for London

Note that trends in mode shares for residents of CREATE Zones 1 and 2 can be derived from other figures in this section.

Peri-urban area

Mode shares for the peri-urban area are only available for residents. Figures 6.2.4 (d) and (e) show these for the inner and outer peri-urban areas, on the basis of an average over the years 2002-2014.

Figure 6.2.4 (d): Mode share for trips of residents of CREATE Zone 3. Percentage of trips by main mode.



Source: UK National Travel Survey.

6.3 Aggregated travel behaviour

6.3.1 Road traffic volumes, trips entering the city

Introduction

The following section presents a range of statistics relating to road traffic volumes and trends in London. The reader should note that a variety of indicators are in use and since these relate to different 'views' of traffic, they do not always show exactly the same trends (although the overall picture is clear enough). The selection presented is considered by TfL to be the most representative.

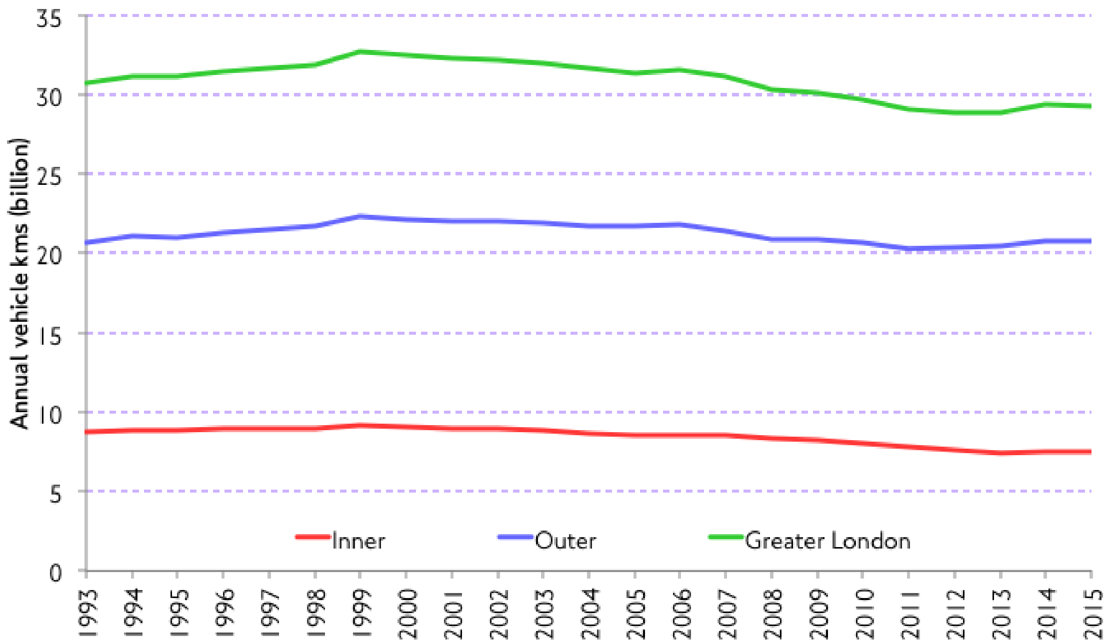
Total traffic volumes – vehicle kilometres

Figure 6.3.1 (a) shows the trend in vehicle kilometres driven in London over the period since 1993. This statistic is collected as part of the UK's national traffic census and is the most consistent long-term indicator of traffic in London (CREATE Zones 1 and 2 only).

We supply here some general trends relating to road traffic volume. The figure below shows annual total vehicle kilometres driven in London. These data are from a consistent series produced by the UK Department for Transport. The trend was one of a slow rise, in most of London, during the mid-1990s but a reversal of trend since then, with all parts of London seeing decreases in traffic volumes over the most recent years. Further traffic trend data is provided later in this report.

The overall trend is for a gradual rise in traffic levels in the early part of the period covered by the figure, with a gentle fall in volumes in the latter years.

Figure 6.3,1 (a): Annual vehicle kilometres driven in London. CREATE Zones 1 and 2.

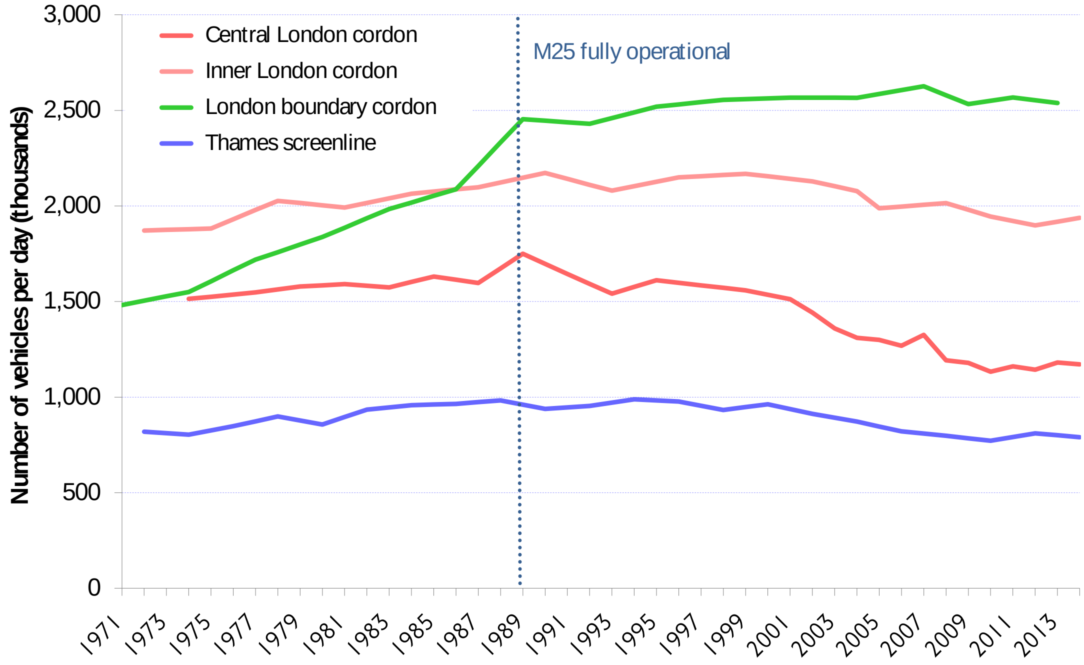


Source: United Kingdom Department for Transport.

Note in particular that the trend towards declining traffic started first in central London, and then spread to inner and finally outer London. Note also that the definition of central London used here is different to and not a good proxy for the Congestion Charging zone, and that the trend towards declining traffic in central London pre-dated the introduction of the congestion charge. This is, we believe, a manifestation of reductions to the effective capacity of the road network, which hit first and hardest in central London, reflecting the intense pressures on road space here. Further information on the specific impact of the congestion charge in central London is given above, and is covered extensively in TfL's Congestion Charging Monitoring Reports (see: https://tfl.gov.uk/corporate/publications-and-reports/congestion-charge).

A longer time perspective, again reflecting consistent data over the period, is provided by looking at the three main traffic counting cordons in Greater London (Figure 6.3.1 (b)). These surround, respectively, the central area, the inner area, and the outer area (the GLA boundary cordon). They are 100% watertight cordon counts that provide a robust long-term indicator of traffic change. However, they only relate to the cordon specified. So, for example, the central London cordon is not necessarily representative of all traffic in central London. The Thames Screenline provides an indicator of traffic crossing the River Thames, which runs west to east throughout the whole of Greater London.

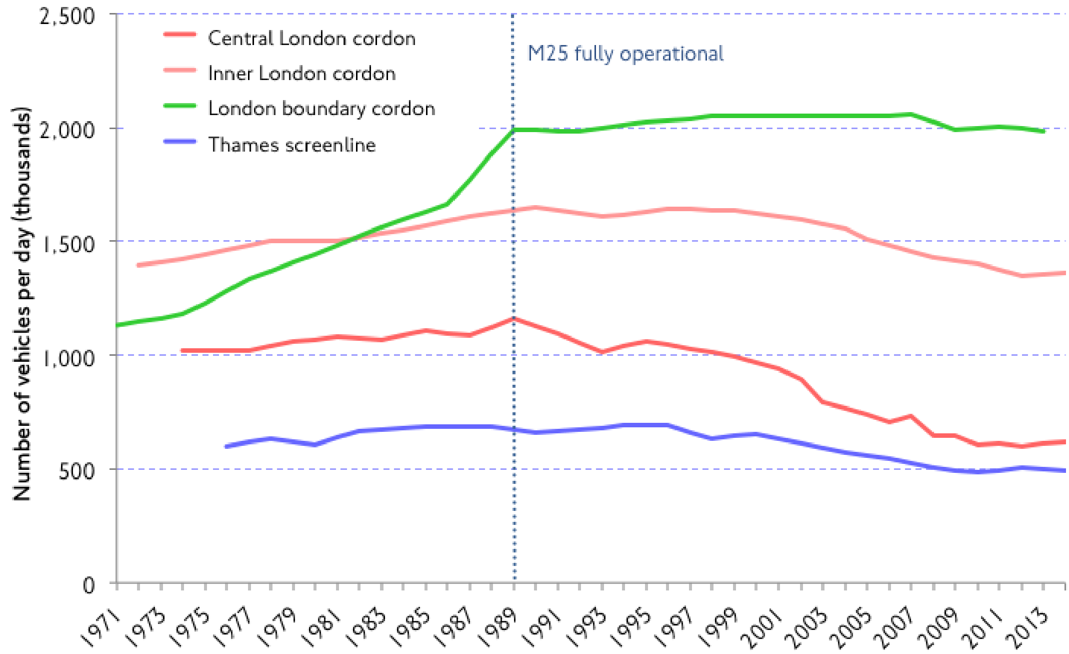
Figure 6.3.1 (b): Long-term trend for traffic crossing strategic traffic counting cordons in London (CREATE Zones 1 and 2). All mechanised modes.



Source: Transport for London.

The pattern shown by the cordons is generally similar to that for vehicle kilometres. However, it is necessary to bear in mind that these indicators are not measuring the same thing. It is of interest to look at the cordon trends for each of the main vehicle types, and this is the subject of the following three figures.

Figure 6.3.1 (c): Cordon traffic flows – cars. CREATE Zones 1 and 2.

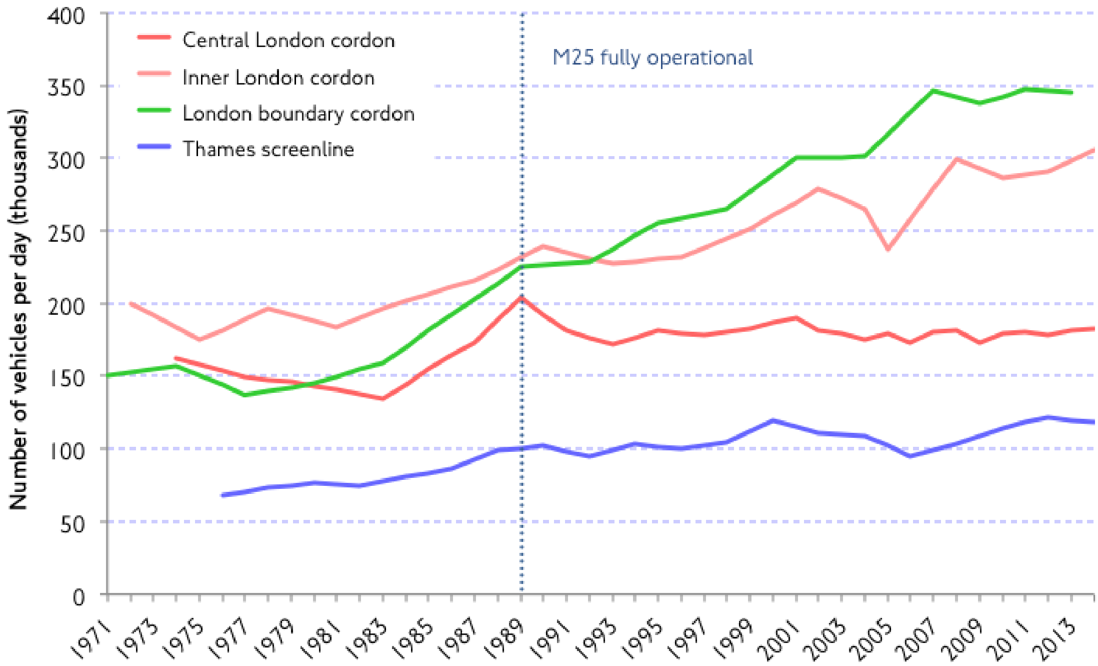


Source: Transport for London.

Looking first at cars (under 1.5 tonnes weight) (Figure 6.3.1 (c), the overall trend for each cordon follows the general vehicle kilometre based traffic trends (about 80 per cent of all traffic in London by volume is comprised of cars). The large decline in traffic in central London over the later period is clearly visible – although again it is necessary to note that the central London cordon is not the same as the boundary of the Congestion Charging Zone. At the boundary of inner London, and with the exception of a sharp but temporary fall reflecting the recent financial crisis, the overall trend is upwards. However, in this case it is necessary to note that the inner cordon is located at the boundary between inner and outer London (coincident with the boundary between CREATE Zones 1 and 2). It is therefore more representative of traffic levels in outer London than inner London. The outer London cordon is located at the boundary of the Greater London area (ie the boundary between CREATE Zones 2 and 3). The overall trend here is again upwards, the influence of the M25 motorway being a key factor here. These cordons are therefore more representative of the boundaries between CREATE Zones rather than conditions in the zones themselves.

Figure 6.3.1 (d) shows the equivalent trend for vans. These are vehicles between 1.5 and 3.5 tonnes weight, and are mostly used for freight and servicing purposes, although there is also a significant element of personal travel undertaken using these vehicles (further details are given in: https://tfl.gov.uk/corporate/publications-and-reports/rtf-supporting-documents (see document 5 of this series)).

Figure 6.3.1 (d): Cordon traffic flows – vans (<3.5 tonnes). CREATE Zones 1 and 2.

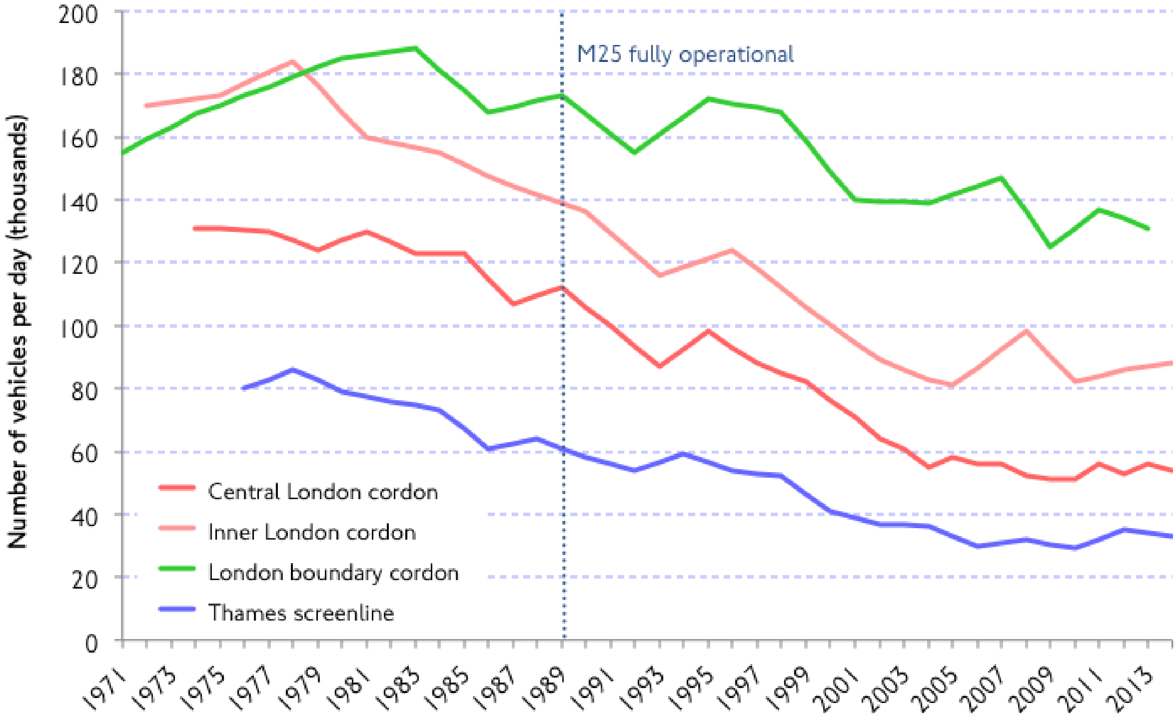


Source: Transport for London.

The overall trends for vans are not dissimilar to those for cars. The main feature of note is that van traffic at the central London cordon has not fallen in the way that car traffic has. This reflects a general increase in van traffic, reflecting wider structural changes in London's economy, but also a degree of substitution, by vans, for heavy goods vehicle trips, given the operational difficulties of operating heavy vehicles in the dense central area.

Figure 6.3.1 (e) shows the equivalent trends for heavy goods vehicles (over 3.5 tonnes weight). These are exclusively used for freight transport. Here, in contrast, the overall trend at all cordons is downwards. However, these vehicles comprise only around 5 per cent of traffic by volume, and have been partly replaced by the growth of vans for freight traffic.

Figure 6.3.1 (e): Cordon traffic flows – heavy goods vehicles (>3.5tonnes). CREATE Zones 1 and 2.



Source: Transport for London.

Note that trends relating to cycling are covered elsewhere in this report. It is important to recognise, therefore, that within the overall pattern of increasing traffic at the start of the CREATE analysis period, and falling general traffic levels towards more recent years, the individual vehicle types have shown very different patterns from each other.

6.3.2 Road traffic average speeds

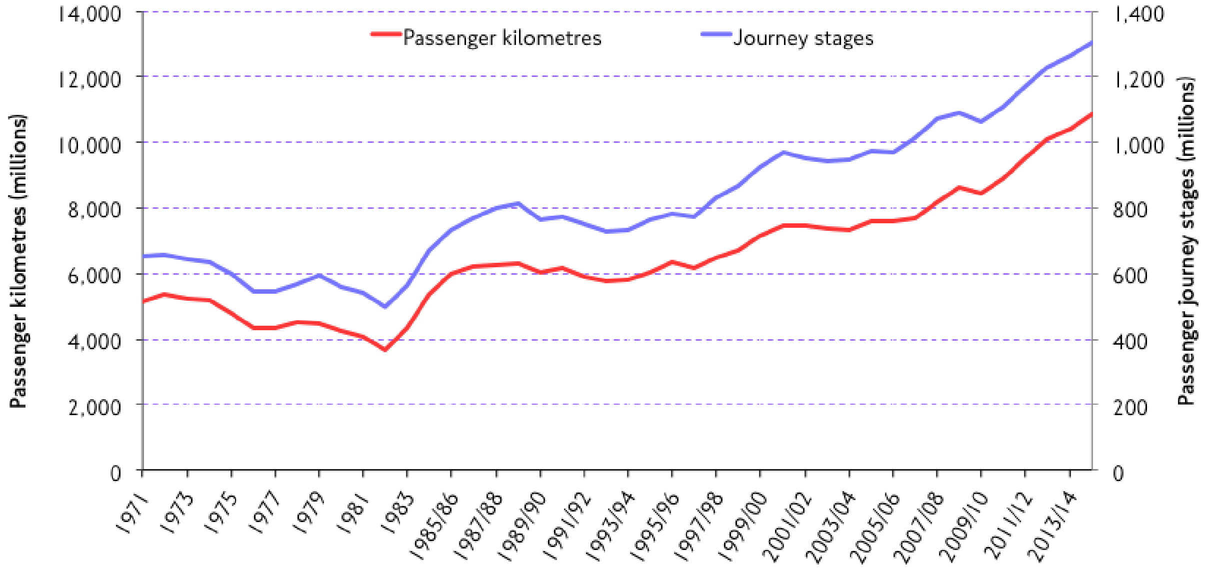
This material is dealt with above, as it is primarily a manifestation of transport supply.

6.3.3 Public transport patronage: passenger kilometres, journey stages

Available patronage trend data for the key public transport modes in London is presented in the figures below (Figures 6.3.3.(a) to (d)). The trends are largely self-explanatory, with a general picture of slow decline in the earlier part of the CREATE period, followed by rapid growth in more recent years.

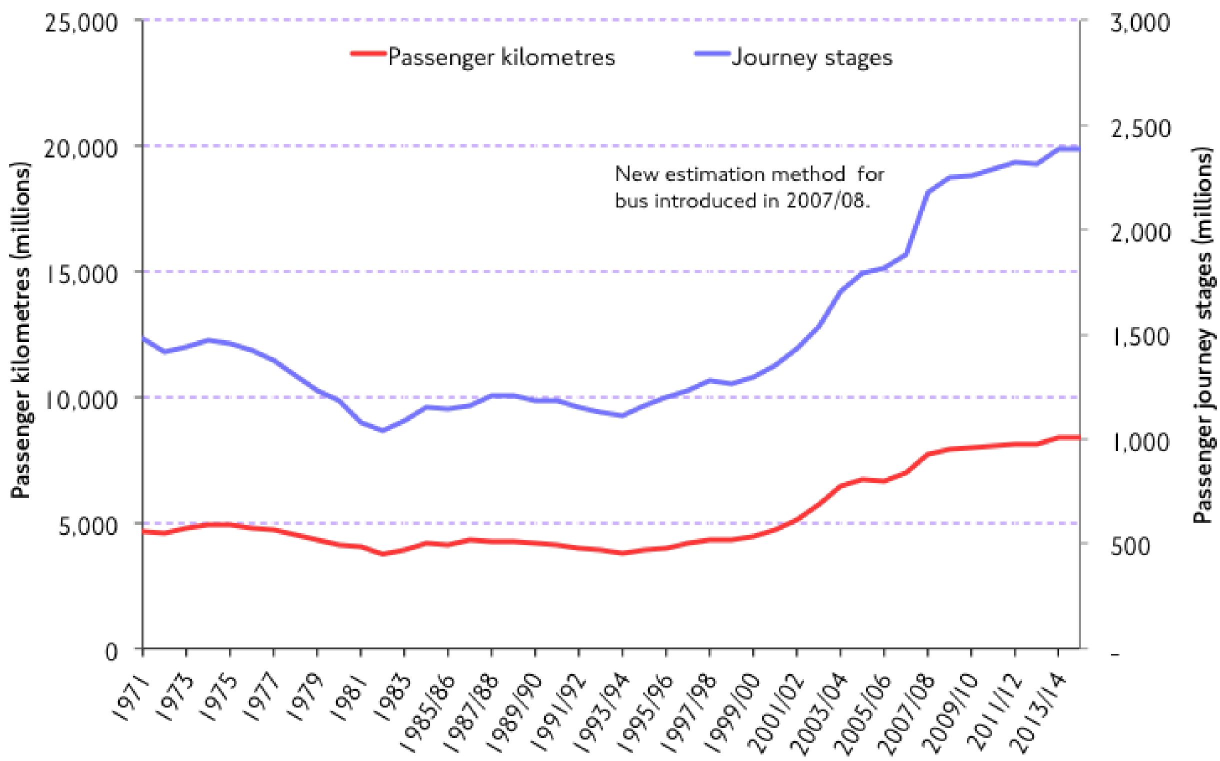
Underground

Figure 6.3.3 (a): Passenger kilometres and journey stages by London Underground. Whole Underground system – largely corresponding to CREATE Zones 1 and 2 combined.



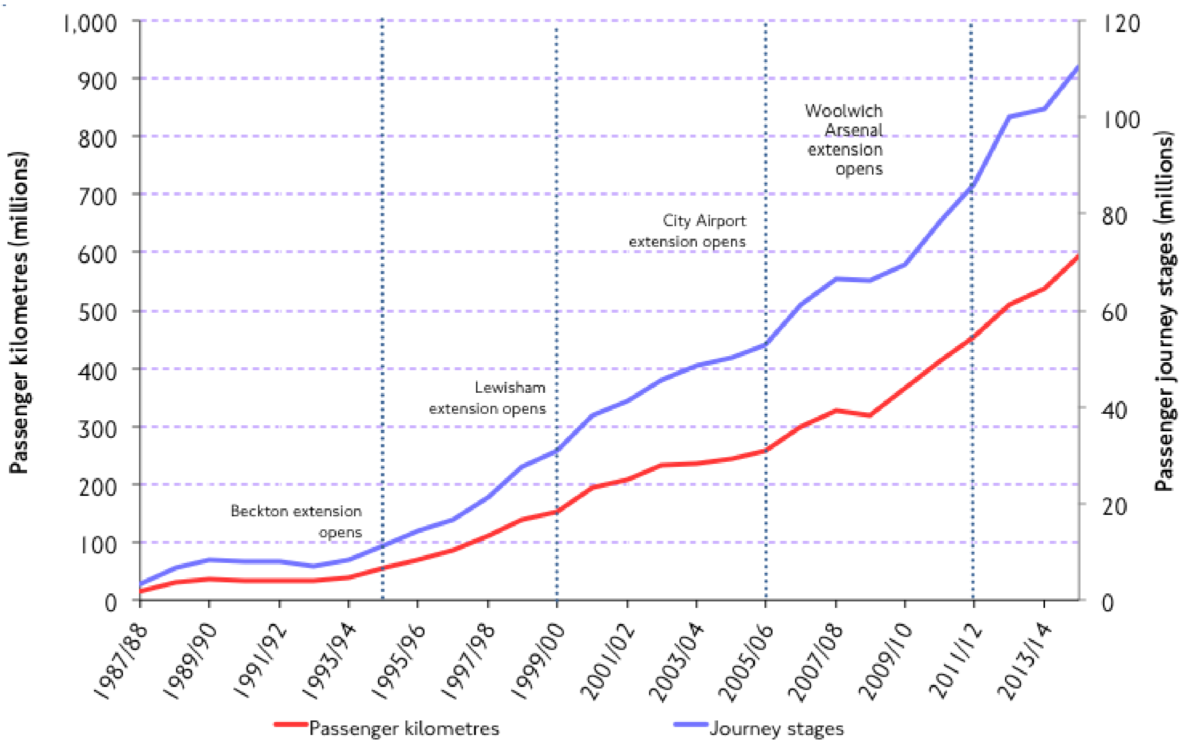
Source: Transport for London.

Figure 6.3.3 (b): Passenger kilometres and journey stages by bus. Whole bus network – largely corresponding to CREATE Zones 1 and 2 combined.



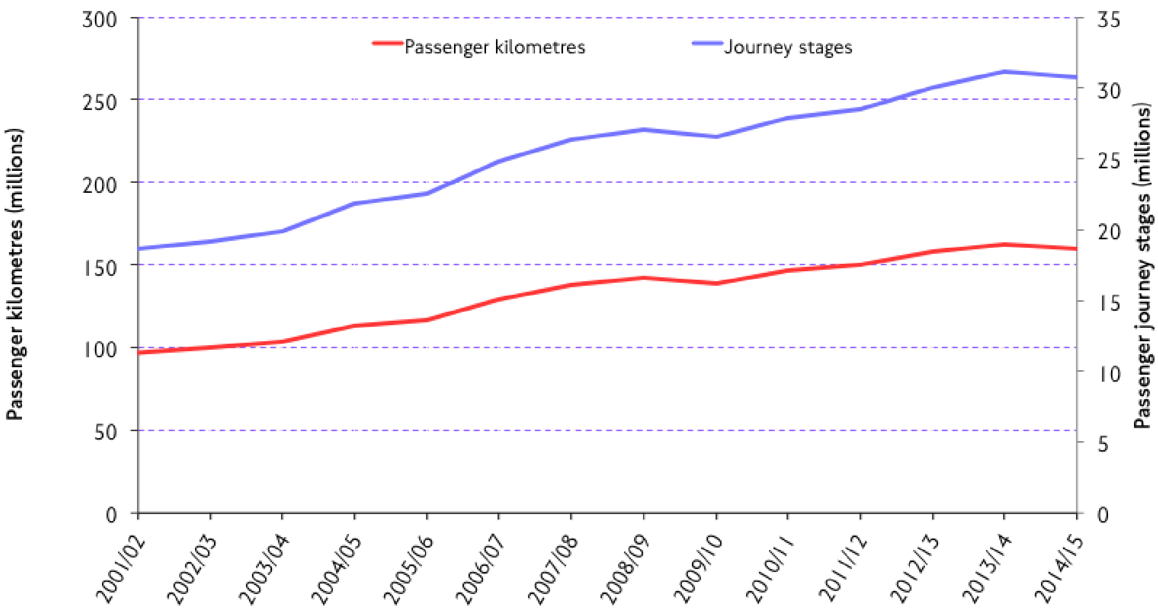
Source: Transport for London.

Figure 6.3.3 (c): Passenger kilometres and journey stages by Docklands Light Railway (DLR). Note that the DLR is largely located in CREATE Zone 1.



Source: Transport for London.

Figure 6.3.3 (d): Passenger kilometres and journey stages by Docklands Light Railway (DLR). Note that the DLR is largely located in CREATE Zone 1.



Source: Transport for London.

In terms of some brief descriptive context to each of the trends shown by the four figures above:

- Underground rail patronage stagnated during the 1970s and early 1980s. Patronage began to increase in the 1980s, associated with the 'Fares Fair' policies of the GLC and the related introduction of zonal fares and the multi-modal Travelcard. Patronage levels have continued to increase consistently since.
- Bus patronage also stagnated in the 1970s and early 1980s. This was, in fact a low point and a continuation of declines that had first been seen in the 1950s and 1960s. Unlike the Underground, bus patronage did not immediately recover with the introduction of fares fair in the 1980s. In contrast, one effect of this policy was to attract users away from the bus, as the multi-modal Travelcard meant that it had become relatively cheaper to use this (quicker) mode. It was not until the 1990s, with increased crowding pressures on the Underground and, at the time, no visible prospect of large-scale investment for new Underground capacity, that substantial investment was made in the bus network (see bus service supply statistics). This continued progressively until the mid-2000s. Mayor Livingstone saw buses as the primary way of creating more public transport capacity quickly, since new bus routes could be introduced without a prolonged construction period.
- The DLR pattern follows the development of Docklands as a centre of employment and the progressive extension of this network. Key dates when new infrastructure opened are annotated on the graphic.
- Croydon Tramlink patronage (only available for more recent years) shows a progressive pattern of growth. This network is important locally in outer south London.

Finally, some consistent data are available for national (surface) rail services in London (Table 6.3.3 (e)). This again shows a strong recent increase, but it is important to note that it relates to franchises defined as 'London and the South east'. It is therefore a much larger area than Greater London (see also elsewhere in this report).

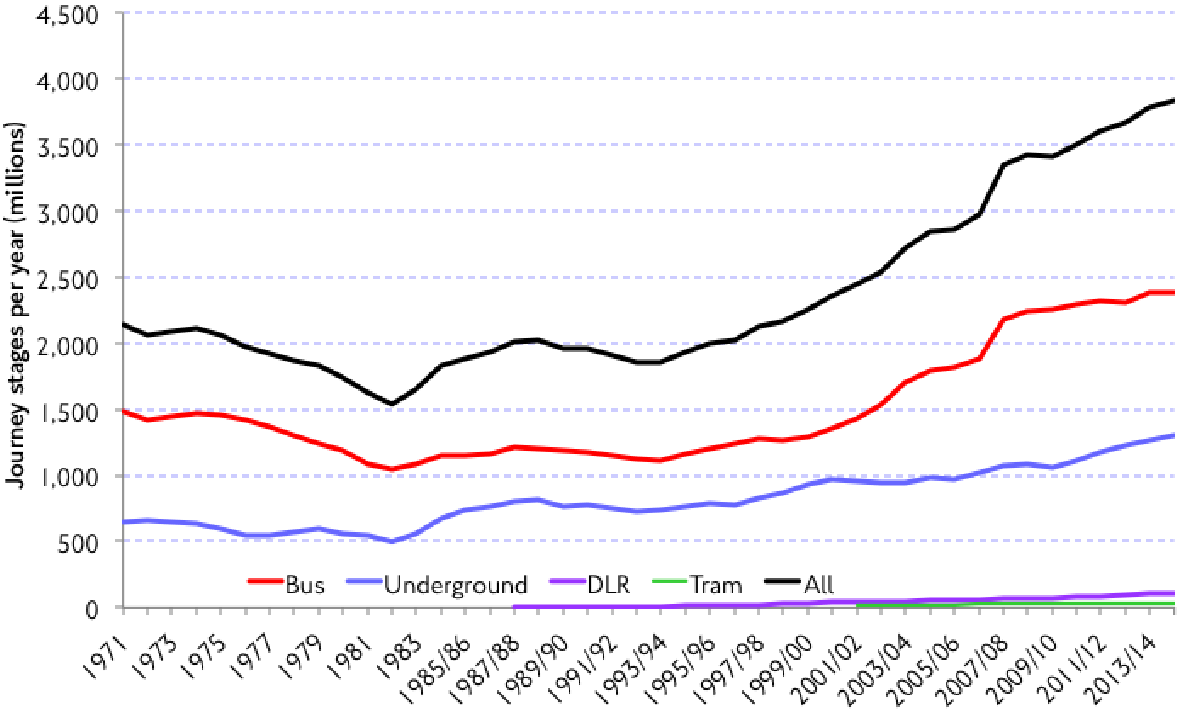
Table 6.3.3 (e): Recent trend for patronage of National Rail services – train operators defined as 'London and South East operators'.

Year	Passenger kilometres (billions)	Year-to-year percentage change	Passenger journeys (millions)	Year-to-year percentage change
1998/99	17.1	..	616	..
1999/00	18.4	7.6	639	3.6
2000/01	19.2	4.3	664	4
2001/02	19.3	0.5	663	-0.1
2002/03	19.8	2.6	679	2.4
2003/04	20.1	1.7	690	1.6
2004/05	20.5	1.9	704	2.1
2005/06	20.7	1.1	720	2.2
2006/07	22.2	7.1	769	6.9
2007/08	23.5	6.1	828	7.7
2008/09	24.2	2.9	854	3.1
2009/10	23.8	-1.8	842	-1.4
2010/11	25	5.2	918	9
2011/12	26.4	5.3	994	8.3
2012/13	27.3	3.4	1,032	3.9
2013/14	28.6	4.9	1,107	7.2
2014/15	29.6	3.4	1,155	4.3

Source: United Kingdom Office of Rail and Road (ORR).

The Figure below brings together these data in a single graphic.

Figure 6.3.3 (f): Public transport patronage trends in Greater London. CREATE Zones 1 and 2 combined.

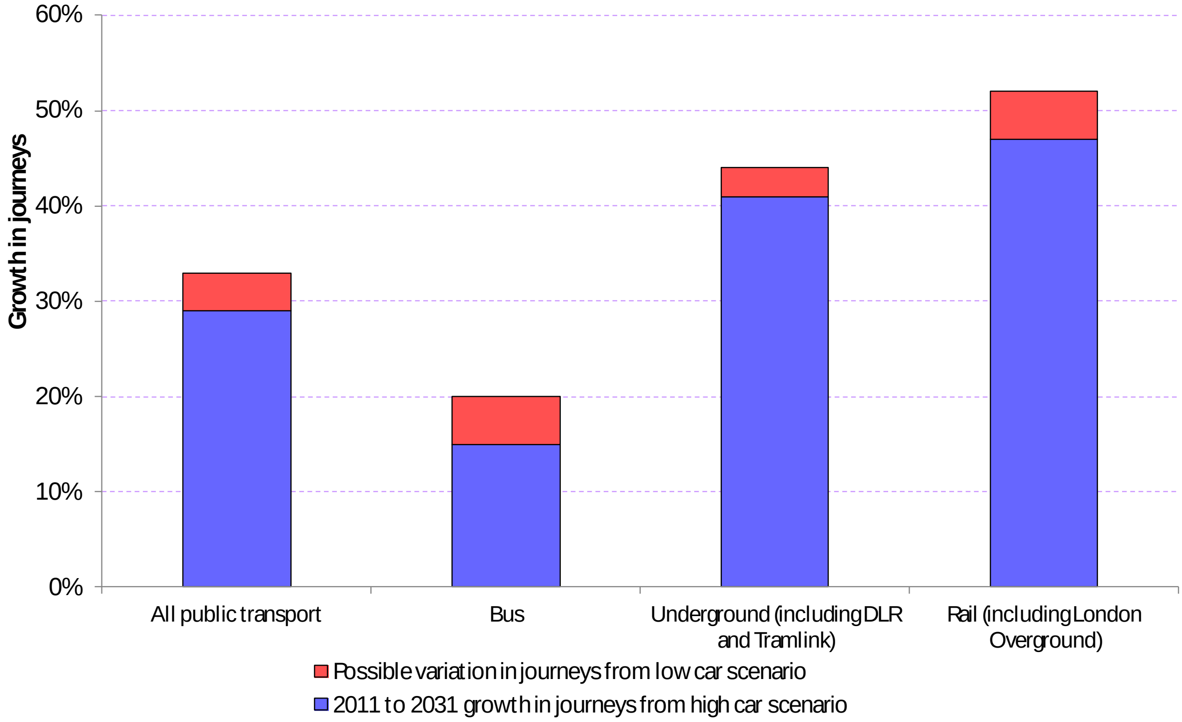


Source: Transport for London.

<u>The future</u>

Public transport demand has been growing rapidly over the past decade and TfL forecasts continued strong growth in rail and Underground demand, reflecting committed investment such as Crossrail and the Tube upgrades. Bus demand is expected to grow in line with population growth, which is lower than in the recent past and reflects planned investment, which is more moderate than the significant service increases in the 2000s (Figure 6.3.3 (g)).

Figure 6.3.3 (g): Future demand growth by public transport mode. CREATE Zones 1 and 2 combined.



Source: TfL Planning, Strategic Analysis.

Peri-urban area

Data for this aspect are not available for the peri-urban area.

6.4 Travel behaviour and policies

6.4.1 Share of car trips and public transport trips indicated by policy action

General points

As will be seen from the total travel and mode share graphics set out above, the trends in travel by each of the main transport modes in London has been one of steady and consistent change over several decades. There are no sharp discontinuities visible in the trend at the Greater London level, but there is clear evidence of evolutionary change. These progressive changes have been brought about by a vastly complex array of policies, together with societal and economic changes and changes to the relative supply of the different transport modes.

This section identifies the principal policy actions that may have explanatory value in interpreting the travel trends/mode share for each of the principal modes. Substantial amounts of documentation describing these policies and their effects are readily available, and so this material covers the basic points only (key references to third party material are given throughout).

Some key 'background' changes

Overall, whilst individual policies have identifiable effects, more background 'secular' trends are overall the most important determinant of trends in mode share. Importantly, specific high-profile policies tend to follow wider societal trends rather than lead them. So, the increased policy emphasis on the quality of the urban environment in recent years reflects growing public concern with these aspects. Some of the key ‘background’ trends in London over the period have been:

- **Changes to the working week**. Up until the early 1960s, it was not uncommon for office workers to work Saturday mornings. This diminished rapidly however, to be replaced during the 1980s by the rapid growth of the ‘night time economy’, which continues to increase in importance. The rise of specialist employment and more flexible working practices over the last 20 years has led to a trend where commuting during the traditional peak hours is becoming increasingly decoupled from the number of jobs. There is proportionally more travel outside of the peaks, within an overall increased total amount of travel.
- **Increased participation of women**. Changes to the role and participation of women have been very significant over the period covered by CREATE. Women now participate almost equally in the workforce and in terms of travel (trip rate). However, in the 1960s/70s, the employment and travel characteristics of women were very different.
- **Increased cost of housing**. This has been a major factor since the late 1980s. The high relative cost of housing in London has led to an increase in commuting from the peri-urban area. However, during the 1960s and 1970s inner areas of London underwent a process of ‘slum clearance’, where older properties were demolished to make way for social housing estates. This lead to a de-densification of inner London. More recently, the trend towards ‘gentrification’ of the inner city has led to these areas becoming relatively affluent, albeit with house prices far beyond the reach of the average worker.
- **Changing role and expectations of younger people**. The trend for younger people to, during the 1960s 70s and 80s, aspire to car ownership (and hence driving license ownership), and the reversal of that trend over more recent years has been documented elsewhere. Over the last decade younger people have faced a relative decline in their own personal wealth, largely resulting from high housing costs, as well as, very recently a changed pattern of activity brought about by the internet and social media. In comparison with earlier years, younger people today have less money and less need to travel than their predecessors.
- **Increased environmental and health consciousness**. Although probably not a major factor, it is notable that the ‘environment’ agenda was not in existence in 1960. Now, after housing, it is probably the second most important policy priority of the new Mayor. This increased consciousness, as well as various measures, such as fuel taxes associated with it, will have had an impact on people’s travel behaviour, particularly recently with the growth of cycling.
- **Technology change** is in general well-documented. Recent manifestations have included things like increasing van traffic. More longer term trends have included things like the centralisation of retail around ‘retail parks’ and the decline of traditional town centres.

Key policy interventions

Some key ‘policy’ interventions, with a sense of the scale of the impact, have been as follows:

- **Zonal fares and ‘Fares Fair’**. Zonal fares were introduced in the early 1980s. They were associated with a policy known as ‘fares fair’, which had the overall effect of lowering public transport fares by increasing the level of subsidy for public transport. Both of these policies were a deliberate attempt to increase the attractiveness of public transport, both in recognition of the increasing problem of road congestion and also to help arrest years of decline and lack of investment in London’s public transport networks. The introduction of the Travelcard and the increased integration, in terms of fares, across all of the public transport networks in London, was a particularly important development. After several years of political argument and legal challenges to this policy, the zonal fares framework as settled down and still applies, with several refinements, today. The policies have been credited with kick-starting a significant rise in public transport patronage. Significantly increases to public transport supply, however, post-dated Fares Fair by several years. The increase in ridership brought about by these policies led to increased crowding which helped to make the case for further investment – a ‘virtuous circle’. See: https://en.wikipedia.org/wiki/London_fare_zones.

- **Fuel price escalator and changes to the taxation arrangements for company cars**. Mainly prompted by the need to increase taxation revenues, the duty applied to road vehicle fuel was increased at a progressively higher rate from the 1990s. This made fuel more expensive, and this effect was exacerbated by fluctuations in the global market price of crude oil. The years around 2000 were when this impact was at its highest. More recent falls in the global price of crude however have lessened the impact such that fuel price has not been a significant constraint on motoring for much of the last decade. Also, during the 1990s, the government moved to reduce the then substantial tax incentives for company cars. Company cars used to be a very common 'perk' for many employees, whether their job required the use of a car or not! This reversal of policy was again largely for fiscal reasons, ie reducing the tax break, rather than for environmental reasons. However, the incentives available progressively diminished such that company cars have almost disappeared as an incentive for employees. One of the features of this earlier policy was that it was not uncommon, anecdotally, for employees to 'drive around the M25 motorway several times' to make up their monthly mileage to a threshold where the tax breaks increased!
- **Introduction of Congestion Charging in central London from 2003** - see under 'history of road user charging' below.
- **Initiation of the Mayor of London and the Greater London Authority, along with the creation of Transport for London (from 2000).** This will be described at length as part of WP4. However, it has undoubtedly been the catalyst for large-scale investment in transport and the development of integrated transport services across London. It has chosen not to invest significantly in new roads infrastructure. Rather it has focused policy on getting the most out of the existing roads network. The Transport Strategies of the successive Mayors have set out policy blueprints that have helped, in very many ways, towards the achievement and stability of CREATE 'Stage 3' policies and conditions within London. See: https://www.london.gov.uk/what-we-do/transport/our-vision-transport/mayors-transport-strategy.

The future

Population is projected to grow across London, with particularly strong growth in east London and the Opportunity Areas, but also in less well connected areas of outer London. Differences in the composition of the population in different parts of London will have implications for future travel demand. The location of population growth and connectivity levels and improvements will play a significant role in the resultant mode share and particularly car use.

The higher concentrations of employment growth are forecast to be located in central and inner areas of London, and will depend on high capacity radial public transport to carry workers from the rest of London and the surrounding region. Future connectivity improvements will play an important role in the viability of jobs and economic performance.

The demand growth expected on public transport is very significant, particularly in inner and central London and links serving Growth and Opportunity Areas. The increase in population is also likely to lead to some growth in car use, particularly in outer London, although there is uncertainty about the scale of this growth. These growth pressures will lead to crowding and congestion challenges which will need to be addressed.

