A Spatial and Statistical Analysis of Commuting to Work in the UK: 1991, 2001 and 2011

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The candidate confirms that the work submitted is his own and that appropriate credit has been given where reference has been made to the work of others.

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Abstract

There is a relative lack of academic research related to spatial and sociodemographic variations in commuting propensities, patterns and behaviours. This is surprising given that commuting is carried out, often daily, by the vast majority of individuals in employment. The expenditure of time and money travelling to and from work on a daily basis means that commuting is often a relatively important part of many people's behaviour, with the nature of an individual's commute impacting upon their lifestyle, both directly and indirectly.

One of the key sources of information about commuting behaviour and patterns is the population census in the United Kingdom, through which travel to work characteristics are captured resulting in large and complex datasets that are disseminated by the census agencies as aggregate data (i.e. stocks of commuters based on where they live), interaction data (i.e. flows of commuters from where they live to where they work) and microdata (i.e. individual records of commuters).

Spatial and sociodemographic variations in commuting propensities, patterns and behaviours, although often recognised in an everyday sense, have not been the subject of much academic research and are far from fully understood. With this in mind, this research employs spatial and statistical methods on the three aforementioned datasets to analyse spatial and sociodemographic variations in commuting.

Geographical Information Systems have been used to visualise spatial variations in commuting propensities and patterns at both national and regional levels. Simple Linear Regression has been employed to examine the correlations and potential relationships between commuting indicators and important continuous socioeconomic variables. Binary Logistic Regression models have been calculated to demonstrate how commuting behaviours vary according to sex, age group, ethnic group and a host of other important categorical sociodemographic variables.

Amongst other findings, the thesis has found that there was an increase in the national commuting rate between 1991 and 2011, that there was a general increase in very long-distance commuting over the same 20 year period, that there was a general decrease in the prevalence of commuting by public transport between 1991 and 2001 but a general increase between 2001 and 2011 and that substantial changes in commuting propensities and patterns have occurred in the Leeds City Region. The findings from the research have been used to make some recommendations for implementation of policies by national, regional or local governments or any other organisations with a responsibility to supply and maintain transport networks.

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i. List of Tables

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iii. List of Abbreviations

BLR – Binary Logistic Regression

BME – Black and Minority Ethnic

CA – Council Area

CAS – Census Area Statistics

CBD – Central Business District

CeLSIUS – Centre for Longitudinal Study Information and User Support

CRAB – Census Research Access Board

EF – Ecological Fallacy

GDP – Gross Domestic Product

GROS – General Register Office for Scotland

H-CAMS – Household Controlled Access Microdata Samples

H-SAR – Household Sample of Anonymised Records

I-CAMS – Individual Controlled Access Microdata Samples

IE – Interaction Effect

I-SAR – Individual Sample of Anonymised Records

ITA – Integrated Transport Authority

LAD – Local Authority District

LAU – Local Administrative Unit

LB – London Borough

LCR – Leeds City Region

LEA – Local Education Authority

LGD – Local Government District

LLMA – Local Labour Market Area

LLTI – Limiting Long-Term Illness

LS – Longitudinal Study

LSCS – Longitudinal Studies Centre – Scotland

LSOA – Lower layer Super Output Area

LUZ – Larger Urban Zone

MAUP – Modifiable Areal Unit Problem

MD – Metropolitan District

MSOA – Middle layer Super Output Area

NILS-RSU – Northern Ireland Longitudinal Study Research Support Unit

NISRA – Northern Ireland Statistics and Research Agency

NMD – Non-Metropolitan District

NRS – National Records of Scotland

NSA – National Statistical Agency

NTS – National Transport Survey

OA – Output Area

ONS – Office for National Statistics

OPCS – Office of Population Censuses and Surveys

OR – Odds Ratio

PAR – Population At Risk

PAYD – Pay As You Drive

PE – Primary Effect

PLASC – Pupil Level Annual School Census

PTA – Passenger Transport Authority

PTALs – Public Transport Accessibility Levels

PTE – Passenger Transport Executive

SAM – Small Area Microdata

SAR – Samples of Anonymised Records

SCAM – Small Cell Adjustment Method

SDC – Statistical Disclosure Control

SLR – Simple Linear Regression

SMS – Special Migration Statistics

SOA – Super Output Area

SRS – Second Residence Statistics

SSS – Special Student Statistics

ST – Standard Table

STS – Special Travel Statistics

SWS – Special Workplace Statistics

TfL – Transport for London

TTWA – Travel To Work Area

UA – Unitary Authority

UK – United Kingdom

UKDS – United Kingdom Data Service

WICID – Web-Based Interface for Census Interaction Data

WPZ – Work Place Zone

1. Introduction

1.1 General Introduction: Background and Context

Commuting to work is an activity that is carried out relatively frequently, often daily, by individuals who are self-employed or in employment. It is, therefore, a relatively important part of many people's lives, with the nature of an individual's commute having an impact upon their behaviour, both directly and indirectly. Commuting to work is the movement of an individual from their place of residence to their workplace and back again. Homeworkers and people with no fixed workplaces are also classed as commuters by the Office for National Statistics (ONS), as both still have a place of residence and a workplace, albeit with individuals in the former category having both in the same approximate location, and individuals in the latter category having multiple workplaces.

Although the core concept of commuting is that of a routine activity, commuting to work often takes varying forms, occurs in diverse ways, and differs by inter-related sociodemographic and geographic factors. It is these sociodemographic and geographic variations in commuting propensities, patterns and behaviours that this research attempts to identify, analyse and understand.

Commuting plays an important role in modern economies, such as the United Kingdom (UK). At the macroeconomic level commuting can, through the daily movement of people for economic purposes, have an impact on levels of national, regional and local employment, unemployment, economic productivity and output (Owen, 2012). At the microeconomic level, individual commuting behaviour can have sizeable impacts on household activities, disposable income and spending power (BBC, 2012i).

In the USA, the economic turmoil following the 2008 global financial crisis has given rise to so-called 'extreme commuters' (USA Today, 2012); those people spending more time travelling than they do at work. This trend and the apparent link between commuting behaviour and economic well-being, with people travelling further in order to reap greater financial rewards, is disturbing when one learns that commuting is the daily activity that has the least positive effect on people's lives (Kahneman *et al*., 2004). It is also problematic from a public health or well-being perspective as many individuals may be 'forced' to commute long distances in order to maintain or improve their family's economic situation but, in doing so, may be sacrificing their own well-being and quality of life (Stutzer and Frey, 2008; Novaco *et al*., 1990).

Whilst the problems associated with commuting are often seen as issues that only pertain to the developed world, this is by no means the case; with major traffic congestion and associated atmospheric pollution problems now affecting cities in many less developed and developing countries (BBC, 2012ii, 2012iii). Mass commuting is therefore a global phenomenon and the global experience of commuting-related problems means that the improvement of transport networks is now no longer the reserve of wealthy western countries (BBC, 2012iv).

Commuting often makes headlines in the popular press. In 2001, there were nearly 26 million cars on the road in the UK, with 62% of workers in the UK travelling to work by car (BBC, 2003). In addition, in 2001, the mean number of cars per household in England and Wales was 1.1, while in 2011 the average had increased to 1.2 cars per household (The Guardian, 2012i). Although this increase in cars per household may not appear particularly large, this increase took place at the same time as the largest ten year rise in population recorded in England and Wales in recent decades, with the population increasing by 7% from 52.4 million in 2001 to 56.1 million in 2011 (ONS, 2012ix). The number of households in the UK grew equally fast over the same period, at 7%, to reach 26.3 million in 2011 (ONS, 2012x). When these population and household growth figures are taken into consideration, the slight increase in the number of cars per household over the inter-censal period begins to look more concerning as these figures suggest that there were 5 million more cars in the UK in 2011 than there were in 2001.

As the 2001 Census indicates, there were 24.2 million daily commuters in the UK, with the region of Greater London at the centre of this dense network (Gargiulo *et al*., 2012); in 2007, 23.8 million trips were made within, to and from Greater London every day on average (Transport for London, 2009). A substantial number of these trips will have been commutes, with London drawing commuters from all over southern England and from further afield. Birmingham, Bristol, Cardiff, Leeds, Manchester and Newcastle, as important regional centres (Tickell, 1993; 1996), are also key commuting nodes in England and Wales. Glasgow and Edinburgh are by far the most important cities in Scotland in terms of Gross Domestic Product (GDP) and commuting; Greater Glasgow alone accounts for over a fifth of Scotland's population (World Population Review, 2012) and Edinburgh is a key financial and political centre (Turok and Bailey, 2004), making them Scotland's regional centres and commuting nodes. Despite the importance of regional cities to the UK economy, and their extensive commuting patterns, the basis of their relatively recent revitalisation has been questioned, with Dutton (2003) suggesting that the economic resurgence of the UK's regional cities may have had more to do with the growing spatial influence of London than with actual improvements in the cities themselves.

1.2 Rationale

The importance of commuting in the UK in the 21st century means that analysis of commuting propensities, patterns and behaviours is required both from an academic perspective, in order to understand the processes, and from a practical perspective, in order to formulate evidence-based policy, as was called for by Adrian Smith in his 1996 presidential address to the Royal Statistical Society (Smith, 1996).

As detailed in Chapter 2, there is a relative paucity of past research addressing spatial and sociodemographic variations in commuting patterns across England and Wales, including variations in commuting rates, homeworking rates, commute distance, mode of transport and commuting self-containment. In addition, there is a shortage of past research addressing spatial and sociodemographic variations in commuting patterns at a fine spatial scale within a functional city region. Finally, given the scarcity of quantitative and qualitative research on commuting, there is also a relatively small amount of literature dealing with the national, regional and local policy implications of contemporary spatial and sociodemographic variations in commuting propensities, patterns and behaviours.

Given the limitations and deficiencies of past research, the research begins by considering how commuting patterns vary at Local Authority District (LAD) level across England and Wales in order to understand the geography of commuting. This involves examining overall commuting rates and modal splits. We then consider variations in commuting behaviour and patterns across a range of sociodemographic variables, including sex, age and ethnicity at national level. This involves examining sociodemographic variations in commute distance, commuting self-containment and public transport usage. Finally, we consider commuting propensities, patterns and behaviours in the Leeds City Region (LCR), with the spatial analysis at Middle Layer Super Output Area (MSOA) level, in order to understand spatial and sociodemographic variations in commuting within a functional city region.

In addition to the above rationale based on past research, the relatively recent availability of commuting data from the 2011 Census enables analysis of changes in spatial patterns of commuting in England and Wales between 2001 and 2011, sociodemographic commuting composition in England and Wales between 1991, 2001 and 2011, spatial and sociodemographic characteristics of travel to work and homeworking between 2001 and 2011 and spatial and sociodemographic characteristics of commuting in the LCR between 2001 and 2011.

The research reported in this thesis therefore seeks both to build upon previous research and to address the current gaps in the literature, while taking advantage of the new and important opportunities generated by the release of UK commuting data from the 2011 Census.

1.3 Research Questions

Given the above rationale, the research attempts to answer the following main research questions:

- What variations exist in commuting propensities and patterns in England and Wales, both spatially and between sociodemographic groups, and how did they change between 2001 and 2011?
- How do commute distance and commuting self-containment vary between different sociodemographic groups and how did these variations change between 1991, 2001 and 2011?
- How does mode of transport vary between different sociodemographic groups and how did these variations change between 1991 and 2011?
- How do commuting propensities and patterns vary spatially and sociodemographically in the LCR and how did they change between 2001 and 2011?
- What are the policy implications of the variations in and dynamics of commuting propensities, patterns and behaviours as shown by the analyses of the preceding questions?

1.4 Research Aims

In order to address the main research questions, the research is based on the following aims:

- To review the relevant research, data and methods.
- To analyse spatial and sociodemographic variations in commuting propensities, patterns and behaviours across England and Wales.
- To focus in more detail on analysis of commuting propensities, patterns and behaviours in the LCR.
- To present some policy recommendations based on the analyses.

1.5 Research Objectives

In order to fulfil the broad aims, the research is designed to achieve the following objectives:

- Review relevant extant academic literature and research on commuting in the UK.
- Outline and evaluate the data and spatial frameworks appropriate for the research.
- Outline and evaluate the methods appropriate for the research.
- Analyse the spatial variations in commuting propensities and patterns in England and Wales in 2001 and 2011.
- Analyse the spatial and sociodemographic variations in commute distance and commuting self-containment in England and Wales in 1991, 2001 and 2011.

- Analyse the spatial and sociodemographic variations in mode of transport usage in England and Wales in 1991, 2001 and 2011.
- Analyse the spatial and sociodemographic variations in commuting propensities and patterns in the LCR in 2001 and 2011.
- Produce a set of policy recommendations based on the findings of the literature review and data analyses that will be useful to the relevant national, regional and local authorities.

1.6 Spatial and Temporal Scope of Thesis

The research reported in this thesis focuses on three separate commuting datasets. Although these datasets are described in greater detail in Chapter 3, they are briefly outlined here in order to set the spatial and temporal scope of the thesis.

The first sets of data are drawn from the 2001 and 2011 Census aggregate data. Aggregate data provide ‘stocks’ of commuters, indicating, for instance, the number of individuals in a LAD who commute to work by mode of transport. The second data source is the 2001 and 2011 Special Workplace Statistics (SWS), also referred to as the interaction data or origin-destination data. The SWS contain ‘flows’ of commuters, indicating, for instance, the number of individuals in one LAD who commute to another LAD by mode of transport. The third data source is the Individual Samples of Anonymised Records (I-SARs) and the Small Area Microdata (SAM), referred to collectively as the census microdata. Microdata from the 1991, 2001 and 2011 censuses reveal the commuting characteristics of individual census respondents, indicating, for instance, whether or not and individual commutes within or beyond their LAD of residence. Analysis of the 1991 microdata has been included in order to provide context for the 2001 and 2011 analyses. It has been possible to use the microdata for 1991 because of their compatibility with the 2001 and 2011 microdata, whilst the aggregate and interaction data for 1991 are not readily consistent with the equivalent data from subsequent censuses and have, therefore, been excluded from the research.

Chapter 4 addresses the first research question. In Chapter 4, the aggregate data and microdata are used to analyse spatial and sociodemographic variations in commuting propensities and patterns across England and Wales and how they have changed over time. In Chapter 5, the microdata are used to examine sociodemographic variations in commute distance and commuting self-containment in England and Wales and how they changed between 1991, 2001 and 2011. Interaction data are also used in Chapter 5 to analyse spatial variations in commuting self-containment at the LAD level across England and Wales in 2001 and 2011. In Chapter 6, the microdata are employed to examine sociodemographic variations in mode of transport and commuting by public transport in England and Wales and how they changed between 1991, 2001 and 2011. The aggregate data are also used in Chapter 6 to analyse modal split at the national level and spatial variations in commuting by public transport at the LAD level across England and Wales in 2001 and 2011. Chapter 7 addresses the fourth research question. In Chapter 7, the aggregate data, interaction data and microdata are used to analyse spatial and sociodemographic variations in commuting propensities and patterns at the MSOA and LAD levels in the LCR and how they have changed over time. The fifth research question is addressed throughout the thesis, with each of the four analysis chapters having a section entitled 'Policy Implications and Conclusions'.

1.7 Thesis Structure

Given the spatial specifications and limitations of the three datasets, which have been outlined in Section 1.6 and are detailed further in Chapter 3, the data analysis chapters (Chapters 4, 5, 6 and 7) are only concerned with spatial patterns and sociodemographic characteristics of commuting in England and Wales, while the review chapters (Chapters 2 and 3) are concerned with the whole of the UK.

Chapter 2 addresses the first research objective by reviewing the relevant extant literature and UK transport policy. The chapter begins by outlining commuting definitions and concepts, with a detailed look at UK census questions related to commuting behaviour. It then moves on to outline commuting theory, asking who commutes to work, why they commute to work and examining the structure and agency debate and different attempts to model commuting. Importantly, this outlines some historical and contemporary commuting trends and patterns in the UK and introduces the sociodemographic variables used throughout the research by examining how commuting behaviour has been seen to vary by sex, age, ethnicity and a host of other sociodemographic variables. The chapter then looks at the relationship between commuting patterns and the definition of local labour market areas (LLMAs). Finally, Chapter 2 provides a brief overview of UK transport policy since the publication of the important Buchanan and Smeed Reports in the early 1960s.

Chapter 3 addresses the second and third research objectives. It contains a review of relevant data sources and an outline of the data, spatial frameworks and methods used in this research. The chapter begins with a review of commuting data from the UK censuses, outlining and reviewing the aggregate data, interaction data and microdata in detail. The chapter then explains some problematic issues with homeworking data that have been encountered during the research before outlining the computation of commuting indicators from the census datasets. The chapter provides an overview of the official census spatial frameworks used in this research before explaining the spatial and statistical methods used in this thesis, including choropleth mapping, binary logistic regression (BLR) and simple linear regression (SLR).

In Chapter 4, the 2001 and 2011 aggregate data and I-SARs are used to analyse sociodemographic and regional variations in commuting numbers and rates. 2001 and 2011 aggregate data on economic activity, employment, and age structure are then used to examine possible links between economic and demographic indicators and commuting rates, with SLR being employed to quantify the potential relationships. The same 2001 and 2011 datasets, with homeworkers excluded, are then used to examine regional and sociodemographic variations in travel to work numbers and rates, with BLR being used to model travel to work. SLR and BLR are defined in full in Chapter 3. The aggregate data are also used to examine LAD level variations in travel to work rates and how these changed over the decade. The same datasets are used again, but with homeworkers included, to examine regional and sociodemographic variations in homeworking numbers and rates, with BLR being used to model homeworking. The aggregate data are used to examine LAD level variations in homeworking rates and how these changed between 2001 and 2011. The chapter then exploits a data release oversight by the ONS, by using two sets of aggregate homeworking data to examine LAD level variations in working at home and working from home. This analysis was made possible by the ONS initially releasing 2011 mode of transport data using a homeworking classification that was not compatible with that used for the 2001 data and then being required to release 2011 mode of transport data using a classification that was compatible. Therefore, it became possible to subtract the first set of data from the second set of data to produce one set of data showing those commuters working ‘at home’ and one set of data showing those commuters working ‘from home’. This is explained in more detail in Chapter 3. Finally in Chapter 4, the 2001 and 2011 aggregate data are used to examine overall modal split in England and Wales and LAD level variations in modal split and how these changed over the decade.

