



# Wider Factors affecting the long-term growth in Rail Travel

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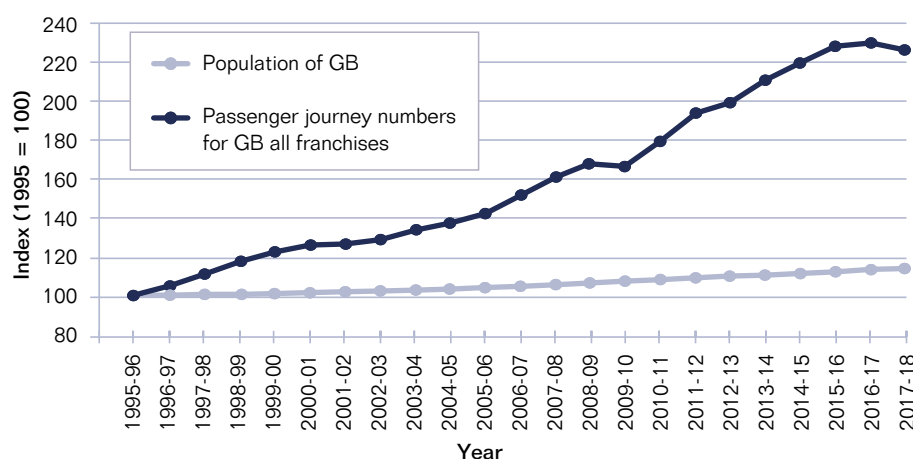
# Executive Summary

## I. Introduction

**1.1** The Independent Transport Commission (ITC) has a central interest in the changing nature of rail and road travel in Britain. Our research into this fundamental topic originated in the first 'On the Move' study published in 2012 and authored by Professor Peter Jones OBE and Dr Scott Le Vine. This used the National Travel Survey (NTS) to illustrate the dramatically changing travel trends in Britain since 1995.<sup>1</sup> This report was updated in 2016 by Peter Headicar and Gordon Stokes, and it confirmed that passenger rail growth had continued to rise strongly, at a significantly faster rate than predicted by forecasting models.<sup>2</sup> Only in the last couple of years has this growth ceased (although the most recent data for Q1 2018-19 shows an upturn in rail ridership).

**1.2** What has been causing this phenomenal growth in rail travel since 1995, such that the number of rail passenger journeys in 2016 hit the highest level since records began, even greater than in the Victorian heyday of rail? We know that the population of Britain has increased significantly since 1995, but as seen below [Figure A], the population has only grown by about 15% over this time period, while the number of passenger journeys has more than doubled.

**Figure A: Population growth vs Rail Passenger Growth for Great Britain, 1995-2018**



**1.3** Clearly, population growth alone is not enough to account for this rise in demand. In addition, we know that official forecasts of total rail passenger kilometres significantly underestimated the observed levels of demand. Many of these forecasting models have in the past relied on factors controlled by the rail industry. The ITC has therefore commissioned this research study to investigate some of the drivers of rail demand extrinsic to the rail industry, to help us better understand what has been causing the demand growth for rail travel in recent decades. We anticipate the findings will be helpful not only to forecasters, but also will help the industry comprehend better rail demand in England at a time when that rise in demand has recently levelled off.

<sup>1</sup> This report can be accessed online from the ITC webpage at: <http://www.theitc.org.uk/docs/47.pdf>

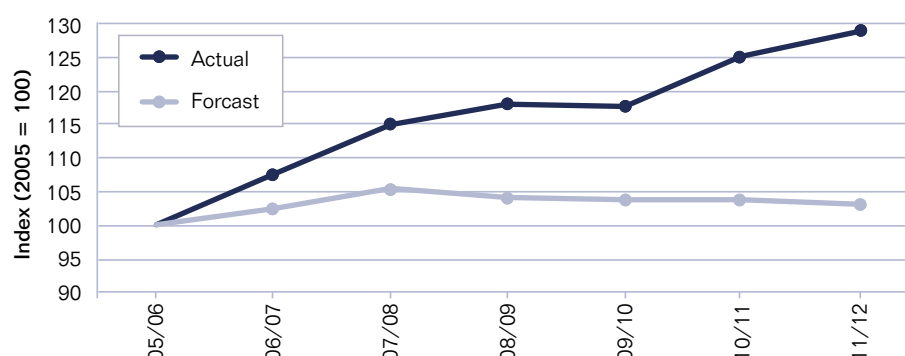
<sup>2</sup> The summary and policy analysis from this report can be accessed online from the ITC webpage at: <http://www.theitc.org.uk/wp-content/uploads/2016/12/ITC-Road-and-Rail-Travel-Trends-England-December-2016.pdf>



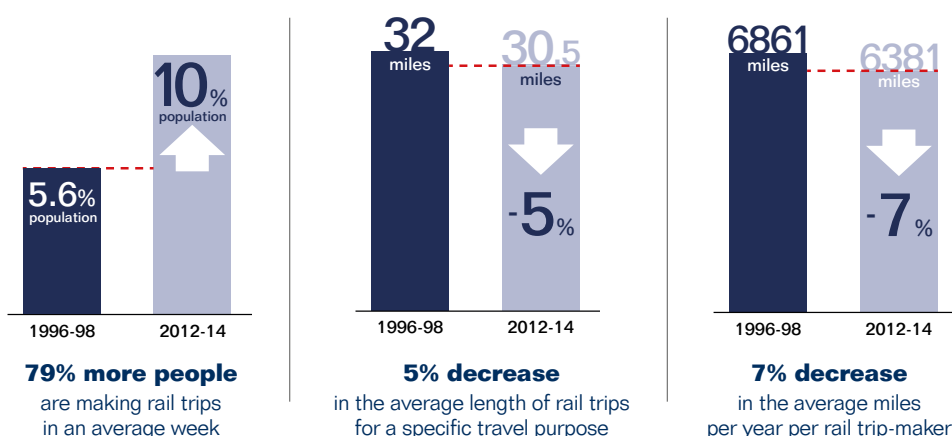
## 2. Key aims and scope of the report

**2.1** Growth in rail passenger demand has been high since 1995 largely due to a greater number of people making rail trips. This is shown by the fact that there is no evidence of strong growth trends through time either in the average number of rail trips made by individual rail travellers or in the average length of rail trips for specific travel purpose and traveller type combinations. Meanwhile, official forecasts of total rail passenger kilometres based primarily on factors under the influence of the rail industry (fares, frequency, comfort, etc) seriously underestimated the observed levels of demand over this period. Between the mid-2000s and the early-2010s, for example, growth was nearly 30% higher than forecast (Figure B). The underestimation has been observed across all the main rail markets, except for season ticket sales for journeys to/from London.<sup>3</sup> This suggests that factors outside the immediate control of the rail industry may be playing an important role in driving rail passenger growth, and that issue is the main focus of this study.

**Figure B: Actual rail travel vs forecast travel by PDFH (Index: 2005 = 100)**



(Source: Rail Demand Forecasting Estimation Study, 2015 (Leigh Fisher, Uni Leeds, et al.))

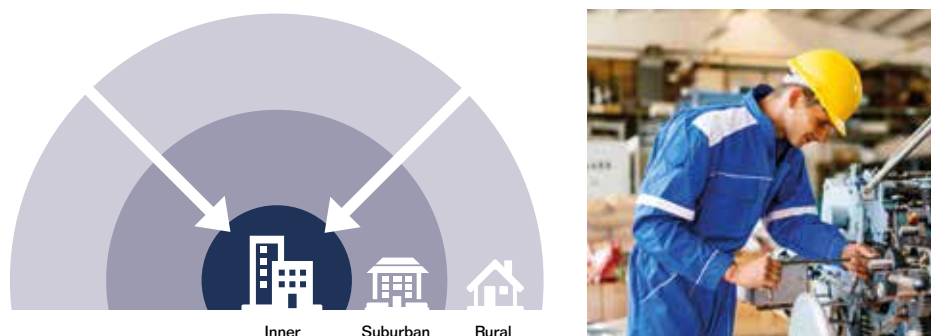


(Source: Recent Trends in Road and Rail Travel in England, ITC 2016; see also Table 1)

## 2.2

Accordingly, the researchers have explored potential reasons why many more people would choose to make rail trips now than before 1995, and have examined the factors that have contributed to unexpected trends in rail use in England. The focus of the report is, therefore, the identification of influential **factors external to the rail industry** and as such it does not cover all the factors affecting demand for rail travel such as supply. In particular, the researchers have chosen to focus on employment patterns and the spatial distribution of population over the long term. They have also chosen to give attention mainly to commuting - the largest journey purpose for rail - and business travel.

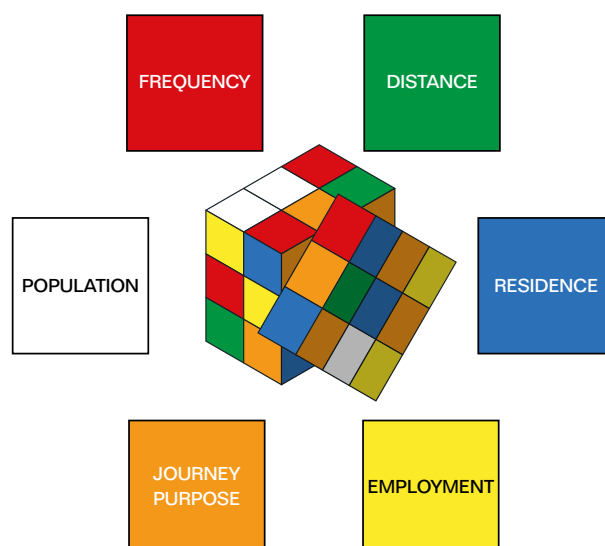
**Figure C:** More people today are living in city centres than in 1995.



## 2.3

The research has used National Travel Survey (NTS) data published by the UK Department of Transport for the years from 2002 to 2016 (the most recent data set available when the research was conducted), as well as ONS Census Data. For reasons of data availability, the analysis from the NTS data is limited to England whereas the Census Data considers the travel trends for England and Wales. The authors of this research study, Ian Williams and Kaveh Jahanshahi, have undertaken empirical research and utilised various statistical models to examine the factors influencing the growth in rail travel. Such analysis is technically complex but the report draws out the most significant findings from this work.

**Figure D:** Such analysis is complex since many variables interact and influence the emerging patterns.



### 3. Key factors affecting rail demand

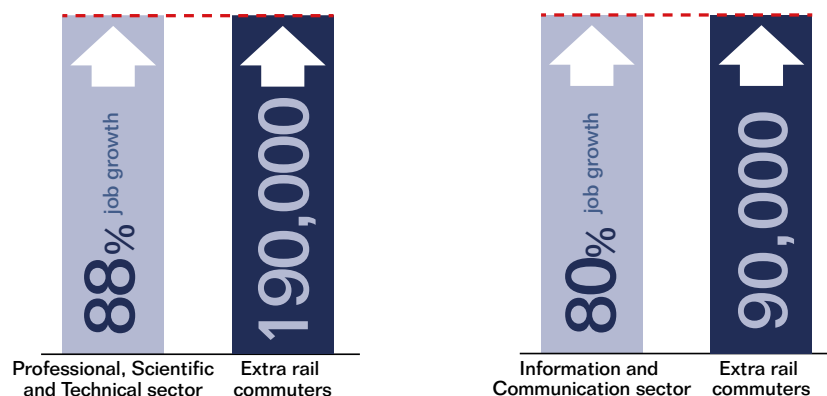
#### 3.1 Employment Structural Changes

- 3.1.1** The type of job that someone has strongly influences his/her propensity to travel by rail to do that job. As a result the structure of the British economy is a significant factor affecting rail demand, especially for commuting and business purposes, which together make up more than half of all rail journeys (58% in 2016 according to the DfT Transport Statistics Great Britain 2017).



- 3.1.2** The research has shown that for England and Wales as a whole, the percentage of commuting trips made by rail (including London Underground, Light Rapid Transit and Tram) is particularly high for Finance and Insurance (30%), Information and Communication services, as well as Professional Scientific and Technical work (both 20%). It is also fairly high for Administrative and support services and Real estate activities (both 10%). The percentage of rail commuters in England and Wales is lowest for those working in the job category of manufacturing (at only 2%).
- 3.1.3** It is therefore significant that job growth in England and Wales since 1995 has been strongest in many of these categories that have a high proportion of rail commuters. Sectors that have seen jobs almost double over that time period include Information and Communication services, Professional Scientific and Technical work, Administrative and support services and Real Estate services. Job growth in Professional, Scientific and Technical work has led to an estimated extra 190,000 rail commuters, while employment growth in Information and Communication services has led to an extra 90,000 rail commuters (Figure E). At the same time jobs have declined the most in the category where rail commuting is lowest: manufacturing. These trends have strongly supported rail passenger growth.

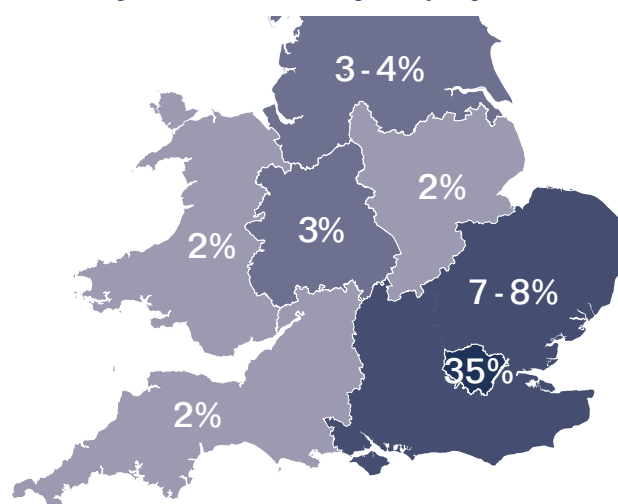
**Figure E:** Additional rail commuters generated by job growth in Professional/Scientific/Technical and Information/Communication sectors between 1996 and 2018.



## 3.2 Employment Location Changes

**3.2.1** Where someone works also has a significant influence on whether they commute by rail. The research has shown that London has by far the greatest proportion of commuters by rail (including London Underground, Light Rapid Transit, and Tram) at 35%, while the South-East and East of England also have higher than average commuters using rail (7-8%). The regions with the lowest percentage of commuters by rail are the East Midlands, South West England and Wales (at 2%).

**Figure F:** Percentage of commuters using rail by region of residence, 2011



(Source: See Table 3 in main report)

**3.2.2** The number of jobs in London since 1995 has increased at a much higher rate – 49% - than the overall average across England and Wales of 27%. London is also the region which has supported rapid growth in some of the categories of jobs where the propensity to commute by rail is highest, such as Professional, technical and scientific services, as well as Information and Communication services. These (usually) office-based professions tend to agglomerate to achieve economies of scale, thereby resulting in the concentration of jobs into reasonably dense urban areas that generally are well served by rail services.

**3.2.3** From 1996 to 2018 there was 27% job growth in England and Wales. However, as a direct result of the spatial and sectoral economic composition of employment growth from 1996, the researchers discovered that **an increase of at least 41% in rail commuters has arisen from this 27% employment growth**. This additional rail commuting growth is a result of two factors: first, job growth occurring more rapidly in employment sectors with a high propensity for rail commuting, and second, the higher rate of job growth in London and the South East, where the propensity to commute by rail is highest.

**3.2.4** In reality, this calculation is likely to underestimate significantly the full contribution to rail commuting growth that results from changing trends in employment location. This underestimation arises because it assumes a uniform job growth rate across all parts of each individual region. In practice, much of the more recent job growth within individual regions has been concentrated at high densities in city centres. These are precisely the locations where rail competes best against other modes. As a result, it is likely that the increase in rail commuting as a result of structural changes in employment sectors and job location is even higher than that estimated above.

### 3.3 Residential location changes

**3.3.1** It is well known that the rate of population growth in England and Wales has accelerated in recent years due both to increases in birth rates and to higher levels of net inward migration. The researchers have demonstrated that recent trends in the spatial location of that population growth have been strongly favourable to growing the passenger rail market.



**3.3.2** A housing supply imbalance has occurred since the 1990s, with new constructions failing to keep up with growth in the number of households in England. In addition, planning policies since the 1990s have encouraged densification of residential development, and restricted building in more rural 'green field' sites. As a result, whereas in the 1970s and 1980s population growth was fastest in rural areas and stagnant or declining in dense urban areas, this situation has been reversed since the 1990s, such that population growth is now fastest in dense urban areas. In addition, people of working age are now much more likely to reside in dense urban areas that tend to have a good range of rail services which encourages rail commuting – and less favourable conditions for car commuting. In contrast, pensioners are more likely to reside in rural areas and low-density towns that are less rail accessible.

**3.3.3** These developments have contributed to modal share changes. The researchers have shown that for those living in remote rural areas, every extra 100 resident commuters gave rise to 62 extra car commuters but only 6 extra rail commuters. By contrast, at the other end of the residential density spectrum, for the Dense London band every extra 100 resident commuters gave rise to 11 fewer car commuters, balanced by 49 extra rail (including London Underground and Tram) users.

**Figure G:** Extra rail commuters per additional 100 residents



1980s	Today (2010s)
Lower density with slow population growth	High density with high population growth
Less proximity to a rail station	More people within reach of a rail station
High levels of car usage	Per capita car usage falling
Employment focused on outer city areas	Move to inner city employment

### 3.4 Impact upon journey purposes for rail

**3.4.1** Looking at the impact of these factors on journey purpose, the researchers found that the observed major growth over time in **commuter rail travel** is not primarily due to increased weekly rail trip rates per person within any specific employment segment. It mainly arises instead from a combination of:



- Overall growth of the workforce, due to population growth coupled with low unemployment rates;
- From recent employment growth occurring in dense central city areas that tend to have good rail accessibility relative to car; and the spatial pattern of the fastest residential growth having switched from the low density, car-captive rural areas into the higher density, urban areas within which a good range of rail services may be accessible to residents;
- From well above average increases in those specific employment segments that have high rates of commuting by rail.

**As previously noted, these factors have generated over a 40% growth in rail commuting between 1996 and 2018 – and probably much more.**

**3.4.2** The researchers found that the rapid rate of growth in the number of **business trips by rail** was not generated by increased business rail trips among rail travellers but is due to an increased number of workers making some business trips by rail. It will have been accelerated by:

- The very rapid growth in those office-based employment sectors which are more likely than average to generate business trips by rail;
- An additional short-term boost in the early 2000s due to the company car taxation changes that encouraged a sharp reduction in company car ownership, leading to a shift in business trips for these workers from car to rail modes (see the ITC's On the Move report by Le Vine/Jones);
- The rapid decline in car ownership rates in dense urban areas (e.g. a 22% decline in cars per adult in Inner London between 2004 and 2017), because **those in households without cars are three times more likely to make business trips by rail**;

Using a similar calculation as for rail commuting, the authors find that **changes in employment structure alone have resulted in a 38% growth in rail business trips**, with car ownership reductions in urban areas adding significantly to this increase.



**3.4.3** For **shopping and personal business trips** by rail, the researchers found that there has been no strong trend through time in the average weekly number of rail trips per rail traveller, or in the average trip length of such rail trips. For **social and holiday rail trips**, since 2002 there has been an annual increase of 1.9% in rail trips per rail user – but outweighed by a 4% annual increase in the proportion of the population becoming a rail user.

Overall, the rapid growth in rail demand for these purposes is mainly due to:

- the overall increase in the population;
- the more rapid increase within this population of those segments with a higher than average propensity for rail use, such as those with high incomes or those in households in dense urban areas without cars;
- some overall increase in the proportion within each segment that make trips by rail.

## 4. The future of rail demand

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**4.1** What can the findings from this research tell us about the future of rail demand? The demand influencing factors explored in the report have a number of aspects in common:

- although each influence has been discussed independently, in reality they are often heavily intertwined in their operations through time and through space, which is why sophisticated statistical techniques are required in order to identify which are the primary influencing factors;
- they are largely external to the operation of the rail industry but have a major impact on rail passenger demand;
- whereas a number of them did not support rail growth during the 1970s and 80s this started to change in the mid-1990s, to mostly be strongly supportive of rail growth, though with some recent lessening.

**4.2** These exogenous demand factors are influenced by policy making external to the rail sector. In particular, policies that influence levels of car ownership and road network performance, patterns of employment, and the location of jobs and housing. As Government policies and circumstances change, it is not clear that these influences would necessarily continue to support rail growth in the future. If, for instance, there was a surge in people moving away from dense urban areas into rural locations, or major structural changes in the economy towards employment growth in manufacturing and a corresponding decline in office-based employment in the fields of IT, science, research and administration, we could revert instead back to the situation before the 1990s when rail passenger demand was in gradual decline. In that case the future trajectory for rail passenger numbers would be very different to that experienced over the last two decades, irrespective of what future actions the rail industry itself might adopt in response.

### 4.3

The below table uses insights from the report to estimate the past and likely future strength of various demand factors for passenger rail.

**Figure H: Changes in demand factors for passenger rail**

Influence	1995-12	2013-17	2018-30?	Confidence level
Sectoral employment trends	↑↑↑	↑↑	↑	High
Home working	↓	↓↓	↓↓	Medium
Urban road car capacity	↑↑	↑	↑	High
Company car tax policy	↑↑	↑	0	Assumes no further changes
Overall car use cost	↓	↓	↓	Medium
Real income growth	↑↑	0	↑?	Low: Depends on health of the economy
Population growth	↑	↑↑	↑	Low
Planning policy	↑↑	↑	↓?	Low: Depends on future policy
Car ownership	0	↑	↑	Medium

Key: ↑ = supports growth in rail passengers  
↓ = supports decline in rail passengers

### 4.4

Policy makers should also bear in mind the following:

- The NTS provides evidence that increased home-working for some days of the week has had a significant impact in reducing weekly commuter trips rates by rail. This is likely to contribute to a future decline in peak period rail use.
- Policy switched within the 2012 National Planning Policy Framework (NPPF) away from the heavily prescriptive pressure for densification associated with the PPG13 era, to localism policies instead. In many locations these policies will have diminished the pressure for residential and employment densification. They may be facilitating a reversal back to the earlier trends of decentralisation of jobs and population away from inner city areas to the suburbs and beyond. Consequently, there is now considerable doubt regarding the extent to which urban densification policies will continue to have a significant impact in supporting rail demand growth.

**4.5**

In summary, the various evidence sources presented in this report examined how much of past rail commuter and business growth has occurred either for sectoral economic reasons or due to spatial workplace and residential location trends, both of which are largely unrelated to the rail industry itself. The service supply provided by the rail industry has, of course, needed to adapt and expand so as to cater for this passenger growth. However, when considering these sectoral economic and spatial influences on rail commuter growth, the authors suggest that rail supply characteristics are best thought of as an enabling feature, rather than as the major driving force.

## 5. Recommendations

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In the light of the research conducted in this study, several recommendations are made to help improve both forecasting and policy making.

**5.1**

First, it is clear that a wide range of factors extrinsic to the rail industry are influencing demand. Some of these have been incorporated in the latest version of the rail industry's Passenger Demand Forecasting Handbook, published in May 2018. There is a clear need when modelling to pay explicit attention to this wider set of influences in order to provide better longer-term forecasts of rail passenger demand and its responsiveness to policy measures. The detailed recommendations of the authors can be found in Chapter 11 of the report.

**5.2**

Second, it is evident that policy making in a wide range of fields outside transport can strongly affect passenger rail demand. Land use and planning policy changes, particularly when these influence the location of residential and employment growth, should be examined for their likely influence upon travel patterns and rail demand. In addition, the development of employment policies and industrial strategy, where these are designed to change the industrial structure of the economy, should take into account the likely impacts upon demand for rail as well as other modes.

**5.3**

Third, the research has demonstrated that current data sets are limited in what they can tell us about the range of factors generating rail demand and especially the relative importance of these. We recommend improvements to data collection and processing so that it is easier to understand the impact of spatial and industrial changes on demand. Further research would also be welcome into the relative importance of demand factors influencing modal choice.

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# I. Introduction

## I.1 Overview

- 1.1.1** Passenger rail travel declined reasonably consistently within Great Britain for many decades until the mid-1990s around the time of rail privatisation. Since then there had been a switch to a continuous pattern of growth such that rail passenger trip numbers peaked in 2016 at a level that is more than 130% higher than the trough around 1995.
- 1.1.2** The purpose of this research study is to understand more clearly the many reasons: why this reversal in rail passenger demand decline took place in the 1990s; why rail then continued to grow rapidly and consistently until 2016.
- 1.1.3** The main emphasis within this analysis will be on those longer-term factors affecting door-to-door travel, that influence the demand for rail passenger traffic, but that **are external to the rail industry itself**. This is because substantial information has existed for many years within the rail industry's forecasting system PDFH<sup>4</sup> regarding the potential impacts on passenger demand (on a station-to-station basis) from changes that are internal to the rail industry, in, say, fares, rail supply characteristics, etc., whereas comprehension of the influence of those factors that are external to the rail industry had historically been less developed. Worsley (2012) in his review of PDFH had identified various influences that had not then been included in PDFH but that merited further consideration. The representation of a number of these external factors has been substantially refined in the newest version 6.0 of PDFH, released recently in May 2018. Both these and other relevant external factors are examined below within this study. Forecasts of total rail passenger kilometres based primarily on factors under the influence of the rail industry (fares, frequency, comfort, etc) have seriously underestimated the observed levels of demand; between the mid-2000s and the mid-2010s, for example, growth was over 25% higher than forecast. This underestimation has been observed in all the main rail markets, except for season ticket sales for journeys to/from London. This suggests that factors outside the immediate control of the rail industry may be playing an important role in driving rail passenger growth, and that is the main focus of this study.
- 1.1.4** To aid our understanding of the evolution of passenger rail demand we explore the extent to which the underlying external causes of recent rail growth are due to each of the following:
- more people have entered into those groups that typically would be rail oriented travellers – the existing rail market is scaled upwards;
  - a wider range of people or trip types have been attracted into rail use – the rail market has been broadened over time;
  - certain types of people have increased the average number of rail trips per annum that they make or have increased their average trip lengths travelled.



If it is mainly the first effect, then observed growth may have little or nothing to do with demand being induced by actions from within the rail sector. If it is mainly the latter two effects, then it might indeed be a balance of a pull effect due to rail service improvements and a push effect due to service dis-improvements in competing modes: mainly car.

- 1.1.5** The insights provided by the research below provide the foundations for a better understanding of whether, where and why rail passenger growth in the future might accelerate, stabilise or reverse again back to the declining trend that was the norm prior to the 1990s. In turn, this should help the Government and the rail industry to upgrade their forecasting methods to take better account of the influences identified and so to better inform their future policy and investment decisions.

## 1.2 The structure of this report

- 1.2.1** The reporting of the research is structured as follows.

- **Chapter 2** sets the scene through an overview of the broad trends in passenger growth through time in rail and in other competing modes.
- **Chapter 3** outlines the methodology adopted for this research along with the list of data sources, the limitation of the available data and the applied methodology.
- **Chapter 4** uses a variety of data sources to analyse how structural economic changes in employment patterns and in the spatial pattern of workplaces, have contributed to the rapid growth in commuter and business travel by rail.
- **Chapter 5** examines analogous aspects but this time at the residence end, focussing particularly on the importance of differential spatial growth trends through time in the resident population. Resident commuters are segmented by residential density to take account of the very different degrees of competition from other modes that are experienced between areas of differing densities.
- The analysis then drills down to examine in turn three main rail trip purposes, namely: commuting, business and other travel purposes combined. **Chapter 6** analyses commuter travel and it identifies the main apparent influences on passenger rail growth trends, while separating these out from the many other variables that have some correlation with rail passenger growth trends but that are unlikely to be the primary influences on this growth.
- Similar models are next estimated of the main influences on rail passenger growth for the business travel purpose in **Chapter 7** and for the remaining purposes combined, in **Chapter 8**. It is to be noted that the National Travel Survey (NTS) is the main data source used but because it provides only a relatively small sample of rail travellers the scope for detailed spatial analysis is limited. To mitigate this limitation, a sophisticated statistical model-based analysis is carried out for each of the trip purposes that maximises the effectiveness of the small sample analysis.



- Having now identified the main spatial and temporal trends and influences on rail passenger travel demand segmented by trip purpose, **Chapter 9** examines several further influences that may have encouraged or discouraged these observed past demand growth trends.
- **Chapter 10** assesses the overall balance of the full set of influences on rail demand growth, focusing on whether these in the last few years may have lessened their previous strong combined support for rail passenger growth.
- Finally, **Chapter 11** discusses the implications of these research findings in the context of how passenger forecasting models for rail and competing modes should be designed and implemented. It focusses on the need to take suitable account of several important influences and relationships (particularly those related to land use and to socio-demographic characteristics of workplaces and residences) that tend to be absent from contemporary forecasting models of rail passenger demand.

**1.2.2** Where possible, the data analysed and presented in the charts in this report relate only to the conventional surface rail sector, while excluding trips on London Underground, metro, LRT (Light Rapid Transit), trams and other track-based systems. For some of the themes, however, the available data sources do not allow this distinction so that a wider range of track-based services have necessarily been combined. In such cases, the precise modal coverage within the dataset used is made explicit.

**1.2.3** The research here analyses a very wide range of datasets, many of which are from outside the transport sector, while using long time series wherever possible. This inevitably leads to some inconsistencies between the categorisations used in these different datasets, so that care has been taken to minimise such data inconsistencies and to explain their implications. It has also led to some gaps or truncations in the time series presented or to delays in the availability of recently observed values. For this reason, some of the charts may stop some years back from the present, whereas others run to within a few months of the report completion.

## 2. Key aims and scope of the report

### Key Findings

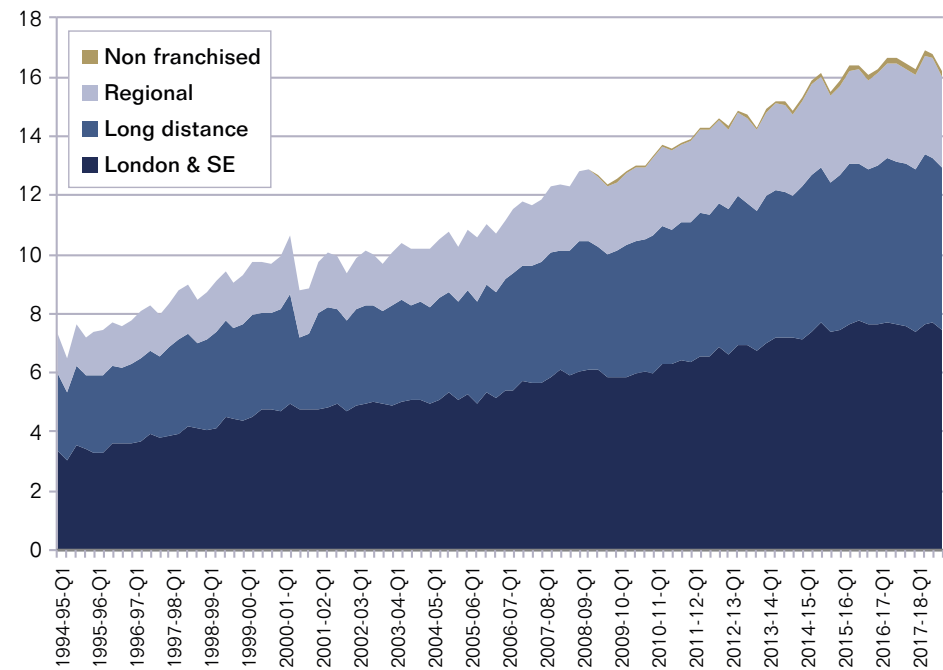
- Overall, during the decade from 2006 to 2016, rail passenger kilometres in Great Britain have grown by 43%, whereas car kilometres have only grown by 2%, which explains much of the increase in rail market share.
- A much higher proportion of commuting and business trips are made by rail (7% in 2017) than for leisure (2.1%), education (1.3%) or shopping and personal business purposes (0.7%).
- Between 2002 and 2017 total rail trips increased by 74%, with significant differences by trip purpose: ranging from a 45% growth for shopping and personal business, to 73% for commuting and around 85% each for business, education and leisure travel.
- In terms of peak arrivals to central London, the rail entrants per day peaked during years of high economic growth and declined during periods of recession or economic stagnation.

### 2.1 Overall trends in rail passenger growth

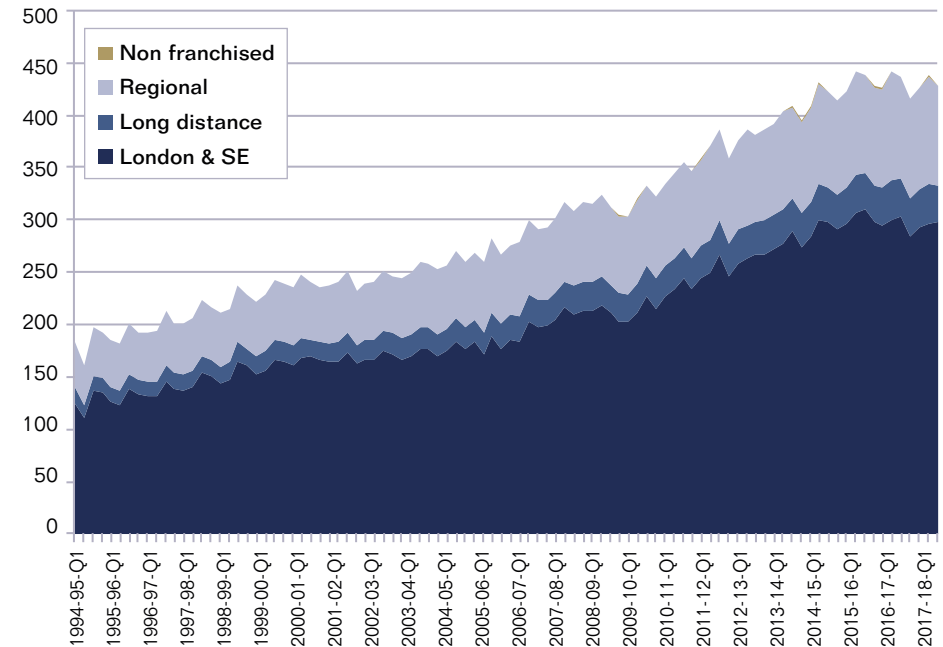
- 2.1.1** We start the analysis with an overview of the long and the short-term growth trends in rail passenger markets to inform subsequent discussions. The aim in this chapter is to identify the main features of growth trends in the rail passenger market and in its competing modes, so that in later chapters the factors that have helped generate the changes in these trends can be understood and quantified.

**Figure 1:** Trends in rail passenger trips (millions) and trip kilometres (billions) by Sector, quarterly from Q1 1994/95 to Q4 2017/18, Great Britain

a. Number of passenger kilometres travelled (billions)



b. Number of passenger trips made (millions)



(Source: Tables 12.3 and 12.6, ORR Data Portal)



- 2.1.2** Prior to the rail privatisation in 1994, rail passenger numbers had exhibited a gradual decline over many decades because of the rapid increase in car ownership and of the decentralisation of population from the inner areas of major cities out to low density suburbs and rural areas. The subsequent trends in rail passenger trips and passenger kilometres for the four sectors distinguished by the ORR<sup>5</sup> are illustrated in Figure 1 on a quarterly basis from Q1 1994/95 through to Q3 2017/18.
- 2.1.3** These charts show a relatively continuous rail passenger growth trend<sup>6</sup> from 1994 onwards for each of the three franchised sectors, though there was a brief flattening out in 2009 related to the effect of the economic recession and a blip around 2002 related to the Hatfield rail crash and to the other rail safety issues around that time that ultimately led to the demise of Railtrack and its replacement by Network Rail.
- 2.1.4** However, the number of trips made within the London and South East (LSE) sector has declined from its peak reached around Q4 2015/16, while the growth in trip kilometres in this LSE sector also has flattened out since then. By the fourth quarter of 2017/18 this decline had spread across also to the Long Distance and the Regional rail markets, so that by then both passenger numbers and passenger kilometres were declining in these three markets.
- 2.1.5** We next investigate in greater detail these more recent rail passenger trends within LSE using a range of data sources from ORR and TfL, in order to have a better appreciation of whether this recent dip in rail trips is spread throughout the London, South East and Eastern Regions or is just concentrated into a few areas therein.
- 2.1.6** The ORR (2017) data for Q2 2017/18 indicates “All of the four largest passenger operators, all of whom operate within the London and South East sector and account for just over 50% of all journeys, saw their journey numbers fall this quarter.” (p. 2 ORR, 2017). This clarifies that the decline was not due primarily to temporary incidents such as strikes or the side-effects of major engineering works for a specific operator.
- 2.1.7** The other major recent rail passenger trend is a large reduction in the number of season tickets purchased. “The number of journeys made on season tickets fell to 142.7m in 2017-18 Q2, the lowest in any quarter since 2010-11 Q2. The fall in season ticket journeys have a direct impact on the journeys in the London and South East sector, as they are the main drivers of journeys in this sector. In contrast journeys made on advance, anytime/peak and off-peak tickets which fall in the ordinary ticket basket experienced growth this quarter, with journeys made on anytime/peak tickets exceeding 100 million for the first time this quarter.” (p. 3 ORR, 2017)
- 2.1.8** This major reduction in season ticket purchases no longer automatically indicates a corresponding major reduction in trips for commuting purposes. Some of the reduction in season ticket purchases may be related to worker’s greater flexibility at the workplace, with an increased ability for some office workers to work at or from home for a few days of the week. For this group the traditional cost savings available through use of season tickets may be off-set by being able to travel to work on fewer days of the week, which negates the potential cost savings from such season tickets. Evidence on reductions in recent years in the weekly commuting trip rates of longer distance commuters is examined below in Chapter 6.