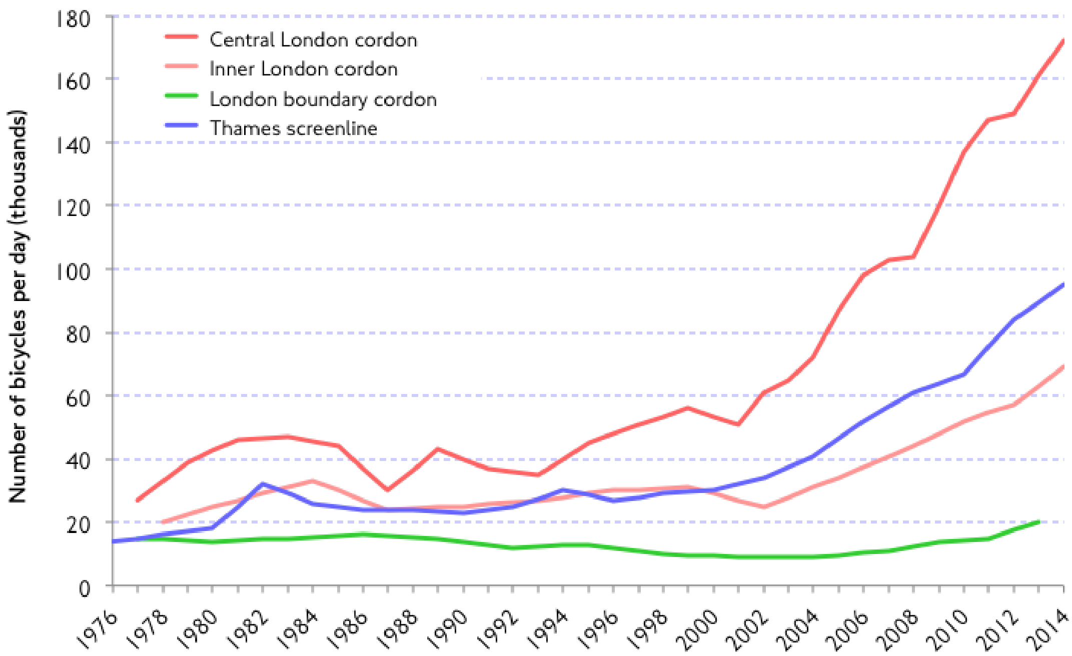
Walking is projected to grow in line with population change and cycling is expected to continue to grow strongly to meet the Mayor's cycling target in 2026. This growth in cycling will also help mitigate some of the increase in public transport demand and crowding.

The new Mayor of London, Sadiq Khan, may choose, over the coming months, to develop a revised Transport Strategy that would provide a 'blueprint' for transport policy in CREATE Zones 1 and 2 for the next two decades.

6.4.2 Share of cycle trips indicated by policy action

The best indicator of the long-term trend in cycling in London comes from the system of long-term cordon-based traffic counts, including the Thames Screenline, as described above. Figure 6.4.2 (a) shows these trends.

Figure 6.4.2 (a): Long-term trend in cycling in London. Number of cycles counted crossing strategic cordons and screen lines in London.



Source: Transport for London.

The overall pattern shown is one of stability/stagnation for much of the period up to the mid-1990s. Levels of cycling then began to increase in all areas, but particularly in central London. This was, initially, partly a response to overcrowding on the public transport networks and congestion on the roads. However, it also reflected a shift in the age structure of London towards younger people, and the wider rise of environmental and health consciousness among the population. Both mayors (two terms each) heavily encouraged cycling, with the establishment of the London Bike Hire scheme and Mayor Boris Johnson's Vision for Cycling in London. There are ambitious growth targets for cycling over the next 20 years. It is probably fair to say that, at least in the early years, the growth in cycling was independent of large-scale policy action. Recent initiatives capitalised on the increasing popularity of this mode (an example of policy action following and being prompted by wider societal change).

TfL can provide further information on recent trends in the socio-demographic aspects of cycling on request.

6.4.3 Share of walking trips indicated by policy action

There are no comprehensive or consistent statistics that chart changes in the role of walking as a mode of transport in London. Reference can be made to the overall mode share graphics above. Reference can also be made to Travel in London report 6, which contains a section (3.13) summarising the available data on walking in London.

The mode share of walking has remained fairly constant – at around 23 per cent of trips – for a long time. It is important to recognise that this relates only to 'walk all the way' trips, where walk is the sole mode of transport used. Growth in the absolute number of walking trips has largely reflected London's growing population, although the measure used is very imperfect. The material in the Travel in London report points out that increased mode share for public transport actually also means an increase in walking, at the journey stage level, because of access/egress and interchange legs of trips, which are accomplished on foot. As with cycling, there is a comprehensive programme of initiatives being taken forward under the Mayor's Transport Strategy to further encourage walking as a mode of transport. The policy emphasis in London in recent years has very much followed the increasing concern for public health. Walking and Cycling are 'active' modes of transport, and people can gain a lot of their recommended weekly physical activity by simply making use of these transport modes.

Key policy initiatives relating to walking include 'Legible London'. Enhancements to the future role of walking in London, and the role of walking in public health and the urban environment, are described in the Mayor's Roads Task Force report (https://tfl.gov.uk/corporate/publications-and-reports/roads-task-force) and TfLs Transport Health Action Plan (https://tfl.gov.uk/info-for/media/press-releases/2014/february/tfl-publishes-worlds-first-transport-health-action-plan).

Peri-urban area

No data on this aspect are available for the peri-urban area.

7 Freight - policy context and policy development

Main factors affecting road freight

Trends in road freight in London are thought primarily to reflect broad economic, lifestyle and vehicle technology trends. Freight is seen as essential to the effective functioning and prosperity of the city. Therefore, policy initiatives have largely sought to tackle the negative externalities of freight traffic, rather than to radically influence the volumes of traffic. The following section of the TfL website gives an overview of the contemporary approach to freight management in London: https://tfl.gov.uk/corporate/publications-and-reports/freight.

The main structural trends affecting road traffic over the CREATE period can be summarised as follows:

- Improving vehicle technologies, including increased efficiency and increased permitted weight.
- Economic growth and the economic cycle, allied with structural changes in the London economy in favour of services and away from heavy industry.
- Increasing operational difficulties and regulatory burden, including congestion, arising from the operation of large goods vehicles in the denser inner city area – leading to a trend of 'substitution' of heavier goods vehicle trips by vans.
- More recent developments associated with internet shopping and deliveries – again resulting in a relative increase in van traffic.

Recent policy initiatives affecting road freight

Aside from policies originating from outside the UK, for example at the EU level relating to things such as 'cabotage', and increases to the maximum permitted tonnage of heavy goods vehicles, the most significant policy in London was the introduction of the **London Lorry Control Scheme** in 1986. The key features of this scheme have remained relatively stable over the intervening period, although there have been periodic moves to review the scheme.

The London Lorry Control Scheme controls the movement of heavy goods vehicles over 18 tonnes maximum gross weight at night and at weekends. The scheme is in place to help minimise noise pollution in residential areas during unsocial hours through restricting the use of these roads. The general success of the scheme is widely acknowledged; however with recent increase in traffic congestion, particularly in central London, there has recently been a resurgence of interest in modifying the scheme, for example to potentially better manage the access of goods vehicles to the central area. These are currently under study as part of the transport strategy of the new London Mayor.

The purpose of the scheme as it stands is to manage the externalities of goods vehicles. Whilst it therefore affects the detailed spatial and temporal patterns of goods vehicle traffic, it would not be expected to affect the overall volumes of goods vehicles in London as a whole.

Further information on the current operation of the London Lorry Control Scheme can be found at:http://www.londoncouncils.gov.uk/services/london-lorry-control/about-llcs and http://urbanaccessregulations.eu/countries-mainmenu-147/united-kingdom-mainmenu-205/london-lorry-control.

The London Low Emission Zone was introduced in 2007. This is a regulation-type scheme that restricts access to goods vehicles (over 3.5 tonnes) on the basis of Euro emissions class. Although there is a system of penalties for non-compliance (in practice compliance rates are very high), the scheme does not raise net revenues. The requirements of the scheme are set such that, whilst there may be compliance costs to goods vehicle operators, it would not be expected to significantly affect the total volumes of goods traffic in Greater London. Again, therefore, it will not be a significant explanatory variable in terms of interpreting the long-term trend for goods vehicle movements in London. Details of the operation of the London Low Emission Zone scheme can be found at: https://tfl.gov.uk/modes/driving/low-emission-zone

The future of the Low Emission Zone is currently under review, with a view to extending the scheme, as part of the strategies of the new Mayor of London. The Ultra-Low Emission Zone (ULEZ), relating to central London and effective from 2020, is the most recent policy initiative. Details of this can be found at: https://tfl.gov.uk/modes/driving/ultra-low-emission-zone

A recent but important feature is a tightening of the safety aspects of heavy goods vehicle traffic. This follows a spike in traffic casualties, especially cyclists, killed in collisions with goods vehicles (at least in part reflecting the increase in the number of bike trips). Examples include the 'FORS' freight vehicle/operator accreditation scheme and the 'Safer Lorries' scheme. Further details of these two schemes can be found at the following links: https://www.fors-online.org.uk/cms/ and https://www.london.gov.uk/press-releases/mayoral/safer-lorry-scheme.

Traffic trends – goods vehicles

There are several sources of time series data that chart the trend for road good vehicles in Greater London. These can be found in the workbook and are copied above in section 6 of this report. The two dominant features of these trends are (a) a correlation against overall economic conditions (eg Gross Domestic Product) and (b) a more recent trend of a decline in the volumes of heavier goods vehicles, counterbalanced by an increase in the numbers of lighter vans (for reasons cited above). The dip in goods vehicle traffic following the banking crisis in 2007 is clearly visible, reflecting the particular sensitivity of goods traffic to economic conditions, whilst it is thought that the rise in vans reflects a mixture of the growth of new activities such as on-line shopping, but also a movement away from HGVs given the greater flexibility of vans in the congested and regulated urban environment.

8 Summary, Conclusions

Summary – how London relates to the CREATE 'Stages' model

This report has presented a variety of data that chart the evolution of the key elements of travel demand in London over the broad period of interest for CREATE. The data presented are only a small fraction of that potentially available, and reference should be made to Transport for London for further enquiries.

Whilst it is not surprising that the quality, consistency and availability of data are less good for the earlier years of the CREATE period, the pattern shown by the trends is clearly in accord with the 'three stage' evolutionary model put forward by CREATE. In the early part of the CREATE period, London displayed many of the characteristics of CREATE **Stage 1** conditions. Car use was growing, both in terms of patronage and infrastructure investment, and public transport was in decline – both in terms of patronage and investment.

Approximately during the mid-1980s these trends started to turn around. The negative externalities implied by growing road traffic demand – within the constrained context of a developed and dense city – became increasingly recognised by public and politicians alike. Policies such as zonal fares, although seen as radical at the time, were intended to reverse the decline in public transport. They kick started a rise in patronage which, in turn demanded and helped to make the case for, further infrastructure investment. At the same time, levels of service on the road network deteriorated to the extent that congestion was seen as a major problem. The growing 'generalised cost' of travel by road combined with increasing availability and attractiveness of public transport to cause travellers to shift mode to public transport. The emergence of these policies was not universally welcomed at the time – there were serious attempts to construct significant new road infrastructure as late as the mid-1990s, as it was also seen as a 'solution to rising congestion'. So, conditions during this period relate well to **Stage 2** of the CREATE evolutionary model.

The trend of removal of capacity from the road network, to support increasing non-driver priorities, has latterly gone hand in hand with increasing congestion to further encourage mode shift to public transport, which, in turn, has further strengthened the case for continued investment in public transport infrastructure. It is clearly possible, therefore, to see a 'virtuous circle' emerging in favour of public transport, walking and cycling – and these ideas currently permeate strategic thinking and planning for the next two decades or so.

The strong emphasis on cycling is more recent, and the impact limited owing to the low starting point (for many years cycling has accounted for just 2 per cent of all trips made by Londoners). However, the level of ambition is very high in terms of future mode share, albeit at the cost of further removal of capacity for general traffic (to support the construction of segregated cycling infrastructure). So, current conditions in London relate well to CREATE **Stage 3** conditions, and their projected continuance, in terms of strategic planning for the future, suggests (at this early stage) that **Stage 4** conditions are likely to be based on a continuance and intensification of current policies, distinguished by a greater emphasis on integrated spatial planning, and a greater public awareness, and acceptance of, the need for sustainable mobility.

It is also possible to discern a spatial element to these trends. In terms of key indicators such as the volume of road traffic, the change in trend was observed first in central London, and has progressively spread since to inner London (both forming CREATE Zone 1). Elements of these trends are now clearly visible in Outer London (CREATE Zone 2), although at a lower level of intensity – primarily (it is thought) reflecting the greater availability of road space (in relation to demand) here, the greater distances involved in typical trips (eg between home and work), and the relatively lower level of availability of public transport. Stage 1 type conditions persisted for the greatest amount of time in the peri-urban area (CREATE Zone 3). This is again thought to be a manifestation of spatial factors, but it is also strongly thought to reflect the lack of a single strategic transport authority in this area. Although the transport policies of the relevant local authorities have undergone a similar process of evolution to those of Greater London (and those at the national scale), the lack of co-ordination, and the lower level of intensity of problems such as traffic congestion, has meant that widespread adoption and the impetus behind them has been at a much lower level than in CREATE Zones 1 and 2.

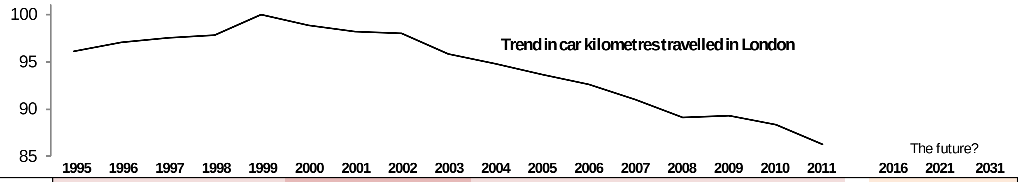
Significance of causative factors in driving change in travel behaviour and aggregate travel demand patterns

TfL's Drivers of Travel Demand report (see: https://www.google.co.uk/search?q=london+drivers+of+demand&sourceid=ie7&rls=com.microsoft:en-GB:IE-Address&ie=&oe=&gfe_rd=cr&ei=CqLWV6WFLsjO8geF87qACg&gws_rd=ssl concluded with a synthesis of the contribution of the various identified causative factors to travel demand change over the period since 1995. This can be adapted for CREATE purposes and is reproduced in this form below.

In the broadest terms, travel demand remains dependent on a range of exogenous factors such as the economy, population, and demographics. While travel demand can only be explained by a wide range of interrelated factors, it is apparent that over the past 10 to 20 years many of the most significant of these factors have been contributing to a shift away from private car travel towards travel by walking, cycling and public transport in London. Figure 8.1 below shows some of these major influences, and the time-span over which they have been in effect. The number of these influences has increased in recent years, with the effects of the recession adding to the many other factors contributing to mode shift over the long term.

It remains to be seen whether these factors continue to have a downward influence on the level of car use in future. While service standards on public transport can be maintained and capacity can continue to be increased, some factors are outside the control of transport policy makers. If outer London returns to more prosperous times, desire for increased car ownership and use amongst its residents may follow. Similarly, if the next 20 years see spatial growth skewed more toward outer London than was the case for the last 20 years the associated growth in travel demand is more likely to be for car travel in the absence of a substantial change in the balance of transport supply.

Figure 8 (a): Major factors contributing to mode shift away from car travel over time in Greater London.



	Factor	1995–2011	The future?
Supply	Bus capacity	2.7% pa growth; 6% pa growth; 1.3% pa growth	Keep pace with population
	Underground capacity	1.6% pa growth	Crossrail & Tube Upgrades
	Bus single fare	8% pa fall; 6% pa rise	Dependent on fares policy
	Bus season pass	8% pa fall; 13% pa rise; Flat; 8% pa rise	Dependent on fares policy
	Underground single fare	Flat; 6% pa fall; 7% pa rise	Dependent on fares policy
	Travelcard	Flat; 1% pa rise	Dependent on fares policy
	Customer satisfaction	Underground Customer Satisfaction overall score up from 73 to 81	Further improvements
	Outer highway capacity	1% pa growth; 1% pa reduction	Expected to stabilise
	Inner Highway capacity	1.2% pa reduction	Aspirations lead to reductions
	Fuel cost	4.5% pa rise; 4.4% pa fall; 1.6% pa rise; 10% pa rise	Forecast to rise
	Parking	Effects of parking standards and parking control regulation introduced in mid-1990s	Dependent on policy
Underlying demand	Population growth	Population growth of 2.5% pa	1% growth pa
	Outer London incomes	2.5% pa growth; Flat	Return to growth and rising incomes
	Inner London economy	5.8% pa growth; 2.3% pa growth	
	Outer London economy	4.6% pa growth; Flat	
Structural	Population distribution	Disproportionate share of population growth in inner London	Re-balancing of growth
	Migration	Increase in non-UK born Londoners, many with profiles matching low levels of car ownership and use	Migration expected to slow
	Licence holding	Decreasing driving licence holding amongst young Londoners	Trend to be monitored
	Unknown factors		Further societal changes

Legend				
Unknown or data break	Contributor to more car travel	Broadly neutral effect	Contributor to less car travel	Stronger trend away from car

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Figure 6.2.1 (d). Three-year moving average of trip rates (average number of trips per person per day – for weekdays only and excludes those that made no trips on survey day) for residents of London's Inner and Outer Peri-Urban areas.

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Figure 6.2.1 (f): Trip rates by journey purpose for residents of CREATE Zone 3 (inner peri urban area).

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Figure 6.2.1 (h): Trip rates for trips starting within the three hour weekday AM peak period. CREATE Zone 1 and 2 residents who make at least 1 trip, trips with at least one end in CREATE Zones 1 or 2.

Figure 6.2.1 (i): Trip rates for trips starting within the three hour weekday AM peak period. CREATE Zone 3 and residents who make at least 1 trip, trips with at least one end in CREATE Zone 3.

Figure 6.2.2 (a): Average daily travel time – London residents (7 day week). CREATE Zones 1 and 2 combined.

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Figure 6.2.2 (d): Average daily travel distance – London residents (weekdays only). CREATE Zones 1 and 2 combined.

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Figure 6.2.2 (g). Three-year moving average of average trip length by mode (average distance travelled in kilometres per person per day – for weekdays only and excludes those that made no trips on survey day) for residents of London's Outer Peri-Urban area.

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Figure 6.2.2 (i): Three-year moving average of trip distances (average distance travelled in kilometres per person per day – for weekdays only and excludes those that made no trips on survey day) for residents of London's Inner and Outer Peri-Urban areas.

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Figure 6.3.3 (a): Passenger kilometres and journey stages by London Underground. Whole Underground system – largely corresponding to CREATE Zones 1 and 2 combined.

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Figure 6.3.3 (c): Passenger kilometres and journey stages by Docklands Light Railway (DLR). Note that the DLR is largely located in CREATE Zone 1.

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Figure 6.3.3 (f): Public transport patronage trends in Greater London. CREATE Zones 1 and 2 combined.

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Figure 6.4.2 (a): Long-term trend in cycling in London. Number of cycles counted crossing strategic cordons and screen lines in London.

Figure 8 (a): Major factors contributing to mode shift away from car travel over time in Greater London.

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Appendix 1: Local Authority units comprising the study zones for CREATE

CREATE Zone 1: Inner and Central London combined

Consists of the London boroughs of Camden, Hackney, Hammersmith & Fulham, Haringey, Islington, Kensington & Chelsea, Lambeth, Lewisham, Newham, Southwark, Tower Hamlets, Wandsworth, the City of Westminster, and the City of London.

CREATE Zone 2: Outer London

Consists of the London boroughs of Barking & Dagenham, Barnet, Bexley, Brent, Bromley, Croydon, Ealing, Enfield, Greenwich, Harrow, Havering, Hillingdon, Hounslow, Kingston upon Thames, Merton, Redbridge, Richmond upon Thames, Sutton, and Waltham Forest.

CREATE Zone 3: London peri-urban area

The peri-urban area is defined as two concentric zones, reflecting the availability of data. The Inner Peri-Urban has an area of 8,807 km^2. It is based on a functional definition that a minimum of 10 per cent of residents commute to central London. The Inner Peri-Urban includes following unitary authorities and districts in the counties listed below:

• Berkshire	Bracknell Forest (a unitary authority), Slough (a unitary authority), Windsor and Maidenhead (a unitary authority)
• Buckinghamshire	Chiltern, South Bucks, Wycombe
• Essex	Basildon, Braintree, Brentwood, Castle Point, Chelmsford, Epping Forest, Harlow, Maldon, Rochford, Southend-on-Sea (a unitary authority), Thurrock (a unitary authority), Uttlesford
• Hampshire	Hart, Rushmoor
• Hertfordshire	Broxbourne, Dacorum, East Hertfordshire, Hertsmere, St. Albans, Three Rivers, Watford, Welwyn Hatfield
• Kent	Dartford, Gravesham, Medway (a unitary authority), Sevenoaks, Tonbridge and Malling, Tunbridge Wells
• Surrey	Elmbridge, Epsom and Ewell, Guildford, Mole Valley, Reigate and Banstead, Runnymede, Spelthorne, Surrey Heath, Tandridge, Waverley, Woking
• West Sussex	Mid Sussex

The Outer Peri-Urban includes the rest of the South East of England. The Outer Peri-Urban has an area of 16,839 km^2.

Appendix 2: Detailed Land Use data

CREATE zones 1 and 2 combined. Land use in 2016.

Land use type	2016 hectares	2016 per cent
Residences	58512	36.5
Recreation and leisure	25186	15.7
Agriculture and fisheries	21958	13.7
Roads	21199	13.2
Education places	5563	3.5
Retail distribution and servicing	5071	3.2
Manufacturing	4205	2.6
Utility services	3033	1.9
Unused land, water and buildings	2993	1.9
Railways	2950	1.8
Community and health services	2396	1.5
Offices	1420	0.9
Airports	1376	0.9
Waterways	3684	2.3
Mineral extraction	437	0.3
Unclassified	150	0.1
Defence	73	<0.1
Wholesale distribution	28	<0.1
Storage	1	<0.1
Total	160236	100.0

Source: London Datastore.(Greater London Authority).

CREATE zones 1 and 2 combined. Land use in 1971.

Land use type	1971 hectares	1971 per cent
Commerce	2940	1.8
Education	6021	3.8
Open areas	45343	28.3
Health	1586	1.0
Industry	2869	1.8
Mineral workings	597	0.4
Offices	1570	1.0
Public buildings	3374	2.1
Residential	54119	33.8
Shops	1221	0.8
Utilities	3408	2.1
Roads	18204	11.4
Transport	6591	4.1
Vacant land	9140	5.7
Water	3099	1.9
Total	160092[1]	100.0

Source: Annual Abstract of Greater London statistics 1976. Greater London Council, 1977. Table 4.09.

UK National Travel Survey

The analyses presented in the tables that follow are based on the National Travel Survey (NTS) which has been coded to the district and unitary authority level, thus enabling the exact spatial areas we require to be defined.

The total annual NTS sample in Great Britain from 2003 was just under about 7 thousand households (20 thousand individuals). About 15% of these were residents of Greater London and 25% of the Rest of the South East of England.

Thus in our analyses we expect to be based on the responses of about 2,000 households for the Inner Peri-Urban and Outer Peri-Urban areas. National travel surveys tend to produce too small a sample for in-depth analysis of travel patterns at a local level. However, because of the large population size of our four zones, the use of two or three year moving averages, makes this analysis possible with quite a robust sample.

Appendix 3: Description of key travel surveys used in this report

The London Travel Demand Survey (LTDS) and predecessor surveys

This covers the Greater London area (CREATE Zones 1 and 2 combined). From 1971 to 2001, comprehensive household-based travel diaries were conducted once per decade, to tie in with the decennial population census. Sample sizes varied between 1 and 2 per cent of all households in Greater London, meaning that very good precision is available from the surveys for top-level estimates of the main dimensions of travel behaviour. From 2005, the survey became an annual survey, conducted on a continuous (rolling) basis, with a correspondingly lower annual sample size of approximately 0.25 per cent of London households. This smaller sample size still gives robust estimates of top-level indicators and is considered to be fully adequate for the purposes of CREATE. All of the surveys share a common basic methodology. However, there are certain differences between the surveys that mean that not all time-series comparisons are directly equivalent. Further details of these limitations can be provided on request.

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Project acronym: **CREATE**

Project title: **Congestion Reduction in Europe - Advancing Transport Efficiency**

D3.2 - Technical report for Stage 3 city

Paris Agglomeration

Work Package 3 "Quantitative Analysis of Travel"

		Date of preparation:	**December 2016**
Start date of project:	**1st June 2015**	Duration:	**36 month**
		Version:	**3**
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		Status:	**Final**
		Dissemination level:	**Public (PU)**

Table of Contents

1 CREATE project

CREATE's work is based on 3 main challenges/activities:

- to establish which policies were most effective at controlling congestion, reducing car use and promoting sustainable transport,
- whether such policies are transferable to other cities,
- how cities are going to respond to the challenges of rapid population growth and new transport technologies in the future.

In other words, and more specifically, CREATE aims to help five cities from Eastern Europe and the Euro-Med countries to decouple traffic from economic growth, with the support of five Western European cities that have already passed the critical phase of rapid increase in car ownership, and are now moving towards a sustainable transport system. CREATE sets out to study and look at options to further improve network efficiency and reduce the overall need to travel in those advanced cities.

CREATE uses knowledge gained from stakeholder interviews, data analysis, detailed research and historical studies in order to develop tools, guidance and teaching packages, providing capacity building and opportunities to enable less advanced cities to accelerate their shift towards a more sustainable mobility system.

This in-depth investigation, supported by leading analysts and a major provider of real-time traffic data will permit CREATE to investigate changing patterns of road traffic and car use, success factors behind decreasing car usage and lessons learnt.

1.1 Concept and approach

The CREATE project is based on four central innovative ideas or assumptions:

1. The way in which the "congestion" debate is framed in a city underlies how transport system performance is measured.
2. The existence of a 3-stage "Transport Policy Evolution Cycle" spread over 40+ years, which gradually shifts the policy emphasis and investments priorities from catering for road traffic growth to building up a liveable city.
3. The examination of future mobility options given a rapidly growing urban population (and a mobility densification), with policy measures which can achieve congestion reduction, promote sustainable mobility, while meeting wider policy goals.
4. Promoting the "policy transfer" of understanding gained from investigating the above mentioned ideas, to those cities which are coping with rapid growth in car ownership and promoting "pro-car" policies. This would provide them with insights into how to short-circuit the 3-stage historical "Transport Policy Evolution Cycle".

1.2 Objectives

The CREATE project is based on achieving four high-level objectives:

1. To explore the nature and the causes of urban road traffic congestion, developing and applying a set of policy relevant and practical indicators of urban road congestion and transport network performance. This will provide network managers and policy makers with metrics to establish the degree to which efficient and sustainable urban mobility is being delivered in the CREATE cities.
2. To work with five economically advanced Western European capital cities, which have already passed through the "peak car" phenomenon, examining how they have succeeded in

decoupling economic growth from traffic growth. It will be particularly interesting to discern which transport and non-transport factors have been most effective in reducing car use, thus encouraging greater use of sustainable modes.

3. To develop specific guidance and promote capacity-building for professionals in the group of cities (Eastern European and Euro-Med) which are at the earlier stages in their economic development, with a view to help them to adopt policies based on sustainable mobility, rather than becoming car dependant cities.
4. To address the serious future issues starting to emerge in many of the CREATE cities due to rapid increases in population and employment, thus potentially overwhelming all modes of transport. Via the investigation of the potential for new technologies, and the changes in business and social habits, there are chances for better managing the transport systems and reducing the overall need to travel as well.

2 About this document

The primary aim of WP3 is to analyse the transport policy evolution cycle as described in Deliverable 2.1 for the five stage 3 cities, from their stage 1 condition to their current status as stage 3 city. The development of relevant travel indicators is mapped over time in order to quantify this trajectory and to identify the various factors which have contributed to observed changes in behaviour – particularly the observed reductions in car driver modal shares.

This deliverable documents the analysis of the data to provide an overview of city development and characteristics as input for further analysis. Trends in congestion and travel behaviour (by purpose, mode, etc.) are measured, charting the emergence of "peak car" and the growth in the use of sustainable modes of travel in different parts of the urban and peri-urban areas. A descriptive analysis for each stage 3 city is conducted across the years. Indicators of changes in conditions in each city are analysed, including traffic volumes, speed, congestion, public, transport patronage, modal shares of different modes depending on data availability.

Indicators of possible causes of changed travel patterns are covering demographic changes, economic developments, car ownership, labour-market, land use, or government policies. Analysis is distinguished between different segments of population in different parts of the cities over time. Data are mainly based on any kind of statistical sources available as well as household travel surveys and are to be documented for the longest possible period of time in each city. Most of data, but in particular household travel survey data, should be available in all stage 3 cities at least 20 years back from 2014, in some cases from the 1970s, and should provide information of the stage 1 situation in the particular city.

The contents of this deliverable are based on the analysis scheme provided in Deliverable 3.1. Technical internal report, detailed analysis scheme for WP3 to ensure the generation of comparable figures over time for all stage 3 cities. The list of indicators to be documented is subdivided into 2 levels: (1) "must-have-indicators" which all stage 3 cities should have to provide and (2) "nice-to-have-indicators" representing additional analyses of specific data available in case these data are easy to access. Additionally, any other documentation of data or further cross analysis of data of interest in a particular stage 3 city are highly appreciated and should be added accordingly.

This deliverable is organised as follows: The city specific framework as the basis for the analysis is presented in chapter 2. Chapter 3 and 4 are dealing with transport supply data and policies influencing travel demand in the city documented in chapter 6. Summary and conclusions are documented in Section 7.

3 City specific framework conditions

3.1 Spatial characteristics

3.1.1 Area definitions

This section is to provide basic information and a description of each area type according to the definition as proposed in Deliverable 3.1:

- Inner-city: city centre or central business district(s)
- Outer-city: city area beyond inner-city but within the city boundary
- Peri-urban I: area bordering the city (e.g. closest ring around city), fulfilling the criteria of high population density, high density of workplaces, high number of commuters to or from the municipalities
- (Optional) Peri-urban II: wider commuting catchment area

Paris Region is called Île-de-France Region. There are 13 regions in France, Paris Region is the capital region, composed of Paris City (105 sq km) and seven departments (or counties) centered on its innermost department and capital, Paris. Then there is the “agglomeration” which is not an administrative level but is considered as the dense part of Île-de-France (2 860 sq km) whereas Île-de-France Region has a land area of 12,011 km2 (4,637 sq mi). Around the department of Paris, urbanization fills a first concentric ring of three departments commonly known as the petite couronne ("small ring"), and extends into a second outer ring of four departments known as the grande couronne ("large ring").

IAU has a zoning called “Morphological zoning” composed of 7 types for the whole île-de-France region

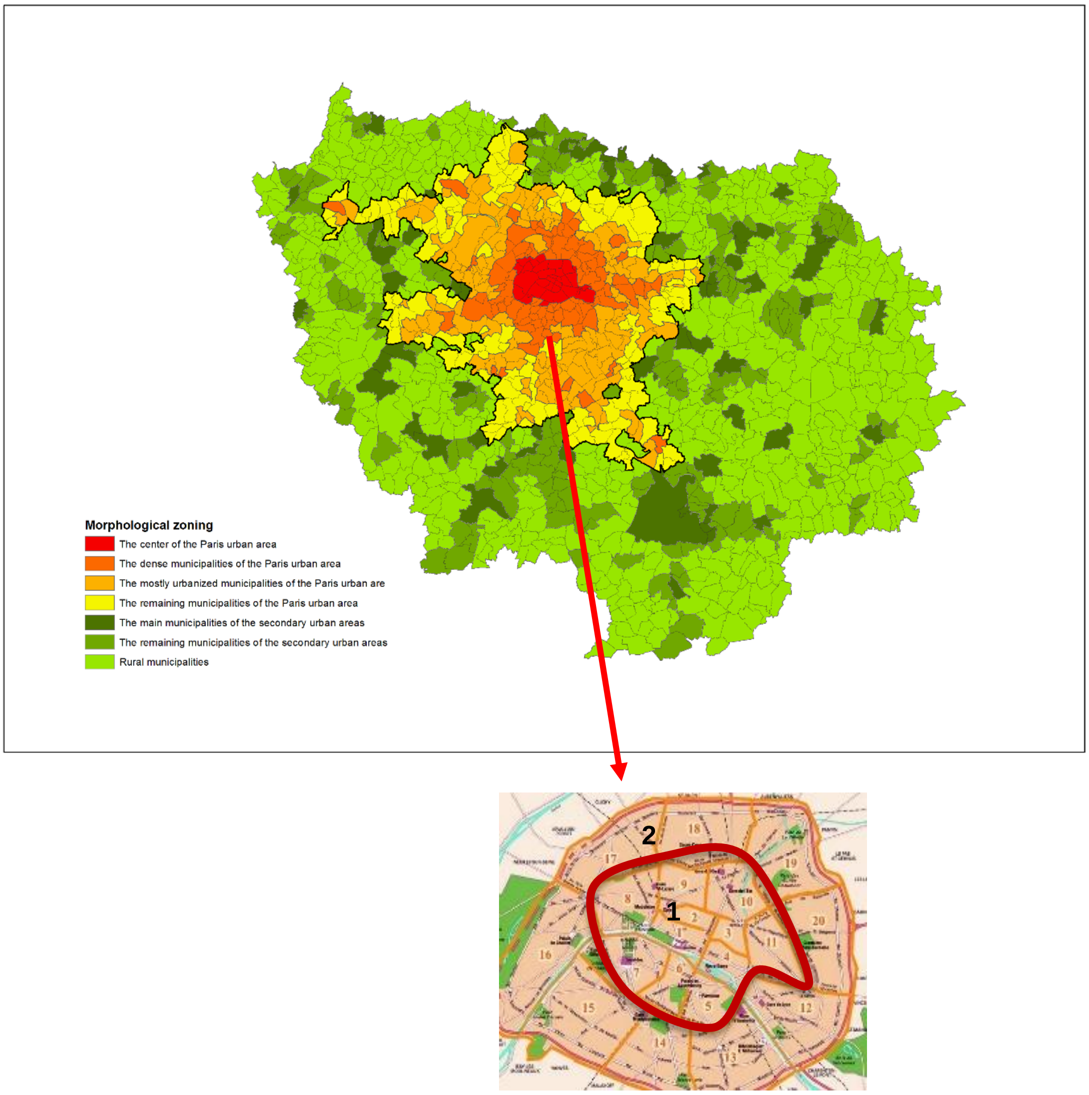
CREATE area types for the “Paris agglomeration” is based on this morphological zoning :

- Zone 1 : Inner city: Districts 1-11 within the city of Paris (arrondissements)
- Zone 2 : Outer city : Districts 12-20 within the city of Paris (arrondissements)

(Inner city + outer city = Paris city or city-wide in the figure 3-1)

- Zone 3 : Peri-urban I: Zone 2 of the morphological zoning + 11 peripherical municipalities
- Zone 4 : Peri-urban II: Zone 3 + Zone 4 of the morphological zoning

We do not take into account Zones 5 to 7 of the morphological zoning which belong to the non-agglomeration area of Paris Region.



Paris, 20 districts

Map CREATE zoning in 4 area types

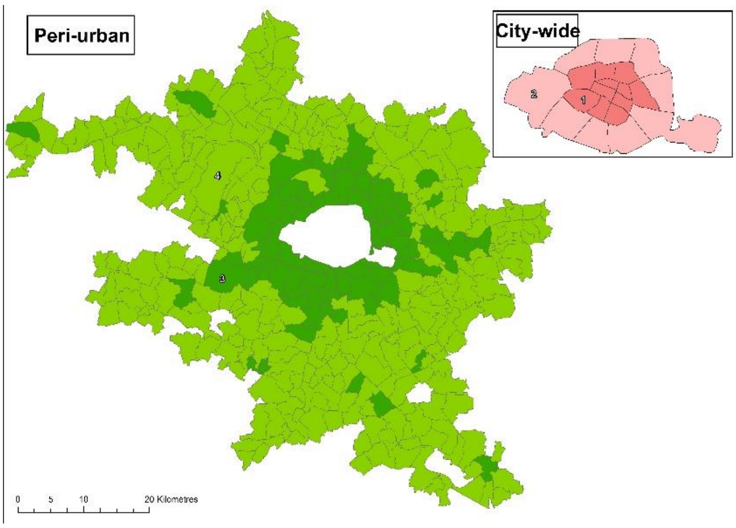


Figure 3-1: Area types of the Paris agglomeration

The classification used here allows us to make comparizons between the five stage 3-cities but the peri-urban term is not appropriate to describe the urban reality of these zones, especially for the zone 3. The zone 3 should be called inner-suburb zone and the zone 4 outer-suburb zone.

When it is possible, that means when the data are available, we provide the data in the CREATE zoning (4 area types composing the "Paris agglomeration"). When it is not possible, either we provide them in two zones (Paris city and the rest of the agglomeration), or very often for the whole Paris île-de-France region (12 000 sq km) or for Paris city only. Paris Region and Paris city are both administrations so they produce a lot of data at their scale.

Table 3-1: Size of study area [km^2]

Area type	total surface area [km^2]
Inner-city	23,3
Outer city (without inner-city)	82,0
Peri-urban I (without inner-city, outer-city)	567,4
Peri-urban II (without inner-city, outer-city, peri-urban I)	2187,8
Total Paris agglomeration	**2860,5**

3.1.2 Land use

For almost 30 years now, IAU has been setting up a geographic information system in Île-de-France covering all areas of its scope of activity (economy, demography, regional development, urban planning, environment, facilities, transport, etc.). The system, used for regional planning and development, is known as Regional Geographic Information System (RGIS). The main reference cover is the numerical land use cover ("MOS"). For the whole region, the land use is composed of 420 000 polygons, each one is classified into a nomenclature of 80 classes (housing, offices, gardens, …). We made an aggregation of theses classes into 7 classes, for 4 years (1982, 1990, 1999, 2012) and calculated the surfaces for each area type.

Table 3-2: Surface of settlement area [km^2] (source : IAU MOS)

	Reference year			
Area type	1982	1990	1999	2012
Inner-city	17,0	17,0	16,9	17,0
Outer-city	43,3	43,3	43,8	44,7
Peri-urban I	314,8	323,0	329,0	335,3
Peri-urban II	576,4	638,2	697,6	732,2
Total Paris agglomeration	**951,5**	**1021,5**	**1087,3**	**1129,2**

Table 3-3: Surface of recreational area [km^2] (source : IAU MOS)

	Reference year			
Area type	1982	1990	1999	2012
Inner-city	2,5	2,6	2,7	2,6
Outer-city	15,5	16,1	16,1	15,8
Peri-urban I	93,3	96,0	96,5	93,8
Peri-urban II	235,0	251,8	275,6	281,9
Total Paris agglomeration	**346,3**	**366,5**	**390,9**	**394,1**

Table 3-4: Surface of agricultural area and forest [km^2] (source : IAU MOS)

	Reference year			
Area type	1982	1990	1999	2012
Inner-city	0,0	0,0	0,0	0,0
Outer-city	0,2	0,1	0,2	0,2
Peri-urban I	28,4	19,0	13,6	10,1
Peri-urban II	684,5	608,0	534,1	459,9
Total Paris agglomeration	**713,1**	**627,1**	**547,9**	**470,2**

Table 3-5: Transport infrastructure area [km^2] (source : IAU MOS)

	Reference year			
Area type	1982	1990	1999	2012
Inner-city	2,9	2,9	2,9	2,9
Outer-city	13,5	12,8	12,4	11,8
Peri-urban I	54,6	56,9	59,1	59,2
Peri-urban II	93,4	104,0	120,0	134,6
Total Paris agglomeration	**164,4**	**176,6**	**194,4**	**208,5**

Table 3-6: Semi-natural area [km^2] (source : IAU MOS)

	Reference year			
Area type	1982	1990	1999	2012
Inner-city	0,0	0,0	0,0	0,0
Outer-city	0,0	0,0	0,0	0,0
Peri-urban I	14,2	11,2	7,0	7,2
Peri-urban II	83,1	76,4	50,4	73,4
Total Paris agglomeration	**97,3**	**87,6**	**57,4**	**80,6**

Table 3-7: Forest area [km^2] (source : IAU MOS)

	Reference year			
Area type	1982	1990	1999	2012
Inner-city	0,0	0,0	0,0	0,0
Outer-city	7,9	7,9	7,8	7,8
Peri-urban I	45,7	44,8	45,6	45,2
Peri-urban II	472,2	464,8	465,1	460,1
Total Paris agglomeration	**525,8**	**517,5**	**518,5**	**513,1**

Table 3-8: Waterarea [km^2] (source : IAU MOS)

	Reference year			
Area type	1982	1990	1999	2012
Inner-city	0,8	0,8	0,8	0,8
Outer-city	1,8	1,8	1,8	1,8
Peri-urban I	16,5	16,8	16,8	16,8
Peri-urban II	41,9	43,3	43,6	44,3
Total Paris agglomeration	**61**	**62,7**	**63**	**63,7**

The tables 3-1 to 3-8 show the land use evolution by area type. The “artificial” (urbanized) areas (settlement, recreational and transports areas) represent 60% of the agglomeration. Urbanization wins 8 % of territory between 1982 and 2012 from the natural spaces. If we look at precisely where the urbanization occurs, it locates mainly along the second ring road (called “la Francilienne”) in the outer suburb (zone 3) and in the “new towns” also located in this outer suburb. Built in the 1960’s, they designate planned sub-cities located between 15 and 35 km away from the center of Paris in relatively underdeveloped areas.The rythm of urbanization has slown down from 1990. That could be explained by the regional politics of planning. Indeed, for the first time in a regional master plan, the quality and protection of environment in the master plan of 1994 (“SDRIF 1994”) prevale clearly on the urbanization politics. Nevertheless, in the outer ring, urbanization has kept on progressing to face the increasing demand of housing.

3.2 Demographics and economy

3.2.1 Population development

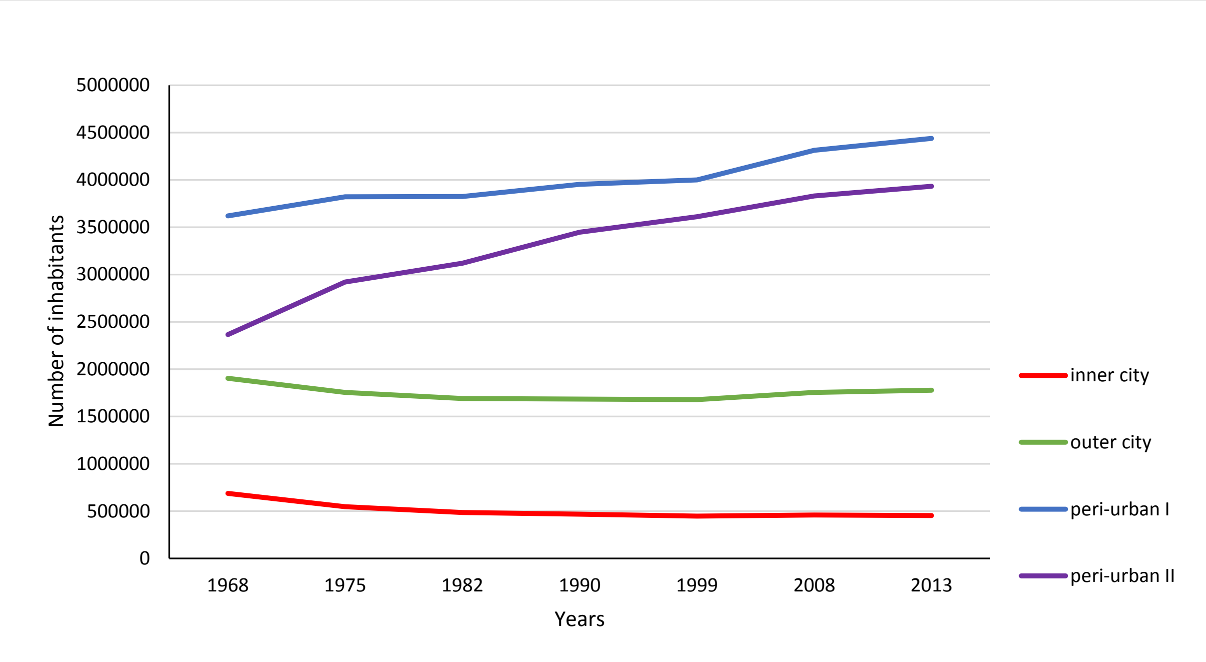


Figure 3-2: Development of the total number of inhabitants by area types [number] (source : French General Census)

On one hand the population in Paris (inner city + outer city) has been stable, roughly 2 millions people since the eighties after a peak in the end of the sixties. On the other hand, population has kept on increasing since the sixties with pace in the peri-urban areas.

The region also benefits from strong demographic growth. Births greatly outnumber deaths. The natural increase in the region’s population has totalled 100,000 every year since the early 2000s. The number of Ile-de-France residents leaving the region for other areas of France, however, exceeds the number of newcomers. Overall, the population has increased by 2.6% since the beginning of 2000.

3.2.2 Household size

The source of this data is the Paris Region Household Travel Survey (HTS). Four HTS 1976, 1983, 1991, 2001, 2010) are used for this data.