In Chapter 5 microdata from three censuses, the 1991, 2001 and 2011 I-SARs, are employed to examine how the distribution of commuters across commute distance bands changed over the two decades. Sociodemographic and regional level variations in the distributions and changes are then examined. The same datasets (with commute distance recoded into a binary variable) are then used to analyse sociodemographic and regional variations in the prevalence of very long-distance commuting. BLR is used to model very long-distance commuting, before probabilities for very long-distance commuting are computed for combinations of the three most important sociodemographic variables. The 1991 and 2011 I-SARs and the 2001 SAM are used to analyse sociodemographic and regional variations in the prevalence of commuting self-containment, before BLR is used to model commuting self-containment. Finally in this chapter, the 2001 and 2011 SWS are applied to examine LAD level variations in commuting self-containment.

In Chapter 6 data from the 1991, 2001 and 2011 I-SARs are employed to examine how modal split changed over the two decades, with sociodemographic and regional variations in modal split also analysed. The same datasets (with mode of transport recoded into a binary variable) are then used to analyse sociodemographic and regional variations in the prevalence of commuting by public transport. BLR is used to model commuting by public transport, before probabilities for commuting by public transport are computed for combinations of the three most important sociodemographic variables. Finally, the 2001 and 2011 aggregate data are used to examine LAD level variations in commuting by public transport.

In Chapter 7 the 2001 and 2011 interaction data are employed to see how effective the LCR is as a representation of a Travel To Work Area (TTWA), with sociodemographic and LAD level variations in commuting self-containment being examined along with the decadal changes in these variations. The same datasets are then used to examine MSAO level variations and changes in commuting outflows, inflows and self-containment. SLR is again employed to examine the potential relationships between commuting outflows, inflows and self-containment and a host of economic and demographic indicators. The 2001 and 2011 I-SARs are used to examine sociodemographic variations in commuting rates, while the 2001 and 2011 aggregate data are applied to examine LAD level and MSOA level variations and changes in commuting, travel to work and homeworking rates. The 2001 and 2011 aggregate data are used to examine overall modal split in the LCR and MSOA level variations in modal split and how these changed over the decade. The 1991 and 2011 I-SARs and the 2001 SAM are used to examine sociodemographic and LAD level variations in the prevalence of commuting by public transport, with BLR used to model commuting by public transport. Finally in Chapter 7, the 2001 and 2011 aggregate data are used to analyse MSOA level variations and changes in the prevalence of commuting by public transport.

Chapter 8 provides a summary of the research data, techniques, methods and findings, an overview of policy recommendations, a discussion of the limitations of the research, some suggestions for further research and the final conclusions of the thesis.

2. Commuting to Work: Definitions, Concepts, Trends and Patterns

2.1 Introduction

Despite the importance of commuting to both national and local economies and to peoples' everyday lives, and notwithstanding the media attention given to the related problems that commuting creates, the concepts of commuting, the variations that exist in commuting propensities and patterns and the forces that underpin these patterns remain relatively under-researched. Therefore, this chapter serves two functions. First, it introduces some of the fundamental concepts of commuting, including the way that it is defined and measured, together with some underlying theoretical issues. Second, it presents a review of the interdisciplinary literature on commuting with particular emphasis on the geographical and social dimensions as manifest in spatial and sociodemographic patterns of commuting behaviour in the UK. Both functions serve to contextualise the research undertaken in the thesis and to identify gaps where further research is required. This chapter attempts to fill a substantial hole in the literature by providing a detailed review of the extant literature related to commuting. No such comprehensive review of the commuting-related literature has been published recently, so researchers have to rely on individual academic papers addressing their own specific concerns without a broad and inclusive overview of the wider topic.

This literature review is divided into broad sections relating to: the history of commuting patterns and how they have changed over time (Section 2.4); the geography of commuting patterns including both the spatial and sociodemographic elements (Section 2.5); and the subsequent policy debates that arise in particular from the problems caused by commuting and the utility of commuting data in defining LLMAs (Section 2.6). Section 2.7 provides a brief outline of relevant UK transport policy, while Section 2.8 provides some concluding remarks. However, we begin with a consideration in Section 2.2 of the ways in which commuting is defined and measured, before moving on to review what constitutes the theory that underpins commuting behaviour in Section 2.3.

2.2 Commuting Behaviour: Definitions and Concepts

2.2.1 Definitions: What is commuting?

According to the Oxford Dictionary (2012i), a commuter is "*a person who travels some distance to work on a regular basis*". This implies that a commuter must work in a geographically different location to where he or she lives and some research by Experian (2007) considers commuters to be individuals in employment who must travel out of their 'area' of usual residence to get to work. Since the use of spatial units to examine commuting patterns often 'hides' very short distance commutes where the individual's area of residence and work are the same, this approach may lead to an undercount of commuters. These short-distance moves might include the journey from the bedroom to the workspace for those who work at home (so-called 'homeworkers'). One key aspect of the Oxford Dictionary (2012ii) definition of commuting is that the travel to work must take place on a regular basis, although it does not define regular, implying that irregular or one-off trips are not seen as commutes even if carried out for employment purposes. However, there is a category of commuters who work from home and travel to and from work regularly but not necessarily to the same workplace destination, e.g. small businesses such as plumbers or decorators who serve customers living in different locations. It is already clear from this brief overview that no single universally accepted definition of commuting exists.

Commuting is often viewed as a stressful, costly and time-wasting part of life by many individuals (Ory *et al*., 2004). However, recent research has begun to criticise the default assumption of researchers that travel time is wasted time (Lyons and Urry, 2005), with researchers highlighting that activities that provide positive utility can be carried out while travelling (Mokhtarian and Salomon, 2001), and that the commute often serves as a useful transition period between work and home (Ellison, 1999). It should also be noted that people generally become more accepting of increased travel time as their incomes and mobility expectations increase (Stopher, 2004).

Indeed, the rise of long-distance commuting in the UK since the early 1990s would suggest that people in the UK are undertaking longer travel times justified by greater financial rewards and better employment opportunities. Between the 1991 Census and the mid-2000s, the number of commuters traveling more than 30 miles to work increased by a third to 800,000 as reported in The Guardian (2005). However, the rise of long-distance commuting has not been driven entirely by individuals wishing to maximise their utility (through higher earnings and better careers); it may also be due to a growing reluctance amongst employees to relocate when the location of their job changes (Green *et al*., 1999), which may be due to the high rates of homeownership in the UK compared to many other Western European countries (Earley, 2004). Either way, it appears that long-distance commuting is increasingly being seen as a substitute for individual and household migration when the circumstances of an individual or a family change, with commuting subsequently becoming an increasingly important part of people's lives in the UK.

However, commuting is not always a ready substitute for migration and the two are often considered in combination by those who seek to improve their employment opportunities and family life and to minimise their travel time. According to Green *et al.* (1999), if the commuting time between an individual's house and workplace is greater than that which they are prepared to tolerate, a 'dual location' household may be created, with an employee living relatively close to their workplace during the week and returning to their primary residence at weekends. Thus, this combination of commuting and migration replaces the relatively traditional phenomenon of long-distance daily commuting with long-distance travel on a weekly basis combined with short-distance daily commuting. In this instance, the long-distance journey is really equivalent to a temporary migration rather than a commuting trip.

The growth of complex and non-traditional commuting patterns is likely to be driven by both labour market changes and individual and family circumstances. Family circumstances, such as children being enrolled at a local school or the inability to finance a house move, may mean that when the location of an individual's job changes, there is no choice but to continue living in the current residence and change commuting behaviour to accommodate the change of employment location.

One could argue that the nature of seasonal work gives rise to seasonal commuting behaviour and patterns. The prevalence of seasonal commuting can be particularly high in areas heavily reliant on the tourist industry, where the incentive for people to migrate for employment opportunities is not permanent (Lundmark, 2006). In these circumstances the commuting and migration behaviour of employees is very similar to that of employees 'commuting' on a weekly basis, but over a longer period of time. Employees live close to their workplace during the season and return to their primary residence when the seasonal employment is no longer available. This behaviour is similar to that of higher education students who move from their parental domicile to term-time address three times a year and then commute from these locations (often halls of residence) to their places of study. The existence of seasonal commuting blurs the boundary between the study of commuting and migration behaviour patterns to such an extent that while some academics and researchers refer to 'seasonal commuting' (Lundmark, 2006), others refer to exactly the same phenomenon as 'seasonal migration' (MacDonald *et al*., 2012).

A further complication regarding the definition of commuting exists because commuting is not always seen as travel in the context of work. Commuting behaviours are often referred to by researchers and academics in a range of different contexts, including: children and schools (Cooper *et al*., 2003), students and universities (Delmelle and Delmelle, 2012) and shoppers and retail centres (Raith, 1996), for example.

This lack of consensus as to what constitutes commuting and how to differentiate between commuting and short-term migration means that an investigation of national commuting patterns can usefully begin with an understanding of the available data and an appreciation of how that data are collected, compiled and adjusted (see Chapter 4). This more pragmatic approach avoids the arguments and uncertainties of the conceptual definitions of commuting and focuses on what data are available to make an investigation possible.

2.2.2 Census questions about commuting

A more practical definition of commuting in the UK may be derived from the commuting data collected, compiled and published by the ONS in England and Wales, and the corresponding National Statistical Agencies (NSAs) in Scotland and Northern Ireland. Although the ONS does not provide an official 'glossary' definition of commuting, this can be inferred from the questions asked in the census and thus from the data collected on commuting at the start of each decade. Data from censuses are derived from the question on the census form relating to the place of work for each respondent's main job (Cole *et al.*, 2002).

However, whilst the census remains the most reliable and comprehensive source of information on commuting in the UK, providing counts of individual commuting stocks and commuting flows between origins and destinations (Stillwell and Duke-Williams, 2005), the definition and measurement of commuting is not the same across the whole of the UK. The NSAs ask different questions and use different methods to collect and compile the commuting data in their respective jurisdictions.

The ONS is responsible for organising and conducting the census in England and Wales and is, through the National Statistician, directly accountable to the UK Parliament (House of Commons, 2006). The two key questions asked by the ONS in 2011 in order to measure commuting behaviour in England and Wales were: (i) *"In your main job, what is the address of your workplace?"* and (ii) *"How do you usually travel to work?"*. It is important to note that the question asking for the address of a respondent's job uses the term 'main job', with the result that it does not capture the commuting behaviour associated with an individual's second job or other jobs, if they were to have more than one. This is important as there are a large number of people in the UK with multiple jobs and this number has remained remarkably constant over time (The Guardian, 2012ii; Simic and Sethi, 2002). It is also important to note that the question on mode of travel does not allow the respondent to give more than one mode, with the question failing to capture any information regarding multimodal commuting. This is important, as arguably nearly all commutes will be multimodal in nature, with walking frequently being required for the employee to get from their residence to their main mode of travel and then from this mode of travel to their workplace. In 2001, the ONS asked essentially the same questions, which contained the same inherent weaknesses.

The National Records of Scotland (NRS) is responsible for organising and conducting the census of households and individuals resident in Scotland, and is responsible to the Culture and External Affairs Minister of the Scottish Parliament (Scottish Parliament, 2012). The questions asked by the NRS in 2011 in order to measure commuting behaviour in Scotland were different from those asked by the ONS: (i) *"What address do you travel to for your main job or course of study (including school)?"* and (ii) *"How do you usually travel to your main place of work or* *study (including school)?"*. In 2001, the General Register Office for Scotland (GROS) asked exactly the same questions.

The Northern Ireland Statistics and Research Agency (NISRA) is responsible for organising and conducting the census in Northern Ireland and is responsible to the Northern Ireland Assembly through the Department of Finance and Personnel (Northern Ireland Statistics and Research Agency, 2010). The questions asked by the NISRA in 2011 in order to measure commuting behaviour in Northern Ireland were exactly the same as in England and Wales. In 2001, NISRA asked the questions: (i) *"What is the address of the place where you work in your main job?"* and (ii) *"How do you usually travel to work?"*.

This collection inconsistency in the UK stands in stark contrast to the situation in Canada, for example, where the same questions about place of work and mode of transport are asked throughout the country (Statistics Canada, 2010), making for a more straightforward investigation of national commuting patterns. However, despite the geopolitical variation in UK censuses, the commuting data that they provide are of more use when conducting an investigation of national commuting patterns than the US census, which asks no questions whatsoever that indicate a person's place of work or their mode of transport (US Census Bureau, 2010).

The Census Act 1920 provided the legal framework for conducting all subsequent censuses in England, Wales and Scotland (The National Archives, 2012i), with the first census to make enquiries from which commuting data could be derived being held in 1921. Despite the censuses of England and Wales and Scotland being under the same legal framework for almost a century, there have always been three separate censuses in the UK and census questions related to commuting in the UK have not remained consistent over time. Although every census since 1921 has asked questions pertaining to commuting, changes in the questions asked mean that a consistent analysis of the data over the time period 1921-2011 would not be straightforward.

The 1921 Census of England asked respondents to "*Give the address of each person's place of work"*. In 1931, respondents in England were given the more complex instruction: *"State Name, Business and Business Address of present employer (person, firm, company or public body) or, if out of work or wholly retired, of last employer"*. By 1951 (there being no 1941 Census due to World War II), the census of England reverted to a simpler instruction, asking the respondents to *"State the full address of each person's place of work"*. In 1961, the census of England asked a similarly simplified question, requiring respondents to *"State the full postal address of the place of work"*.

In 1969, Northern Ireland was added to the legal framework for conducting censuses by the Census Act (Northern Ireland) 1969 (The National Archives, 2012ii). Before the 1920 legislation, it was necessary to deal with the England and Wales, Scotland and Northern Ireland censuses separately (Hooker, 1894). However, with the passing of both the 1920 and 1969 Acts, all censuses across the UK were covered under the same legislation, despite the fact that separate censuses are still taken for the different nations of the UK. An additional intermediate census was taken in 1966, which was the first census to enquire about the mode of transport people used to travel to work (Vidler, 2001). However, it was the 1971 Census which was the first decadal census to enquire about mode of travel to work. The 1971 Census of households in England asked *"What is the full address of the person's place of work?"*. In addition, for the mode of transport question, the 1971 Census asked: *"What means of transport does the person normally use for the longest part, by distance, of the daily journey to work?"*.

The place of work questions asked by the 1981 and 1991 censuses of households in England and Wales asked respondents for the *"Full address and postcode of workplace"* and to *"Please write full address and postcode of workplace"*, respectively. The mode of transport question remained the same for both censuses, asking respondents to *"Please tick the appropriate box to show how the longest part, by distance, of the person's daily journey to work is normally made"*. The questions asked in the 2001 and 2011 censuses have already been identified and, as was the case with the 1981 and 1991 censuses, the mode of transport question stayed the same in both, asking "*How do you usually travel to work?"*. This mode of transport question was significantly simplified compared to the 1971, 1981 and 1991 mode of transport questions.

The changes in questions are important as they have implications as to what type and how much analysis of the data can be accurately carried out. Different questions will have elicited different responses, which in turn will have produced different data. However, the changes in questions are likely to have occurred due to the ONS' key objective of producing more accurate and robust statistics (ONS, 2012vii). Given this objective, questions will have changed in order to improve individual responses and the coverage of the census and therefore improve the overall reliability and representativeness of the data. In addition to changes in the census questions asked over time, changes in the imputation and adjustment methods used on the data by the different NSAs also mean that long time-series data comparisons are difficult to complete and interpret.

Further compounding the consistency and continuity problems as well as changes in the imputation and adjustment methods used on the data over time, the 1981 and 1991 SWS were derived from a 10% sample of the UK population. Although this means that no adjustment problems related to preserving confidentiality are encountered (Stillwell and Duke-Williams, 2000), it does mean that the data have issues related to representativeness. The sampling problems are particularly limiting when attempting time-series comparisons between the findings of the 1981, 1991, 2001 and 2011 censuses, as the 2001 and 2011 SWS are calculated using the whole England and Wales population. Moreover, detailed spatial analysis becomes impossible with relatively small sample sizes.

This synopsis of changes in questions over the 90 year period (1921-2011) shows that, overall, the questions about an individual's place of work have remained remarkably similar, with a tendency, if anything, for the question to become more specific over the years; the 2001 and 2011 censuses specifically asked for the address of the respondents' "main job". Conversely, the question related to the mode of transport used by an individual to get to work has been simplified since 1971. Whereas the 1971 Census asked the relatively complex question: *"What means of transport does the person normally use for the longest part, by distance, of the daily journey to work?"*, the 2001 and 2011 censuses asked the simplified question: *"How do you usually travel to work?"*, with no mention of distance or how often the commute takes place.

In addition to examining the questions asked by the NSAs, and how they have changed over time, it is also necessary to recognise that various methods are used by the NSAs to compute, compile, impute and adjust the raw data to generate the final set of census estimates. Thus, an analysis of commuting data across the UK is not straightforward, with the data for Scotland having substantial differences to the data for England and Wales and Northern Ireland.