5 ORR – the Office of Rail and Road is an independent statutory body that regulates the rail industry. It also collates statistics on the operation of the rail system.

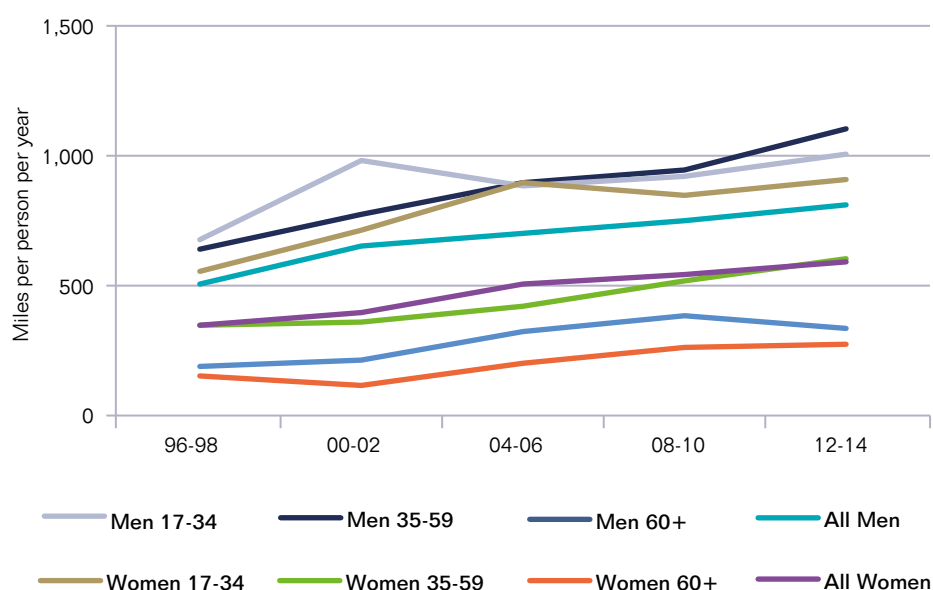
6 We exclude from consideration the short-term seasonal effects of the Summer and Christmas holiday periods.

## 2.2 The demographic composition of rail passenger growth

**2.2.1** The analysis so far has just considered rail passengers as a homogeneous group. We now turn to the National Travel Survey (NTS) dataset as this is the only dataset that can provide consistent trend data for rail travel in a form that is segmented in detail, albeit with relatively small sample sizes. We use the NTS dataset to examine the extent to which the observed rail growth trends are common across demographic groups and across the range of trip purposes.

**2.2.2** The ITC's Recent Trends in Road and Rail Travel research study (ITC, 2016) has investigated the demographic characteristics of rail travellers as illustrated in Figure 2. This indicates that the miles travelled per person per year by rail has increased significantly for all groups within the population between 1996-98 and 2012-14, though rail mileage has stagnated since 2004-06 amongst older men (over 60) and younger women (17-34).

**Figure 2:** Rail passenger miles per adult per year\* by age and gender 1996-98 to 2012-14



(Source: NTS data within Figure 10, ITC (2016); \*based on the main mode of the trip)

### Overview of passenger rail proportion by socio-demographic profile of the rail users.

**2.2.3** The ITC's Recent Trends in Road and Rail Travel (2016) report breaks down rail travel using various measures of travel (see Table 1). "In this table it is clear that the proportion of the population making trips has rapidly increased, even though the number of trips made by each rail user has remained fairly constant. Strikingly, although children are making longer journeys, young men and women (17-34) and older men are actually making shorter average journeys by rail than in 1996-98. This suggests that the huge per capita growth in rail travel is chiefly attributable to a much higher proportion of the population using rail rather than to an increased frequency of travel by individual users or to longer average trip distances."

**Table 1:** Trip-making by surface rail 2012/14 and change from 1996/98

	% population making trips		Trips per year per rail trip-maker		Miles per trip		All miles per year per rail trip-maker		Rail miles per person per year	
	12/14	Change from 96/98	12/14	Change from 96/98	12/14	Change from 96/98	12/14	Change from 96/98	12/14	Change from 96/98
All Persons	10%	79%	209	-2%	30.5	-5%	6381	-7%	617	68%
Children 0-16	5%	80%	164	-9%	21.8	54%	3575	40%	176	152%
Men 17-34	16%	79%	239	-1%	25.8	-19%	6166	-20%	1009	49%
Women 17-34	16%	91%	212	-5%	27.3	-10%	5788	-15%	913	63%
Men 35-59	12%	86%	251	-3%	36.0	-4%	9036	-7%	1102	72%
Women 35-59	9%	69%	199	-4%	32.6	5%	6487	1%	605	71%
Men 60+	6%	89%	161	12%	36.7	-25%	5909	-16%	340	71%
Women 60+	6%	55%	127	1%	39.6	6%	5029	7%	281	77%

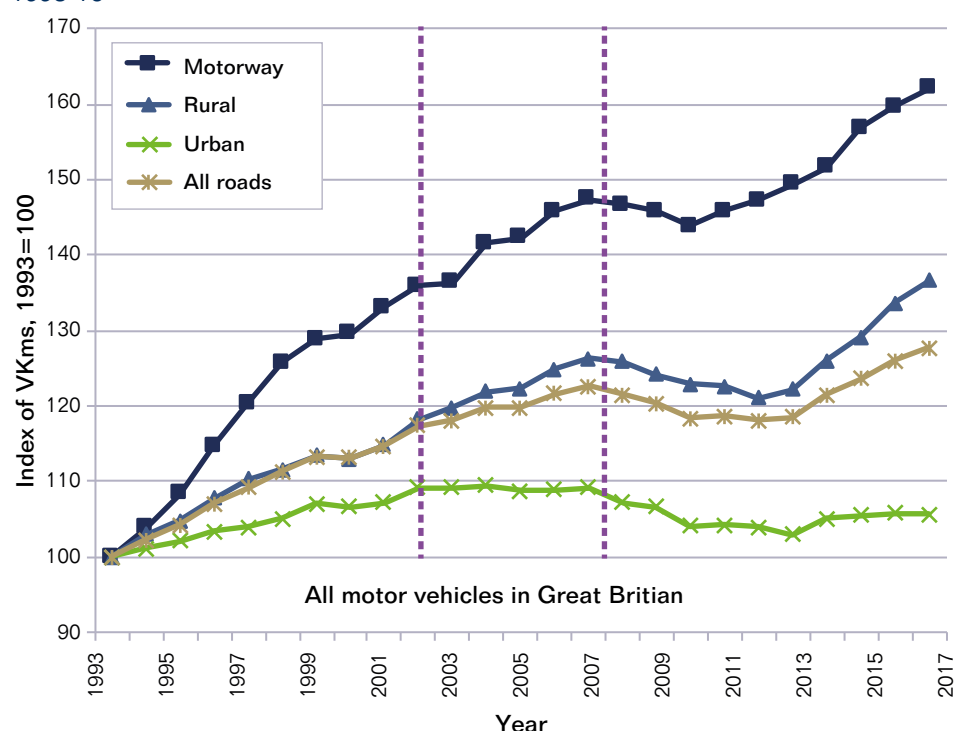
(Source: Table 4.4 in 'Recent Trends in Road and Rail Travel' ITC (2016).)

Key:  = significant rise in ridership;  = significant fall in ridership

## 2.3 The Trend in Car traffic growth

- 2.3.1** Because bus and cycle tend to capture mainly short distance trips for which rail services tend not to be well suited, car is in practice the predominant mode that is in competition with rail. Accordingly, it is instructive to examine the broad spatial and temporal trends in car traffic growth to understand how these trends match to or deviate from those exhibited by rail.
- 2.3.2** Figure 1 has shown that rail passenger kilometre growth was only marginally affected by the major economic downturn after 2007 and has continued to grow significantly in all but one year in the decade since then. This is in strong contrast to road vehicle kilometres (Figure 3) which took until late 2015 to match the previous all-time peak that was reached in the year ending June 2007.

**Figure 3:** Road vehicle traffic by road class in Great Britain, annual index numbers 1993-16



(Source: Table TRA0102, DfT)

**2.3.3** The economic recession is probably the cause of the reductions after 2007 in motorway and rural road vehicle traffic because these traffics have started to grow strongly again subsequently. In contrast, traffic on urban A-roads in 2017 is lower than in 1999. The recession cannot have been the cause of the stabilisation in urban road vehicle traffic from 2002 to 2007. The recession is unlikely to be the cause of the 3% reduction in urban areas in overall road vehicle traffic from 2007 to 2017 and of the larger reduction of 4% in the car component of this overall traffic.

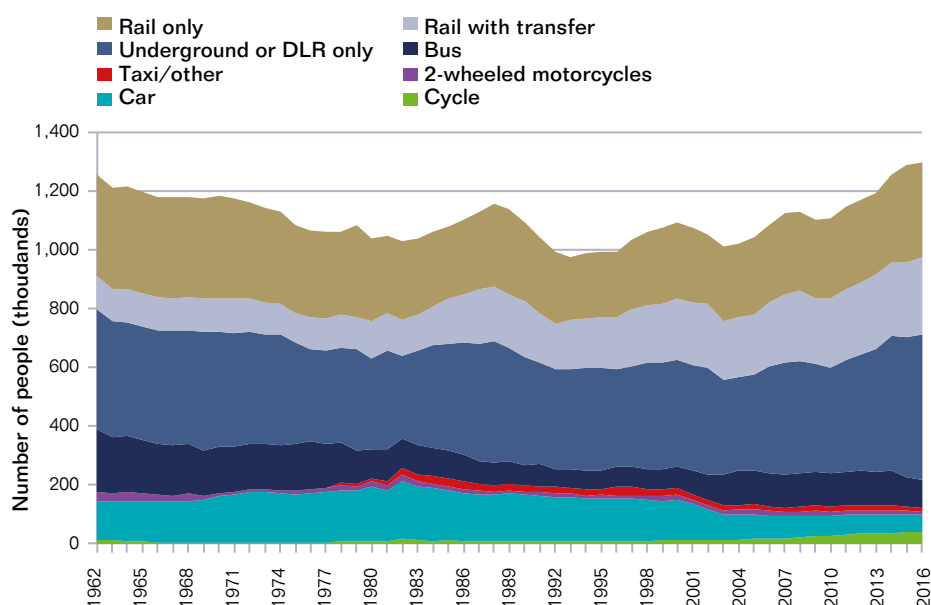
**2.3.4** Chapter 9 examines a number of factors that have reduced the attractiveness of car travel within urban areas, especially within the denser urban areas that are now growing rapidly. We will see that this reduction in car quality of service in those areas where rail has the best potential to compete is one of the major influences that has accelerated the past growth in rail passenger demand. Overall, during the decade from 2006 to 2016, rail passenger kilometres in Great Britain have grown by 43%, whereas car kilometres have only grown by 2%, which explains much of the increase in rail market shares that is shown below in Figure 6.

## 2.4 Trends in trips to London and within London

### 2.4.1 Central London AM peak arrivals by mode

**2.4.1.1** An alternative data source provides support that rail commuting to London had continued to grow up to 2016. Figure 4 illustrates for the period from 1962 to 2016 the number of entrants by mode to Central London, as measured by the cordon survey (TfL, 2017) carried out every autumn for the AM peak (07:00 to 10:00). It distinguishes those arriving by rail between: those who then transfer on to LU or DLR services; and other rail entrants.

**Figure 4:** People entering central London in the weekday morning peak, 1961 to 2016



(Source: Table 10.3, TfL (2017) and earlier TfL sources)

**2.4.1.2** Over the longer term this chart illustrates the importance of the economic cycle in determining the overall total number of entrants to Central London, particularly those entering by rail. There were a series of rail peaks of around 470k rail entrants per day in the economic boom periods in the years 1964, 1970, 1989 and 2001, followed by troughs associated with the subsequent economic recessions. However, since 2004 there appears to have been a change in Central London towards longer term employment growth, with a peak of 511k in 2007, followed by a small drop through to 2009 due to the major recession, and then reaching back up to an all-time high of 584k in 2016, the most recent year for which data on peak entrants has been published.

**2.4.1.3** Other relevant recent trends in modal competition within Central London that are illustrated by Figure 4 include:

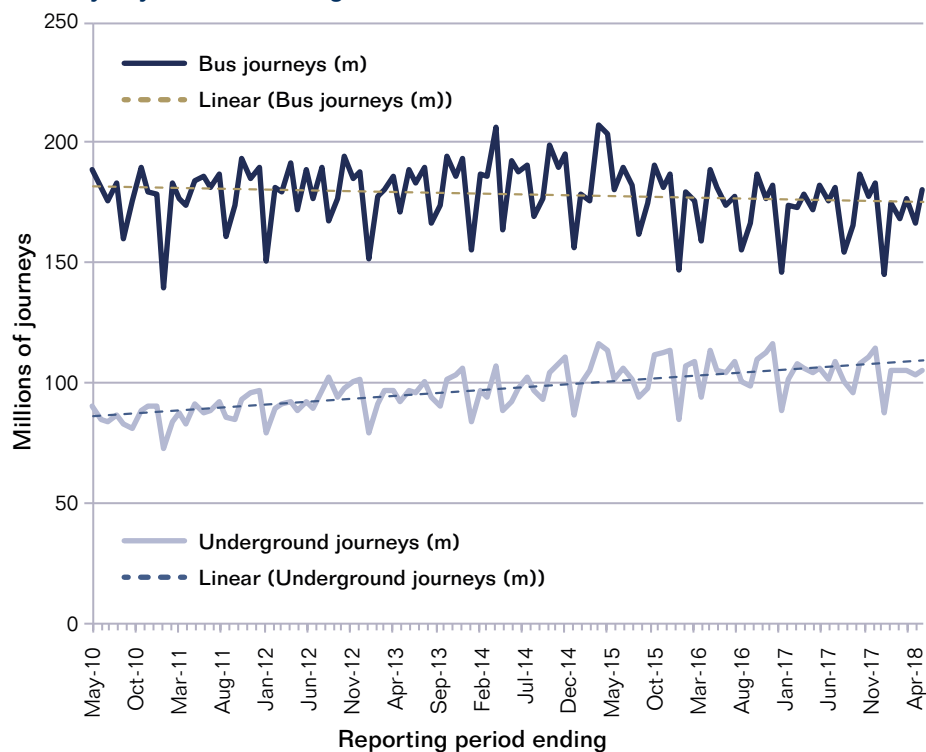
- A relatively stable proportion of the rail entrants (45% in 2016) transfers to LU or DLR services, rather than travelling onwards by bus or on foot to areas adjacent to their Central London rail terminal;
- Direct entrants by Underground and DLR have grown strongly from a short-term low of 320k in 2004 to an all-time high of 495k in 2016;
- After more than 30 years of decline in bus entrants, the freeing of road space and consequent improved service provision associated with the introduction of the Central London congestion charge in 2003 led to a period of increasing bus numbers up to a peak of 117k in 2014, then followed by a drop back down to 94k in 2016, in part associated with the slowdown of bus speeds resulting from recent increases in road congestion;
- Car entrants to Central London in the AM peak have been in decline since their peak of 192k in 1982, reducing to an all-time low of 58k in 2016, which is a 71% overall decline in the absolute number of car entrants since 1982, despite the 26% growth in total entrants during this period;
- Much of the car traffic has switched to cycle which has grown rapidly in recent years, increasing from 12k in 2003 to 40k in 2016, so that soon the total AM peak entrants on cycles and motorcycles are likely to exceed those in cars.

## **2.4.2** Other public transport trends within London

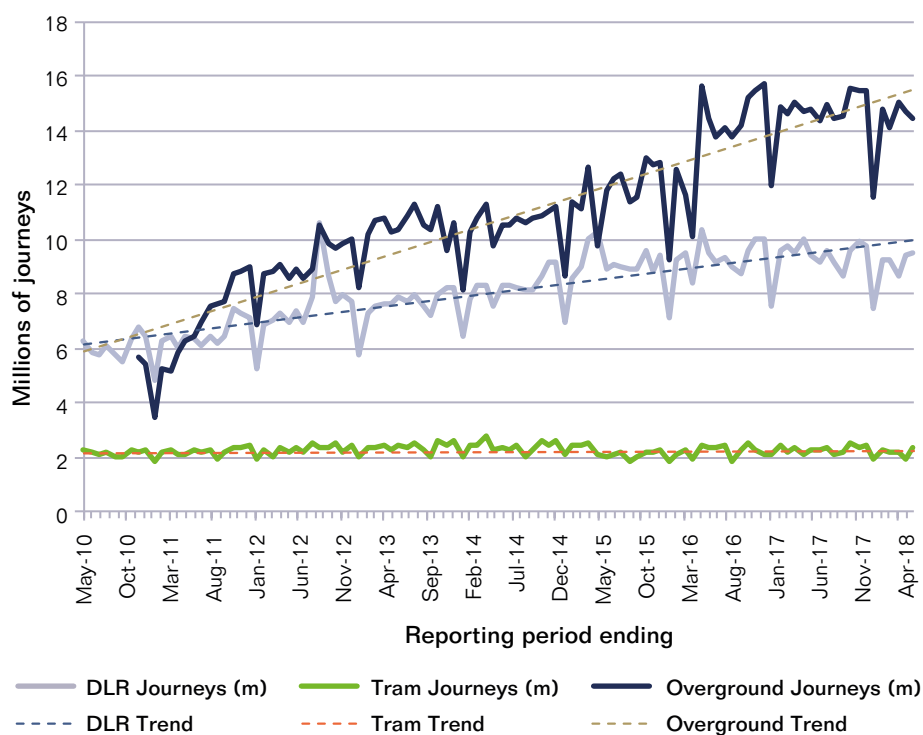
**2.4.2.1** Although the most recent evidence available on AM peak entrants to Central London shown in Figure 4 dates back to Autumn 2016, there are more recent TfL data sources available through to May 2018 for public transport passenger numbers within London, as illustrated in Figure 5.

**Figure 5: Number of journeys (millions) in London, by TfL reporting periods (1 to 13), by type of public transport, May 2010 to March 2018**

### Journeys by London Underground and Bus



### Journeys by Rail, DLR and Tram



(Source: TfL. <https://data.london.gov.uk/dataset/public-transport-journeys-type-transport>)

**2.4.2.2** The growth trends in passenger numbers exhibit a broad similarity across the public transport modes in London:

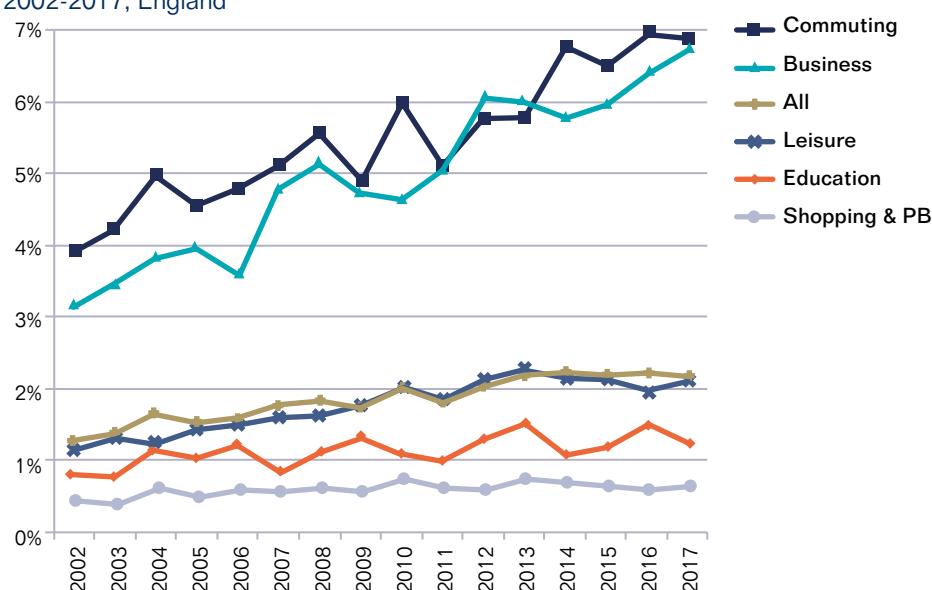
- Underground journeys rose consistently to a peak in mid-2016 and have declined by 1% since then;
- Overground, DLR and Tram journeys each rose rapidly up to a peak in 2016/17 and have declined slightly since then.
- Bus journeys grew slowly up to a peak in early 2015 but have declined slightly since then.

**2.4.2.3** Each of the various rail modes within London appears to exhibit a similar pattern to that previously shown in Figure 1 for mainline rail services for London and the South East. Passenger numbers grew rapidly for many years up to a peak around mid-2016 and have stabilised or declined since then. This constancy across these various services in their temporal growth trends suggests that some external non-public transport related influences may be the primary cause of these recent changes in trend.

## 2.5 Rail growth trends by trip purpose

**2.5.1** The trend through time in the rail mode share for trips for individual travel purposes is presented in Figure 6 from 2002 to 2017. Although commuting and business travel purposes have much higher rail proportions than education, leisure, or shopping plus personal business, the rate of growth over time in the rail share is substantial for all individual travel purposes. By 2017 the overall rail share had increased by 71% from a 1.3% to a 2.1% share, varying from 50% growth in rail share for education, to 115% growth for business travel.

**Figure 6:** Percentage of all trips within the travel purpose that are by rail, 2002-2017, England



(Source: NTS Table NTS0409 and Mid-Year Population Estimates, ONS)

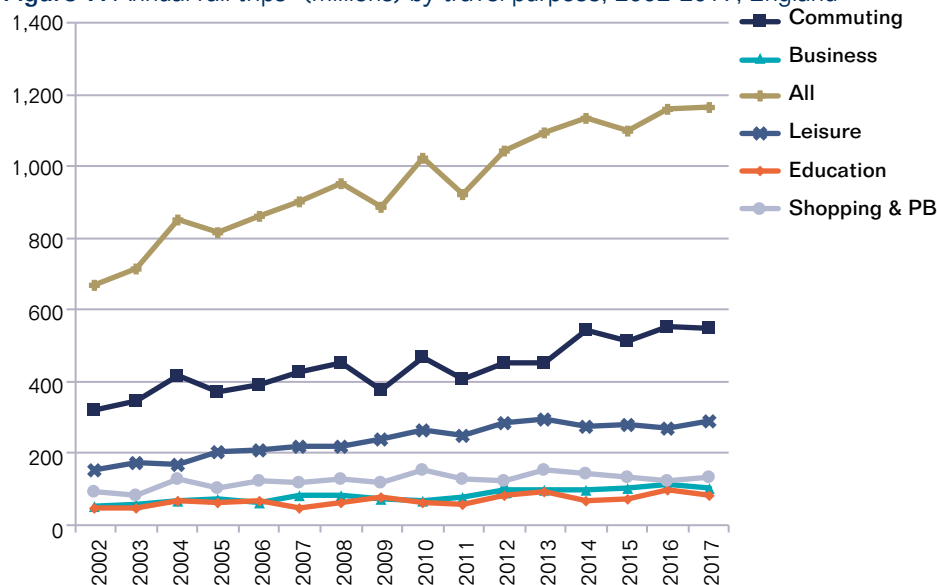


**2.5.2** This rate of growth in rail share does not translate directly into the same growth rate in total annual rail trips because:

- the National Travel Survey has indicated that since 2007 overall trip rates per capita have tended to decline for most trip purposes - this in turn has produced a downward pressure on annual rail trip rates per capita;
- the population has risen rapidly since 2007<sup>7</sup> which acts to increase total rail trips.

**2.5.3** The net result of these two offsetting effects is illustrated in Figure 7 which presents the annual total rail trips by travel purpose from 2002 to 2017 for England. Over this period the population of England has grown by 12%, whereas its total rail trips have grown by 74%. The growth rate in rail trips in England ranges from: 45% for shopping and personal business; 73% for commuting; to around 85% for each of business, education and leisure travel purposes.

**Figure 7: Annual rail trips<sup>8</sup> (millions) by travel purpose, 2002-2017, England**



(Source: NTS Table NTS0409)

**2.5.4** Clearly there are other specific features particular to the rail mode, which must have counteracted these modal cost trends, and so would have generated an improvement over time in the competitive position of rail relative to the other modes. These features are explored in subsequent chapters.

<sup>7</sup> See Figure 38 below for the population growth index for Great Britain from 1995 onwards.

<sup>8</sup> The units used in this NTS-based Figure 7 necessarily differ from those in the earlier ORR-based Figure 1. The NTS combines all individual legs of a journey into a single trip, whereas the ORR statistics count each of the separate train legs as trips. The NTS totals are annual for just England, whereas the ORR are quarterly for Great Britain.

**2.5.5** The rest of the discussion in this Report is mainly complementary to, rather than in competition with, the PDFH approach to forecasting rail demand. PDFH uses ticket sales data to focus on the elasticity of rail passenger demand growth to changes internal to the rail sector in rail fares and in rail service characteristics, such as frequency, journey time, etc. It also includes the impacts of the broad external trends discussed above, such as the growth in GDP, population and employment. The analysis in subsequent chapters uses a variety of data sources to identify additional aspects that need to be considered in order to better understand and measure the full set of influences, which are external to the rail sector, on passenger rail growth trends. It does not focus in detail on those topics internal to the rail sector because such topics have already been explored within the analyses underlying the development of the elasticities central to the PDFH methodology.

## 2.6 Recent investigations into rail passenger demand

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- 2.6.1** A number of recent reports have examined various aspects of the sources of the growth in rail passenger demand in Great Britain. Worsley (2012) outlines the strengths and weaknesses of the PDFH approach to rail demand forecasting and then discusses the options for an alternative behavioural rail model approach. He examines where the main gaps are in its coverage and makes recommendations for further work to provide a more complete approach to rail demand forecasting. A number of the topics that we discuss below in this report could help inform this proposed improved approach.
- 2.6.2** The Specifying the Demand Cap for Rail study by Bates et al. (2013) for DfT examined: the evidence for saturation in the market for rail travel; and the techniques that might be used to represent market saturation within rail demand forecasts. Overall, they found that as yet there is little evidence of rail demand saturation effects in Great Britain.
- 2.6.3** The Revisiting the Elasticity-based Framework study (Arup, 2012) for DfT, includes a detailed rail trends analysis that looks at potential influences from income, employment, fares, population, etc. expanding on many of the topics summarised in the previous section above.
- 2.6.4** The Rail Demand Forecasting Estimation (RDFE) study was recently completed for DfT by ITS, Leigh Fisher, Rand Europe and SYSTRA (2017). The Phase 1 report reviews the problems incurred in past studies on forecasting models and on the data sources potentially available with which to improve them. It provides a long list of suggestions on how to make best use of the NTS data for analysis of rail demand forecasting. The Phase 2 Final Report documents the detailed modelling of rail trip demand that they have carried out with NTS data. It includes similar demographic variables to those that we have used and they likewise adopt a two-stage model of (a) who makes rail trips? (b) how many rail trips do these rail users make? However, the mathematical formulation they adopt is less refined than that used below and it does not focus to the same extent on the potential differences in supply and of behaviour within different types of areas and between trip purposes.



- 2.6.5** The larger part of the report is based on more traditional ticket sales analysis, focusing particularly on influences within the rail industry. The findings relating to the influences on rail travel are broadly as they had expected. However, they stated that: "In general, we were not able to identify significant effects of changes in rail service variables on rail demand from the NTS data. We suspect that this is because of the relatively coarse geography that we could use to compare rail and NTS (local authority level)." (p.7).
- 2.6.6** Many of the recommendations of this RFDE study have since been included in the May 2018 version (DfT, 2018) of the Department's 'TAG Unit M4 Forecasting and Uncertainty' transport guidance, as well as within the current version 6 of PDFH that also was released in May 2018. Two of the major enhancements introduced in PDFHv6 are the EmplIndex and PopIndex variables that segment Employment and Population, respectively, into a number of socioeconomic classes. The findings below from our various analyses of rail growth strongly support the need to use a detailed explicit segmentation of residents and workplaces as a key component in rail demand forecasting.
- 2.6.7** A number of the reports from the ITC's On the Move series of studies, which have analysed travel on rail and on other modes using the NTS dataset, have provided solid foundations for the work reported below here. Some topics presented below are based heavily on these earlier analyses, e.g. the analysis of the impacts of company car taxation policy changes in Chapter 9, quotes extensively from Le Vine and Jones (2012).

## 3. Methodology

### 3.1 Overview

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- 3.1.1** This chapter outlines the analytical methods adopted in this research to understand the impact of factors influencing rail trends that are external to the rail industry. The report has adopted two methods of analysis. The first, Multi-dimensional Analysis for workplace and residential location (Chapter 4 & 5) and the analysis is generally carried out visually in the form of multidimensional tabulations or charts that enable a number of the most important potential influences to be identified and to be tracked through time. Secondly, Statistical Modelling Approach for analysis of rail travel by trip purpose (Chapter 6, 7, 8). This provides a clearer picture of which are the main determining factors for rail growth and which are factors that are more loosely associated.
- 3.1.2** Because of the absence of spatially detailed, large-scale surveys through time of rail users, it has been necessary to assemble and combine a variety of data sources that can provide insights into the main determinants of the growth in rail travel that are external to the operations of the rail industry.

### 3.2 The main data sources

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#### ONS Population Census

- 3.2.1** The most important data source for this stage in the analysis is the ONS Population Census because it provides spatially detailed data on a reasonably consistent basis every 10 years both for households at the residence end and for the workforce at the employment end. It provides information on the number of cars available to the household as well as the occupation type and industry class of all of those in employment. The journey to work data within the Census provides information on the main mode used for the usual journey to work, as well as on whether a worker travels to a fixed place of work or instead works at or from home. The fact that it is a 100% Census avoids sampling errors and enables spatial differentials to be rigorously analysed in detail.
- 3.2.2** Because the Census is only available every 10 years, it is necessary to also make use of a number of other more specialised data sources to generate annual time series that enable the changes over time in rail demand to be compared with:
- Workforce job locations, segmented by type of industry – available from NOMIS at the regional level segmented by industry type, or at the local authority level just for total jobs;
  - Population locations – available from the ONS Mid-Year Population Estimates at the local authority level;
  - Additions to the stock of dwellings – available from the VOA at the local authority level.



## The National Travel Survey dataset

- 3.2.3** The National Travel Survey (NTS) is the data source that is used to examine rail travel demand on a consistent basis: through time from 2002 to 2015; across the area types of England; across different types of individuals; and across various trip purposes. This NTS data is collected in a form that maximises its internal consistency through time and across space. It contains many, though not all, of the variables analysed in the multi-dimensional analysis charts but in a number of cases such variables are defined differently or categorised differently from those available for the other analyses carried out in this study.
- 3.2.4** The analysis of rail travel observed from the NTS that was presented in the various previous 'On the Move' reports (ITC, 2016), showed that the growth in rail travel over the past 20 years has almost entirely been due to a greater proportion of the population recording some rail travel in their diary, rather than due to rail users travelling more frequently by rail. The analysis shown in Chapter 6 and Chapter 7 rigorously confirms this earlier research, through developing analytical relationships between the propensity to use rail and a range of explanatory factors.
- 3.2.5** The emphasis of the analysis is on rail trip rates rather than on rail trip distance. This is because the growth in rail trips has occurred only at a slightly faster rate than that for rail kilometres, thus leading to a modest 7% reduction in the average rail trip length since 2002. This contrasts with the more than doubling of total rail passenger trips since 1995, which accordingly is of much greater interest for analysis.
- 3.2.6** Within the NTS dataset, the analysis of rail travel is more challenging than that of other major transport modes because of the relatively small sample size that comprises the set of rail travellers. Despite the rapid recent increase in rail trips, they still comprised only 3% of all trips made in England in 2014, though due to their longer than average trip lengths this equates to 10% of the total travel distance covered. Accordingly, it is necessary to analyse rail travel demand using appropriate statistical regression techniques in order to make productive use of this limited sample size, when quantifying the range of potential interacting factors that may influence rail travel behaviour and then analysing how these influences evolve over time. In particular, for the set of rail trips for the business purpose, its small sample size implies that only a more limited range of segmentation detail than for commuting can safely be adopted within its statistical analysis.

### 3.3 Identifying and quantifying the key external influencing factors on rail growth

**3.3.1** To understand how rail passenger numbers may evolve into the future, it is crucial to identify and quantify the main genuine influences on rail growth. Various potential influences are examined within the visual analysis presented in the chapters 4 and 5. The next step then is to drill down to adopt a more structured approach to the examination of these influences on rail growth. This has three main strands.

- **Segmentation:** Rail passengers are not a single homogeneous group. In particular, the characteristics of travel and of rail travellers differ greatly between distinct travel purposes. Accordingly, the influences on each of the main travel purposes benefit from being examined separately. This is particularly important for this study which focuses primarily on those influences external to rail industry operations, rather than on the impacts of rail supply improvements, such as more frequent rail services or fare reductions, which may be more homogeneous across rail travellers in their effects. The statistical models used in this report are used to identify for each of the individual travel purposes in turn, the main population segments that have distinct levels of rail use for that travel purpose.
- **Distinguishing behavioural change from change in incidence:** Box 1 provides a simple example to illustrate the interaction between these two important concepts when analysing trends. Chapters 4 and 5 focus largely on the impacts on rail usage from changes in population incidence, whether through differing employment growth rates across industry sectors and/or across areas of differing residential densities, etc. Such analyses carry the assumption that the underlying behaviour of individual homogenous segments remains largely constant over time. In contrast, the statistical models used in Chapters 6 to 8 can examine the evidence on whether behaviour has actually been constant over time within each relevant segment. However, such estimation has only been feasible for those travel purposes for which the NTS data sample of rail travellers is large enough to facilitate this examination.
- Otherwise in cases where the NTS rail travel sample size is small, then due to potentially large sampling variation within individual time segments it becomes difficult to distinguish sampling errors from genuine changes in behaviour over time: the estimation results would not be statistically significant in such cases. Accordingly, where the temporal variation is statistically significant, the model results provide strong evidence of temporal change. However, where the variations across time periods are not statistically significant, that can either be due to behaviour being reasonably constant through time or it may just be a side-effect from a small sample size. We have tested for temporal variations for all travel purposes but a statistically significant change was indicated only for one influencing factor for one travel purpose, commuting<sup>9</sup>, as reported later in Chapter 6.



- **Quantifying the net impacts on rail growth of the strands above:** The next logical step would be to combine the two strands above within a forecasting system that merges: the model based rates of rail use for every segment; with the growth over time in the size of each such population and employment segment. However, applying this forecasting step lies beyond the scope of the current study, though the broad principles involved in creating such forecasts are discussed further below in Chapter 11. In parallel, a qualitative informal overview of the evolution from the past into the future of all of the main influences on rail growth is provided in Chapter 10.

**Box 1** Understanding the effects of changes in incidence versus changes in behaviour

This box illustrates the importance of distinguishing within a population between:

- differences/changes in the incidence of groups within this population;
- differences/changes in the behaviour of groups within this population.

The latter are what are investigated in our statistical models, while the former may be equally influential, though not necessarily obvious, within our more aggregate charts and tabulations.

The simple example in the table below illustrates the issue for two homogeneous population sub-groups A and B that differ in their travel behaviour. In the year 2000 the larger Group A had an average trip length of 20 miles, whereas Group B had a much longer trip length of 40 miles. The resulting overall average trip length in the year 2000 was 29 miles.