According to the national census (same definition used fort he HTS), a household means all people who share the same residence, not necessarily that these people are united by ties of kinship. A household may consist of one person. There is equality between the number of households and the number of primary residences.

The household size has been decreasing since 1976 in the four zones. It’s a general trend in the modern times, largely due to the aging of the population. The main factor of the reduction of the household size is split families but the trend is about to change in the center of the agglomeration. Young people leave their families later because of economics reasons, especially in the social housing sector.

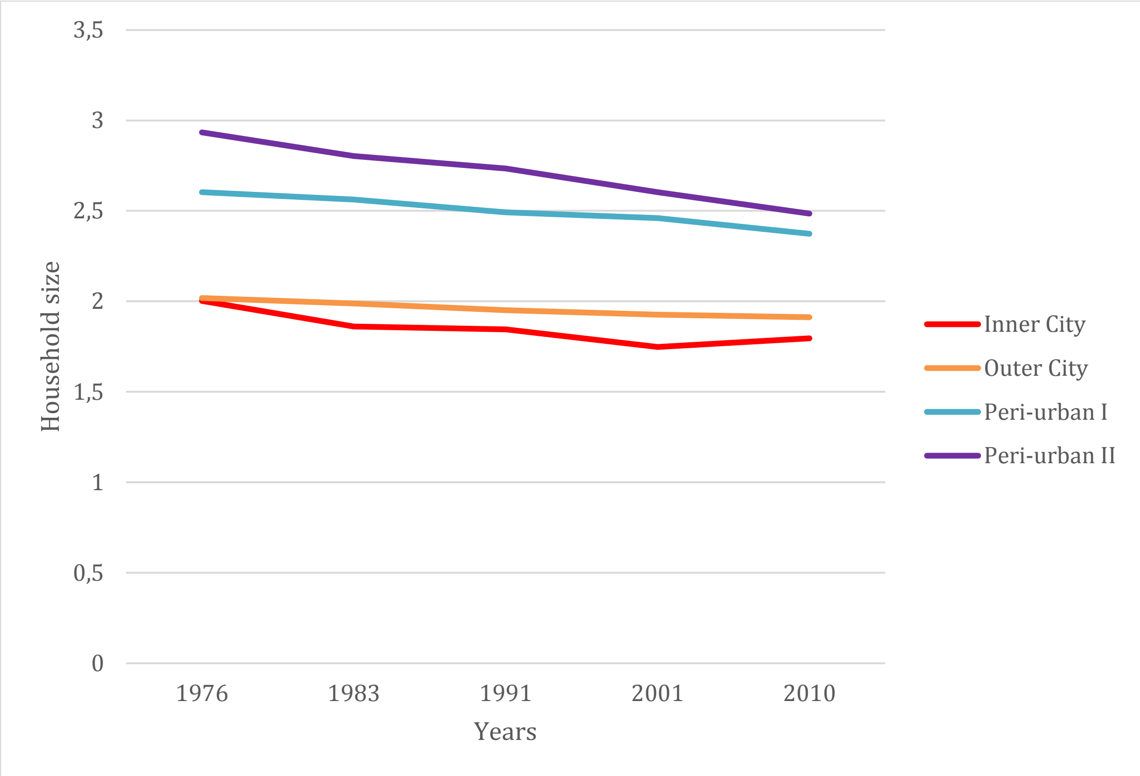


Figure 3-3: Development of the average household size by area type (average number of persons per household) (source : Paris Region HTS)

3.2.3 Gender balance and age class distribution

We provide values for two years (1976 and 2010) and gather the four areas types into two only : city-wide (Paris city) and the suburb (peri-urban I + II). Over this period (1976-2010), it was the outer suburb that brought the population growth of the region through the development of the “villes nouvelles” (new towns). But more recently, the center of the Parisian agglomeration becomes dynamic again. In the recent period (since 2000) the Île-de-France population grew at the same rate in Paris, in the inner suburb and in the outer suburb (+ 0.5% to + 0.6% per year). But it is in the center of the Paris agglomeration that the natural balance progresses the most and the migratory deficit is accentuated the least. This inflection is most marked in Paris. Indeed, while between 1982 and 2011, the Parisian population increased by only 0.1% on average per year, since 2006, this rate of growth reaches 0.6%. Paris sees its population growing since the late 1990s, following a period of decline that began in the mid-20th century. The composition of the population of the Ile-de-France region has also changed. Retirees make up a larger part of the population.

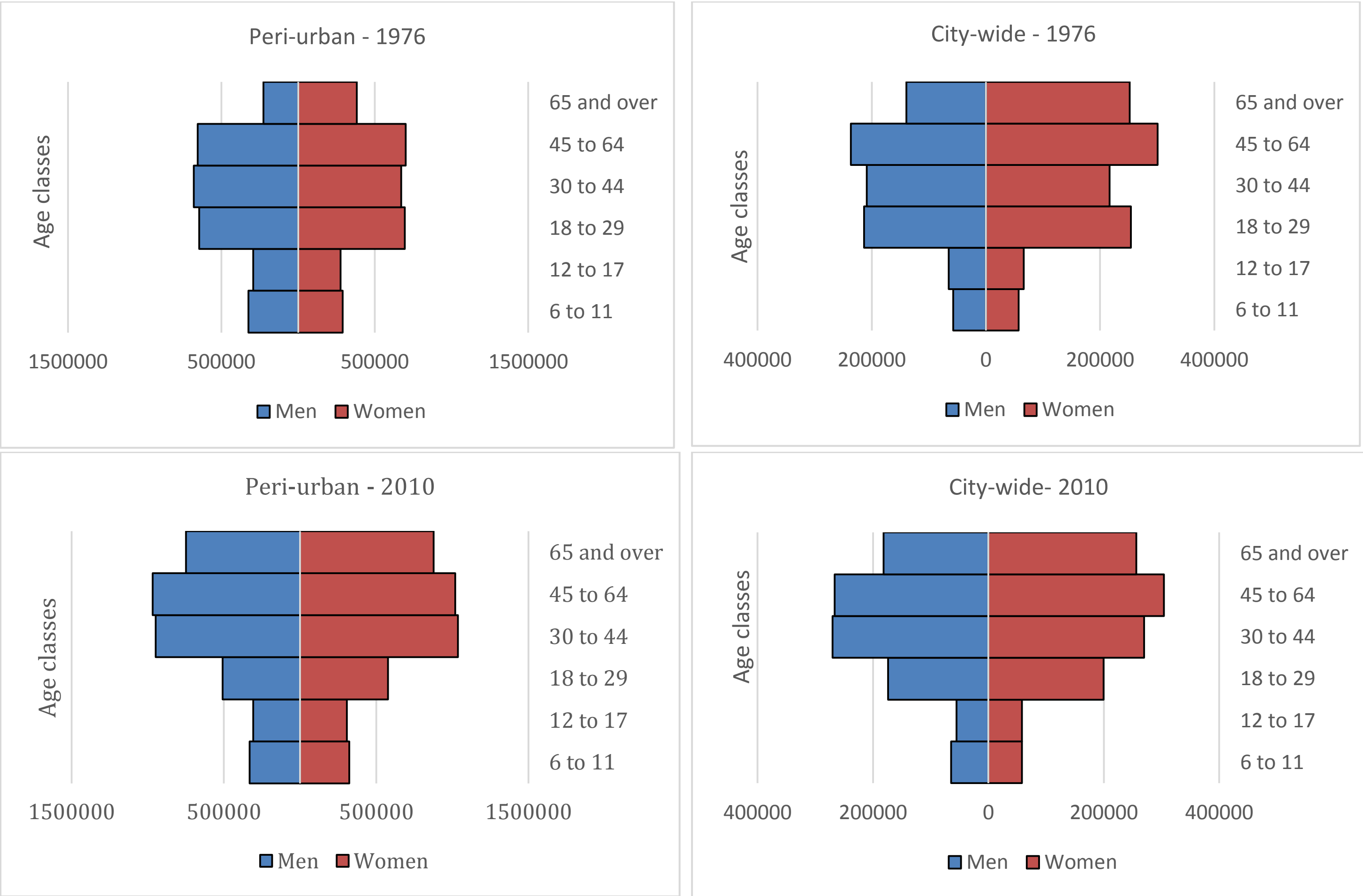


Figure 3-4: Comparison of gender balance of population between 1976 and 2010 (Total number of residents per gender) (source : Paris Region HTS) .

3.2.4 Ownership of driving licence by age class

We gather the four areas types into two : city-wide (Paris city) and the suburb inside the agglomeartion (peri-urban I + II). In 1976, the HTS didn't ask information about driving licence to the respondants. So the evolution is figured from 1983 to 2010.

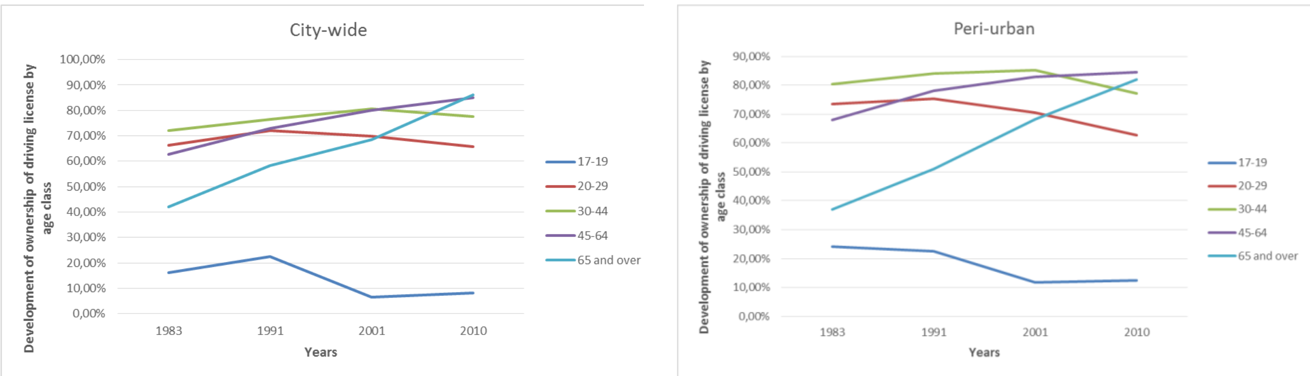
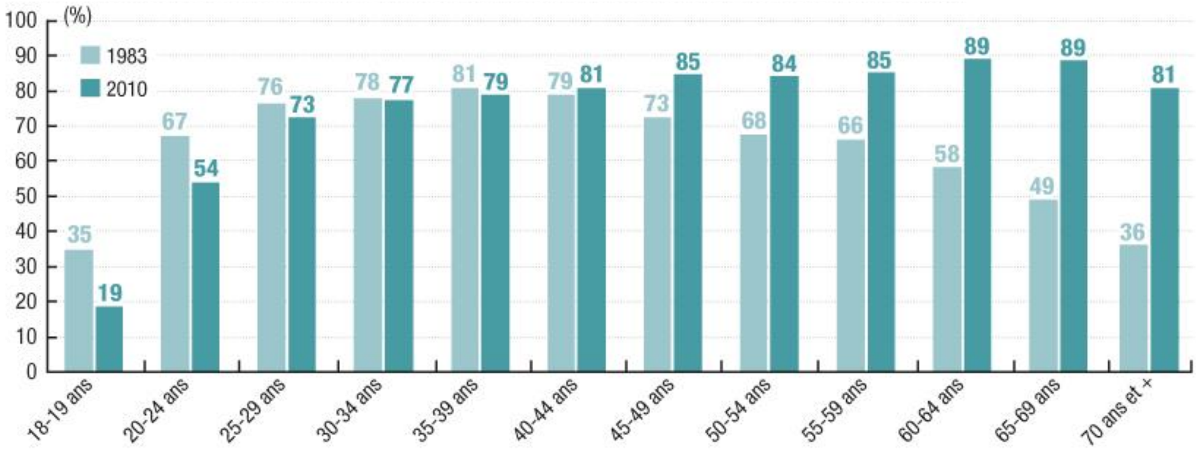


Figure 3-5: Comparison between peri-urban and city-wide data of the development of ownership of driving licence and age class (source : Paris Region HTS)

There is a strong increase in the age group "65 and over", which may balance the decrease of the younger groups.

Driving licence rate according to the age and the survey's year (%)



Source : EGT 2010 STIF - OMNIL - DRIEA - Traitements IAU ÎdF.

Among young adults, we observe a trend with a significant decrease in the rate of driver's license ownership. This decline affects all less than 30 years old; it is particularly marked among the 18 to 25 year old. In 1983, nearly 60% of them had a driver's license. In 2010, this proportion felt to 44%. A multitude of causes can help explain this trend. First of all, there is the economic side of things with to start off the cost of a driver's license itself, then the cost of a car, and finally the maintenance and fuel costs which all weigh heavily in the budget of a student or a young working adult. In comparison, public transports are more affordable, thanks to appropriate pricing, and the supply is probably sufficient for most of them. Finally, we cannot overlook the fact that the relationships to the automobile continues to evolve and that new information technologies probably took the symbolic place that the car use to occupy as an object of purveyor of freedom.

Nevertheless, beyond the symbolic aspect, cars have not yet lost their usefulness, or even their almost essential nature, especially in certain areas deprived of alternative modes of transportation or at certain life stages such as after the arrival of a child in the household. It is therefore likely that this decline in the rate of driver's license ownership among the younger generation is primarily the effect of a form of delaying. The future of this trend is more difficult to appreciate than previous ones. Everyone does not have the option to move without a car, even among young adults, but this "minimum" is not easy to assess. The cost question is also uncertain because of the emergence of new practices of automotive mobility (e.g. carpooling, car sharing...), the evolution of oil prices, and many other factors that cannot yet all be accounted for. Even the non-ownership of a driver's license will not necessarily be a brake to automotive mobility if "driverless cars" become reality...

3.2.5 Employment status of residents

We provide figures by occupation levels as follows: Artisans, merchants and entrepreneurs ; managers and higher intellectual professions ; intermediate professions ; employees ; workers ; unemployed ; students ; retired ; other inactive.

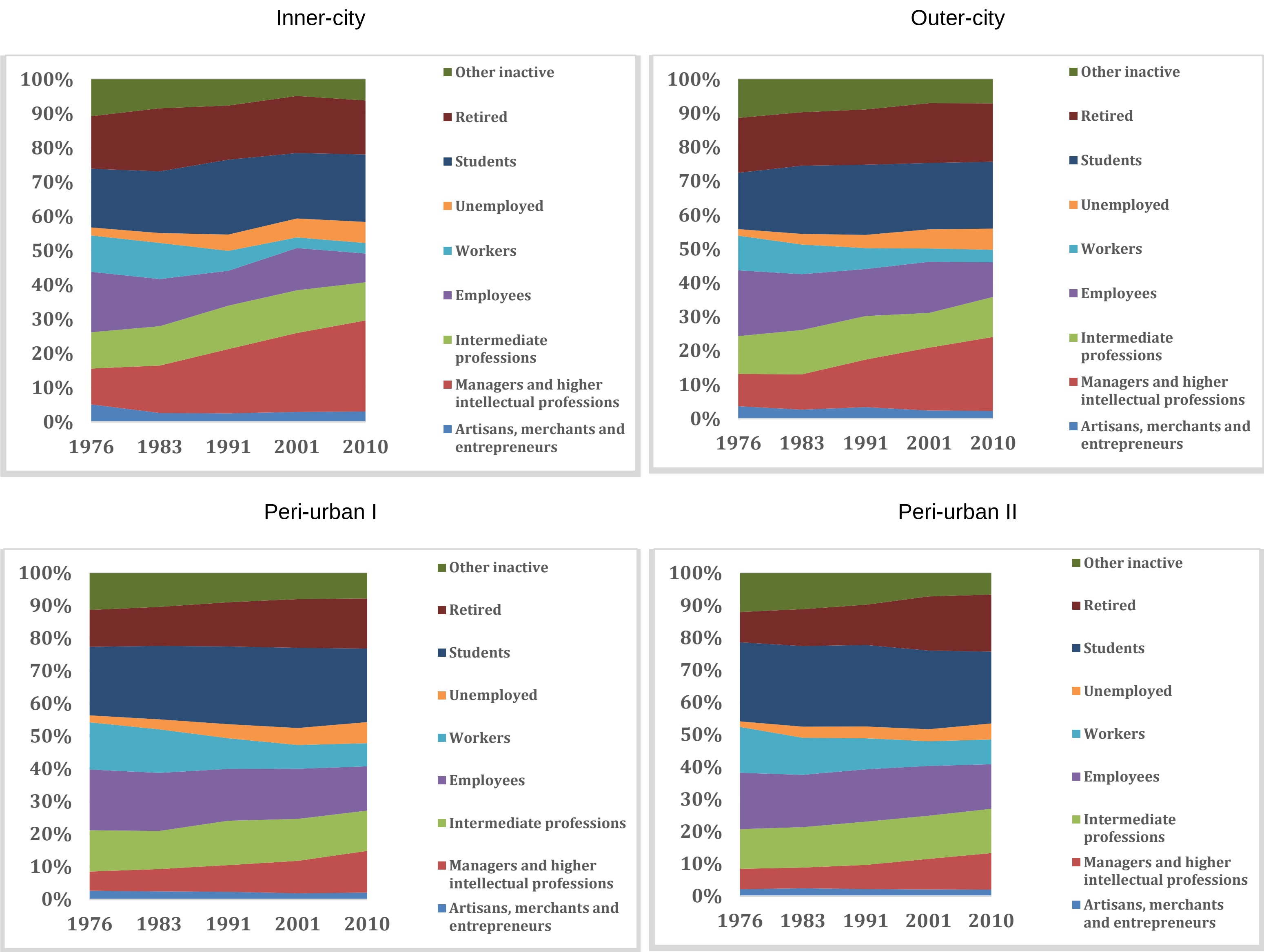


Figure 3-6: Development of the distribution of residents by employment status and area type (source : Paris Region HTS)

The classification has changed over years. The previous classes weren't stable among years, especially for the young people (no distinction between student and pupils in the early years and no distinction for the apprentices most of the time). It's why it is difficult to compare over the different years.

3.2.6 Number of workplaces

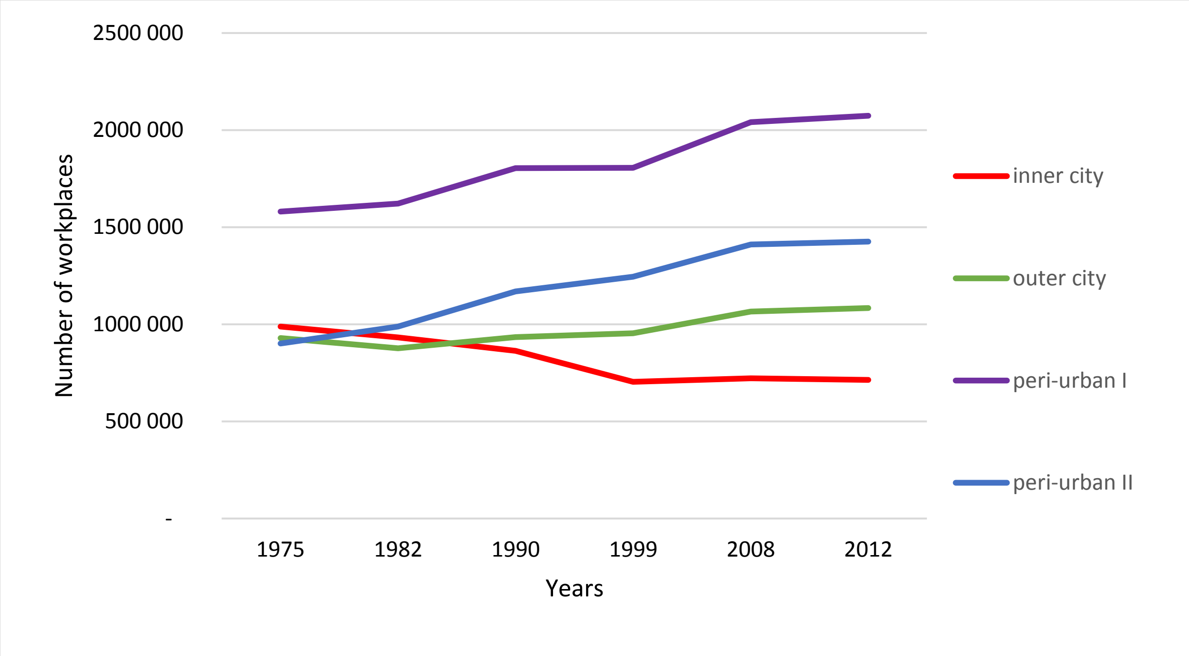


Figure 3-7: Development of the total number of workplaces by area type (source : French General Census)

We observe a continuous decrease in the number of unskilled jobs in the services sector in Paris city from the 1980s, while in the same period the number of managerial, professional and intellectual jobs increased. This change in the structure of the job market in Ile-de-France was the result of the redistribution and reorganisation of production worldwide. Some firms have moved from the inner city to the outer city or to the close suburb (most of the time for a matter of cost). It's hard to have a clear view on how it affects the mobility because there are too much parameters. But in general if the close suburb has a good transport public servicing, it is less good than the inner city one.

Moreover, the patterns of housing and the structure of the housing market accentuated the contrasting dynamics between professional and intellectual categories and working-class categories. The policy of mass construction of "social" housing in the Paris periphery in the 1970s led to the departure of large numbers of working-class people from Paris to its suburbs.

In the Paris region, 60.3% of the working-age population is employed. Among Ile-de-France workers, approximately one out of ten was unemployed in 2014. Among unemployed workers in Ile-de-France, women are more likely to be affected than men. One woman out of ten was unemployed in 2013 compared to one out of twelve men.

3.2.7 GDP and income per capita

We provide this data for the whole Paris île-de-France region (not the agglomeration).

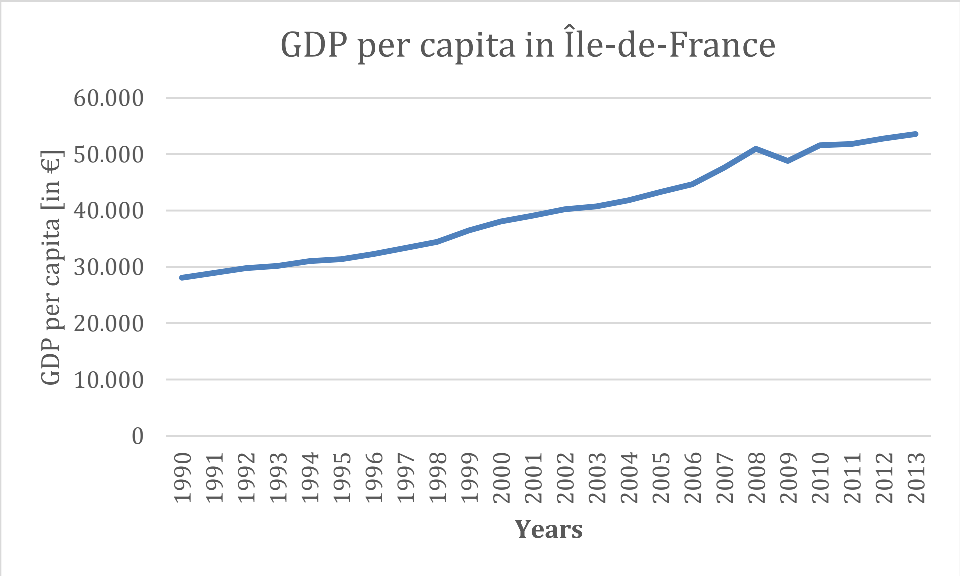


Figure 3-8: Development of the GDP per capita [€/capita] (source : INSEE).

The GDP of the region in 2012 was 612.3 billion euros. The Paris region is France's premier center of economic activity. Its GDP is estimated to reach €650 billion by 2015. In 2013, its GDP ranked second among the regions of Europe and its per-capita GDP was the fourth-highest in Europe. While the Paris region's population accounted for 18.8 percent of metropolitan France in 2013, the Paris region's GDP accounted for 30.1 percent of metropolitan France's GDP. It hosts the world headquarters of 30 Fortune Global 500 companies.

As far as concerned the income per capita, we have data for Paris and for the whole region in 2013.

	Paris city (100 sq km)	**Region (12 000 sq km)**
Median	25 981 €	22379 €
First decile (D1)	9 652 €	10 183 €
Last decile (D9)	63 417 €	46 038 €

4 Transport supply

4.1 Road infrastructure and parking

4.1.1 Road network

Table 4-1: Speed limits by types of infrastructure

Type of infrastructure	Speed limit (max. allowed speed) [km/h]
Motorways	From 90 to 130
Main roads (except motorways, within city)	70
Minor roads (within city)	50
Low-speed zones, shared space	30
Ultra low-speed zones or encounter zones	20

For the last 15 years, one of the measures of the road transport policies has been to reduce the speed limit on the roads, under the pretext that this reduction enables to decrease any externalities (pollution, noise, congestion and accidents). For example, on the main express road of Paris, the "boulevard périphérique" all around Paris, the speed limit was lowered to 70 km/h in 2015.

Roads	Length (km)
Motorways and expressways	1 314
National and departmental roads	9 992
Important secondary roads	2 675
Others	26 790
	40 771

Length of roads network in 2012 for the whole region [km]

No information is available for the previous years because of the decentralization during the years 2005 to 2010. A lot of national roads have been transferred to departements for management, so the statistics are not comparable.

4.1.2 Parking space

We provide this data for Paris city only. Parking policy is managed by municipalities. There are 1300 municipalities in Paris Region, so it is impossible to collect data of parking space outside Paris city.
We distinguish between on-street and off-street public parking lots (we don't take into account private parking lots). The drop in 2003 is explained by a re-counting that took place that year. In 2003, the data also started to distinguish between free and tolled parkings lots.

city-wide

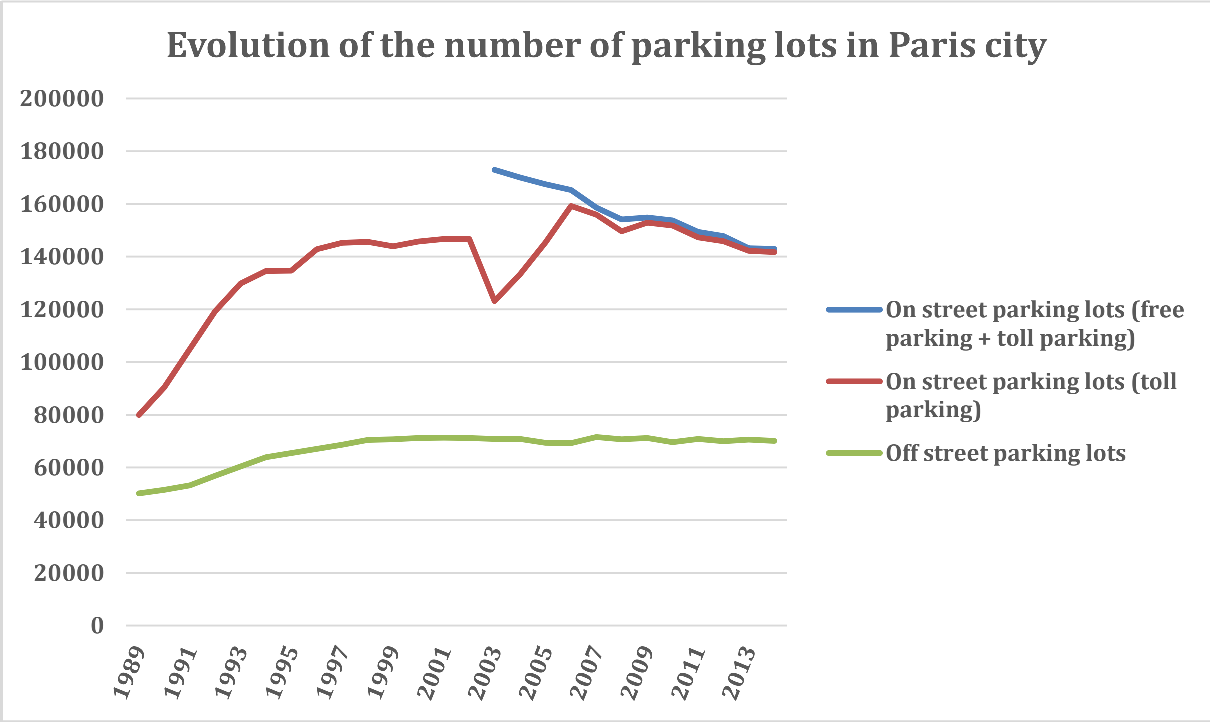


Figure 4-1: Development of number of parking lots for Paris city (source : Paris city)

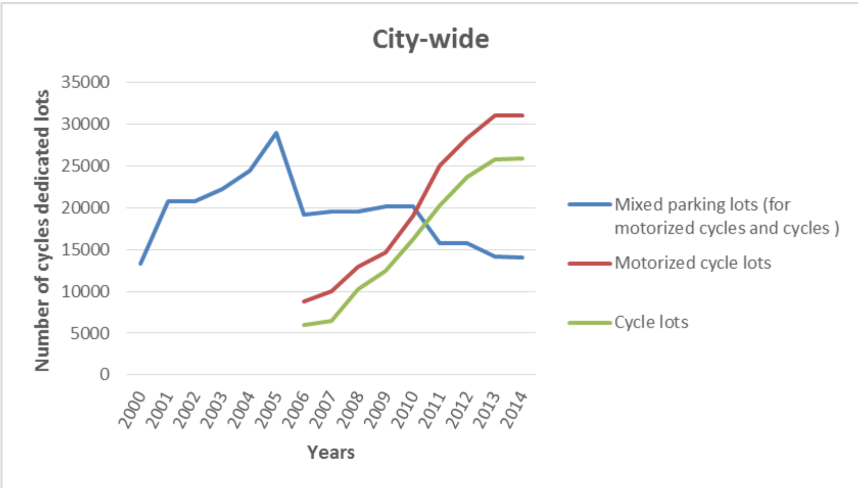


Figure 4-2: Development of the number of dedicated cycle parking lots in Paris city (source : Paris city)

4.2 Public transport and taxi supply, car-sharing

4.2.1 Public transport network

We got the information for the whole region.

Mode	Length (km)
Subway	218
Rail	1 651
Tramway	145
Bus	34 506
	36 521

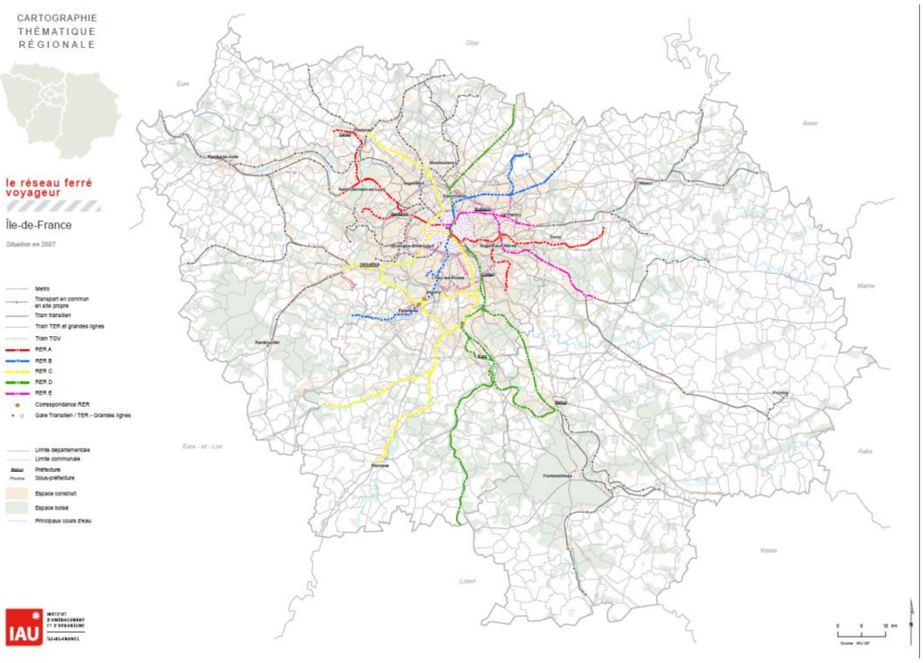


Figure 4-3: length of public transport network by mode (length of infrastructure of all urban lines in regular service on weekdays) in 2012 for the whole region [km]

Tram and bus modes have increased their length steadily for the last twenty years in Paris city. The first tramway line dates back from 1992 in the suburb of Paris (line T1). Then inside Paris, the line T3a was opened in 2006. Urban public transit is considered as a key policy to ease urban congestion and promote modal shift from roads.

4.2.2 Public transport supply

The indicator of the development of the scheduled (offered) public transport service supply, all types [million seat-km per year] is not available.

In September 2016, a single metro ticket costs 1.90 € (2 € if sold on-board the bus), and can be used for only one journey, including all connections, valid for the whole region. It allows travel on all Metro lines, the RER lines (zone 1), the lines of Île-de-France bus (except Orlybus and Roissybus), the lines of Tramway and the Montmartre Funicular . The following matches are possible:

- Subway / subway for 2 hours between the 1st and the last validation,

- Subway / RER and RER / RER in Paris for 2 hours between the 1st and the last validation,

- Bus / bus (including between the RATP networks and OPTILE) for 1h30 between the first and final validation,

- Bus / tram and tram / tram for 1h30 between the first and the last validation.

White-coloured tickets can be purchased singly or in a book of 10 ("carnet") for 14.50 €.

The Paris Visite travel card is valid for 1, 2, 3 or 5 consecutive days in zones 1-3 or 1-5. The validity period starts at midnight on the first day and ends at midnight on the last day. Depending on the selected zones, Paris Visite allows to travel on:

- metro lines;

- RER lines (RATP and SNCF);

- Transilien SNCF

- Ile-de-France bus lines (RATP and OPTILE), except those circulating on Jetbus, Allobus Roissy CDG, tourist excursion and Air France networks;

- the Orlyval line (linking Orly Airport to the RER B);

- the Montmartre funicular.

The Paris Visit card price goes from 11.65 € for the one day zone 1-3 pass to 63.90 € for the 5 days zone 1-5 pass (half price for child).

Monthly or weekly Navigo packages can also be purchased. For one year, there is no longer zones in Paris Region for the weekly and the monthly pass. With these pass you can move on all modes of Île-de-France, Metro, RER Bus, Tram and train except for the Orlyval line, lines for booking the train lines and special pricing Optile.

The weekly pass cost 22.15 € and the monthly is 73.00 €.

Figure 4-4: Development of the price for a PT single trip ticket (Paris Ile-de-France Region) [€]

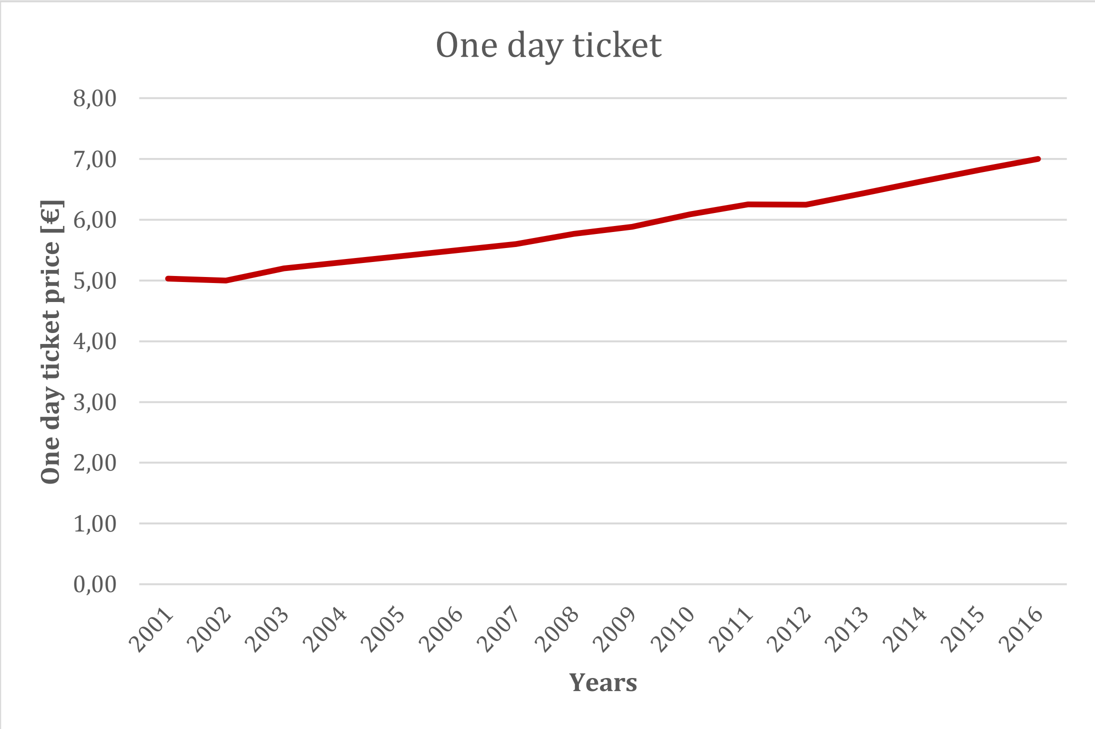


Figure 4-5: Development of the price for a PT one day ticket (Paris Region) [€]

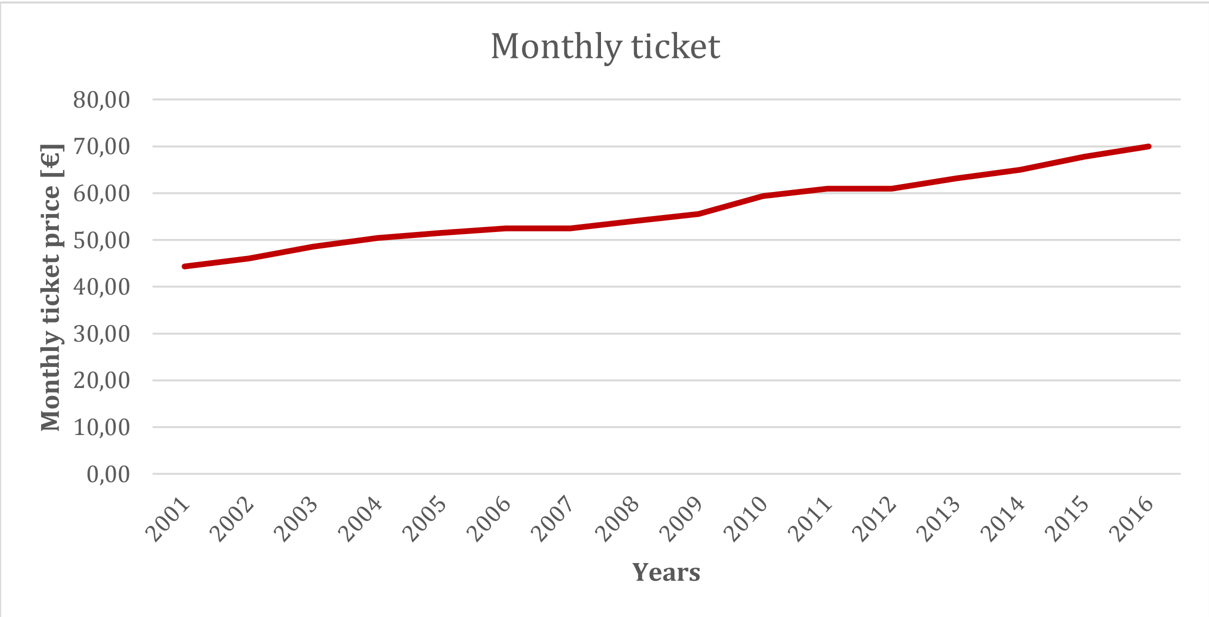


Figure 4-6: Development of the price for a PT monthly ticket (Paris Region) [€]

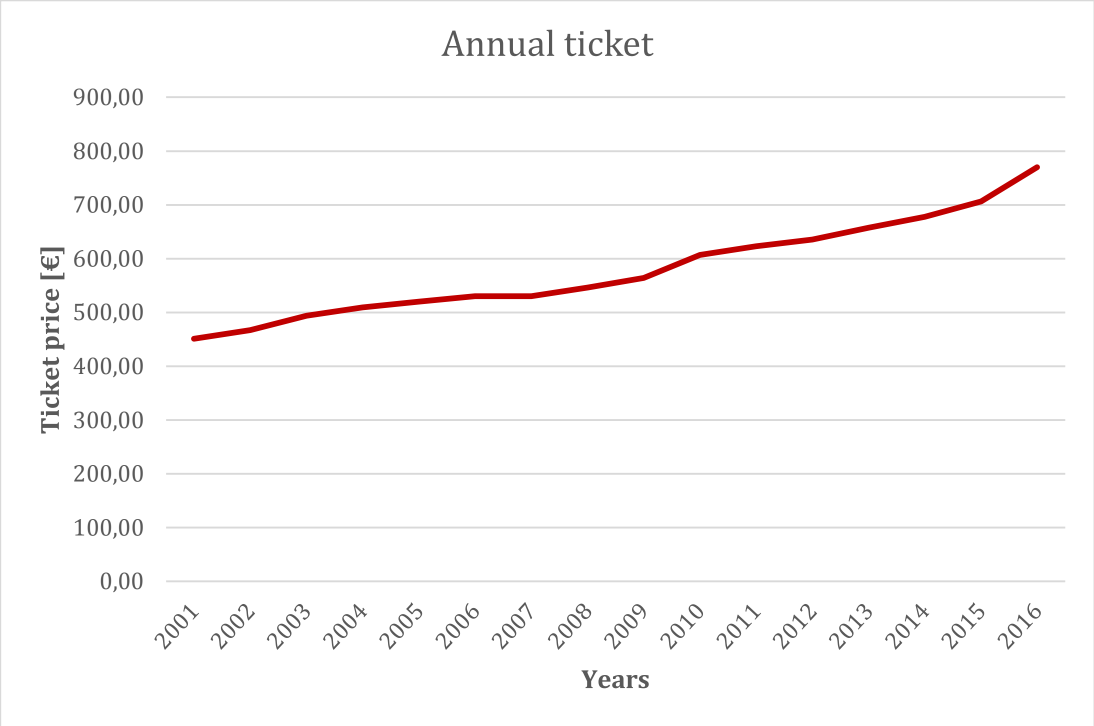


Figure 4-7: Development of the price for a PT annual ticket (Paris Region) [€]

4.3 Cycling

The cycling netwok length growth in the Ile-de-France region have accelerated markedly since 2010, reaching today more than 3,500 km of linear roads. It reflects the action of local and regional policies in favor of cycling. With 3,532 km registered at the end of 2012, the Ile-de-France cycleway continues to grow. It rose by 61% between 2007 and 2012. The municipalities in the heart of agglomeration, Paris and the neighboring départements, were precursors in developing their networks more strongly : more than 300% of evolution for Paris, which went from 129 km in 1999 to 545 km in 2012.