Methodologically, it is important to note that the commute distances are calculated by the NSAs using the postcode centroids of the place of residence and place of employment of the respondent. The NSAs assume that the commute distance is equal to the Euclidean distance between the postcode centroid of an individual's place of residence and the postcode centroid of an individual's place of employment. This means that the commute distances produced by the NSAs are not the actual real-world commute distances of individuals. Given the complex and non-linear nature of the UK transport network, every individual's commute is likely to be noticeably different from the Euclidean distance between the two relevant postcodes, meaning that the census commuting data presents an oversimplified estimate of the actual situation.

Related to the above issue is that the NSAs ask about commute distance and not commute time. Ideally, the research would analyse variations in commute time, as opposed to variations in commute distance, due to both the ubiquity of the commute time concept in the general commuting population and that research has been done on the tolerability of different commute times (van Ham and Hooimeijer, 2009). Asking about an individual's commute time may be more relevant, given differences in it are likely to be more important than differences in commute distance to the average commuter. Without the aid of a computer, many commuters would struggle to correctly state the distance of their commute; this is not the case with time, as the vast majority of commuters are likely to know approximately how much time it takes them to get from home to work and *vice versa*. Asking about commute time would have the added advantage of giving some information about different levels of network congestion, as congestion affects commute time but not commute distance. However, collecting and analysing these data would be complicated as commute time varies by time of day, day of the week and seasonally. Overall, data constraints, with census data for commute distance being available and no official national-level data for commute time available in the UK, mean that this thesis only analyses commute distance.

In summary, the key weaknesses of the census data are three-fold: the current national variations in census questions in the UK mean that a cross-sectional analysis of current UK commuting patterns is confined to those commuting to work rather than study, the changes to the questions asked and the methods used over time mean that an analysis of commuting time-series data is not straightforward, and the census does not collect data on the actual distances travelled by commuters.

2.2.3 Other commuting definitions

Although the census is the main source of commuting data in the UK, and therefore the main source to consult in order to derive a definition of commuting, there are other sources of commuting data and other definitions of commuting which should be acknowledged.

In the UK, the Integrated Transport Authorities (ITAs), which are responsible for the Passenger Transport Executives (PTEs) and were previously called Passenger Transport Authorities (PTAs), collect their own information and data related to travel behaviour and patterns in their respective jurisdictions. Different ITAs cover most of the major metropolitan areas of the UK, including Strathclyde, Tyne and Wear, West Yorkshire, Merseyside and West Midlands, with Greater Manchester and Greater London being covered by Transport for Greater Manchester and Transport for London (TfL), respectively. Each ITA is free to define commuting as they see fit, as the Local Transport Act 2008 (The National Archives, 2008) gave the ITAs and their respective PTEs across the UK the power to govern, review and propose their own local travel arrangements in order to support the coherent planning and delivery of transport at the local level (Department for Transport, 2012).

Overall, it is clear that commuting is not a phenomenon that is universally fixed and agreed upon. Different individuals and institutions operating in different contexts have different understandings of what constitutes commuting and what it means. These differences must be borne in mind when analysing the relevant literature and data, as they could have important implications on the applicability of findings or data when they are used in a different context from that in which the research was originally conducted or data were originally collected.

2.2.4 Mode of transport, commute distance and homeworking

People travel to work using different modes of transport over different distances. The 2011 Census in England and Wales asked respondents how they travelled to work and to choose between the following options: ‘underground, metro, light rail, tram’; ‘train’; ‘bus, minibus, coach’; ‘taxi’; ‘motorcycle, scooter, moped’; ‘driving a car or van’; ‘passenger in a car or van’ or ‘bicycle’; or ‘on foot’. Despite respondents being able to tick an ‘other’ box, certain recent developments in commuting transport options are not identified explicitly. For example, the cable car is not included as an option, despite the development and opening of a cable car system in London in 2012, operating between the O^2 Arena in Greenwich and the Royal Docks in east London (BBC, 2012v). With the possibility that it will be included as part of the Oyster Travelcard system (BBC, 2012vi) and that it carried over 1.3 million people in its first year in operation (BBC, 2012vii), it is possible that it will become a more important aspect of the wider London transport network in the near future. In a similar vein, the 2011 Census mode of transport question did not include a river bus option. River buses are now an established part of London’s commuting network. In a city that is constantly addressing transport issues and congestion problems, commuting to work using river buses is starting to be seen as a more attractive option, with the London Mayor’s River Action Plan aiming to double passenger journeys by 2020 (Transport for London, 2013i). Indeed, commuting by river in London is seen as such a desirable alternative to using buses, the underground and cars that house-builders have started constructing new housing developments close to London’s river bus stops (Norwood, 2013). The aims of the London Mayor’s River Action Plan and the recent interest in constructing residential developments close to river bus stops mean that commuting by river bus is likely to become a more significant part of London’s commuting landscape over the coming years.

Although the 2011 Census question on transport mode allowed people to indicate that they work from home, it did not allow for the distinction between different types of home working such as teleworking, telecommuting or home-based business working. Even the use of data from other 2011 Census questions would only allow a distinction to be made between an individual working from home who is not self-employed and an individual working from home who is self-employed. This lack of distinction remains despite teleworking and telecommuting being around since the early 1980s (Martino and Wirth, 1990) and that 59% of UK businesses operate from home (Levie and Mason, 2009). The inability to differentiate between those individuals who are at home telecommuting and those individuals at home running their own home businesses is especially important when dealing with commuting issues from a spatial perspective due to both having distinctive geographies (Shen, 1999; Levie and Mason, 2009), with home-based businesses account for a substantial part of the economies of rural areas (Dwelly *et al*., 2006) and 12% of the rural workforce (Levie and Mason, 2009).

Despite distinguishing between different types of teleworking and telecommuting and between teleworking and home working being challenging for academics and researchers (Sullivan, 2003), the prevalence and importance of these practices in rural areas means that rural commuting and the rural economy cannot be fully understood without them. The production of these data also requires the application of definitions and criteria that are not vague or arbitrary (Sullivan, 1997) in order to ensure that what they reveal is reliable, consistent and accurate. Given that neither the data, nor the definitions that would be required to produce such data, are currently well developed, it is not possible to analyse these increasingly important parts of the UK economy and the commuting landscape as two distinct subsections of homeworking. In order to clearly differentiate between homeworking on the one hand and telecommuting and teleworking on the other, there would have to be an option on the census that allowed respondents who partake in these practices to distinguish between them.

Although the differences between a homeworker and a telecommuter or teleworker may seem rather academic, they have important implications for an investigation of commuting propensities and patterns in the UK. While a homeworker is defined as a person who works at home for pay, usually on a piecework basis (Dictionary.com, 2013i), the terms telecommuter and teleworker, which are noted to be interchangeable by the Oxford Dictionary (2013), refer to an individual who works at home using a computer terminal that is electronically linked to their place of employment (Dictionary.com, 2013ii).

The modern rise of telecommuting and teleworking across the UK arguably requires a reconceptualization of commuting in general. Whereas initial conceptualisations of telecommuting and teleworking focused on their potential for avoiding and eradicating traditional commuting from home to work (Huws *et al.*, 1990), this is no longer the case. Modern understandings of the relationship between telecommuting and traditional commuting behaviours tend to see telecommuting as a complementary form of commuting behaviour (Zhu, 2011) and not the antithesis of traditional commuting. Indeed, Zhu (2011) found that telecommuting has actually had the opposite effect to that which was expected and actually had a complementary effect on the number of commutes. The interrelated nature of telecommuting and traditional commuting means that it is now more important than ever to reconceptualise telecommuting as a distinctive form of commuting, and move away from the assumption that it is merely some invisible sub-section of home working. Ultimately, unlike a teleworker whose residence is different from their physical place of work, it is not possible for a homeworker to commute in any traditional sense as their place of residence is also their physical place of work.

The rise of new forms of commuting and working are not the only problems faced when investigating modern commuting patterns. There are issues and difficulties with identifying multi-modal commutes, distinguishing between long and short-distance commuting and separating non-daily commuting and short-term migration, as has been alluded to already.

The subtext accompanying the 2011 Census question *"How do you usually travel to work?"* instructed respondents to *"Tick the box for the longest part, by distance, of your usual journey to work"*. This instruction means that the 2011 Census did not identify or measure multi-modal commuting despite that fact that some people use more than one mode of travel to commute to work (Heinen and Bohte, 2014).

Despite the increasing focus of census questions over time, and the relatively detailed picture that the census data give of commuting in England and Wales, there is no consistent and widely accepted distinction between long-distance and short-distance commuting. The decision of how to define long-distance commuting is left to individual researchers. One definition of long-distance commuting is *"all employment in which the work is so isolated from the workers' homes that food and lodging accommodations are provided for them at the work site, and schedules are established whereby employees spend a fixed number of days working at the site, followed by a fixed number of days at home"* (Storey and Shrimpton, 1991, pp. 281). This definition is from an Australian mining context and cannot therefore be readily applied to the UK, though the travel of workers to oil rigs out in the North Sea may be a similar UK example. However, the definition does raise the key issue that commuting does not necessarily take place on a daily basis and this criterion could therefore be used to define long-distance commuting or, arguably, identify dual location households. The distinction between long-distance and short-distance commuting is an important one, not least because long-distance commuting can erode the traditional distinction between short-term mobility and long-term or permanent migration (Houghton, 1993). This means that the division between the traditionally separate fields of enquiry involving migration and commuting becomes less clear. This emerging 'grey area' is due to the rise in compromises being made at the individual level between long-distance commuting and migration, with many people choosing to live further from their place of work and commute further, sometimes, on a weekly, monthly or seasonal, rather than a daily, basis.

This rise of non-daily commuting is problematic in the sense that the census does not distinguish between daily, weekly, monthly or seasonal commuting. The traditional census question about main job and workplace does not allow for a distinction to be made in the data between individuals who commute between their home and their workplace on a daily basis and individuals who commute between their home and workplace on a weekly, monthly or seasonal basis, and reside at a different address during periods away from home. However, this weakness of the census has been partially addressed in the most recent census which asked people whether they spend time at a second address and, if they do, what the purpose of their second address is. The 2011 Census asked the question: *"Do you stay at another address for more than 30 days a* *year?"*, and then asked the respondent to indicate whether the address was in or outside the UK and to provide the address, and to answer the question: *"What is that address?*", giving the respondents the options of: (i) "*Armed forces base address"*, (ii) *"Another address when working away from home"*, (iii) *"Student's home address*", (iv) *"Student's term time address"*, (v) *"Another parent or guardian's address"*, (vi) *"Holiday home"* and (vii) *"Other"*. By providing the option of *"Another address when working away from home"*, the 2011 Census provides an indication of the number of people who use a second address for commuting purposes, and thus the number of employees who have commutes that do not fit with the traditional assumption of daily travel from a single place of residence to a single workplace.

2.2.5 The temporal dimension

The fuzziness between what constitutes commuting and migration leads to questions regarding the point at which individuals decide that daily commuting is not a sensible option and that a migration, whether it be temporary or permanent, is required. Although every individual's tolerance of commuting time and distance will be different, research has shown that individuals generally accept a commute of between 30 and 45 minutes (Getis, 1969; van Ommeren *et al*., 1997), with residential relocation being considered as people become resistant to increasing commute time. Interestingly, Champion *et al.* (2009) found that recent in-migrants are more likely to tolerate longer commutes than longer-term residents. These findings suggest that individuals are prepared both to migrate in order to shorten their commute, and then to shorten their commute at some point after a migration when they have become more settled in their new residential area. However, there is a lack of research and literature related to formally modelling commuting behaviour before and after residential changes (Clark *et al*., 2002).

Although the time budgets that determine the amount of time that individuals are prepared to spend commuting (Peck, 1989) have been very stable over time (Schafer, 2000), changes in the UK labour market have had an impact on the commuting times of different parts of the population. The increases in female participation in the labour market, the rise of flexible employment and changes in the locations of workplaces have all had an impact on commuting times (see below).

Changes in gender relations which led to an increase in female participation in the labour market (Scheiner and Kasper, 2003) mean that women are now far more likely to commute than in the past, with the number of households with two separate commutes now being equal to the number of one worker households (Clark *et al*., 2002). Whereas 70% of women in the 1950s did not participate in the labour market (Tzannatos, 1999) and therefore did not make commutes, or made commutes that were 0km if one considers them to have been homeworkers, in 2002 only 28% of women did not participate in the labour market as they were not in paid employment (Gutierrez-Domenech and Bell, 2004). This general change in the role of females from homemakers to employees means that the commuting patterns and behaviours of women have changed considerably since the middle of the twentieth century.

The rise of flexible employment practices (Dex and Scheibl, 2001) and the dissolution of traditional time-regimes (Le Bihan and Martin, 2004) may also have had an impact on the temporal characteristics of commuting. The workday is now less regimented than it was in the past, with family and childcare friendly working practices meaning that workday start and finish times and breaks in-between are more negotiable than previously (Budd and Mumford, 2005). These practices will have had an impact on commuting behaviour, as less regimented workplace start and finish times ultimately feed through into less regimented commuting schedules.

In addition to changes in employment practices, changes in residence and employment locations have also impacted on the temporal characteristics of commuting. Pucher and Lefevre (1996) suggest that the spreading out of land-use, or urban sprawl, has steadily increased the amount of time needed for individuals to reach employment locations, with this increased travel requirement largely offsetting concurrent increases in the speed of travel. Urban sprawl is due to the continued building of suburbs on greenfield sites at the rural-urban fringe and the rise of industrial estates and commercial centres outside and on the edges of urban areas. In this context, increased commute time is because, while in the past the majority of employees were commuting from inner-city areas that were close to the central industrial and commercial employment centres, an increased number of employees are now commuting from relatively distant suburbs to peripheral industrial estates and commercial centres.

Finally, changes in the temporal characteristics of commuting have not only been about the impact of changing employment practices and patterns or locations on commuting. Limtanakool *et al*. (2006) found that travel time considerations impact on the modal split of medium and long-distance journeys, while Bel (1997) found the same to be true for inter-city rail travel. Thus, changes in the temporal characteristics of commuting can have a direct impact on how people choose to commute, with individuals considering public transport a more attractive transport option if the bus, train or tram stop is close by. Cervero (1996) found this to be true for leisure trips as well as commuting journeys.

Overall, it is important to note that variations in commuting distance are accompanied by variations in commuting time. While the general pattern is for longer commuting distances to coincide with longer commuting times and shorter commuting distances to coincide with shorter commuting times, this is not always the case. For instance, an employee who commutes from the suburbs to a city centre on foot will take a relatively long time to commute a relatively short distance, while an employee who commutes from one city to another by train will take a relatively short time to commute a relatively long-distance. This variation is likely to be more noticeable when comparing the commutes of professional and managerial employees to the commutes of non-professional and non-managerial employees and comparing the commutes of employees who live and work in different cities to the commutes of employees who work in their local areas.

2.3 Commuting Theory: Explanations and Modelling

As commuting to work is a major part of the daily routine for most employees in most countries (Schaeffer *et al*., 1988), it is important to understand the theory behind the commuting process. It is particularly important to include a review of theory that explains commuting behaviour, as many academic studies in the field have been largely atheoretical (Kluger, 1998). An understanding of the theories relating to commuting behaviour is a prerequisite for subsequent analysis of the actual commuting patterns and propensities suggested by the literature and shown by the data.

2.3.1 Who commutes to work?

Given the earlier discussion of the definition of commuters and commuting, it is possible to start from the premise that only those individuals who are employed or self-employed have the potential to commute to work, although this begs the question of what constitutes employment. Many people have voluntary unpaid 'occupations' (Low *et al.*, 2007); these are not captured by the census statistics even though they likely involve some travel on a regular basis.

Despite commuting being a big part of many peoples' working lives (Benito and Oswald, 2000), commuting over different distances and for different time durations tends to be dominated by certain groups. Sociodemographically, owner occupiers and individuals with university degrees are far more likely to be commuters than private renters and the less well educated (Benito and Oswald, 2000), with long-distance commuting being particularly dominated by the well-educated. Spatially, time-consuming long-distance commuting in the UK tends to be concentrated in London and the South East, with employees in London now spending 75 minutes a day on average commuting to and from work, compared with 52.8 minutes in the rest of the UK (BBC, 2012viii).

2.3.2 Why do people commute? Choice or necessity?

A traditional view of the commute to work is that it is an obstacle and a source of discomfort that has to be endured in order for individuals living in residential areas to carry out work activities at workplace destinations. Indeed, it is argued that commuting by car, which is regarded by many as the most desirable mode of travel (Steg, 2005), exposes the individual to the negative effects of environmental pollution and the costs associated with traffic congestion (van Vugt and Meertens, 1995), particularly when travelling at peak hours.

However, there has been a relatively recent shift away from the traditional view that commuting is always a source of disutility. Despite conventional thinking holding that commuting is a stressful inconvenience (Redmond and Mokhtarian, 2001), Edmonson (1998) has argued that commuting itself can actually provide positive utility to those individuals involved. Mokhtarian and Salomon (2001) highlight that, in addition to the traditional assumption that the utility of commuting only consists of the utility of the activity at the destination, utility can also be derived from the enjoyment of the travel experience itself and activities that can be carried out while commuting (Richter, 1990; Shamir, 1991), such as conversing with fellow commuters, thinking about work for the day ahead and sometimes carrying out work.

Some people consider commuting to be a preferred alternative to residential migration. Commuting allows them to take advantage of both the best of rural, often village-based, living and the opportunities offered by employment in urban areas (Deshingkar and Anderson, 2004). Wealthy residents, specifically, may choose to commute rather than live close to their places of work in central city areas, in order to avoid the poor schools and high crime rates that are often associated with inner city suburbs and their relatively impoverished populations (Glaeser *et al*., 2000).