	Group A		Group B		All
Date	Number	Ave. trip length	Number	Ave. trip length	Ave. trip length
2000	500	20	400	40	29
2010	800	23	200	43	27

Between 2000 and 2010 the population in Group A increased to 800, whereas the population decreased in Group B to 200. In response to reductions in travel costs over time, the average trip length for each individual group **increased** by 3 miles. However, despite this, the overall average trip length reduced by 2 miles from 29 to 27.

In this case the **individual** travel behaviour changed in the expected direction but the external changes in population incidence caused the **overall average** trip length to move in the reverse direction, implying a **counter-intuitive aggregate response**.

**3.3.2** The simple example in Box 1 highlights: why the identification and subsequent disaggregation of the population into reasonably homogeneous segments is necessary; and why the changes over time in the relative sizes of such groups must be tracked. In the contexts identified in this research, where the relative proportions of, say, employment by SIC or of residents by density class, are changing strongly through time, then such incidence changes may swamp the signals of behavioural change whenever these signals are measured only at an aggregate level.

**3.3.3** A proper understanding and quantification of the important behavioural influences can only be achieved by disaggregating the analysis so as to identify and track sub-groups of the population that exhibit reasonably homogenous behaviour within them. The identification of these sub-groups is carried out rigorously using the statistical modelling approach summarised next.

## 3.4 Approach for data analysis

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### Multi-dimensional Analysis for workplace and residential location (Chapters 4 & 5)

**3.4.1** Using combinations of a wide range of data sources the propensity for rail use is analysed in Chapter 4 at the workplace location end of commuter trips to examine how the propensity to commute by rail varies across Standard Industrial Classification classes (See Appendix 1 for SIC definitions) and to clarify the extent to which these usage patterns are common across all of the regions. It then quantifies how differential employment growth rates across industry sectors have impacted on the rate of growth of rail travel for commuting and business travel purposes. The empirical analysis covers all regions of England and Wales though with more detailed scrutiny on the travel market for London and surrounds.

**3.4.2** Chapter 5 uses the Census and various other datasets instead at the residential location end of a trip to examine how the propensity to use rail varies between areas of different population densities.

**3.4.3** The analyses of evidence in Chapters 4 and 5 have largely been presented in the form of visual presentations of sets of independent charts or of tabulations of spatial and temporal trends in which each presentation contains only a relatively small number of cross-tabulated dimensions or variables. This visual approach has a number of advantages in that: it is relatively easy to present, interpret and understand; and it allows the use of a very wide range of data sources without the need for a complex resolution of the inevitable differences in the definitions or categorisations of the variables that can arise in these distinct presentations.



**3.4.4** Nevertheless, this approach has limitations from a scientific viewpoint because the evidence assembled indicates:

- that the number of important individual influencing factors on rail passenger demand is potentially quite large;
- that these individual influences will often interact with one another rather than having purely distinct and independent effects on rail demand;
- that these influencing factors may correlate strongly through space or through time with other subsidiary variables that in reality are not the real factors that directly influence rail demand.

**3.4.5** Consequently, this visual approach may not be very discriminating in separating out: the genuinely important influencing factors on rail travel demand; from a variety of other less relevant factors that just happen to correlate with them. To address the methodological limitations of the purely visual approach to multi-dimensional analysis, it is complemented in the following three chapters (6, 7 & 8) by the results from a rigorous statistical modelling approach that is designed to operate on a single, internally consistent dataset, the NTS.

### **Statistical Modelling Approach for analysis of rail travel by trip purpose (Chapters 6, 7 & 8)**

**3.4.6** In Chapters 6 to 8 an alternative methodological approach is adopted which estimates rigorous statistical models of observed rail usage for individual commuting, business and other travel purposes.

**3.4.7** The analysis of each trip purpose in turn examines how much of the observed growth in rail trips between 2002 and 2015 is due to:

- there simply being a larger population within the particular residential and workforce segments and locations that traditionally have used rail regularly.
- a larger proportion of the population within each segment now making some rail trips.
- existing rail users making more trips per week.

**3.4.8** Analysis techniques are adopted that mitigate the impact of internal correlations between the factors being analysed, a problem often termed the self-selection effect. Those who locate in any particular area will often tend to have many characteristics in common with the other local residents there. Accordingly, it can be difficult within the analysis to distinguish:

- influences that are related to the built form of that location;
- from influences that are related to the residents or the workplaces in the locality.

**3.4.9** A sophisticated statistical approach is required that can estimate those factors that have a direct influence on rail demand, while separating these factors out from those whose apparent influence appears instead to be an indirect result that is due more to the spatial and or temporal associations of various demographic and other trends.

**3.4.10** A combination of Latent Cluster Analysis and of Zero Inflated Negative Binomial modelling techniques has been adopted here that has been designed to disentangle the key relationships in complex situations, such as those analysed within this rail study. Variants of this Structural Equation Modelling (SEM) approach are estimated individually for the key rail travel purposes:

- Commuting: which comprises the largest overall market for rail trips – Chapter 6;
- Business: this comparatively small number of trips is disproportionately important to the rail revenue stream – Chapter 7;
- Other travel purposes: including retail, personal business, leisure, visiting friends and relatives and holiday trips – Chapter 8.

**3.4.11** Education trips have not been explicitly modelled because: they are not large in number; they are typically over short distances with low revenue yields; and they do not combine naturally within any of the other three categories above. To avoid unduly complicating and lengthening this report, most of the detailed description of the implementation and methodology of the models for the three trip purposes has been assigned to appendices<sup>10</sup>.

## 3.5 Overview of assumptions and approach to model-based analysis of rail commuting

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**3.5.1** Trips for the travel purpose commuting comprise the largest proportion of overall trips by rail. This ensures that the NTS dataset contains a large enough sample of commuter rail trips to enable advanced statistical modelling techniques to be suitably applied. These techniques are needed in order to:

- a) Identify the distinctive rail market segments for commuters (based on the built form characteristics of their area of residence and on their individual socio-economic characteristics) and then to track changes in their number of rail trips over time;
- b) Disentangle the influences of their socioeconomic characteristics from those of the built form, in order to understand the distinctive role of each in influencing trends in rail commuting trips.

**3.5.2** For point a), we use Latent Cluster Analysis (LCA) to specify distinct clusters by homeplace and workplace characteristics that are conditional on socioeconomic characteristics but not on modal travel choices. Then, for each of these clusters, we derive the changes in rail travel outcomes over time.

**3.5.3** For point b), we use a two-level regression-type analysis to disentangle the variations across individuals from those across built form clusters. We apply a Zero Inflated Negative Binomial (ZINB) regression (Jahanshahi et al. 2017) to each distinct cluster in order to estimate all of the significant influences on the number of rail trips made per survey week. This ZINB model uses the number of tours (i.e. pairs of rail trips: 0,1+2, 3+4,5+6, ...) rather than of individual trips in order to avoid lumpiness in the independent variable. The two decision stages in the model are:

- Does an individual make any commuting trips by rail in the course of a week?
- If yes, how many pairs of trips are made in the week?



**3.5.4** ZINB adds an extra layer of complexity to the latent cluster analysis<sup>11</sup>. Having shown the importance of built form characteristics at homeplace and workplace through LCA, we then fixed the clusters by the main built form indicator - i.e. area type pairs - in order to then study the variations in commuting rail trips across homogeneous clusters over time. The aim is to examine how travel behaviour has or has not changed, while cancelling out influences due to the changes in the incidence (spatial pattern) of residential and of employment locations.

**3.5.5** The following summarizes the approach taken for analysing the time trend for commuting rail trips for England as a whole:

- Firstly, we defined the appropriate clusters by area type pairs at homeplace and workplace.
- Secondly, we analyse the average rail usage (in terms of both: weekly rail trip rates per rail user; and the propensity for an individual to make at least one rail trip within the survey week – termed “rail propensity”) within the selected cluster. At this stage we focus only on that subset of clusters that have sufficient rail trip sample numbers - defined either as rail being a large proportion of the total commuting trips or as a relatively large absolute number of rail commuting trips. This concentrates this stage of the analysis onto the commuting trips into London.
- Then we examine how the incidences of rail trip making have changed over time, within the various clusters.

## 3.6 Disaggregate ZINB model of rail commuting to major rail clusters

**3.6.1** The main assumptions adopted within this ZINB model of the influences on rail commuting are as follows.

**3.6.1.1** The analysis here only includes those people who are making commuting trips. It makes the rail trip analysis conditional on making at least one commuting trip in the course of the survey week. This reduces model complexity through avoiding mixing two different functional zeros:

- zero trips for not making a commuting trip - excluded within this model;
- zero trips for not making commuting trips by rail.

**3.6.1.2** It uses a Zero Inflated Negative Binomial (ZINB) regression model for analysing the number of rail trips per week. This provides a two stage model analysis:

- analysing influences on the decision to make rail commuting trips (i.e. whether such a trip is made or not);
- analysing the number of commuting rail trips which are made within a week, conditional on making at least one rail commuting trip.

- 3.6.1.3** The correlation across independent variables is controlled in estimating influences. For instance the correlation of car ownership with income is considered in controlling each of the car ownership and income influences on rail trips.
- 3.6.1.4** The model framework, including the list of segmentation variables that have been considered within it, is similar to that presented later in Chapter 7 for business travel.

## 3.7 Standard Industrial Classification – SIC (2007)

A key element in the analysis of commuting patterns relates to the industry sector of the employee. This is represented by the Standard Industrial Classification – SIC (2007) as specified in Table 2 and explained in more detail in Appendix 1.

**Table 2:** Standard Industrial Classification – SIC (2007)

A	Agriculture, forestry and fishing
B	Mining and quarrying
C	Manufacturing
D	Electricity, gas, steam and air conditioning supply
E	Water supply, sewerage, waste management and remediation activities
F	Construction
G	Wholesale and retail trade; repair of motor vehicles and motor cycles
I	Accommodation and food service activities
H	Transport and storage
J	Information and communication
K	Financial and insurance activities
L	Real estate activities
M	Professional, scientific and technical activities
N	Administrative and support service technical activities
O	Public administration and defence; compulsory social security
P	Education
Q	Human health and social work activities
R	Arts, entertainment and recreation
S	Other service activities
T	Activities of households as employers; undifferentiated goods and services producing activities of households for own use
U	Activities of extraterritorial organisations and bodies



## 4. Workplace Analysis

### Key Findings

- The propensity to use rail for commuting travel across different employment sectors in England and Wales indicates that people working in financial and insurance activities have the highest percentage of rail commuting while the manufacturing sector has the lowest percentage.
- Commuter rail use is high for office-based jobs in high-density urban areas and low for employment based on the outskirts of cities in low-density development.
- Jobs in those industry sectors with higher than average rates of rail commuting and business travel have increased at a much faster rate since 1996 than the jobs in the rest of the economy, accounting for part of the increase in the overall growth of rail travel per capita.
- Analysis of the impact of sectoral industrial growth on rail travel demonstrates that at least a 41% increase in rail travel for commuting purposes has arisen from 27% growth in overall employment since 1995.
- The spatial location of workplaces has also contributed to the increase in rail commuters. An increased concentration of jobs in Central London with dense urban development has generated increased growth in rail trips on account of its accessibility and the convenience of services.

### 4.1 Differential rates of rail commuting by SIC

- 4.1.1** This section examines the ONS 2011 Census Journey to Work (JTW) data, segmented by industry (SIC – see footnote<sup>12</sup> and Table 2) and mode, in order to identify the strength of the relationship between industry type and the propensity to commute by rail.
- 4.1.2** The percentage of commuters who normally use the rail mode (rail data presented in this section also unavoidably includes London Underground, light rail and tram usage) is presented by SIC and region of residence in Table 3. It indicates that for England and Wales as a whole, the percentage of rail commuting varies between a high of 30% for SIC K: Financial and insurance activities, and a low of 2.4% for SIC C: Manufacturing. However, the percentage point spread between SICs K and C in the proportion using rail differs across the regions, being greater than the national average in the East (39% v 5%) and particularly in London (63% v 21%).

12 The definition of each of the individual SIC codes is listed in the Annex. **A:** Agriculture, forestry and fishing, **B:** Mining and quarrying, **C:** Manufacturing, **D:** Electricity, gas, steam and air conditioning supply, **E:** Water supply, sewerage, waste management and remediation activities, **F:** Construction, **G:** Wholesale and retail trade; repair of motor vehicles and motor cycles, **H:** Transport and storage, **I:** Accommodation and food service activities **J:** Information and communication, **K:** Financial and insurance activities, **L:** Real estate activities, **M:** Professional, scientific and technical activities, **N:** Administrative and support service technical activities, **O:** Public administration and defence; compulsory social security, **P:** Education, **Q:** Human health and social work activities, **R:** Arts, entertainment and recreation, **S:** Other service activities, **T:** Activities of households as employers; undifferentiated goods and services producing activities of households for own use, **U:** Activities of extraterritorial organisations and bodies

**Table 3:** % of commuters using rail, LU, LRT or tram: by SIC, by region of residence, 2011<sup>13</sup>

	All	A B D E	C	F	G	H	I	J	K	L	M	N	O	P	Q	R S T U
North East	4	4	2	2	3	3	4	6	7	2	7	4	5	4	3	4
North West	3	2	1	1	3	3	3	6	11	3	8	4	6	3	2	3
Yorks & Humber	3	1	1	1	2	2	2	6	9	3	7	3	5	3	2	3
East Midlands	2	1	0	1	1	2	1	5	7	2	4	1	3	2	1	2
West Midlands	3	2	1	1	2	3	2	5	11	4	8	3	5	2	2	3
East	8	2	2	5	4	7	4	17	39	9	18	7	13	4	4	7
London	35	24	21	30	27	21	34	47	62	29	49	37	41	23	26	33
South East	7	4	3	4	4	6	4	14	28	8	16	6	12	4	4	7
South West	2	1	1	1	1	2	1	4	5	1	4	1	3	2	1	2
Wales	2	2	1	1	2	2	2	5	8	2	5	2	3	2	1	2
England & Wales	9	3	2	6	5	7	8	20	30	10	20	10	11	6	5	9

(Source: ONS 2011 Census Table DC7602EW1a<sup>14</sup>)

**4.1.3** The probability of commuter rail use relates strongly to the likelihood that the workplace will be an office-based activity, SICs J to O (highlighted in gold colour in the Table) of the type that is attracted to high density urban areas. It is lowest for manufacturing activities that increasingly tend nowadays to be located on the outskirts of town in low density areas that accordingly tend not to be accessible to passenger rail stations.

**4.1.4** The broad pattern of differences between SICs persists across all regions, with the highest proportion using rail in every region being SIC K, followed generally by M: Professional activities, then J: Information and communication, then O: Public administration. These SICs that have high rates of rail usage tend to be office based jobs and often have relatively high average incomes. Furthermore, they may benefit from agglomeration economies because they often are not primarily serving the local population in their neighbourhood but serve a wider spread of clients throughout a region or sub-region. In this way they differ from other professional activities, such as P: education and Q: health and social work, most of which are spread widely throughout the population to serve their local communities.

<sup>13</sup> ONS. Red/green denote high/low percentages

<sup>14</sup> The available ONS 2011 Census tables (i.e. DC7602EW1a or LC7602EW) that are jointly segmented by SIC and by mode, unfortunately always combine together the rail mode with the LU, LRT and tram modes. They also aggregate the SICs as indicated above. Furthermore, these tables are only available by location of residence and not by location of workplace. Nor are they available for 2001.



## 4.2 Differential growth trends over time by SIC

- 4.2.1** The question examined here is whether the jobs in those industry sectors within which there are higher than average rates of rail commuting and rail business travel are growing at an above average rate over time in the economy as a whole?
- 4.2.2** The analysis was carried out over the period from 1996 to early 2018 using the NOMIS Workforce Jobs dataset that is segmented by industry (SIC 2007). This dataset provides quarterly estimates of workforce jobs that are adjusted to compensate for seasonal variations in employment.
- 4.2.3** “Workforce jobs” is a workplace measure, so these estimates indicate the number of jobs located in the geographical areas selected. Estimates are available from NOMIS at the national and regional levels only. No estimates are produced below this level, i.e. no data for local authorities. Accordingly, the analysis illustrated in the Figures below is for the major concentration of workplace jobs located in the London region which is contrasted with the trends in two other regions that were selected so as to provide a representative cross-section: the East of England and the North West. In addition, Table 4 provides information on the total change in jobs for each category of SICs between 1996 and 2018 across the whole of England and Wales.
- 4.2.4** Figure 8 gathers together the set of SICs: J, K, L, M, N, O and R whose activities will mainly take place within office-type environments. The other large SICs: C, F, G, H, I, P, Q and S are presented in Figure 9. These latter activities will generally take place in non-office-type environments, such as factories, building sites, warehouses, schools, medical practices or hospitals. Such activities, with the partial exception of retail, tend: either to be better suited to lower density, low rent developments that would struggle to compete within city centre areas that are adjacent to major rail passenger terminals; or to benefit from being dispersed widely among the local population to which they provide services. A few other SICs: A, B, D, E, T and U are not included in either chart due to their relatively small job numbers throughout the regions.
- 4.2.5** What is most striking from these charts is the broad similarity across the three regions in the trend over time for any specific SIC. In Figure 8, the employment growth in each of the regions is due most strongly to M: Professional, and N: Administrative support, as well as to J: Communication. The SICs L: Real estate and R: Arts grow significantly in each region but still remain as rather small classes. In contrast, the more substantial SICs K: Finance and O: Public admin are stable or slightly declining over time in all three regions. This similarity across regions in trends is at odds with the considerable differences in the relative sizes of the various SICs across the regions. M and K are larger than average in London, whereas O and N are larger than average in the North West.
- 4.2.6** Analogous patterns are exhibited by the set of non-office based SICs presented in Figure 9. The most rapidly growing SIC in all three regions is Q: Health and welfare, whereas C: Manufacturing declines by close to 50% in all three regions. Again, the incidence of some SICs differs strongly between regions, with London nowadays having very little manufacturing industry still in existence.

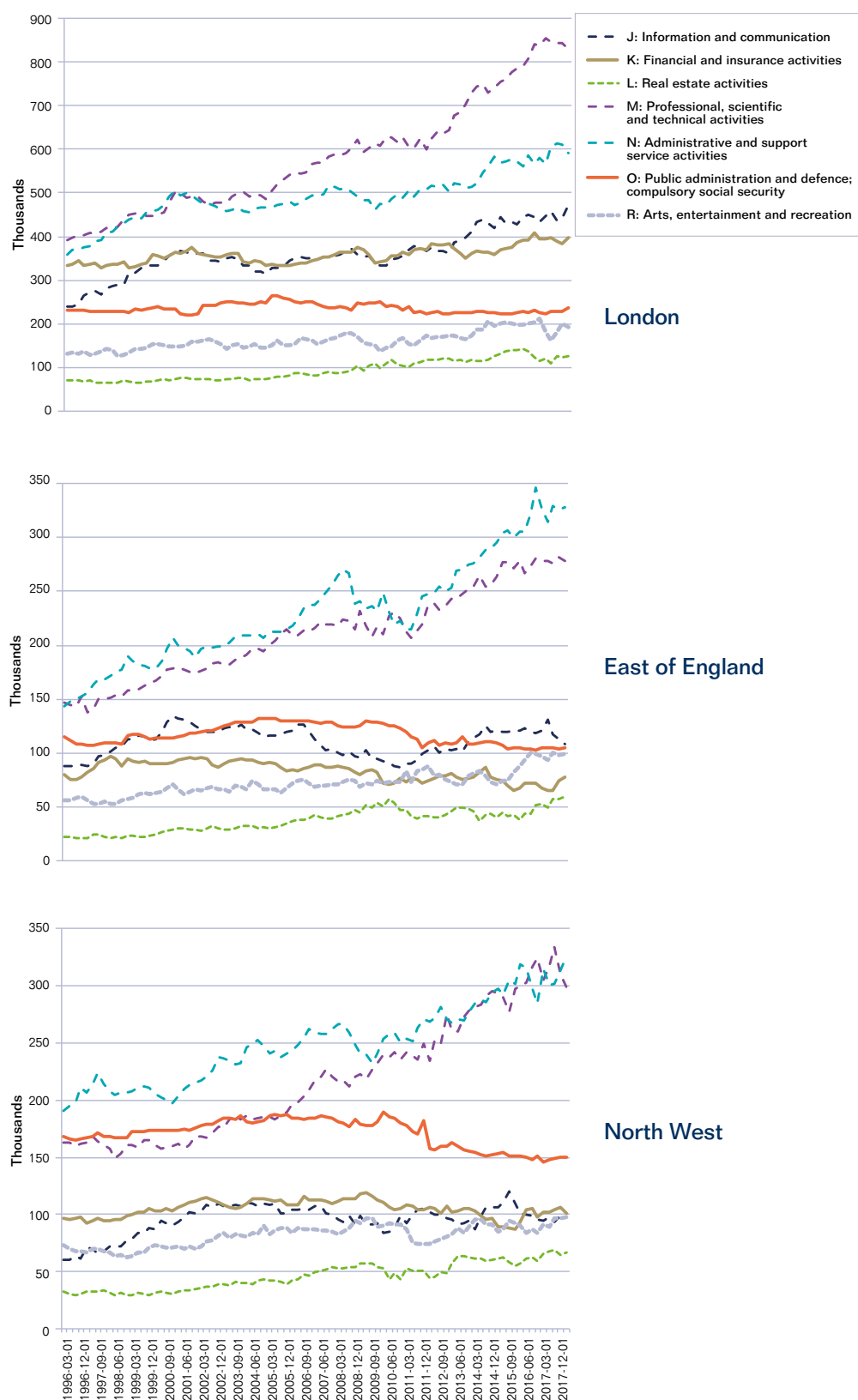
**Table 4:** Total workforce jobs (000) in England and Wales by industry (SIC) change from 1996 to 2018

	England and Wales March 1996	England and Wales March 2018	
SIC category	Workforce jobs (000s)	Workforce jobs (000s)	Percentage change
ABDE	635	696	9.6%
C	3,812	2,410	-36.8%
F	1,582	2,060	30.2%
G	4,188	4,457	6.4%
H	1,127	1,632	44.8%
I	1,434	2,165	51.0%
J	754	1,356	79.8%
K	990	1,028	3.8%
L	259	523	101.8%
M	1,489	2,800	88.1%
N	1,599	2,756	72.4%
O	1,391	1,270	-8.7%
P	1,797	2,651	47.5%
Q	2,535	3,898	53.8%
RSTU	1,303	1,831	40.6%
All	24,895	31,534	26.7%

(Source: NOMIS)

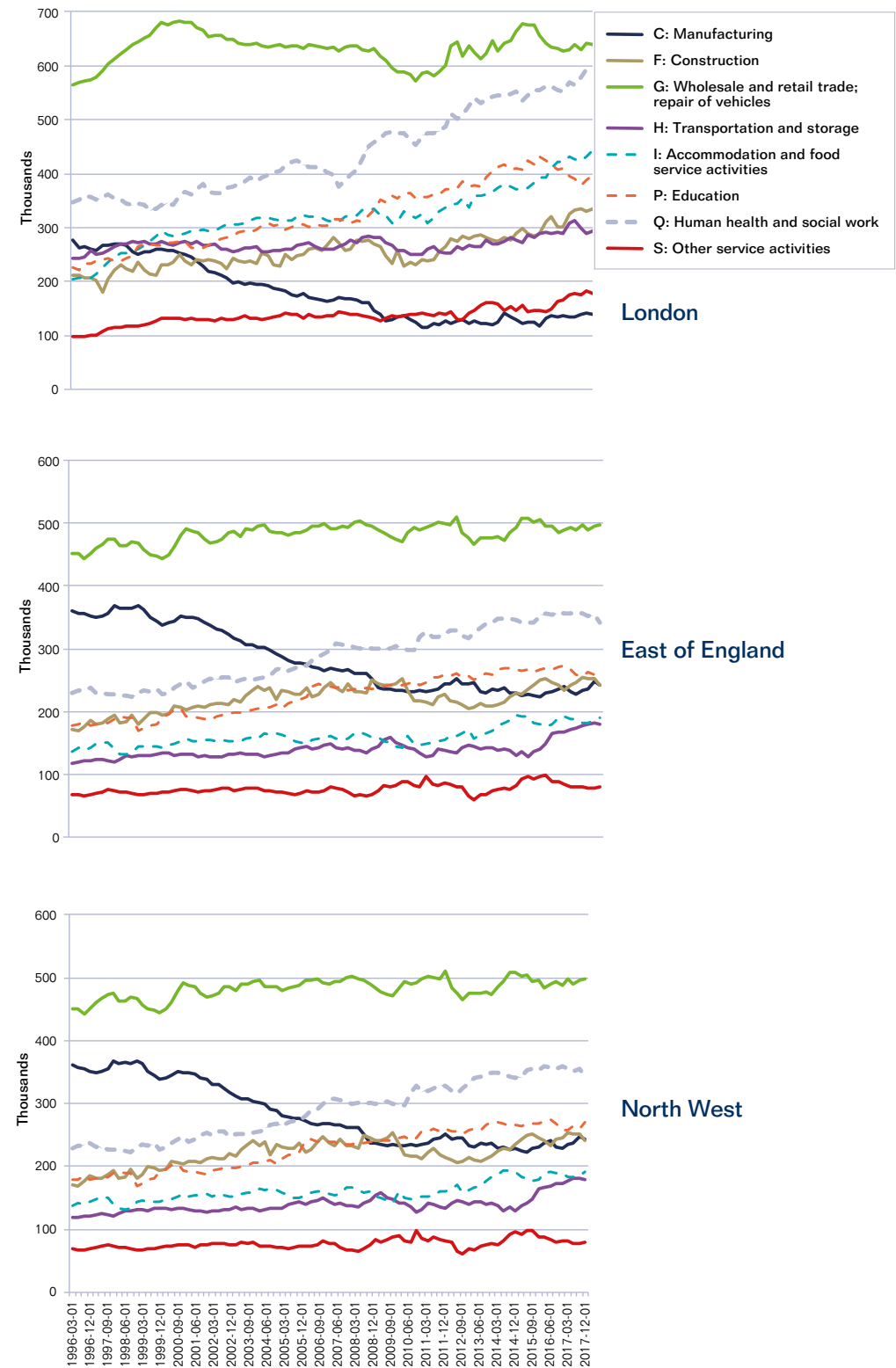


**Figure 8: Regional workforce jobs for office based SICs, Quarterly 1996-2018, Q1**



(Source: NOMIS Workforce Jobs dataset.)

Figure 9: Regional workforce jobs for other SICs, Quarterly 1996-2018, Q1



(Source: NOMIS Workforce Jobs dataset.)

**4.2.7** The primary interest in these charts from the point of view of this study is that they demonstrate that many of the SICs with high propensities to commute by rail are growing rapidly everywhere, while most of those SICs with a low propensity to commute by rail are growing slowly or in the case of SIC C: manufacturing, which has the lowest rail share, are declining rapidly everywhere.

## 4.3 Impact of industrial sectoral change on rail growth

**4.3.1** This section combines together the findings from the previous two sections in order to quantify across England and Wales the impact on the rate of growth in rail commuters of the observed changes over time in the structure of British industry. The question examined here is how much of the growth in rail commuter traffic since 1996 is a direct result of sectoral economic growth and change, over and above the component of commuter growth due simply to the growth over time in the number in employment?

**4.3.2** This effect has been measured by applying the 2011 percentage commuting by rail (Table 3) in a form that is segmented by SIC and region, to the corresponding regional workplace totals, segmented by SIC, for England plus Wales. The calculation of the expected number of rail commuters is carried out using the same 2011 rates, for both the 1996 and the 2018 workforce totals that are illustrated in Figure 8 and Figure 9 above. The resulting estimated growth in the number of rail commuters due simply to differential sectoral employment increases is presented in Table 5 both as an absolute increase (000s) and as a percentage increase from 1996.

**Table 5:** Estimated increase in rail commuters from 1996 to 2018 attributed to differentiated sectoral economic growth, England and Wales

SIC	ABDE	C	F	G	H	I	J	K
% increase 96-18	13%	-41%	45%	8%	38%	81%	85%	7%
% contribution of each SIC to overall rail growth	0%	-5%	5%	2%	4%	8%	15%	2%
Abs. increase (000s)	2	-30	27	14	23	50	89	14

SIC	L	M	N	O	P	Q	RSTU	Total
% increase 96-18	100%	94%	71%	-7%	55%	58%	46%	41%
% contribution of each SIC to overall rail growth	3%	32%	13%	-1%	7%	9%	6%	100%
Abs. increase (000s)	18	190	79	-9	39	54	37	597

(Source: Workforce jobs, NOMIS)

Key:  = Office type employment for SIC code

### Background to the methodology used in Table 5

There are some inherent limitations and minor inconsistencies in the form of the analysis above that should be noted. The percentages of regional rail use are calculated per person based on the residents in the region, but these are applied to the regional jobs (not workforce or residents) based within each region. To avoid upward bias, all the % rail rates for London (but not in other regions) presented in Table 5, have been reduced across the board, based on the London workplace ratio of: 48% rail users within the rail plus LU commuter total in 2011, prior to being used within this estimation.

These inconsistencies are a direct result of inconsistencies between the formats in which the data are made available from the different data sources that have needed to be combined to complete this analysis. They are unlikely to impact significantly on the main conclusions presented.

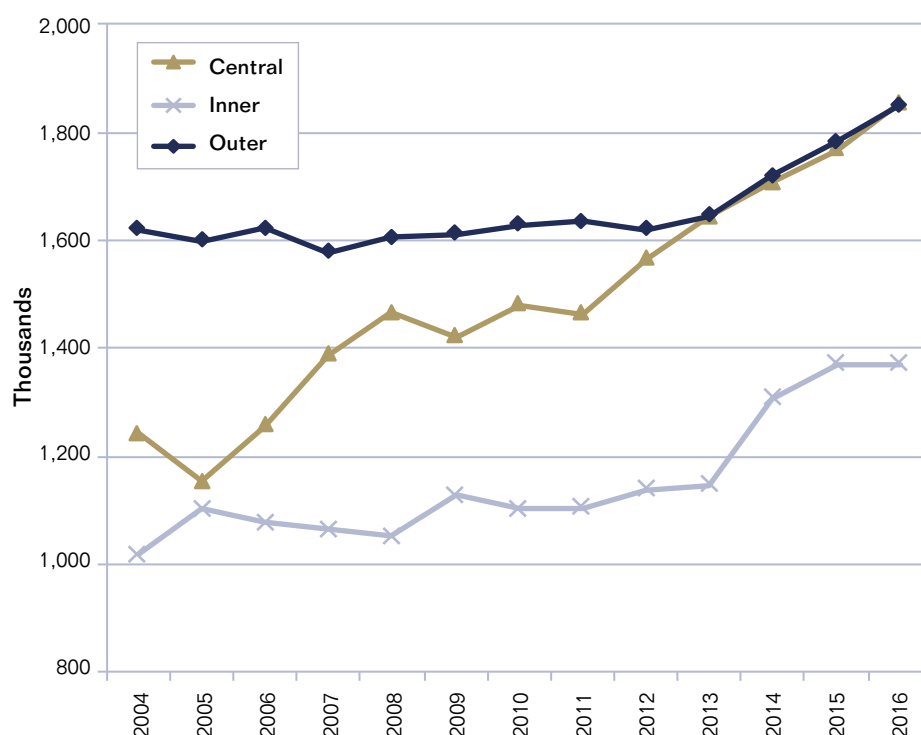
- 4.3.3** It can be seen from the bottom row of Table 5 that SIC M: Professionals provides almost a third of all of the estimated rail commuter growth, due to a combination of its rapid employment growth in all regions and to its high propensity for rail use. SICs: J and N also contribute considerably to rail commuting growth.
- 4.3.4** The actual growth in employment numbers is 27% job growth from 1996 to 2018. However, as a direct result of the spatial and sectoral economic composition of employment growth from 1996, this calculation at the regional scale indicates that an increase of 41% in rail commuters would be expected to arise from this 27% employment growth. This further 14% growth (=41%-27%) is a result of two interrelated trends, with approximately equal contributions:
- Those SICs with above average rates of rail commuting have generally grown much more rapidly in all regions than those SICs with low rail usage;
  - The number of jobs in London, the region that has the highest rate of rail use, has increased by 49%, a rate that is well above the 27% average jobs increase across England and Wales overall.
- 4.3.5** In reality, this approximate calculation is likely to significantly underestimate the full contribution to rail commuting growth that results from differential spatial trends in job growth. This underestimation arises because in effect it assumes a uniform job growth rate across all parts of each individual region. In practice, much of the more recent job growth within individual regions has been concentrated at high densities in the city centres. These are precisely the locations where rail competes best against other modes. This indicates that the additional spatial and sectoral impacts on rail commuter growth are likely to be considerably greater than the 14% indicated by the method described above.



### 4.3.6

Data from the Annual Population Survey (APS) illustrates this pattern for London through analysis of the individual growth trends for Central, rest of Inner and Outer London in the main workplace of individuals for all industry sectors combined. Figure 10 shows that between 2004 and 2013 the vast majority (72%) of the employment growth in London was concentrated within Central London workplaces. It indicates a growth of over 600k workplaces to 2016 within the Central London area that is highly accessible by rail, whereas until 2013 there had been little workplace growth in Outer London where rail is a minor mode, and had only been modest growth in the rest of Inner London. In contrast from 2013 to 2015 all three areas have increased at similar rates but the workplace growth rate tailed off again in 2016 for the rest of Inner London.

**Figure 10:** Main workplaces in Central, rest of Inner (excluding Central) and Outer London 2004 - 2016<sup>15</sup>



(Source: APS.)

**Table 6:** Rail commuting shares for London workplaces, 2001 and 2011

	2001		2001	Abs. increase 01-11		2011	% point gain 01-11
	All modes	Rail	Rail share	All modes	Rail	Rail share	Rail share
Inner London (inc. central)	2,168,808	574,763	26%	489,436	121,630	26%	0%
Outer London	1,636,847	86,403	5 %	2,053,90	45,490	7%	2%
<b>London</b>	<b>3,805,655</b>	<b>661,166</b>	<b>17%</b>	<b>694,826</b>	<b>167,120</b>	<b>18%</b>	<b>1%</b>

Rounded off to nearest %

(Source: ONS Census JTW tables 2001, 2011)

**4.3.7** Table 6 uses Census data to analyse the changes over the decade from 2001 to 2011 in the share of rail<sup>16</sup> trips for those commuting to workplaces in Inner and Outer London. Although all of the boroughs, which contribute to the Central London area within the Inner London total, achieved major increases in the number of rail trips, nevertheless the percentage share of rail has actually decreased in many of the most significant boroughs over this decade, and has decreased marginally for workplaces across Inner London as a whole. The rail traffic gain appears to be due primarily to the increase in employment numbers in Central London, rather than to rail gaining share from other modes for the workplaces within these locations.

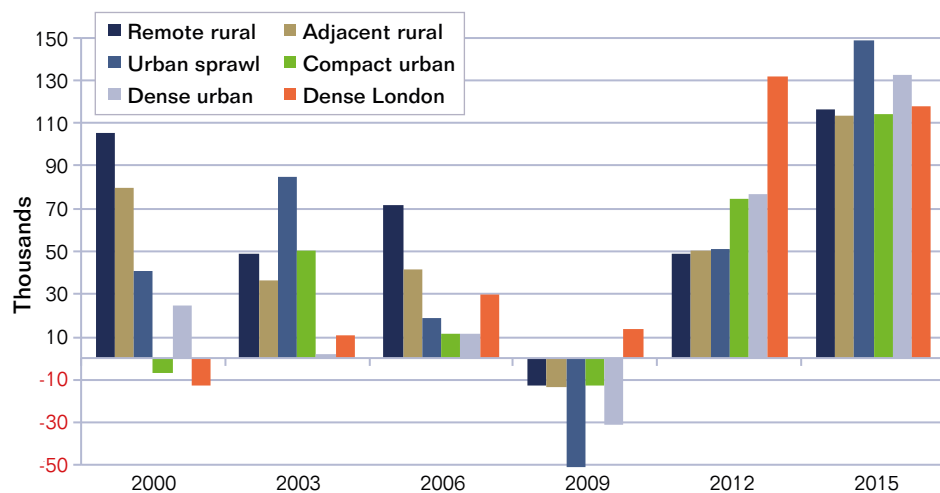
**4.3.8** In summary, the various evidence sources presented above measure how much of past rail commuter growth has occurred either for sectoral economic reasons or due to spatial workplace trends, both of which are largely unrelated to the rail industry itself. The service supply provided by the rail industry has, of course, needed to adapt and expand so as to cater for this passenger growth but there is no compelling evidence that it is a strong driving force generating this growth. When considering these sectoral economic and spatial influences on rail commuter growth, rail supply characteristics are instead best thought of as an enabling feature, rather than as the major driving force.