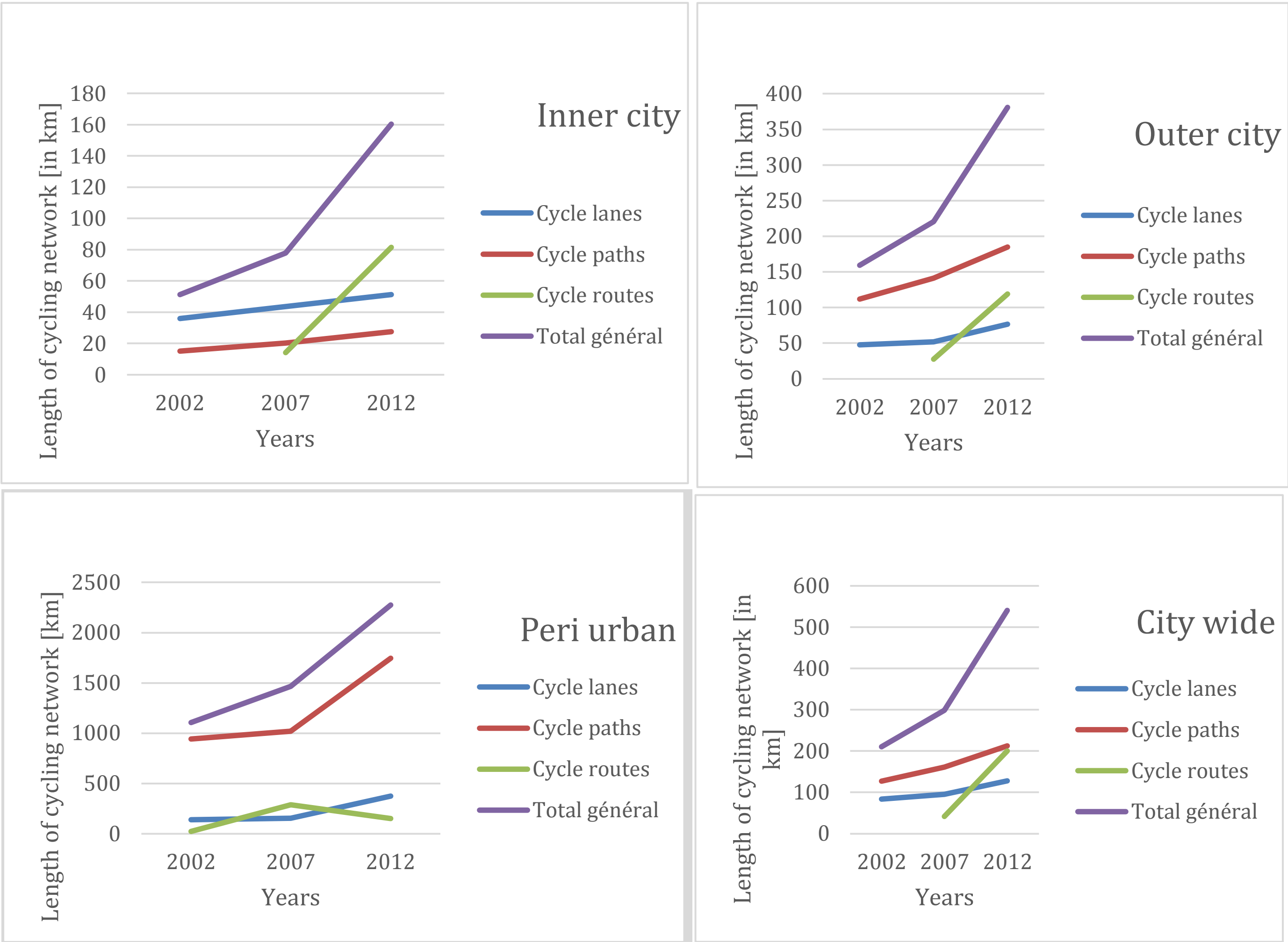


Figure 4-8: Development of the length of cycling network, in total and distinguished by type of infrastructure

4.4 Taxi supply

In the early 1930's, there were more taxis than today in Paris. The economy was not performing well, and many jobless people became cab driver while the population they were supposed to transport was becoming poorer and poorer. As a result, the competition among drivers was intense and only a few could decently live off of their work. A surge in the gas price caused a very serious strike and in 1937, the government, in order to improve the situation, set up a numerus clausus to limit the number of taxi drivers.

What was a good idea in the beginning (the majority of cities set up such limits) turned into a power struggle between taxis and authorities. The regulator got quickly captured by the taxi operators' lobby. As a result, despite increasing needs for transport, the number of taxis in Paris almost flattened from 14,000 in 1937 to around 18,000 today. Moreover, the taxi lobby gave no place for private hire sector to develop arguing that there were struggled by the massive offer of public transport.

The result of this scarcity is a very high price of taxi licenses sold. In Paris, selling a license could bring back around 200,000-250,000€. This rent tend to reduce firstly with more licenses given by the administration since 2002, and secondly with the introduction of new players (PHV and Uber…) on the Parisian market.

city-wide

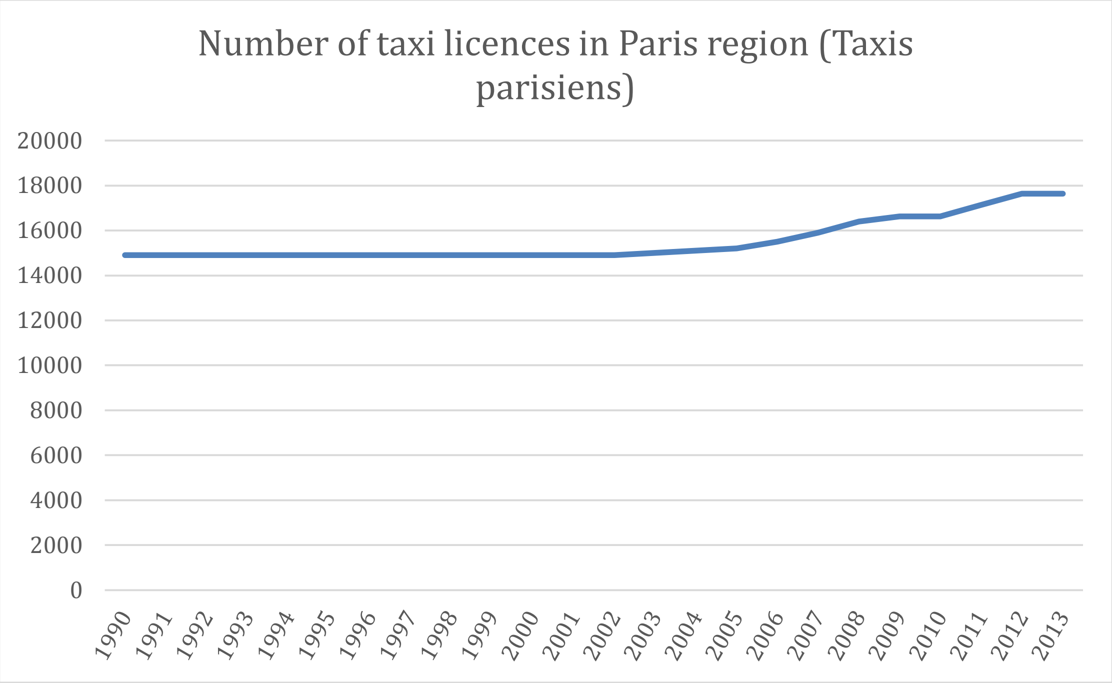


Figure 4-9: Development of the number of licensed taxis

1.5. Car sharing, ride sharing

A Parisian is now, more than ever, encouraged to use a car, as a service. Available in Paris and in 60 metropolitan towns, is the Autolib' service, which sees close to 70 000 active subscribers per year in the Ile-de-France region and is, by its magnitude, the most well-known. It enables one to make short trips. Autolib is continuously increasing its number of stations and cars. Between 2012 and 2013 alone, the number of cars increased from about 1,750 to 2,000 and the number of stations increased by 100 to 830. The use of electric cars is going to be promoted through a network of charging points to be placed every 500 m.

Other forms of car sharing have also been developed to respond to various needs (Mobizen, Zipcar). To make short trips over longer distances of the weekend or holiday variety, it is also possible to have access to platforms where one canrent vehicles amongst individuals. Drivy, which is the leader in this sector, offers rental vehicles belonging to residents in your suburb or even to your neighbour at a bargain price. There are also new types of shared parking.

This collaborative momentum extends even further to sharing trips with multiple forms of carpooling. In addition to these occasional offers and long-distance trips that one recognises from the success of BlaBlaCar, new alternatives are beginning to appear for short and regular trips of the « home-work » variety. A few start-up are trying (Wayz-up, Ecov, Karos) are also trying to develop this type of "dynamic" practice. Uber and UberPool know a real success in the young population and the tourists.

5 Transport policies

5.1 Private motorized transport

The Government (not the Region) has experimented access management policy on highways and installed a few one. But this policy is not generalized because it encounters the acceptability of the drivers who consider that it is a constraint to their liberty of moving.

There is no road pricing system in Ile-de-France Region, neither toll zoning, nor Low emission zone so far. But, in the beginning of 2017, Paris city will set up for the first time time in France a light low emission zone at the entrance of Paris. Through a system of “vignettes” called “Crit’Air” allowing to differente between old, polluting vehicles and new environmentally friendly vehicles. The differentiation is supposed to be taken in 6 categories. Only vehicles being equipped with a Crit'Air Vignette are allowed to enter into Paris area. Already since July 2015 old trucks and buses no longer have a permission to enter into the environmental zone of Paris.

Each department has its own dynamic traffic lights management system. Paris city and the department Hauts-de-Seine have tried to gather their systems.

Paris does not have a congestion charging system, but maintains a comprehensive parking management scheme. There were two parking zones arranged in circles with about 143,000 on-street paid parking spaces and 70,500 parking spaces in car parks in 2013. Theoretically 0% but effectively 1% of spaces are free of charge, the remaining 99% cost between €2.40 and €4.00 per hour. Continuous reductions of parking spaces are due to installing motorcycle or car-sharing spaces. The anti-air-pollution plan envisages free parking for electric vehicles and also free charging during the night from 2015. Since 1st January 2015, motorists in the capital must now comply with the new paid parking regulations. There are significant rate increases, the main objective is to increase the rotation of parking spaces.

This decision, which is part of the decentralization of paid parking act, is above all a strong sign from the local authority to encourage Parisians to change their transportation habits. The objective is not only to modify the use of the individual car but also parking behaviour.Up until now, due to a very low residential parking rate, the number of Parisians who own a car, that being 40% of households, were rather privileged. As a matter of fact, in addition to the annual parking card, which was free of charge, these rates increased to 0,65€ per day or 3,25€ per week, which is about 170€ per year. This scenario, which had initially been devised to entice the motorists not to use their car, quickly had an adverse effect. In effect, out of the 80 000 residential parking places in the capital, 60% of the vehicles did not move during the week and thus represented the so-called « ventouses » cars. As a result, residential parking became long-stay parking and the parking bay rotation rate was very low. It is estimated that a parking bay remains free on average for 1 minute in Paris and that 20 to 30% of the vehicles in traffic are permanently looking for one . This makes the daily parking exercise extremely complex.

As for the numerous underground parking bays which could solve residential parking, they are often too expensive and less easy to access.

Similarly, the parisian motorist is the worst off in the hexagon as the rotation parking payment rate is 14% in the capital, compared with 20 to 30% the average in France. This problem, on the one hand, explains the amount of the fine in the case of non-payment (which is fixed at 17€) and the weak control rate. It is simply not dissuasive enough. The low risk of being caught has slowly lead to a feeling of impunity. This is a direct consequence of the problem and is a significant shortfall.

For residents, the parking card is payable from 1st February 2015, for an amount which totals 45€ per year or 90€ for three years. It remains, by contrast, free and non-taxable for residents and owners of electric vehicles or vehicles running on natural gas. Added to this are also strong increases in the daily rate of 0,65 to 1,50€, and the weekly rate of 3,25 to 9€. For comparison, the Paris city council reminds one that in Brest the daily residential rate starts at 4€, and 2€ in Grenoble, Metz, or Rennes.

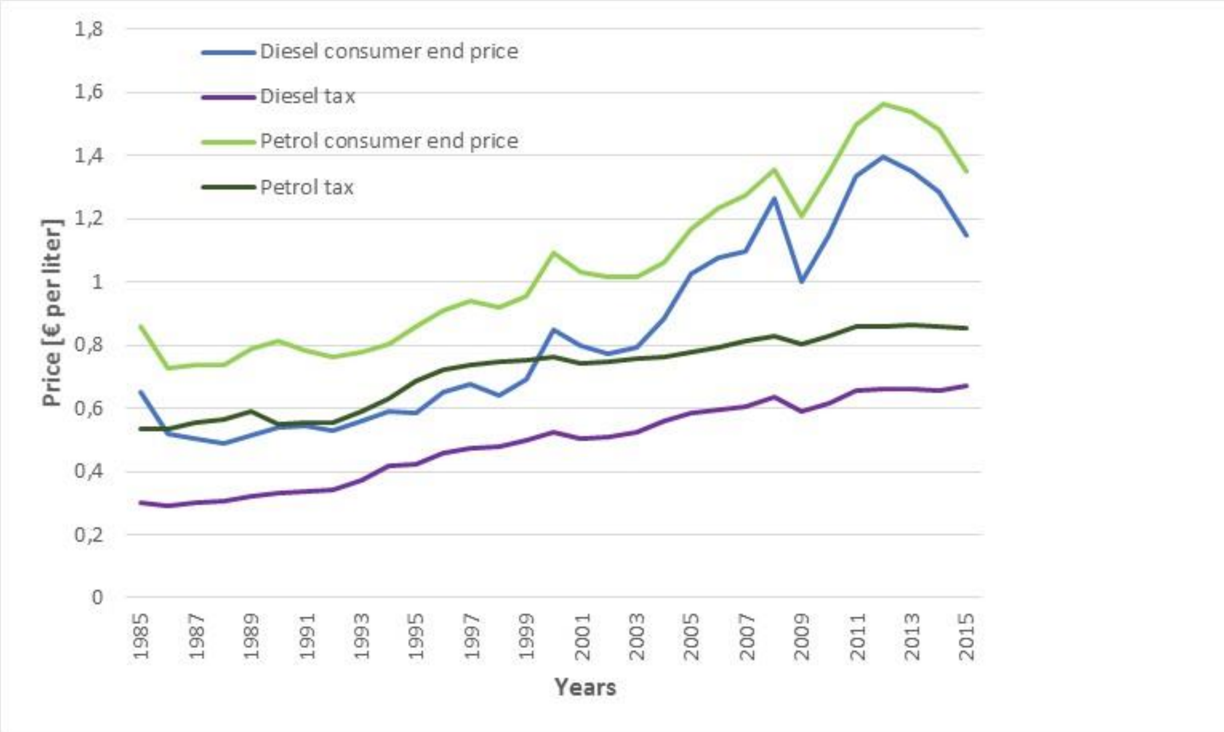


Figure 5-1: Development of annual average fuel prices (diesel and petrol) [€ per litre]

The global rise shown on the graph is mainly due to the taxes directly imputed on the consumption prices and to the worldwide evolution of the fuel prices. The taxes represents 49,1% of the final price for a litre of fuel in 2014 and have rose steadily since the 90's. 16,4% of the price is due to the T.V.A (taxe sur la valeur ajoutée) which stands for the VAT (value added tax), and 32,7% is due to the TICPE (taxe intérieure de consommation sur les produits énergétiques), which stands for "interior tax of energetic products consumption". As that tax was constantly rising to reach a climax in 2014, representing 42,84 euro cents per litre of diesel and 60,9 euro cents per litre of petrol, the prices were rising too. There is a strong correlation between the global prices and the taxation system, which has changed since the EU gave a derogation to France in order to allow the French regions to slightly modulate the taxation threshold on their territories. That was in 2005, and the global rise can be explained by that taxation transition and positioning operated by the government. The final decrease observed between 2014 and 2015 is the result of the worldwide decrease on the prices of the Brent baril which led to a decrease of the sell prices (sources: developpement-durable.gouv.fr, economie.gouv.fr).

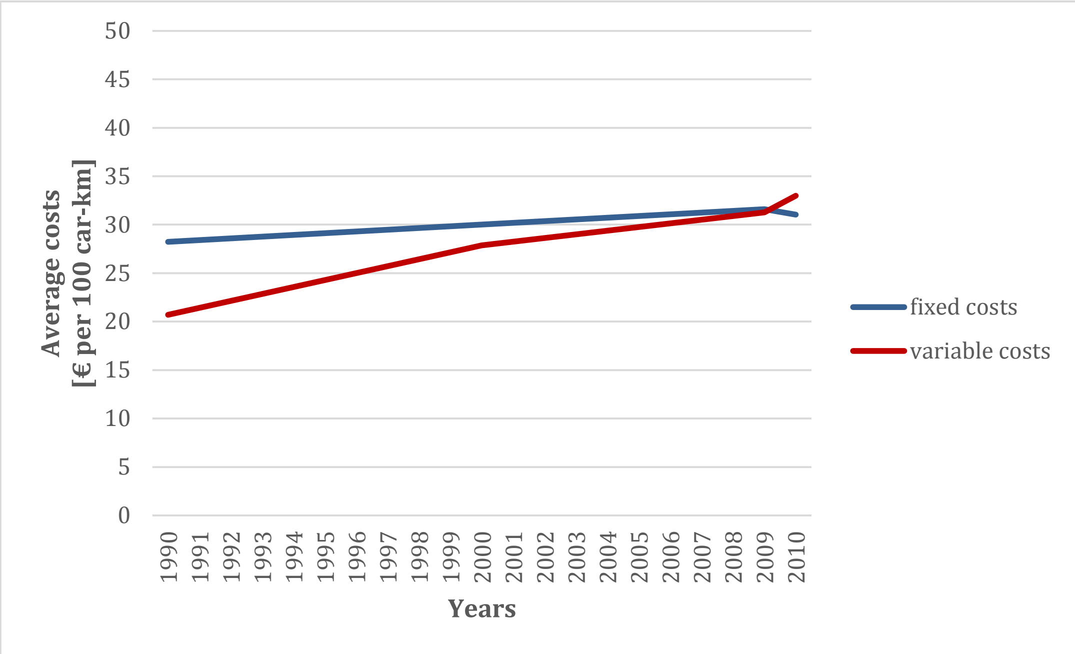


Figure 5-2: Development of the average variable and fixed costs of private car [€ per 100 car-km]

Fixed costs contain cost of the vehicule (new or second-hand) plus insurance and taxes. Variable costs contain operating costs (maintenance, repair, spare parts & accessories, fuel lubricant, tolls, parking, location, driving school …). As the fixed costs are relatively stable throughout the years, the variable costs slowly but constantly increased on the same period of time. That is due to three particular consumption sets: the fuel, the repairs and the maintenance of the vehicle. According to a study led by the French concurrence and consumption ministry, the fuel prices nearly doubled between 1998 and 2012 (+95%). On the same period, the average repair costs got increased of 77% and average maintenance costs of 50%. That pricing evolution then led to a change of habits in the car consumption: the cars are globally older, and they take a more important place in the households budgets.

5.2 Public transport

The Paris public transport system is composed of a large metro system with 16 lines and local trains that connect the surrounding areas. Since 2010, the metro network has been extended by 4 km to over 200 km. An additional major extension by 5 km is planned to be realised until 2030. The bus network is composed of 65 lines covering about 600 km in Paris and 242 lines covering 2,400 km in the suburbs. On the other hand, the tram network has seen the number of lines and network length reduced since 2010.

Investments of 1,100 million euros are envisaged by the new mayor of Paris city for developing the public transport system (including the cycling infrastructure) between 2015 and 2020.

At first, since 2015, the STIF (regional transport authority) has set up a unique tarification for all the region. Evryone pays the monthly ao annual card the same price wherever he lives. Before, there were 5 zones. The more you lived far from Paris, the more you paid.

Secondly, there is a specific card for pupils and students, roughly 50% less expensive. There are also many social grants to help retired and poor people. This financial helps are provided by the departments which have a real mission of social help in France.

The city supports comprehensive measures for encouraging cycling and walking. So far, the cycling network in the framework of "Plan Vélo" was extended by about 300 km from 2009 to 730 km in 2013. A big further step for the promotion of soft modes of transport is the doubling of cycling lanes by 2020 envisaged by the new mayor through large investments. There will also be a cycling lane along the Champs Élysées. An introduction of extensive 30 km/h zones, 20 km/h "zones de rencontre" and pedestrian areas is planned. The extensive bike sharing programme Vélib comprises 1,800 bike stations located every 300 meters with 20,000 bikes and more than 25 million journeys per year.

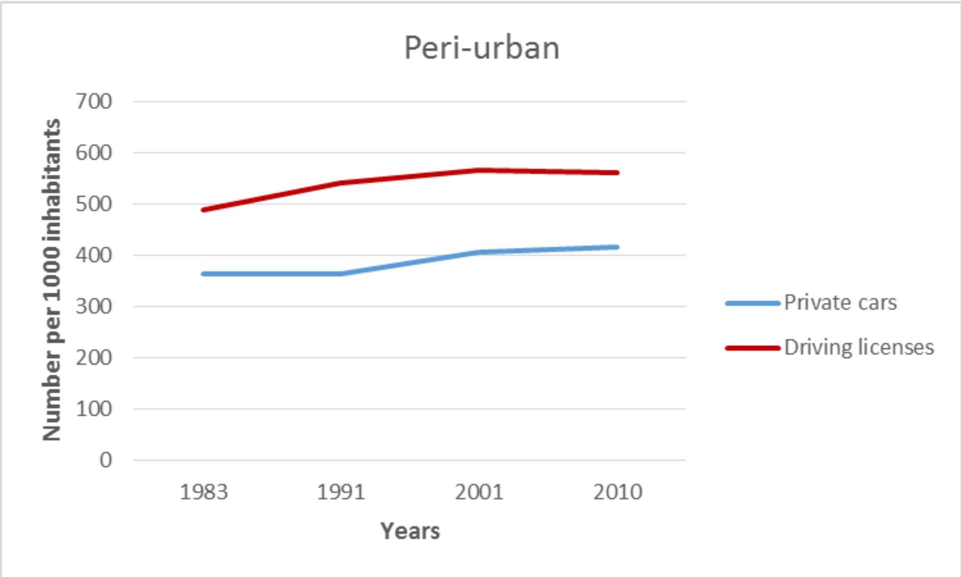
The Regional Council is launching in september 2016 his own “Plan biking” which aims to invest in the services (bikes parking lots at stations, fixing shops, etc) and not only in the infrastructure (cycle tracks).

6 Transport demand and car ownership

6.1 Car ownership

6.1.1 Private car ownership and driving licence possession

Since the 00's the increase in the car fleet available to households is considerably lower than in the past: annual growth was twice as low over the period 2001-2010 as it was between 1991 and 2001. However, this regional trend hides disparities across territories. In the outer suburb, the car fleet increased by 10%, in the inner suburb, by 5%, while in Paris the trend is clearly down (-7%). It is also in the outer suburb that the level of automotive equipment is highest, reaching 530 vehicles per 1 000 inhabitants, whereas it is twice as low in Paris. Almost half of the Ile-de-France households own a single car, a proportion that varies little according to the territory of residence. However, the proportion of non-motorized households or, on the contrary, having a large number of cars distinguishes the territories. In dense territories, many households have no vehicles. For example, 55% of Parisian households are non-motorized, while this share falls to 29% for Île-de-France as a whole.



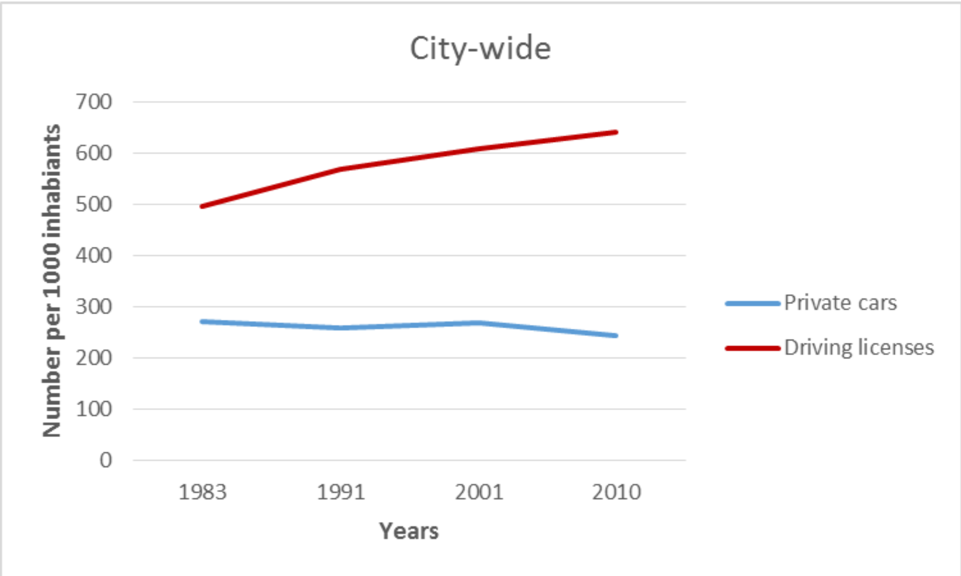
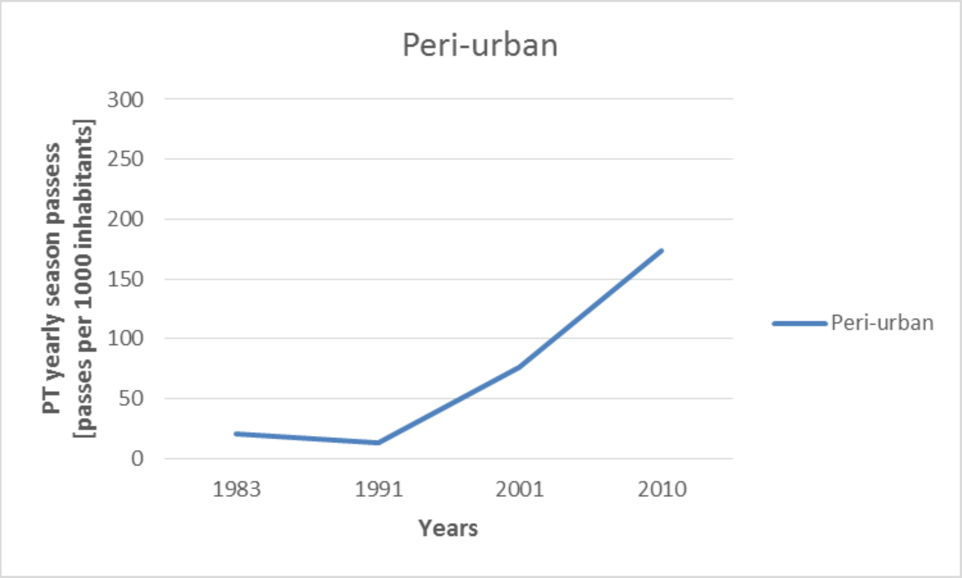


Figure 6-1: Development of the number of private cars and number of driving licences per 1000 inhabitants [number per 1000 inhabitiants] (source : Paris Region HTS)

6.1.2 PT yearly season pass ownership

At the end of the 90's, most of the public transport users used to buy monthly PT pass. In 2000 there were ten more time monthly passes than yearly ones. Since this date the annual solutions have been more and more used and now there are approxymatively the same numbers of monthly passes and annual passes. The introduction of the Navigo card in 2001 and its generalisation in the mid 2000's may explain a large part of this trend.

peri-urban



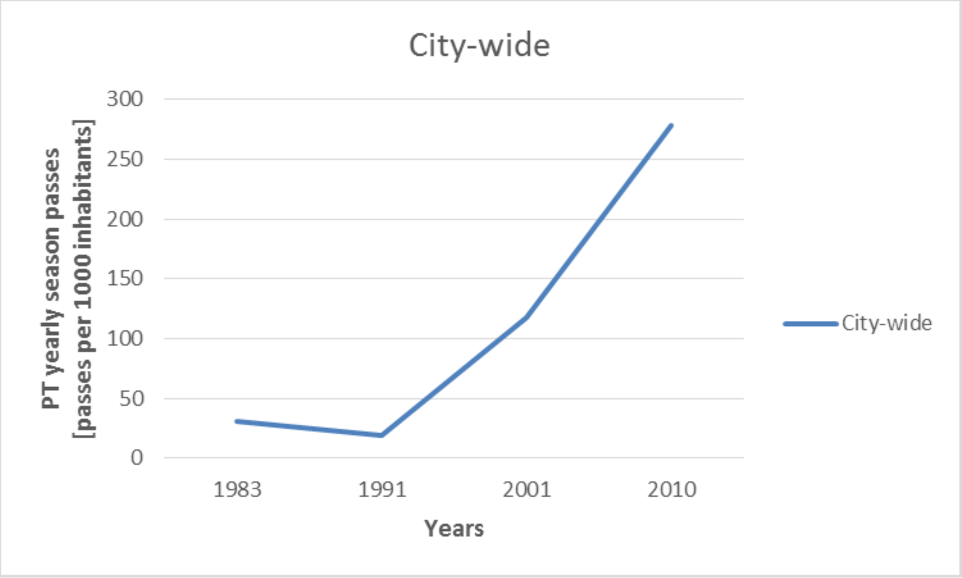
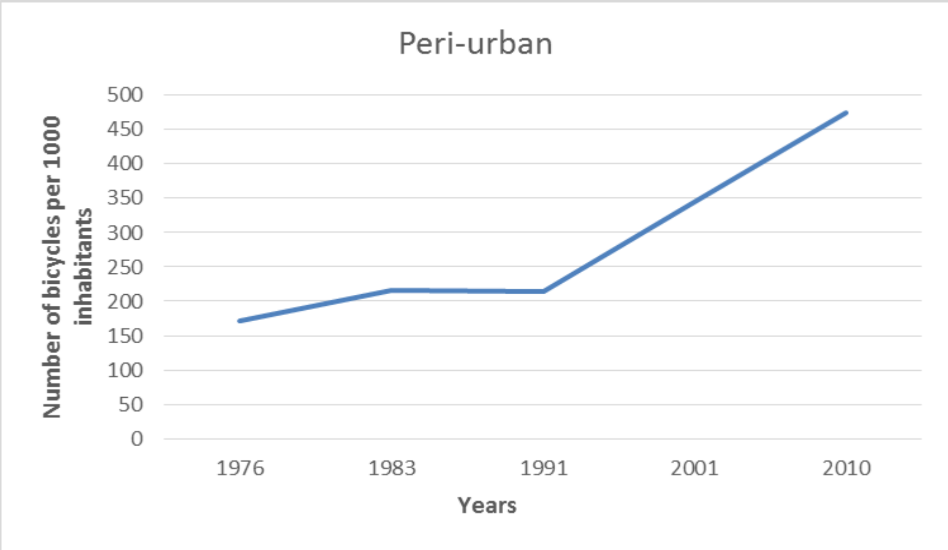


Figure 6-2: Development of number of people with PT yearly season pass [passes per 1,000 inhabitants] (source : Paris Region HTS)

6.1.3 Bicycles ownership

The inhabitants of Ile-de-France are very well equipped by bicycle: the Ile-de-France region has ten times more bicycles than motorized two-wheelers (according to the answers of those surveyed who were able to declare also bicycles little used). However, possession of bicycles varies depending on the place of residence. Parisian households are the least equipped: 71% of them do not have a bicycle. Outside Paris, the proportion of multi-equipped households is very high. We are not completely confident in the data of number per bicycles per inhabitant coming from the Paris Region HTS. However we provide even so the charts below showing an increase of the ratio from 1991 and then a steady rise until 2010, in all the agglomeration (Paris and its dense suburb).



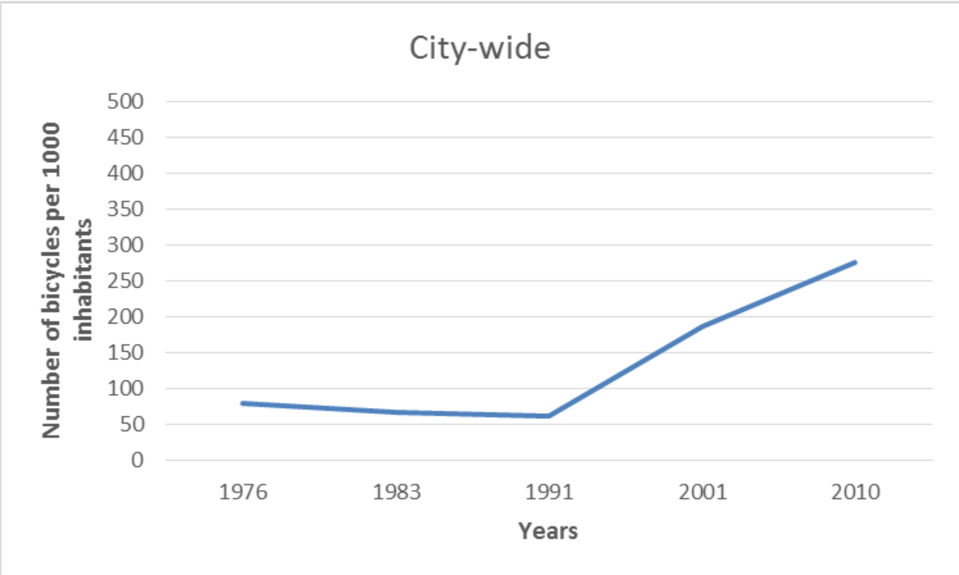


Figure 6-3: Development of the number of bicycles per inhabitants [bicycle per 1,000 inhabitants] (source : Paris Region HTS)

6.2 Individual travel behaviour

6.2.1 Average number of trips (per tripmaker and day)

We analyse here the average number of trips per trip maker and not for all residents, so we exclude those without any trip reported on the reporting day. Since the first survey the average number of trips by tripmaker used to be very constant in the whole region with a few difference between the city of Paris and its suburb. Since the beginning of the 2000’s we assist to a growth of this mobility mainly using walk. It explains why the average number of kilometers doesn't grow at the same rate.

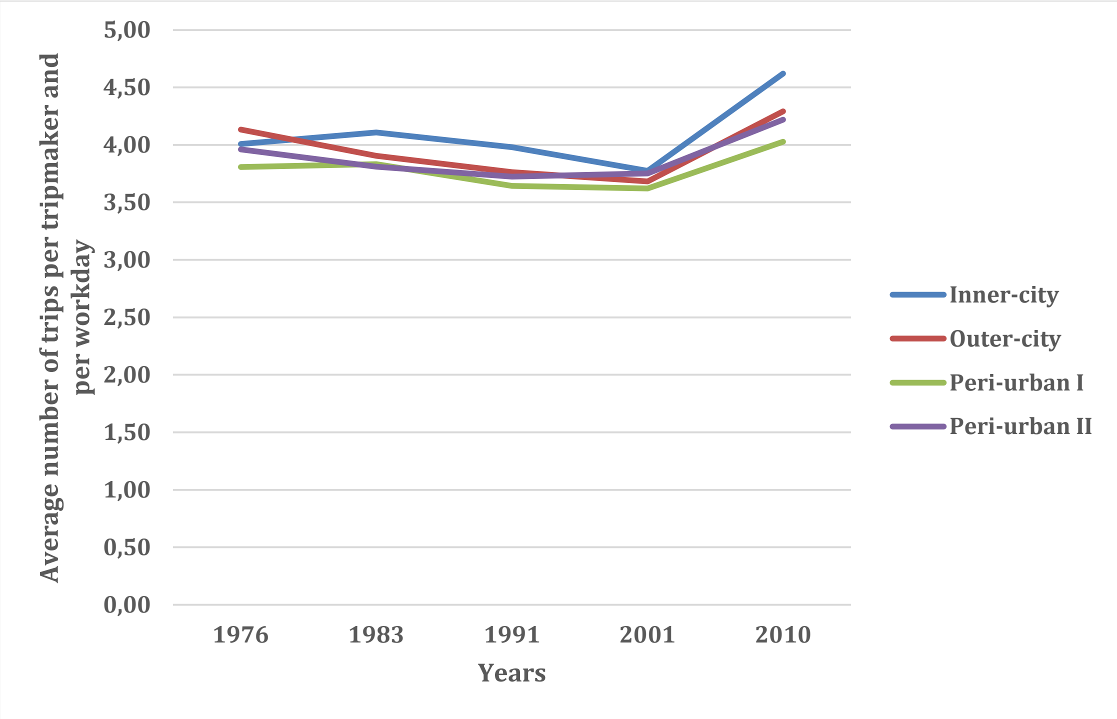


Figure 6-4: Development of the average number of trips per tripmaker and workday [trips / 24h] (source : Paris Region HTS)

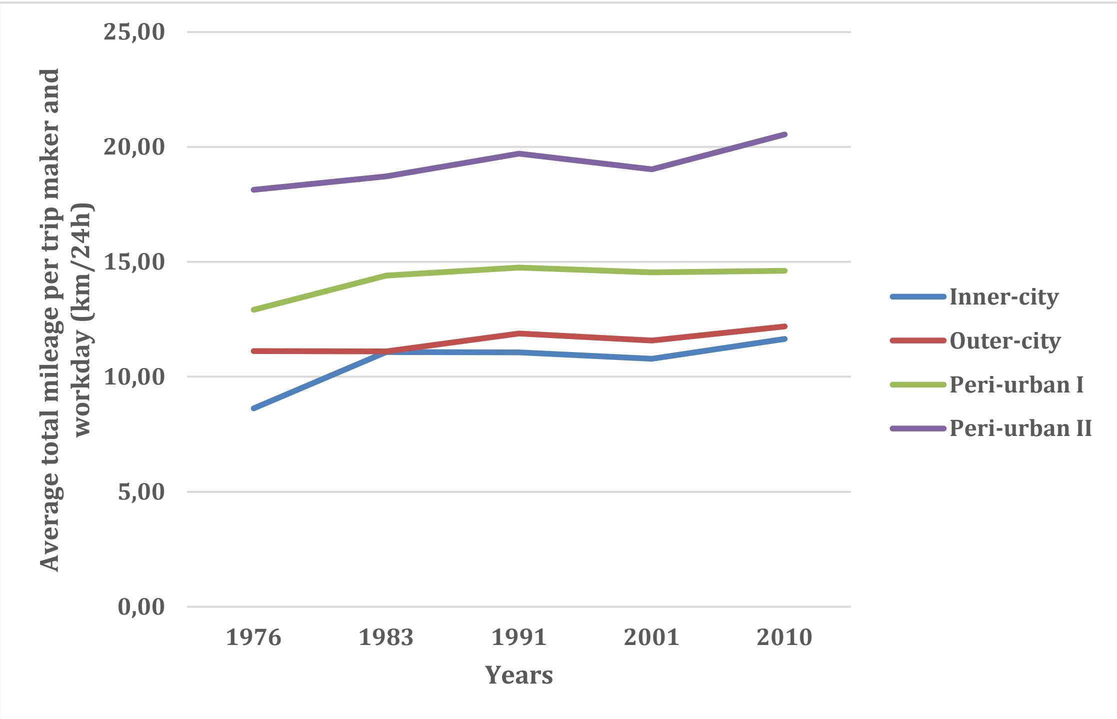
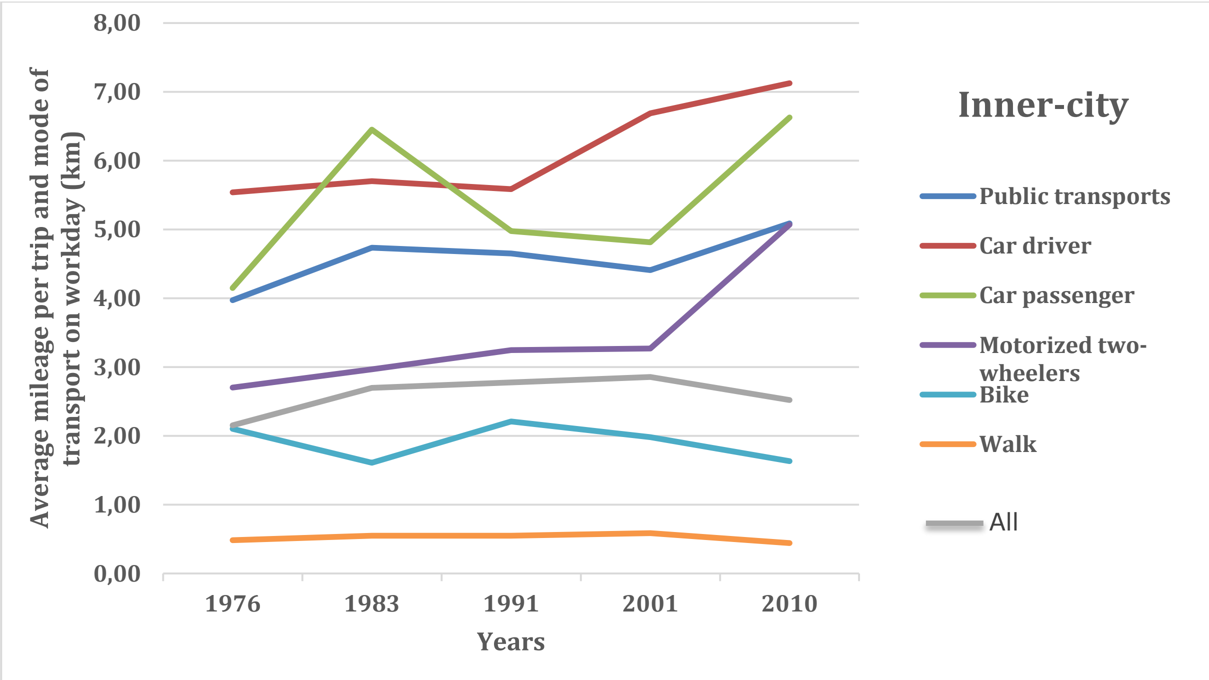
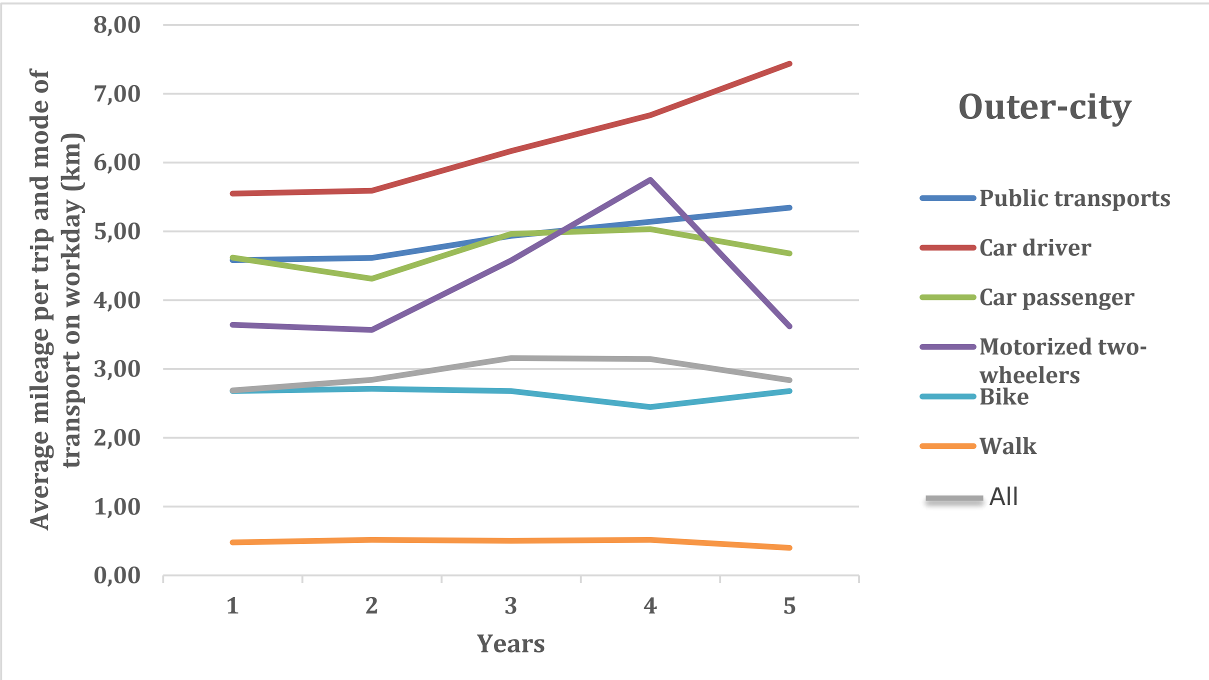


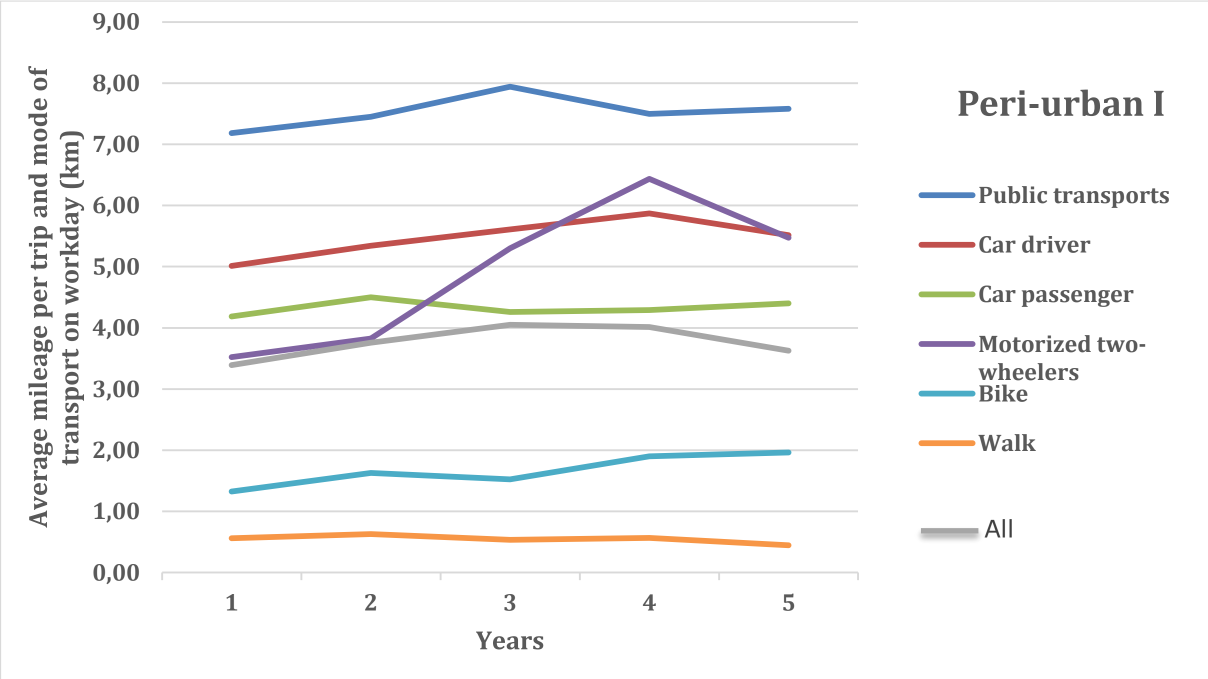
Figure 6-5: Development of the average total mileage per tripmaker and workday [km / 24h]

6.2.2 Average trip length

In Paris the use of car has been decreasing since a long time and the people who still use it make longer trips, that's why the average mileage per trips for this mode increases in the inner-city and the outer-city and remains stable outside.