However, commuting is not always due to choice and preference. Many people cannot afford to live in a residential area close to where they work and must therefore commute from relatively poorer areas where housing is more affordable. This is particularly likely to be the case in large, popular and economically successful cities. London is a prime example, with its core employment areas of The City, The West End and Westminster being surrounded by prime, desirable and expensive residential areas, around Hyde Park and Regents Park, which are only available to the wealthiest individuals. This means that the majority of individuals who work in London's core employment areas have no choice but to commute substantial distances from more affordable areas further away.

2.3.3 Explaining commuting patterns

Despite the existence of unofficial labour markets (Low *et al.*, 2007), the majority of commuters are paid employees, therefore it is the spatial and aspatial structure of the local labour market that will be the driving force behind commuting propensities and patterns. From a spatial perspective, the division of the UK into LLMAs is caused by a dynamic spatial equilibrium (Topel, 1986), with differences in opportunities or wages between areas incentivising people to move to, and subsequently live and work in, certain local or regional labour markets. Therefore, each local labour market will have a unique spatial structure, with the places people live and the places people work defining the spatial extent of local labour market supply and demand. Spatially, the structure of local labour markets is also affected by the trade-off between commuting and housing costs, a trade-off that has been placed at the heart of models of residential location (Wingo, 1961; Muth, 1969).

From an aspatial perspective, labour markets are an economic phenomenon and can be local, regional, national or international in nature. In general terms, a labour market is formed through the interaction of employers and workers, with the demand for labour being provided by employers and the supply of labour being provided by workers. In classical economic theory (Smith, 1776; Ricardo, 1817; Mill, 1848) and neoclassical economic theory (Jevons, 1866; Menger, 1871; Walras, 1874), involuntary unemployment and underemployment cannot exist, since any unemployment must be due to disparities in wage rates (Hillier, 1991). It is these disparities that cause the perpetual ebb and flow of workers into and out of the labour market and between jobs within that market, with this movement of workers changing the wage rate such that competitive and profit-maximising firms hire workers (Mankiw, 2007) and thus clear the market.

In classical economic theory, it is assumed that labour markets are efficient, with supply and demand equilibrating instantly. However, more recent experience suggests that this is not always the case, especially in relation to youth unemployment (Barton, 2012). Therefore, although classical economics provides some important insights into the workings of the labour market, it is not an adequate framework from which to understand the actual functioning of local labour markets from a spatial perspective. The latter requires a more nuanced approach; one which recognises that market forces are not all-powerful and that the living and commuting patterns of workers and the hiring and firing behaviours of employers are not completely dictated by the interaction of labour supply and demand.

As commuting patterns are driven by the locations of residences and workplaces, the study of commuting is intrinsically linked to the study of urban form. The complex links that form the urban spatial structure are due to the processes of spatial interaction (Bourne, 1982), of which commuting is one. Thus, commuting behaviour influences urban form, which in turn influences commuting behaviour, creating a self-perpetuating cycle of movements and spatial interactions within a local labour market.

However, in some cases, the extent of the local labour market is predetermined by the arrangement of homes in close proximity to the workplace. In the nineteenth century, for example, many factory and mine owners created workers' villages that were built alongside factories and mines (Fullerton and Bullock, 1968), exemplifying how the commuting behaviour of employees was directly determined by their employer and, by extension, the work they were employed to do. In one particular instance, during a period of industrial cutbacks, workers at one factory in northern England were kept in employment or paid off depending on how far from the factory they lived, with those living furthest away being paid off first (Fullerton and

Bullock, 1968). Thus, the preferences of those employers with greatest influence over the local labour market directly affected the overall commuting patterns in the local area. Classic examples of this are the model villages of the nineteenth century like Saltaire, Bournville and Port Sunlight, which put into practice the ‘utopian’ ideals of town planning at the time, such as small population size, rural location, cheap housing and self-containment (Sutcliffe, 1990). This shows that, contrary to the assumptions of classical economics, the structure of a labour market can be planned and that structure can often impact directly on commuting behaviour.

Saltaire, which is now within the City of Bradford, was founded in 1851 by Sir Titus Salt, a prominent industrialist in the Yorkshire woollen industry, who built his large textile mill next to the Leeds-Liverpool Canal and the Airedale Railway Line. Salt built an entire town, including houses, a school and a park, for his workers in close proximity to the mill (Holroyd, 2000). Due to the radical combination of residences, places of employment and social services, Saltaire is seen as a significant milestone in nineteenth century urban planning (Cherry, 1979). Similarly, Bournville, which is now part of the West Midlands conurbation, was founded in 1893 by George Cadbury, who moved his cocoa and chocolate factory there in order to expand and have easy access to the Birmingham West Suburban Railway (Cherry, 1996). Cadbury planned a model village close to the factory for his workers to live in, complete with parks, recreation areas and pavilion. Port Sunlight, on the Wirral, was founded in 1888 by William and James Lever, who needed to accommodate over 3,000 workers for their new soap factory (Jeremy, 1991). The construction of Port Sunlight took place between 1899 and 1914, with the final development including a hospital, schools, a church and leisure facilities. Like Saltaire, Port Sunlight was seen as an important development in the field of urban planning, with its plans, and the underlying ideas, being widely reproduced and referred to in the garden city and town planning movements in the twentieth century (Freestone and Nichols, 2004).

These three model towns are classic examples of planned and employer-led labour markets. They stand in stark contrast to the traditional, organically developed and more common form of labour markets, whereby workplaces occupied certain areas of a city or region and residential areas occupied other parts of the city or region. Saltaire, Bournville and Port Sunlight are all regarded as having been successful developments, not only because they provided for all of the employment and residential needs of employees and their families, but many of their social and leisure needs too (Cherry, 1996). From a modern perspective, one could judge them to have been successful developments in that they reduced the need for employees to travel substantial distances to work and thus minimised the negative aspects of commuting. This successful aspect of the above examples is more apparent now, given the realisation that planning can reduce the need for individuals to travel (Diepen and Voogd, 2001) and the view that the removal or reduction of the necessity to travel should be the focus of new residential and commercial developments and of neighbourhood, city and regional plans (Pharoah, 1996), as it is the only way to both improve the environment and reduce congestion (Banister, 1999).

However, planned and integrated towns were not only popular in the Victorian era, the potential of planned and cohesive communities, with integrated residential areas, industrial zones, retail complexes and transport systems, was emphasised in the Fourth Memorandum national structure plan of The Netherlands in the 1990s (Geertman and Toppen, 1990). The main aim of the Fourth Memorandum was to reduce mobility by reducing the need for people to travel. This reduction in mobility was to be achieved by integrating land uses and building residential areas adjacent to built-up areas and within walking distance of railway stations.

Despite the modern appreciation of the social and economic benefits of planned communities (Golant, 1985), planned and employer-led developments and labour markets were not universally successful, with many being criticised for not meeting the high-minded and often utopian ideals that led to their development in the first place (Cherry, 1996).

The traditional and common form of labour markets, whereby workplaces and residences are located in different areas, often produces substantial movements of people commuting from home to work and back again. Despite the generally unplanned and self-regulating nature of these labour markets, and the commuting behaviour associated with them, they are determined by a certain level of self-containment and can therefore be seen as functional regions (Feldman *et al*., 2005), as will be discussed in more detail later in this chapter. The traditional form of labour markets, and thus commuting, is a product of the current economic system, with the process of suburbanisation and then gentrification being driven by the very nature of the capitalist system and temporary disequilibrium within it (Smith, 1982).

Although an understanding of urban form from a labour market perspective is important in the study of commuting patterns, an understanding of the urban form of industrial cities in and of itself is equally important. The current form of industrial cities is important as these cities constitute a large part of the urban system in the UK and in Europe and North America (Hall, 2006), and therefore a substantial part of commuting networks. Understanding industrial urban form is also important as the theories related to it shaped many ideas related to political ideology and town planning in the twentieth-century (Short, 1984).

Despite the rise of postmodernism in geography and other academic fields in the 1980s (Zukin, 1988), modern understandings of industrial form are still grounded in the twentieth-century structural theories of Burgess (1925), Hoyt (1939), Harris and Ullman (1945), and Mann (1965). The models of urban structure that were produced by these academics have dominated urban theory in the UK and North America and therefore have important implications for commuting theory.

The first major structural theory of urban form was the Concentric Zone Model, developed by Ernest Burgess and outlined by him in 1925 (Burgess, 1925). This was based on Chicago, and makes the key assumption that cities expand outwards from their Central Business District (CBD). Burgess envisioned a series of demographic changes whereby each inner zone 'invaded' the next outer zone and led to the development of a series of concentric zones around the CBD. Burgess referred to the zone immediately surrounding the CBD as the zone of transition, which contained businesses and light manufacturing, and the next area as the zone of working men's homes. Further out from the zone of working men's homes there was the residential zone and, furthest away from the CBD, the commuter zone. The Concentric Zone Model is a particularly important theory in the study of commuting, as the trade-off between better quality housing and commute time is a key aspect of the Burgess model (Rodrigue, 2013). The land-use patterns seen in the Concentric Zone Model are due to Burgess' assumption that those middle and higher-class individuals who are able and prepared to commute further will choose live on the edges of cities, while those working-class individuals who are not able to commute as far will be forced to live closer to the CBD.

One of the major theories underpinning the Concentric Zone Model is Bid Rent Theory which was developed by Alonso (1960) in order to explain variations in land use over an urban area. Bid Rent Theory posits that the demand for land across a city varies according to the distance that it is from the CBD, with the most expensive land being in and around the CBD and the cheapest land being located on the edges of the city. According to Bid Rent Theory, the most expensive land is in and around the CBD as commercial and industrial businesses wish to locate in this area for accessibility reasons, while the cheapest land is on the edges of the city as its level of accessibility is the lowest.

Although Bid Rent Theory can explain the emergence of concentric land-use zones, it does not explain the exact configuration the zones as suggested by Burgess' Concentric Zone Model. Instead it suggests that low-class housing would be located on the edge of the city, as this is the only land that poor individuals would be able to afford, while high-class housing would be located closer to the industrial zones and CBD as wealthy people would choose to live in the most accessible areas. Therefore, although Bid Rent Theory does give rise to an urban form defined by concentric land-use zones, these concentric land-use zones are in a different order to that suggested by the Concentric Zone Model and that observed in most modern industrial and post-industrial cities.

The second major structural theory of urban form was the Sector Model developed by Homer Hoyt in 1939 (Hoyt, 1939). Like Burgess, Hoyt based his Sector Model on Chicago, but placed a greater emphasis on the role of transport networks in shaping land-use patterns. Hoyt suggested that different types of land-use zones would develop outwards from the CBD along roads and railways and other transport infrastructure. The key aspect of Hoyt's model was that land-use remained similar along radii emanating from the CBD, with areas of industry and high, middle and low-class residences around the CBD developing outwards over time to form continuous strips of industry and high, middle and low-class residences stretching from the CBD to the edge of the city.

Hoyt's Sector Model was also partly based on the commuting behaviour of individuals. Hoyt assumed that high-class individuals would migrate outwards, and thus create high-class residential areas, along the fastest and most established lines of travel and transportation (Harris and Ullman, 1945). More broadly, in keeping with the rest of his theory, the spatial aspects of Hoyt's Sector Model suggest that those areas around the CBD with good commuting links develop outward, away from the CBD, into larger areas with equally good commuting links, while those areas around the CBD with poor commuting links develop outward from the CBD into larger areas with equally poor commuting links. Thus, as far as Hoyt's Sector Model is concerned, commuting behaviour affects urban form, which in turn affects commuting behaviour.

Another structural theory of urban form is the Multiple Nuclei Model developed by Chauncy Harris and Edward Ullman in 1945 (Harris and Ullman, 1945). The aim of the Multiple Nuclei Model was to be a more realistic model of urban form than Burgess' and Hoyt's models, at the expense of being more complicated. Harris and Ullman suggested that while the development of an original CBD may have been what caused surrounding urban development to occur, smaller CBDs develop over time near high-class residential areas to allow for shorter commutes from the high and middle-class residential areas, thus giving rise to an urban area made up of multiple nodes (nuclei).

It is clear from the above review that the Multiple Nuclei Model is an attempt to incorporate the impact that the changing structure of cites, that is the changing location of workplaces and residences, has on the commuting patterns of residents. This explicit inclusion of the impacts that changes in urban form have on commuting patterns and the impacts that commuting patterns have on urban form means that the Multiple Nuclei Model, like the Concentric Zone Model and Sector Model, is an important theoretical contribution that underpins commuting patterns.

In 1965, Peter Mann praised Hoyt's Sector Model and Harris' and Ullman's Multiple Nuclei Model, but particularly Burgess' Concentric Zone Model saying: *"Burgess's theory never did, and never was intended to, fit all cities exactly; it was a rough guide of a valuable sort, and with this we should be satisfied. There is no doubt that the Sector Theory adds more detailed knowledge and the Multiple Nuclei Theory enables us to go into further detail but, as a starting point for understanding, Burgess's scheme will do good work"* (Mann, 1965, pp. 95). Mann then went on to propose a model of the British city, drawing heavily on Burgess' previous work on Chicago.

Mann's model of the British city was very similar to Burgess', but took account of the prevailing westerly wind in the UK to suggest that middle class and lower middle class residents would choose to live on the western side of cities in order to avoid the air pollution emanating from the city centre and industrial zones. Conversely, Mann suggested that working class and municipal housing areas would be located to the north east, south east and east of the city in proximity to the industrial zones to the east of the city centre.

As with Burgess' Concentric Zone Model, Mann's model of the British city was underpinned by commuting practices. In both models, those individuals able to commute long-distances choose to do so in order to avoid the less desirable areas of cities, with the defining characteristic of both models; the segregation of the city along class and housing-type lines, being caused by these commuting practices.

Although all these initial structural theories of urban form have important implications for the study of commuting patterns, and urban areas more generally, they all suffer from the same major weakness. All were developed during an era in which cities in industrialised countries had relatively fast growing populations, and were experiencing a general migration of people away from city centres and inner cities towards the newly developing suburbs. Now, well into the twenty-first century, fast population growth and the migration of people from central and inner-city areas towards the suburbs are no longer stereotypical characteristics of many cities in industrialised countries, with the processes of suburbanisation and counter-urbanisation often reversing due to urban regeneration and re-urbanisation (Seo, 2002; Ogden and Hall, 2000).

Firstly, in post-1960 Europe, cities have been facing problems associated with economic and population decline (Turok and Mykhnenko, 2007). The era of fast growing urban populations has long since passed in industrialised countries. Secondly, there have been gentrification and 'back to the city' movements in many of the cities in industrialised countries, with an opposing current to suburbanisation being detected as early as the late 1960s (Helms, 2003). Gentrification and the back to the city movements (Laska and Spain, 2013) have been driven by the increasing economic and social costs of transport and travel, especially over long-distances. The back to the city movements of people and capital (Smith, 1979) have mainly been driven by property developers, who have recognised that many individuals wish to live relatively close to their places of work and who have discovered a new profit channel in the conversion and redevelopment of old industrial premises into city centre residential developments. Prime examples of property-led city centre regeneration in the UK include the London Docklands (Turok, 1992) and Leeds Waterfront (Unsworth and Smales, 2004). Concomitantly, the gentrification of certain inner-city areas has mainly been driven by individuals, with people moving to relatively desirable residential areas close to city centres and carrying out extensive home improvement works (Smith, 1996). When undertaken by many individuals and families over an extended period of time, the result is a substantial physical and economic improvement in the residential area in question, albeit with questions surrounding the overall desirability of such practices (Atkinson, 2004). Prime examples of gentrified inner-city areas in the UK include Notting Hill in West London (Hamnett, 2001), Islington and Camden in North London (Hamnett and Williams, 1980), Leith in Edinburgh (Doucet, 2009), and parts of Glasgow (McIntyre and McKee, 2008).

However, changes in commuting behaviour and patterns are not solely driven by the supply side; changes on the demand side also play a part. While the supply side refers to those changes in urban and economic structure that effect commuting behaviour and patterns by changing how employees supply their labour services, the demand side refers to those changes in urban and economic structure that effect commuting behaviour and patterns by changing the demand for labour supply.

Changes on the demand side, such as the perpetual location and relocation of different workplaces, influence commuting behaviour. With changes in commuting distance affecting labour supply choices (Gutiérrez-i-Puigarnau and van Ommeren, 2010), and therefore commuting behaviour, it is clear that changes in the location of workplaces will impact on commuting patterns. These forces of workplace location and relocation have been driven by the spatial division of labour (Massey, 1984) and, from a Marxist perspective, profit maximisation on the part of employers.

The general rise in real incomes over time leads to higher levels of car ownership (Dargay, 2007). Since 2000 there have been more households in the UK with two or more cars than with no cars (Department for Transport, 2011). This means that individuals and households with relatively easy access to car transport are now more common than individuals and households with no access to car transport. As such, it is likely that problems associated with high car usage and ownership, such as congestion and air pollution, will become more of a concern in the UK than problems associated with the lack of access to a car, such as lack of access to services and poorer employment prospects (Gurley and Bruce, 2005). It is this increase in the number of cars that has helped shape the key defining aspect of commuting journeys from a macro viewpoint, which is that they peak at certain times throughout the weekday, differentiating them from journeys made for shopping, social and leisure purposes (Vaughan, 1987). It is the peak-time nature of journeys to work that means they have such an impact on travel patterns (Liepmann, 1944). In 2010, 31% of commuting trips started at some point in the two hours between 7am and 9am (Department for Transport, 2011).