## 4.4 Spatial imbalances between resident supply and workplace demand for labour

**4.4.1** As stated in Chapter 5, Residential Analyses, there has been an imbalance in the housing supply and demand. However, despite its many costs and inconveniences to the public in general, it may have encouraged the growth in rail demand for commuting. The lack of sufficient local housing can lead to an increased demand for long distance commuting in order to access the job growth in city centres and this is exactly the commuting market for which rail competes best.

**Figure 11:** Average annual growth in total jobs by workplace in 3 year periods, by residential density band, 2000 - 2015



(Source: NOMIS Jobs density tables)

**4.4.2** Figure 11 illustrates the annual average growth in jobs by the location of workplace, using the standard residential density bands to indicate the spatial pattern in a form that is consistent with the Figure 12 for population growth, in the next chapter.

**4.4.3** In the early 2000s the jobs growth was highly concentrated towards the lower density (refer Box 2 in the next chapter for definition of Density Bands) bands in a pattern that paralleled the spatial pattern of population growth in that early period. By the most recent 2014-16 period, the absolute growth in jobs was similar across all density bands, again not dissimilar to the most recent pattern of population growth. However, the switch of the focus for employment growth away from the lowest density bands appears to have lagged behind that of population by some years, even prior to the recession induced employment collapse during 2008-10. For example, the Dense London employment growth did not accelerate until the 2005-07 period, about a decade after its population growth accelerated.

**4.4.4** Nevertheless, overall in the years after the recession, the job growth has been greatest in the denser distance bands, particularly in the Dense London band, which will tend to have supported the growth in rail demand both for commuting and for business travel.

## 5. Residential Analysis

### Key Findings

- The spatial location of population growth since 1995 was found to be strongly favourable to growth in the passenger rail market.
- In the decades leading up to rail privatisation, almost all of the growth in population and in dwelling construction took place in low-density areas that traditionally had low rates of rail use by their residents. The major metropolitan areas, where rail usage by residents was higher were declining during this era.
- In contrast, from the mid-1990s onwards the spatial patterns of residential growth gradually reversed, led by Inner London, so that today the highest rates of population growth are observed in areas of highest residential density, which are also those in which the rates of rail use are highest per capita.
- The imbalance has also resulted in rapid house price inflation in London hence making it difficult to afford owning a car and further increasing the propensity to use rail for commuting.
- A reduction in urban car ownership rates has resulted in the growth of commuting by rail in the denser urban areas exceeding that of any other mode of transport.

### 5.1 Introduction

- 5.1.1** The analysis of spatial trends in workplace growth of the previous chapter is complemented below by a similar analysis of the spatial trends in the growth in residents. It combines a range of disparate data sources to investigate and then quantify a variety of aspects of residential location characteristics that have combined together to influence recent rail growth trends for commuting and for other travel purposes.
- 5.1.2** Firstly, the spatial pattern of residential growth is examined, which indicates a major switch through time: reversing from a pattern where residential growth originally was greatest in the least dense areas; to now being greatest within the most dense urban areas. Then it explores whether this spatial shift in residential growth patterns through time has been matched by a corresponding shift in dwelling supply. Surprisingly, it finds an unhelpful ever-increasing spatial imbalance between dwelling growth and residential population growth.
- 5.1.3** Next the gradual changes over time in the age composition of those residing in different types of areas are examined, together with their implications for commuting patterns by mode. Finally, the increasing differentiation in car ownership levels between different types of areas is investigated to ascertain the extent to which this has supported the overall growth in rail passenger travel demand.

## 5.2 Overview of residential growth

**5.2.1** It is well known that the rate of population growth in England and Wales has accelerated in recent years due both to increases in birth rates and to higher levels of net in-migration. What has been less studied is how this pattern of increasing growth over time translates into very different growth rates across areas categorised by their residential density. We show below that the more recent trends in where population growth has been located have been strongly favourable to the passenger rail market.

**5.2.2** To support this analysis, six residential density bands have been defined in the manner specified in Box 2. These summary density band categories are widely used below to analyse in a consistent fashion the changes in trends over time in the spatial pattern of growth in population, in new dwelling construction and in employment.

### Box 2: Specification of Residential Density Bands

The residential density band at the Unitary Authority / Local Authority District (ULAD) scale allocates each ULAD to a band that is determined by its number of persons per hectare, as measured in 2001 across England and Wales. For consistency in spatial coverage, this allocation to one of six density bands is then maintained constant over time, irrespective of any further densification post-2001. A cross-section of the main types of ULAD allocated to each band is summarised below, together with its overall 2001 population and the number of ULADs that comprise it.

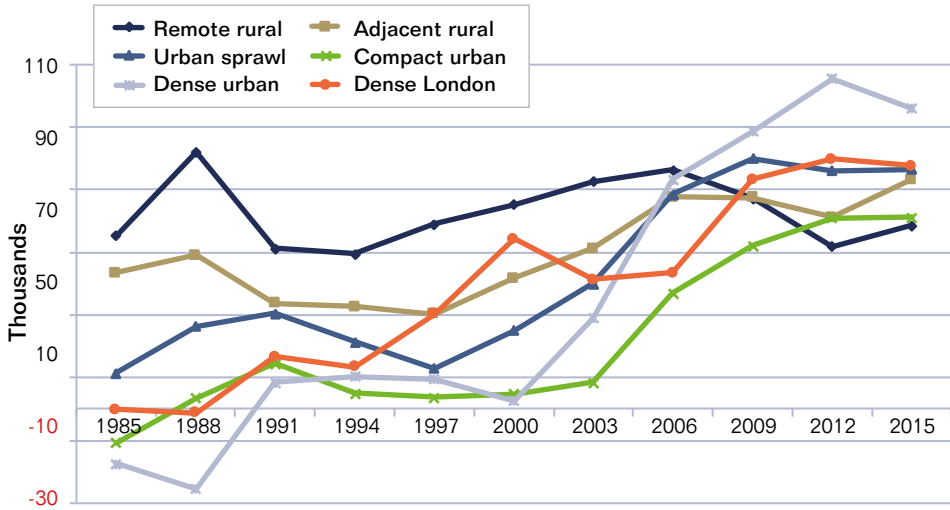
Density band	2001 Pers./ Ha	No. of ULAD	2001 popn. (millions)	Examples of component ULADs by band in E&W
0. Remote rural	0 - 2	91	9.8	<b>Large land areas and sparse settlements:</b> particularly in Cumbria (5), North Yorkshire (7), Lincolnshire (6), East Anglia (13), Mid /North Wales (9) and the South West (20).
1. Adjacent rural	2 - 5	77	9.7	<b>Rural areas with scattered small towns:</b> particularly in Lancashire (6), East Midlands (9), West Midlands (9) and the Home Counties (34).
2. Urban sprawl	5 - 15	75	11.6	<b>Old industrial areas of:</b> North East (4), North West (11), South and West Yorkshire (9), East Midlands (8) and South Wales (8). <b>Commuter areas</b> adjacent to London (21). <b>New/Expanded Towns:</b> Milton Keynes, Swindon, Telford, Corby, Warrington + many others.
3. Compact urban	15 – 30	51	8.4	<b>Metropolitan boroughs:</b> Tyne & Wear (4), Greater Manchester (8) Merseyside (3). <b>Standalone cities:</b> Middlesbrough, Derby, Lincoln, Stoke, Worcester, Cambridge, Ipswich, Brighton & Hove, Oxford, Exeter, Cheltenham, Gloucester, Cardiff. <b>Southern coastal:</b> Castle Point, Eastbourne, Hastings, Poole, Torbay & Weymouth. <b>New/Expanded Towns:</b> Northampton, Basildon, Harlow and Crawley.
4. Dense urban	30 - 45	34	8.2	<b>Outer London boroughs</b> (10); <b>Metropolitan boroughs:</b> West Midlands (6), Manchester MB, Liverpool MB; <b>Large cities (12):</b> Nottingham, Leicester, Hull, Blackpool, Norwich, Reading, Slough, Luton, Southampton, Bournemouth, Bristol, Plymouth <b>Medium sized towns:</b> East (3) and South East (2).
5. Dense London	45+	20	4.3	<b>Inner London boroughs</b> (all 13); <b>Densest Outer London boroughs</b> (6) & Portsmouth.
All Types		348	52.0	

5.2.3

Figure 12 presents the smoothed annual average<sup>17</sup> growth in population from 1981 through to 2016 across England and Wales in a form that is segmented by six residential density bands for ULADs. It highlights two main effects:

- growth patterns differ considerably between the density bands;
- within each density band the level of growth has changed strongly across the decades.

**Figure 12:** Average annual population growth (000s) in 3 year periods, by residential density band, 1981-2016, Great Britain.



(Source: Mid-Year Population Estimates, ONS.)

5.2.4

It illustrates that in the 1980s, the three lowest density bands (see Box 2) captured all of the national population growth, with the greatest growth occurring within the lowest density: Remote Rural band 0. This 1980s period was a continuation of the then long-term trend of suburban and rural population growth, contrasting with inner city decline. Since then there has been continuing population growth throughout in these lower density bands, irrespective of the national growth rate. However, the balance of growth between these bands has gradually reversed so that in recent years the growth in the Remote Rural band 0 is the lowest and growth in Urban Sprawl band 2 has increased greatly to now be the highest of these three lower density bands.

5.2.5

The higher density ULADs tell a very different story within Figure 12. The long-term major decline in population in the Dense London Band 5 had ended by 1984 but urban population decline continued until 1987 for the Compact Urban band 3 and until 1989 for Dense Urban band 4 areas. Then rapid population growth re-emerged: in the early 1990s in band 5 ULADs; in 2002 in band 4 ULADs; and in 2005 in band 3 ULADs, while this population growth has accelerated strongly since then in all three of these density bands.

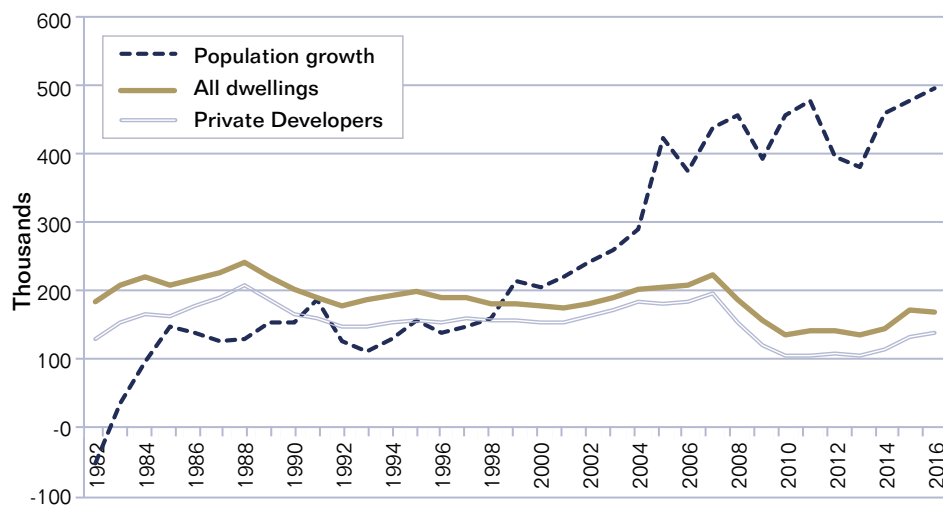


- 5.2.6** The overall result has been a complete reversal in the nature of the relationship between residential density and residential population growth. In the 1980s the lower the residential density the greater was the rate of population growth, whereas nowadays, the higher the residential density, the greater is the rate of population growth and vice versa. The strong pattern of population dispersal that was the norm in the 1980s has subsequently been replaced by strong inner city densification.
- 5.2.7** The probability of using rail is influenced by accessibility to rail stations and to frequent rail services. The inherent economies of scale of the operation of rail systems imply that such accessibility tends to increase in line with residential density. Accordingly, the major reversal indicated above in where residential population growth is greatest will have led to a corresponding reversal over time from strongly supporting car growth to now strongly supporting rail growth.

### 5.3 Contrasting dwelling and residential growth trends

- 5.3.1** In a well-planned world it would be expected that the number of dwellings provided at each time and location would match to the growth of households there, while providing some extra building to replace obsolete stock. A good match would avoid major mismatches between the supply and demand for housing and so would avoid generating extremes in local house price inflation and would mitigate the growth in otherwise avoidable long distance commuting and in its environmental and travel time costs. Next we examine the extent to which this has been achieved in England and Wales over the last 30 years.
- 5.3.2** Unfortunately, the evidence suggests that the spatial pattern of new dwelling additions does not track closely to either:
- the annual rate of population growth;
  - or the spatial pattern of population growth locations.

**Figure 13:** Annual dwellings completed and population growth, 1982-2016, UK.

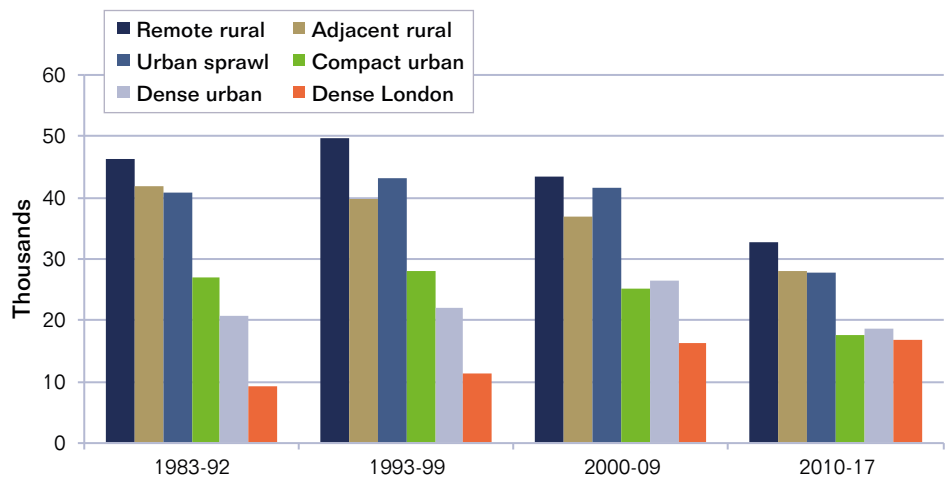


(Source: Live table 241, CLG, for dwellings, Mid-Year Population Estimates, ONS.)

**5.3.3** Figure 13 presents a time series from 1982 to 2016 of the annual number of dwellings completed, together with the annual increase in population. In the early 1980s some of the new construction in major urban areas will have been the replacement of obsolete stock, which is consistent with the more rapid rate of housing completions than of population growth in this early period. This was also a period of reducing household size and of low population growth. It is unhelpful that when the population started to grow rapidly from the mid-2000s onwards, this was followed by the major downturn in housing completions in the recession, which has continued through to the present.

**5.3.4** The recent picture is quite stark. The annual rate of dwelling completions has been less than 190k per annum since 2008, a rate lower than in any year since the Second World War. The annual rate of population growth since 2005 has been above 375k, a rate higher than in any period in the past.

**Figure 14:** Average annual dwellings (000s) built by period, by residential density band, 1983-2017, Great Britain



(Source: Dwelling Stock, Table CTSOP4.1, VOA.)

**5.3.5** This recent imbalance between the demand and the supply of housing is even worse when viewed at a more detailed spatial level. Figure 14 presents the pattern of dwelling construction by ULAD residential density band in a format that can be contrasted with that of population growth illustrated previously in Figure 12. In every period the number of houses built has been largest in the lowest density Remote Rural area and has broadly declined in line with increasing residential density, always being least within the Dense London area. The slope of the decline with respect to increasing density has decreased over time. This indicates that back in the 1980s there was a logical spatial match between the rates of population growth and of dwelling construction. However, since then the spatial pattern of dwelling construction has not adjusted adequately to match to the major changes in the location of rapid population growth.

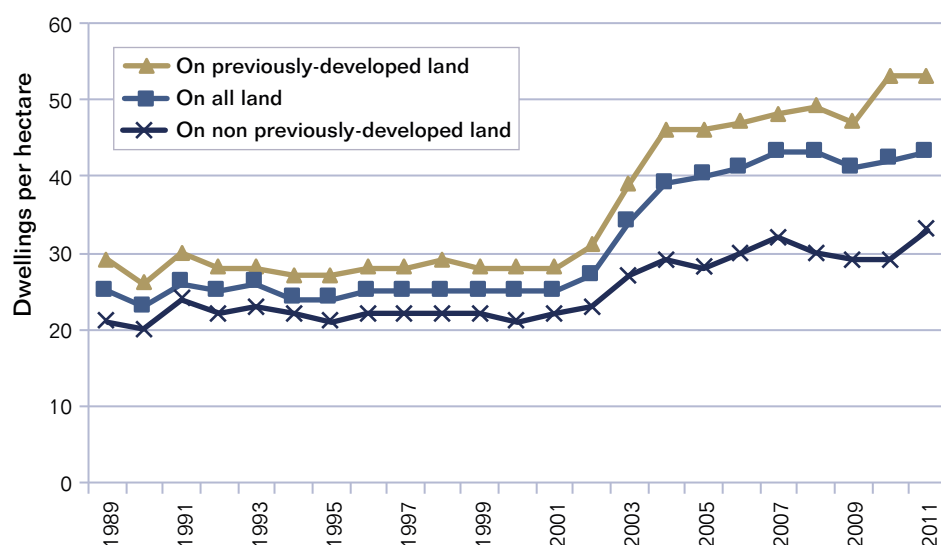


- 5.3.6** From 2010 onwards the match has become quite perverse! It matches the highest historic levels of population growth with the lowest historic levels of housing construction at the national level. This is exacerbated further by having the lowest growth levels for new housing in the Dense Urban and Dense London areas, despite these having the highest growth levels for population, leading to a ratio of one extra dwelling for every five extra people.
- 5.3.7** This has meant that average household sizes have increased rapidly in dense cities in recent years<sup>18</sup>. These cities have switched from traditionally having the smallest household sizes to now having the largest. As we shall see below, part of this change is due to changes in recent decades in the age profiles of those who reside in dense urban areas but much is also due to increases in overcrowding in urban areas.
- 5.3.8** One side-effect from the magnitude of this housing imbalance is the very rapid growth in house prices over the last decade in Inner London and in other fast-growing cities of the South East. London, Oxford, Cambridge and Bristol all have house prices that have grown by >70% since the previous price peak in 2008 (Hometrack, 2018). Many other large cities, such as Birmingham, Manchester, Leicester, Nottingham, also have had increases of 35+% since the previous peak. This contrasts with many other lower density parts of the UK where house prices have not as yet returned to their pre-recession levels. This spatial pattern of house price growth is also an indicator of the growing imbalance between the increased pressure for residents to locate in these dynamic cities, and the increased net shortage of dwellings in which they could live there.
- 5.3.9** The operation of densification in practice can be understood by examining housing construction in more detail. There has been a major increase since the early 2000s of the density of new dwellings in England as highlighted in Figure 15. In contrast to the period 1989-2001 when the density of new residential developments was stable at around 25 units per hectare overall, it gradually increased to 43 units per ha by 2011, up by 73%, in response to the then requirement (ODPM, 2003) that larger sites for new housing would have at least 30 dwellings per hectare. In 2011 the density of new built dwellings averaged 33 units per ha. on non-previously developed land, and 53 on previously developed land. At the same time, the proportion of new dwellings built on previously developed land had risen: it was stable around 56% through the 1990s, rising to a peak of 81% in 2008 and dropped back to 68% in 2011 (DCLG, 2013).

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For example, in the 2001 Population Census, the average household size of 2.35 in London was below the overall average of 2.36 for England and Wales. However, for London in the 2011 Census, this had increased by 5% to 2.47, whereas the national average only increased marginally to 2.36. Leicester, Manchester and Birmingham also experienced increases over 4%.

Figure 15: Density of new dwellings, by previous land type, 1989 to 2011



(Source: Live Tables on Land Use Change, DCLG, 2013)

**5.3.10** The increase over time in the density of new residential developments is particularly pronounced in many of the larger cities, where it has more than doubled since the 1990s in Sheffield, Leeds, Manchester, Liverpool and Birmingham. In Inner London the typical density of new residential developments in the late 1990s was around 75 units per ha, which increased over the decade by 114% to around 165 per ha. These increases in density were achieved primarily by a switch to constructing blocks of flats rather than individual dwellings in the larger cities.

**5.3.11** The net result of this major densification of housing in the inner areas of the larger cities has ensured that a much larger population is within the catchment area of the rail stations located in these city centres. Indirectly as will be demonstrated below, the difficulty and cost of owning a car for inner-city residents increases as a function of residential density so that the ability of car to compete with rail has reduced over time in many major inner-city areas.

## 5.4 Demographic changes

**5.4.1** Another one of the side-effects of the stresses and imbalances in the housing market in the rapidly growing urban areas is set of changes that have occurred over time in the age composition of residents across the set of residential density bands.

**Figure 16: Residential Location Trends, % by Age Group, by density band, by decade, 1981-11, Great Britain**



(Source: ONS)

**5.4.2** Figure 16 analyses the changes through time in residents' age group composition across residential density bands. Following the available Census categories, we divide the population into five groups: the under 16's, 16-24, 25-44, 45-64, and those of 65 years or older. The groups broadly correspond to the significant thresholds in an individuals' life cycle in terms of schooling, further education, the earlier and later years of working life, and retirement. The analysis shows that the age group profiles across the residential density bands have changed significantly over the last three decades.

**5.4.3** In 1981, the relatively flat shape for the blue lines in all cohorts, indicates that the percentage shares of most age groups were broadly constant across the whole range of density bands; there were only two exceptions: the 16-24 group were more common in the denser areas (where most universities are located), and those under 16 were most common in lower density areas. In 1991 through 2001 this constancy had started to disappear for the various groups aged over 25. By 2011, the 25-44 age group was strongly concentrated in higher density areas, representing 39% of the population in Dense London, but only 24% in Remote Rural, whereas the 45-64 and especially the 65+ groups had concentrated in lower density areas, comprising 29% and 21% respectively in Remote Rural (by contrast, in the Dense London area the equivalent figures are only 20% and 10%). Notably, the presence of those aged under 16 has become more pronounced the denser the area, reversing the pattern seen in 1981-1991. It is only for the 16-24 age group that the spatial pattern is little changed over the decades.

**5.4.4** As a result of these changes, those of working age are now much more likely to reside in dense urban areas that tend to have a good range of rail services which would encourage rail commuting. In contrast, those beyond working age will have freed up housing in such areas through moving to live in low density areas that are less rail accessible.

**5.4.5** In order to better understand future possible residential location trends it is instructive to consider potential reasons why the recent rapid growth trends for ages 25-44 might have arisen in dense urban areas? In and around economically successful, rapidly growing, dense cities we have shown that there is a shortage of housing supply due to the much lower rate of dwelling growth relative to the rate of population growth there. This is exacerbated over the last decade by the reduced national dwelling construction rate in contrast to an increased population growth rate. These when combined have led to high house prices and to high rent levels there.

**5.4.6** These high costs combined with university debts and/or lower incomes make it difficult for the young to afford:

- to buy a first house, even taking account of the lower prices further outside the city;
- plus to afford the high rail fares or car parking costs to commute back in every day.

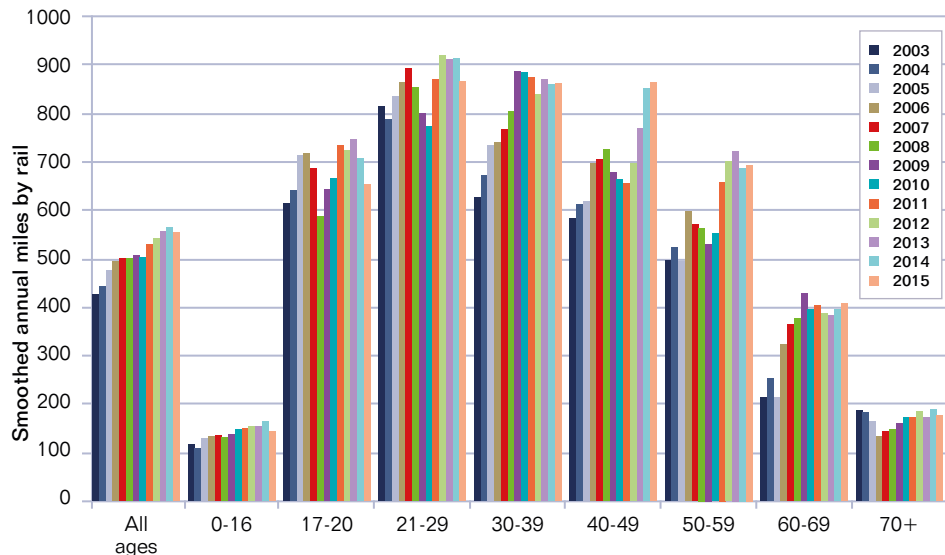


**5.4.7** Substantial recent dwelling growth in inner cities has enabled more of the 20+ age group to retain an “urban” lifestyle as they age, though with ambiguity over whether or not they need to (can afford to?) purchase a car, as discussed later in this chapter.

**5.4.8** Checking rail usage per person by age band in the NTS shows clear trends over time in Figure 17:

- rail mileage per person has increased strongly over time for each age band, except the 70+;
- in almost all years the greatest annual rail mileage per person is for the 21-29 and 30-39 age bands;
- these are also the two age bands that from 2002 to 2016 have experienced the largest percentage point increases (4.5 and 4.3 % points, respectively) in the proportion of their total annual mileage that is by rail mode.

**Figure 17:** Smoothed annual miles by rail per person, by age band, 2002-2016, England



(Source: NTS. (3-year smoothing) )

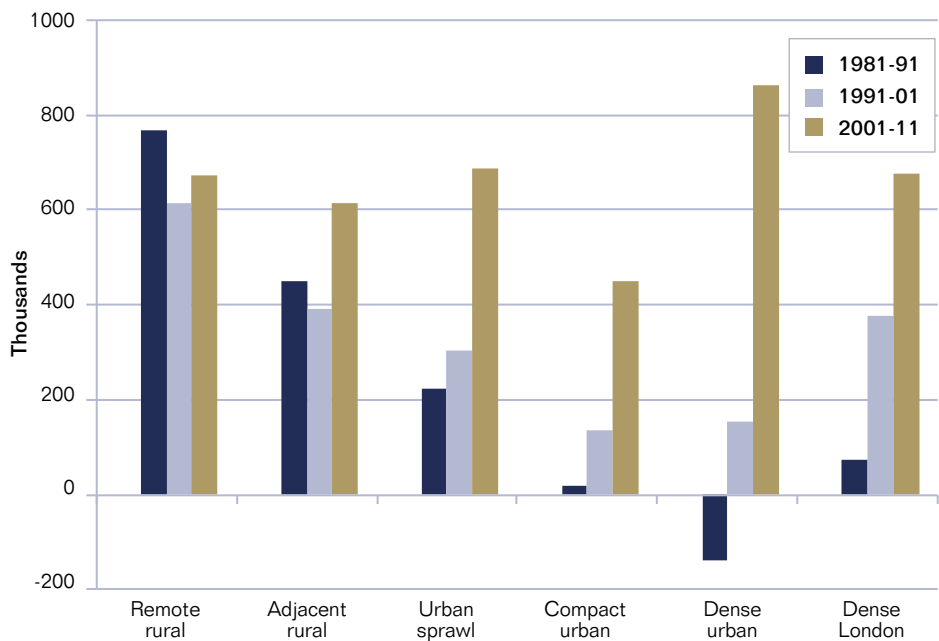
**5.4.9** This differential level in rail use between age bands is partly an indirect result of the changing spatial patterns of residents by age band, as discussed above. This is one of many instances in which apparent parallel trends may not necessarily indicate a direct causal relationship but may instead be more a result of some other common influence to which they are both related. The statistical modelling methodology adopted in Chapter 6 onwards is designed to control for such effects.

## 5.5 Spatial trends in car ownership growth

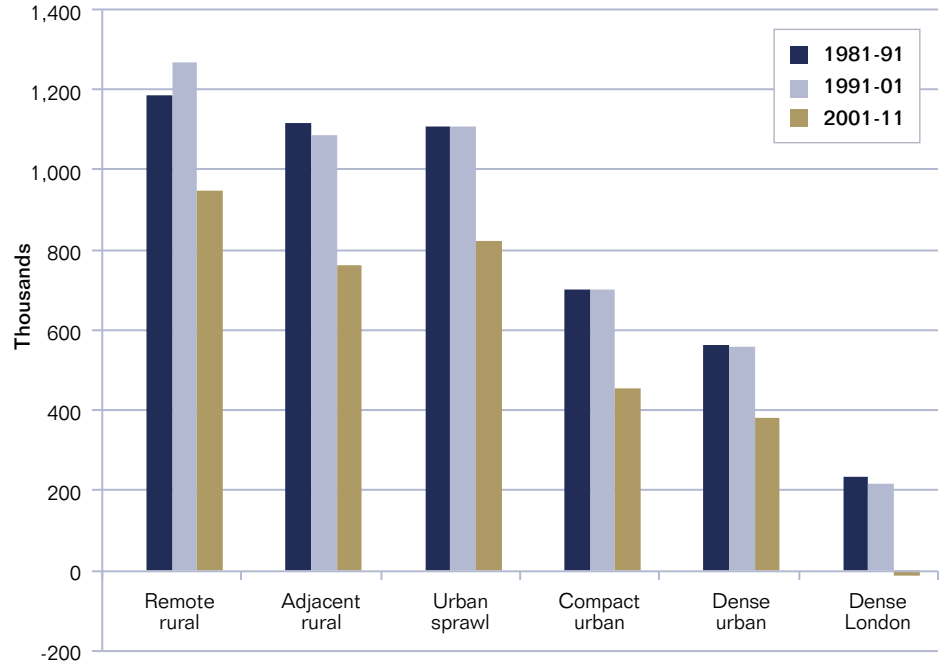
**5.5.1** The Census data provides a systematic source for examining the spatial pattern of car ownership changes over time. The impact of densification in urban areas on the total number of cars and vans available to residents is presented in Figure 18. This contrasts the absolute growth in the adult population aged 16+ in each density band with the absolute growth in cars and vans available to their residents, contrasting the data across the last three decades.

**Figure 18:** Increase in population aged 16+ and in cars owned by decade, by density band, 1981 to 2011

**Increase in population by decade**



**Increase in car ownership by decade**



(Source: 1981 to 2011 Population Census, ONS)



**5.5.2** It indicates that residential density has had an increasing influence over the decades, whereas adult population growth has had a decreasing influence on the numbers of cars in an area. More specifically:

- in all years, car numbers increase most where densities are lowest;
- in 1981-91 cars increased for all density bands even for those where the adult population had declined;
- by 2001-11 in contrast, cars had low or no growth in those higher density bands where the adult population had increased most;
- the higher the residential density, the lower the car ownership rate per adult, ranging in the 2011 Population Census from a low of 0.33 cars per adult in the highest residential density urban areas, up to 0.75 cars per adult in the lowest density peripheral rural areas.

**5.5.3** In summary, the evidence from the Census indicates a clear break from past car ownership trends. There is now a strong effect where higher residential density areas experience declines in car ownership rates over time in line with increased population density. These contrast with the continuing growth in car ownership rates experienced in the lower density areas. The higher the residential density, the stronger the downward pressure on car ownership rates.

**5.5.4** Although within any density band the rate of household car ownership continues overall to be a direct positive function of household income, this positive income effect is increasingly counterbalanced by the negative urban density effect<sup>19</sup>. This is why there continues to be a downward trend in car ownership rates in high-income inner city areas but upward trends in rates in some relatively low-income but low density rural areas. The resulting rapid increase in dense urban areas in the number of persons of working age that have no household car will have strongly encouraged the growth in rail use both for commuting, as illustrated in the next section, as well as for other travel purposes.

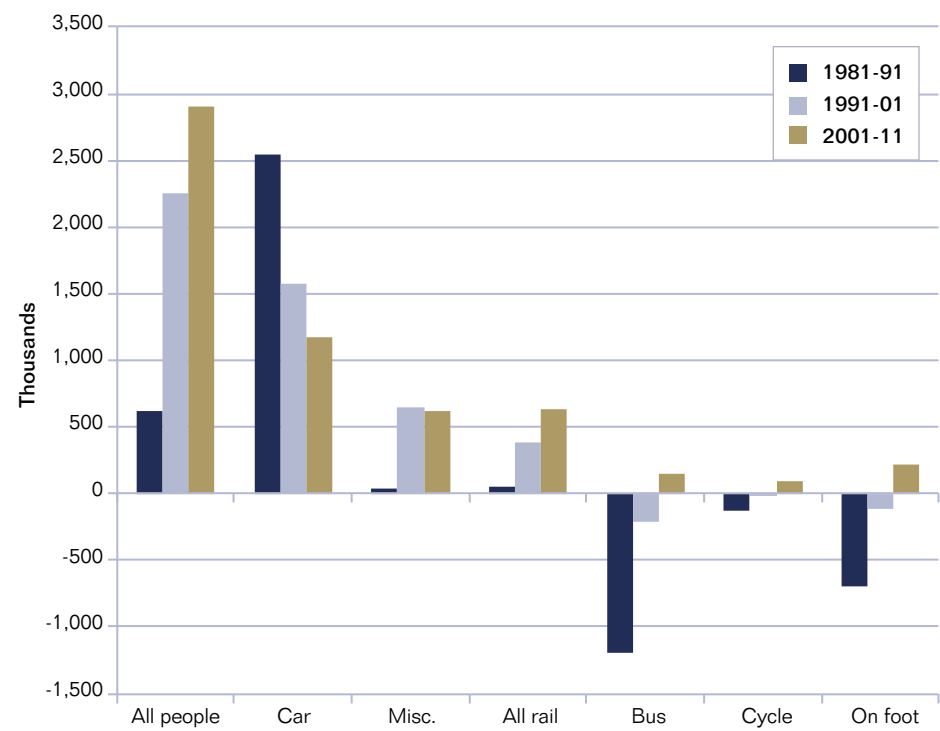
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The 2011 Population Census table DC6403EW indicates for example that for 4 dense boroughs partly within Central London, the proportion of adults from the AB social grade (Higher and intermediate managerial/administrative/professional occupations) that have 2 or more cars per household is below 9%, with a further 5 dense Inner London boroughs having proportions below 16%. These proportions for AB adults are still generally higher in than those in each of the lower social grades also residing in the same borough. In contrast, for all Outer London boroughs, even the lowest social grade, DE (Semi-skilled and unskilled manual; unemployed and lowest grade occupations), has at least 16% of its adults in households with two or more cars, whereas again this car ownership rate generally increases within each borough in relation to social grade, though with C2 (skilled manual) frequently having ownership rates similar to or higher than ABs. In broad terms, for each individual social grade the lower the density of the borough the higher the proportion of adults with 2+ cars.

## 5.6 Modal competition trends for commuting

**5.6.1** The long time-series of consistent data that is available from the Census facilitates the detailed analysis of modal commuting trends. Figure 19 presents the absolute gains in commuter numbers for groups of Census modes, using data for the successive decades 1981-91, 91-01 and 01-11.

**Figure 19:** Absolute growth in commuters (000s), by mode, by decade, England and Wales



(Source: : 1981 to 2011 Population Census, ONS.)

"Car" includes driver, passenger and taxi ; "Misc." includes: motor cycle; At or from home; and Other;<sup>20</sup> "All rail" includes conventional rail, London Underground, metro and LRT.<sup>21</sup>

20 Some of the change in growth levels between decades within the "Misc" category may be due to changes over time in the Census definition used for its constituent category: working at or from home.

21 Throughout the discussion within this Section, the terms "rail" or "all rail" refer to conventional rail plus London Underground, metro and LRT. This is because these modes have all been combined together within the source ONS Census journey to work tables that were used to create the three charts with consistent data definitions over the decades.