Inner-city
Average mileage per trip and mode of transport on workday (km)
8,00
7,00
6,00
5,00
4,00
3,00
2,00
1,00
0,00
1976
1983
1991
2001
2010
Years
Public transports
Car driver
Car passenger
Motorized two-wheelers
Bike
Walk
All


Outer-city
Average mileage per trip and mode of transport on workday (km)
8,00
7,00
6,00
5,00
4,00
3,00
2,00
1,00
0,00
1
2
3
4
5
Years
Public transports
Car driver
Car passenger
Motorized two-wheelers
Bike
Walk
All



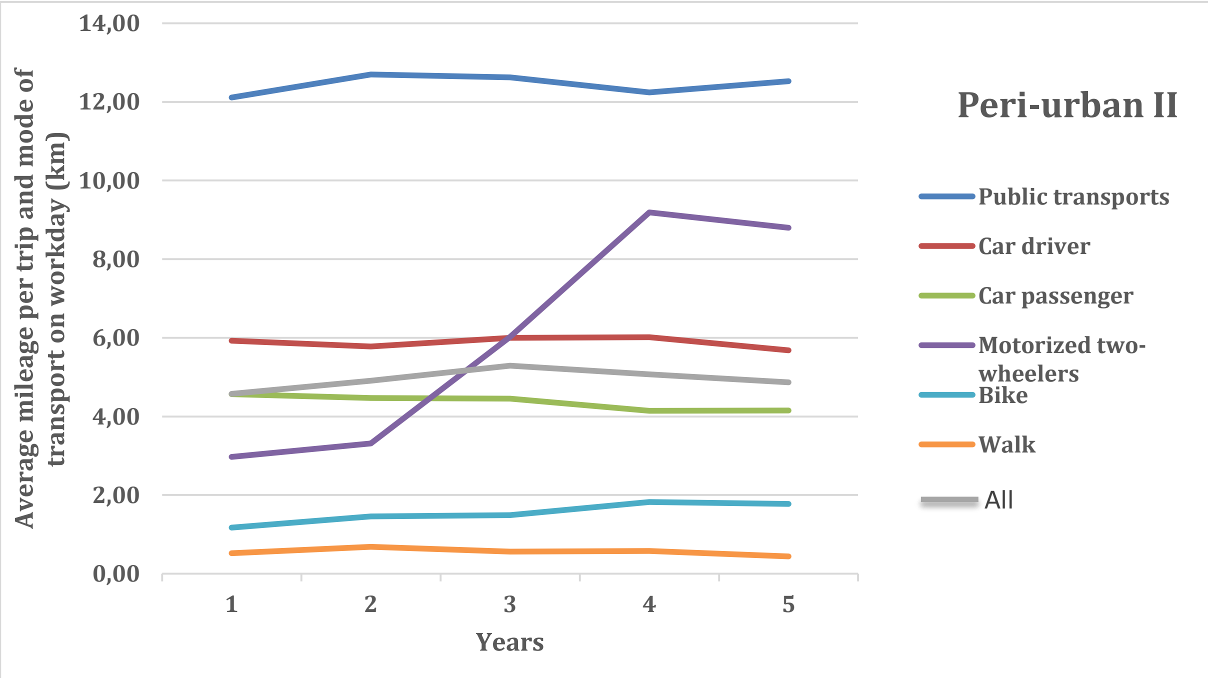
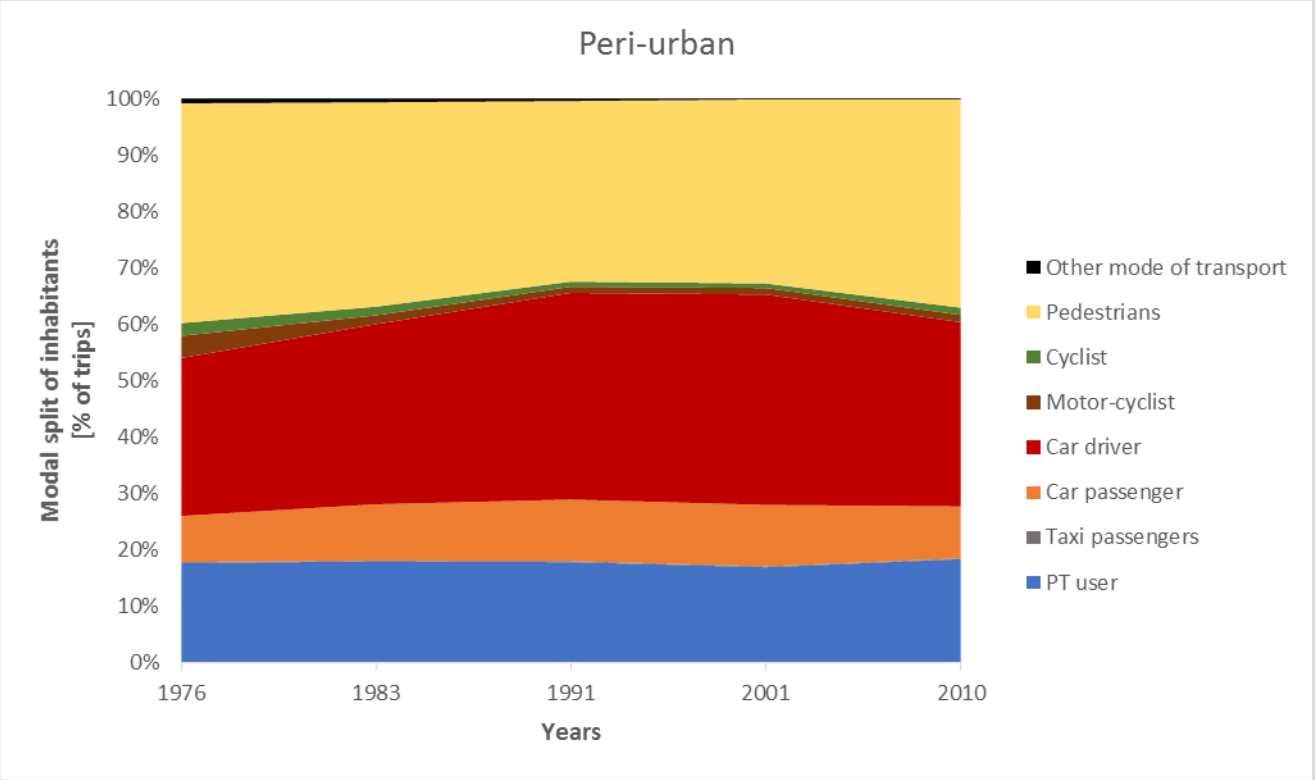


Figure 6-6: Development of average trip length per mobile person and mode of travel per workday [km / 24h]

6.2.3 Modal split of the inhabitants



Figures on the weekday modal split for 2010 show that 46.6% of people in Paris walk, 33.5% use public transport and 16.2% use cars and motorcycles as mode of transport. The share of cycling is very low at 2.7%. In 2013, the weekday modal split improved with regard to cleaner modes of transport. Here, the share of walking increased to 48%, the share of public transport increased to 36%, and car and motorcycle use decreased to 13%. However, bike use also decreased to 2%, the share of motorcycles decreased to 2% and other modes of transport have a share of 1%.

In Paris city, the general speed limit for cars is 50 km/h, but the anti–air pollution plan envisages a speed limit of 30 km/h across most central districts and soft modes of transport are to feature more strongly. By now, a third of roads in the city (560 km) have a speed limit reduced to 30 km/h. Additionnally, there are "zones de rencontres" ("encounter zones") with a maximum of 20 km/h, in which cyclists, pedestrians and car users share the same space. On the motorway “péripherique” the speed limit was lowered from 80 to 70 km/h in 2015.

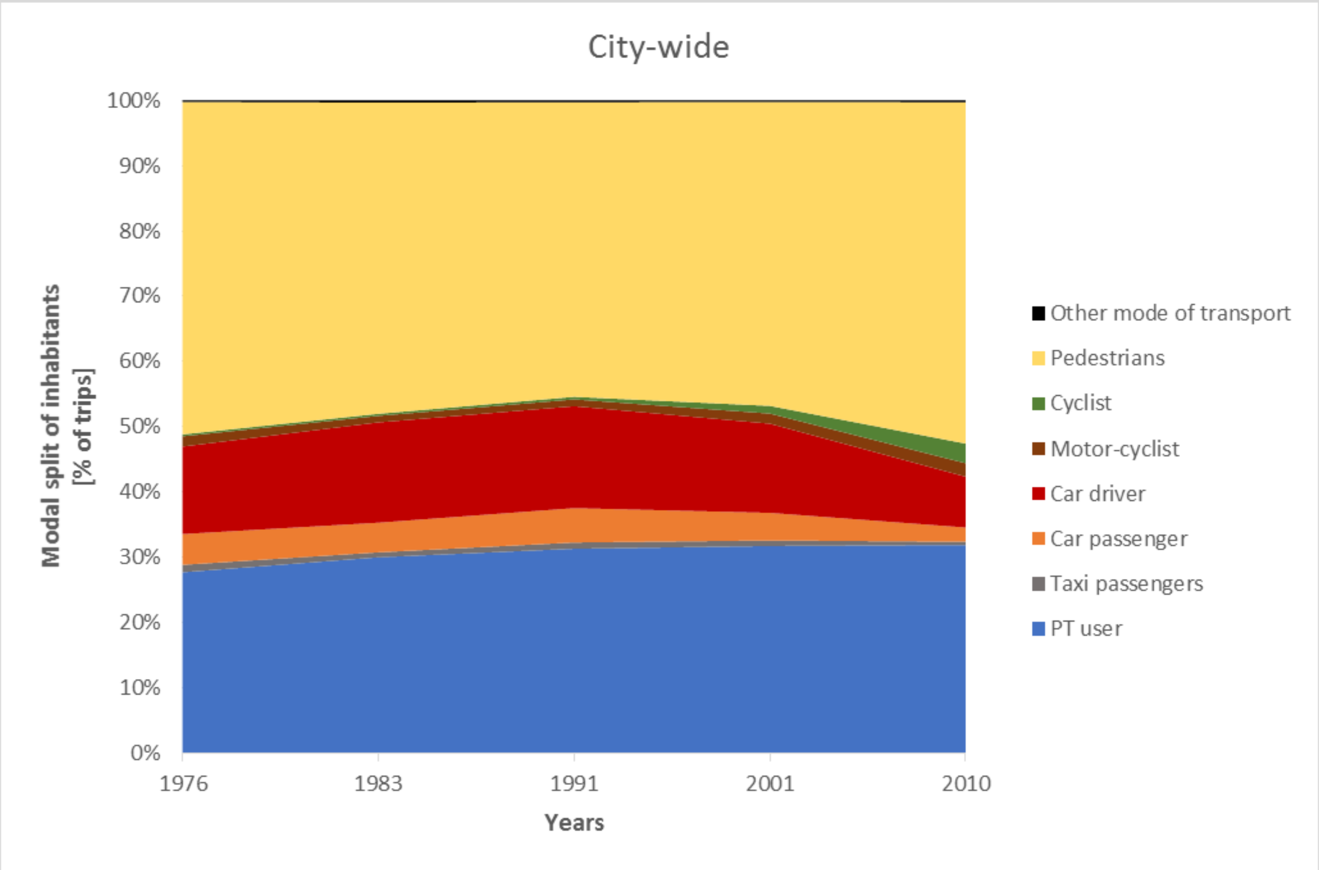
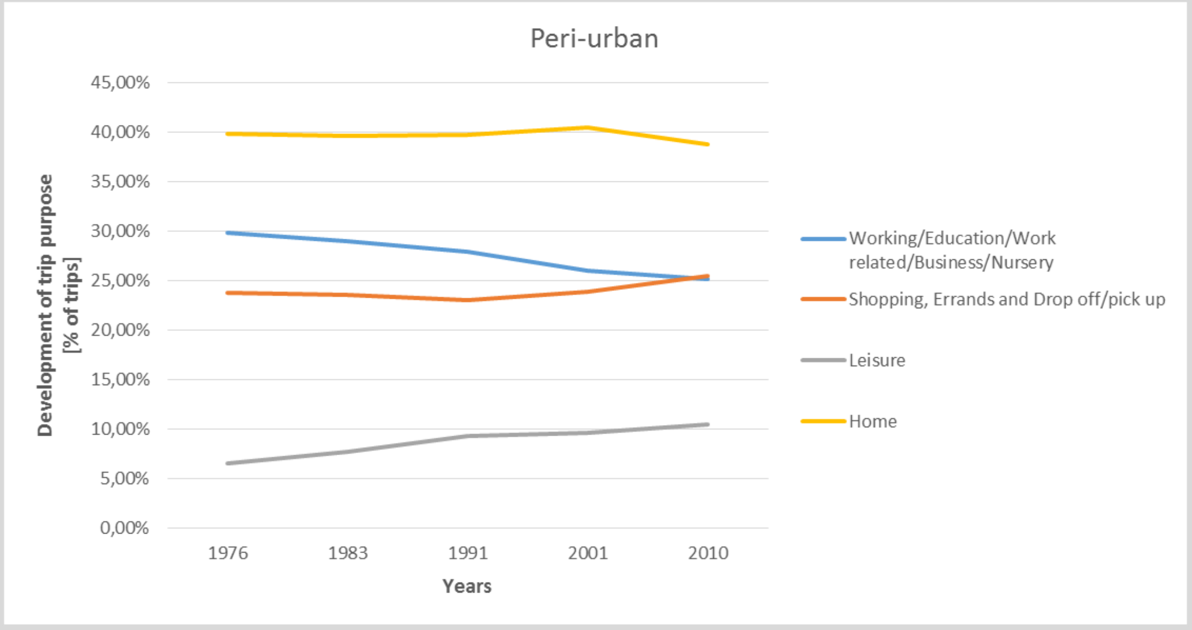


Figure 6-7: Development of modal split of inhabitants (workday) [% of trips] (source : Paris Region HTS)

6.2.4 Trip purpose

It is very difficult to comment the following charts because the grouping of purposes is not usual. What we can say is that the home-work purpose part has been reducing for the last 25 years in the daily mobility but that the absolute value has remained stable. It is the consequence of structural evolution of French society and of the labour organization : increase of the number of holidays, development of part time jobs, reduction of legal work time (35 hours/week), fewer return to home for lunch.



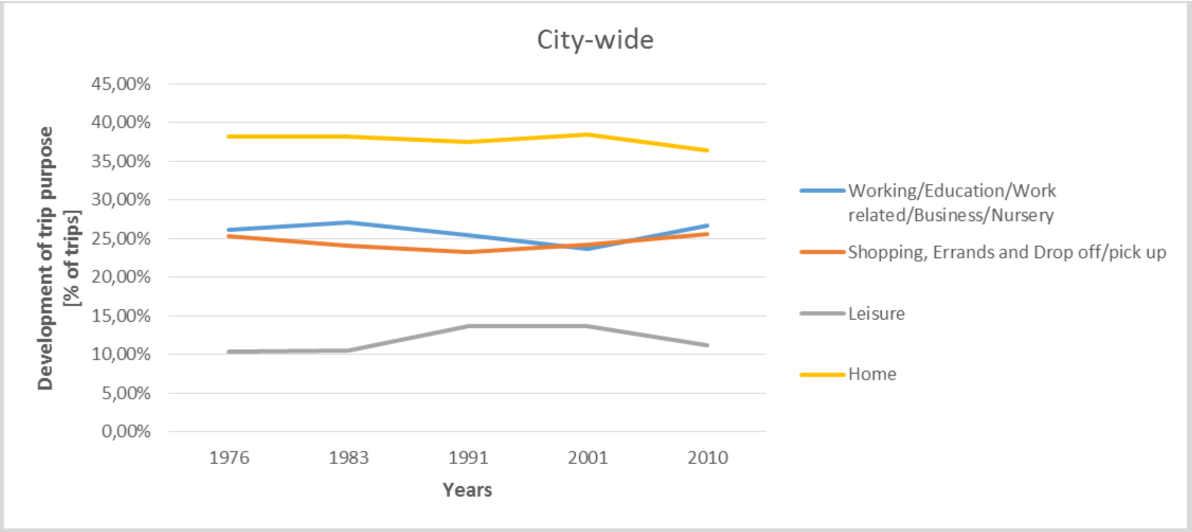


Figure 6-8: Development of the trip purpose according to 4 groups (source : Paris Region HTS)

6.3 Aggregated travel behaviour

6.3.1 Annual road traffic volume

This data is provided only for Paris city. There are 3313 sensors installed on 196 km of axes.

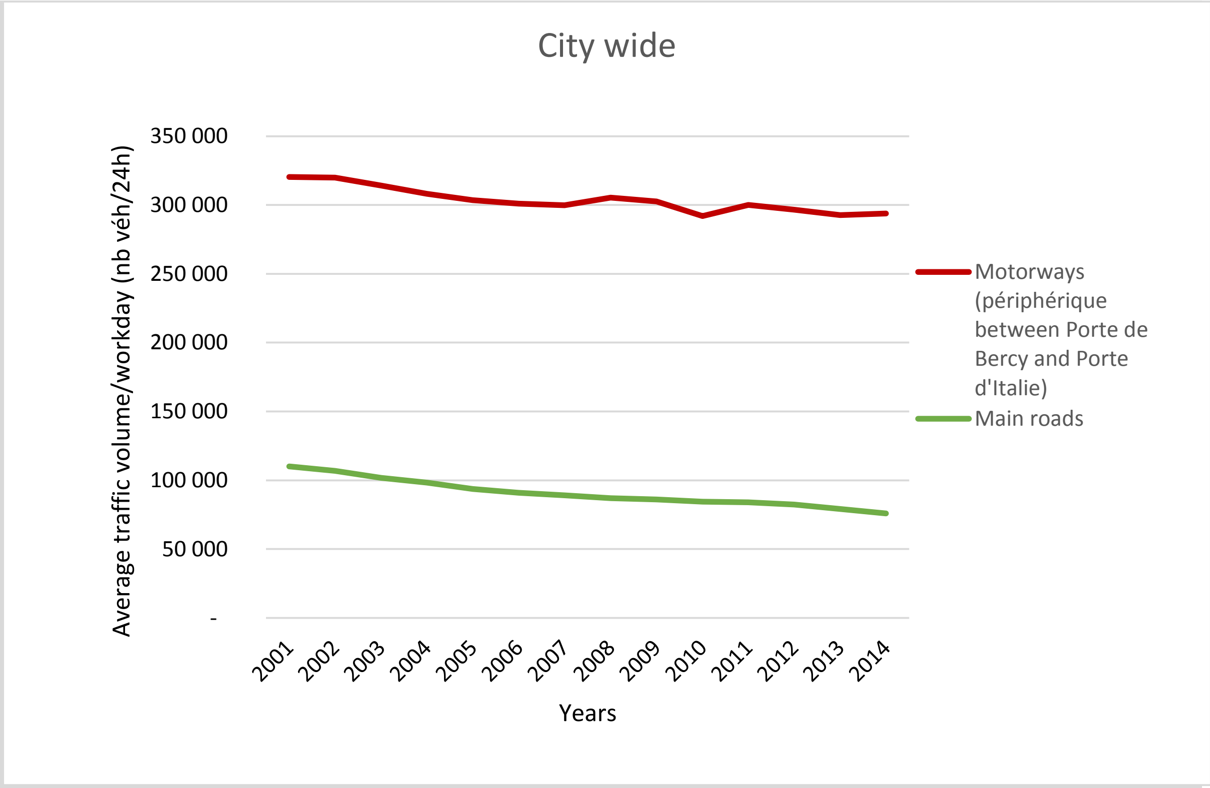


Figure 6-9: Development of average cross sectional road traffic volume per workday and road type [cars / 24h] (source : Paris city)

6.3.2 Average speed level

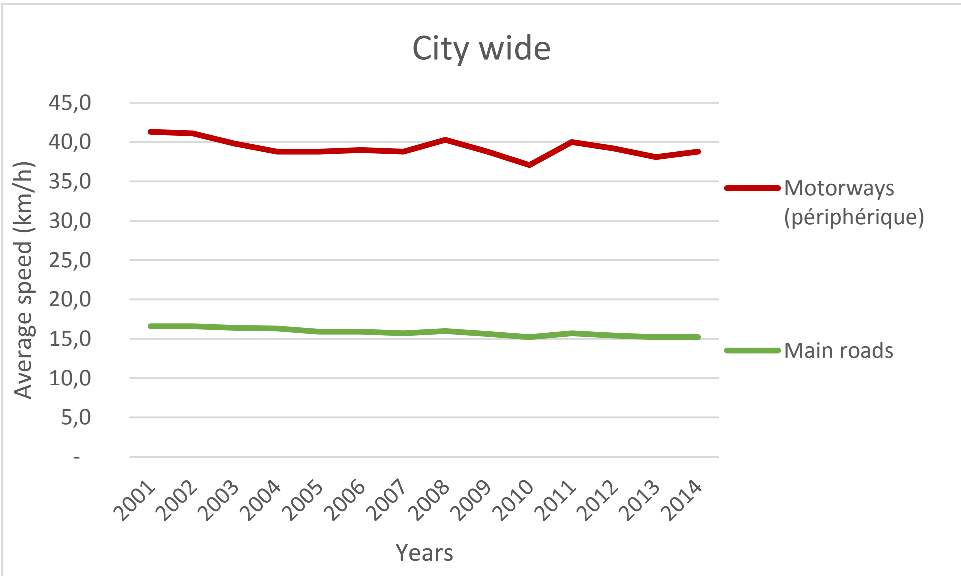


Figure 6-10: Development of average speed level, private vehicles [km/h] (source : Paris city)

We provide data for Paris city. We distinguish between :

- Total annual PT passanger trips
- Annual metro / underground passanger trips
- Annual tram passanger trips
- Annual bus passanger trips

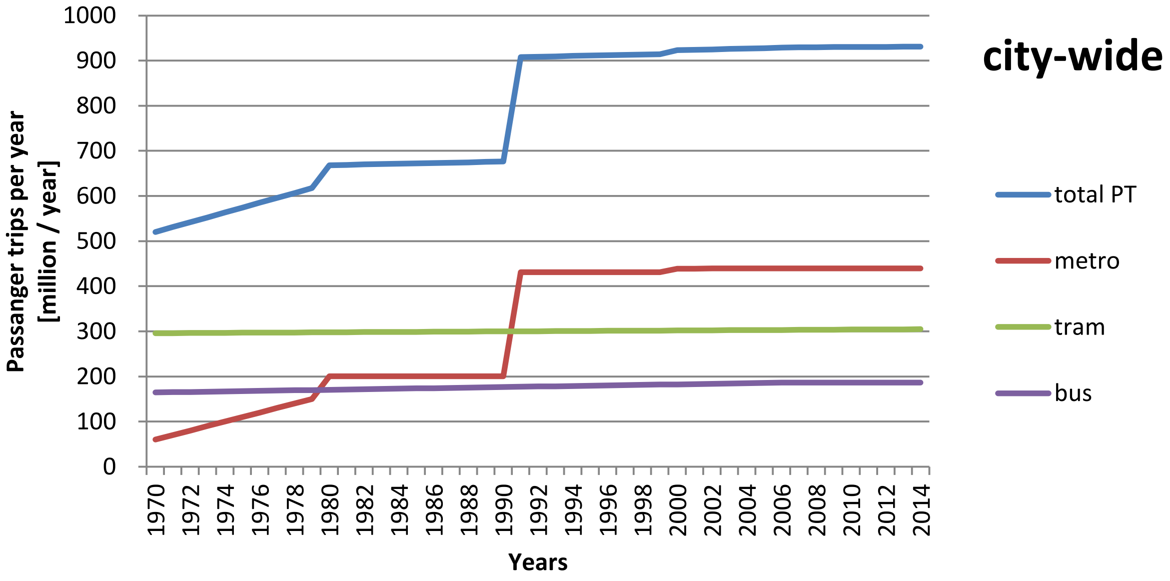


Figure 6-11: Development of the number of PT passengers [million trips / year] for Paris city (source : Paris city)

The years 1990's have seen an enrichment of the public transport offer :

- 1991: classes' removal in public trains.
- 1991: creation of the porte de Clichy's station (RER C)
- 1992: Line 1's extension between Neuilly's bridge and la Défense
- 1992: RER A's extension until Marne la Vallée
- 1994: RER A's extension until Cergy
- 1994: Juvisy Versailles's branch's integration in the RER C
- 1994: RER B's extension until Roissy CDG
- 1995: RER C's extension from Chatelet to Melun
- 1997: creation of a tramway between Issy and La Défense
- 1998: Line 13's extension between Saint Deni's church and Saint Deni's university
- 1998: Line 14's creation between Madeleine and the new national library
- 1998: Plaine Stade de France's station creation (RER B and RER C)
- 1999: RER E's creation between Haussmann and Chelles

The opening of a new public transportation line provides accessibility to new territories, thus draining new users towards the service. The accessibility gain does not only concern the new public transportation line, but all the other lines connecting with the new one.

During that period, there were also social evolutions and behavior's change due to:

- a steady increase of the fuel's price since 1992
- 1992 : climate's change convention and Kyoto's conference.
- 1995 : Parisian's subway's terrorist attack (should have led to a lower use of public transportation for a short period ?)
- 1995 : major strike in public transportation
- 1995 – 1996 : free use of the public transport card until the end of the strike.

The increase in the use of the Parisian subway during the 90's comes from the enhancement of the global offer in public transportation (the Parisian subway is only a part of a global network composed also of regional trains, tramway and bus lines). However, the approach based on the public transportation offer must be completed by a closer look towards new behaviours, linked with different social evolutions.

6.4 Travel behaviour and policies

6.4.1 Share of cycle trips indicated by policy action

The introduction of cycle routes in île-de-France region (the whole region, not the agglomeration) has risen steadily since 2010, with over 3,500 km of cycle ways in use today. It is the result of local and regional policies encouraging bicycle use.

The cycle networks in the Paris region are continuing to swell. They grew by 61% between 2007 and 2012, not far off the 67% average rate observed in France as a whole over the same period.

Between 1999 and 2012, the cycle route network in Île-de-France tripled from 1,375km to 3,532km (+157%). Paris city provided the greatest impetus, developing its network most significantly: cycle routes have grown by 300% in Paris itself, from 129 km in 1999 to 545 km in 2012.

The extension of demarcated cycle paths has been accompanied by an overall rise in the popularity of cycling; residents in and around the Paris region are biking more than they did ten years ago. According to the HTS, bike journeys in Île-de-France rose from 300,000 per day in 2001 to 650,000 per day in 2010. This trend is true of all active modes of transport, with walking also seeing a rise in popularity. The Regional council tries to develop its own "Plan bike" by focusing more in the needs, the usages rather than in the extension of cycles tracks.

6.4.2. Share of walking trips indicated by policy action

Starting in 2012, the municipal program Pedestrian Paris Initiative has been aimed at shifting the focus from other modes of transportation to pedestrians in order to enhance sustainable mobility as a way to experience the city.

To facilitate pedestrian trips, Paris is radically clearing sidewalks from any obstacles. Walking gets smoother as the easiest way to move through the city, like it was before cars blocked our streets. Thus, the Pedestrian Paris Initiative is changing Paris streets by freeing and widening sidewalks. The commitment to make the pedestrian travel experience as convenient as possible can lead to a notable reduction of informal activities like outdoor displays or terraces. However, some amenities cleared off from the sidewalks are relocated on former parking strips. To enhance even more street activities and uses, the reuse of some parking spaces gave the opportunity to add amenities openly requested by Parisians such as café terraces, benches, greenery, fountains, or bike racks. This form of Placemaking makes for an even more comfortable pedestrian experience.

Paris city has also focused on creating a balance in the street between motorized vehicles, public transportation, bikes, and pedestrians, in part by implementing lower speed limit areas. Paris has expanded the zone "30 km/h" speed limit policy along with areas labeled as 20 km/h where pedestrians dominate the street. Once all projects are completed, 37% of Paris streets will have a speed limit under or equal to 30 km/h. By smoothing car traffic, the city aims to make streets more welcoming for slower and more sustainable users like pedestrians and people on bikes. In addition to increasing traffic-safety, lower speeds foster the opportunity to give more and specific rights for bicyclists to support and promote travelling by bike.

Besides the goal of facilitating active transportation, the city of Paris is ambitiously creating and expanding shared spaces as streets that do more than just circulate traffic. These are spaces where you can experience the urban environment.

7 Summary, Conclusions

All is done in Ile-de-France, especially in Paris city, to discourage to use a car. The global cost of owning a vehicle never ceases to rise, the constraints of traffic are becoming worse. The image of the car has evolved and it is no longer a vital social symbol since less than one household out of two owns one in Paris. It is therefore becoming more and more reasonable to question the place of the car in our daily trips and the principle of owning a car.

The public transportation system consists of tram and bus lines, suburban railways and a large metro system, which is composed of 16 lines and 303 stations. 4,8 millions passengers use everyday the subway, 3.5 millions use buses, 3 millions are in the trains ans express railways and 1 million in the tramways. It is more than 21% traffic within 10 years in the public transport in the region. In recent years, Paris city has made efforts to achieve a modal shift towards public transport, cycling and walking.

The new services of car sharing and ride sharing characterise the evolution of the place of the car in our daily trips. More than reducing the use of the personal car, they point to a behaviour change, characterised by an increase in trips by foot, bicycle or public transport. Transport and mobility policies conducted by Paris and the Region encourage the use of alternatives to car. Large investments were realized in the new infrastructure of public transport and cycle tracks in the last 15 years. In Paris, the goal of sustainability encompasses transportation and public space policies. Walking and bicycling practices have been promoted as a way to reduce traffic injuries and promote greener trips. The pedestrian-friendly urban environment of Paris seems to give an opportunity to enhance a new experience of the city in promoting new social behaviors between street users. Probably all these reasons explain the phenomena of peak-car which affect the motorization rate, the private car modal share and the number of car trips per day. But what is important to highlight is that the peak car affects the urban areas but not the peri-urban and rural areas. If you want to reduce the place of the car in these areas, you have to find other solutions than walking and bucycling which are only relevant in urban dense areas where the travel distance are relatively short.

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10 List of Tables

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Project acronym:	**CREATE**
Project title:	**Congestion Reduction in Europe - Advancing Transport Efficiency**

D3.2 - Technical report for Stage 3 city

Vienna

Work Package 3 "Quantitative Analysis of Travel"

		Date of preparation:	**November 2016**
Start date of project:	**1st June 2015**	Duration:	**36 month**
		Version:	**3**
		Prepared by:	**Oliver Roider, Roman Klementschitz, Nora Spiegel, BOKU**
		Checked by:	**Rico Wittwer, TUD**
		Verified by:	**Peter Jones, UCL**
		Status:	**Final**
		Dissemination level:	**Public (PU)**

Table of Contents

1 CREATE project

CREATE's work is based on 3 main challenges/activities:

- to establish which policies were most effective at controlling congestion, reducing car use and promoting sustainable transport,
- whether such policies are transferable to other cities,
- how cities are going to respond to the challenges of rapid population growth and new transport technologies in the future.

In other words, and more specifically, CREATE aims to help five cities from Eastern Europe and the Euro-Med countries to decouple traffic from economic growth, with the support of five Western European cities that have already passed the critical phase of rapid increase in car ownership, and are now moving towards a sustainable transport system. CREATE sets out to study and look at options to further improve network efficiency and reduce the overall need to travel in those advanced cities.

CREATE uses knowledge gained from stakeholder interviews, data analysis, detailed research and historical studies in order to develop tools, guidance and teaching packages, providing capacity building and opportunities to enable less advanced cities to accelerate their shift towards a more sustainable mobility system.

This in-depth investigation, supported by leading analysts and a major provider of real-time traffic data will permit CREATE to investigate changing patterns of road traffic and car use, success factors behind decreasing car usage and lessons learnt.

1.1 Concept and approach

The CREATE project is based on four central innovative ideas or assumptions:

1. The way in which the "congestion" debate is framed in a city underlies how transport system performance is measured.
2. The existence of a 3-stage "Transport Policy Evolution Cycle" spread over 40+ years, which gradually shifts the policy emphasis and investments priorities from catering for road traffic growth to building up a liveable city.
3. The examination of future mobility options given a rapidly growing urban population (and a mobility densification), with policy measures which can achieve congestion reduction, promote sustainable mobility, while meeting wider policy goals.
4. Promoting the "policy transfer" of understanding gained from investigating the above mentioned ideas, to those cities which are coping with rapid growth in car ownership and promoting "pro-car" policies. This would provide them with insights into how to short-circuit the 3-stage historical "Transport Policy Evolution Cycle".

1.2 Objectives

The CREATE project is based on achieving four high-level objectives:

1. To explore the nature and the causes of urban road traffic congestion, developing and applying a set of policy relevant and practical indicators of urban road congestion and transport network performance. This will provide network managers and policy makers with metrics to establish the degree to which efficient and sustainable urban mobility is being delivered in the CREATE cities.
2. To work with five economically advanced Western European capital cities, which have already passed through the "peak car" phenomenon, examining how they have succeeded in

decoupling economic growth from traffic growth. It will be particularly interesting to discern which transport and non-transport factors have been most effective in reducing car use, thus encouraging greater use of sustainable modes.

3. To develop specific guidance and promote capacity-building for professionals in the group of cities (Eastern European and Euro-Med) which are at the earlier stages in their economic development, with a view to help them to adopt policies based on sustainable mobility, rather than becoming car dependant cities.
4. To address the serious future issues starting to emerge in many of the CREATE cities due to rapid increases in population and employment, thus potentially overwhelming all modes of transport. Via the investigation of the potential for new technologies, and the changes in business and social habits, there are chances for better managing the transport systems and reducing the overall need to travel as well.

2 About this document

The primary aim of WP3 is to analyse the transport policy evolution cycle as described in Deliverable 2.1 for the five stage 3 cities, from their stage 1 condition to their current status as stage 3 city. The development of relevant travel indicators is mapped over time in order to quantify this trajectory and to identify the various factors which have contributed to observed changes in behaviour – particularly the observed reductions in car driver modal shares.

This deliverable documents the analysis of the data to provide an overview of city development and characteristics as input for further analysis. Trends in congestion and travel behaviour (by purpose, mode, etc.) are measured, charting the emergence of "peak car" and the growth in the use of sustainable modes of travel in different parts of the urban and peri-urban areas. A descriptive analysis for each stage 3 city is conducted across the years. Indicators of changes in conditions in each city are analysed, including traffic volumes, speed, congestion, public, transport patronage, modal shares of different modes depending on data availability.

Indicators of possible causes of changed travel patterns are covering demographic changes, economic developments, car ownership, labour-market, land use, or government policies. Analysis is distinguished between different segments of population in different parts of the cities over time. Data are mainly based on any kind of statistical sources available as well as household travel surveys and are to be documented for the longest possible period of time in each city. Most of data, but in particular household travel survey data, should be available in all stage 3 cities at least 20 years back from 2014, in some cases from the 1970s, and should provide information of the stage 1 situation in the particular city.

The contents of this deliverable are based on the analysis scheme provided in Deliverable 3.1. Technical internal report, detailed analysis scheme for WP3 to ensure the generation of comparable figures over time for all stage 3 cities. The list of indicators to be documented is subdivided into 2 levels: (1) "must-have-indicators" which all stage 3 cities should have to provide and (2) "nice-to-have-indicators" representing additional analyses of specific data available in case these data are easy to access. Additionally, any other documentation of data or further cross analysis of data of interest in a particular stage 3 city are highly appreciated and should be added accordingly.

This deliverable is organised as follows: The city specific framework as the basis for the analysis is presented in chapter 2. Chapter 3 and 4 are dealing with transport supply data and policies influencing travel demand in the city documented in chapter 6. Freight transport is described in chapter 7. Summary and conclusions are documented in Section 8.

3 City specific framework conditions

3.1 Spatial characteristics

3.1.1 Area definitions

This section is to provide basic information and a description of each area type according to the definition as proposed in Deliverable 3.1:

- Inner-city: city centre or central business districts
- Outer-city: city area beyond inner-city but within the city boundary
- Peri-urban: area bordering the city (e.g. closest ring around city), fulfilling the criteria of high population density, high density of workplaces, high number of commuters to or from the municipalities (the political district of Mödling is used as reference for characteristics of the peri-urban area)

With an area of 415 km^{2,} Vienna is the largest city and the capital of Austria (Table 3-1). The relevant area bordering the city spans over 797 km^2. For the CREATE project the area was classified into three homogenous areas to enable the identification of specific developments. The **inner-city** covers an area of 46 km^2 and contains the central political districts 1 to 9 and 20 of Vienna. The **outer-city** covers 367 km^2 and spreads over the remaining city districts, 11 to 19 and 21 to 23. The **peri-urban** area surrounds the city of Vienna and covers an area of 797 km^2. This area has 41 municipalities including those of the political district of Mödling. Due to limited data availability at times the political district of Mödling is used as a point of reference for analysing the development in the peri-urban areas.

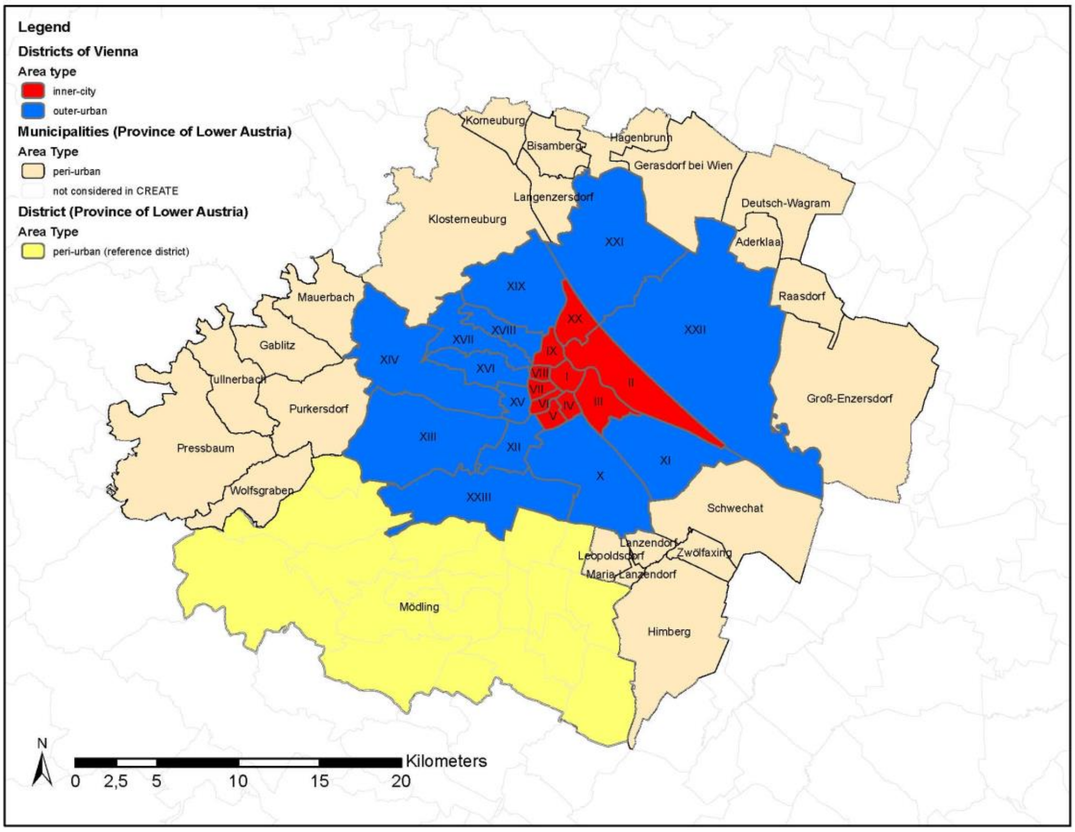


Figure 3-1: Area types of the stage 3 city “Vienna” (2014)

Table 3-1: Size of study area [km^2]

Area type	total surface area [km2] (2014)
Inner-city	46,13
Outer-city	368,74
Peri-urban	797.21

3.1.2 Land use

The city is located in north-eastern Austria in the Vienna Basin along both sides of the River Danube. In 1970 30 % of the area was used for settlement and 12 % for transport infrastructure (Figure 3-2). The urbanized area of Vienna expanded steadily, at the expense of arable land and vineyards, and covered 50 % by 2014. The agricultural area decreased by 12 % in the last decades. In 2005 a biosphere park was established in the wooded areas of the western districts of the outer-city area (Wien-konkret, 2008). By 2014 207 km^2 were used for settlement and infrastructure and about 100 km^2 were forest or water areas and 57 km^2 arable lands. Unfortunately, a distinction between area types in the city was not available (Table 3-2).

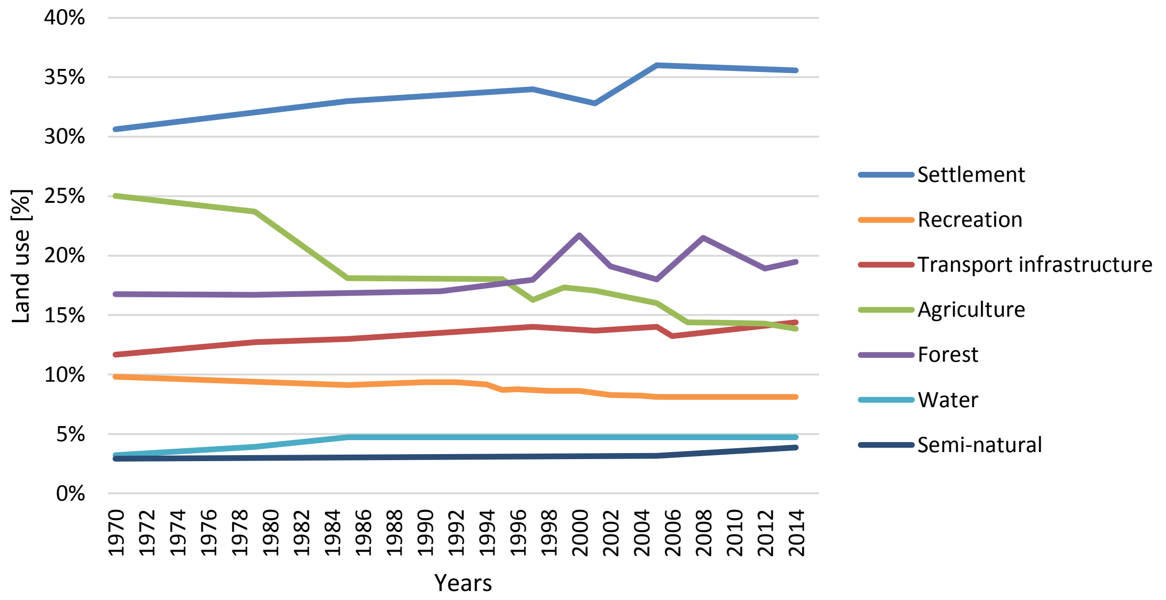


Figure 3-2: City-wide development of land use distribution

Source: (Stadt Wien, 2000), (Magistrat der Stadt Wien, various years 1970 to 2014), (Stadt Wien, 2005), (STATcube, 2016a)

Table 3-2: City-wide development of surface area according to land use characteristics [km^2]

	Reference year			
Land use type	1970	1997	2005	2014
Settlement	126,92	140,98	149,27	147,53
Recreation	40,72	36,32	34,04	33,67
Transport infrastructure	48,41	58,05	58,81	59,63
Agriculture	103,77	67,51	66,34	57,47
Forest	69,43	74,51	74,64	80,77
Water	13,31	19,61	19,61	19,61
Semi-natural	12,09		13,07	15,97

Source: (Stadt Wien, 2000), (Magistrat der Stadt Wien, various years 1970 to 2014), (Stadt Wien, 2005), (STATcube, 2016a)

3.2 Demographics and economy

3.2.1 Population development

In 1970 Vienna was home to 1.62 million people (Figure 3-3). Until 1987 the population decreased to 1.48 million inhabitants, mostly due to lower numbers of births than of deaths. The national labour deficit, the dissolution of the Soviet Union and the war in former Yugoslavia subsequently caused an increase in the city's population. This trend was mitigated by stricter migration policies in the mid-nineties (Magistratsabteilung 24, 2010). Before Austria joined the EU in 1995, the population of Vienna was 1.55 million and by the year 2014, it had risen to 1.76 million inhabitants. The peri-urban area exhibits a steady population growth from 1.77 million inhabitants in 1970 to 2.61 million in 2014.