The commuting propensities and patterns associated with peak commuting are related to Downs' Law, which states that traffic congestion rises to meet maximum capacity of urban road networks during peak hours (Downs, 1962). Downs' Law is a variation of Parkinson's Law, which was first expounded in The Economist (1955) and states that work expands so as to fill the time available for its completion (Parkinson, 1960). Downs' law is based on three main assumptions: (i) that commuters seek to minimise the amount of time they spend travelling to and from work; (ii) that most commuters stick to the same mode of transport and the same route; and (iii) that commuters change their mode of transport and route when an event convinces them that the change will reduce their travel time. In addition to the above assumption, the operation of Downs' law relies on the existence of two distinct types of commuters, which Downs terms 'explorers' and 'sheep'. 'Explorers' are commuters who are willing to continually change their commuting behaviour in order to 'test' the best routes for commuting, while 'sheep' are commuters whose commuting behaviour is more fixed and ingrained. 'Sheep' are only prepared to change their commuting behaviour when they have received decisive information that suggests their commute would be improved by changing their route. These assumptions about the operation of the overall system and commuter behaviour interact to produce convergences in commuters' time and route schedules, which force the level of congestion on urban road networks up to the maximum capacity of the network during peak traffic periods (Downs, 1962).

As appealing as Downs' law is for understanding the behaviour of peak hour traffic congestion, and appreciating that Downs accepted that the findings of his model were only valid if its axioms remained accurate, it fails to grasp the full complexity of commuter behaviour. By dividing all commuters into one of two groups, the theory oversimplifies the real characteristics of commuters and their behaviours. In addition, the simple assumption that the findings of the 'explorers' will eventually filter through to the 'sheep', leading to general changes in commuting behaviour, is questionable.

Despite the above criticisms, Downs' peak-hour expressway congestion model has two important contemporary policy implications. The first is that, in large urban areas, it is impossible to build roads with a capacity large enough to carry rush-hour traffic at the speed and congestion levels considered optimal or adequate by policy makers or commuters. The second policy lesson is that the improvement of existing road networks or the construction of new roads, without the simultaneous improvement or development of public transport networks, may cause traffic congestion to get worse.

Overall, it is clear that urban structures and the transport networks that operate within and between them are under constant pressure to change. Urban structures and transport networks are forced to change as the dynamics of people's lifestyles and working practices affect the location of residential areas and industrial and commercial districts and how and when they travel between the two. Changes in commuting behaviour and transport networks in the UK will be dealt with in more detail in section 2.4.

2.3.4 Structure and Agency

Within human geography, and the social sciences in general, there is a longstanding debate between structure and agency as to which one is primarily responsible for human behaviour (Barker, 2005). Structure refers to those resilient patterns or arrangements that limit the opportunities open to individual human beings and which tend to order social life, whereas agency, on the other hand, refers to the ability of individual human beings to act independently and make their own individual free decisions (Barker, 2005; Sewell, 1992). The debate between structure and agency has become so significant within the social sciences that, as Hay and Wincott (1998) point out, all political, economic or ideological assertions must be analysed in terms of structure and agency if they are to be taken seriously.

The structure-agency debate, within the commuting context, arises as there are two different ways of trying to understand commuting, with the debate having impacts on the theoretical understandings of why, when and how people commute. The structure dimension suggests that commuting behaviour is strongly influenced by the structure of labour markets, which is to say that the location of residences, the location of workplaces and the transport networks that connect them strongly influence commuting behaviour. Conversely, the agency component suggests that individuals are ultimately in control of where they live and work and how they commute, with commuting behaviour subsequently being driven by the individual preferences and choices of individual employees. As indicated by the examples of nineteenth century model towns, structure plays a key role in determining commuting behaviour because it represents the location of the origins (homes) and destinations (workplaces) of those who commute. Both locations were determined by those who planned the towns. In contrast, human agency had a much more important role to play in the process of suburbanisation as workers had sufficient income to make their own decisions about where to live in relation to their place of work and to weigh up the benefits of alternative locations against the costs of commuting over particular distances using different routes or means of transport.

Despite the sound logic behind both of these approaches to understanding why, when and how people commute, it is clear that rarely are either structure or agency entirely dominant. While the structure perspective appreciates the importance of factors outside of the individual’s control in determining commuting behaviour, and the agency perspective takes account some individuals living in places and commuting in ways that seem irrational, neither perspective takes into account all of the structural constraints and individual decisions that explain commuting behaviour.

The structure-agency debate also has impacts for the policy debates related to commuting behaviour and patterns. The structure side of the debate suggests that government policy should aim to change the structure of the systems in which commuters operate and on which they rely, and thus impact on commuting behaviour indirectly as individual commuting behaviour changes in order to take account of the structural changes. However, the agency side of the debate suggests that government policy can work by focusing on changing the commuting behaviour of individual and groups of commuters, without changing the structure of the systems in which they operate and on which they rely.

The structure-agency debate has important implications for every aspect of an investigation into commuting, including modelling commuting behaviour at both the aggregate and individual level. From an academic and research perspective, an assessment of the merits and failures of different commuting and transport models, and the methods behind them, will ultimately be partly informed by which side of the structure-agency debate has the greatest influence.

2.3.5 Modelling commuting behaviour

An in-depth investigation of commuting patterns not only requires an appreciation of past research and literature, but also a recognition and comprehension of the different approaches to modelling commuting and transport flows in general. Ortuzar and Willumsen (2011, pp. 2) define a model as: *"a simplified representation of a part of the real world – the system of interest – which focuses on certain elements considered important from a particular point of view"*. This definition makes it clear that models are specific to the issues or problems being investigated and the viewpoint of the modeller. Whether or not a model should be used to further an investigation and, if so, what model should be used, are the key questions to be asked before carrying out any modelling exercise. Wilson (1974) confirms the need to identify the purpose behind any model-building exercise and to specify what techniques are available for model development. Even if the use of a model is the best course of action, there are a number of decisions that need to be made and a number of issues that need to be addressed. These decisions and issues impact on the final choice of which model is to be used.

The first major decision to be made is whether to use aggregate or disaggregate approaches. The key issue here is whether or not data related to the model's exogenous variables should be disaggregated or aggregated. A model representing more than one individual is normally referred to as an aggregate model whereas a model representing individual behaviour is referred to as a micro model whose exogenous data are more likely to be disaggregated. However, there are also issues related to cost, with the use of less detailed data often being preferable on cost grounds (Daly and Ortuzar, 1990). Although the decision to use aggregate or disaggregate approaches is important, the difference between the two systems is sometimes overstated. Williams and Ortuzar (1982) suggested that while disaggregate models were initially seen as a complete departure from previous modelling methods, it became apparent over time that they were more evolutionary than revolutionary in nature. In fact, in many cases, there are essentially no differences between the different aggregate and disaggregate model types (Daly, 1982).

The second decision is whether to employ a cross-sectional or time series model. A cross-sectional model will rely on data for one point or period. The census is a good example of a source of cross-sectional commuting data because it refers to data taken at one point at the start of each decade. Time series models require data such as annual flows occurring over consecutive years, although it is possible to make time series comparisons between censuses over a number of decades if the problems of inconsistency can be resolved. While the vast majority of transport studies up until the 1980s relied on cross-sectional data, it was realised that improvements to forecasting models could only be made if data on behaviour changes over time were used (Ortuzar and Willumsen, 2011).

Finally, there is the decision of whether to use revealed or stated preference techniques. Whereas revealed preference techniques rely on observed behaviour, stated preference techniques rely on the given responses to hypothetical choices and situations. Similar to the situation with the use of cross-sectional or time series data, the assumption until the 1980s was that transport models should be based on revealed preference data, with stated preference techniques for examining hypothetical transport choices taking hold at the end of the 1970s (Ortuzar and Willumsen, 2011).

In addition to the improvement and refinement of modelling techniques, much research, development and technological improvement over the years means that the processing power of computers is no longer as big an impediment as it used to be. However, the classic transport model has remained more or less unchanged since the 1960s (Ortuzar and Willumsen, 2011) and uses a zoning system, base-year data and future planning data to model travel patterns through four stages. First, the model generates a total number of trips and assigns them to different origin zones. Second, the model allocates the trips to different destination zones. Third, the model produces the modal split, allocating different trips to different transport modes. Finally, the model assigns each of the trips to their respective network, based on the transport mode used for each trip. Although this classic transport model is clearly not completely realistic, as it assumes that all transport decisions are taken using the same four step sequence, which is not necessarily the case (Williams, 1977), it has stood the test of time and is a good starting point for the development of more complex transport or commuting models. From a policy perspective it is necessary for models to be suitable for the institutional and decision-making context within which they are planned to operate. A model which is developed to operate in an institutional context that is characterised by a ‘substantive rationality’ approach to decision-making (Kay, 2010) is unlikely to be successful operating in an institutional context characterised by a ‘muddling through’ approach to decision-making (Lindblom, 1959), and *vice versa*.

Statistical and mathematical models have been proposed and calibrated for a range of transport applications (Kühlwein and Friedrich, 2000; Page, 2001); possibly the most famous model that is applicable to modelling commuting flows is the gravity model. This was first used by Casey (1955) to model town and regional catchment areas for shopping trips, and was derived from Newton’s gravitational law. The gravity model was specifically derived for interaction modelling at an aggregate level. As commuting flows are a form of interaction they are subject to the gravitational laws and principles associated with all flows between origins and destinations. Therefore, it is possible to use the gravity model to model aggregate commuting trip flows between residential origins and employment destinations.

In a commuting context, the gravity model asserts that the size of the flow of commuters between any origin area i and any destination area j, T_{ij}, is directly proportional to the size of the origin area, W_i, directly proportional to the size of the destination area, W_j, and inversely proportional to the distance between the origin area and the destination area, $1/d_{ij}$. The early gravity modellers in human geography proposed model formulations (Senior, 1979) as follows:

$$T_{ij} = W_i \, W_j \, d_{ij}^{-\beta} \qquad (2.1)$$

where the parameter on the inverse distance term (β), referred to as the distance decay parameter, was calibrated using log-linear regression methods, by transforming equation 2.1 into:

$$\log T_{ij} = \beta_0 + \beta_1 \log W_i + \beta_2 \log W_j - \beta_3 \log d_{ij} \qquad (2.2)$$

where β_0 is the intercept and the other β’s are regression parameters that define the nature of the relationship between the dependent commuting variable and the explanatory variables.

Although the gravity model has stood the test of time and is still widely used in academia and practice, it is not without weaknesses. As Senior (1979) notes, the gravity model has four main deficiencies. First, one must question the validity of deriving a social science model from a natural science model when the behaviour of agents may not necessarily depend on the structure of the system. Second, it only works at the aggregate level and says nothing about how aggregate interactions relate to individual interactions. Third, as indicated above it cannot accurately predict interactions which are inconsistent with the known constraints on their number. Finally, it is known to exaggerate the magnitude of interaction changes when opportunities for those interactions to change arise.

Given the weaknesses of the basic unconstrained gravity model, Wilson (1969) radically reengineered it using entropy-maximising techniques. Wilson (1970) explains how the basic gravity model can be transformed into a spatial interaction model by adding balancing factors, A_i and B_j, and replacing the power distance-decay function with an exponential decay function, $exp^{-\beta dij}$. The result is the transport model, a doubly constrained spatial interaction model with constraints based on the known information about the origin-destination flows. The model was initially used for modelling journey to work flows and took the form:

$$T_{ij} = A_i\, B_j\, O_i\, D_j\, exp^{-\beta dij} \quad (2.3)$$

where O_i is the total outflow from zone I, D_j is the total inflow to zone j and A_i and B_j are balancing factors which are computed using an iterative procedure, as outlined by Furness (1965) and Senior (1979), as:

$$A_i = [\sum_j B_j\, D_j\; exp^{-\beta dij}]^{-1} \quad (2.4)$$

$$B_j = [\sum_i A_i\, O_i\, exp^{-\beta dij}]^{-1} \quad (2.5)$$

and where the decay function, $exp^{-\beta dij}$, reflects the exponential decline in the number of commuters between origin and destination zones as the distance between the zones (d_{ij}) increases.

Although mathematical commuting models may seem very academic, there has been an ambitious implementation of such a model (TRANSIMS) in New Mexico (Beckman, 1997). TRANSIMS models the commuting behaviour of thousands of people in New Mexico's largest city, Albuquerque, with traffic jams being observed virtually and anticipated (O'Sullivan and Haklay, 2000). Also on a practical level, commuting behaviour has been included in technical agent-based models designed to help understand the behaviour of retail consumers (Rand, 2012). It is therefore clear that although mathematical and technical commuting models may have an academic origin, they are produced for practical purposes and can ultimately be used in the real world.

As well as being used to generate original commuting flows, modelling can be employed to correct defective data or re-estimate old data for a new purpose. An example of modelling being employed for the latter purpose is provided by Boyle and Feng (2002), with their re-estimation of the migration and commuting interaction data from the 1981 Census for the geographies used for the 1991 Census. They employed a modelling technique that proportionally assigned the commuting flows in the original 1981 output geography into the equivalent commuting flows for the new 1991 output geography. This example shows that modelling in a commuting context need not be employed to generate hypothetical commuting data, but can be used on actual commuting data in order to make it appropriate for a desired purpose.

Modelling commuting can also be undertaken at the micro level, in order to gain a better understanding of the commuting behaviours and patterns of individuals. Nelson *et al*. (2008)

modelled commuting to school behaviour for 15 to 17 year olds in the Republic of Ireland using a logistic regression model. In this study, the distance variable was used in a BLR model to predict mode choice (that is active versus inactive commuting to school), controlling for sex, population density, socioeconomic status and population clustering. In a similar vein, Helminen and Ristimaki (2007) used a BLR model to examine the relationship between the length of commuting trips and the prevalence of teleworking in Finland. In this study, the length of commuting trips was entered into the model as the independent variable, while the prevalence of teleworking was the dependent variable. Although the Nelson *et al*. (2008) and Helminen and Ristimaki (2007) studies were focused on school commuting and teleworking, respectively, the principles of both studies could equally be applied to many of the issues related to the commuting of employees to work.

2.4 Historical and Contemporary Commuting Trends and Patterns

2.4.1 Historical commuting trends in the UK

Whilst it has been possible to articulate some of the theoretical explanations for commuting that relate to labour market structure, commuting patterns in the UK have also been determined over time by the complex interplay between current and past technological developments, urban form and personal preferences. The evolution of transport systems has been driven by technological innovations but has also been influenced by economic and social changes (Rodrigue *et al*., 2009). As such, the movements of people, and the modes they use, are as much guided by past developments as they are by the demands of the present (Daniels and Warnes, 1980). At the most fundamental level, the current configuration of urban areas, and the provision of transport networks linking places within them, is due to the different reasons and ways that urban areas have developed over time.

It is arguable that modern commuting patterns are largely a product of the Industrial Revolution, which mainly occurred in the UK between 1760 and 1830 (Crafts, 1996), and the concomitant large-scale rural to urban migration that accompanied it. These two historical processes were so radical and far-reaching that the consequences of them are still to be seen in the urban forms, transport networks and social and economic structures throughout the UK. As these processes radically altered the social and economic structure of the UK, they also altered the commuting patterns of the population. Prior to large-scale industrialisation and urbanisation, commuting patterns were based on subsistence living, with whole families living and working on the same agricultural plot (Wharton, 1969). After the processes of industrialisation and urbanisation had become established, commuting patterns were based on the existence of wage labour, with employees commuting from their places of residence to their places of work. It is therefore arguable that the Industrial Revolution gave rise to the traditional understanding of commuting as a process of travel from residence to workplace.

Despite the radical changes brought about by industrialisation, it is often assumed that the twentieth century witnessed the most fundamental changes in transport and the most sizeable increases in both the average distance travelled to work and the average time spent travelling to work in the UK (Aldcroft, 2012). However, Pooley and Turnbull (1999) show this assumption is only part of the full story which saw the average travel to work distance increase fourfold between 1890 and 1990, but the average time spent travelling to work only double over this time period, with most of this increase occurring before 1920. This difference in rates of increase was likely due to improvements in technology and transport systems, such as the invention of motorised transport and the building of the railways. With the development of motorised transport from the mid-nineteenth century, the spatial structures of cities were drastically altered (Daniels and Warnes, 1980). The construction of the railways made it possible for suburbs to be developed in areas considerably further away from historical town and city centres than before (Docherty *et al*., 2008), producing commuting flows that had not existed previously. Not only did the expansion of the railways influence commuting behaviour indirectly, by giving people a further transport mode to add to their existing commuting options, in many cases it directly influenced where people chose to live, with some railway companies offering people free season tickets if they built houses along the railway lines (Thomas, 1971), a further example of the role of structure *vis a vis* agency.

Despite the continuing legacy of transport innovations from the nineteenth century, it was not until the twentieth century that the most substantial transport shift in human history took place (Docherty *et al*., 2008). This was the major shift from rail, and public transport more generally, to road, and private transport more generally. In the UK, transport shifts in the twentieth century can be split into three quite distinct eras: the pre-1930s, the 1930s-1960s and the post-1960s (Pooley and Turnbull, 2000). Before the 1930s and after the 1960s, walking and driving to work were the most common commuting experience, respectively, with over 40% of people walking to work before the 1930s and over 40% of people driving to work after the 1960s (Pooley and Turnbull, 2000). The ‘cross-over’ period of the three decades from 1930 to 1960 saw a sharp decline in the number of people walking to work and an increase in the number of people cycling or using public transport to commute (Pooley and Turnbull, 2000), before the rise of commuting by car began to dwarf all previous shifts in commuting behaviour.

Studies across the UK (Lawton, 1963; Westergaard, 1957; Humphrys, 1965) have shown that in the middle of the twentieth century commuting from rural areas to towns became more common. This rural to urban commuting is still seen today; arguably more so than in the past as the processes of suburbanisation and counterurbanisation have now been occurring for over half a century in many parts of the UK (Grey *et al.*, 2003). Given that post-war suburban developments were often not established in conjunction with peripheral commercial or industrial developments, the enlargement of suburbs in the UK has corresponded with increases in the size of TTWAs or labour-sheds and hence commuting journey distances (Fullerton and Bullock, 1968).