### 5.6.2

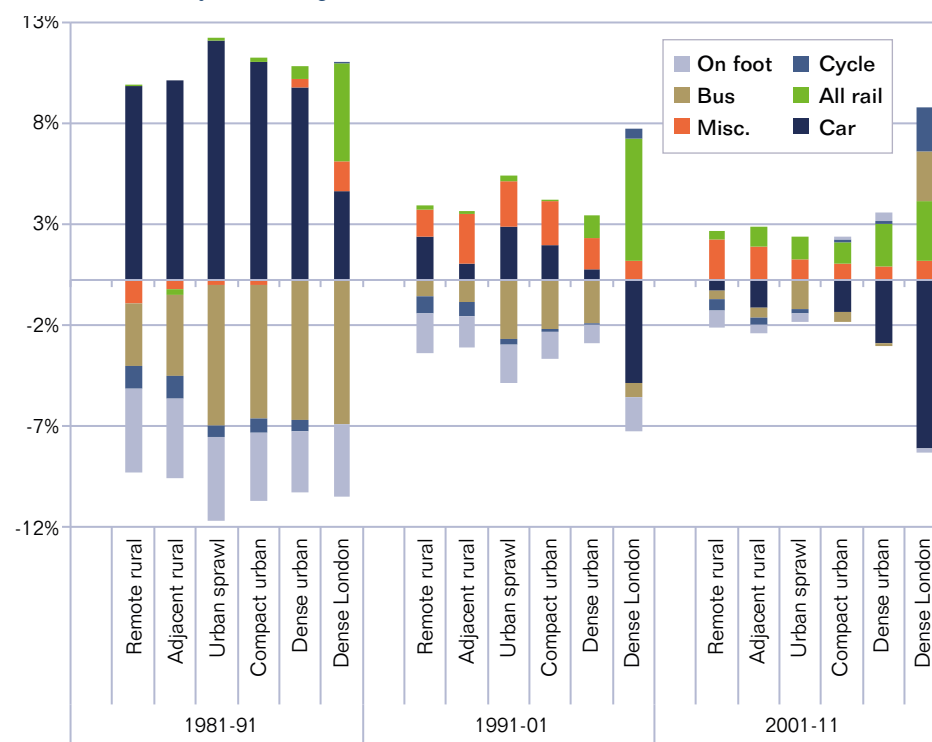
This indicates that over England and Wales as a whole the growth over each decade in the number of commuters increased from 600 thousand in 1981-91 to 2.25 million in 1991-01 and to 2.9 million in 2001-11. This is mainly a result of population increases in those of working age.

- In the 1981-91 decade all commuter growth was captured by car, which grew strongly by 2.5 million, with much of this growth being due to switching away from bus, cycle and walk modes each of which declined significantly. Rail commuting changed little.
- The main changes by 1991-01 were that rail numbers grew by 381 thousand and the switching from bus, cycle and walk modes was much reduced, so that the overall growth in car commuting declined to 1.6 million, despite an increased increment in the total number of commuters.
- By 2001-11, bus, cycle and walk modes all had marginal increases (though not necessarily across all individual density bands), while rail growth increased to 638 thousand and the numbers working at or from home also increased. Together these increases led to yet slower car growth of 1.2 million, despite the greater overall increment in the total number of commuters over this decade.

### 5.6.3

An alternative approach to analysing modal trends for commuting travel is to examine the percentage point shifts between modes over successive decades. Figure 20 presents this information using Census data that is further segmented by the residential density band of the ULAD of residence of the commuter. It indicates that mode switching trends differ strongly across the density bands over time so that examining the trends using Figure 19 above, just at the national level, is less informative.

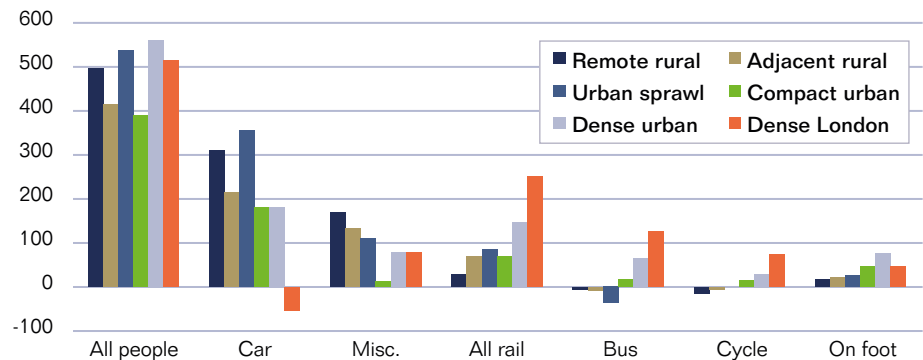
**Figure 20:** Percentage point growth in mode share of commuters, by decade, by residential density band, England and Wales



(Source: 1981 to 2011 Population Census, ONS.)

- 5.6.4** Over the 1981-91 period there is a strong trend in all density bands for greater use of car (increases of around 10 percentage points) which is generally associated with significant switches from the bus, walk and cycle modes. However, in the Dense London band, rail (including London Underground and metro) increases its mode share by 5 percentage points compared to only a 4 percentage point increase there for car.
- 5.6.5** Over the 1991-01 period, the rate of mode switching is much lower in all density bands. Nevertheless, car gains 0.8 to 2.5 percentage points in all but the highest two density bands due again to switching from bus, walk and cycling. There is also an increase of 1 to 2.5 percentage points in all bands within the modal category, Misc., which is primarily due to increases in the proportion working at or from home. The Dense Urban band has a much reduced increase in car share down to 0.5 percentage points, relative to its 9.5 points gain in the previous decade. In contrast it has an increased 1.1 percentage point gain in rail, relative to the 0.6 points gain in the previous decade. The most pronounced mode switching the 1991-01 period occurs in the Dense London band in which car declines by -5.2 percentage points, together with lesser declines in walk (-1.6) and bus (-0.7) shares. The main gains there are for rail with +6, cycle with +0.5 and Misc. with 0.9 percentage points.
- 5.6.6** During the 2001-11 period, the rate of mode switching decreased further for all but the Dense London band. Again, there is also an increase of 0.5 to 2 percentage points in all bands within the modal category, Misc. Rail gains mode share by 0.5 to 2.9 percentage points, at rates that increase broadly in line with increases in residential density. Analogously, car mode share is now declining by -0.6 to -8.3 percentage points, through reducing broadly in line with increases in residential density. Bus, cycle and walk all continue to lose mode share from their already low base shares, within the three lowest density bands but are more stable in the Compact and the Dense Urban bands. In contrast in the Dense London band bus with +2.4 and cycle with + 2.2 percentage points gain significantly, while walk is stable. These trends in total lead to a loss of -8.3 percentage points for car share in the Dense London band.
- 5.6.7** In Figure 21, we conclude this analysis of commuting trends by examining in greater detail for the decade 2001-11 how the absolute growth in commuting numbers by mode from the Census differs between the residential density bands of their homes.

**Figure 21:** Absolute growth in commuters (000s) from 2001 to 2011, by mode, by residential density band of home, England and Wales



(Source: Population Census, ONS.)

**5.6.8**

This chart shows directly how modal patterns relate to residential density patterns. The overall increase in total resident commuters is not too dissimilar across the 6 residential density bands. However, the allocation of this increase among individual modes is systematically different across these density bands:

- for the Remote Rural band every extra 100 resident commuters gave rise to 62 extra car commuters and to 6 extra rail commuters, with a further 34 in the Misc. category, mainly those working at or from home;
- at the other end of the residential density spectrum, for the Dense London band every extra 100 resident commuters gave rise to 11 fewer car commuters, balanced by 49 extra rail (including LU etc.) commuters, 15 extra in the Misc. category, 25 extra by bus, 14 by cycle and 9 by walk;
- in general, as residential density increases at a rate that is between these two extreme bands, the share of car use within the commuter growth declines proportionately and the share of active and public transport modes increases proportionately.

**5.6.9**

In summary, the combined set of trends discussed in this chapter of: increasing residential density in major urban areas; the advent of very high urban house prices/rents; a shift to a younger population profile in major cities; and the reductions in urban car ownership rates, have all combined in the recent past to encourage higher usage of rail for commuting and for other travel purposes. Again it illustrates the importance of residential factors that are external to the rail industry sector in generating the rapid past growth in rail demand. It should not be automatically assumed that these factors will continue to provide strong support for rail growth through into the future. Some further underlying mechanisms that have influenced the observed past growth in rail passenger demand are discussed in Chapter 9.

## 6. Analysis of commuter rail travel

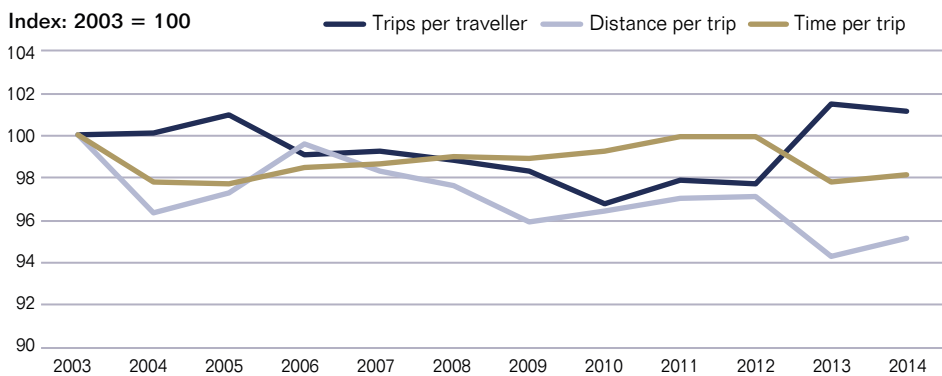
### Key Findings

- Across all industries, households with the highest income have higher commuter rail trip rates when compared to those in the middle and lower income bands.
- The increase in commuter rail trips is due to the increase in the proportion of commuters choosing rail within each industry segment and to the major increase in the number of employees in those industry segments with a high rate of rail commuting.
- The largest absolute number of rail trips is by commuters to central London either from surrounding urban areas or from outer London.
- Income and the industrial sector where one works were found to be the two most important factors affecting the propensity to commute by rail.

### 6.1 Introduction

**6.1.1** Commuting to work comprises the largest single travel purpose within the rail market, due to the large number of regular trips that are made in the course of a week, and then repeated for most weeks of the year by individual rail commuters. Although commuter trips by rail tend on average to be longer than commuter trips on other modes, they are significantly shorter on average than business rail trips. This chapter analyses the trends and influences on commuter rail travel.

**Figure 22:** Trends for commuting trip purposes in trip numbers per rail traveller and average rail trip length and time, 2003-14, England & Wales



(Source: NTS - smoothed 3-year moving average.)

**6.1.2** Figure 22 presents for England and Wales, for commuting, indices of the smoothed trends from 2002 through to 2015 for three distinct rail travel characteristics:

- the average number of rail trips per capita for this travel purpose that are made in the survey week by those that have made at least one such rail trip;
- the average trip length across the set of rail trips for this purpose;
- the average trip duration across the set of rail trips for this purpose.



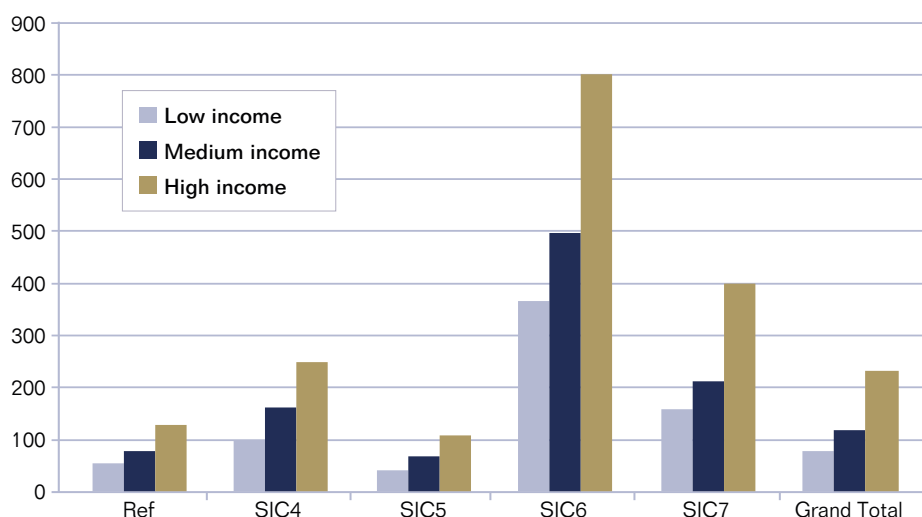
**6.1.3** For rail commuting there is no strong headline trend over time in any of these indicators. Due to the aggregate nature of these indicators, which are averaged across all person types, industry sectors and area types, this observed constancy does not guarantee that there has been no change in underlying behaviour, since there still could be countervailing trends that cancel one-another out. This chapter examines the trends and influences of commuting rail trips in greater detail, using more sophisticated statistical models that are designed to provide discriminating multi-dimensional analyses. It is based primarily on the analysis of NTS data that covers England, as the modal commuting data available from the Census has already been explored in earlier chapters.

**6.1.4** The analysis is in three stages. Firstly, various tabulations of commuter rail travel characteristics are presented that provide an overall picture of the main groups of individuals that make up this market. Then a more complete model-based analysis is used to identify systematically the main determinants of commuter rail travel in a form that discounts the many cross-correlations between its influences. Finally, these elements are drawn together to provide pointers on the evolution of trends in commuter rail demand.

## 6.2 Who are the main rail commuters?

**6.2.1** We start by a broad examination of the main characteristics of rail commuters, based on the NTS dataset. Figure 23 presents the average weekly outbound number of commuting trips made by rail, per 1000 employed persons in the segment, averaged across the period 2002 to 2014. These trip rates are cross-classified by both: the income group of the head of household (high, medium and low); and by the grouped Standard Industrial Classification (gSIC<sup>22</sup> Table 7) of the type of industry in which they are employed. It shows that for each of the grouped SICs those residents within households with high income heads of household have considerably higher commuter rail trip rates than those in households with medium income heads, which in turn are considerably higher than those from households with lower income heads.

**Figure 23:** Weekly outbound trip rate for commuter trips by rail per 1000 employed persons in the grouped industry sector, by head of household income group

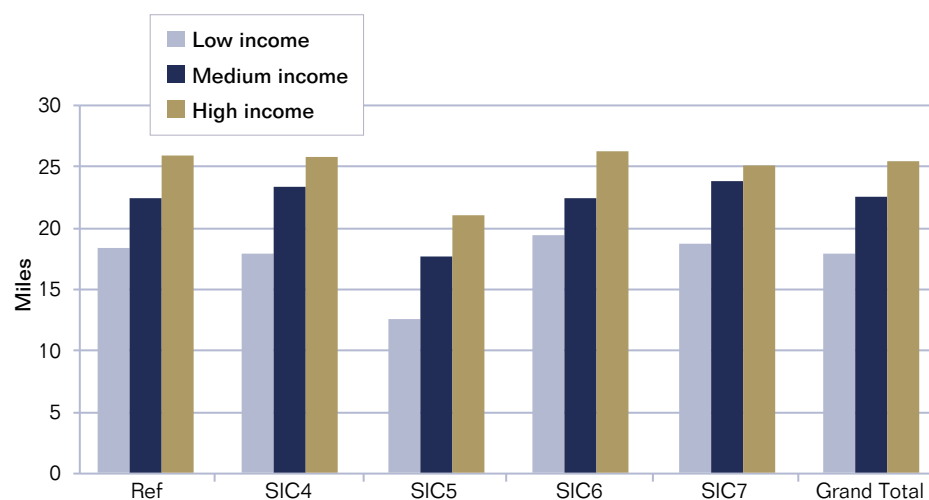


(Source: NTS)

**Table 7:** Definitions adopted for grouped SIC codes – gSIC

Grouped SIC	SIC-2007 codes	Comment
Reference	A, B, C, D, E, F, H, I, P, Q, R, S, T, U	Mainly non-office based activities
4	O	Public administration and defence; compulsory social security
5	G	Wholesale and retail trade; repair of motor vehicles
6	K	Financial and insurance activities
7	J,L,M,N	Other office-based activities

**6.2.2** The differentiation in rail trip rates is even greater across the grouped SICs. Those from high income households who are in employment in the office-based financial services (gSIC6) and professional, business or related services (gSIC7) have commuting rail trip rates, respectively, of 802 and 400 trips per week per 1000 persons, whereas the rate for those in high income households in the non-office based reference set of gSICs is just 128 and is only 56 for those from the reference gSIC who are in low income households.

**Figure 24:** Average commuter rail one-way trip length in miles, by industry sector, by head of household income group 2002-2014


(Source: NTS)



### 6.2.3

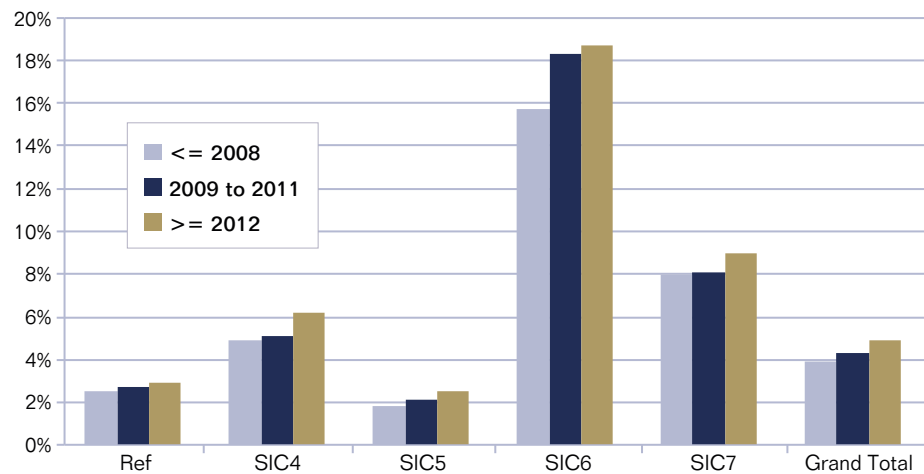
Figure 24 presents the analogous average commuter rail one-way trip length in miles. The differentiation between segments is much less pronounced than for the trip rates in Figure 23. Average rail commuter trip lengths are fairly similar across most gSIC categories but they increase by household income group, from 18 miles one-way for those in low income households to 26 miles for those in high income households. These results clearly demonstrate that the differentiation across employment segments in commuter rail use relates primarily to the very different incidences in their rail trip making rather than to differences in their average rail trip lengths travelled.

### 6.2.4

The observed major growth over time in commuter rail trips is not primarily due to increased weekly rail trip rates per rail traveller within any specific employment segment. It mainly arises instead both:

- from an increased proportion within any given employment segment of those that commute by rail (Figure 25);
- from major increases in the numbers within those segments that have high rates of commuting by rail (Table 8).

**Figure 25:** Proportion of employed persons, segmented by grouped SIC, commuting by rail in each period



(Source: NTS)

### 6.2.5

Figure 25 presents the proportion of those in employment within each gSIC that commute by rail, segmented into three periods. In each gSIC this proportion has increased over time, so that it grew by 25% overall from a rate of 3.9% in the period 2002-08 to 4.9% in 2012-15.

**Table 8:** Number of employed persons in annual NTS sample, segmented by grouped SIC, Head of household income group in each period

Segment	SIC Ref			SIC 4			SIC 5		
Year	2008	2011	2012	2008	2011	2012	2008	2011	2012
Low Income	1298	1039	1072	263	180	179	386	304	350
Medium Income	2055	1791	1942	259	331	358	484	426	490
High Income	1255	1619	2051	276	339	398	233	279	418

Segment	SIC 6			SIC 7		
Year	2008	2011	2012	2008	2011	2012
Low Income	58	33	43	223	212	275
Medium Income	136	97	114	378	374	494
High Income	149	189	225	388	542	781

**6.2.6** Table 8 presents the average annual number of employed persons in each of the cross-classes of: the income group of the head of household; the grouped SIC; and three time intervals. It indicates that the high income SIC7 class that has the second highest commuter (Figure 23) rail trip rate has increased by 100% during the three periods which demonstrates a reweighting of the employed population in the direction of the higher income and higher commuter rail trip rate classes. The general growth trends over time in employment by SIC have been presented previously in Figure 8 and Figure 9.

**6.2.7** In summary, the analysis above of the NTS data has confirmed the earlier findings that a major determinant of the growth in rail commuting has been due to structural employment changes in which the numbers within those segments that are most likely to travel by rail have increased much more rapidly than other segments.



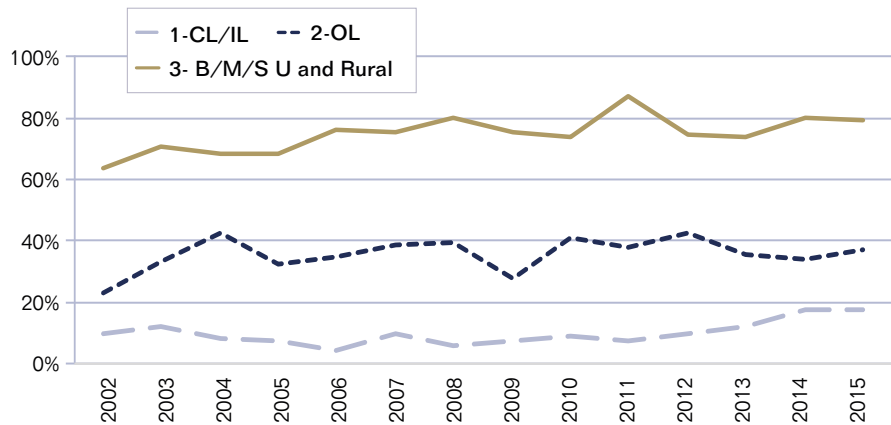
## 6.3 How does rail commuting vary spatially?

- 6.3.1** Our analysis (seen in the charts published separately online as Appendix 2) reveals the striking differences in spatial and socioeconomic profiles across the latent clusters defined by the LCA model. The main findings relating to commuters in general (i.e. for all modes combined so not just rail) are:
- Jobs in the financial sector (gSIC6) and in the business services sector (gSIC7) have a greater propensity to locate in Central and Inner London than those of other industry sectors. For finance in particular, its commuters are more likely to be resident in Outer London or the surrounds outside, than in the adjacent Central/Inner London.
  - The majority of manufacturing jobs are in the Medium Urban and Small Urban and Rural area types, followed by Metropolitan and Big Urban areas but only with very few in London. Its commuters to Metropolitan areas are more likely to be from further away large urban areas, while a large proportion of those who commute to Big, Medium and Small Urban and Rural areas are internal to these area types.
  - Wholesale and construction jobs are mainly located in less populated areas though the proportion of commuters in those sectors is fairly similar across clusters.
  - As expected, a large proportion of those who commute to Central/ Inner London (between 40% and 65%), Outer London (between 40% and 57%) and to a lower extent Metropolitan and Large Urban areas (between 20% and 42%) are members of high income households. Also, with the exception of commuters from Central/Inner London to Central/Inner London, the general patterns show that those who commute from less populated Small Urban and Rural areas to London, Metropolitan and Big Urban areas are more likely to be in high income households while those in the low income band tend to commute shorter distances making trips internal to their area type (specifically when they reside in less populated areas).
  - A large proportion of commuters (around 40%) in clusters of commuting from less populated areas to more populated ones, are in professional/managerial households. This trend is the reverse of that for manual workers who tend to reside closer to their workplace.
- 6.3.2** Having identified the commuter clusters without any reference to rail trip making, we then looked into the commuting rail trips within each of these clusters. This helps in identifying the major market segments (clusters) for commuting. It was found that there is a striking difference in rail commuting trip totals across the clusters. Those who commute to Central/Inner London, either from surrounding Rural and Big to Small Urban areas or from Outer London, have the largest absolute number of rail trips as well as the largest proportions of rail use within their total commuting (respectively 70% and 45%). The next largest rail trip clusters are: commuting wholly within Inner/Central London; then commuting from Large Urban areas to Metropolitan areas.

## 6.4 Analysis of trends over time

**6.4.1** Having identified the major rail market segments, we next examined variations within these segments over time. This type of analysis within built form clusters allows us to control within time series analysis for built form influences and for the self-selection effect. To ensure that there is an adequate sample size for examining the trends over 14 years, this time series analysis is carried out only for those area type pairs that have sufficiently large numbers of rail commuting trips. Figure 26 shows the changes over time in the share of rail trips within total commuting. These trends indicate that the share of rail within commuting to Central and Inner London workplaces has increased over time. For those who reside in Big, Medium and Small Urban and Rural areas, this share increased from around 60% in 2002 to 80% in 2015. For those commuters resident in Outer London, the increase is sharp at the start (from 20% in 2002 to 40% in 2004) but the trend has then stayed fairly constant at around 40% of total commuting since 2004. For those commuters resident within Central and Inner London, after an initial drop, we observe a sharp increase in the share of rail within commuting trips since 2006.

**Figure 26:** Percentage of commuting trips by rail in clusters destined for Central/Inner London, as a percentage of total commuting trips in these clusters over time.

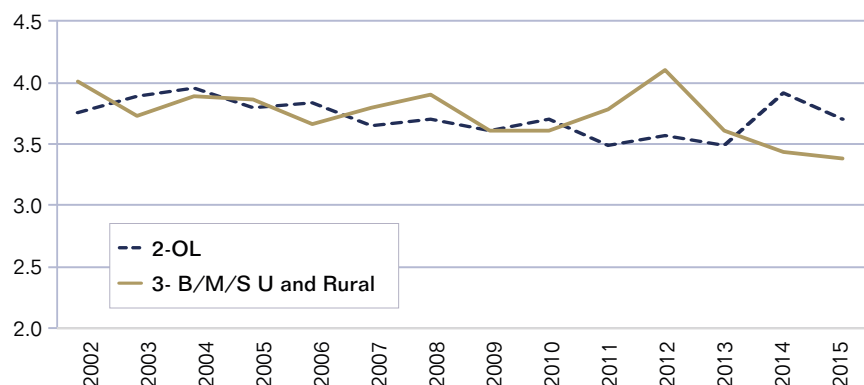


(Source: NTS)

**6.4.2** Figure 27 charts the weekly rail commuting trip rates per rail commuter. It indicates that there has been a general decrease in the weekly number of commuting trips made by those rail travellers with central London workplaces, who reside either in Outer London or further out. In the next section, we examine in greater detail the results of the SEM model for two major rail fixed clusters (i.e. commuters from outer London, and those from Big/Medium/Small Urban and Rural areas to Central/Inner London).



**Figure 27:** Changes in average weekly rail commuting trips per rail traveller over time, by clusters: from Outer London or from surrounding Rural and Big, Medium, Small Urban areas to Central and Inner London



(Source: NTS)

## 6.5 Analysis of Disaggregate ZINB model of rail commuting to major rail clusters

**6.5.1** In order to evaluate the other influences on rail commuting trips, while controlling for built form influences, and also to examine in more detail at a disaggregate level, the findings above on variations in rail trips over time, we have developed a two-stage Zero Inflated Negative Binomial model for each of the two major rail fixed clusters: C1-3\*: commuters from Outer London, and C1-4\* those from Big/Medium/Small Urban and Rural areas, both to Central/Inner London. The other fixed clusters do not have adequate sample sizes individually to support such analysis.

**6.5.2** The set of potential explanatory variables that are considered within the model are listed in Table 9 and the underlying assumptions are outlined in Chapter 3. When representing segmentation variables that indicate discrete categories rather than amounts, it is necessary within the regression model methodology to quantify their influence relative to a reference category (e.g. the extra trips associated with a full time worker relative to those made by the reference: part time worker). Accordingly, for each of the explanatory variables that are include within models for commuter and business trips, the table presents the reference category, together with the set of all of its other categories.

**Table 9:** Explanatory variables included in the model for individuals

Explanatory variable	Segments	Reference category
Work status	Full time	Part time
Employment type	Self-employed	Employed
Household size	Single adult	2+ adult
Head of household occupation	Manual Skilled manual Managerial/professional	Clerical - -
Household income - annual	High: >£50k Low: <£25k	Medium: £25k - £50k -
Gender	Male	Female
Age	16 to 24 years old 25 to 34 50 to 64 Over 65	35 to 49 years old - - -
Industrial Classification	gGSIC: 4 Public admin. etc., SIC O,R,S,T,U gGSIC: 5 Wholesale, retail, SIC G gGSIC: 6 Financial, SIC K gGSIC: 7 Business services, SIC J,L,M,N	gSIC Ref: Non-office, SIC A,B, C,D,E,F H,I,P,Q - - -
Household car ownership	With car	No car
Time	Continuous variable	1: the year 2002, .... to 14: the year 2015

**6.5.3** Table 10 presents the set of significant influences (at the 90% confidence level) on generating commuting trips by rail, among those making at least one commuting trip on some mode within the survey week. It shows the set of significant influences within each of the two fixed clusters. The value of the estimated odds ratio with respect to the reference case shows how much more likely (if over 1) or less likely (if below 1) that person type is to make at least one commuter trips by rail (in the first model stage) or to make more than one rail commuter trips, conditional on making at least one rail commuting trips in the week (in the second model stage).

**Table 10:** Significant influences on: generating at least one rail commuting trip; and on the number of rail trips, conditional on generating at least one rail commuting trip

a) Influences on making at least one rail commuting trip in the week			
		c1-3*	c1-4*
Influence	Reference group	Odds ratio	Odds ratio
Head of household: manual	... in clerical work	0.59	not significant
Head of household: skilled manual	... in clerical work	0.67	0.40
High income households: > £50k	Medium income: £25-50k	1.52	1.64
Self employed	Employed	0.53	0.48
Work in public admin, etc. – gSIC4	gSIC Ref.	1.37	2.04
Work in financial sector – gSIC6	gSIC Ref.	4.35	3.45
Work in business services – gSIC7	gSIC Ref.	2.08	2.04
b) Influences on number of commuting rail trips, conditional on making at least one such trip			
Influence	Reference group	Odds ratio	Odds ratio
Full time work	Part time work	1.5	2.0
Head of household: skilled manual	... in clerical work	1.10	1.17
High income households: > £50k	Medium income: £25-50k	not significant	0.91

**Key:** C1-3\*: commuters from Outer London, and C1-4\* those from Big/Medium/Small Urban and Rural areas, both to Central/Inner London.

**6.5.4** It is interesting to note that many socio-economic characteristics from Table 9, either are not significant or are not highly significant, once segmentation by built form clusters has been introduced. For example, once these effects have been taken into account, neither the car ownership nor the age of the individual commuter have a significant influence on the use of rail for commuting. This highlights the importance of taking into account the geographical self-selection effect when analysing influences on travel behaviour so as to remove those influences that appear merely to correlate with spatial location or other influencing variables. This approach also factors out apparent behavioural changes that in reality are due to spatial or structural changes in population incidence.

- 6.5.5** Within the first model stage, the industrial sector (SIC) and the household income level are the most important factors governing the propensity for rail commuting (i.e. making or not making a rail commuting trip). In both clusters: C1-3\* and C1-4\*, those working in the financial sector (gSIC6) are much more likely to make a rail commuting trip (respectively 4.3 and 3.4 times more likely) compared to the reference SIC; this is also true for commuters working in real estate, professional, scientific and technical sectors (gSIC7 with odds ratios of around 2 for both C1-3\* and C1-4\*) and, to a lesser extent, those working in public admin, etc. (gSIC4 by 1.4 and 2 times more likely, respectively).
- 6.5.6** As expected, high income households are also more likely (around 1.6 times for both clusters) to commute by rail than are medium income or low income. On the contrary the self-employed and those in skilled manual and manual jobs are less likely to commute by rail than are the employed and those in clerical occupations, respectively.
- 6.5.7** Within the second model stage to estimate the weekly number of rail commuting trips, conditional on making at least one rail commuting trip in the survey week, the only highly significant factor is work status; full timers have a higher tendency to make more rail trips per week compared to their part time counterparts. Other influences are either weakly significant or not statistically significant at all. It is interesting to note that work status is not a determining factor in explaining whether people commute by rail but not surprisingly rail commuters in full-time employment have significantly higher rail commuting trip rates than rail commuters in part time rail employment.
- 6.5.8** Having examined the important influences, we then looked into whether there was evidence of behavioural changes in these over time. First, we looked into variations in the set of significant influences reported in Table 10; then we examined the variations in coefficients for the most significant influences within each of the two major rail fixed clusters. We ran a multiclass ZINB model to compare these influences across four time periods: 2002 to 2004, 2005 to 2008, 2009 to 2012, and 2013 to 2015. The Wald test analysis suggests that, except for the full-time workers commuting into Central/Inner London from Big/Medium/Small Urban and Rural areas (cluster C1-4\*), none of the other variations over time in influences are statistically significant. This could either indicate the stability of these influences over time, though it could simply instead be a result of the increases in standard errors, due to the drop in sample sizes resulting from this further degree of segmentation by time periods. In summary, there is no significant evidence of changes in inherent rail trip making behaviour over time.
- 6.5.9** Table 11 indicates that the odds-ratio measuring the difference in the weekly rail commuting trip rate of full-time, compared to the reference part time, rail commuters, has reduced consistently from 2002 to 2015, by 68% ( $=1.72/2.52$ ) overall for cluster C1-4\*. This cluster is a major medium distance rail market segment within which over 70% of commuting trips are made by rail, so that the overall impacts on rail demand from this finding are noteworthy.



**Table 11:** Variation over time in the odds-ratio for work status in influencing the weekly rail commuting trip rate of rail commuters from outside to Central/Inner London (cluster C1-4\*)

Influence	2002 to 2004	2005 to 2008	2009 to 2012	2013 to 2015
Full time work (ref group: Part Time)	2.52	2.51	2.04	1.72

**6.5.10** Despite the limitations imposed from the small sample size, this clear pattern supports the hypothesis that full-time, longer distance rail commuters to Inner/Central London are adjusting their number of weekly rail commuting trips over time, making their rail trip rates closer to those of part timers. Some of this behavioural change may be related to greater flexibility in working locations and hot desking, with an increased ability for some office workers to work at or from home for a few days of the week, as discussed further in Chapter 9. In summary, there is no significant evidence of changes in inherent commuter rail trip making behaviour over time, other than the reduction in the weekly number of rail trips by those in full-time employment.

## 6.6 Overview of the model results for rail commuting

**6.6.1** The main rationale for the introduction of the model based analysis was to make certain that the importance of the set of influences on rail commuting demand that had been determined from the earlier visual analyses, was confirmed through this more rigorous analytical approach. This has been achieved;

- Using both approaches and their different data sources, the key importance within the demand for rail commuting of the same subset of agglomerated, office-based SIC sectors has been independently determined.
- It also confirms that the market for rail is strongly focussed on those in non-manual occupations and on those in high income households. In part this will represent that some of those in senior management positions in non-office based industry sectors, may in reality have workplaces in city centre offices, rather than in the out-of-town factory sites of their lower income employees, and so these managers may potentially be attracted to rail.
- Many of the other demographic variables that might correlate in aggregate with rail commuting demand within a simpler regression-based approach, have dropped out once clustering had been introduced to represent the differences between built-forms / area types in the cross-sections of the set of individuals that reside within them.

**6.6.2** Another important finding is the observed small reduction over time in commuter rail trip rates for rail commuters to central London. It indicates that the continuing rapid growth in the number of workplaces that exhibit a greater than average rate of rail usage does not automatically generate an ever increasing number of rail commuting trips.

**6.6.3** Other recent research into commuting trip rates (Le Vine et al., 2017) using the National Travel Survey dataset, has found evidence of reductions over time in the number of days a week that both full-time and part-time workers commute by rail. This may be part of the explanation of the recent tapering off in passenger journey growth in the London and South East rail sector that was illustrated in Figure 1, noting that the charts of the trends in regional workforce numbers in London (Figure 8 and Figure 9) have not, as of quarter 1, 2018, indicated any significant downturn in the workforce up to then. There is further discussion in Chapter 9 that explains how the growth in various forms of home working may likewise have a significant impact in reducing rail commuter trip numbers.

**6.6.4** In summary, the observed major growth over time in commuter rail travel is not primarily due to increased weekly rail trip rates per person within any specific employment segment. It mainly arises instead from a combination of:

- Overall growth within the workforce, due to an acceleration of population growth since the mid-2000s (Figure 13), followed eventually by high adult-employment rates and historically low unemployment rates;
- from an increased proportion of those commuting by rail within any given employment segment - this is influenced in part by:
  - particularly rapid recent employment growth occurring in dense central city areas (Figure 10 and Figure 11) that tend to have good rail accessibility relative to car;
  - the spatial pattern of fastest residential growth having gradually switched (Figure 12) from the low density, car-captive rural areas into the higher density, urban areas within which a good range of rail services may be accessible to residents;
- from well above average increases in the numbers within those specific employment segments that have high rates of commuting by rail (Figure 8 and Table 5).