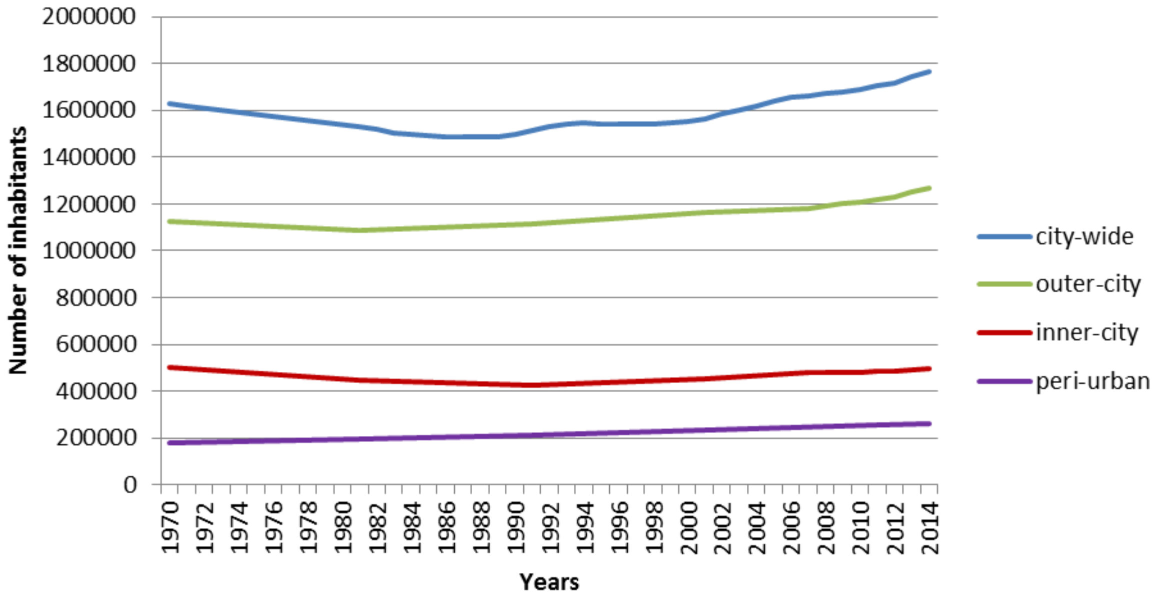


Figure 3-3: Development of the total number of inhabitants by area types [number]
Source: (Statistik Austria, 2002), (Statistik Austria , 2015)

3.2.2 Household size

The household size is calculated according to the number of people living one household (household-dwelling-concept), even short stay people are counted in a given reporting week. The city-wide average household size was 2.16 in 1970, the peri-urban average was higher with 2.51 persons per household. Over the following 30 years the number of single households increased by 33 % in Vienna, and by 2014 the average household had 1.99 residents. Until 2011 the peri-urban average number of persons per household sank by 9 % to 2.28 (Figure 3-4).

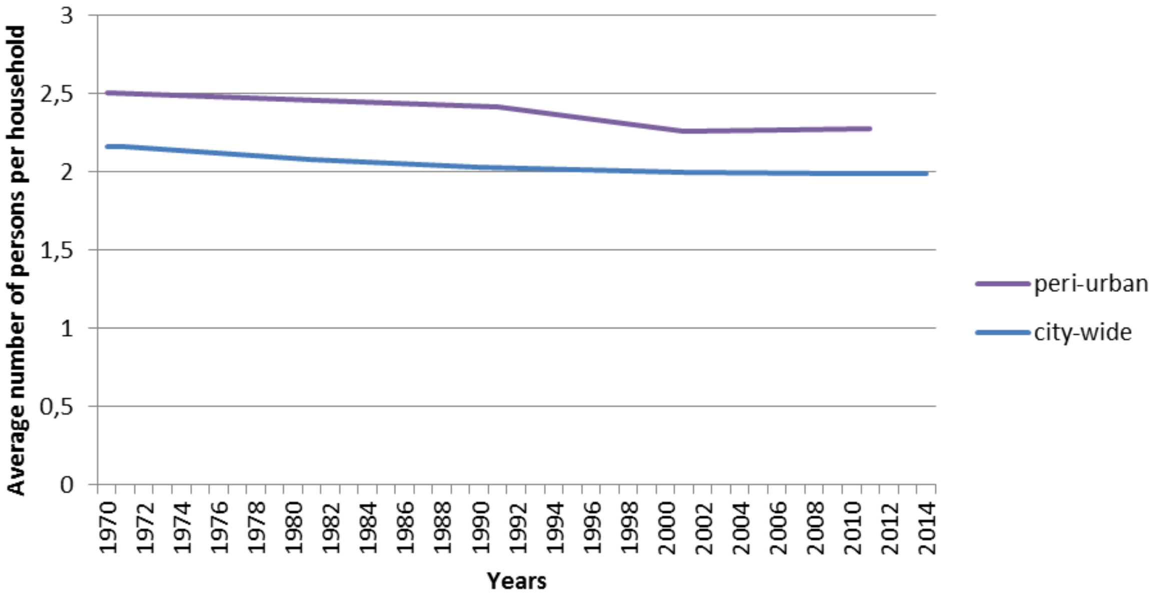


Figure 3-4: Development of the average household size by area type

Source: (Hanika, 2011), (Magistrat der Stadt Wien, various years 1970 to 2014), (NOE Landesregierung, 2012)

3.2.3 Gender balance and age class distribution

Comparing the city-wide gender balance by age groups across the years reveals that the surplus of female residents aged 45 to 64 has decreased (Figure 3-5).). In 1981 there were 1.3 women for every man, in 2014 only 1.04 within this age group. The gender imbalance within the age groups is gradually disappearing; there is even a slight male surplus in the two youngest age groups. Across all age classes there were 1.24 women for every man in 1981 and 1.07 in 2014. The peri-urban residents have a fairly balanced gender distribution across all ages with 1.06 women for every man in 2014. Compared to city-wide numbers, the residents aged 20 to 29 are underrepresented in the peri-urban area.

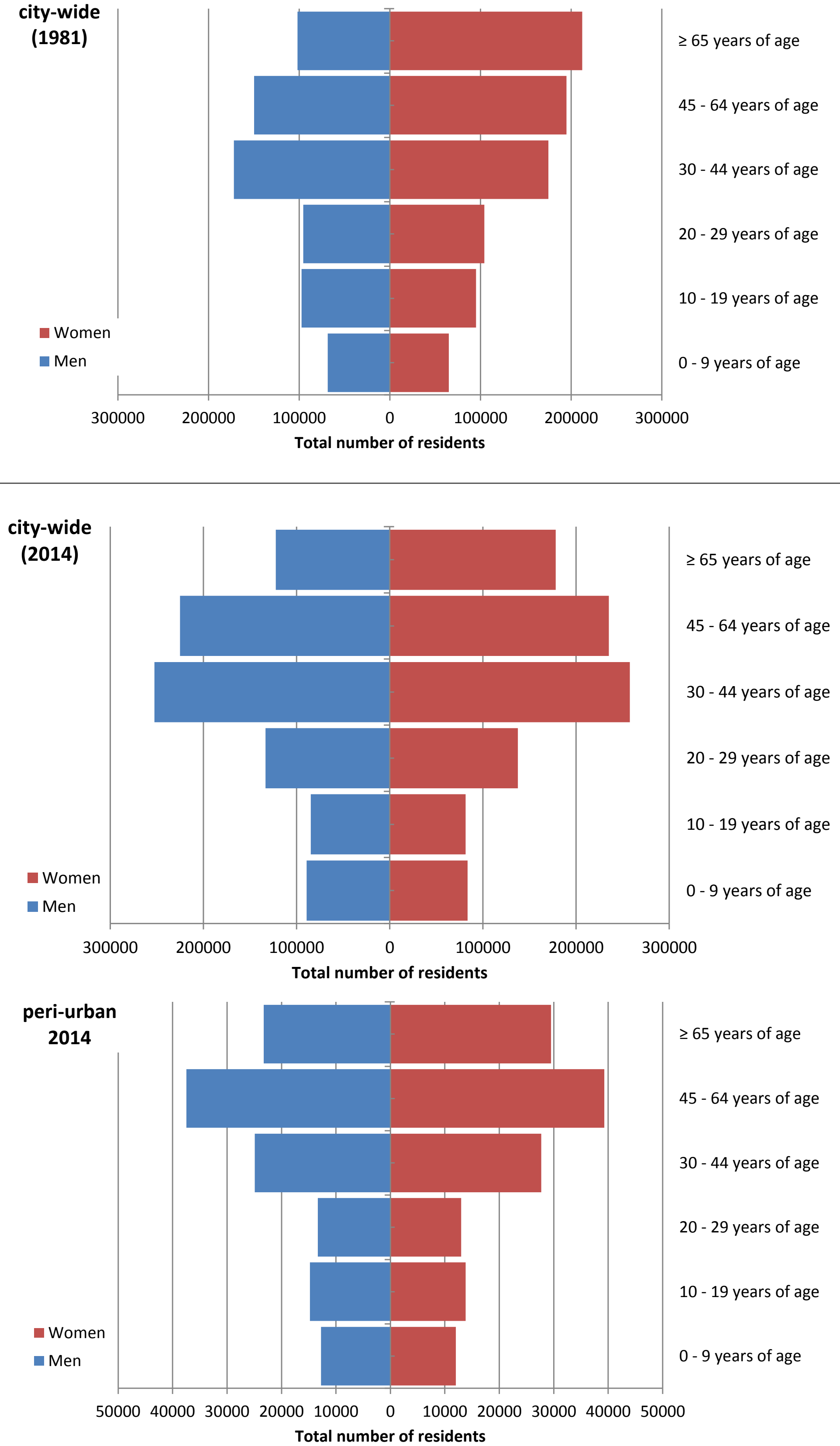


Figure 3-5: Comparison of the gender balance of the population between 1981 and 2014 (Total number of residents per gender and age class)

Source: (STATcube, 2014)

3.2.4 Ownership of driving licence by age class

A city-wide mobility survey provides the distribution of driving licence ownership by age classes in 2013 (Figure 3-6). With only 54 % for women and 57 % for men, the youngest age class had the lowest ownership rate. In 2013 the age class over 65 years had the second lowest rate with an apparent gender imbalance – for every female driving licence owner there were 1.45 male driving licence owners. Across all age classes 86 % of men and 60 % of women owned a driving licence in 1995 (BMVIT, 2007). The male ownership rate was unchanged in 2013, while the number of female driving licence owners had increased significantly by 13 %.

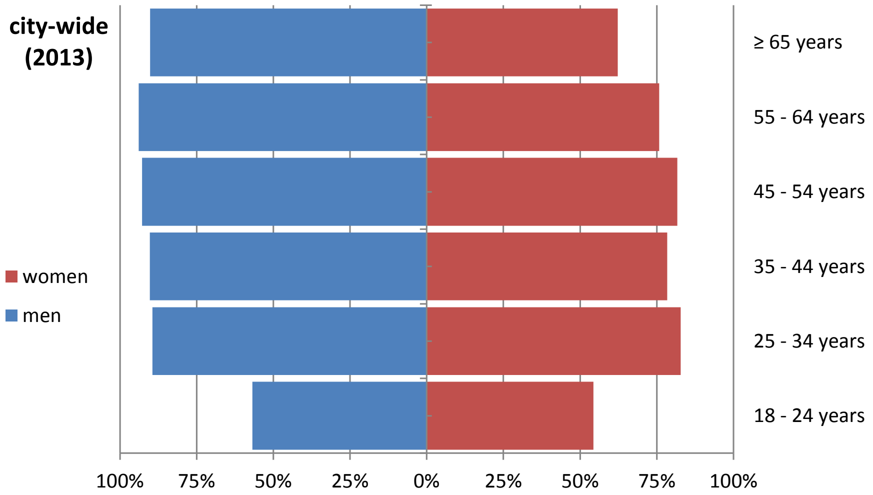
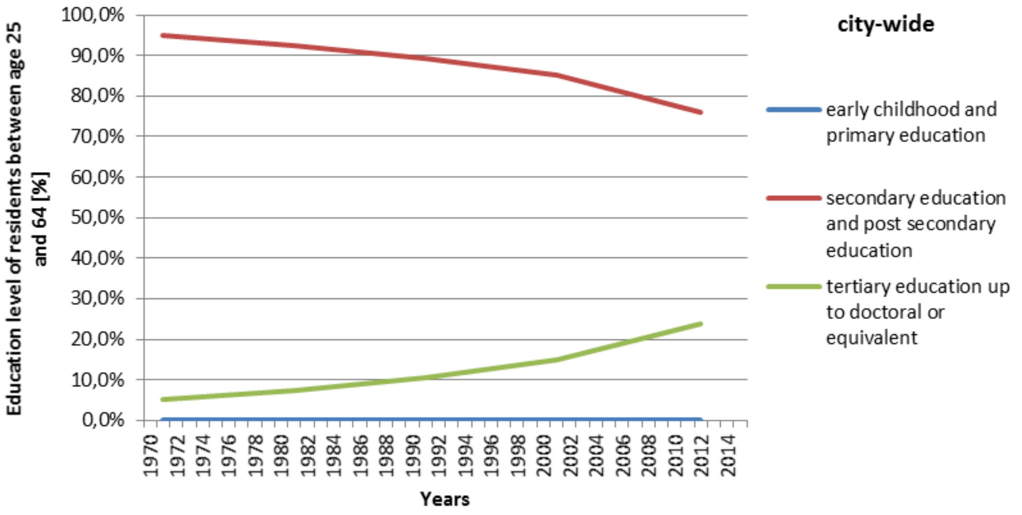


Figure 3-6: City-wide ownership of driving licence and age class in 2013
Source: (BRAWISIMO, 2013)

3.2.5 Education level of residents

In 1970, 94.8 % of Viennese residents aged 25 to 64 had attained a secondary education level and 5.2 % had finished tertiary level education (Figure 3-7). Within the following years the education level gradually rose, and by 2012 23.9 % of the residents had attained a tertiary level. Among the residents of the peri-urban area 87.2 % had attained a secondary education level and 12.7 % a tertiary level in 1991. By 2012 the share of peri-urban residents who had finished tertiary education had risen to 26.4 %.



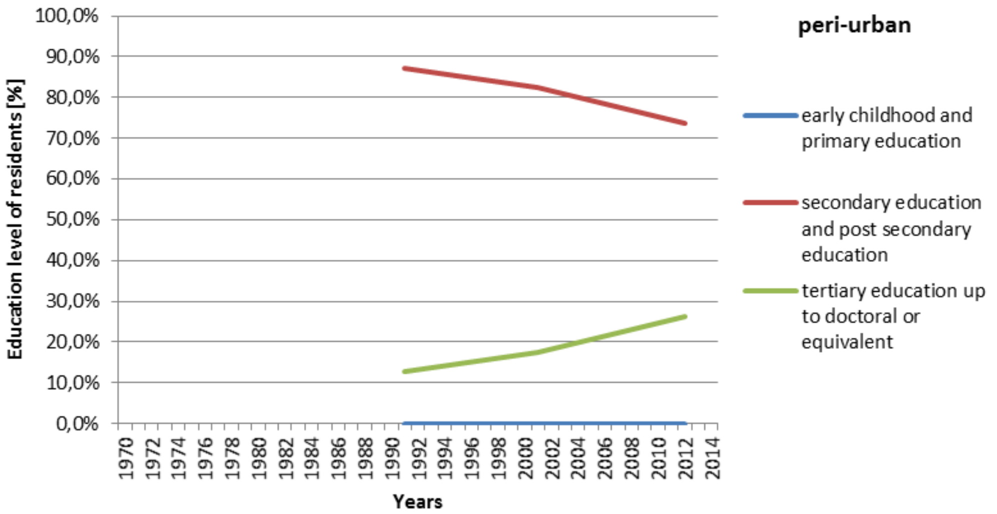


Figure 3-7: Development of the distribution of residents (aged 25 to 64) by education level and area type
Source: (STATcube, 2013b), (Magistrat der Stadt Wien, various years 1970 to 2014)

3.2.6 Employment status of residents

At the beginning of the 1970s, there were approximately 690,000 employed persons, of which 89 % were fully-employed, in Vienna (Figure 3-8). 460,000 people were retired, 290,000 were pupils, 19,000 trainees and 31,000 students. The unemployment rate was particularly low at 1.5 %, but increased steadily after the first oil crisis in 1973 and reached 11.6 % in 2014 (AMS, 2016). The number of residents in part-time employment rose by 220 % over the last 40 years. Corresponding to the increased education level (Figure 3-7) the number of students quadrupled until 2014. The number of trainees remained constant at about 17,000.

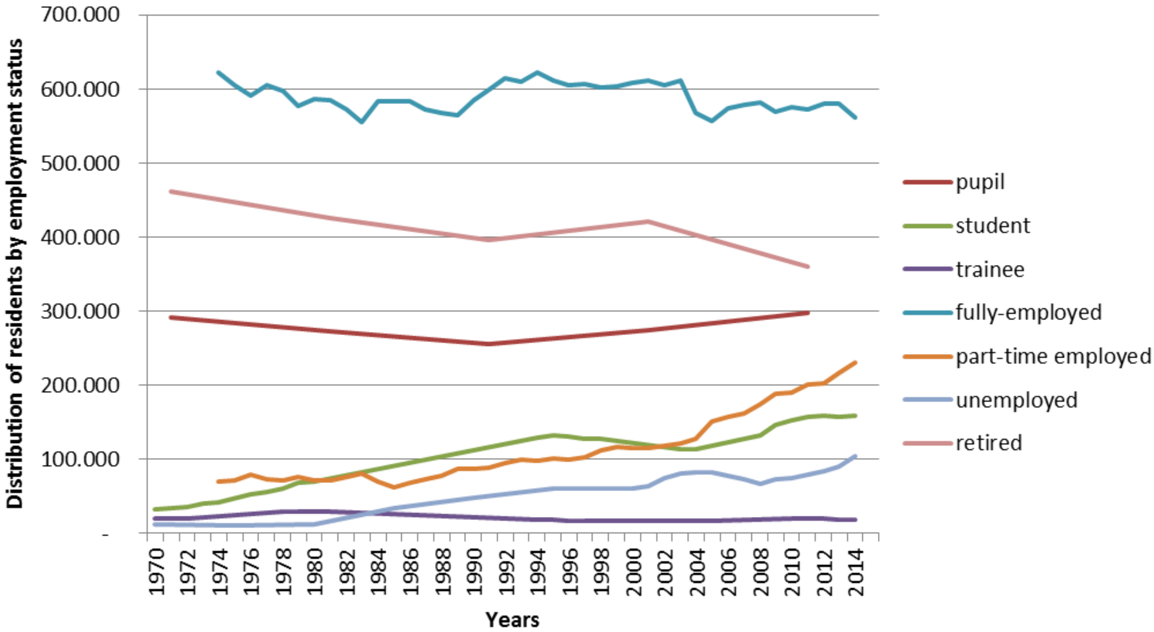


Figure 3-8: City-wide development of the distribution of residents by employment status and area type
Source: (Magistrat der Stadt Wien, various years 1970 to 2014), (STATcube, 2016b), (STATcube, 2016c), (STATcube, 2016d), (STATcube, 2016e), (Arbeitsmarktservice, 2015)

3.2.7 Number of workplaces

In 1973 the total number of workplaces in Vienna was 66,958, 52% of which were located in the inner-city and 47% in the outer-city (Figure 3-9). In the 1980s the rising number of commuters and the influx of foreigners who took up residence in Vienna led to an increase of workplaces by 7.3% (European Commission, 1996). Within the last twenty years this number has further increased by 29% city-wide. The distribution of workplaces has gradually shifted. By 2011, 54% of the workplaces were located in the outer-city area and only 45% within the inner-city districts. The development of the distribution of these workplaces according to economic sectors reflects the trends in the education levels of the residents (Figure 3-7). In 1970 manufacturing industries – the secondary sector - accounted for 41% of employment, compared with 58% for service industries – the tertiary sector (Figure 3-10). Within Vienna the share of manufacturing workplaces declined to 14% until 2014. Correspondingly, the service industries have increased and account for 86% of employment.

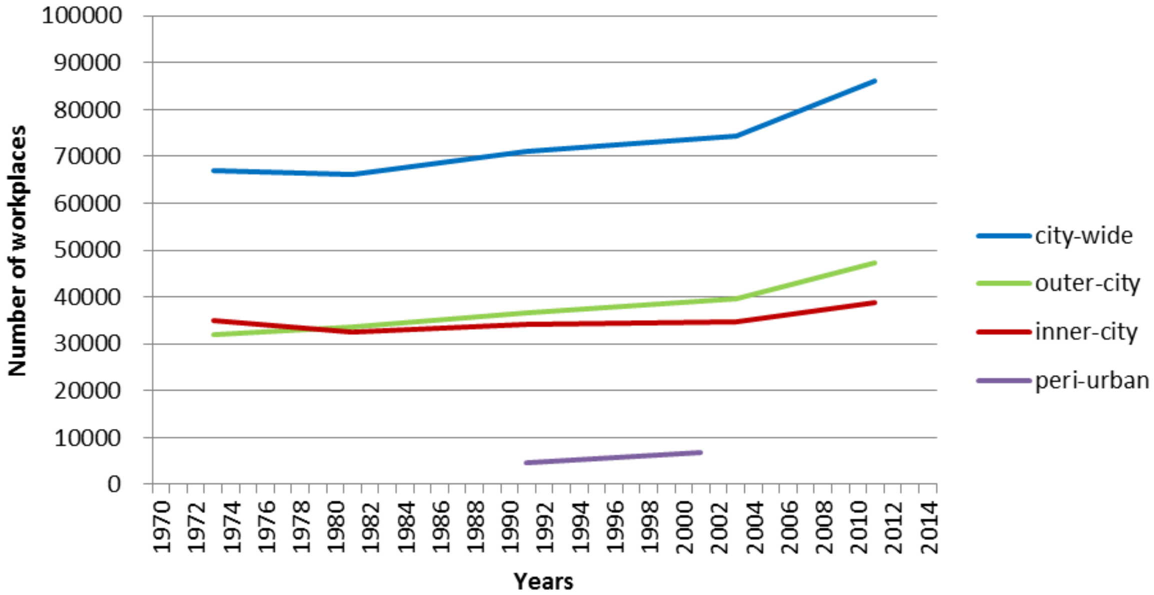


Figure 3-9: Development of the total number of workplaces by area type
Source: **(Magistrat der Stadt Wien, various years 1970 to 2014)**, **(Statistik Austria, 1991, 2001)**, **(STATcube, 2013a)**

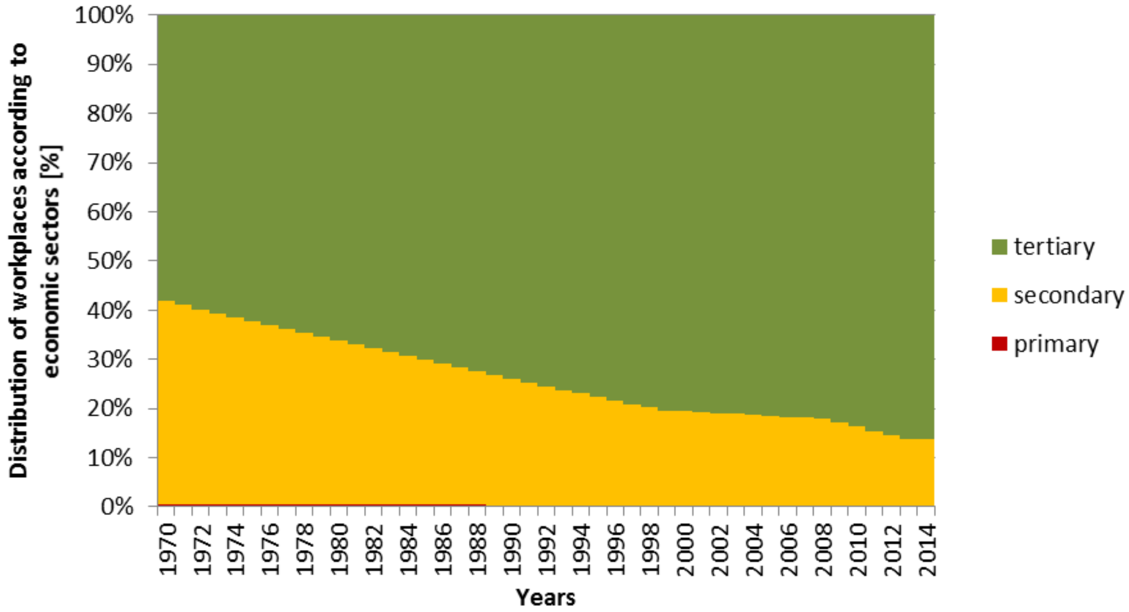


Figure 3-10: City-wide development of the distribution of workplaces according to economic sectors
Sources: (Schneeberger & Petanovitsch, 2010), (Stadt Wien, 2000), (Magistratsabteilung 24, 2010), (WKO Wien, 2015)

3.2.8 GDP and income per capita

The nominal gross domestic product of Vienna was € 4,940 per capita in 1970 (Figure 3-11). The development of the consumer price index (CPI) shows the increase of the price level of national consumer goods and services, using the year 1966 as a point of reference for the calculation with CPI set at 100%. By 1981 the GDP had increased by 71% and the CPI by 111%. In the year 2000, the nominal GDP was € 35,920 per capita, which represents an increase by 203% compared to 1970; the

CPI had risen by 260%. By 2014 the GDP had further gone up at an annual rate of 2.3% to € 47,200 per capita. The development of the nominal yearly income per capita (Figure 3-12) depicts a steady growth by 7% annually. In 1989 the average annual income of an inhabitant of Vienna was € 18,317, by 2005 it had risen to € 27,612 and in 2014, it was € 31,190.

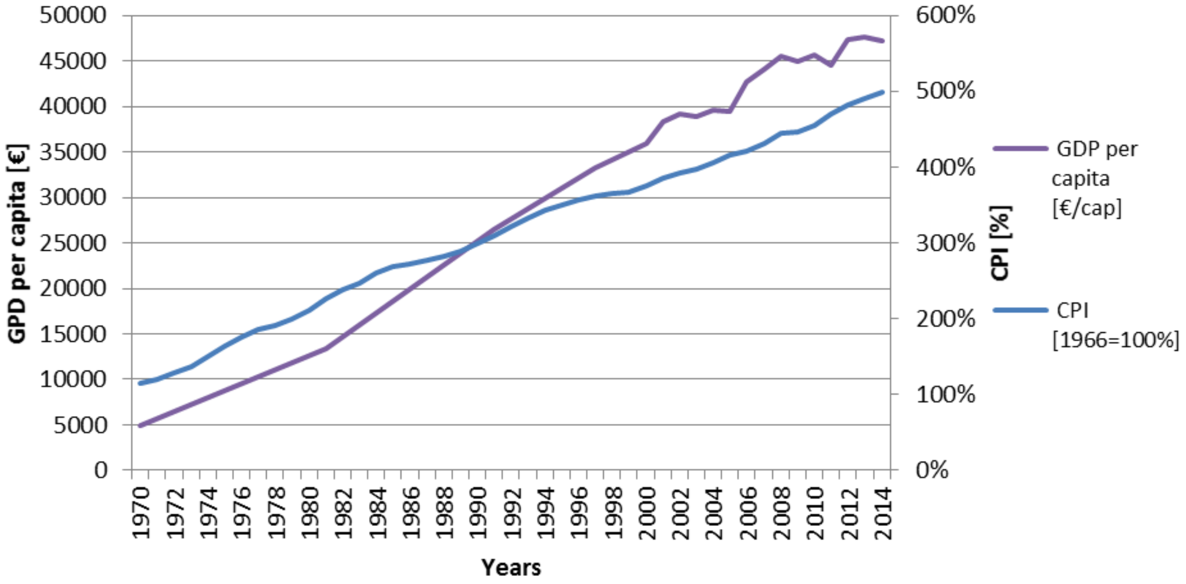


Figure 3-11: City-wide development of the GDP per capita [€/capita] and the national consumer price Index [%]

Sources: (Magistrat der Stadt Wien, various years 1970 to 2014), (Statistik Austria, 2016)

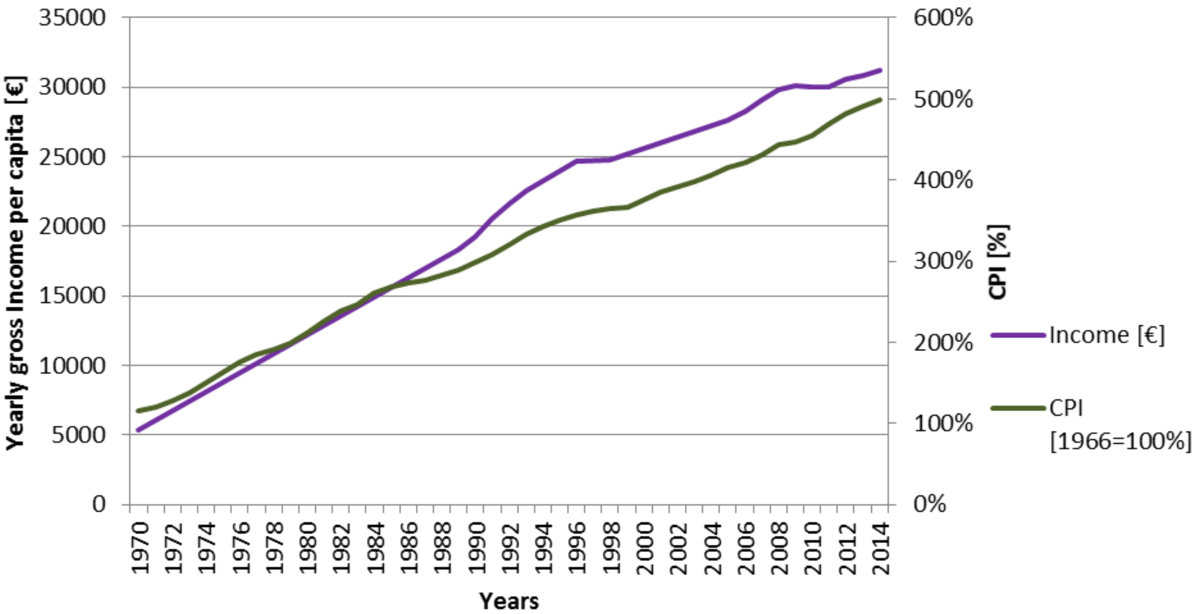


Figure 3-12: City-wide development of annual income per capita (gross) [€] and the national consumer price Index [%]

Sources: (Statistik Austria, 2016), (Magistrat der Stadt Wien, various years 1970 to 2014)

4 Transport supply

4.1 Road infrastructure and parking

4.1.1 Road network

The total length of the road network in Vienna was 2,365 kilometres in the year 1970 (Figure 4-4). The network consisted of 95% minor-municipality roads and the rest was classified as major-state road network. In 1981, the length of the network had expanded by 13%, the major roads in particular had been extended by 52 kilometres. Within the following 15 years, the total network length grew by 4% and in 2014 the total length of the road network was 2,814 kilometres with 51 kilometres of motorways, 222 kilometres of major roads and 2,541 kilometres of minor roads.

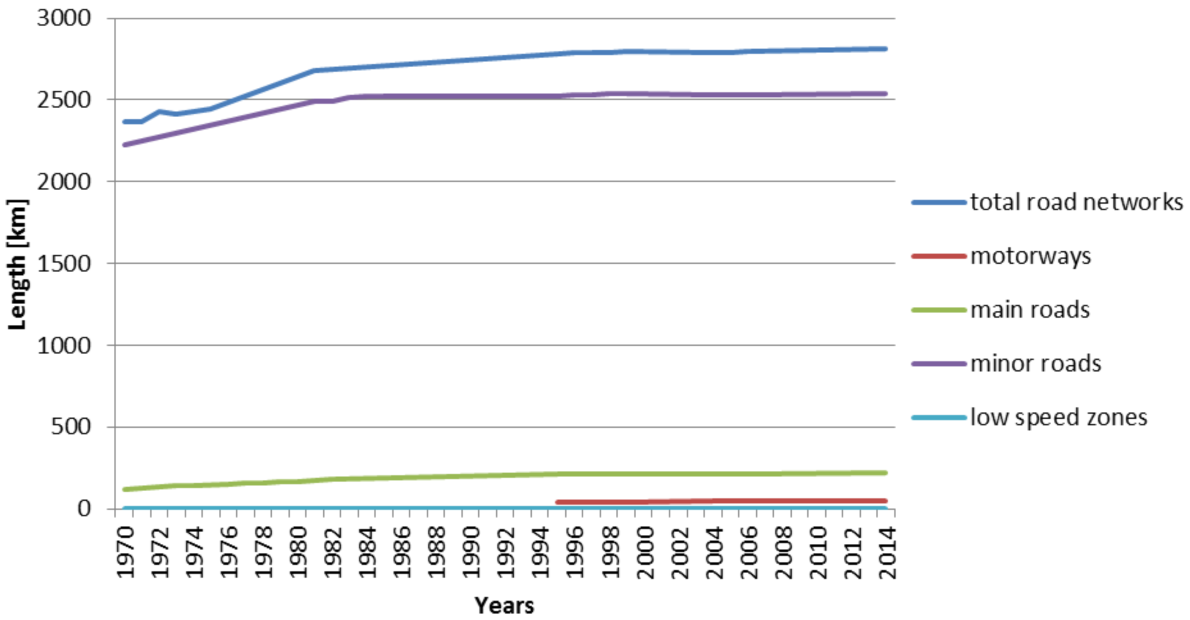


Figure 4-1: City-wide development of length of road network (not considering multiple lanes) [km]
Source: (Magistrat der Stadt Wien, various years 1970 to 2014)

The city-wide speed limits were reformed in 2005, following the implementation of a federal law on pollution control. The speed limit for the majority of main roads, which until then was often 60 or 70 km/h, was set at 50 km/h particularly for roads within settlement areas (Table 4-1). The general city-wide 50 km/h limit was also introduced in 2006 (Wien-konkret, 2005). Low speed zones – in Vienna predominately 30 km/h zones – have been introduced since the late 1980s. In 1987 30 km/h zones were established on merely 33 kilometres of the city-wide road network. During the following decades these zones were substantially expanded. In 2013 1,624 kilometres of the road network were low speed zones (Kocina & Renner, 2014).

Table 4-1: Speed limits by types of infrastructure within the city limits

Type of infrastructure	Speed limit (max. allowed speed) [km/h]
Motorways	80 km/h
Main roads (within uninhabited areas)	70 or 80 km/h
Main roads	50 km/h
Minor roads	50 km/h
Low-speed zone	30 km/h or 40 km/h
Shared space	20 km/h

Source: (Magistratsabteilung 46, 2008), (Wien-konkret, 2016)

4.1.2 Parking space

Within Vienna there were 39,625 public parking lots in garages accessible to the public in 1997 (Figure 4-2). This number increased by 73 % until 2005, and by 2014 there were about 90,000 parking lots in 272 public garages. Additionally, there were 14 park-and-ride facilities in Vienna with 9,035 parking lots (Stadt Wien, 2013b). Growth is really impressive, but it can be seen as reaction to the implementation of paid short-term-parking zones implemented in 1993 in the first district and further extended up to now (see chapter 5.1).

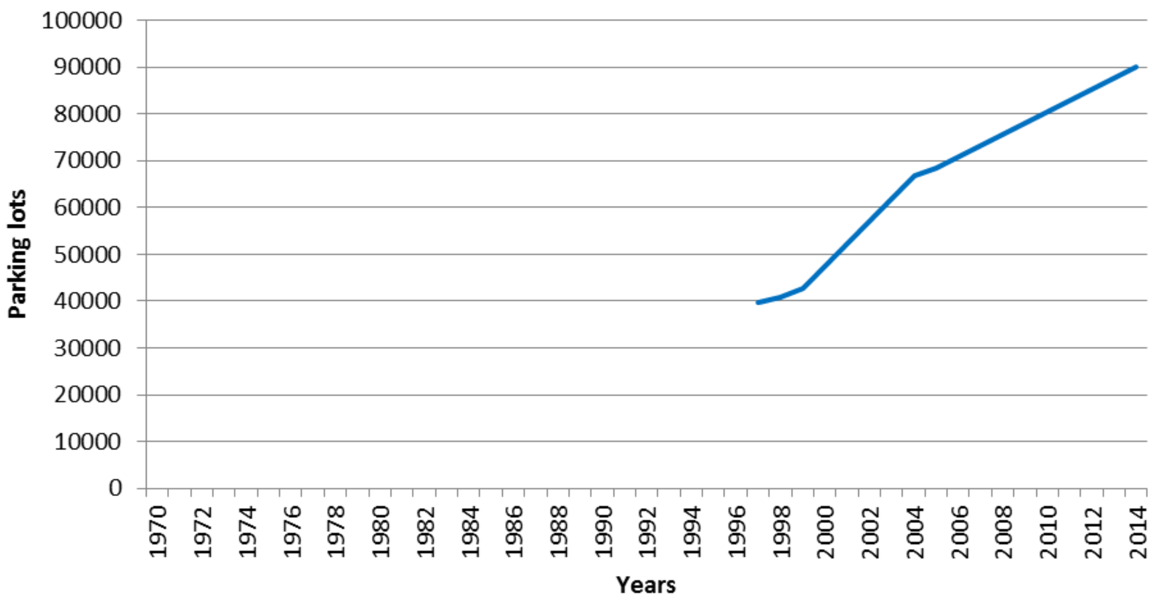


Figure 4-2: City-wide development of number of off-street parking lots
Source: (Magistrat der Stadt Wien, various years 1970 to 2014), (Stadt Wien, 2013b)

In the mid 1980s there were merely 25 bicycle parking facilities in Vienna (Figure 4-3). Corresponding to the expansion of the cycling network, more the parking facilities were created as well (Figure 4-11). Already in 1993, 1,023 facilities provided about 8,700 bicycle parking lots. Since 2010 when the Social Democrats entered a coalition with the Green party, the number of dedicated bicycle parking lots has increased by 35 %. There were 27,429 lots in 2010 and 36,917 in 2014, 59 % of which were located within the inner-city area. A bicycle parking facility provided lots for 9.5 bicycles on average (Pfaffenbichler & Niel, 2013).

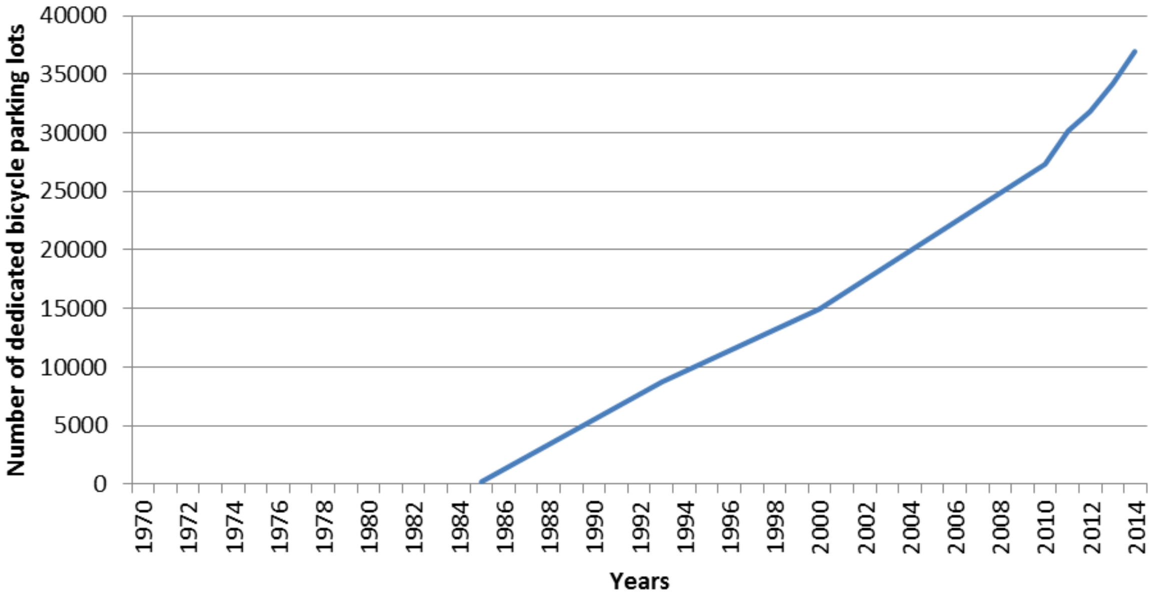


Figure 4-3: City-wide development of number of dedicated bicycle parking lots
Sources: (Magistratsabteilung 18, 2002), (Magistratsabteilung 46, 2015b)

4.2 Public transport and taxi supply, car-sharing

4.2.1 Public transport network

In 1970 the total operating length of the public transport network within the city was 628 kilometres. By that time Vienna already possessed a well-established tram network, which spanned over 232 kilometres. The metro system started to operate in 1976 across 30 kilometres. These were substantially extended over the following years and by 2014 the metro network covered 78 kilometres. The total public transport network was increased by 116% to 1,356 kilometres, predominately resulting from the development of the bus network, which was expanded from 192 kilometres in 1970 to 826 kilometres in 2014. In 1990, 52 % of the city-wide tram network was separated from the road traffic and 3 % of the bus network (Figure 4-5). To increase the public transport operational speed the share of separated infrastructure was expanded over the next two decades. In 2013 76 % of the tram infrastructure and 9 % of the bus network was separated.

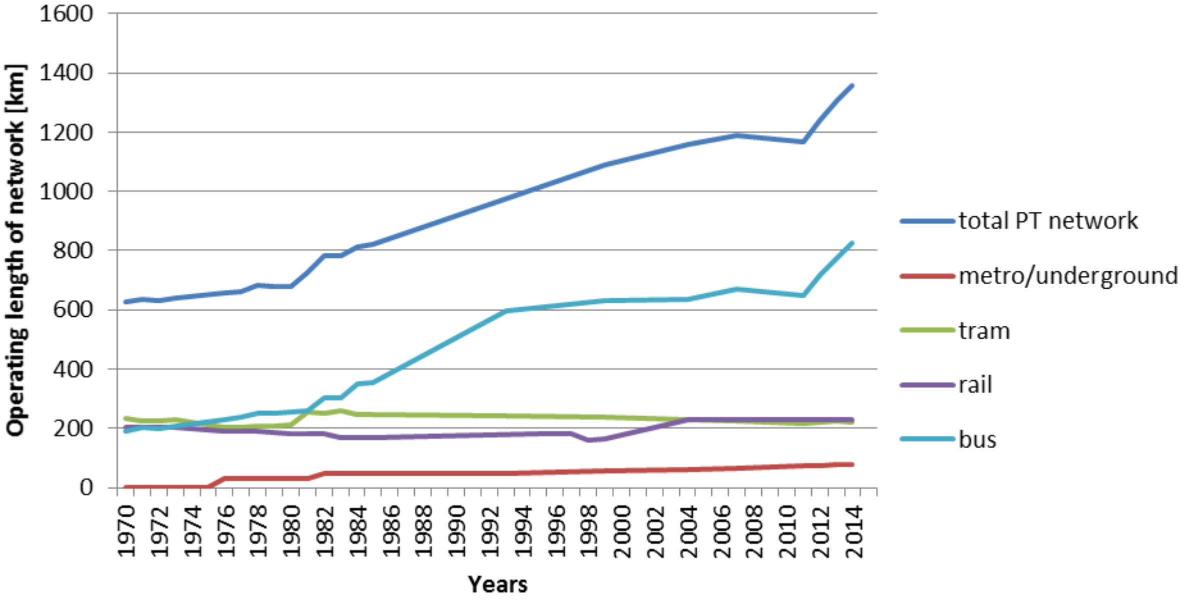


Figure 4-4: Development of the length of public transport network by mode (operating length of infrastructure of all urban lines in regular service on weekdays) [km]

Source: (Magistrat der Stadt Wien, various years 1970 to 2014)

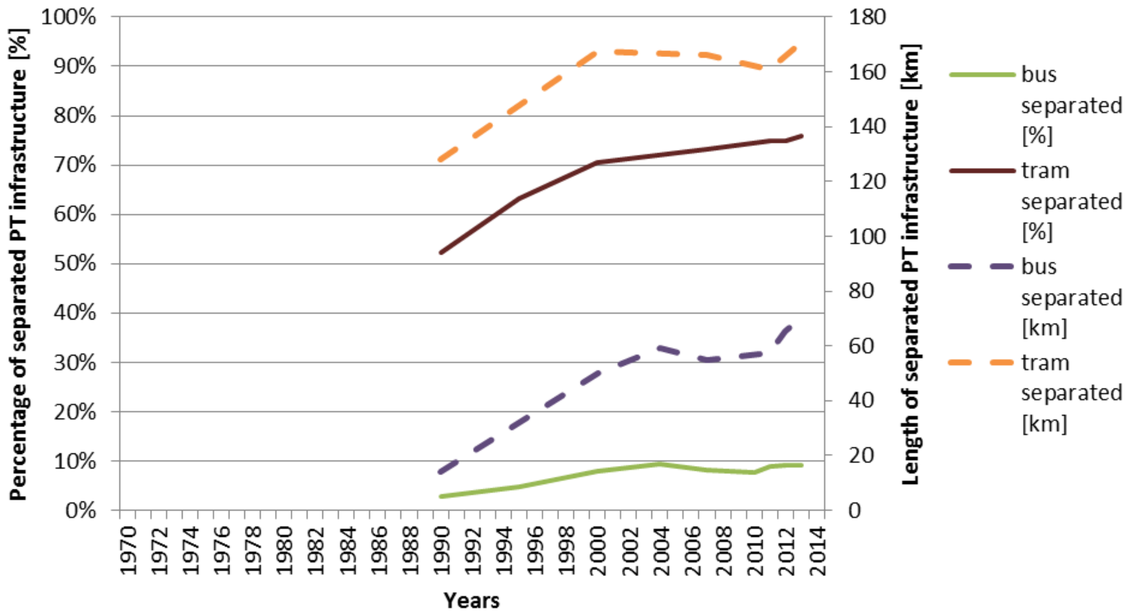


Figure 4-5: City-wide development of the length of separate bus and tram infrastructure) [km]

Source: (Wiener Linien, various years 1993 to 2015)

4.2.2 Public transport supply

In 1993 the major public transport supplier of Vienna – Wiener Linien – scheduled 11,884 million seat-kilometres for their total network of metro, tram and bus services. The metro provided 5,562 million seat-kilometres. Through further network expansions and higher frequency of service the supply was increased by 123% to 12,400 million seat-kilometres until 2014. The bus service was expanded by 31% while the tram service maintained about 4,186 million seat-kilometres during the last two decades.