The analysis of commuting patterns has become more and more difficult over time due to the increased complexity of urban and regional systems. A key driver of this is the emergence of the general trend of urban areas becoming more deconcentrated (Docherty *et al*., 2008). This decentralisation of urban areas has meant that commuting is no longer simply about workers travelling from inner and outer suburbs to city centres and central industrial areas. The decentralisation of employment opportunities and the growth of peripheral developments (e.g. edge cities) have radically changed urban spatial structures and therefore new commuting patterns have emerged (Clark *et al*., 2002), with rapid growth in the number of suburb to suburb trips (Pisarski, 1987).

The decentralisation of urban areas was historically assumed to cause an increase in the average commuting distance. However, research by Ma and Banister (2007) shows that the decentralisation of the urban spatial structure can lead to an increase or a decrease in the average commuting distance. In fact, as early as the 1980s, Gordon and Wong (1985) argued that the decentralisation of urban areas, and the resulting polycentric city, was leading to shorter commuting trips. However, there has been little research to produce solid evidence on the relationship between urban decentralisation and commuting (Crane and Chatman, 2003).

2.4.2 Contemporary spatial commuting patterns in the UK

Even though commuting to work is now commonplace across the whole of the UK, not every part of the country experiences the same commuting propensities and patterns. These vary spatially across the UK, with commuting flows and patterns being different between localities (Nielsen and Hovgesen, 2008). For instance, the most popular mode of commuting in Central London, with the high usage of its well-developed railway and underground networks (ONS, 2011i), is very different to the most popular mode of commuting in other British cities, with their higher dependence on car usage (ONS, 2011i). In turn, the differences in the nature of commuting between London and other British cities seem minor in comparison to the differences between London and very rural areas of the UK, such as the Scottish Highlands, where the cost of movement is much higher due to the distances involved (Wiggins and Proctor, 2001) and movements between different areas are of much lower magnitude (Frost and Dennett, 2010).

It can also be argued that commuting patterns are linked to the prevailing political and economic ideologies that countries subscribe to. The liberal and capitalist USA has the most extensive road network in the world (CIA World Fact Book, 2015), which subsequently promotes the usage of private cars often at the expense of public transport systems. Conversely, the socialist and communist states of the eastern bloc generally had less well developed road networks but significantly better developed public transport systems, with the aim of promoting communal travel (Shaw *et al*., 2008). It is particularly noticeable that those European countries that generally subscribe to social-democratic political and economic values, particularly the Nordic countries, have well developed public transport systems (Taylor, 2005).

Although the UK does not fit neatly into any of the three ideological groupings outlined above, its party political system could be seen as a microcosm of the debate. Whereas the *laissez-faire* credentials of the Conservative party meant that it understood the shortcomings of state control in the 1980s and had a commitment to the preferences of individuals, the social-democratic principles of the New Labour party meant that it had an understanding of the failures of privatisation, especially in the railway network, and a concern for public transport (Clarke, 2004). However, despite the importance of ideology and political policy, the key drivers of commuting patterns have been economic in nature. Changes in transport and travel have historically been intrinsically liked to economic changes. Present transport and travel issues are no exception.

2.4.3 Commuting behaviour in other parts of the world

As indicated earlier, commuting is a phenomenon that is occurring throughout the world and it is important to recognise that there is an extensive literature about commuting in other countries and well as studies that compare indicators of commuting between countries. However, before reviewing some of the literature related to international variations, it is necessary to point out that there are likely to be major comparability problems since commuting concepts, data sources and data counts will differ from country to country. As Pucher and Lefevre (1996) point out, even basic statistics like vehicle registration per capita can be measured in different ways and have different meanings.

Banerjee *et al*. (2007) used the USA National Household Travel Survey, the 2000 Switzerland Microcensus Travel Survey and the 2001 India Household Travel Survey to calculate the maximum amount of time that individuals in the USA, Switzerland and India were prepared to spend travelling every day. They found that commuters in the USA and Switzerland were prepared to spend three hours every day on average commuting to and from work, while commuters in India were only prepared to spend two and a half hours commuting every day. Although Banerjee *et al*. (2007) argue that these findings have important policy implications; however, two problems that are likely to limit the study’s policy impacts somewhat should be noted. First, an acceptable theoretical maximum commute time does not necessarily coincide with the actual commute times of individuals. Second, the study was based on peoples’ self-reported subjective maximum commute times and is therefore not necessarily accurate.

Schafer (2000) found that time and money budgets for travel are largely similar across time and space for all the countries, both developed and less developed, that were examined in his study. This finding suggests that differences in commuting patterns and propensities between counties are likely to be due to differences in transport infrastructure rather than differences in individuals' preferences regarding their commuting behaviour.

It is clear from these selected examples that national commuting patterns and individual commuting behaviours will vary in different countries. In addition to differences in the actual commuting propensities and patterns between countries, there are differences between countries in their public policy approaches to transport networks and town planning. Pucher and Lefevre (1996) have highlighted that the financing of road transport has favoured car ownership far more in North America than in Europe, with road users in the USA paying only 60% of the costs of road construction, maintenance and administration through taxes and road charges. Conversely, the International Roadway Federation (1994) notes that the ratio of road taxes to expenditure is 5:1 in The Netherlands, with most European countries collecting at least twice as much in taxes from road users than they spend on roads.

2.5 Commuting Composition: Sociodemographic Characteristics

Even though commuting from home to work, often over substantial distances, has become a fact of life for many people in the UK, different sections of the population experience different commuting propensities and travel in different ways. It is apparent from the literature and research reviewed below that, in addition to, and in combination with, the spatial commuting patterns outlined above, commuting propensities and patterns vary by sociodemographic group. This variation is due to the different preferences and circumstances of individuals within those sociodemographic groups, and the rise of flexible employment practices and the dissolution of traditional time-regimes mean that some individuals are now freer than they were in the past to vary their commuting behaviour in order to take account of their personal characteristics and circumstances (Dex and Scheibl, 2001; Le Bihan and Martin, 2004).

It is important to note, before remarking on the relationship between different sociodemographic groups and different commuting behaviours and patterns, that the causal relationships between characteristics and commuting behaviours and patterns are not completely clear. As the spatial distribution of some sociodemographic groups, such as ethnic minority groups (Buckner *et al.*, 2007), is subject to clustering behaviour, there are at least two dimensions to the different commuting behaviours of the different groups. As such, it is unclear as to whether the different commuting behaviours observed are due to the preferences of the different sociodemographic groups, and thus directly related to the characteristics of the group, or if the different commuting behaviours observed are due to the spatial distributions and spatial clustering of the different sociodemographic groups, and thus only indirectly related to the characteristics of the group.

2.5.1 Commuting and personal circumstances: sex, age, ethnicity and health

The Department for Transport reported that, in 2010, males made 5% fewer trips on average than females, but males travelled 23% further on average than females (Department for Transport, 2011); thus males generally make long trips but fewer of them, while females generally make short trips but more of them. However, the differences between the travel patterns of males and females are narrowing, as the average distance travelled in a year declined by 17% for males and increased by 21% for females over the 1995-2010 period, according to the Department for Transport (2011). However, the average commuting distance travelled by women depends on their lifestyle, with women with the most childcare constraints having the shortest commutes and independent middle-aged women having longer commutes (Pickup, 1981). The variation in commuting distances by gender may also be because men are more likely to increase their earnings by commuting longer distances to work whereas this is less likely to be the case for women (Madden, 1977; Andrews, 1978). It also appears to be the case that women workers are more interested in moving jobs in order to work in their local area (McCarthy *et al*., 1968), resulting in shorter commutes, while men are less interested in moving jobs in order to reduce their commute time. Women are also more likely to work in low-skilled and low-paid jobs (Grant *et al.*, 2005; Hurrell, 2005), which tend to be local, meaning that it is not necessary for them to commute as far as men. This variation in commuting distance by gender has also been observed in other European countries (European Commission, 1980), indicating that it is not only a product of UK commuting practices but caused by more general differences in the preferences and characteristics of men and women.

There are also interesting variations in commuting behaviour across different age groups, with commuting propensities and patterns being linked to the stage that an individual is at in the life course. Differences in commuting behaviour between younger and older commuters may be linked to changes in income over an individual's working life. Increasing household and personal income may explain the trend of increasing car ownership and usage as people grow older (Witte *et al.*, 2008). This trend of increased car ownership and usage continues until age 50, when it goes into reverse (Dargay, 2007), which partly explains variations in public transport usage by age. At the other end of the age spectrum, public transport users are often young middle-income professionals who cannot afford to buy their own car (Kamid, 1999). However, the link between individual commuting propensities and patterns and the stage that an individual is at in the life course is not as simple as it may first seem. Changes in commuting behaviour over an individual's life may also be due to changes in employment type, with younger and older workers more likely to be working part-time and those in middle-age more likely to be working full-time (Nardone, 1986). This variation in employment type by age is likely to have an equal, if not greater, impact on changes in commuting behaviour than differences in age *per se*. It is also the case that older commuters tend to be more apprehensive about driving than younger commuters and more likely to take advantage of traffic information systems, such as local radio announcements (Caplice and Mahmassani, 1992), while it has also been suggested that older commuters may be willing to tolerate greater delays and commuting uncertainty than younger commuters (Mahmassani and Liu, 1999). These points taken together raise interesting questions about the safety of the commuting behaviours of different age groups. If older people are more apprehensive about commuting, more likely to take advantage of information on offer about commuting, and are more likely to be relaxed in the face of commuting delays, it is unsurprising that there is concern regarding the travel and transport behaviour of young people from all sociodemographic groups (Laflamme and Vaez, 2007).

Using data from the 1980s, Thomas (1998) found that people from ethnic minority groups are significantly less willing to commute long-distances than their White counterparts, with ethnic minority individuals being 71% more likely to prefer a commute of 4 miles or less. Differences in commuting propensities between the two broad ethnic groups, White and non-White, contribute to the spatial mismatch hypothesis developed by Kain (1968) which attempts to use commuting propensities, as well as migration propensities, to explain differences in unemployment rates and length of unemployment spells between the two groups. It is hypothesised that as some individuals from Black and Minority Ethnic (BME) groups have lower propensities to commute and migrate than individuals from White ethnic groups who make up the vast majority of the population, they are likely to be excluded from many jobs in suburban areas that are available to individuals from White ethnic groups. Although the spatial mismatch hypothesis was first developed in an American context, it has been argued that it is relevant to the UK as well (Rogers, 1997). However, the situation is complicated in that not all individuals from BME groups have the same migration propensities, with South Asians having the lowest propensities and Chinese having the highest propensities (Stillwell and Hussain, 2008), and that convergence is taking place over time (Stillwell *et al*., 2008). Despite these differences and the convergence occurring over time, the difference in commuting propensities between individuals from White ethnic groups and individuals from BME groups was substantial enough to explain up to 20% of the average difference in the length of periods of unemployment between the two groups during the late 1980s (Thomas, 1998). Although it is assumed that there is a positive correlation between the willingness to commute and the likelihood of finding employment, this may not be the case. In addition to BME individuals being more likely to live in large urban areas (Buckner *et al*., 2007) where jobs are more likely to be located, it is argued that ethnic minorities concentrate on finding jobs in their local area as this is more productive (Thomas, 1998). If this is indeed the case, then policies that are aimed at encouraging ethnic minorities to increase job search areas, such as those proposed by Kasarda (1993), may actually be detrimental to their job search efforts if local searches are more fruitful. Indeed, Rouwendal (1998) found that wasteful excess commuting occurs as a result of the utility maximising behaviour of individual workers as well as employers, whereby workers and employers act according to their own individual interests in order to maximise their economic wellbeing. This means that maximising behaviour of both employees and employers need not necessarily lead to the efficient allocation of resources, in this case resources related to commuting and employment.

The extent to which people's health status affects their commuting propensities and patterns is likely to be linked to occupation and labour market status. The reasonably robust relationships that have been established between the labour market status of an individual and their health and well-being (Roberts *et al*., 2011) can be used to infer that commuting long-distance is dominated by people in better health; as people with better health are more likely to have achieved a high labour market status, they are more likely to be commuters and commuting long-distances. However, the complex interplay between labour market status, health and commuting patterns and propensities is complicated as the relationship is not simply one way. People with longer commutes, who axiomatically are more likely to be in good health, report systematically lower subjective well-being (Stutzer and Frey, 2008). In addition to the present negative impact on well-being, commuting has delayed effects on an individual's health and family life (Novaco *et al*., 1990). Although people with longer commutes are more likely to be in good health than the general population, long commutes, especially for commuters driving cars, are linked with certain physiological health problems. Long commutes by car are known to be associated with back problems, possibly caused by car vibrations (Kelsey and Hardy, 1975; Kelsey *et al*., 1990), cardiovascular stress, possibly caused by the inhalation of air pollutants by drivers (Aronow *et al*., 1972) and some types of cancer (Gubrean *et al*., 1992). In addition to the relationship between commuting behaviour and physiological health, psychologists have long been aware of the potential detrimental effect of commuting on the psychological health of individuals (Koslowsky *et al*., 1995). However, there is a gender difference, with commuting having a detrimental effect on the psychological health of women but not men (Roberts *et al*., 2011). Interestingly, Mann and Holdsworth (2003) found that individuals who telecommute experience significantly more mental health problems, related to stress, and slightly more physical health problems than office-based workers. Social isolation (Huws, 1984), lack of time off when ill (Montreuil and Lippel, 2003), and the blurring of boundaries between home and work life for both the telecommuter and their family (Ellison, 1999), are seen as some of the major disadvantages of telecommuting that can impact on people's health. However, it should be noted that some of these problems, such as feeling unable to take time off work when ill, can apply to all commuters in times of job insecurity (Clark, 1994). These findings have policy implications in that promoting telecommuting as a solution to congestion and pollution problems is likely to have a trade-off with the general psychological and physiological health of the individuals changing their commuting behaviour.

Although there are relatively recent studies investigating the relationship between commuting and health, most research during the 1980s and 1990s into the impact that commuting has on the psychological and physiological health of individuals was based solely on the commute impedance model (Kluger, 1998), first developed by Novaco *et al.* (1979), which contains two central propositions. The first proposition is that commuting causes stress, and that this stress is a function of commute impedance (defined as anything that affects the ease of a commute, such as increased distance, slow speed and congestion). The second proposition is that the negative impacts of commute impedance on the individual commuter can be attenuated by individual commuters perceiving that they are in control of their commute. Despite the success of the commute impedance model in providing a theoretical framework for the analysis of commuting behaviour and health, it was not without criticism. Guttman (1982) suggested that the use of the term impedance confused the definition with the hypothesis, in that the term impedance is used by the model creators to refer to both the characteristics of the commute and a consequence of the commute (Kluger, 1998). It is also the case that the negative impacts of increased commute distance may be due to the exposures that the drivers suffer during the commute rather than due to the act of commuting itself, as the model assumes. More seriously, Kluger (1998) asserts that the second proposition of the commute impedance model requires drastic revision, mainly because research has failed to support it.

From a policy perspective, there has been recent interest in investigating the relationship between commuting and health indicators (Abu-Omar and Rutten, 2008), with the ultimate aim of examining the extent to which promoting 'healthy' commuting can improve the general health of the population (Shephard, 2008). The question, ultimately, is whether getting people to commute to work by walking or cycling can help tackle the obesity epidemic (Howard, 2012) and hence improve the cardiovascular health of the commuting population. This policy aspect further complicates the commuting-health relationship by adding another dimension to it, reinforcing that the relationship between health and commuting activity is two way, with an individual's pre-existing health having an impact on their commuting behaviour and their commuting behaviour impacting on their health.

2.5.2 Commuting and family circumstances: caring responsibilities and childcare

Caring responsibilities, such as looking after sick or disabled children or sick, disabled or elderly partners or parents, are likely to impact on an individual's commuting decisions and therefore their actual commuting behaviour. McQuaid *et al.* (2001) found that the presence of dependents influences the distance that people are prepared to commute, both when in work and when looking for work, with people without dependents being prepared to travel further than those with dependents. These differences in commuting behaviour between carers and non-carers are likely to become more important over time, especially with the recent news from the

ONS, drawing on the 2011 Census, that over 1 in 10 (5.8 million) people in England and Wales are now providing unpaid care (BBC, 2013ii). Similarly, childcare commitments are likely to influence an individual's commuting decisions and behaviour, with Gibbons and Machin (2006) finding that women with children commute less than women without children.

The relationship between both caring responsibilities and childcare commitments and commuting behaviour is likely to intersect with the relationships between gender and commuting behaviour and ethnicity and commuting behaviour. Women are more likely than men to be carers (Arber and Ginn, 1994; Parker and Lawton, 1994) and provide childcare (Equality and Human Rights Commission, 2011), with this disproportionate responsibility for caring having an impact on their commuting behaviour. In addition, ethnic minority groups, especially the Indian, Pakistani and Bangladeshi ethnic groups, are more likely to be carers (Buckner and Yeadle, 2006), with these disproportionate responsibilities similarly feeding through to affect their commuting behaviour. Given this intersectionality between gender and ethnicity and caring/childcare responsibilities, it is unsurprising that the differences in commuting behaviour between carers and non-carers are similar to those between women and men and between ethnic minority and non-ethnic minority groups.