## 7. Analysis of business rail travel

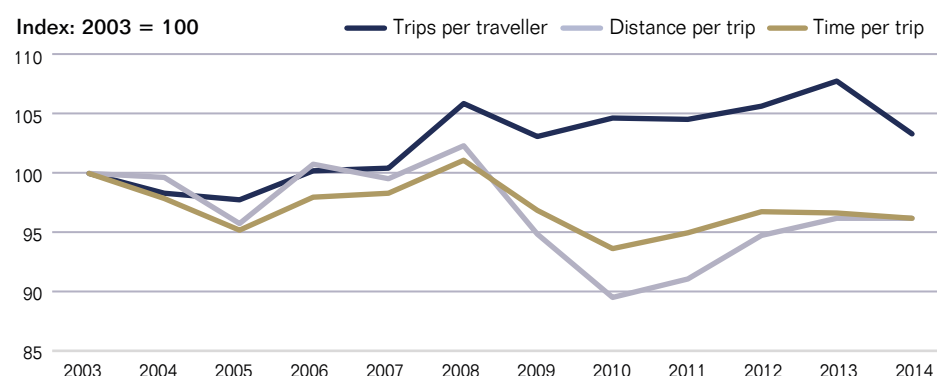
### Key Findings

- The analysis supports the finding that the source of the rail growth throughout is due to a larger market of rail travellers, rather than more intensive rail usage by existing rail travellers.
- High-income households have a higher rate of business rail travel when compared to lower income households.
- High income households who are in office-based services make three times more rail trips than high income households who are not. Additionally, the self-employed have a lower propensity to make rail business trips than the employed. Households with a car are less likely to make a business rail trip and make fewer of them; but the trips they do make are considerably longer (an extra 23 miles) than those made by people in non-car owning households.
- The analysis of commuter and business rail travel indicates that for both purposes, office based industries such as financial services, scientific, technological and professional services have the highest rates of rail travel.
- Between 2002 and 2014, the workforce increased by 27%, but given differential growth in sectors that favour rail travel for business strips, at least 38% of the growth in this market can be attributed to changes in employment composition over time.
- For the decade before 2006 company car ownership and annual car kilometres travelled fell the most amongst high income groups, as well as within employment categories and regions that have had the highest rates of rail commuting. A proportion of modal switch away from car towards rail was due to reductions in company car tax benefits up until 2006.

### 7.1 Introduction

- 7.1.1** Business travel has traditionally been an important component of the rail market. Its importance is not so much in terms of the number of trips made, just 9% of all rail trips, but rather it is because many business trips are over comparatively long distances and will often be paying full rather than discounted fares. In this way, their importance for rail revenues is larger than might be expected if based solely on the total number of business rail trips made.

**Figure 28:** Trends for business trip purposes in trip numbers per rail traveller and average rail trip length and time, 2003-14, England & Wales



(Source: NTS - smoothed 3-year moving average)

**7.1.2** Figure 28 presents for England and Wales, for business trips, indices of the smoothed trends from 2003 through to 2014 for three distinct rail travel characteristics:

- the average number of rail trips per capita for this travel purpose that are made in the survey week by those that have made at least one such rail trip;
- the average trip length across the set of rail trips for this purpose;
- the average trip duration across the set of rail trips for this purpose.

**7.1.3** For the business travel purpose there might be a small increase in rail trip rates but even this is uncertain due to the relatively small sample available and the associated large sampling error for this rail travel purpose.

**7.1.4** This chapter analyses the trends and influences on business rail travel. It is based primarily on the analysis of NTS data, complemented by some other statistical data sources. In the absence of better indicators within the published ORR rail datasets<sup>23</sup>, past analyses of business travel based on ORR statistics have often used the sales of non-discounted “Anytime” tickets or of first class ticket types as indirect indicators of trends in business travel. However, the direct usage here instead of trips for the travel purpose business within the NTS dataset provides more discriminating analyses below that enable greater stability through time in the interpretation of the underlying data.

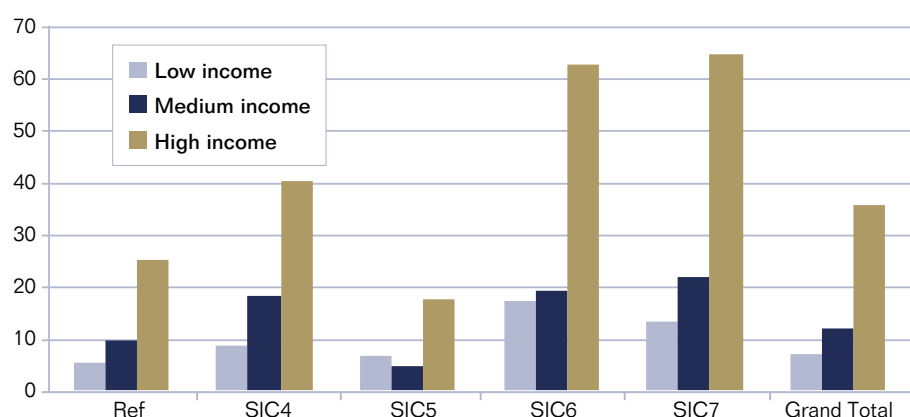
**7.1.5** The analysis is in three parts. Firstly, various tabulations of business rail travellers and of their travel characteristics are presented that provide an overall picture of the main groups that contribute to the market for business rail travel. Then a more complete model-based analysis is used to identify systematically the main determinants of business rail travel in a form that discounts the many cross-correlations between such influences. Finally, these elements are drawn together to provide pointers on the evolution of trends in business rail demand.



## 7.2 Who are the main business rail travellers?

**7.2.1** All those in employment except those who work from home will make regular commuter trips in most weeks of the year. This contrasts with business travel which is not spread uniformly across all those in employment but instead is focused strongly on just some specific segments within the workforce (Figure 29). Even within these particular segments many people will make relatively few business trips in any given week, and even fewer such trips by rail<sup>24</sup>. Accordingly, the analysis of rail business trips within the NTS dataset can only be carried out at a relatively aggregate level in order to avoid the sampling errors that otherwise would emerge.

**Figure 29:** Weekly outbound trip rate for business trips by rail per 1000 employed persons in the industry sector, by head of household income group

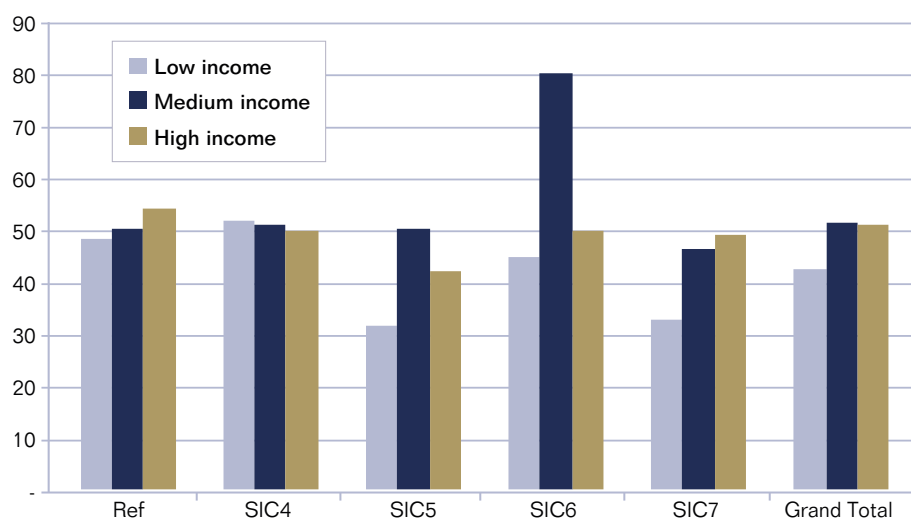


(Source: NTS)

**7.2.2** Figure 29 presents the average weekly outbound number of business trips made by rail, per 1000 employed persons in the segment, averaged across the period 2002 to 2014. These trip rates are cross-classified by both: the income group of the head of household (high, medium and low); and by the grouped Standard Industrial Classification (gSIC - see Table 7) of the type of industry in which they are employed. It shows that for each of the grouped SICs those residents within households with high income heads of household have considerably higher business rail trip rates than those in households with medium income heads, which in turn are higher than those from households with lower income heads.

**7.2.3** The differentiation in trip rates is even greater across the gSIC. Those from high income households who are in employment in the office-based financial services (gSIC6) and professional, business or related services (gSIC7) have weekly business rail trip rates of around 60 trips per week per 1000, which is close to 3 times the rate for those in high income households in the non-office based reference set of gSICs and is 13 times the rate for those from the reference set of gSICs who are in low income households. In broad terms, those employment segments with the highest rates of rail use for commuter trips, tend also to have the high rail usage for business travel purposes.

**Figure 30:** Average business rail one-way trip length in miles, by industry sector, by head of household income group



(Source: NTS)

**7.2.4** Figure 30 presents the analogous average business rail trip one-way length in miles. The differentiation between segments, either by SIC or by household income group, is much less pronounced (except for some sampling noise) than for the trip rates in Figure 29. It is around 50 miles one-way, combining together both home-based and non-home-based business trips. The main differentiation in business rail use across employment segments relates to their very different trip rates rather than to their average rail trip lengths travelled.

**Table 12:** Weekly trip rate for business trips by rail per 1000 employed persons in the head of household income group or in the industry sector, in each period

	2002 - 08	2009 - 11	2012 - 14	All years
Total	17	19	22	19
Low income	7	7	8	7
Medium income	12	10	15	12
High income	36	35	36	36
SIC ref	13	13	16	14
SIC4	21	24	30	24
SIC5	8	7	11	9
SIC6	39	52	38	42
SIC7	38	38	44	40

(Source: NTS)



- 7.2.5** The stability of business rail trip rates over time is explored in Table 12 which indicates little trend for the individual income groups but perhaps a small increasing trend for some of the SIC groups. However, the sampling errors here are considerable due to the low number of business rail trips in some classes, so caution in interpretation is required.
- 7.2.6** Surprisingly, the clearest growth trend in trip rates is shown for the overall unsegmented rate. It grows by 28% from 17 to 22 between the earlier and the latest period. Because this overall growth rate is actually higher than that for each of its component income groups, it indicates that the balance of employed persons within the population has evolved over the periods in a manner that has supported the use of rail mode for business travel. This confirms again, the crucial importance introduced in Box 1 for aiding our understanding of how systems operate, through making a clear distinction in all analyses between: effects due to changes in population incidence; and those due to changes in actual individual behaviour.
- 7.2.7** The earlier Table 8 provides the evidence to confirm that indeed those population segments with high rates of business travel are growing substantially more rapidly than the average. This was explored further through examining in more detail the impacts on business rail trip growth due to the differential workforce growth between SICs from 1996 to 2018. This repeated a broadly similar exercise to that previously presented for the commuting trip purpose in Table 5.
- 7.2.8** The same set of business rail trip rates in the final column of Table 12 was applied to the total workforce for England in Wales for each of the years 1996 and 2018. These trip rates were applied in two distinct forms:
- Aggregate - multiplying the total workforce jobs by the overall average rail trip rate of 19 per week per 1000 employed persons;
  - Segmented - multiplying the workforce jobs in each gSIC by the corresponding rail trip rate for that gSIC (from the last five rows of Table 12) and then summing these trips together.
- 7.2.9** The aggregate method estimated a growth in business rail trips of 27%, which is purely due to the corresponding 27% growth in workforce jobs over the period. However, applying the more appropriate segmented method to this same workforce growth increased the growth in business rail trips to 38%. This segmented business rail growth estimate is 41% higher than the aggregate figure, due simply to taking appropriate account of incidence effects for one single dimension: industry sector. This simple segmented estimation example clearly underestimates the total impact of incidence effects on business rail trip growth, for the following reasons, at least.
- Because the NTS sample of business rail travel is relatively small, no attempt was made to take account of any differentiation in business trip rates between regions, analogous to those clearly indicated for commuting in Table 3.
  - Because the time series for workforce jobs does not include segmentation by income level, it was not possible to apply the more appropriate trip rates from Table 12 that are jointly segmented by income and gSIC. Because that table indicates major differences in trip rates across income groups, this additional segmentation in turn would have generated a substantial additional impact.

**7.2.10** This simple example again highlights the critical importance of ensuring that the full set of relevant incidence effects are explicitly represented within forecasting models for business rail travel. This would then avoid underestimating the impacts of simple population growth impacts in situations where the balance of segments is changing within the population. Without this appropriate explicit representation of incidence effects within the model design, there is a real danger of misallocating its impacts and so of inappropriately exaggerating the influence of some other modelled factors. This in turn would lead to poorer future forecasts and to the danger of providing misleading estimates of the impacts of policy measures.

**7.2.11** The preferred approach is to ensure that all area-type and socio-demographic dimensions that have a statistically significant influence on rail trip rates are estimated jointly using an appropriate modelling methodology, such as that now explained.

## 7.3 ZINB model of business rail travel

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**7.3.1** This Section summarises the findings from the structural equation model based analysis of business trips by rail. The main assumptions adopted for this model are the business travel assumptions, equivalent to those that are presented above in Chapter 3 for the ZINB model of commuting travel. It includes the same set of explanatory segmentation variables that has been listed previously in Table 9. The estimation covers England as a whole because the small size of the business rail sample within the NTS, coupled with the absence of business trip destination location information, ensures that the latent cluster identification approach used for commuter trips would not be feasible.

**7.3.2** Table 13 shows the set of significant (at the 95% confidence level) influences on generating business trips by rail, among those making at least one business trip on some mode within the survey week. Using the ZINB regression, we have estimated a two stage model:

- analysing influences on the decision to make at least one business rail trip (i.e. whether such a trip is made or not);
- analysing the number of business rail trips which are made within a week, conditional on making at least one business rail trip.



**Table 13:** Significant influences on: generating at least one business rail trip; and on the number of rail trips, conditional on generating at least one business rail trip.

a) Influences on making at least one business rail trip in the week		
Influence	Reference group	Odds ratio
Head of household: manual	... in clerical work	0.16
Head of household: skilled manual	... in clerical work	0.22
High income households: > £50k	Medium income: £25-50k	2.38
Self employed	Employed	0.48
Work in financial sector – gSIC6	gSIC Ref.	20.00
Work in business services – gSIC7	gSIC Ref.	2.70
1 + car in household	No car in household	0.33
b) Influences on number of business rail trips, conditional on making at least one such trip		
Influence	Reference group	Odds ratio
Head of household: manual	... in clerical work	2
Head of household: skilled manual	... in clerical work	2.2
1 + car in household	No car in household	0.48

**7.3.3** In Table 13 the value of the estimated odds ratio with respect to the reference case shows how much more likely (if over 1) or less likely (if below 1) that person type is to make at least one business trips by rail (in the first model stage) or to make a more than one business rail trip, conditional on making at least one business rail trip in the week (in the second model stage).

**7.3.4** Table 13 suggests that most significant influences are those that govern the decision to make rail business trips rather than those that govern the number of business trips to be made. Car ownership and work status of the head of household (i.e. manual or skilled manual workers) affect both the propensity to make business trips on rail and the number of such trips made. Those in manual and skilled manual work are correspondingly only 0.16 and 0.22 times as likely to make business rail trips as those in the reference group in clerical work but if they do make a business rail trips, they are more likely to make more than one such trip. Those with a car in their household (after controlling for the correlation with household income) are a third as likely to make some business trips on rail, while if they do such travel, they tend to make less than half as many business rail trips as those in the reference households without cars.

**7.3.5** The business travellers with a higher propensity for rail use than their reference category are those:

- in high income households - 2.4 times as likely
- in the financial sector (gSIC6) - 20 times as likely;
- in the real estate, professional, scientific and technical sectors (gSIC7) - almost 3 times as likely;
- while the self-employed have a lower propensity to make rail business trips.

**7.3.6** However, these segments are not different to the reference case in the number of rail business trips that they make, conditional on them making at least one such trip. An analogous analysis is used to evaluate the main influences on the average travel distance per rail trip among those who make at least one rail business trip. Because the dependent variable, travel distance, is a continuous variable, a multivariate normal regression is used for this second model stage instead of a negative binomial model.

**Table 14:** Significant influences on average rail trip length for those making business rail trips

Influence	Reference group	Estimate
Head of household: managerial/profess.	... in clerical work	8.3
1 + car in household	No car in household	22.7

**7.3.7** Only two variables (Table 14) were significant in modifying the average business rail trip length. Those in professional and managerial jobs tend to travel 8.3 miles longer per rail trip than the reference clerical workers. Also those who have a car in their household are likely to make longer business rail trips (on average by 22.7 miles per trip); this is perhaps because those with access to car may tend to make most of their shorter business trips by car (this is evidenced from car owners' lower propensity to make rail business trips).

**7.3.8** It can be seen that the NTS modelling and analysis above for business trips on rail has been rather simpler than that in Chapter 6 for commuter trips. No attempt was made to identify latent clusters. This simplification largely arises because of the relatively small sub-sample of business rail trips within the overall NTS database. The vast majority in the NTS sample make no rail business trips within the sample week. Accordingly, further disaggregation within the model to take account of trends over time and through space would suffer from large confidence intervals in their parameter estimates.



## 7.4 Overview of the model results for business rail

- 7.4.1** Again the statistical modelling approach has confirmed more precisely the relationships that had been derived from the simpler analyses of the influences on business rail demand. The rapid past rate of growth in the number of business trips by rail will have been accelerated by:
- the very rapid growth in employment within the set of SICs: J,L,M,N, which are the office-based sectors that are much more likely than average to generate business trips by rail - there will have been an additional short-term boost due to the company car taxation changes that have encouraged a shift on business trips for these workers from car to rail modes;
  - the rapid decline in car ownership rates within the dense urban areas, because those in households without cars are three times more likely to make business trips by rail;
  - the general trend within the economy away from manual work towards office based work will again increase the number of business trips by rail.
- 7.4.2** The growth has not been generated by increased business rail trips among rail travellers but is due to an increased number of workers making some business trips by rail.

## 8. Analysis of rail for other travel purposes

### Key Findings

- An examination of trends, segmented by household income for non-commuting and non-business travel purposes, did not indicate any strong trend in the number of rail trips per rail traveller or the average rail trip length.
- Much of the increase in rail trips occurs indirectly as a result of rising incomes or a greater proportion of the population living in dense urban areas leading to a higher propensity to use rail.
- The study examined rail trip rates across different socio-demographic characteristics and observed that females, those not in full-time employment, and those without access to a car in their households are much more likely to make rail trips for shopping and personal reasons. However, households with a car are more likely than those without a car to make longer rail trips for these journey purposes.
- For social and holiday trips, households with no access to car are much more likely to make rail trips.

### 8.1 Introduction

**8.1.1** This Chapter presents the main findings from analysing rail trips for the remaining other trip purposes. In summary the other trip purposes categories analysed here comprise the set of all trip purposes, except for: commuting and business, because these have already been analysed in the previous two chapters; and education, which has not been analysed in detail here due to its relatively small size.

**8.1.2** The other purposes are split into two groups that are analysed and modelled individually below:

- travellers for shopping and personal businesses (S&PB - an aggregate of “food shopping”, “non-food shopping”, “personal business medical”, “personal business eat/drink”, “personal business other”, and “escort shopping/personal business” purposes in NTS dataset);
- travellers for social and holiday purposes (S&H - an aggregate of all other purposes except work, business and education).

### 8.2 Who are the main rail travellers for other purposes?

**8.2.1** For each of these travel purposes, this section examines how rail trip rates and average rail trip lengths are differentiated between population segments. Figure 31 presents the average weekly outbound number of trips made by rail, per 1000 persons in the segment, averaged across the period 2002 to 2014. These trip rates are cross-classified by travel purpose and by both: the income group of the head of

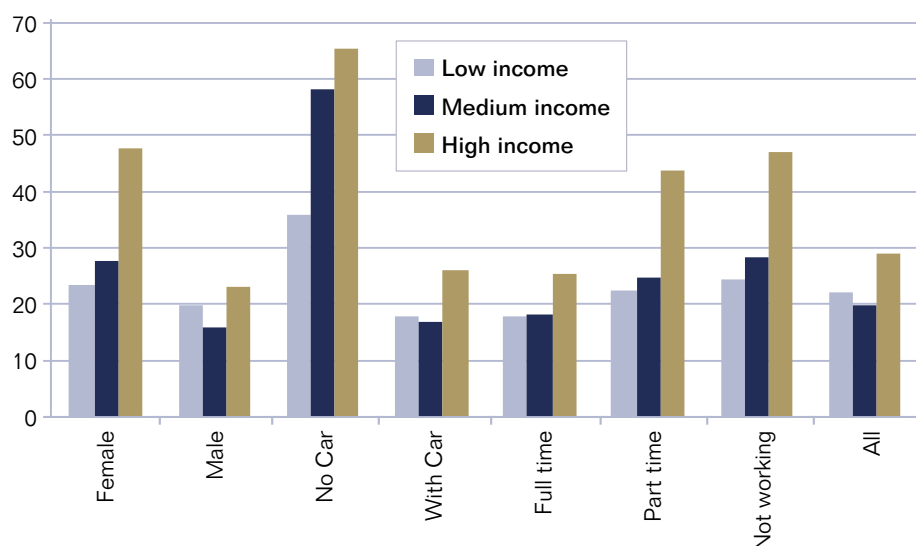


household (high, medium and low); and by various other categorisations. The average weekly rail trip rate for S&PB is 20 rail trips per 1000 persons, whereas for S&H it is a substantially larger rate of 47 trips<sup>25</sup>.

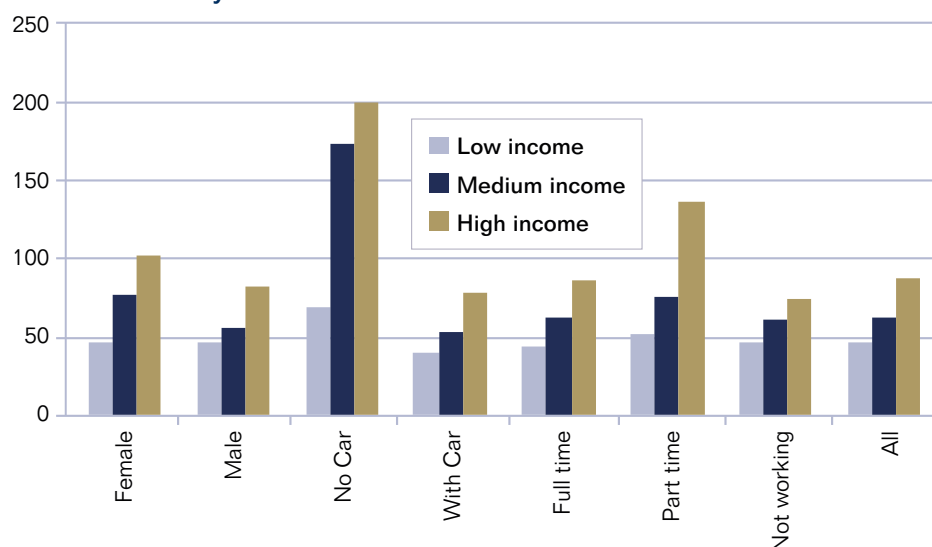
**8.2.2** Figure 31 shows that for both of the travel purposes, the high income group has a substantially larger trip rate throughout most segments, with an overall rate of 29 for S&PB and of 87 for S&H. However, for S&PB the medium and low income group members have similar trip rates of around 21 rail trips per 1000 persons, though for S&H the overall rate of medium income is 62, well above the low income rate of 46. In each income group the rail trip rates tend to be substantially lower for: males, those working full time; and those with cars. The highest rail trip rates for both travel purposes are associated with those within households without cars (note these will often be residents in large cities that can provide a good range of rail services).

**Figure 31:** Weekly outbound rail trip rate per 1000 persons in the segment, by travel purpose, by head of household income group and other categorisations

#### Shopping and personal business



#### Social and holiday



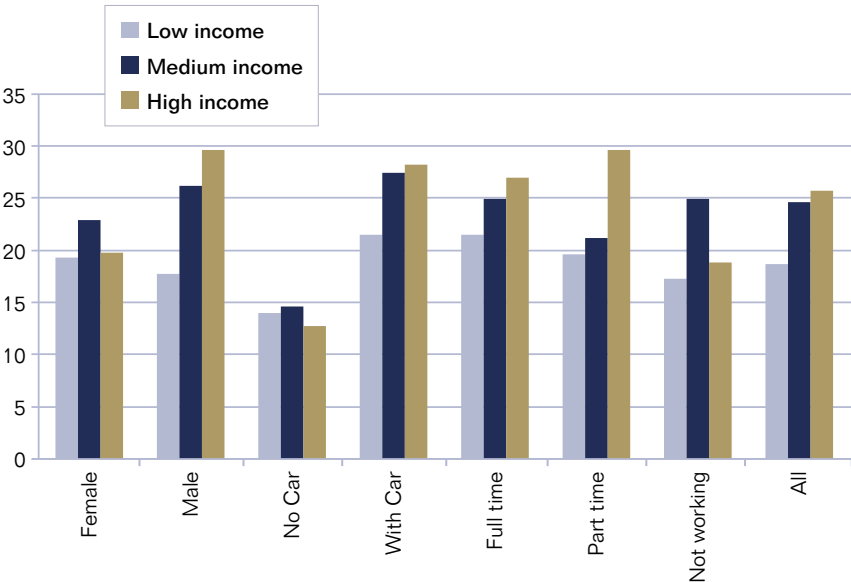
(Source: NTS)

**8.2.3** Figure 32 presents the analogous average rail trip one-way length in miles for each travel purpose, with an overall average of 19 miles one-way for S&PB and of 39 miles for S&H. The differentiation between segments, either by household income group or by personal characteristics, is much less pronounced than for the trip rates in Figure 31, with very little variation at all for S&H either across income group or personal characteristics.

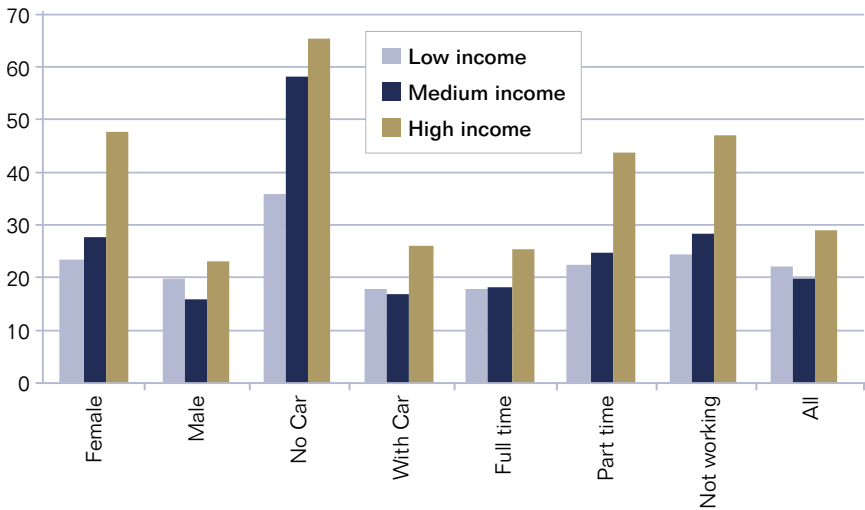
**8.2.4** For S&PB those in households without cars are the one group with substantially lower than average trip lengths of around 14 miles for each of the income groups. Noting that this no-car group has by far the largest rail trip rates, suggests that they need to make their shorter trips by rail, whereas others may use car for many of their shorter trips.

**Figure 32:** Average rail one-way trip length in miles in the segment, by travel purpose, by head of household income group and other categorisations

Shopping and personal business



Social and holiday



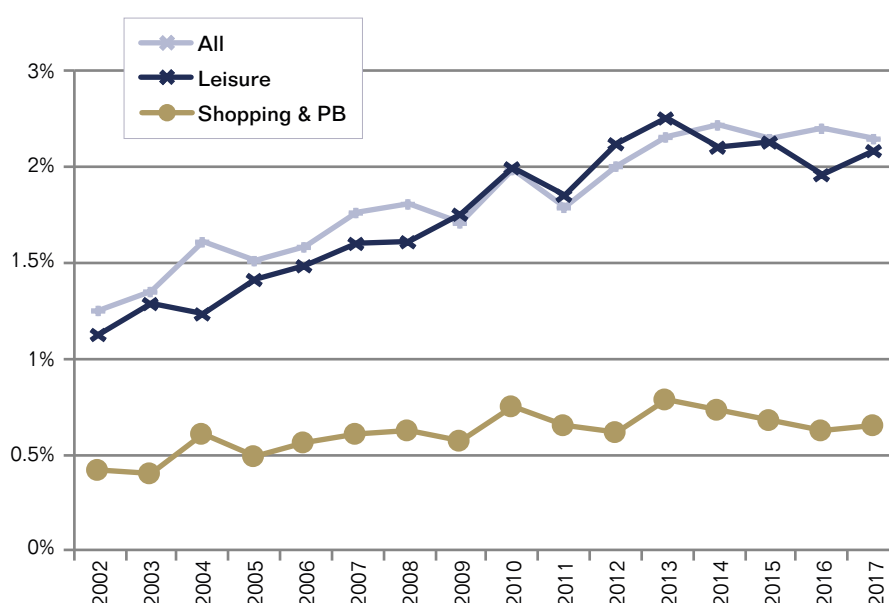
(Source: NTS)



### 8.2.5

Although the increase in rail mode share in Figure 33 for all travel purposes combined grew gradually throughout the years 2002 to 2017 in England, increasing from 1.1% to 2.1%, the growth trajectory for each of the leisure travel purposes appears to have flattened in recent years, though sampling variation may also have played a part. Strong growth in rail mode share: from 0.4% to 0.8% for purpose shopping and personal business; and from 1.0 % to 2.0% for purpose leisure, occurred in the period from 2002 to 2010 but rail shares in subsequent years simply oscillated around their 2010 values. This tapering off in rail share growth may relate partly to the absence from 2008 onwards of any strong growth in real personal income.

**Figure 33:** Percentage of all trips within the travel purpose that are by rail, 2002-2017, England



(Source: NTS Table NTS0409)

### 8.2.6

An examination within the NTS dataset of time series trends, segmented by household income for each travel purpose in both: the number of rail trips per rail traveller; and the average rail trip length, did not indicate any strong trend through time for any of these cases. Accordingly, the growth in rail share indicated in Figure 33 for each of these two leisure travel purposes is primarily due to increases in the overall proportion of the population that is making at least one rail trip per week. Much of this increase occurs indirectly as a result of a greater proportion of the population being in the high income group or living in the dense urban areas, where car ownership rates are declining and where access to a good range of rail services is more common.

## 8.3 ZINB models of rail travel for other purposes

- 8.3.1** The model framework and the main assumptions made in creating the models for these other purposes are analogous to those already listed in Chapter 6 for the rail commuting model, except for the following adjustments and interpretations: only those who are making at least one trip in the course of the survey week for that specified purpose are included in its analysis; the latent cluster analysis stage is not implemented.
- 8.3.2** The set of explanatory segmentation variables included within it are similar to those listed previously in Table 9 for commuting and business travel, except for the following customisations:
- all adults are now included in the analysis, not just those in employment;
  - the reference category for: Work status, is changed from: Part time, to: Economically inactive.
  - the reference category for: Head of household occupation, is changed from: Clerical, to: Economically inactive head of household.
- 8.3.3** The significance of each of the explanatory variables is tested within the two-stage ZINB model when quantifying each of:
- the decision on whether to make at least one rail trip for the specified purpose; and
  - the number of rail trips for that purpose that are made, conditional on making at least one such trip.
- 8.3.4** Shopping and personal business trips
- 8.3.4.1** Table 15 presents the estimated odds ratios (significant at the 95% confidence level) with respect to the reference case. Similar to what was reported for commuting trips, part (a) presents the influences on making at least one rail trip for shopping and personal business, while part (b) presents the influences on making more rail trips, conditional on making at least one shopping and personal business rail trip per week.
- 8.3.4.2** Males or those who are working full time or those with access to a car in their households are more likely to make rail trips for shopping and personal business (perhaps because they combine that with their commuting or because they already have a seasonal ticket) but they make fewer of these trips per week (perhaps due to their time budget). Also, among those who are making rail trips for shopping and personal business, high income groups and younger adults tend to make a greater number of rail trips per week.



**Table 15:** Significant influences on: generating at least one rail trip; and on the number of rail trips, conditional on generating at least one rail trips for shopping and personal business

a) Influences on making at least one S&PB rail trip in the week		
Influence	Reference group	Odds ratio
Full Time workers	Economically Inactive	Over 100
Male	Female	2.08
1 + car in household	No car in household	1.96
b) Influences on the number of S&PB rail trips, conditional on making at least one such trip		
Influence	Reference group	Odds ratio
Full Time workers	Economically Inactive	0.59
Male	Female	0.79
High income households	Medium income: £25-50k	1.46
Age below 24 years	Age 35 to 49	1.8
Age 25 to 34 years	Age 35 to 49	1.28
1 + car in household	No car in household	0.32

**8.3.4.3** Table 16 presents the significant influences (at the 95% confidence level) on average rail trip length for rail travellers for shopping and personal business purposes. Similar to the business trips analysis, for shopping and personal business trip purposes those with household access to car tend to travel longer distances (8.6 miles longer per trip) by rail, compared to those who have no household access to car. This is likely to be because their shorter trips may generally use car rather than rail. Also those in single adult households travel longer distances by rail compared to those in multiple adult households.

**Table 16:** Significant influences on average rail trip length for those making rail trips for shopping and personal business

Influence	Reference group	Estimate
Single Adult households	2+ adult households	3.7
1 + car in household	No car in household	8.6

### 8.3.5 Social and holiday trips

**8.3.5.1** The most striking result in part (a) of Table 17 is that those with access to car are much less likely to travel by rail for social and holiday trips. Also, in contrast to shopping and personal business travel, male and full time workers are less likely to use rail for their social and holiday trips<sup>26</sup>. Moreover, those in manual and skilled manual jobs tend to avoid rail for these purposes. On the contrary, high income bands and younger groups are more likely to travel by rail for social trips and holidays.

**8.3.5.2** Among those who are making rail trips for social and holiday activities: males; those in managerial/professional and in clerical households; and younger adults below the age of 34, each tend to make more rail trips, while: those in low income households; those above the age of 65; and those with household cars, each tend to have lower rail trip rates for holiday and social activities.



**Table 17:** Significant influences on: generating at least one rail trip; and on the number of rail trips, conditional on generating at least one rail trip for social and holiday purpose

<b>a) Influences on making at least one S&amp;H rail trip in the week</b>		
Influence	Reference group	Odds ratio
Full Time workers	Economically inactive	0.67
Male	Female	0.74
Single Adult households	2+ adult households	1.41
Head of household: skilled manual	Economically inactive HoH	0.48
Head of household: manual	Economically inactive HoH	0.66
High income households	Medium income: £25-50k	2.27
Age below 24 years	Age 35 to 49	3.87
Age 25 to 34 years	Age 35 to 49	1.48
1 + car in household	No car in household	below 0.01
Year	Continuous variable	1.04
<b>b) Influences on the number of S&amp;H rail trips, conditional on making at least one such trip</b>		
Influence	Reference group	Odds ratio
Male	Female	1.13
Head of household: managerial/profess.	Economically inactive HoH	1.41
Head of household: clerical	Economically inactive HoH	1.43
Low income households	Medium income: £25-50k	0.67
Age below 24 years	Age 35 to 49	1.65
Age 25 to 34 years	Age 35 to 49	1.4
Age over 65 years	Age 35 to 49	0.82
1 + car in household	No car in household	0.86
Year	Continuous variable	1.019



- 8.3.5.3** The influence of changes in trip making over time was tested for the other travel purposes by including year as a continuous variable. It was only for the social and holiday purpose<sup>27</sup> that this year variable was statistically significant. Its coefficients indicate, respectively, that that in each year from 2002 onwards:
- the proportion of the population making at least one rail S&H trip per week increases by 4% (odds ratio of 1.04);
  - the average weekly number of S&H rail trips made by this rail travel group increases by 1.9% per annum.

**8.3.5.4** Table 18 shows the influences on average rail trip length for rail travellers on social and holiday purposes. It indicates that both full time and part time workers travel longer rail distances than those who are economically inactive but males travel shorter distances by rail than females. When those above 65 years old and those with household cars use rail for social and holiday trips, then they tend to travel longer distances; specifically the older cohorts tend to travel a further 10.8 rail miles per rail trip. When everything else is constant, rail travellers for social and holiday purposes tend over time to travel shorter distances.