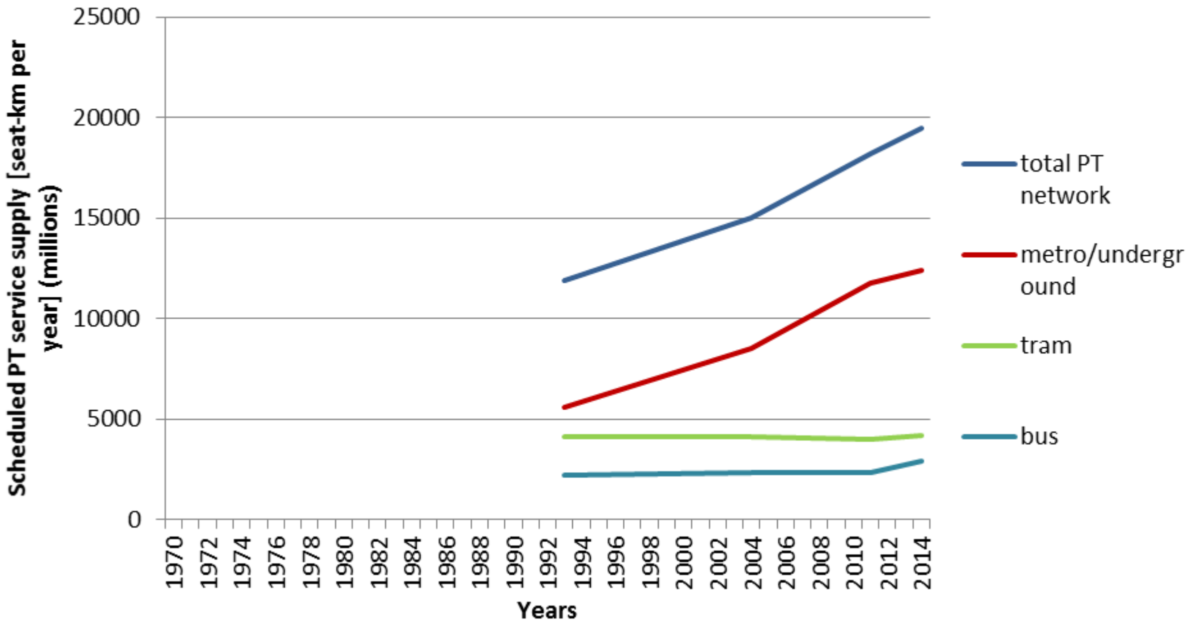


Figure 4-6: City-wide development of the scheduled (offered) public transport service supply [million seat-km per year]
Source: (Wiener Linien, various years 1993 to 2015)

Most public transport services within the city presently operate from 5 a.m. until 30 minutes after midnight. During peak-times in the mornings and afternoons, the metro runs a 2 to 5-minute frequency and in the evening hours trains arrive every 7.5 minutes. When the metro started to operate in the 1980s, the frequency was 5 minutes during peak times and 10 minutes off-peak times (Die Presse, 2013). The higher frequency was accomplished by raising the average travel speed from 30 km/h up to peaks of 80 km/h, amongst other things. Since 2010 the metro has also operated during the night on public holidays and weekends, from Friday to Sunday at a 15-minute frequency (Wien-konkret, 2010a). The tram and bus services generally run every 10 to 15 minutes as well as every 30 minutes during the night on selected bus lines.

There are various time- or journey-based public transport tickets available for the city-wide services. In 1970 a single ticket cost € 0.62, a one day ticket € 3.20 and a monthly ticket € 28.71. The annual ticket was only introduced in 1982 at a price of € 233. Through several reforms of the ticket tariffs the prices of single, one day and monthly tickets were raised continuously over the years and in 2014 cost € 2.20, € 7.60, and € 48.20 respectively. The price of the annual ticket went up similarly until 2012 when it was lowered from € 449 to € 365. This reform was accomplished by the city government of social democrats and the green party.

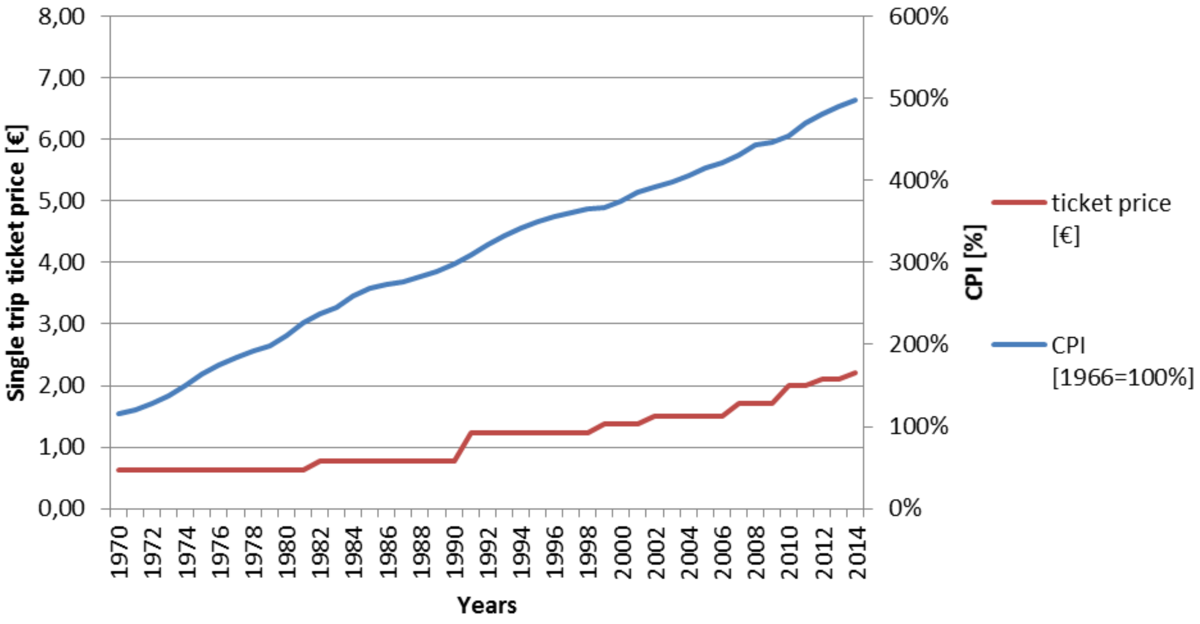


Figure 4-7: Development of the nominal price for a PT single trip ticket (central zone) [€] and the national consumer price Index [%]

Source: (Wiener Linien, 2002), (Wiener Linien, 2004), (Wiener Linien, 2007), (Stadt Wien, 2007), (Statistik Austria, 2016), (VOR, 2014)

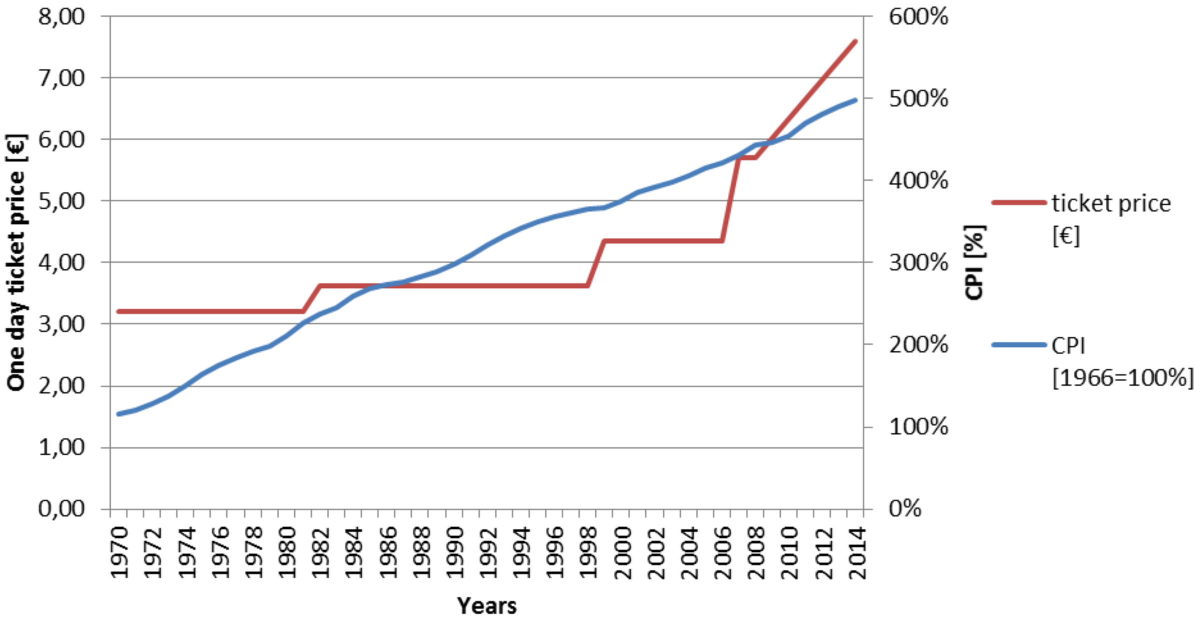


Figure 4-8: Development of the nominal price for a PT one day ticket (central zone) and the national consumer price Index [%]

Source: (Wiener Linien, 2002), (Wiener Linien, 2004) (Wiener Linien, 2007) (Stadt Wien, 2007) (VOR, 2014) (Statistik Austria, 2016)

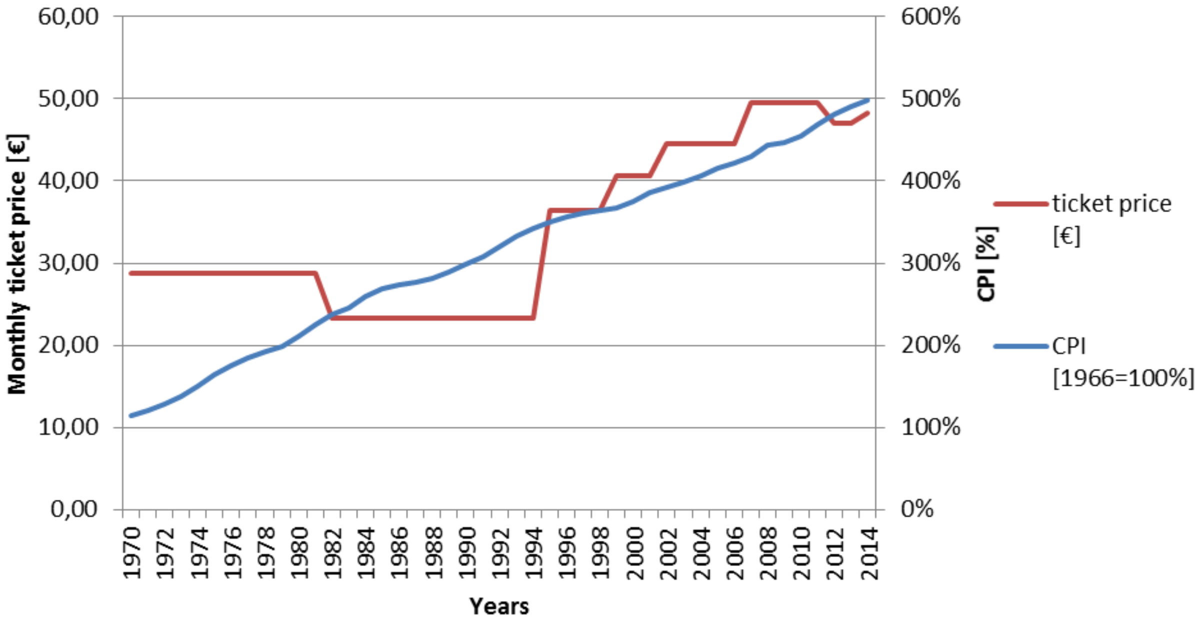


Figure 4-9: Development of the nominal price for a PT monthly ticket (central zone) and the national consumer price Index [%]

Source: (Wiener Linien, 2002) (Wiener Linien, 2004) (Wiener Linien, 2007) (Stadt Wien, 2007) (VOR, 2014) (Statistik Austria, 2016)

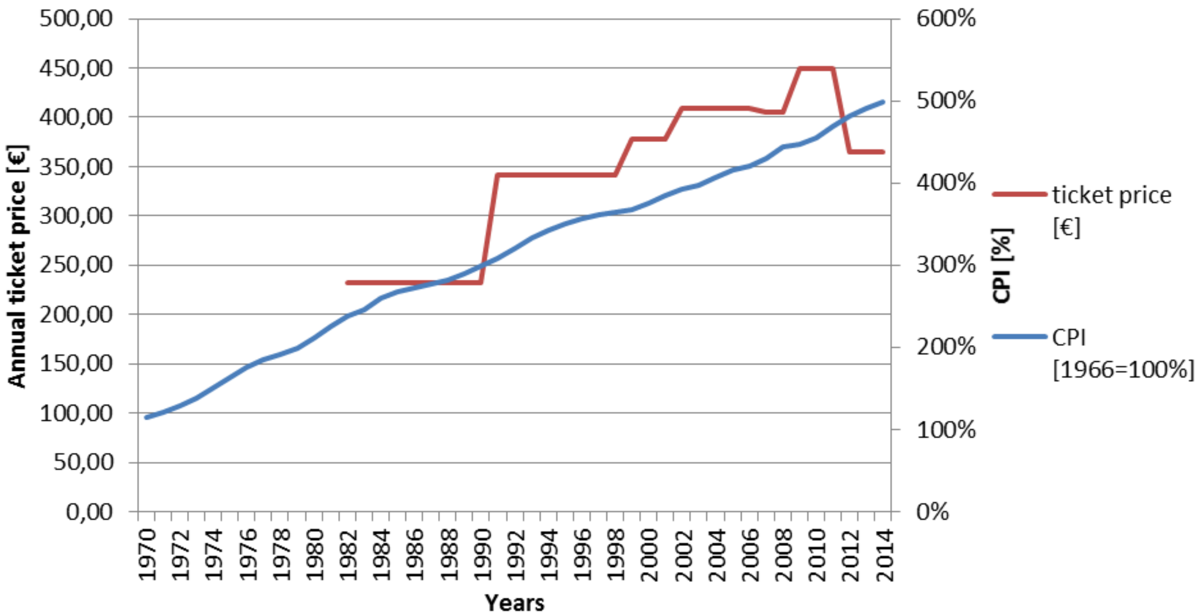


Figure 4-10: Development of the nominal price for a PT annual ticket (central zone) [€] and the national consumer price Index [%]

Source: (Wiener Linien, 2002), (Wiener Linien, 2004), (Wiener Linien, 2007), (Stadt Wien, 2007), (VOR, 2014), (Statistik Austria, 2016)

4.3 Cycling

At the beginning of the 1970s, providing cycling infrastructure was not of great importance to the city government. In 1975 the existing cycling network was reduced from 24 to 11 kilometres to accommodate motorised traffic (Stadt Wien, 2013a). Not until 1980 did the city council resolve on promoting cycling and expanded the total network to 388 kilometres. The infrastructure included scenic routes for leisure but also direct links for commuter traffic. In 2000 the cycling infrastructure consisted of 22 % cycle paths, 51 % cycle lanes and 27 % cycle routes (Magistratsabteilung 18, 2002). Until 2014 the total cycling network was further developed and extended to a total length of 1,270 kilometres.

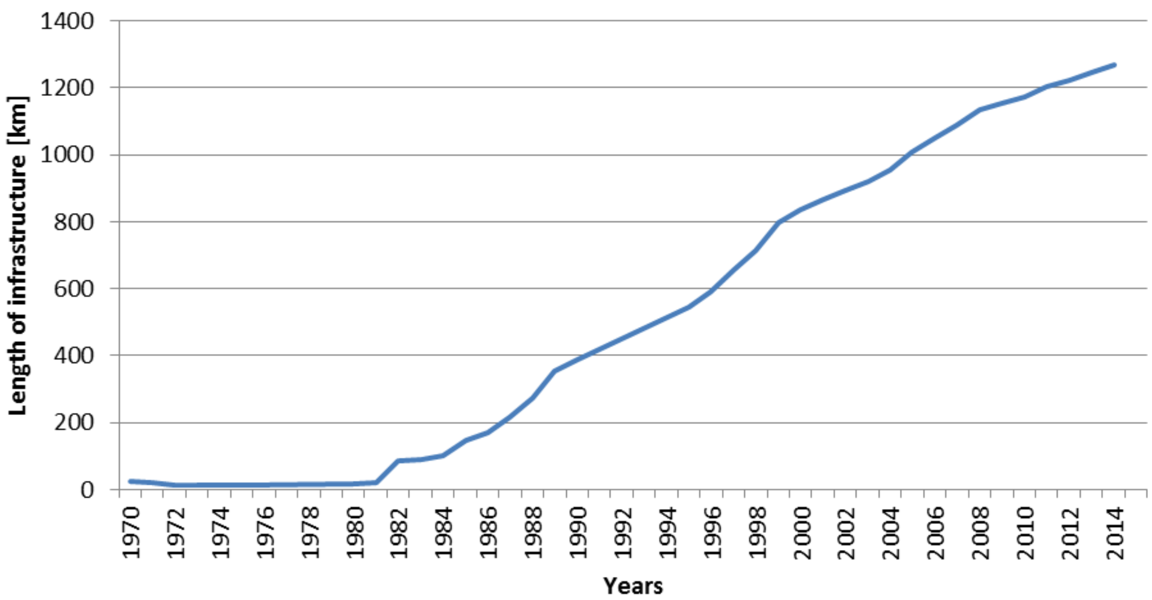


Figure 4-11: City-wide development of the length of the total cycling network
Sources: (Magistrat der Stadt Wien, various years 1970 to 2014), (Magistratsabteilung 46, 2015a)

In 2000 the transport masterplan of Vienna envisaged an increase to 6 % of the cycling share within the modal split (Magistratsabteilung 18, 2002). Therefore the cycling infrastructure was extended, in particular by closing the network gaps through the introduction of two-way cycling on numerous one-way streets. The 6 % share was surmounted in 2009. Since then, the city government has been focusing on establishing cycling corridors and green wave systems to further the attractiveness of cycling (Der Standard, 2013). Moreover, the city provides 20 cargo-carrying rental bicycles (Blum, 2014). As of 2014, a smartphone application, called “BikeWave” is being developed and tested in Vienna that helps cyclists adjust their speed to the current light signal cycle to minimize waiting at traffic lights and actively generate an individual green-wave (Schönauer, 2015).

4.4 Walking

The first pedestrian zone in Vienna was established in 1974 on a high-end shopping street in the city-centre and it covered an area of 13,440 m^2 (Magistratsabteilung 28, 2012). The construction of the metro through the city-centre was a good opportunity to redesign this area. Over the following years pedestrian zones were gradually extended by an average of 15 % per year (Figure 4-12). By 2013 pedestrian zones had been established on 295,938 m^2 within the city. For a brief time, from 1999 to 2004, an additional 118,252 m^2 of a recreational area within the inner-city area were counted as pedestrian zone due to the the ban of motorised vehicles of the crossing street. This was ban was lifted in 2004 as the congestion in neigbouring streets was too high. However, they city government decided to close the road at least on weekends and public holidays to offer uneffected space for recreation activities at these times.

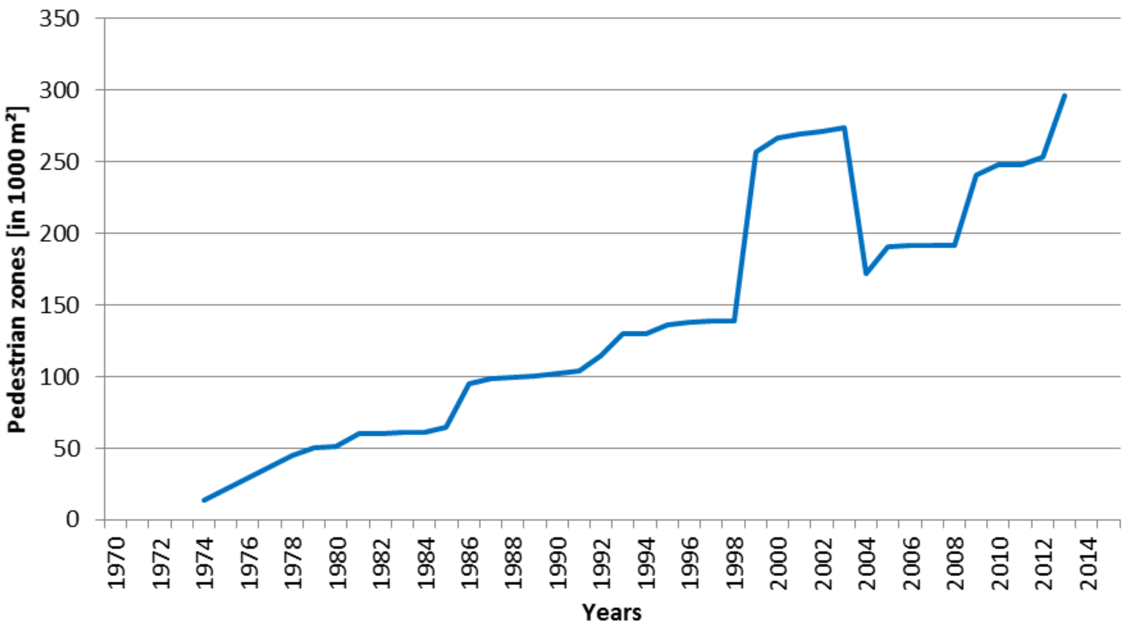


Figure 4-12: City-wide development of car-free zones (Pedestrian zones) [1000 m²

Source: (Magistratsabteilung 46, 2014)

4.5 Taxi supply

In 1970 there were 2,370 taxis licensed in Vienna. This number gradually rose until 1994 when there were 4,795. Thereafter the number of taxis declined by 19 % until 2007, only to rise again up to 4,643 licensed taxis until 2014. The introduction of the 24-hour metro service at weekends in 2010 did not impact the supply of taxis.

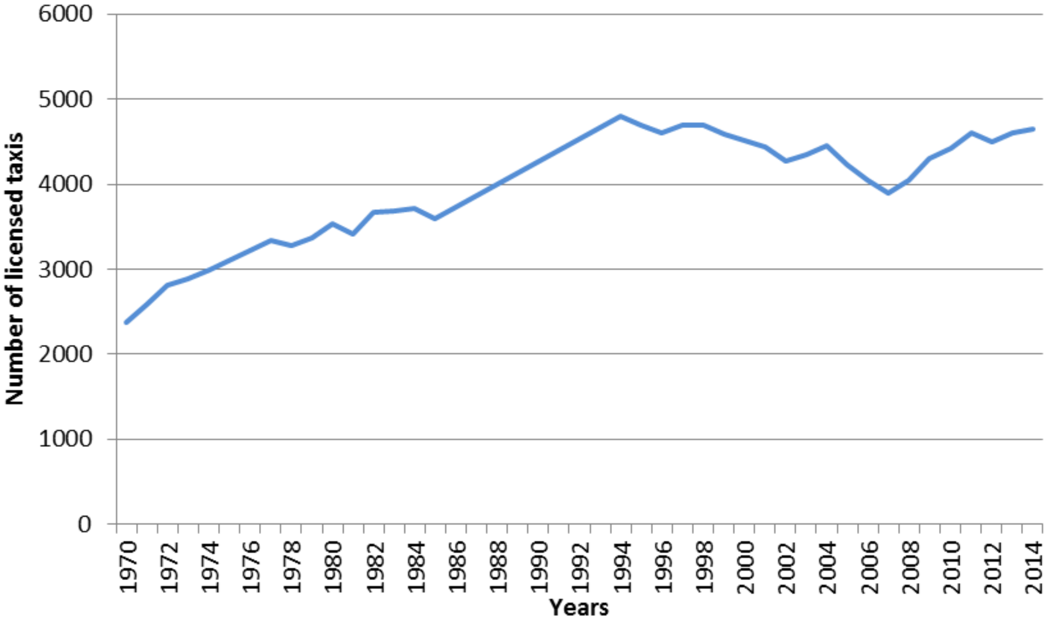


Figure 4-13: City-wide development of the number of licensed taxis

Source: (Magistrat der Stadt Wien, various years 1970 to 2014)

4.6 Car sharing

The first car sharing organisation of Vienna was founded in 1994 and by 1996 there were 59 cars available across all of Austria (Kumer & et al., 1997). Currently, there are three main car sharing companies - Car2Go, DriveNow, ZipCar - and 7,000 users (Carsharing Wien, 2016). Car2Go operates with 630 vehicles across the city and offers one-way point-to-point rentals. The charge is € 0.31 per minute, discounted fixed rates for hourly or daily usage are also available, and fuel is included. DriveNow has a fleet of 400 vehicles which can be rented across an area of 81 km^2. The rate per minute is € 0.34 and fuel is included as well. ZipCar provides a wider variety of car models, especially larger ones that are better suited for transporting goods. The company operates with 50 cars which have to be picked up and dropped off at the same location. Its hourly rate starts at € 7 depending on the model of the car. Fuel for the first 80 km is included.

5 Transport policies

5.1 Private motorized transport

Private car transport access restrictions

Access restrictions, particularly for the inner-city area, have been discussed repeatedly over the last years. In 2010 a referendum was held on the introduction of a congestion charge for the inner-city districts of Vienna (Wien-konkret, 2010b). As 76.5 % of the people decided against such a metering scheme, with a voter turnout of 36 %, the city government decided to focus on implementing a parking management system instead.

Parking regulations, priority zones for residents and time restrictions

In the 1960s Vienna implemented a short-term parking management system in specific sections within the inner-city (BMVIT, 2012). The entire first district – the city-centre – was turned into a short-term parking zone in 1993 and in subsequent years short-term parking was extended in specific sections in inner- and outer-city areas. By 1999 an inner-city-wide parking management system was in place. Since 2012 several outer-city districts have been gradually integrated into this system. Residents of the particular districts can purchase an annual parking ticket which excludes them from short-term parking time restrictions in their home districts and certain adjacent areas. Within the inner-city the parking regulation are generally valid on workdays from 9 a.m. to 10 p.m., in the outer-city districts from 9 a.m. to 7 p.m. The maximal parking duration is 1.5 hours. From 1986 to 2002 the price for one hour parking in a short-term-parking zone was 0,87 € and even decreased to 0,80 € due the conversation from Schilling to Euro, i.e. index adjusted the price for parking decreased over this time period. From 2006 to 2012 a one-hour parking ticket cost € 1.20, afterwards € 2, which means that the prices were increased significantly in last decade (Wien-konkret, 2013). Nowadays, these tickets can also be ordered with a smartphone application. Fifteen-minute parking tickets are free of charge. The annual parking permit for residents costs € 120 for the inner-city districts and € 90 for the outer-city districts, plus € 35.70 administrative fee (€ 30.70 for online application). Upper limits of the fees for residents are not specified.

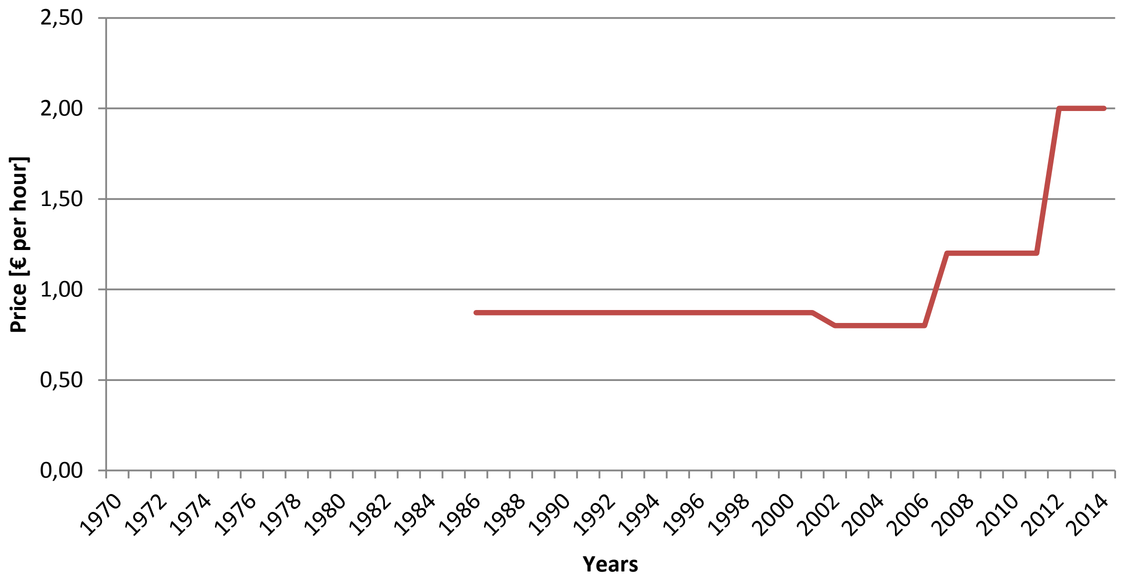


Figure 5-1: Development of the price for one hour parking in a short-term parking zome [€ per hour]

Transport demand management

In 2009 the graph integration platform GIP, a geographic information system network, was founded (GIP, 2012). This platform began collecting incident records for digital traffic management with public transport and individual traffic detection as well as floating car data from 3,500 taxis. GIP was implemented in 2013 and provides data for the routing application AtoB (AnachB) for public transport, cycling, walking and driving as well as a combination of these travel types (Stadt Wien, 2016).

Description of development of the annual average fuel prices (diesel and petrol)

In 1970 the annual average net fuel prices in Austria were € 0.18 per litre diesel and € 0.28 per litre petrol. Due to the first oil crisis in 1973, diesel and petrol prices rose by 50% (BMVIT, 2012). The second oil crisis in 1980 caused the diesel price to go up to € 0.59 per litre and the petrol price to € 0.72. In the second half of the 1980s the fuel market recovered and the diesel price sunk by 30% and the petrol price by 22% until 1992. Afterwards the fuel prices rose gradually until they peaked in 2008 – diesel at € 1.40 and petrol at € 1.45 - due to the financial crisis. Thereupon they decreased substantially and afterwards developed more moderately in accordance with the crude oil price. In 2014, the average diesel price was € 1.29 per litre and the petrol price € 1.34. Correspondingly, the fuel taxes were raised in 1973 from € 0.08 to € 0.13 for diesel and from € 0.1 to € 0.125 for petrol. Subsequently, the taxes were raised by € 0.05 in the years 1981, 1988 and 1995. Thereafter they were increased gradually and by 2014 the taxes on diesel and petrol per litre were € 0.39 and € 0.48 respectively.

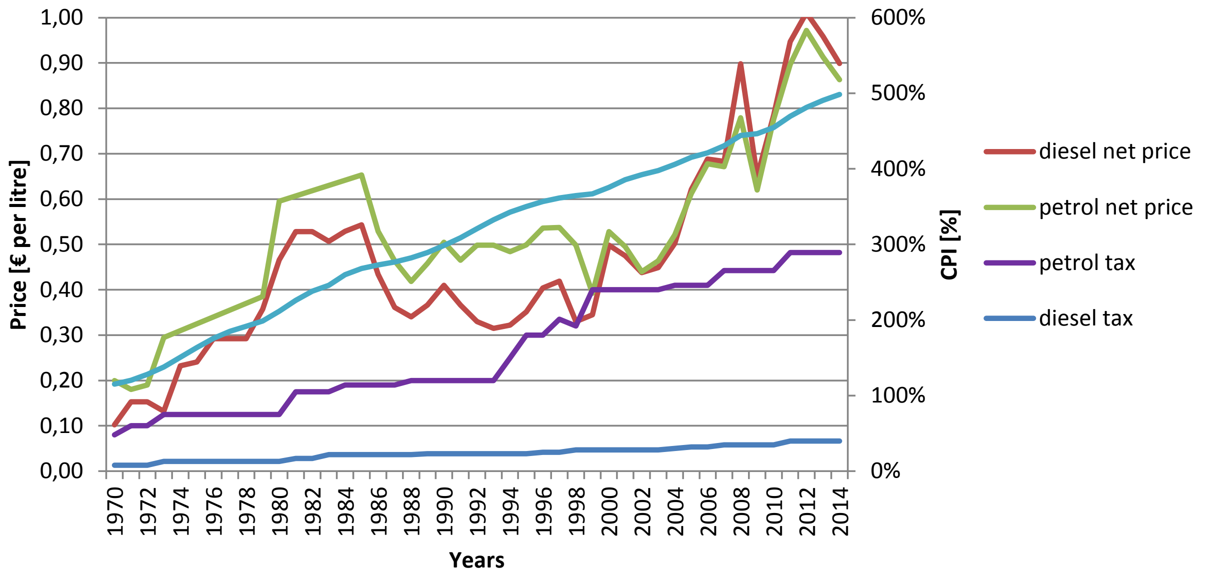


Figure 5-2: Development of nominal annual average fuel prices (diesel and petrol) distinguished between net values and taxes [€ per litre]
Source: (BMVIT, 2007), (ÖAMTC, 2016), (BMVIT, 2012), (Puwein, 1995)

Average costs of private car

A calculation of the costs of private cars was carried out in 2010 by Herry Consulting (BMVIT, 2012). The cost structure was based on the average of the 9 most commonly licensed car brands in Austria, assuming a 5-year usage and a mileage of 12,000 km per year. The calculated fixed costs per month were € 104.22, the total costs € 469.89 per month and the average total costs per kilometre amounted to € 0.47.

5.2 Public transport

Priority for public transport at intersections

In 2014 the traffic light circuit at several specific intersections in Vienna was adapted to tram and bus journeys (Magistratsabteilung 53, 2015). Additionally, the separated public transport infrastructure is being expanded to further increase travel speed.

Subsidies for public transport

To increase public transport use in Vienna the government subsidises its operation by 40 %, half of which is financed by the city, the other half is from the national budget (Die Presse, 2015). This annual subsidy amounts to 500 million euros. A bonus-malus regulation has also been introduced, and will be implemented in 2017 to ensure lasting compliance. The regulation evaluates the actual transport supply as well as quality criteria such as customer satisfaction, accessibility, cleanliness and safety. Without the governmental subsidy the price of the annual public transport ticket might be double its current price of € 365.

6 Transport demand and access to transport modes

6.1 Access to transport modes

6.1.1 Private car ownership and driving licence possession

At the beginning of the 1970s there were 236 private cars per 1000 inhabitants within Vienna. Until 2001 the motorisation rate rose consistently by an average of 2.3 % every year. Thereafter the number of private cars per 1000 inhabitants decreased from 414 to 387 in 2014. This trend of declining motorisation was incidentally affected by the population growth while the absolute number of cars in Vienna still rose by 37,000 within this period.

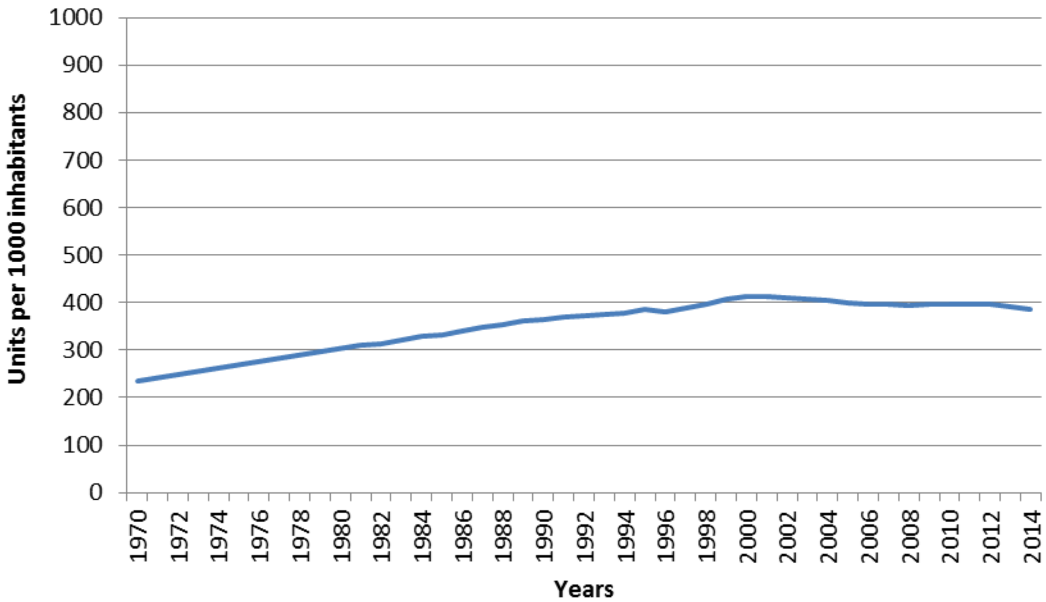


Figure 6-1: City-wide development of the number of private cars per 1000 inhabitants

Sources: (Statistik Austria, 2013), (Statistik Austria , 2015), (Magistrat der Stadt Wien, various years 1970 to 2014)

6.1.2 PT yearly season pass ownership

In 1995, 155 out of 1000 inhabitants had an annual season ticket for the public transport service. Over the following fifteen years, the public transport services increased their regular customer base steadily by 2.4 %. In 2011, 219 out of 1000 inhabitants owned a yearly ticket. The price reduction to a 'one-Euro-a-day'- season ticket caused a noticeable increase. By 2014 pass ownership had risen to 368 out of 1000 inhabitants.

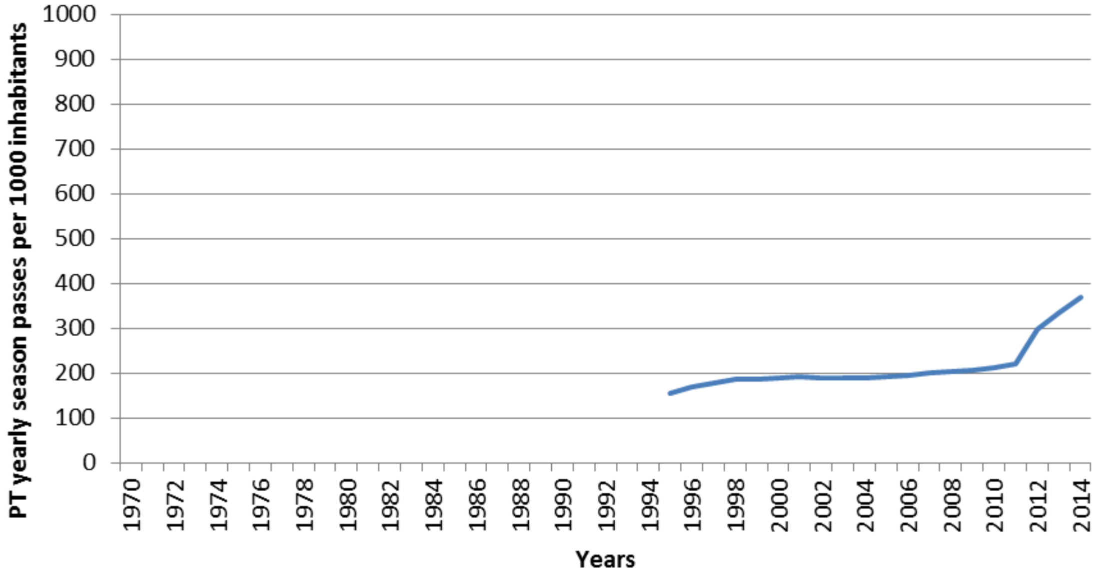


Figure 6-2: Development of number of people with PT yearly season passes [passes per 1,000 inhabitants]

Source: (Wiener Linien, 2002), (Wiener Linien, 2004), (Wiener Linien, 2007), (Stadt Wien, 2007), (VOR, 2014), (Statistik Austria, 2016)

6.1.3 Bicycles ownership

The number of households in Vienna which owned at least one bicycle increased from 58 % in 2003 to 61 % in 2010 (Magistratsabteilung 18, 2013). On average there were 591 bicycles per 1,000 inhabitants in 2003 and 627 by 2010 (Figure 6-3). By 2014 the number had slightly decreased to 620 bicycles.

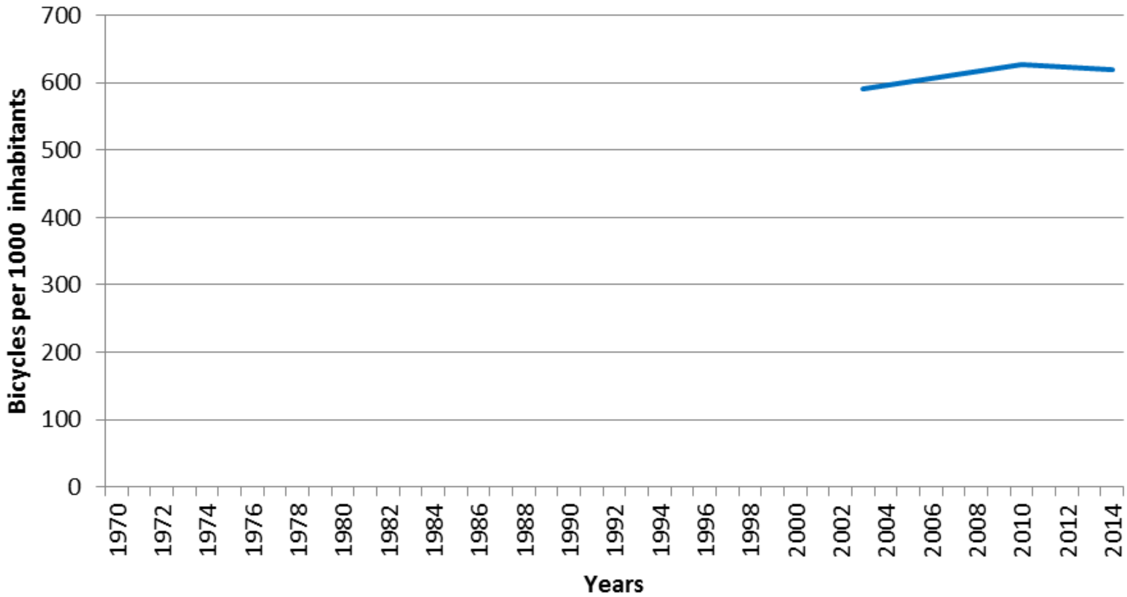


Figure 6-3: City-wide development of the number of bicycles per inhabitants [bicycle per 1,000 inhabitants]

Sources: (Magistratsabteilung 18, 2013), (Die Presse, 2014)

6.2 Individual travel behaviour

6.2.1 Average number of trips

In 1986 an inhabitant of Vienna made 2.74 trips per workday on average, compared to 3.4 trips made by every mobile person. A mobility survey performed by the same company in 1991 showed a slight increase to 2.85 and 3.44 trips respectively. In 1995, their survey yielded an average of 3.2 trips made by every inhabitant and 3.6 trips by every mobile person. In 2000 and 2009, the average trip rate was again lower at 2.7 and 2.8 for every inhabitant of Vienna. The 2014 survey shows a further decrease to 2.57 trips per inhabitant and 3.14 trips made by every mobile person.