2.5.3 Commuting and labour market engagement: occupation, qualifications, employment type and employment sector

The pattern in the UK, in general, is for managerial and professional workers to commute longer distances, which may be a reflection of their residential preferences, while unskilled manual and low grade non-manual workers commute shorter distances (Pickup and Town, 1983; Owen and Green, 2005). Occupation is highly correlated with income, with employees in professional and managerial positions earning substantially more than employees in unskilled jobs (ONS, 2014i). Therefore, it is easier economically to justify longer and more expensive commutes for professional and highly paid workers than it is for unskilled and low paid workers. This is closely linked to the theory of spatial wage gradients, whereby individuals have lower propensities to commute if they earn less (Madden, 1977). The link between income and commuting behaviour is strong enough to override gender differences and spatial considerations; those individuals in higher income groups have longer commutes regardless of their sex (Pickup and Town, 1983) and regardless of whether they commute to city centres or suburban places of work (Catanese, 1971). Variations in commuting by employment status have also been observed in the Republic of Ireland (Bannon *et al*., 1980) and other European countries (Ganser, 1969; Six, 1976).

As with occupation, an individual's level of qualification is likely to be related to income and commuting behaviour. Gibbons and Machin (2006) found that graduates are more mobile than non-graduates. As the 2005 National Transport Survey (NTS) (Department for Transport, 2006) found that individuals living in households with an income in the top 20% have an average commute distance of 20km compared to 9km for those individuals living in households with an income in the bottom 20%, it is not surprising that individuals with higher qualifications, who are likely to earn more, commute further on average than individuals with no or low qualifications.

Differences in commuting patterns between full-time and part-time workers can be caused by both differences in characteristics and differences in spatial locations. These two aspects interact to produce distinctive commuting patterns for full and part-time workers. First, there are differences in the commuting behaviours of the two groups, regardless of their spatial locations. Benito and Oswald (2000) found that, on average, full-time workers spend 7 minutes longer commuting than part-time workers (25.1 minutes and 17.9 minutes, respectively). This difference in commuting time between full and part-time workers is mirrored by a difference in commuting distance, with MVA Consultancy (2005) finding that while full-time workers in Scotland commute 13km on average, part-time workers only commute 7km. The differences in commuting behaviour between full and part-time workers may be due to part-time workers being less willing or able to pay commuting costs than full-time workers (Ermisch and Wright, 1993). This is because work is likely to provide greater financial rewards to full-time workers and therefore justify longer and more complex commutes. It may also be due to a desire of women, who are more likely to be part-time workers, to spend more time on domestic and childcare activities and therefore less time commuting (Madden and White, 1980). Second, however, the commuting behaviours of the two groups are affected by their spatial locations. Areas with high proportions of men and women in part-time employment tend to be in inner cities and on the edges of large cities, respectively (Dent and Bond, 2008). These locational characteristics of the male and female part-time workers lead to short commuting distances, while the part-time working men are likely to both live and work in the inner city and city centre areas, the part-time working women are unlikely to commute out of their local area for work. This difference by gender is backed up by research by the East Midlands Development Agency (2007) which suggests that differences in commuting distance and commute time between full and part-time workers may be due to gender differences, with women being more likely to work part-time in the first place and less likely to travel outside of their local area for work (East Midlands Development Agency, 2007).

Given that occupation, qualifications and employment type have various impacts on an individual’s commuting behaviour, one would also expect the employment sector that an individual works in to have a similar impact. However, Shearmur (2006) found that differences in commute length were largely independent of economic (employment) sector at the metropolitan level, and that differences in commutes may instead be due to the different local cultures or ‘milieus’ of different job locations and how people react to them.

Given the previous point from Shearmur (2006), it is important to note that there is a subjective aspect to all commuting behaviour. When looking at the macro commuting patterns of different sociodemographic groups, one must be careful not to succumb to the ecological fallacy (EF). Not all men commute further than women, not all professionals commute further than unskilled workers, and not all full-time employees commute further than part-time employees. There are important individual micro-level differences in individuals commuting behaviour that are driven by the individual's circumstances, characteristics, preferences and feelings. Although it is not possible to deal with these issues from a macro quantitative perspective, it is important to acknowledge them and affirm their importance in influencing commuting behaviour.

The above point reaffirms the importance of locality. It is important that locality is examined, in addition to the various sociodemographic variables, in relation to variations in behaviour (Buckner, 2009), as local level analysis can highlight issues that are hidden in macro level analysis (Buckner *et al.*, 2004). An understanding of how locality interacts with different sociodemographic indicators is particularly important from a policy perspective as the implementation of many government policies occurs, and their impacts are felt, at sub-regional and local levels (Bruegel, 2000).

2.5.4 Intersectionality

As outlined above, multiple independent variables can have an impact on a dependent variable individually. However, through the process of intersectionality, multiple independent variables can also have a joint impact on a dependent variable. Intersectionality was conceptualised by critical race theorists in order to describe the interconnectedness of different sociodemographic characteristics, such as sex, ethnicity and social class (Crenshaw *et al.*, 1995) and, although the ideas underpinning the theory of intersectionality existed beforehand, the term 'intersectionality' was first used by Crenshaw (1989) in her paper on feminism, race and sex.

Crenshaw argued that when examining multiple independent variables (in this case race and sex) it is not good enough to use a 'single-axis framework', treating each independent variable as 'mutually exclusive' and examining each individually, as this 'erases' certain groups (in this case black women) from the examination and leads to an incomplete understanding of variations in experiences between different groups. The theory is therefore a product of the argument that different sociodemographic characteristics need to be studied simultaneously and be seen as a "matrix of domination" (Collins 1990) or as part of an inequality complex (McCall, 2005). The theory maintains that one cannot simply add or subtract different inequalities, as they can impact on each other when combined (Walby, 2007). Adding or subtracting the relative advantages or disadvantages that different sociodemographic characteristics may give an individual does not take full account of the intersection(s) between the different characteristics, as the advantages and disadvantages may mutually constitute/affect each other (Brah and Phoenix, 2004; Phoenix and Pattynama, 2006).

Although the theoretical concept of intersectionality has been somewhat ignored by geographers (Valentine, 2007), it has important implications when analysing the relationships between different sociodemographic and geographic variables and commuting propensities, patterns and behaviours. In much the same way that Crenshaw (1989) proposed that the experiences of black women cannot be understood simply by examining the experiences of black people and the experiences of women separately; but must instead be examined in conjunction with each other; while it is initially necessary to understand how individual sociodemographic and geographic characteristics have an impact on commuting, the commuting propensities, patterns and behaviours of individual commuters can be reinforced by the interplay of the different sociodemographic and geographic characteristics of those individuals. Therefore, one cannot fully explain variations in commuting propensities, patterns and behaviours by compartmentalising an individual's characteristics and statistically analysing them separately from each other.

This means that, for example, in order to fully understand the commuting propensities, patterns and behaviours of BME females living in London, we must first examine the commuting propensities, patterns and behaviours of BME commuters, female commuters and commuters living in London individually and then examine the interactions and interplay between the three independent variables. Only when the individual effects of the variables and the effects of the interplay between them have been combined can we have a full understanding of the commuting propensities, patterns and behaviours of that specific sociodemographic group.

2.6 Commuting and the Definition of Local Labour Market Areas

Commuting propensities, patterns and behaviours are used by academics and policy makers to define LLMAs. An example of this is the generation of TTWAs from the 2001 Census commuting data by Coombes (2002). TTWAs were first developed as functional regions in order to better understand spatial variation in variables for LLMAs across the UK, particularly unemployment rates (Coombes, 2010). TTWAs were seen as providing more appropriate spatial units and boundaries than LADs for the analysis of unemployment and other socioeconomic variables, and are therefore important from a policy perspective.

TTWAs are functional regions derived from the analysis of commuting flow data. The creation of TTWAs based on commuting data in order to define LLMAs is operationalised through the concept of self-containment. A high level of self-containment means that TTWAs are a good way of delineating functional 'local' areas, resulting in them being particularly important and useful for monitoring local labour market trends and local level policy making.

TTWAs have been defined as areas where at least 75% of the resident economically active population actually work in the area, and where at least 75% of people working in the area are actually resident in the area (ONS, 2012i). TTWAs are important for labour market analysis and planning (ONS, 2012i), as they are widely accepted as the bases of local labour markets (Vance, 1960), with Harvey (1985) commenting that they represent the areas within which labour can be exchanged and substituted on a daily basis. TTWAs are appropriate for analysing commuting behaviour as labour is mobilised at the local level (Broadbent, 1977), with time-space budgets imposing spatial limits on peoples' job search activities and daily commuting behaviour (Peck, 1989). TTWAs are the spatial manifestation of the fact that, for work and other daily activities, it is necessary for people to exist within a restricted area (Hagerstrand, 1970).

TTWAs appear to be the ideal spatial units to use for the analysis of commuting as they are a set of boundaries that have been as consistently and appropriately defined as possible (Coombes, 2002). However, TTWAs are not without problems. First, as TTWAs are created using commuting data, they manifest the biases in commuting data. TTWA boundaries are based on the commuting behaviour of the so-called 'average' worker and do not accurately represent the different commuting behaviour of different social and labour market groups (Peck, 1989). As such, TTWAs will not effectively represent the commuting behaviour of those groups at either end of the commuting spectrum, such as women and ethnic minorities at the less mobile end of the spectrum, and wealthy and professional workers at the more mobile end. Coombes *et al.* (1988) have commented that TTWAs break down when closely scrutinised due to their reductionist nature and the imposition of a single set of boundaries onto a multilevel mosaic of different commuting patterns. However, this first criticism is not universally accepted, with Green (1997) and Coombes (2002) arguing that TTWAs do a good job of representing commuting behaviour. Second, TTWAs are formed through largely subjective judgements about 'acceptable' levels of self-containment and, by implication, cross-boundary 'leakage' (Goodman, 1970). The second aspect of the subjective judgement, that of cross-boundary leakage, is a weakness of TTWAs in and of itself, in that many TTWAs in the UK are either extremely large or suffer from high levels of cross-boundary leakage (Coombes *et al.*, 1988). In addition, there is a trade-off to be made between the level of self-containment of TTWAs and their internal cohesiveness (Clark and Gertler, 1983), in that, theoretically, a TTWA could be expanded to a point at which it achieved 100% self-containment; however, it would be likely to suffer from extremely heterogeneous commuting propensities and patterns and be far from internally cohesive at this point. It is also worth noting that different economic sectors and different population subgroups may have different LLMAs, with these specific LLMAs having the potential to overlap with one another.

However, these weaknesses do not mean that TTWAs are not useful for the analysis of commuting propensities and patterns, and they do not mean that researchers and policy makers should do away with TTWAs and see them as interchangeable with 'towns' (Robinson, 1970) or 'city regions' (Pinch, 1987).

2.7 UK Transport Policy

As outlined in Chapter 1, this thesis has a policy focus, with each analysis chapter providing some policy recommendations based on the data analysis carried out in that chapter. Although different transport policies have been mentioned throughout this literature review chapter, this section reinforces the importance of transport policy in the UK and provides a brief overview of transport policies since the 1960s. The analysis of commuting is important from a policy perspective. As journeys to work accounted for 16% of all trips and 20% of total distances travelled in 2010 (Department for Transport, 2011), understanding commuting patterns is necessary if transport network problems are to be tackled.

Transport policy is an important aspect of government expenditure, partly due to transport-related policy falling under the remit of several government departments. Due to the stand-alone nature of the Department for Transport, the Department for Communities and Local Government, the Department for Environment, Food and Rural Affairs and the Department of Energy and Climate Change, all have substantial interests in transport policy. When considering these four departments together, direct expenditure on transport policy and expenditure on transport-related policy has been responsible for £47.2 billion worth of government expenditure in one year (HM Treasury, 2014). This means that expenditure on transport and transport-related policy has amounted to 15% of total UK government spending, without taking into account separate spending in Scotland, Wales and Northern Ireland and extra spending at the regional and local levels within England. The sheer size of the UK Government's budget that is directly or indirectly related to transport emphasizes the need for evidence based policy.

It is now half a century since the UK Government published two key reports that ignited the debate about road traffic that continues today. The two reports were the Buchanan Report (Ministry of Transport, 1963) and the Smeed Report (Ministry of Transport, 1964). The Buchanan Report started with the basic observation that severe and increasing congestion was the inevitable result of a failure to increase the capacity of the nation's road network, i.e. the Government had failed to match the high and increasing demand for car travel with an increased supply of road space. The Buchanan Report offered the Government two stark options; it could either follow a policy of 'Predict and Provide' or find and provide alternatives to car-based mobility.

The Smeed Report was summarised by Goodwin (1999) as suggesting that road traffic congestion is the product of a peak-time battle between individual liberty and the common good in which neither wins. The Smeed Report applied Schumpeter's (1909) work on welfare economics and public goods to the transport problems of the day. The logical conclusion that could be drawn from the Smeed Report was that road pricing should be introduced in order to ensure that journeys for which the marginal cost to society is greater than the marginal benefit to the individual do not take place. This journey discrimination, based on marginal costs and benefits could not take place as long as the road network was a public good.

The Smeed Report also made some important insights into the spatial variation in traffic and congestion problems. At the level of individual towns and cities, Smeed (1968) found that the amount of traffic flowing into town and city centres was related to the size of the area that the centre covered, and that there was a consistent negative relationship between the intensity of traffic and the distance from the town or city centre. It is therefore clear that, despite the UK-wide coverage of both the Buchanan and Smeed reports, they were mainly discussing issues that disproportionately affect densely populated urban areas.

From an academic perspective, Pucher and Lefevre (1996) carried out a systematic and wide-ranging, albeit now dated, review of government transport policy in Europe and North America. They asserted that public policy differences explain much of the variation in transport trends and patterns between countries in Europe, and between Europe and North America. The overarching point of the review was that transport trends and patterns are largely dependent upon the level of government intervention in the public transport sector. Countries that generally subscribe to an anti-government, deregulation and pro-market paradigm, such as the UK, the USA and Canada, tend to be more dependent on car usage and have lower levels of public transport usage than those countries that generally subscribe to a pro-government and pro-subsidy paradigm, such as France, The Netherlands and Germany.

Even in the most private transport and pro-market oriented country, the USA, road networks have failed to expand at the same rate as car ownership and usage. Koslowsky *et al*. (1995) commented that while the number of cars on the road in the USA increased by 90% between 1970 and 1989, the capacity of the urban road network increased by only 4%. This inability of even American style road building to keep pace with the growth in car ownership and usage clearly brings into question the sustainability and desirability of the ‘Predict and Provide’ approach to road transport.

Although the present day transport paradigm often appears to demonise car use and car users, this was not always the case. As recently as the 1960s, UK government departments saw car use as indispensable when it came to national transport policy (Ministry of Transport, 1963). However, by the mid-1970s, the situation had changed significantly. It was argued that urban crises, wherever they are found and in whatever form, are due to the modern reliance on car transport (Schafer and Sclar, 1975). However, the dominance of the car was not only caused by policy favouring its use; it was also caused by a lack of political and financial focus on alternative modes of transport.

For a substantial number of years in the middle of the twentieth century there was seen to be no meaningful alternative to car ownership and usage, leading to financial underinvestment in public transport and a lack of political interest in promoting alternative modes of transport. These periods of underinvestment in certain transport systems in certain areas resulted in unsatisfactory infrastructure systems that still often break down when faced with non-average conditions (Ortuzar and Willumsen, 2011).

The failure of 'Predict and Provide' and the realisation that chronic underinvestment in public transport is not sustainable mean that there has been a relatively recent shift in financial and political focus towards public transport investment and the promotion of alternative travel modes. The relatively recent policy focus on getting people to use public transport has been somewhat successful as the number of trips made by private transport fell by 14% over the period 1995-2010, while the number of trips made by public transport increased by 8% over the same period (Department for Transport, 2011). This is proof that the rise of private car transport and the simultaneous decline of public transport systems are not inevitable. Private car use can be curtailed while increasing public transport usage if only the political will and financial capability are present. Although government policy objectives related to commuting, especially those aimed at getting people out of their cars and onto public transport, can often seem hopeless and ineffective, the history of commuting in the UK has shown that individuals are prepared to change the forms of transport they predominantly use when presented with viable options at the right time, at the right price and in the right place (Pooley and Turnbull, 1999).

In addition to policy debates directly related to transport modes and changing how people use them, there have been policy debates related to urban development and urban form. These debates are also important from a commuting perspective as, as outlined earlier in this chapter, urban development and urban form are the key drivers of commuting patterns and travel behaviour in general. Recent policy debates regarding urban development and transport planning have been based around the core question of whether cities should be allowed to become more dispersed and decentralised, or whether they should be forced to be more dense and compact (Buchanan *et al*., 2006). Currently, the argument for more dense and compact cities seems to be winning out, mainly due to environmental and social concerns (Burton, 2000). Compact cities have been promoted in order to create higher density living spaces and reduce car use (Thomas and Cousins, 1996), thus producing considerable environmental benefits. However, compact cities have also been criticised for prioritising housing density over quality and increasing congestion and overcrowding (Breheny, 1997).

On a practical level, recent policy in the UK has sought to examine cities and areas that appear to have particularly sustainable commuting patterns, and sustainable transport and travel patterns in general, and then try to recreate the situation in cities and areas where commuting and transport and travel patterns are not so sustainable (Department for the Environment, Transport and the Regions, 1998). Thus, the success of the congestion charge in London, which has reduced car travel into Central London and increased the use of public transport throughout London, has been seen as a way forward for other cities in the UK. It has been perceived as so successful that the previous UK Government asked ten areas in England to prepare plans to introduce congestion charging (Swinford, 2007). Cities in the UK that have contemplated introducing congestion charging schemes include the major commuting nodes of Manchester (The Guardian, 2007), Leeds (Milne *et al.*, 2004) and Edinburgh (Ryley and Gjersoe, 2006).

Despite transport trends and transport systems having changed massively, many of the problems faced in the past are still present today, including congestion, pollution and poor access (Ortuzar and Willumsen, 2011). Transport problems are not new; they have changed over time, and have been greatly exacerbated by the rise of car ownership and usage (Pucher and Lefevre, 1996). It has long been recognised that the ultimate aim of policy is to provide a transportation system that minimises unnecessary travel and travel time and offers a diversity of options to fit different needs (Mumford, 1964).