**Table 18:** Significant influences on average rail trip length for those making rail trips for social and holiday purpose

Influence	Reference group	Estimate
Full Time workers	Economically inactive	4.2
Part Time workers	Economically inactive	5.0
Male	Female	-4.9
Age over 65 years	Age 35 to 49	10.8
1 + car in household	No car in household	4.8
Year	Continuous variable	-0.63



## 8.4 Overview of the model results for other rail travel purposes

- 8.4.1** One finding for the trip purpose shopping and personal business is that there has been no strong trend through time in either the average weekly number of rail trips per rail traveller or in the average trip length of such rail trips.
- 8.4.2** The models above indicate that the rapid growth in the rail demand in these two trip purposes is mainly due to the following reasons. First, the overall increase in the population of 14% from 1995 to 2017 in Great Britain, shown later in Figure 38.
- 8.4.3** Second, the more rapid increase within this population of those segments with a higher than average propensity for rail use who are resident within the areas that already have the highest rates of rail usage.
- ONS data<sup>28</sup> for regional gross disposable household incomes indicate that the percentage growth in income (GDHI) per head from 1997 to 2016 in Inner London greatly exceeded that in Outer London, which in turn grew more rapidly than the national average. Accordingly, the number in higher income groups has increased rapidly in Inner London.
  - the number of adults who are in the younger age groups has increased rapidly within the denser urban areas (Figure 12 and Figure 16).
  - the proportion of the population without cars has increased rapidly within the densest urban areas (Figure 18). DfT vehicle licensing statistics<sup>29</sup> indicate that the number of cars per adult (aged 18+), reduced by 22% (from 0.32 in 2004 to 0.25 in 2017) in Inner London, generating a major increase in the absolute number there without access to car, due to its rapidly growing population. In contrast, in England outside London, the number of cars per adult increased marginally in the same period.
  - for the case of social and holiday trips there is some overall increase in the proportion within each segment that make trips by rail and in their rail trip rates.
- 8.4.4** The fact that the trends in age profiles, income distribution, car ownership and other potential influences on rail use are moving in contrasting directions across different area types, calls into question the relevance of using just national trend values for such variables within forecasting models. Instead it is more appropriate when constructing forecasting models to recognise that socio-demographic and economic trends in those areas in which rail is well placed to compete, may have evolved through the past in rather different ways to the trends in areas in which rail usage is low.

<sup>28</sup> See <https://www.ons.gov.uk/economy/regionalaccounts/grossdisposablehouseholdincome/bulletins/regionalgrossdisposablehouseholdincomegdhi/1997to2016>.

<sup>29</sup> See DfT Table VEH0105.

## 9. Underlying influences on rail trends

### Key Findings

- Analysis of workplace agglomeration indicates that industry sectors with jobs in dense urban areas generate the highest propensity for rail use. Therefore a rapid increase in employment in these sectors supports growth in rail use.
- The planning policy initiative, PPG13 which aimed to establish more sustainable patterns of development, has facilitated rail passenger growth by promoting the location of new jobs and housing in higher-density, inner urban areas.
- Within dense urban areas the attractiveness of car use has been diminished as a result of various policy interventions such as congestion charges, parking charges, and reductions in road space. These have helped to generate modal shift.
- Reductions in road capacity were found to be the most influencing factor causing a reduction in car use. In turn this is likely to act disproportionately in supporting rail (or LU and LRT) passenger growth and in cycling. However, cycling competes mainly over short journey distances and is not normally in competition with rail.
- The growth in home working impacts on travel demand in various ways that are likely to reduce rail passenger demand.

### 9.1 Overview

**9.1.1** A wide variety of spatial trends and relationships have been identified in Chapter 4 for workplace influences and in Chapter 5 for residential influences that correlate with rail demand trends. Then in subsequent chapters statistical models have been estimated in turn for the four travel purposes: commuting; business; shopping plus personal business; and social plus holiday. These models have been developed to disentangle the main underlying influences on rail demand trends from the other variables that correlate with rather than directly influence these trends.

**9.1.2** Next we explore individually the reasons that have driven the observed rail demand trends in order to:

- firstly, identify each of the specific detailed underlying mechanisms external to the rail industry that have generated much of the past growth in rail passenger numbers – this is what is covered below in this current chapter;
- secondly, examine the most recent trends in these and in other emerging mechanisms that may currently be contributing to reducing the previous rapid growth in rail passenger demand – this topic is covered subsequently in Chapter 10.



### 9.1.3 The underlying mechanisms considered below are:

- **Spatial Agglomeration of workplaces:** Are certain types of jobs increasingly located at high densities in areas likely to be adjacent to major rail terminals?
- **Planning policy, PPG13:** Has the recent growth in residences, office space and retail focussed on inner city areas, rather than the 1980's focus on edge-of or out-of-town business parks?
- **Workplace accessibility by car:** Has a combination of reduced road capacity, increased road congestion during the peak periods, increases in parking costs and reductions in parking capacity made rail commuting relatively more attractive in those inner-city areas where jobs and residences have increased most rapidly?
- **Company car taxation changes:** Has the reduction in the car use as a result of reduction in the company car taxation supported the increase in rail use?
- **Productivity of on-board rail time:** Has the growth in access to tablets and other mobile communication devices enabled time spent commuting on-board trains to be more productive than the commuting time on other transport modes?
- **Home working:** Has the increase in home working for an increasing part of or for all of the week impacted to reduce the number of rail commuter trips per person per week?
- **Trends in population, GDP, Fares, and Transport Costs:** How have the trends in these factors contributed to the growth of rail travel?

Each of these underlying influences is now examined and quantified in turn in the following sections.

## 9.2 Underlying influences on rail growth

### 9.2.1 Spatial agglomeration of workplaces

- 9.2.1.1** The question examined here is whether the jobs in those industry sectors within which there are above average rates of rail commuting and rail business travel are increasingly concentrated into locations adjacent to stations that are well served by rail services?
- 9.2.1.2** The analysis was carried out using the ONS Census Journey to Work dataset at the workplace end in a form that is segmented by industry (SIC). This dataset indicates the main workplace of a person. Accordingly, their basic unit is the person, rather than the basic unit of a job that is used within the NOMIS workforce jobs dataset analysed in previous sections. This difference in units should not cause significant issues in analysis, provided that no attempt is made to explicitly combine together these two different datasets.

**9.2.1.3** The conclusion from the analysis of the 2011 workplace dataset indicates that the use of rail for commuting correlates strongly with the extent to which an SIC has its jobs agglomerated into relatively few but dense urban locations. Workplace agglomeration is measured in Table 19 by the count of the minimum number of local authorities (within the complete set of 348 LA districts and unitary authorities for England and Wales) required within an SIC to comprise 20%, 33.3% and 50%, respectively, of the national workforce for that SIC. A low count indicates a high degree of workplace agglomeration. Table 19 also includes the national percentage of commuting by rail, transcribed from Table 3.

**Table 19:** Agglomeration of workplaces and % rail commuting, by SIC, England & Wales, 2011

SIC	Cumulative # of LAs			E&W	
	20%	33.30%	50%	SIC	% rail
All industries	20	46	88	All	9
A: Agriculture, F,F	11	24	48	ABDE	3
C: Manufacturing	22	46	86	C	2
F: Construction	28	57	101	F	6
G: Whsale & retail	24	50	94	G	5
H: Transp & store	17	39	76	H	7
I: Accom. & food	18	42	85	I	8
J: Info & coms	9	23	50	J	20
K: Finance	2	7	27	K	30
L: Real estate	14	34	71	L	10
M: Professional	7	21	55	M	20
N: Administrative	20	43	81	N	10
O: Public admin.	14	34	71	O	11
P: Education	20	44	84	P	6
Q: Health & social	20	44	84	Q	5
R: Arts & recr.	19	43	85	RSTU	9

(Source: ONS, 2011 Census Table WP7606EW)<sup>30</sup>



**9.2.1.4** The highest level of agglomeration occurs in SIC K: Finance and insurance activities, which has 20% of its national workforce within just the City of London and the Tower Hamlets borough. A further 13% of the workforce is within the next 5 largest authorities: Westminster borough and the major cities of Leeds, Birmingham, Manchester and Bristol. The cumulative jobs total rises to 50% when a further 20 authorities are included, the majority of which are reasonably dense urban centres, often with good rail accessibility. This SIC K in 2011 had 30% of its jobs accessed by rail mode, within England and Wales as a whole, and is the SIC with the highest rate of rail commuting in every individual region (Table 3).

**9.2.1.5** The other two highly agglomerated SICs M: Professional and J: Information & communication activities, exhibit a similar, though less extreme clustering of workplaces. These both had 20% of their jobs accessed by rail mode nationally, while having higher than average rates of rail commuting in every individual region.

- SIC J is particularly Inner London focussed, with 8 out of the 9 largest authorities (that together comprise 20% of its national workforce) being London boroughs (all except Hounslow are in Inner London). Furthermore, of the next 14 largest authorities (up to 33% of the workforce), 3 also are Inner London boroughs, 5 are located within the Thames Valley, with 5 others being major cities and finally Wiltshire UA.
- SIC M: Professional, scientific and technical activities, includes Birmingham, Manchester and Leeds as well as 4 Inner London boroughs to comprise its top 20% of workplaces. Of the next 14 largest authorities (up to 33% of the workforce), 6 are Inner London boroughs, with the rest being major cities plus Wiltshire UA, Cheshire East and Cambridge city.

**9.2.1.6** In summary, those rapidly growing, office-based SICs that agglomerate their jobs to achieve economies of scale tend to concentrate these jobs into reasonably dense urban areas that generally are well served by rail services. As already demonstrated in Chapter 4, the SICs J and M are the two SICs that have had the largest total increases in employment between 1996 and 2018, so that this period will have generated substantial agglomeration increases overall, which in turn will have acted to support rail demand growth for both commuting and business travel purposes. Paradoxically as we shall demonstrate later in this chapter, these two SICs are also the two with high levels of working at or from home – the antithesis to agglomeration!

## 9.2.2 Planning policy, PPG13

- 9.2.2.1** During the period from the 1960s to the mid-1990s the land use policies in operation in the UK facilitated the expansion of low density residential and employment developments in the suburbs of cities as well as in small and medium sized towns. This development pattern was tied closely in a symbiotic relationship with the rapid growth in car ownership and use.
- 9.2.2.2** From the mid-1990s onwards there was a desire for a more sustainable pattern of economic growth. This led to major changes to the planning system through Planning Policy Guidance 13: Transport (PPG13, see Box 3) and through related land-use planning policies. These sought to produce a more sustainable transport system that would achieve reductions in the previous rapid rate of growth in the greenhouse gas emissions from transport, especially from road modes.

### Box 3: Guidance within PPG13: Transport

In order to deliver the objectives of this guidance, when preparing development plans and considering planning applications, local authorities should:

- 1** actively manage the pattern of urban growth to make the fullest use of public transport, and focus major generators of travel demand in city, town and district centres and near to major public transport interchanges
- 2** locate day to day facilities which need to be near their clients in local centres so that they are accessible by walking and cycling
- 3** accommodate housing principally within existing urban areas, planning for increased intensity of development for both housing and other uses at locations which are highly accessible by public transport, walking and cycling
- 4** ensure that development comprising jobs, shopping, leisure and services offers a realistic choice of access by public transport, walking, and cycling, recognising that this may be less achievable in some rural areas
- 5** in rural areas, locate most development for housing, jobs, shopping, leisure and services in local service centres which are designated in the development plan to act as focal points for housing, transport and other services, and encourage better transport provision in the countryside
- 6** ensure that strategies in the development and local transport plan complement each other and that consideration of development plan allocations and local transport investment and priorities are closely linked
- 7** use parking policies, alongside other planning and transport measures, to promote sustainable transport choices and reduce reliance on the car for work and other journeys
- 8** ...

Source: Office of the Deputy Prime Minister (2001)



**9.2.2.3** These policies sought to concentrate the construction of new dwellings and of new retail and office floorspace onto previously developed (brownfield) land, mainly within the existing urban areas within which alternative modes could compete more effectively with car. We have demonstrated in earlier chapters that these land-use planning policies, when combined with the much more rapid national growth in population over the last decade than had occurred in earlier years, have together led to a major densification of population and of employment in many, though not all, of the major English cities.

**9.2.2.4** This switch in planning policy was precisely to improve the ability of alternative modes to compete with car. The types of urban locations where rail can best compete are those that have recently grown most rapidly in both jobs and population, so we have demonstrated that these external planning policy influences have strongly facilitated rail passenger growth since 1995, although it has not led to growth in bus usage other than within London.

**9.2.2.5** However, Chapter 10 below explains that recent changes in planning policy may greatly reduce through into the future what had previously been the positive impacts of land use planning policy on rail passenger demand growth.

### **9.2.3** Reduced accessibility by car in dense urban areas

**9.2.3.1** We have asserted in previous chapters that car accessibility within urban areas with dense concentrations of workplaces and/or residences has become increasingly less attractive and less available because of the increased densification in such centres. Here we explain in more detail the evidence that underpins this assertion.

**9.2.3.2** Within many dense urban areas in the UK, car has gradually been discouraged from competing effectively with public transport or with active modes. Based on the general absence of any commitments for new roads that would increase the number of road lanes within major inner cities, it has become clear that low-occupancy cars will be an inefficient use of their scarce road space during congested times of the day. Road lanes can potentially carry many more cyclists, bus or tram users per hour than they could in cars that maintain the low vehicle occupancy rates that are typical of commuters. However, in general, the policy of reallocation of road capacity away from motorists has tended to be introduced in a low key fashion rather than as a headline explicit policy measure.

**9.2.3.3** The Transport for London Roads Task Force (2013) indicated that the bus lane kilometres on the London network increased between 2000 and 2008 from 162 kms to 279 kms. TfL (2009) have assembled an inventory of information on past measures that may have led to reductions in physical road capacity including increases in bus lanes, numbers of traffic signal installations and junctions, and increases in the number of pedestrian phases added to these installations. They comment that

*"the moving-motor-vehicle capacity of the (London) network has been adjusted in favour of the people moving capacity" (Traffic Manager's Mid Year Report 2008/2009, TfL, 2009).*

**9.2.3.4** TfL (2011) estimated that the resulting rate of reduction in road network capacity that occurred gradually between 1993 and 2009 was around: 30% in central London; 15% in Inner London; and 5% in Outer London. It noted

*"However, the loss of highway capacity accelerated, in central London particularly, after the introduction of congestion charging. This may have been due to highway authorities taking advantage of the reduced traffic demand for road space, following the introduction of charging, to reallocate capacity to other beneficial uses." (p. 103, TfL, 2011)*

**9.2.3.5** Although the road capacity reductions in Inner and especially Outer London are limited in scale, they will by nature tend mainly to occur in and around those local centres of densest employment and/or residential activity so that their overall impact on the population as a whole will be much greater in scale.

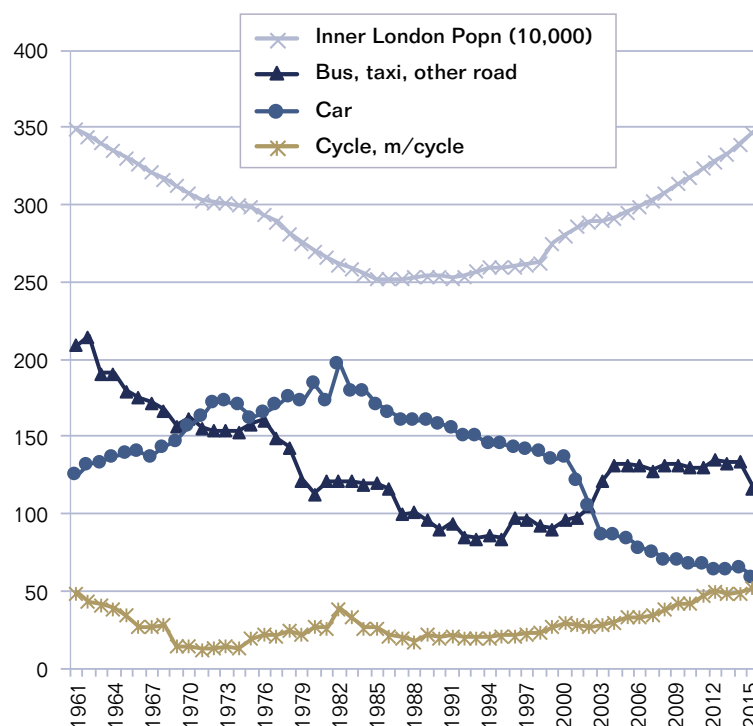
**9.2.3.6** The car trip suppression mechanism functions for densifying areas through a mixture of:

- increased congestion, uncertainty about delays and reduced car speeds, especially during the peak periods, resulting from the reallocation of road capacity away from car into bus and cycle lanes and into increased priority for pedestrians at crossings, which together have generated reductions in the overall urban road capacity available for cars;
- widespread real increases in parking charges;
- reduced on-street and reduced private non-residential supply of available car parking spaces, so generating reductions in parking capacity for commuters and/or local residents;
- forms of road pricing but only in very few cities as yet.

**9.2.3.7** We have already demonstrated in Figure 4 above for Central London that since the high point in AM peak car entrants of 192k in 1982 there has been a continuing decline in car entrants down to 58k in 2016. Despite the widely perceived importance of the congestion charge in London<sup>31</sup>, the AM peak car reduction in the year of its initial introduction in 2003 does not look very much greater in Figure 4 than the general level of reduction indicated in other prior or subsequent years. The decline in car traffic since 2000 has been associated with a resurgence of growth in both bus and cycle entrants.

**9.2.3.8** Clearly, the congestion charge is a minor rather than a major influence in generating this decline in Central London AM peak car entrants. Nor is the continuing decline in car entrants caused by a general lack of demand to enter Central London because Figure 4 indicates that the total number of AM peak entrants is now higher than at any time since before 1960. Nor is it due to shrinkage in the population in Inner London, quite the reverse, as illustrated by Figure 34. The period in the early 1980s with the highest rate of car entries coincided with the low point in the resident population of Inner London. The larger Inner London population on both sides of the 1980s population trough is associated with an increased use of bus, cycle and motor/cycle modes, rather than of cars. This indicates a surprising inverse relationship between population growth and the growth in AM peak car entrants to Central London.

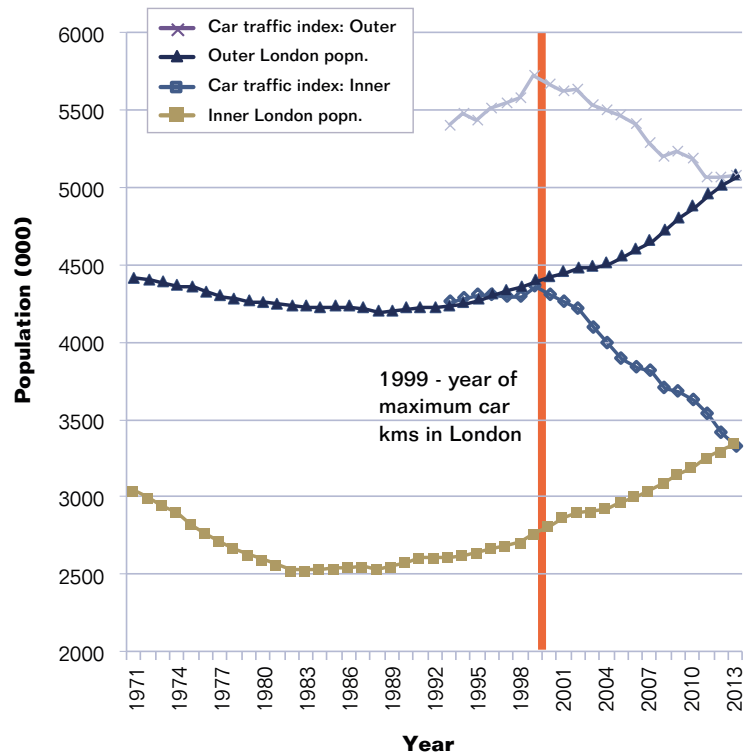
**Figure 34:** Persons (000s) entering central London by road modes in the AM peak, Inner London population (10,000s), 1961 to 2015.



(Source: CL Entrants - TfL; Population - Census and Mid-Year Estimates, ONS.)

**9.2.3.9** It is also of interest to note in Figure 34 that not alone have bus (inc. coach and taxi) entrants exceeded those by car since 2001 but also that the entrants on 2-wheeled vehicles were already by 2015 close to exceeding the number of car entries for the first time since the middle of the last century. Rather than focus just on the Central London crossings, Figure 35 broadens the picture by presenting indices since 1993 of the growth in car kilometres and of population throughout all of Inner and of Outer London. It again shows the pattern that once the population commenced to increase rapidly in an area, the car kilometres reduced rapidly in that area.

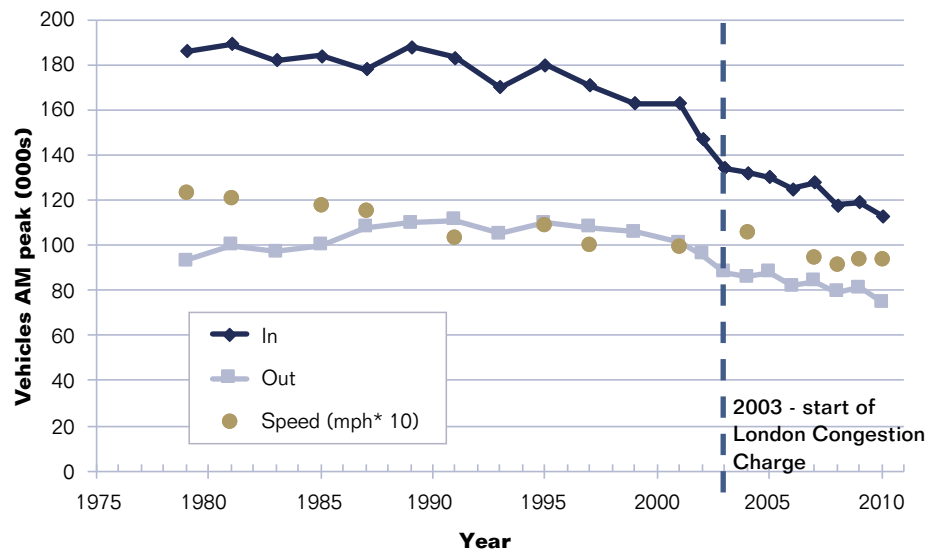
**Figure 35:** Population levels and car km growth indices for Inner and Outer London 1971 to 2013



(Source: Population – Mid-year Estimates ONS; Car kms -, AADF Database DfT)

**9.2.3.10** An explanation that is sometimes presented for this phenomenon is that the increase in population density generates a sufficient improvement in public transport provision to lure people away from car use. Although, undoubtedly this may have some such effect, it appears to be unlikely to be the main influencing factor in the major UK cities for the reasons that are now explained.

**Figure 36:** Long term trend in AM peak in- and outbound vehicles crossing the central London cordon and of AM peak vehicle speeds within the central area



(Source: vehicle crossings from TfL (2012); speeds from TfL periodic speed surveys)

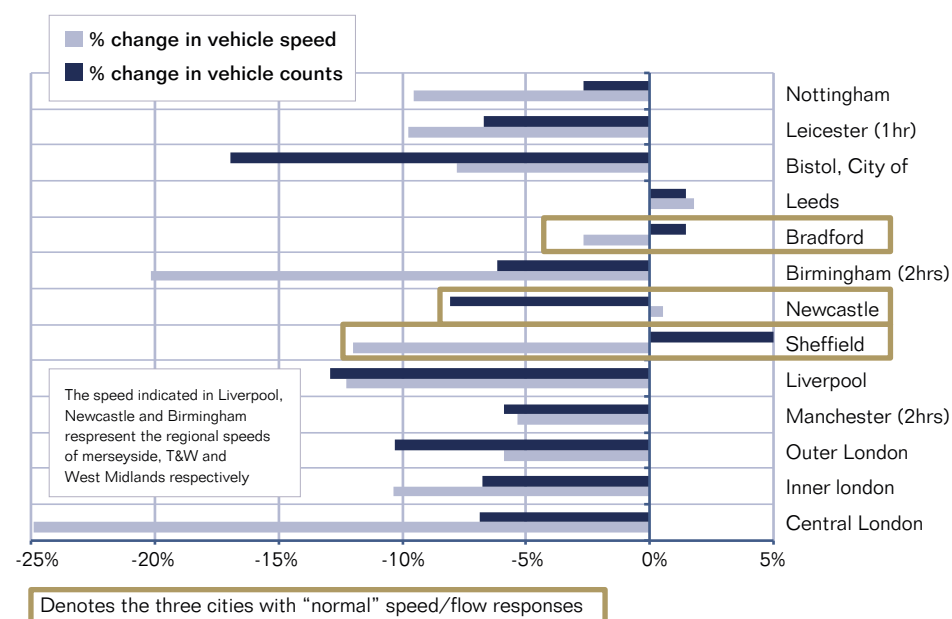
**9.2.3.11** Figure 36 focuses just on the central London cordon in the AM peak and shows the trend from 1997 to 2010 in the number of inbound and of outbound vehicles (i.e. not just cars). For the inbound traffic the relative stability in flow in the 1980s has been followed by a decline since 1989 of 40%, reducing from 188,000 to 113,000 vehicles per weekday peak in 2010. For the outbound traffic the decline started later in 1995 and has reduced by a lower rate of 32% down to 75,000 outbound vehicles per weekday peak in 2010.

**9.2.3.12** Despite these major reductions in vehicle movements, the average speed in the AM peak within the central area has reduced by 20% from 11.8 mph in 1985 to 9.4 mph in 2010. There was a brief increase in speed after the introduction of the congestion charge in 2003 but this was subsequently dissipated so that 2010 speeds in all periods of the day within the central area are lower than those prior to the introduction of the charge. This speed reduction occurs even though the number of vehicles travelling there is much reduced. This would appear to be contrary to the logic of the standard speed/flow response curve used widely for transport modelling.

**9.2.3.13** Moreover, this apparently counterintuitive relationship is not confined to London but is equally true of many other large British cities. This is demonstrated in the Evaluation of the Urban Congestion Programme for the largest 10 Urban Areas of England that was carried out by WSP (2010) for DfT. This examined the AM peak period traffic inbound to various urban centres<sup>32</sup>. The results indicated that private vehicle traffic was declining into many but not all of these centres. In urban centres where medium to large percentage reductions to inbound vehicle traffic have been observed, outbound traffic generally has declined less or has increased. These include London, Merseyside, Bristol, Leicester, Nottingham and most of the city centres in Greater Manchester and the West Midlands.

**9.2.3.14** However in general, the reductions in peak inbound road traffic volumes have not been accompanied by the expected increase in vehicle speeds. On the contrary, speeds have been stable or have reduced, implying that congestion has increased. Figure 37 summarises the relationships for individual cities between changes in speeds and changes in traffic, highlighting the few situations in which the normal speed/flow response was observed.

**Figure 37: Relationship between changes in speed and traffic, by Urban Area**



(Source: Table 3.4, WSP (2010))

**9.2.3.15** WSP examined the potential sources for the reduction in AM peak inbound road traffic. They found evidence of peak spreading and of a considerable shift to rail-based modes and to walk/cycle. Bus also gained in some areas, notably London, but declined in most other major urban areas. It is likely that parking policy will also have played some role in reducing the demand for car commuting to the city centres through a combination of increases in the cost and reductions in the availability of long-stay city centre car parking.



- 9.2.3.16** Nevertheless, the observed widespread reductions in vehicle speeds that are coupled with reductions in vehicle traffic must imply that it is the reductions in effective road capacity that have been the major determinant of the reduction in inbound AM peak traffic to these Urban Areas. If motorists had been lured away from their cars by other mechanisms then the resulting road speeds would have increased, not reduced. WSP concluded that “that reduced traffic in the Urban Areas owes more to reductions in supply than to reductions in demand” (WSP, 2010).
- 9.2.3.17** The reductions in urban road capacity have the strongest impact on the number of car movements. The vans and lorries that enter dense urban areas are almost invariably entering to carry out some service or delivery activity within these areas. These activities normally could only be carried out by road modes so there is only very limited scope for switching away from the use of vans and lorries. Yes there has been some growth in cycle courier activity in city centres, but LGV traffic has still continued to grow strongly in cities despite the falls in overall traffic there. Because it is easier for most private motorists to switch from car trips to central areas, than for LGV trips to switch mode or destination, the bulk of the traffic decline in response to capacity reductions is observed to be for car rather than for other vehicle types.
- 9.2.3.18** Overall, those cities where road speeds plus car traffic have reduced tend to be those which have been growing more rapidly in population and in employment. In these economically dynamic UK cities, road congestion due to lack of road capacity is a major cause of growth in demand for non-car modes. The transfer of road capacity from car to alternative modes both hinders car and helps the alternative modes<sup>33</sup>. However, despite the increased allocations of bus lanes within these cities, their net impact may be more than offset by the increased road congestion faced by buses for the greater parts of their routes that do not have bus lanes available.
- 9.2.3.19** For instance, just after the London Congestion Charge was introduced in 2003 there was indeed a short-term boost for bus speed to 11.6 kms/hr within the Central Charged Zone. This in turn achieved higher bus patronage levels. However, the average bus speed gradually declined to 9.8 kms/hr in 2014. This bus speed is 10% lower than that experienced in 2002, prior to the introduction of charging (TfL, 2015). From 2002 onwards at least, bus speeds have continued to decline gradually across most areas of London (TfL, 2015 and 2017).
- 9.2.3.20** Accordingly, the net impact of the reductions in road capacity in fast growing dense urban areas is likely to act disproportionately to support rail (or LU and LRT) passenger growth, as well as the growth in cycling, though cycling competes mainly over short distances and so is not in direct competition with rail.

#### **9.2.4** Impacts of company car taxation changes

**9.2.4.1** The ITC's 'On The Move' report by Le Vine and Jones (2012) used the NTS to examine the major reduction in the rate of company car ownership, particularly from 2000/2 to 2005/7, in response to the reduction in its hitherto favourable taxation. They showed that this reduction was mainly focused on professionals (-60%) and on employers/managers (-25%), the two categories with by far the highest rates of company car ownership. These groups also showed the sharpest decline in annual company car mileage; and both ownership and mileage reductions were greatest in the London, Eastern and South East regions.

**9.2.4.2** The study found that men living outside London but travelling into London regularly for work-related purposes, showed the highest levels and rates of growth in rail use and corresponding reductions in car use. In particular, between 1995/7 and 2005/7:

- Company car mileage for commuting purposes dropped on average by 1,208 miles (67%), while rail commuting mileage increased by 1,285 miles – suggesting a complete substitution between the two modes;
- Company car mileage for business purposes fell by 2,833 miles (a drop of over 70%), and increased on average on rail by only 614 miles, indicating only a partial transfer; and
- Company car mileage for 'all other' purposes fell by 931 miles (61%) but did not correspond with any substantial increase in rail mileage.

**9.2.4.3** The direct impact of these policies in the most recent decade is unlikely to be large. However, there is also a longer-term indirect result from the policy change that may continue to have some effect. The previous benefits from locating in out of town offices with high car accessibility that facilitated tax savings have greatly reduced for those people (company car owners in senior management) who are likely to be the decision makers relating to office locations. Once these decision makers no longer gain strong personal financial benefits from undertaking commuting and business travel by car, then alternative city centre employment locations could increase in relative attractiveness for them. If so, this would have knock-on amplified impacts also on all other less senior non-company car owning staff who would also be relocated to city centre offices and so would have improved options to travel by rail or by other non-car modes.



## **9.2.5** Productivity of on-board rail time

- 9.2.5.1** Various aspects relating to the productive use of time spent on board trains require consideration. Much of the actual work carried out by those in office-based occupations is done on computers, which may include reading reports, answering e-mails, analysing information, etc. With the widespread availability of laptops, tablets and smart phones it is increasingly feasible for many office workers to carry out some of their work duties while commuting to or from their workplace. Similar benefits will be available to those involved in senior administrative type work in other industry sectors. As seen above, these productivity beneficiaries happen to be the types of workers that are most likely to use rail for commuting and for business rail trips.
- 9.2.5.2** This productivity that is potentially available during rail travel implies that long commuting journey times may be less of a problem for those employed in office-type jobs than for those in other forms of employment for which there is little scope for working while in transit, though of course their travel time could be spent on recreational uses through social media, etc.
- 9.2.5.3** Lyons et al. (2007) in a survey of over 25,000 rail users in 2004 examined how passengers used their time on the train and found that more than half of business travellers and more than a quarter of commuters spent some of their journey time working/studying, with about a quarter of all travellers spending most of their time working/studying. They identified a substantial if not overwhelming incidence of a positive utility of travel time, especially for business travel but also for commuting and leisure travel. Susilo et al. (2012) used the 2010 NTS to examine similar effects and found similar incidences of working/studying by travellers.
- 9.2.5.4** Pawlak et al (2017) modelled the travel characteristics of a sample of almost 1000 business rail travellers of 2008, including their usage of Information and Communication Technologies (ICTs). They concluded that developments in ICT continue to be significant determinants of how travel time is spent and experienced.
- 9.2.5.5** This increased productivity of rail travel time may encourage longer commuting distances but perhaps working fewer days at the office, thus generating fewer but longer rail trips and reduced benefits from the purchase of season tickets. These productivity benefits are normally conditional on having a seat at which one can work, so that in the significant number of peak services where seats are far from guaranteed, this productivity gain may be of no more than sporadic benefit.
- 9.2.5.6** Having increased in recent years due to information technology improvements, this productivity advantage for rail may however reduce in the longer term. The expected rapid future expansion in the use of autonomous cars may ensure that on-board time in cars may ultimately become more productive than on rail, through avoiding the incidence of disruption from other passengers and through avoiding the unproductive time spent in accessing rail terminals.

## 9.2.6 Home working

**9.2.6.1** The growth in home working impacts on travel demand in various ways that mainly will reduce rail passenger demand. Firstly, the increasing number through time of those who work primarily at or from home are effectively removed from the overall commuter market thus making it smaller and so acting against all transport modes. However, much of this home working growth will be within office-type employment, other than SIC K: Finance, which is heavily office-based with just an 8% home working rate. Accordingly, the potential losses will be more concentrated in those SICs in which rail competes well. The 2011 Census table DC7602EW1a indicates that, other than understandably agriculture, the two other SICs with the largest proportion working at or from home are the SICs J: Information and communication (20%) and M: Professional activities (19%). However Chapter 4 has already demonstrated that these two SICs have been the greatest contributors to the growth in rail commuting between 2001 and 2011, so that continuing growth in home working could impact disproportionately on commuter rail demand. Some of this commuter trip loss might be offset by an increase in business trips by rail to meetings at clients' offices, perhaps on longer journeys generating higher revenues per trip for the rail providers.

**9.2.6.2** With the advent of improved technology, it may be expected that this trend towards home working for office-type jobs will continue to grow through into the future. The second set of impacts relates to the increase in the number of days working at home available to some of those working in more senior positions in some types of industries that have switched their office premises to hot-desking and related forms of organisation. In general, this market will again be concentrated heavily on the office-based SICs: J to O, within which rail competes most strongly. It will have a number of potential impacts:

- those workers who normally can spend at least two days working at home will avoid purchasing season tickets, settling instead to save money through daily fares;
- it may be feasible for some workers to adjust their hours so as to avoid peak rail services and the associated high fares;
- some may avail of the reduced number of trips to live further from the office, thus reducing their housing costs but increasing the rail cost per trip – this longer travel time may perhaps be used for work purposes as discussed in the previous section.