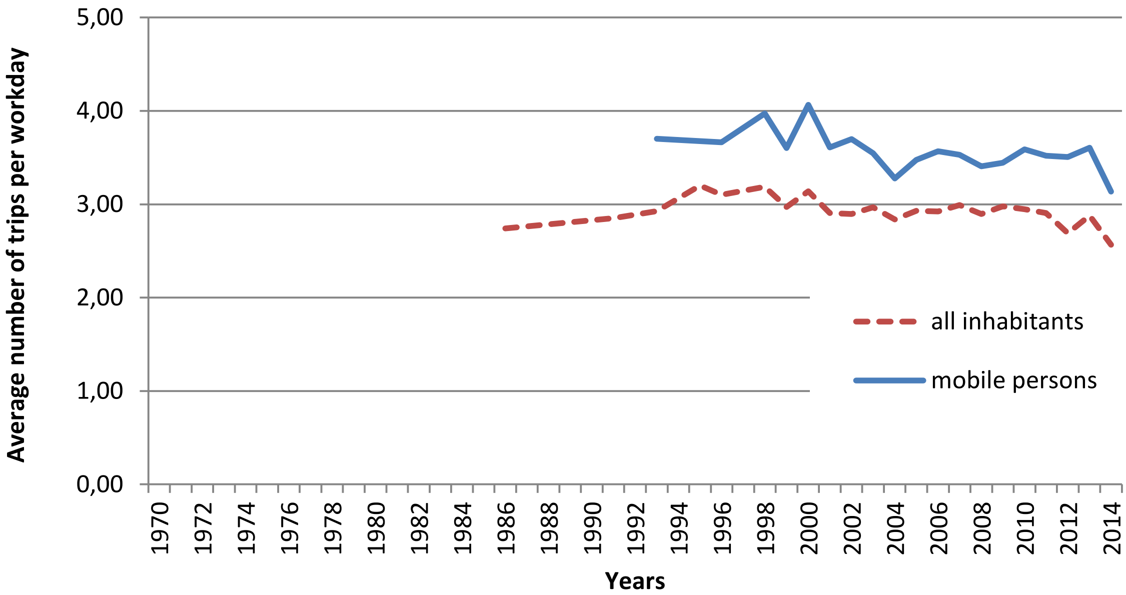


Figure 6-4: City-wide development of the average number of trips per inhabitant, mobile person and workday (including non-mobile persons) [trips / workday]

Source: (Herry & Snizek, Verkehrsverhalten der Wiener Bevölkerung 1991, 1993), (Herry & Sammer, 1999), (Socialdata, 1993-2009), (Socialdata, 2010), (Omnitrend, 2010 - 2014)

6.2.2 Average mileage (per trip maker and day)

In Vienna the average mileage per person and workday was 25.5 kilometres in 1986. Surveys from 1993, 2000 and 2009 show a mean mileage of 19 kilometres. In 1995 the average mileage was 21.6 kilometres. In 2010 the survey method was changed from postal to telephone survey and the trips only within the city were considered. Thus, the average total millage decreased to values from 13.5 to 15.5 km per workday.

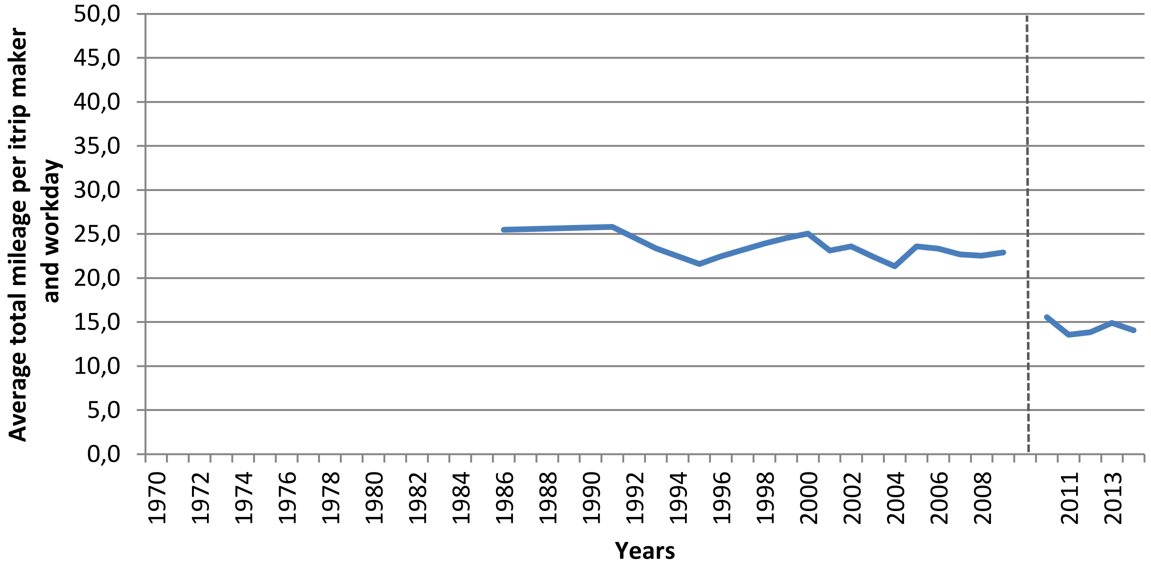


Figure 6-5: City-wide development of the average total mileage per trip maker and workday [km / 24h] (dotted line indicates change of survey methods)

Source: (Herry & Sammer, 1999), (Herry & Snizek, 1993), (Socialdata, 1993-2009), (Socialdata, 2010), (Omnitrend, 2010 - 2014)

6.2.3 Average trip length

In 1993 the average pedestrian trip length was 0.9 kilometres. In 2011 it was 0.8 kilometres, and a survey for the year 2014 yielded an increase to 1.28 kilometres. Bicycle trips had an average length of 2.6 kilometres in 1993. Surveys from 2006 and 2014 showed a longer distance with 3.9 and 3 kilometres respectively. The average length of car trips registered a slight decrease from 7.8 kilometres in 1993 to 7.5 in 2001 and finally to 6.5 in 2014. Car passenger trips had an average length of 6.8 kilometres in 1993 and 5.3 kilometres in 2014. Public transport trips registered an increase from 6.3 kilometres in 1993 to 7.6 kilometres in 2006. The 2014 survey, however, showed a shorter length with 5.5 kilometres per trip. A survey in 1993 yielded an average trip length for motor-cyclists of 3.1 kilometres; the 2014 length was 7.44 kilometres.

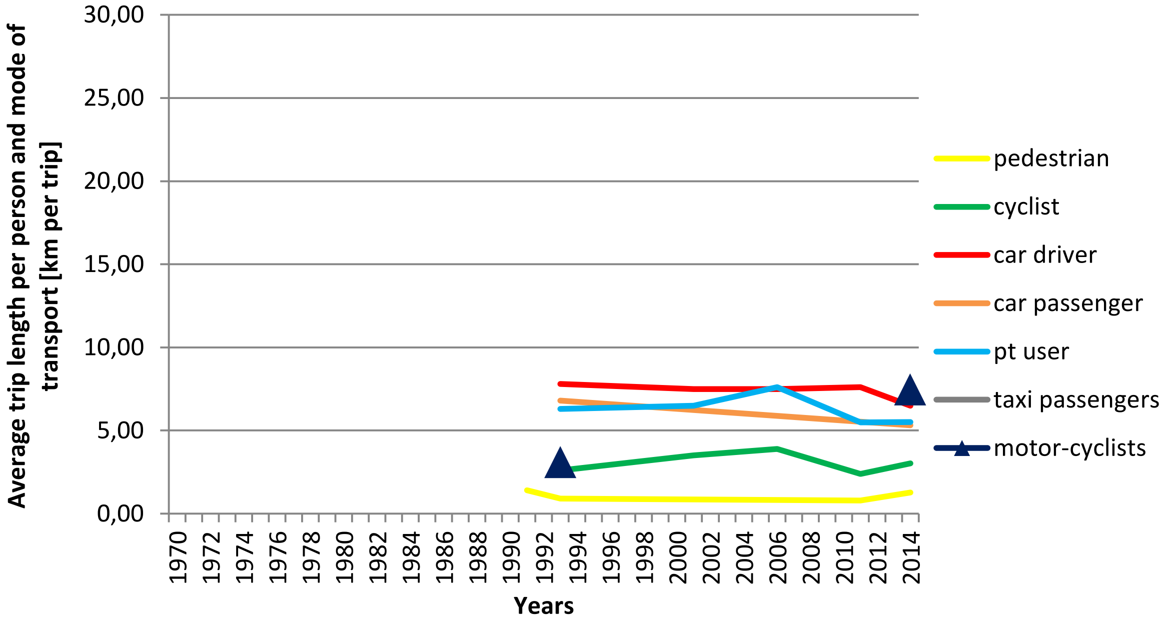


Figure 6-6: City-wide development of average trip length by mode of transport (km per trip)

Source: (Herry & Snizek, 1993), (Socialdata, 1993-2009), (Socialdata, 2010), **(Omnitrend, 2010 - 2014)**

6.2.4 Modal split of the inhabitants

In 1986, 37 % of the trips were made by public transport, 36 % by car (28 % as a driver, 8 % as a passenger), 23 % were pedestrian and 3 % cycling trips. The share of public transport trips decreased slightly to 32 % in 1998, but the recent survey shows a recovery with a share of 35 % in 2009. The share of car driver trips peaked in 1991 at 30 %. Thereafter, it decreased gradually to 24 % in 2009. Pedestrian trips have consistently remained at about 27 % within the last decades. The share of cycling trips had increased moderately to 6 % by 2009. Since the year 2010 the mobility survey has been carried out by Omnitrend, no longer postally but via telephone. This change in methodology is indicated by the dotted line in Figure 6-7. The telephone survey yielded a decrease of car driver trips to only 19 % in 2014, while the share of public transport trips increased from 36 % in 2010 to 39 % in 2014. The bicycle share was 7 % in 2014.

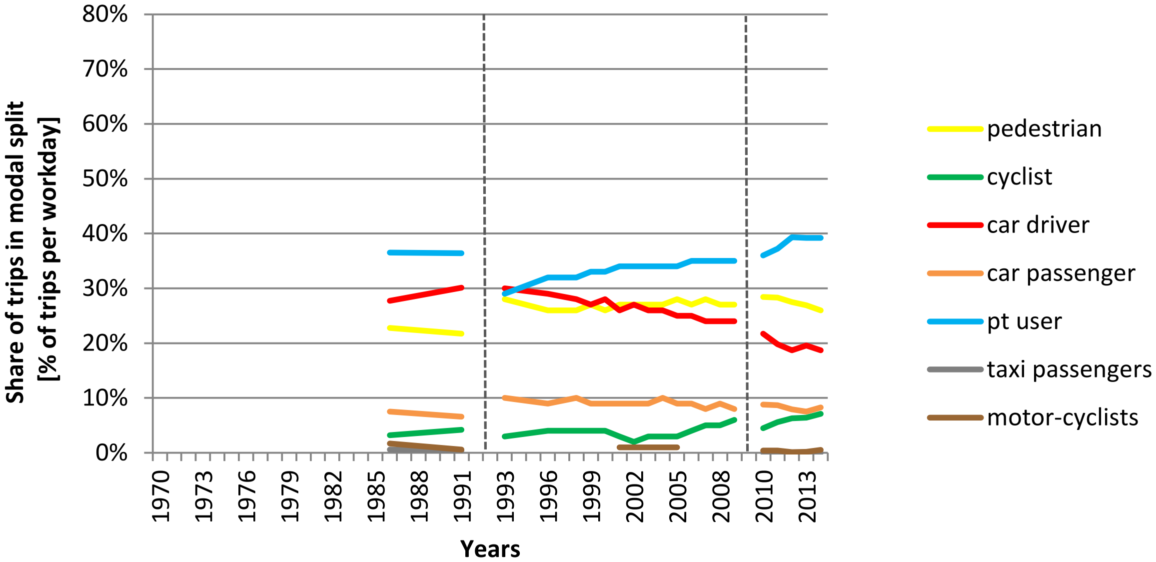


Figure 6-7: Development of modal split of inhabitants (workday) [% of trips] (dotted line indicates change of survey methods)

Sources: (Herry & Snizek, 1993) (Socialdata, 1993-2009), (Omnitrend, 2010 - 2014)

6.2.5 Trip purpose

The city-wide mobility surveys from 1986, 1991 and 1996 were carried out postally by Herry Consulting and yielded rather differing trip purpose distributions for those years. Work or education was named as trip purpose for 41 % of the trips in 1986 and 1996, and for 47 % of the trips in 1991 (Figure 6-8). The category shopping and errands shows a similar variation with a 36 % and 33 % share in 1986 and 1996 respectively and a noticeably lower share of 28 % in 1991. The rate of leisure trips followed a more constant trend and increased gradually from 21 % in 1986 to 35 % in 2014. A telephone survey carried out in 2014 yielded a 32 % share for trips with the purpose work or education as well as shopping and errands.

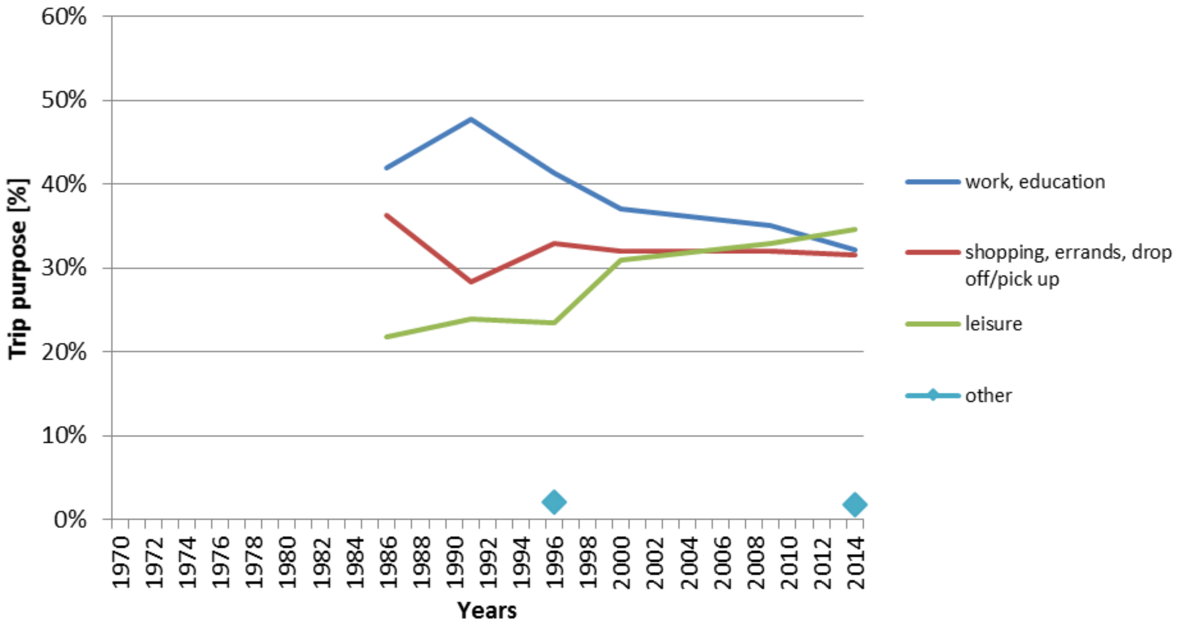


Figure 6-8: Development of the trip purpose
Sources: (Herry & Sammer, 1999), (Herry & Snizek, 1993), (Socialdata, 2010), (Omnitrend, 2010 - 2014)

6.3 Aggregated travel behaviour

6.3.1 Annual road traffic volume

Within Vienna numerous automatic traffic monitoring systems have been in operation since the 1970s. In order to illustrate a development trend of the average annual road volume, 26 relevant counting stations across the city have been selected (Figure 6-10). In 1995 the combined annual average daily traffic of these 26 cross sections was 1,080,113 cars / 24h across both directions (Figure 6-9). The busiest cross section in 1995 was on the road encompassing the inner-city districts with 80,482 cars / 24h. The annual average daily traffic of this specific road section decreased over the following five years by 5 %, rose by 8 % until 2005 and finally sank to 75,389 cars / 24h in 2010. The combined annual average daily traffic of the 26 cross sections decreased by 1% from 1995 to 2000, rose by 5% within the following five years and decreased again by 5% until 2010. In that year the cross sections recorded 1,071,272 cars / 24h.

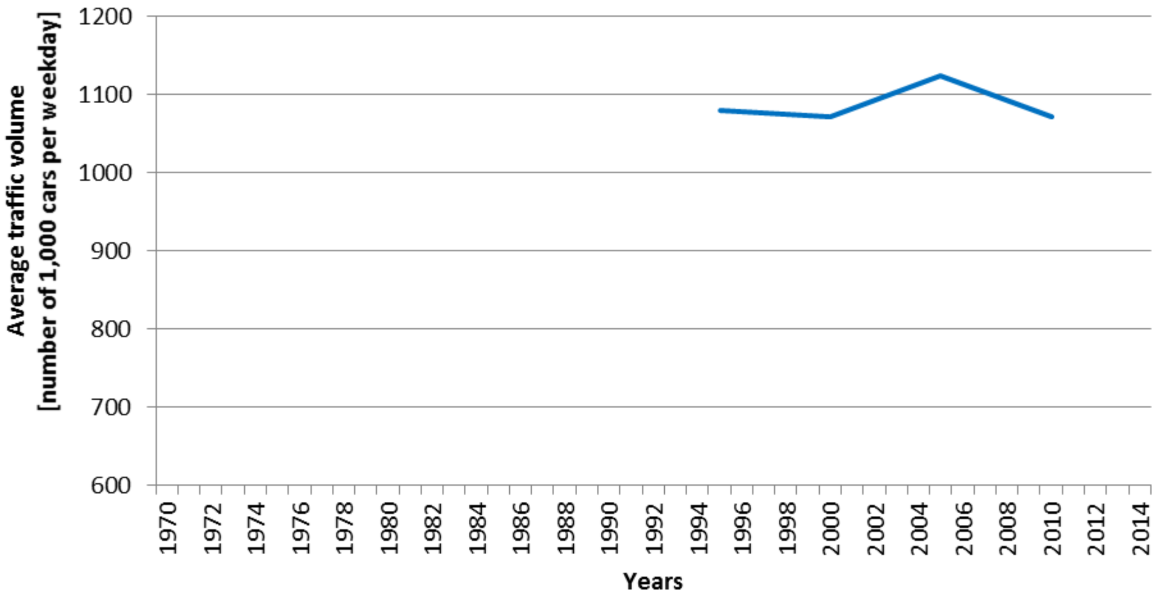


Figure 6-9: Development of total average cross sectional road traffic volume of 26 selected automatic count stations per weekday [1,000 cars / 24h]
Source: (Käfer & Fürst, 2011)

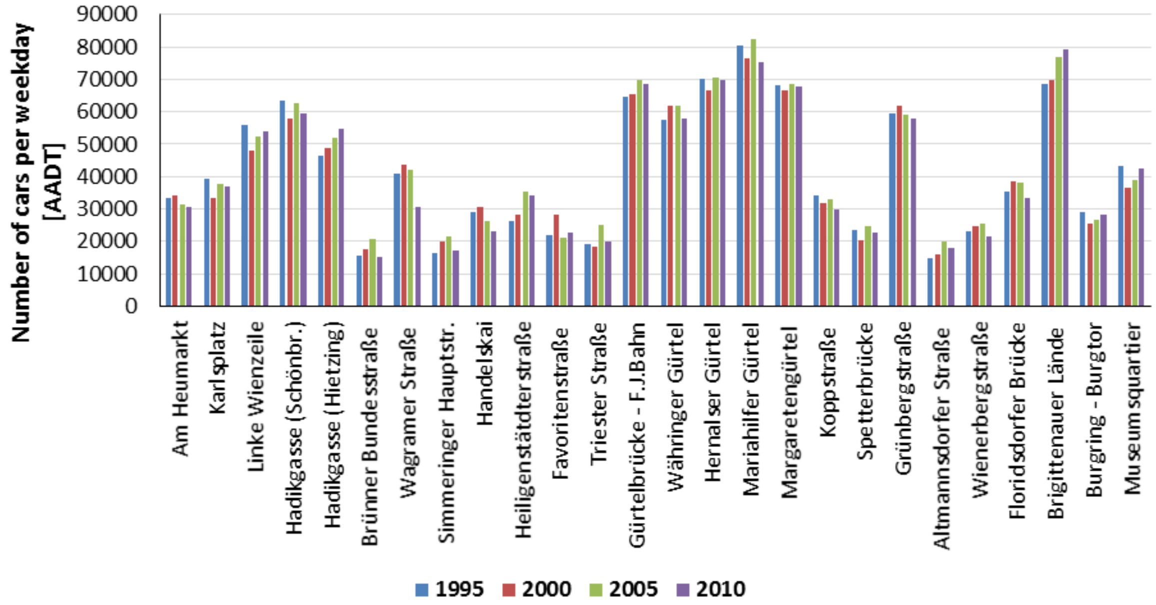


Figure 6-10: Development of annual average daily road traffic volume of 26 selected automatic count stations [cars / 24h]
Source: (Käfer & Fürst, 2011)

6.3.2 Average speed level

A mobility survey from 1991 yielded an average travel speed of 27.5 km / h for cars in Vienna (Herry & Snizek, 1993). In 1995 the speed level had decreased to 24 km / h (Herry & Sammer, 1999). The recent mobility surveys from 2010 to 2014 show a gradual decline from 20.5 to 19 car kilometres per hour (Omnitrend, 2010 - 2014).

6.3.3 Annual PT passenger trips

In Vienna the total number of annual public transport passenger trips has more than doubled within the last 45 years. In 1970 the public transport services accommodated 420 million passenger trips, the majority of which were tram or city railway trips. The continual expansion of the public transport system and the population growth resulted in an increase in annual passenger trips. The first commissioning of the metro, and in particular its expansion in 1982, led to an increase in tram, city railway and metro passenger trips to 453 million in 1983. By 1999 the total number of trips per year had risen to 669 million, with 549 million trips attributed to tram, city railway and metro services and 111 million to bus trips. Since 2001 the passenger numbers have distinguished between tram and metro. Until 2011 passenger trips were allocated to the different public transport modes according to the respective scheduled seat kilometres, thereafter on the basis of actual passenger counts. This resulted in a visible shift between metro, tram and bus passengers. In 2014 the metro accommodated 305 million passenger trips, the tram and city-railway 440 million and the bus services 187 million.

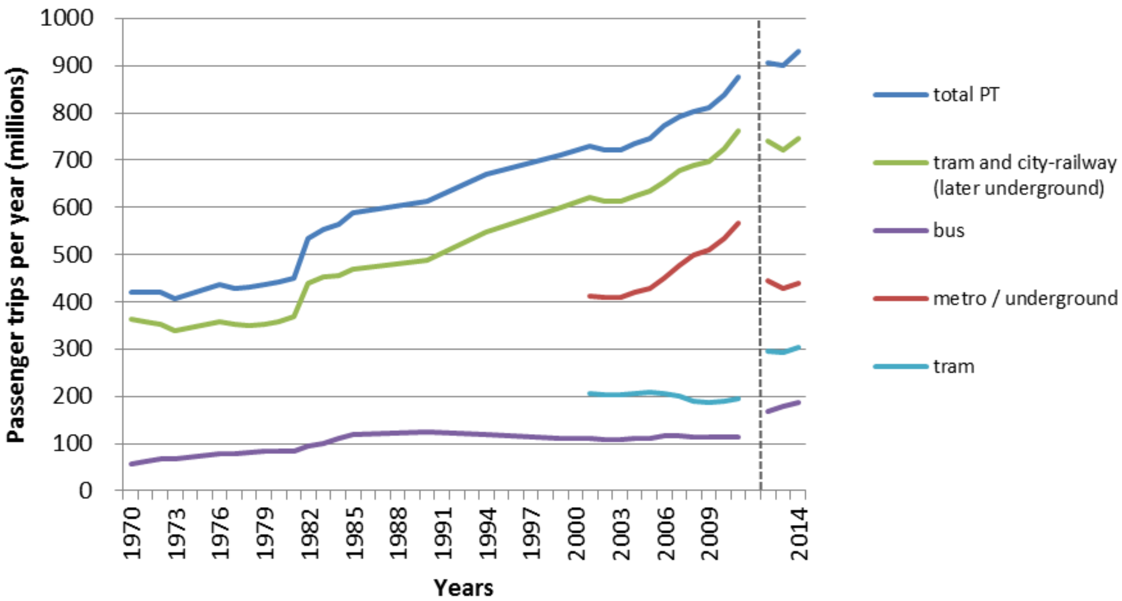
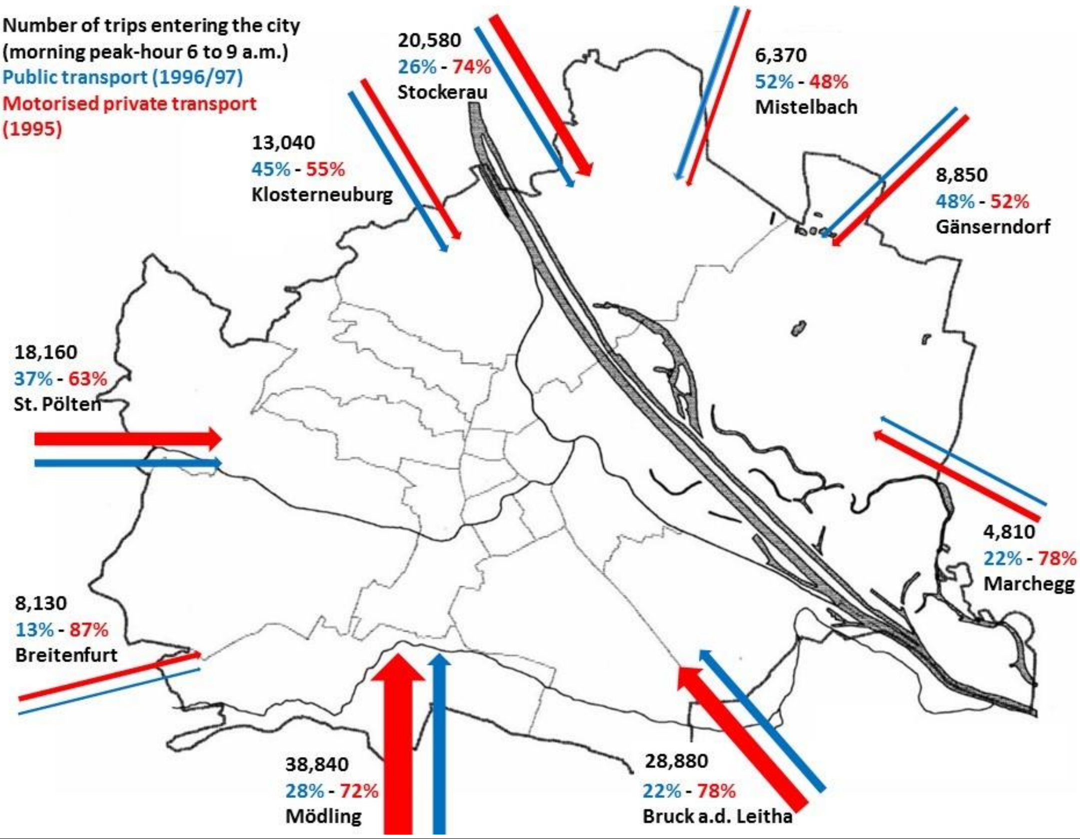


Figure 6-11: City-wide development of the number of PT passengers [million trips / year]
Sources: (Magistrat der Stadt Wien, various years 1970 to 2014)

6.3.4 Trips entering the city

A survey of trips entering the municipal area of Vienna between 6 a.m. and 9 a.m. from the 1990s shows a share of 70 % of private motorised transport for a total number of 147,660 trips (Figure 6-12). The largest commuting area is in the south of the city; from Mödling alone 38,840 trips entered Vienna, with only a 28 % share of public transport. A recent survey from 2010 shows an increase of trips by 54 % from this area. The total number of trips has increased by 47 % to 172,036 trips between 5 a.m. and 9 a.m. The public transport share grew by 2 %. The number of trips entering the city from the east increased the most within those 15 years - trips from Marchegg by 66 % and from Gänserndorf by 69 %.



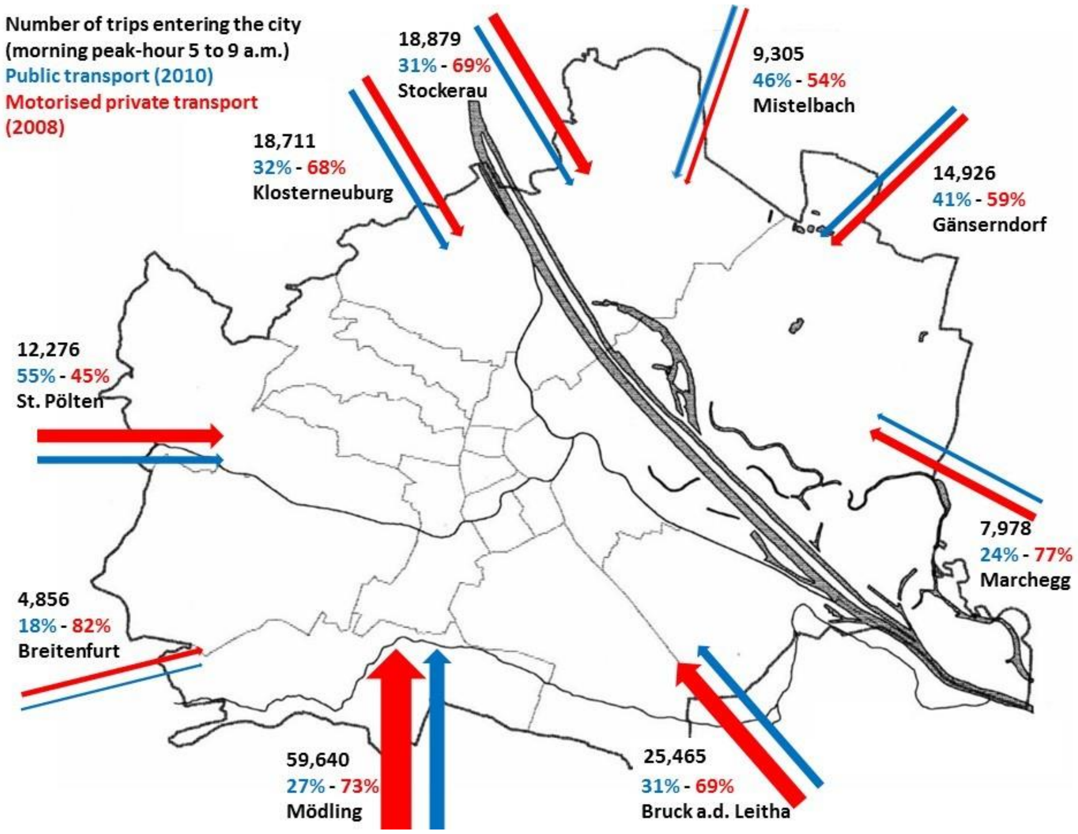


Figure 6-12: Development of the number of trips entering the city (morning peak hour)
Source: (Magistratsabteilung 18, 2001), (Ritter, 2011)

6.4 Mindsets, attitudes, mobility cultures

Changes in the attitudes towards sustainable mobility were identified recently. Both passenger car ownership and passenger car trips of young adults are stagnating or have declined since the end of the 1990s (Magistratsabteilung 18, 2013). This development can be explained by changes of socio-economic framework conditions (income, employment status, household size), but also by changes of attitudes towards mobility (Institut für Mobilitätsforschung, 2011). Moreover, a general social trend is "using instead of owning", which is associated with increased demand for conventional car sharing or new car-sharing models (free floating), bike rental systems and even more flexible approaches in transportation (Arthur D. Little, 2012).

In September 2016 a study about the status of the car has been published. The results show that the car (still) has a high-ranked value, however, car use will steadily decrease driven by the socio-demographic developments in the city. The population group of the under-35s is the fastest growing one. In this age segment car use and car-ownership is less than the average, although these people might feel the wish for a car as well. However, nowadays the entry in the labour market is later, which means that people of this age-group have less disposable income and define other priorities than buying a car (Ringler P., Hoser B., 2016).

A key element of successful "Intelligent Mobility Policy" in the city of Vienna is the promotion of sustainable transport policy and to raise the awareness among transport users and opinion leaders. Survey commissioned by the Viennese transport operator as well as a quality of life study showed the changes in the perception of green modes. For example, in 2008 35% rated the performance of the public transport as very good. This value increased to 50% in 2013. The perception of the cycling network increased from 19% of respondents saying that it is very good to 23% in 2013 (Magistratsabteilung 18, 2013).

6.5 Travel behaviour and policies

This chapter deals with the comparison of transport policies and transport measures in the city with the development of the modal split, in particular the reduction of car use and the increase of environmental-friendly mode use. As it is not possible to analyse the impact of each particular measure implemented in the last 40 years having an influence on the mode choice of transport users (e.g. improvement of public transport rolling stock, separated bus lanes, public transport priority at traffic signals etc.), we decided to focus on milestones in the development of the transport system (e.g. metro network development or car-restrictive measures), although the whole transport system is always influenced by a bundle of bits and pieces. However, general trends can be identified (Figure 6-3).

Transport policy in the City of Vienna was dominated by car-oriented masterplans up to the 1970’s. A network of motorways crossing the city was planned to be established. In line with this way of thinking, several tram lines were converted into bus lines, however, the main tram network stayed alive. The opening of the metro network started in 1978, however, it is said, that the construction of a metro system at this time was not only to motivate people to use public transport more often, but also to generate new spaces for individual motorised traffic. For example, along the metro line U1 tramlines were removed and a 4-lane main road was built instead. Pedestrian underpasses were built in order to have less disturbance of the car traffic on the surface (e.g. along the ring road around the city centre). At the end of the 1970’s the length of cycle facilities was not more than 20 km. The inner city was crossed by to main roads passing St. Stephan’s cathedral.

In the 1980’s the environmental awareness increased. An impact of this was the stopping of further extensions of the inner-city main road network after pressure from residents and ecological movements. A lot of planned motorway connections were skipped or re-dimensioned. The transport and city development masterplan published in the 1980’s defined the acceleration of the public transport on the surface as one of the main goal for the city. Pedestrianisation started in the inner-city. At the end of the 1980’s 100.000 m² of pedestrian zone were built. However, car use still increased due to the booming economic situation, even the implementation of a paid-short-term parking zone in the first district (city centre) had no influence on this development. From 1986 to 1998 the share of car users (driver and passengers) steadily increased from 35% to 38%. Both, pedestrianisation and inner-city parking management seemed to motivate people more to shift from public transport to walking. From 1991 to 1999 the share of walking trips increased from 22% to 27%, whereas the public transport use decreased from 37% to 32 %.

A turn-around was achieved by the extension of the paid-short-term parking zone to all inner-city districts at the end of the 1990’s as well as the opening of further extensions of the metro network. The trend of increased car use could be stopped and reversed. 1999 were the first year where car use dropped. Although a lot cycle facilities were built in the 1990’s the share of cycling trips stayed almost stable at 4 %.

At the beginning of the first century pedestrian zones were further increased, in 2005 190.000 m² were opened. This was the first year showing equal values in the modal split for public transport and car use (34%). However, walking stayed almost stable. A noticeable development can be identified in the recent years. In 2010 the Green Party became part of the government of the city in a coalition with the socialist party and the councillor for transport was a member of the Green Party. A bundle of measures were implemented since then. Pedestrian zones were extended (plus 60.000 m² from the year 2005 to 2010), the third phase of the metro network was opened (in total 75 km now), but most important seemed to be the reduction of the annual public transport ticket price (from 450€ to 365 €) and further extensions of paid-short-stay-parking zones to furthe city districts. Unfortunately, the survey methods were changed in 2010, so that the figures of the past are not fully comparable with the recent ones, but a general trend can be identified. Due to the bundle of measures the share of public transport trips increase to 39% (an all-time high value since the 1980’s), whereas the share of car trips dropped to 26%. Together with the extension of cycling facilities this bundle of measures mentioned above seemed to influence the use of bikes as well. From 2005 to 2014 the share of cycle trips increased from 3% to 7%.

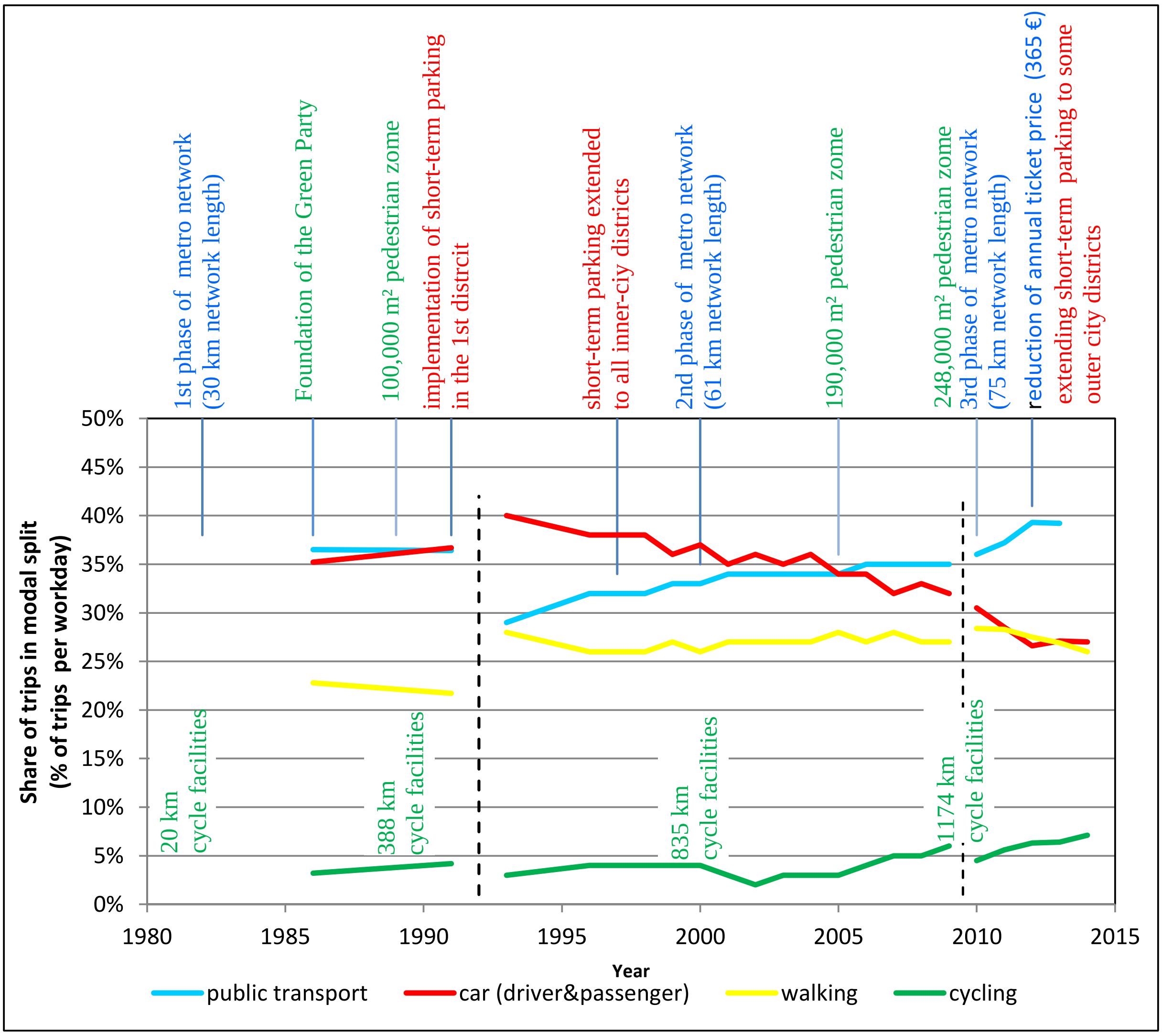


Figure 6-13: Mode share indicated by policy actions (dotted line indicates a change of the survey method).

Source: Sources: (Herry & Snizek, 1993) (Socialdata, 1993-2009), (Omnitrend, 2010 - 2014) , (Stadt Wien, 2013b), (Magistrat der Stadt Wien, various years 1970 to 2014)

7 Freight Transport

The city development plan of 1984 defined two milestones for the organisation of freight transport of the city: The construction of a rail freight terminal in the southern part of the city for preparation of freight waggons and handing of goods should attract more rail-based freight transport towards the city and upgrade the inner-city rail infrastructure to be used for distribution. Road freight transport should be bundled at the border of the city. The transport masterplan of 1994 described a bundle of measures to decouple passenger rail and freight transport und to optimise the rail freight transport in the city. A second major rail freight terminal was proposed. The city development plan for 2025 described strategies to strengthen the position of the in-land harbour of the river Danube and to improve the local-level distribution of goods including the possible use of environmental friendly modes.

Data of freight transport towards the city of Vienna are online available as time series from 2004. Further historical data could be found for 1991. Notwithstanding the fact of economic development having an influence of the total tons of freight volume, the data show a slight increase of road freight transport, which is the dominate mode of freight transport heading the city of Vienna (including internal traffic within the city). However, after 2008 the share of rail-based freight transport increased slightly from 10.5% to 14.5 in 2011 but dropped afterwards. Freight transport by ship using the river Danube still plays a minor role (Figure 7-1)-.

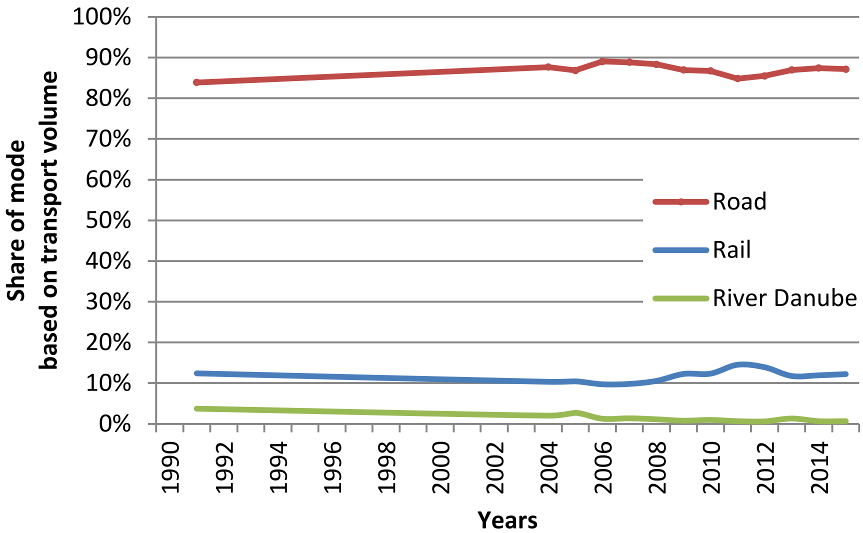


Figure 7-1: Share of modes (based on transport volume) heading the city of Vienna (including internal traffic)

Source: (Statistik Austria, 2004 - 2015), (Hiess et al, 1994)

8 Conclusions

In 1970 Vienna had about 1.62 million inhabitants with a decrease of the population until 1990. Thus, even the increased values of car ownership rates in the city did not affect the road based transport system seriously as the road capacity could cope with it, represented in the increase of car users shown in the modal split. This situation changed completely from 1991 onwards due to mitigation caused by the war in former Yugoslavia, the dissolution of the Soviet Union as well as the communism in Eastern Europe and accession of Austria (and other neighbouring countries) to the EU. The iron curtain was cut down and freedom of travel was possible; Vienna was and is a popular destination since then.

As in most of the capital cities in Europe, transport policy of the city of Vienna was mainly car-oriented up to the 1970's. Transport masterplans proposed a bundle of motorways and multiple lanes of main roads across the city. However, at the end of the 1970's and beginning of the 1980's environmental impacts of traffic become more and more an issue. The first main pedestrian zone was opened in 1974 in city centre by converting a main road axis for motorised traffic crossing the city centre, followed by the opening of first metro line U1 crossing the city. However, the car ownership rate increased steadily from 1970 to 2001 with an average value of 2.3% every year, but since then stays stable at about 400 (or even slightly less) cars per inhabitants.

Apart from numerous punctual measures aiming at shifting car users to environmental-friendly modes (e.g. public transport prioritisation due to separate bus lanes or at the traffic signal priorisation programme), the main pillars of transport policies focused on push-and-pull strategies. The metro network was continuously extended forming the backbone of the public transport system in order to make the use of public transport more attractive. At the same time paid short-term-parking restrictions were extended to almost half of the area in Vienna. Pedestrian zones were extended, mainly in the inner-city area and cycle facilities established. Additionally the price of the annual public transport ticket price in the city was reduced to 365 €, which was implemented in 2012.

It is obvious, that shifting car users to environmental-friendly mode is not depending on particular single measures, but on a bundle of transport measures aiming at making green modes more attractive for the inhabitants. In doing so, acceptance for car-restrictive measures among inhabitants was increased as people are getting aware of alternatives to car use in the city realising the positive overall impacts. However, it is not a self-driven process and a certain break-even point is needed, as shown in the values of the modal split. Even though the focus of the transport and spatial masterplans changed in 1980's the share of car users (driver and passengers) increased until 1998. Since then, possible as a result of push-and-pull measures, the share of car use drops.

The main challenge of the future in the city will be the increased number of people living in the city questioning if the capacity of the transport system is sufficient and can cope with the increased demand of more people living in the city even if if car use is reduced to a minimum level.

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