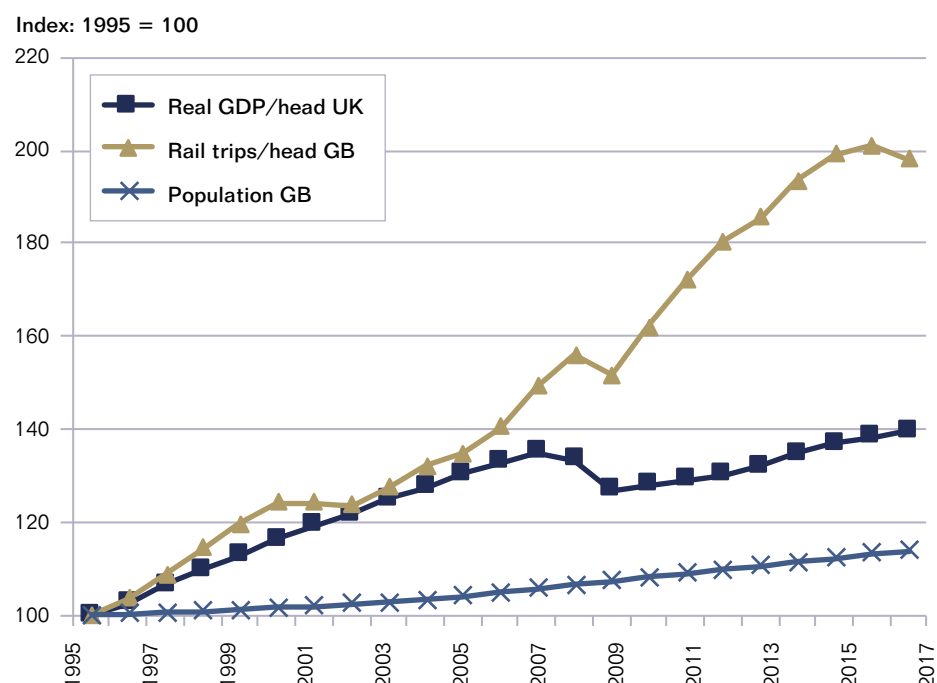
**9.2.6.3** Here again with the advent of improved technology, it may be expected that this trend for office-type jobs towards fewer rail commuter trips per worker per week will continue to grow through into the future, as discussed further below in Chapter 10.



## 9.2.7 Trends in population, GDP, fares and transport costs

**9.2.7.1** Figure 38 provides a comparative chart of indices of growth since 1995 in real GDP/capita for the UK and in rail passenger trips/capita and in population for Great Britain. It indicates that over the last 22 years, the growth in rail passenger trips per capita has been much greater than that for real GDP per capita. Up to the mid-2000s the growth rate in rail trips broadly mirrored that in real GDP. However, the stagnation in GDP/capita since 2007 has been accompanied by a continuing rapid rail passenger growth, other than a brief initial dip associated with the major drop in GDP after 2008, and a very recent dip that is not associated with either a drop in GDP or in population growth.

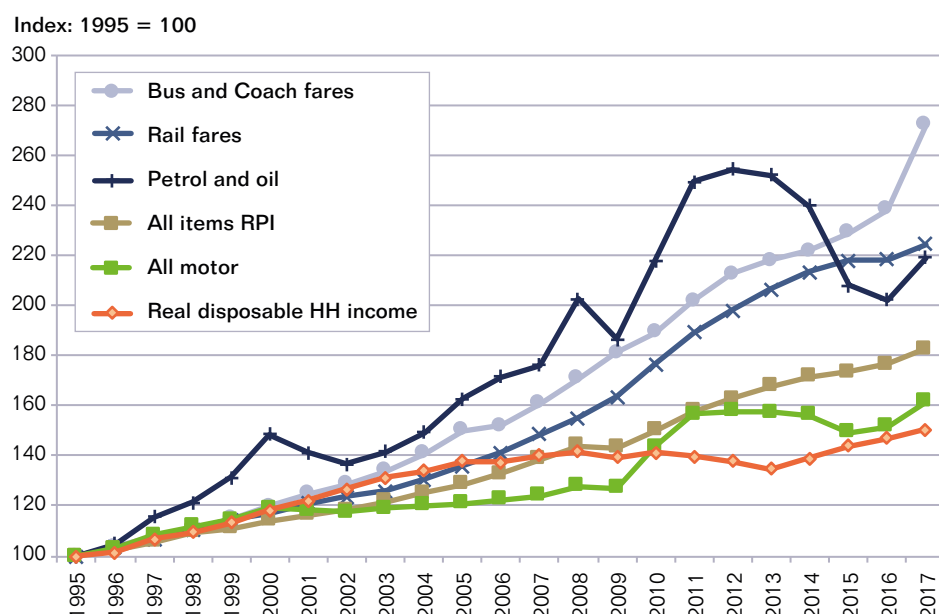
**Figure 38:** Indices of growth in UK GDP/capita and in rail trips/capita and population, GB, 1995 - 2017



Source: GDP - ONS<sup>34</sup>, population – MYEs, ONS, rail passenger trips - ORR

**9.2.7.2** This rapid rail passenger growth since 1995 has occurred despite a major growth in nominal rail fares of 125% from 1995 to 2017 (Figure 39) though this is lower than the 172% growth rate in bus and coach fares. Each of these fare increases is much greater than either the overall retail price index of 83% or the 62% growth in car overall operating costs during this 22-year period. Even the 119% growth in the narrower car fuel cost component index is now lower than the rail fare index, as a result of the major fuel price reductions that have occurred since 2013.

**Figure 39: Retail Price Indices, transport components, 1995 - 2017**



(Source: Table TSGB1308, DfT)

**9.2.7.3** Figure 39 also presents the trend in median real disposable household income<sup>35</sup>. It indicates continuing real income growth for the initial decade after rail privatisation, followed by no real income growth between 2008 and 2014 and an upturn since then. This contrasts with the rapid real growth in rail fares throughout the years.

Clearly there are other specific features particular to the rail mode, which must have counteracted these modal cost trends, and so would have generated an improvement over time in the competitive position of rail relative to the other modes. These features have been explored in previous chapters.



## 10 Assessment of past exogenous influences on rail demand

### Key Findings

- Analyses of agglomeration of workplaces suggest that industry sectors with jobs in dense urban areas generate the highest propensity for rail use and therefore rapid increases in employment in these sectors support the growth in rail use.
- The external planning policy initiative PPG13 which aimed to establish more sustainable patterns of economic growth has facilitated rail passenger growth by promoting the location of jobs and higher residential density in inner urban areas.
- The decline in the attractiveness of car use by various policy interventions such as congestion charges, parking charges, reductions in road space, and higher costs of ownership have supported growth in rail use.
- The growth in home working impacts on travel demand in various ways that mainly will reduce rail passenger demand.

## 10.1 Summary of influences on passenger rail demand

**10.1.1** Drawing together the various strands of research and analysis, Table 20 summarises our broad conclusions on the potential strength that each individual influence has had in encouraging “↑” or discouraging “↓” rail passenger growth over recent decades. It also lists the chapter and charts where the empirical evidence that led to these assumed strengths of influence is assessed.

**Table 20:** Potential strength of influences on passenger rail growth over time

Influence	1995-12	2013-17	2018-30	Figures/ Tables	Chapter
Real income growth	↑↑ (2008)	(2009) 0	0/↑	Fig. 38	9
Population growth	↑ (2005)	↑↑ (2006)	↑	Figs. 12 & 38	5, 9
Age related location trends	↑	↑	?	Figs. 16 & 17	5
Planning policy	↑↑	↑	↓?	Figs. 10 & 11, Box 3	4, 9
Housing construction	↑↑	↑	↓?	Figs. 14 & 15	5
Sectoral employment trends	↑↑↑	↑	↑	Fig. 30, Tables 5 & 19	4, 7, 9
Home working	↓	↓↓	↓↓	Fig. 27	9
Urban road car capacity	↑↑	↑	↑	Figs. 35, 36, 37	9
Company car tax policy	↑↑	↑	0	-	9
Car ownership	0	↑	↑?	Fig. 19	5
Money costs/km: rail v car	↑	↓↓	?	Fig. 39	9
Overall car use cost	↓	↓	↓	Fig. 39	9
Time productivity on rail	↑↑	↑↑	↑/0	-	9
Net sum of “↑” & “↓”	16	7	0/0		

**Key:** ↑ to ↑↑↑ denotes increasing strength of influence towards growth in rail passengers

↓ to ↓↓↓ denotes increasing strength of influence towards decline in rail passengers.

(20xx) indicates year in which the strength of effect changed significantly – if distant from 2012.



- 10.1.2** The estimated strength and direction of the influences in the early years generally has a solid evidence base as discussed within the indicated chapters and charts. The estimated strength for the most recent past is less certain in some cases because:
- the publication of the relevant data sources on which to carry out the underlying detailed analysis is often lagged by some time;
  - the brief length of the available time series may imply that short-term noise could still be masking longer-term significant trend changes.
- 10.1.3** The final row summarises the net effect by totalling the sum of the “↑” values, less the “↓” values. This result indicates a reduction in the overall score from 16 during the period ending approximately in 2012, down to 7 from 2013 onwards. Although this is a relatively coarse metric<sup>36</sup> and so it is not a substitute for suitably designed forecasting models, it does nevertheless indicate that recent circumstances have been considerably less favourable to encouraging rail growth than the circumstances typical of the earlier years following rail privatisation.
- 10.1.4** The 4th column presents some speculative estimates of the likely future influences on rail growth over the period 2018 to 2030. Much of this uncertainty is related to future government policy decisions on issues such as: car fuel duty, rail subsidy, immigration, land use planning regulations, etc. as discussed further below. The overall net score has slipped from 7 in the 2013-17 period, down to 0 through the short and the medium term future, though this future score is subject to major uncertainties.
- 10.1.5** Figure 1 has indicated that after a long period of almost continuous rail passenger trip growth starting in 1995, this has reversed to a downward trend since 2016 in the London and South East (L&SE) market and then more recently for the rest of Great Britain. Understanding the potential explanations of this break in trends is clearly important to policy makers and to rail operators.
- 10.1.6** Each of the various other track based modes within London (i.e. LU, DLR, Tram and Overground) likewise appears to exhibit a similar pattern to that for L&SE rail. Their passenger numbers grew rapidly for many years up to a peak in mid-2016 (See Figure 5) and have stabilised or declined since then. This ubiquity of the break in growth trends across these various track-based services suggests that some external non-transport related influences might be its primary cause. The rest of this chapter provides further detail on some of the recent developments that may already have contributed to encouraging this break in passenger rail growth trends.

## 10.2 Sectoral employment growth

**10.2.1** Based on the data published to date up to quarter 1, 2018 (see Figure 8 and Figure 9), job numbers have continued to grow up to the present. In London however, this annual employment growth rate was just 1.9%, which is well below the 3.1% to 5.2% range of annual job growth rates experienced there in recent years back to 2012. Furthermore, in London in the 12 months to quarter 1, 2018 there has been a downturn of 24k (-3%) in the workforce job numbers in the SIC: M - professionals, that has been responsible for much of the previous rail growth both for commuting and for business trip purposes. However, this decline has been more than offset by the total employment increase of 51k across the SICs J and N combined that also are rail intensive for commuting.

**10.2.2** An alternative indicator of the evolution of job numbers is provided by LinkedIn. It recently identified a net movement from the UK to overseas among professional workers (within the significant proportion of the professional workforce that are its members):

*"The UK continues to experience a net loss of overseas talent. The significant shift in the net outflows of overseas workers that had become evident in the first quarter of 2018 continued in May. The UK has become a net exporter of talent mainly as a result of the fall in migration into the country since the referendum on its membership of the European Union. This is in line with the latest ONS quarterly bulletin which has also indicated a significant decrease in the number of European Union citizens migrating to the UK in search of work over the last year. ...*

*London continues to see a net outflow of professional talent overseas. In May the capital lost workers abroad for the fourth month in a row. The city became a net exporter of talent to the EU27 in the first quarter of 2018. In the capital there has also been a consistent decline in the proportion of total new arrivals that have moved from countries, compared to those who have moved from other parts of the UK."* Workforce Report for the UK: July 2018, LinkedIn<sup>37</sup>.

**10.2.3** LinkedIn does still indicate in the year to May 2018 an overall (i.e. domestic plus international) net migration of jobs into London, though this total represents just 60% of the previous net in-migration measured in the year to October 2017, which indicates that the recent net international outflow is not being fully replaced by the net domestic inflow to London.

**10.2.4** However, it is too early as yet to confirm that these reductions in some of the components of London's workforce jobs growth are an established trend that will gather pace, rather than just a temporary blip. Accordingly, there is some tenuous evidence that recent workplace trends may have partially contributed to a reduction in rail growth trends.



## 10.3 Growth in working partially or fully at home

- 10.3.1** A stronger recent effect on rail commuter numbers is likely to be that related to the behavioural change of the growth in office workers who are working at home for a few days a week, as discussed in Chapter 9. The NTS-based analysis of commuter rail trip rates presented in Figure 27, provides evidence of the pattern of reduction that has been observed in the weekly rail trip rates of those commuting by rail. This is unlikely to be due to reductions in the proportion of workforce jobs that are full-time as this proportion has increased slightly for London from 2012 to 2018 (ONS, 2018).
- 10.3.2** Le Vine et al (2017) used the NTS to study working patterns across the week and concluded that there has been a large drop in the proportion of workers who travel to work six or more days per week. They also found a growing group who describe themselves as employed full-time, but who are observed to travel to work fewer than five days per week (up from 30% in 1988/92 to 35% in 2013/14), or who did not travel to work at all during their diary week (up from 12% to 17%). They found that those most likely to work at home occasionally were in SEGs: Professionals (16% in 2008) and Employers/managers (14%), which we have shown are groups with a well above average propensity for commuting by rail. They examined rail commuting in particular and found a downward trend in those using National Rail services for their commute five or more days per week, from 36% in 1988/92 to 30% in 2011/12. In summary, the NTS provides evidence that increased home-working for some days of the week has had a significant impact in reducing weekly commuter trips rates by rail.

## 10.4 Recent changes to the planning system

- 10.4.1** There was a major change in 2012 from the PPG13 policy framework, discussed above in Chapter 9. Policy switched within the 2012 National Planning Policy Framework (NPPF) from the heavily prescriptive pressure for densification associated with the PPG13 era, to adopt localism policies instead. In many locations these policies will have diminished the pressure for densification and so may have facilitated a reversal back to the earlier trends of decentralisation of jobs and population from inner city areas to the suburbs and beyond. The introduction of the Revised National Planning Policy Framework (RNPPF - Ministry of Housing, Communities & Local Government, 2018) in July 2018 has introduced a Housing Delivery test in an attempt to address the decline in new housing supply that was associated with the abolition of top-down regional controls on new housing requirements within the original 2012 NPPF. That original NPPF had in a variety of ways reduced the ability of local councils to effectively control the location of new residential and employment developments. The associated reduction ever since in the rate of housing construction (Figure 13) at a time of rapidly increasing population totals has unsurprisingly increased the pressure on local councils to now allow new housing construction in the locations where developers will find it to be most profitable, rather than where it will cause least environmental impact.

- 10.4.2** The previous legislation on maximum limits on the number of parking spaces in new developments was removed in 2012 and has now been changed to
- "Maximum parking standards for residential and non-residential development should only be set where there is a clear and compelling justification that they are necessary for managing the local road network, or for optimising the density of development in city and town centres and other locations that are well served by public transport."* (p.106, RNPPF)
- 10.4.3** The RNPPF takes account of the desirability of densification but within limited circumstances:
- "Where there is an existing or anticipated shortage of land for meeting identified housing needs, it is especially important that planning policies and decisions avoid homes being built at low densities, and ensure that developments make optimal use of the potential of each site."* (p.123, RNPPF)
- 10.4.4** Consequently, there is now considerable doubt regarding the extent to which urban densification policy will continue to have a significant impact in supporting rail demand growth.
- 10.4.5** It is less clear whether the radical changes to the planning system have as yet started to impact strongly in diminishing rail travel demand growth. The evidence assembled in Chapters 4 and 5 suggested a time lag of some years between the initial introductions of the PPG13 policy measures and their full effects on residential location patterns. It has suggested an even longer lag before their full impacts on job location patterns were in operation. Accordingly, similar time lags might be expected before the full effects of the recent planning policy reversals start to emerge and start to remove some of the major support mechanisms underpinning the past growth in rail passenger demand.

## 10.5 Comparative costs of rail and road

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- 10.5.1** One of the main influences on the recent reversal of rail growth is likely to have been the major change since 2013 (Figure 39) in the balance between: the trend in rail fares, which have continued their long-term growth at a rate well above inflation; and the trend in car fuel costs. Car fuel cost increases had generally exceeded rail fare indices from 1995 to 2013, in part due to fuel duty increases, but since then because of world oil price reductions they dropped substantially until recently. Because the last decade has seen minimal real growth in disposable income (Figure 39), the cumulative effect of the continuing annual real rail fare increases will have increased sensitivities to the balance between rail and car costs per kilometre. It remains to be seen whether the low value of the pound coupled with recent major increases in the price of crude oil might act to offset into the future the reversal of relative cost trends of the last few years.

## II Implications for modelling rail and other modes

### II.1 Adopting the analysis for forecasting the growth in rail commuting over time

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- 11.1.1** Although the scope of this study did not include the significant resources required to actually implement a forecasting model of rail passenger growth for England, it is helpful to provide a broad outline of the methodology by which this could potentially be implemented in the future. The forecasting model approach would be applied separately to each of the individual trip purposes and then all of these results could be combined together across the purposes. This is necessary because the statistical analyses have confirmed that the important segments and the rail trip rates are very different between the individual trip purposes. For simplicity, we concentrate here on summarising the approach for the commuting purpose, but a broadly similar and slightly simpler approach could be used for each of the other trip purposes.
- 11.1.2** The results from the statistical model have not indicated significant behavioural changes over time in rail commuter trip making, except for work status, so the default assumption is that the model parameters should remain constant through time, with just the population size and composition changing over time. For the full-time worker parameter, when forecasting it might be justified to assume additional reductions in its influence over time. A broader discussion was provided above in Chapters 9 and 10 of the recent observed changes in working patterns towards greater numbers working at or from home for some or all of the week. This discussion could provide a basis for scenarios projecting into the future, various assumptions regarding changes in the proportions of part-time and full-time work and in the proportions of their days that are worked at home, without a commuting trip.
- 11.1.3** The rail demand growth over time arises both due to: growth in the overall population; and a change in the incidence of the segments within this population. To represent this changing situation it is necessary to adopt a population enumeration type approach that generates a synthetic population profile through time, in which all of the required key segmentation variables can be distinguished within the overall population for each forecast year. The rail trip model is then applied to each sub-population total to estimate the total commuter rail trips associated with that segment.
- 11.1.4** In the particular case of the commuter model, the size of the NTS rail sample has enabled some spatial differences between clusters to be distinguished but it is only for commuters to London that the sample size is large enough to provide robust results. Accordingly, a simpler fall back model estimation approach would be needed to cover spatial differentiation within the other parts of England for which the samples are smaller.

**11.1.5** For the other trip purposes, the NTS rail sample has not been large enough, nor does it provide detailed locations of trip destinations, to allow latent clusters similar to those for commuting to be examined. Nevertheless, it might be feasible to include some spatial differentiation within the model estimated for these other trip purposes. For the reasons highlighted above in Chapter 3 (Box 1), it is very important when forecasting to avoid misrepresenting effects due to changes in incidence, by implying that instead they represent changes in individual travel behaviour. This is why it is important to identify as many as possible of the relevant segmentation influences within each estimated trip purpose model.

**11.1.6** As stated at the outset, the focus of the research in this study lay mainly in examining those influences that are external to rail industry operations. Accordingly, the models estimated here for each of the individual trip purposes did not set out to include a number of important explanatory variables (e.g. rail fares, generalised journey times, performance, etc.) that are central to PDFH and to other rail models. Consequently, the models developed here would need to be extended and re-estimated to also include such influences, prior to being suitable for comprehensive rail forecasting purposes, analogous to PDFH.

## 11.2 Wider factors and their use in future rail forecasting

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**11.2.1** This report has explored the evidence on a wide range of factors that have significantly influenced the spatial and temporal pattern of growth in rail passenger demand over the last twenty years. However, at present the majority of these influences tend not to be well represented within many current forecasting models, whether for rail or for other modes. Accordingly, a set of broad recommendations is drawn up below for how transport models might be extended to enable them to provide an improved representation of the factors that have been found to be important in generating the growth of the rail passenger mode share across different types of areas and for different groups within the population.

**11.2.2** These recommendations do not seek to stipulate precisely which particular methodological extensions should specifically be included within each of the individual specialist sub-markets of transport modelling, such as:

- Elasticity based rail models (e.g. PDFH);
- Rail focussed network models (e.g. PLANET);
- Multi-modal models (e.g. LTS or NTM).

**11.2.3** Instead they explain the situations in which it will be important for certain behavioural response mechanisms to be convincingly represented in order to ensure that the responses of the model are realistic in the context both of baseline forecasts through to future years and for the appraisal of specific policy measures. In broad terms this implies that:

- as a minimal requirement, the models should explicitly include forecasting mechanisms that enable them to internalise the observed changes in trends that have already taken place – the effectiveness of these mechanisms could be tested by initially running the model thorough from a starting point that is set, say, 15 years back from the base year for which the model has been calibrated;



- the models ideally should contain an improved representation of the underlying drivers of travel demand patterns which would enable them to forecast in advance the likely future breaks in key travel demand trends – this is a challenging aim to confront as it would need to rely less on simple extrapolations into the future and would need to include a significantly wider and deeper understanding and representation of the set of forces influencing travel choices, particularly those forces that have been identified in previous chapters.

**11.2.4** To support these objectives the sections below explain in more detail the modelling extensions and mechanisms that would help to represent these influences effectively within models that estimate rail passenger demand.

## 11.3 Land use modelling and impacts of densification

**11.3.1** One clear message from the evidence presented above, is that land use policy measures, together with the land use patterns that they generate, do have a major impact on the scale of transport demand and on ability of individual modes to capture and cater for this demand. Back in the 1980s when all parts of the country exhibited broadly similar demographic and car ownership trends, though starting from quite different base positions, simple transport models that ignored land use effects may well have been sufficient. Even today, in those sub-regions that are without major dense urbanisations, the traditional car-only models may continue to perform acceptably.

**11.3.2** However, the body of evidence assembled in this study has demonstrated unequivocally that realistic modelling of modal transport demand, for the many rapidly growing, dense urban areas plus their surrounding commuter sub-regions, will require tools that explicitly represent a wider range of behavioural mechanisms than has previously been the norm.

**11.3.3** In turn, because such sub-regions generate a major proportion of overall rail passenger demand, the modelling of the rail sector needs to take active account of land use related features, such as:

- the densification of residences and the associated impacts on car ownership rates, on age-group patterns and on employment activity rates;
- the rates of growth, of agglomeration, of densification and of home working for the jobs within individual groups of SICs.

**11.3.4** There is now considerable uncertainty regarding whether recent planning policy changes might switch spatial growth patterns back towards the car oriented developments of the 1980s. Accordingly, it seems advisable that travel demand forecasts should include sensitivity test scenarios of the implications of: a continuation of recent trends towards densification; versus alternative scenarios of a more laissez faire planning approach that could lead to a return to earlier trends of the counter-urbanisation of activities. The implications of this uncertainty over future residential and employment location trends should be considered explicitly within forecast scenarios of future rail traffic growth and for infrastructure investment assessment. Otherwise, these forecasts could be quite misleading and so might ultimately create expensive policy failures.

## 11.4 Factors influencing the competition between car and rail travel

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**11.4.1** The main influences on the switching of travel demand from car to rail or other modes will generally have a greater impact within dense urban areas than elsewhere. These influences include the following.

- The high price of and/or lack of residential car parking spaces in high density areas leads to a longer term decline in their household car ownership rates.
- At the national level (Le Vine and Jones, 2012), there now are lower levels of car ownership and of driver licences among the younger age cohort than in the previous decade, due to higher insurance costs, less disposable income, etc. Dense urban areas in recent years have attracted an above average proportion of their population from the 16-35 age group.
- The high price of and the lack of workplace car parking spaces in dense inner cities has led to a mode shift away from car use for commuting and business travel, with much of this transferring to rail. MVA (2005) estimated that there had been a reduction of 45% in the number of parking spaces for employees in central London over the five years to 2005.
- Improvements to rail supply, through better service reliability, new and/or more frequent services to cater for the increased density, have led to greater competition with car.
- Improvements in facilities for bus, walking and cycling, through more bus and cycle lanes, safe cycle routes and through increased pedestrianisation and priority for pedestrians at junctions, again have led to greater competition with car for short journeys. Often these policies have also aided rail demand over longer distance trips, through their indirect effect of reducing the road capacity for car, as discussed more fully in the next section.
- The observed decline in road speeds, which was generated by the reduction in effective road capacity in many rapidly densifying urban areas, has led to a reduced ability for car to compete there with other passenger modes.

**11.4.2** Transport demand models that include dense urban areas should provide a convincing representation of this interconnected set of influences in order to be able to forecast the future patterns of movements and to quantify the likely transport responses to transport or to land use policy measures.

## 11.5 Reductions in road capacity

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**11.5.1** The trend of major declines in road traffic illustrated in this report has not been accompanied by the corresponding increase in road speeds that would have been expected if the behavioural mechanism in operation was that improved PT services or higher car parking costs were what had attracted people out of their cars. In reality speeds throughout London, including within the congestion charged area, have in recent years been at their lowest ever long term levels. This implies that the observed reduction in traffic has been accompanied by (or more likely has been caused by) a corresponding reduction in road capacity and/or a reduction in free-flow speed.



- 11.5.2** There is need for better data and for improved research into measuring more precisely how the impacts of the wide range of bus, pedestrian and cycle support schemes and lanes within an urban area will impact on reducing the car-carrying capacity of the individual junctions and links within that area. Some of this may be achievable through developing further the reverse-engineering approach that was adopted to measure road capacity reductions across areas of London (TfL, 2011).
- 11.5.3** One of the other reasons why the maximum number of vehicles carried on many congested links has reduced through the years relates to average vehicle size. The average physical size of cars has grown substantially over the years, in line with increased incomes (“the Chelsea Tractor” effect). For LGV most of the rapid growth in its vehicle stock has been for the largest vehicles, while the total number of the smaller car-based vans has remained constant. Consideration should be given regarding whether the capacity factors for individual vehicle types that are used within the capacity restraint procedure need to be adjusted to take account of past and future large scale changes in average vehicle size, within congested urban areas.
- 11.5.4** To represent the major impact of reductions in road capacity on the use of car in dense urban areas, it is critically important that all forecasting models contain an effective link-based mechanism in the highway assignment that will meter vehicle demand to ensure that it does not exceed the available road capacity for each individual link. Note that this link capacity may in fact be determined by the junctions on the link rather than the link itself. This feature is available only in some modelling software packages, such as Saturn and MEPLAN, but its effects also need to be filtered back up the choice hierarchy of mode and destination choice and not just to occur simply within the road assignment stage only.
- 11.5.5** The metering mechanism should act to deflect excess traffic away from a link and onto other competing routes, modes, times of day and destinations, with the balance of adjustment between these alternatives being determined by the characteristics of the traveller and of the alternatives themselves. The effect of flow metering must pass up through the choice model hierarchy and be part of the overall model equilibration procedure, rather than having its effects only influencing the route assignment stage. In general, LGVs and HGVs are likely only to have scope for rerouting plus some limited possibilities for retiming due to the commercial imperatives for their journeys and to the absence of alternative modes. For car travellers, those on discretionary trip purposes are likely to have greater flexibility than those on non-discretionary purposes.
- 11.5.6** If this flow metering mechanism is not included then many of the trips that in reality will use cycle, walk or PT modes will be wrongly allocated to car and the model will fail to forecast the past observed decline in car traffic. If instead the model is “calibrated” in a form that forces a reduction in car travel over time through use of the wrong behavioural mechanisms, its usage for policy testing will be severely compromised through this misrepresentation of a major behavioural mechanism.
- 11.5.7** For policy testing purposes, it is crucial that a model can distinguish realistically between: travellers being lured onto a mode by its attractive qualities; and travellers being forced onto that mode by virtue of lack of viable alternatives.

## 11.6 Capacity effects on rail

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- 11.6.1** Similar requirements to those for flow metering on road may arise with respect to rail and to London Underground overcrowding. On certain longer distance services, such as rail services to Paddington and to Kings Cross, the rail capacity in the peak periods is struggling to carry all of the demand, much less to provide seats for it, and there is no guarantee that peak ridership could grow significantly on some routes without major investment to increase their capacities. This implies that there should be an explicit representation of the metering effects of rail and Underground overcrowding when the future traffic demand approaches the maximum service capacity. The model should not effectively assume that all travellers always are carried, irrespective of service capacity. This metering mechanism is in addition to the representation of the increased disutility faced by passengers needing to stand on longer journeys, in situations where there is insufficient seating to cater for all travellers.
- 11.6.2** A peak spreading mechanism needs to be included explicitly as one of the responses to lack of capacity on road or rail modes. It will need to be designed with care as the greatest traffic peak is not always at the same hour across all cordons, directions, modes or vehicle types. The availability and preferences regarding options for travelling earlier or later will also depend on the trip purpose so that this purpose dimension will need to be maintained within the peak spreading model stage.

## 11.7 Summary of modelling recommendations

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- 11.7.1** The main recommendations for improvements to models are summarised in Box 4, together with a brief explanation of the need for each feature in the context of improving the modelling of rail demand.
- 11.7.2** Many of these improvements relate to mechanisms that have tended in the past to be absent from mainstream rail models. However, the main thrust of the research that has been compiled within this report is that the longer term pattern of demand for rail is at least as dependent on factors that lie outside the rail sector as it is on those within the rail sector. Moreover, from the viewpoint of assessing the impacts of specific policy measures, it is crucial to be able to distinguish which are the real driving forces behind observed changes in demand patterns. For example, it matters greatly whether: an observed increase in commuting patronage on the rail services to some rapidly growing employment centre arises simply because no other competing mode can currently provide adequate capacity to carry these extra commuters; or whether these commuters have been attracted to rail as a result of the inherently attractive features of its services. In the former case a future increase in capacity on other modes (e.g. new road building) would cause major reductions in rail demand, whereas in the latter case the loss to rail is likely to be much less severe.



**Box 4:** Summary of recommended enhancements to models to improve rail estimations

Segment **commuter travel** for generation, distribution and mode choice stages

- By the main SIC groups
  - Different employment growth trends over time
  - Different agglomeration and high density / city centre location propensities – suitability of rail V car
  - Different ability to work when on board train
- Consider reduced commuter trip rates / per week for full-time office workers by SIC
  - increased rates of home working 1 or 2 days/week
  - high rates of working at/from home + associated business trips

Segment **residential location** models by:

- Age of population/households – they face very different housing choices/ costs
- SIC groups for employed residents - in order to represent their accessibility to relevant job opportunities

Segment **workplace location** models by:

- SIC groups –they have radically different spatial location requirements

Segment **car ownership** models by:

- Residential density
  - Differences in costs and convenience of residential car parking
  - Differences in availability of suitable alternatives to the car mode
  - Range of facilities within a short distance from residence
- Disposable household income – after discounting housing costs
  - Probably implies segmentation by age group

Represent **road capacity** as a hard constraint, where relevant in dense urban areas:

- To ensure that LGV and HGV can displace cars within the assignment
- While feeding back this hard constraint to the mode and destination choice stages

Represent **rail/LU/metro service capacity** as a hard constraint, where relevant:

- While feeding back this hard constraint to the mode and destination choice stages

**11.5.3** Accordingly, there is a clear need when modelling to pay explicit attention to this wider set of influences in order to provide better longer term forecasts of rail passenger demand and of its responsiveness to policy measures than those forecasts achievable through simpler extrapolations based on a more limited set of influences.

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# Appendix I

## Standard Industrial Classification - SIC (2007) classes

To facilitate consistent comparisons over time it is necessary to maximise the consistency of the definitions of the Standard Industrial Classification (SIC) that have been used through time. The issues involved are now discussed.

The current SIC (2007) classification replaces the earlier SIC (2003), which in turn was a minor update of the SIC 92 classification.

*"SIC (2003) had 17 sections and 62 divisions; SIC (2007) has 21 sections and 88 divisions. At the highest level of SIC some sections can be easily compared with the previous version of the classification. However, the introduction of some new concepts at the section level, e.g. the Information section or the grouping of activities linked to environment, makes easy overall comparison between SIC (2007) and its previous version impossible.*

*The table set out below presents the broad correspondence between the sections of SIC (2003) and SIC (2007). Please note that this table presents only the rough one-to-one correspondence between the sections: further additional details are necessary to establish the complete correspondence."* P.6 [http://doc.ukdataservice.ac.uk/doc/6727/mrdoc/pdf/sic\\_2007\\_user\\_guidance\\_and\\_explanatory\\_notes.pdf](http://doc.ukdataservice.ac.uk/doc/6727/mrdoc/pdf/sic_2007_user_guidance_and_explanatory_notes.pdf)

The overview of the changes introduced by ONS from the original 17 Sections in SIC 92 to the current 22 Sections in SIC (2007) are summarised in Table 20 Column 3 presents the aggregation of the SIC (2007) Section codes to a 14 code aggregate level that has been adopted in the analysis for this study so as to ensure the closest match back to the original SIC 92 codes. The aim is to ensure that the change in the details of the SIC classification that was introduced to the NTS dataset, should not lead to significant upheavals or inconsistencies in the travel analysis overtime. The final column specifies the grouped SIC (gSIC) aggregation that we have adopted for the modelling of the determinants of rail demand in Chapters 7 to 9.

**Table 21: Matching of SIC (2007) Sections to SIC (2003) Sections**

SIC (2003)	SIC (2007) - Sections	SIC2007 aggrgn.	gSIC
A Agriculture, hunting and forestry	A Agriculture, forestry and fishing	A	Ref
B Fishing		A	Ref
C Mining and quarrying	B Mining and quarrying	B	Ref
D Manufacturing	C Manufacturing	C	Ref

Cont...



...Cont

SIC (2003)	SIC (2007) - Sections	SIC 2007 aggrn.	gSIC
E Electricity, gas and water supply	D Electricity, gas, steam and air conditioning supply	D,E	Ref
	E Water supply, sewerage, waste management and remediation activities	D,E	Ref
F Construction	F Construction	F	Ref
G Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods	G Wholesale and retail trade; repair of motor vehicles and motor cycles	G	5
H Hotels and restaurants	I Accommodation and food service activities	I	Ref
I Transport, storage and communications	H Transport and storage	H	Ref
	J Information and communication	J,L,M,N	7
J Financial intermediation	K Financial and insurance activities	K	6
K Real estate, renting and business activities	L Real estate activities	J,L,M,N	7
	M Professional, scientific and technical activities	J,L,M,N	7
	N Administrative and support service technical activities	J,L,M,N	7
L Public administration and defence; compulsory social security	O Public administration and defence; compulsory social security	O	4
M Education	P Education	P	Ref
N Health and social work	Q Human health and social work activities	Q	Ref
O Other community, social and personal services activities	R Arts, entertainment and recreation	R,S,T,U	4
	S Other service activities	R,S,T,U	4
P Activities of private households as employers and undifferentiated production activities of private households	T Activities of households as employers; undifferentiated goods and services producing activities of households for own use	R,S,T,U	4
Q Extraterritorial organisations and bodies	U Activities of extraterritorial organisations and bodies	R,S,T,U	4

The largest definitional changes that cannot be undone simply through aggregation at the section level are:

- A new section J (Information and communication) has been created by extractions from the 2003 Sections: sections D (Manufacturing), I (Transport, storage and communications), K (Real estate, renting and business activities) and O (Other community, social and personal service activities).
- A new Section S (other service activities) includes: Repair of household goods that have been removed from section G; Computer repair activities that have been removed from 2003 section K,
- Substantial components of SIC (2003) section O (Other community, social and personal service activities) have been moved to SIC (2007) sections E (Water supply; sewerage, waste management and remediation activities) and J (Information and communication)

Accordingly, any longer time- series that span these two SIC definitions are likely to exhibit significant jumps for those SIC sections that are not reasonably consistently defined over time.

## Author Profiles

### Ian Williams

Ian is a mathematician/statistician by training with 47 years research, academic and consultancy experience in transport planning. He was one of the founding partners in 1978 of the land-use and transport planning consultancy ME&P and subsequently its Managing Director prior to its merger into the engineering consultancy WSP where he continued until 2011. He now acts as an independent consultant, combining this sporadically with land use and transport research back in the Architecture Department in Cambridge University, where his research career had started.

Ian's particular interest lies in research into understanding the many interlocking factors that influence the spatial and temporal evolution of demand for passenger and freight transport across all modes of transport. He has used this understanding to inform the design and implementation of freight and passenger forecasting models and their usage for policy analysis.

### Kaveh Jahanshahi

Kaveh has over 15 years of academic and consultancy experience in transport modelling and planning, with expertise in developing land use and transport models, data analysis, developing mathematical and statistical models and machine learning techniques. He is currently working partly at the Architecture Department in Cambridge University with teaching and research responsibilities, and partly as transport modelling team leader at DfT's Joint Air Quality Unit.

Kaveh's particular interest lies in research into understanding the interrelating factors influencing built form pattern and travel demand through using state of the art statistical and mathematical techniques. He also has extensive experience in applying these findings in design and development of spatial economy, land use, and travel demand models which are extensively used in informing policies.

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