Given the above, transport is one of the most highly politicised subjects in the UK (Hennessy, 1990). Transport policy in the UK has gone through a large number of changes over the past century. Notwithstanding these changes, the key transport problems and the key players in UK transport policy have remained relatively constant over time. Substantial changes in these problems and organisations have tended to occur only with the creation/invention of new transport networks and modes of transport, such as the emergence of a national railway network, the development of a national road/motorway network and the invention of new vehicles for these transport networks.

Overall, even with all of the changes in UK Government that have occurred over the past 50 years, which have all brought about changes in policy, the practical implementation of transport policy has persistently remained somewhere between the European model of state control and regulation and the American model of privatisation and free market forces (Pucher and Lefevre, 1996), providing a sense of relative stability and continuity (Dudley and Richardson, 2000).

2.8 Conclusions

The aim of this literature review was to set the scene for the subsequent research and highlight gaps in current research, which helped inform the trajectory of the research. Past research has highlighted the importance and magnitude of commuting in the UK, including the issues it raises and problems it creates. Commuting is an important part of the UK economy, both in its own right and as a product of individuals carrying out other economic activities, such as attending their place of work. The recognition of commuting's importance is accompanied by an acknowledgement of the related issues and problems that society and the environment confront. On the societal front, commuting practices can be socioeconomically exclusionary, with the high financial cost of some modes of travel (such as car and train) effectively excluding individuals from lower socioeconomic groups from using them, and forcing them to use cheaper modes of travel (such as bus and walking). This issue is becoming particularly acute with the recent rises in train fares (BBC, 2013i, 2013iii, 2014, 2015vi, 2015ix) and whenever petrol prices rise (BBC, 2013iv). On the environmental front, commuting practices cause air and noise pollution and contribute to the UK's greenhouse gas emissions. Commuting in the UK is therefore both important and problematic.

Despite the general recognition of the importance of commuting, an exact definition of what commuting is appears to be all too elusive. There is a certain theoretical fuzziness surrounding what commuting is and who is involved. There is very little work related to establishing where to draw the line between which journeys count as commutes and which do not. By extension, it is very difficult to find an exact and research-grounded definition of what commuting actually is. Many pieces of research related to commuting appear to assume that the reader instinctively 'knows' exactly what commuting is and exactly what the research is referring to.

The review of literature and past research has exposed the paucity of academic work related to commuting behaviour, patterns and propensities. This scarcity is understandable given the lack of data sources. Although the censuses in the UK, which are examined in detail in chapter 3, have gathered data on commuting behaviour since 1921, these data only present a snapshot of UK commuting propensities and patterns on a relatively infrequent basis. Away from the census years, other than the annual NTS, the provision of data and information pertaining to commuting in the UK is rare and sporadic. The NTEs and PTEs, which are also examined later in this thesis, do not collect or release any useable or substantial data or information on commuting in their respective jurisdictions. This means that from a quantitative research perspective the consistency and availability of secondary commuting data, outside of the census, are somewhat questionable. The published commuting data that are available are documented in detail in Chapter 3.

The literature review has helped clarify some of the interesting dynamics of commuting propensities and patterns in the UK. The review has highlighted how overall commuting patterns are determined by the different propensities that population sub-groups have to travel by certain modes, and how these have changed over time. Thus, the observed macro UK or regional level commuting patterns and propensities are the product of the sociodemographic makeup of the area in question. Likewise, the sociodemographic variations in commuting propensities are the product of micro level individual preferences and constraints.

By extension of the above point, the review has provided an initial insight into the different commuting propensities of different population sub-groups. Thus it has made clear that researchers have identified distinct differences in commuting behaviour and propensities between different sociodemographic groups. Some of the key differences are between: men and women, younger people and older people, individuals from a BME background and those not, individuals in good health and those not, individuals with caring or childcare responsibilities and those without, professional employees and non-professional employees, highly qualified individuals and unqualified individuals, and full-time workers and part-time workers.

Attention has been drawn to the emergence of homeworking practices in the UK. The relatively recent increase in homeworking is an important trend when considering spatial and sociodemographic commuting patterns and propensities. It could be relatively easily excluded from an analysis of commuting patterns as no traditional form of commuting is taking place in order to transport the employee from their place of residence to their place of work. However, the rise of homeworking, specifically in the form of teleworking or telecommuting, arguably requires a wholesale reconceptualization of the meaning and process of commuting. Given that a teleworker or telecommuter still has a place of residence and is still in employment, homeworking raises interesting questions about how one defines a place of work in contrast to a place of residence and where one draws the line as to what counts as commuting.

Finally, and perhaps most importantly, the review has expounded the key drivers of the commuting system and thus the patterns observed within it. It has covered historical and contemporary theories of urban development and urban form that have assumptions about commuting behaviour at their core. Each theory of urban development and urban form has followed a slightly different way of thinking about commuting behaviour and the propensities of different population sub-groups which lead to markedly different urban development trajectories, which in turn lead to different commuting patterns. It is therefore the case that the relationship between commuting and urban form is two-way, with commuting behaviour impacting on urban development, and the subsequent urban form impacting on commuting patterns.

3. Data Sources, Spatial Frameworks and Methods

3.1 Introduction

This chapter reviews the available data on commuting to work in the UK that were partially identified in chapters 1 and 2, introduces the spatial frameworks with which these data are analysed and outlines the methods used for data analysis in this research.

Census data are used in this thesis to address the research questions, aims and objectives outlined in Chapter 1. The decadal Census of Population is the key source of commuting data across the UK due to its universal coverage and the detailed information available from different datasets; each of which provides different characteristics of commuters in the UK: the aggregate data, the interaction data; in the form of the SWS, and the microdata; in the form of the I-SARs and SAM (Stillwell *et al.*, 2010). Discussions of alternative sources of commuting data, such as: the LS, commissioned tables, data provided by LAs and the PTEs, as well as commercial data, such as that collected by Telefonica, are also provided.

The main systems of spatial units used to analyse commuting data, which conform to the hierarchy of census geographies, are reviewed in this chapter. Particular attention is paid to OAs, MSOAs, LADs and regions, and how they are aggregated up to different spatial levels. The chapter also discusses alternative spatial frameworks, in the form of functional spatial units, such as TTWAs.

Standardised commuting rates, choropleth mapping and BLR are the main three methods featured in this thesis. However, Simple Linear Regression (SLR), cross-tabulation and chi-square testing are also made use of. The spatial and statistical methods used in subsequent chapters are described and explained in detail in this chapter. Suggestions of alternative methods are reserved for Chapter 8 as they form the basis of some suggestions for further research.

The rest of this chapter is divided into four major sections. Section 3.2 contains a review of different commuting data sources. Section 3.3 introduces the different commuting indicators used in the research. Section 3.4 reviews the available official census based spatial systems for analysing commuting data. Section 3.5 describes and explains the different methods used to analyse the different datasets; with Section 3.5.1 outlining the spatial methods used and Section 3.5.2 outlining the statistical methods used. The final section of the chapter (Section 3.6) contains some concluding remarks.

3.2 Data Sources

This section introduces the commuting-related data and variables that are collected and classified by the census, reviewing the aggregate commuting data and the interaction data. In contrast to these sources of aggregate data, data on individuals are available from the Samples of Anonymised Records (SARs) and SAM, which will also be considered in this section.

Despite every UK census since 1921 having collected information related to commuting behaviour, this chapter will focus primarily on the commuting data available from the 2001 and 2011 censuses as these data are the focus of the research, although 1991 Census microdata are also used.

As indicated in Chapter 2, the 2001 and 2011 censuses in England and Wales and Northern Ireland asked two questions directly related to commuting; they were: *"In your main job, what is the address of your workplace?"* and *"How do you usually travel to work?"*. In Scotland, the equivalent censuses asked the questions: *"What address do you travel to for your main job or course of study (including school)?"* and *"How do you usually travel to your main place of work or study (including school)?"*. Using the responses to these and other questions, the respective NSAs of England and Wales, Northern Ireland and Scotland have produced estimated univariate measures of commuting behaviour such as: commuter inflows, outflows, origin-destination area flows, distance travelled and mode of transport used for commuting. More complex multivariate data are produced when the commuting data from the census commuting questions are cross-tabulated with data from other census questions by the NSAs to produce data on commuter counts, commuting distance and mode of transport in relation to age, sex, ethnic group, etc.

The major difference in the census questions asked in the UK relates to the inclusion of children and students 'commuting' to school and college in Scotland. Whereas the 2001 SWS in England and Wales and Northern Ireland only contain commuting data related to people travelling from their home to their workplace; the equivalent data in Scotland are called the Special Travel Statistics (STS), reflecting that they also contain commuting data for those travelling from their home locations to their places of study (Stillwell and Duke-Williams, 2007).

While in Scotland the STS contain data for both individuals commuting to their places of work and their places of study, in England and Wales the main source of data for individuals commuting to their places of study is the Pupil Level Annual School Census (PLASC). PLASC data are available through the National Pupil Database, which contains all the PLASC data collected since the 2001-02 academic year, allowing one to examine the spatial dynamics of commuting to school (Harland and Stillwell, 2007i). Although the PLASC dataset can be analysed to understand the commuting patterns of pupils *per se*, the PLASC dataset is particularly important from a policy perspective, with it being used to improve the predictive capabilities of local education planners in the context of changing demographics and an increasingly liberalised education market (Harland and Stillwell, 2007ii).

Commuting variables are also available from the SARs and the SAM. Like the aggregate and interaction commuting datasets, these microdata datasets both have data on commuting by distance and mode of transport. However, they cannot be used at a small area level because their sample sizes are too small for detailed spatial analysis. The main advantage of these microdata datasets is that they can be used to investigate relationships between commuting behaviour and certain combinations of individual and household demographic and socioeconomic variables that are unavailable from the aggregate and interaction data.

Each of the above sources provides data and information on commuting from a different perspective, with each having its own specific advantages and disadvantages when used for research purposes. Access to most of these different types of data is facilitated through the services of the new UK Data Service (UKDS) or Nomis. The following sections look in more detail at the information available from each of these datasets.

3.2.1 The aggregate data

Census aggregate data are currently available from InFuse[1], Casweb[2] and Nomis[3]. InFuse, which is now a primary portal for accessing the aggregate data, currently provides access to 2001 and 2011 census data. Casweb, which is in the process of being completely replaced by InFuse, currently provides access to 1971, 1981, 1991 and 2001 census aggregate data. There are no plans to make the 2011 Census data available through Casweb (Census Dissemination Unit, 2013). Since Nomis, which is part of the ONS, provides access to data related to the UK labour market, it is another access route for commuting aggregate data. Nomis is largely focused on providing access to labour market-related 2011 Census data, but also provides access to 1981, 1991 and 2001 census data. Given Nomis' focus on labour market related data, it provides access to commuting data that are somewhat less varied and detailed than those provided by InFuse.

The 2001 aggregate data have three topic combinations on commute distance (age; age and daytime population; and age and economic activity) and six on mode of transport (age; age and economic activity; age and sex; age, NS-SeC and sex; age and daytime population; and age and NS-SeC). The 2011 aggregate data only have two topic combinations on mode of transport (age; and age and alternative population). There is no 2011 aggregate data on commute distance. The 2001 commute distance variable has nine categories: 'less than 2km'; '2km to less than 5km'; '5km to less than 10km'; '10km to less than 20km'; '20km to less than 30km'; '30km to less than 40km'; '40 km to less than 60km'; '60km and over' and 'Other (includes no fixed place of

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[1] http://infuse.mimas.ac.uk/

[2] http://casweb.mimas.ac.uk/

[3] https://www.nomisweb.co.uk/

work and working outside of the UK)'. The 2001 mode of transport variable has eleven categories: 'work mainly at or from home'; 'underground, metro, light rail, tram'; 'train'; 'bus, minibus or coach'; 'motorcycle, scooter or moped'; 'driving a car or van'; 'passenger in a car or van'; 'taxi or minicab'; 'bicycle'; 'on foot' and 'other', while the 2011 mode of transport variable has twelve categories: 'work mainly at or from home'; 'underground, metro, light rail, tram'; 'train'; 'bus, minibus or coach'; 'taxi'; 'motorcycle, scooter or moped'; 'driving a car or van'; 'passenger in a car or van'; 'bicycle'; 'on foot'; 'other method of travel to work' and 'not in employment'.

Through InFuse, the 2001 aggregate data are available for countries, regions, counties, LADs and Standard Table (ST) wards, while the 2011 aggregate data are available for countries, regions, counties, LADs, wards, MSOAs, Lower Layer Super Output Areas (LSOAs) and OAs. Through Casweb and Nomis, the 2001 aggregate data are available for countries, regions, counties, LADs, MSOAs, LSOAs, ST wards, Census Area Statistics (CAS) wards and OAs, while the 2011 aggregate data are available through Nomis for countries, regions, counties, LADs, wards, MSOAs, LSOAs and OAs. Due to a lack of disclosure risk, all of the 2001 and 2011 univariate and multivariate aggregate data are available at all of the respective spatial scales. This is not the case with the interaction data.

3.2.2 The interaction data

Census interaction data are currently available from the Web-Based Interface for Census Interaction Data (WICID[4]) (Stillwell, 2006; Stillwell and Duke-Williams, 2003) and Nomis. WICID, which is the primary portal for accessing the interaction data, currently provides access to 1981, 1991, 2001 and 2011 census interaction data. Nomis, which provides some commuting interaction data due to its relevance to the labour market, provides access to far less interaction data for the same four censuses. The interaction data are always amongst the last census products to be created by the ONS from counts supplied by each of the NSAs, mainly due to their complex nature and particular concerns regarding personal confidentiality and data disclosure.

The Special Migration Statistics (SMS), SWS, STS, Special Student Statistics (SSS) and Second Residence Statistics (SRS) constitute the interaction data that have been produced from recent censuses. These are large and complex datasets because they involve two geographies, an origin geography and a destination geography, and capture the counts of flows between each origin and destination pair at each of the spatial scales they are available for.

Commuting flows between residences and workplaces for England and Wales and Northern Ireland are available in the form of the SWS from the 1981, 1991, 2001 and 2011 censuses.

[4] https://wicid.ukdataservice.ac.uk/

Whilst commuting data were available for Scotland from the SWS in 1981 and 1991, in 2001 they were replaced by the STS, a dataset providing commuting flows to places of study as well as to places of work, when the destination was in Scotland. This inconsistency means that the England and Wales data and the Scotland data are not directly comparable. Due to the STS only being available for Scotland and due to the inclusion of schoolchildren and students in the datasets and the resulting inconsistency, the STS are not used in this research.

Through WICID, the 2001 SWS can be disaggregated by eight univariate variables at LAD level: sex; age; ethnic group; NS-SeC; mode of transport; living arrangements; employment status and industry, and six multivariate variable combinations: age and sex; living arrangements and employment status and sex; NS-SeC and sex; industry and sex; ethnic group and sex; and employment status and sex, while the 2011 SWS can be disaggregated by 13 univariate variables at LAD level: sex; age; mode of transport; NS-SeC; occupation; family status; hours worked; economic activity; industry; approximated social grade; car or van availability; country of birth and passport held.

In addition to collecting data directly related to commuting behaviour, the 2011 Census in England and Wales collected information for the first time on the usage and locations of second addresses for work purposes. The 2011 Census in England and Wales asked two questions related to the ownership and usage of second homes (ONS, 2010). Question 5 of the 2011 Census asked: *"Do you stay at another address for more than 30 days a year?"* The census form then directed the respondent, if the answer was yes, to write the UK address of the property or the country where the property is located, if outside of the UK. Question 6 of the 2011 Census then asked: *"What is that address?"*, directing the respondent to tick one of the following seven options: 'armed forces base address'; 'another address when working away from home'; 'student's home address'; 'student's term-time address'; 'another parent's or guardian's address'; 'holiday home' or 'other'. As the latter question allowed respondents to indicate that their second address was an address used when working away from home, the SRS provide useful additional information for the investigation of commuting behaviour and patterns, as their availability opens up the possibility of researching the behaviour and patterns associated with short-term temporary migration (or long-term commuting) within England and Wales for employment purposes. The use of a second address for employment purposes is likely to impact on an individual's commuting behaviour, and therefore national commuting patterns, both directly and indirectly. The 2011 censuses in Scotland and Northern Ireland did not ask any questions about the ownership of second homes. The data from the second home question were used to produce the SRS, providing flow data on the locations of usual residences, places of work and locations of second residences in England and Wales.

Through WICID, the 2011 SRS can be disaggregated by 11 univariate variables at LAD level: second address type; sex; age; ethnic group; mode of transport; NS-SeC; family status; economic activity; tenure; country of birth and passport held.

The 2001 SWS and the 2011 SWS and SRS are available for regions, LADs, wards, MSOAs, LSOAs and OAs. However, due to disclosure risks, different SWS and SRS datasets are available at different spatial scales, so not all 2001 and 2011 SWS and 2011 SRS datasets are available at all of the respective spatial scales. Confidentiality and disclosure are a particular concern with interaction data as OAs have been used to collect, compile and compute the flows. OAs were introduced in 2001 when the decision was taken to use a different set of geographical areas for census outputs to the Enumeration Districts that were used for data collection, and were the smallest geographical units used for the 2001 Census (Stillwell *et al.*, 2010). Although it was this OA geography that was used as the basic geographical building bricks by the different NSAs to collect, compile and compute the interaction data, only a limited set of interaction data were released at the OA level.

As the SWS take the form of large sparsely populated matrices they are of particular concern to the NSAs when it comes to protecting the confidentiality of individual respondents and preventing the disclosure of data about particular individuals, even at the MSOA and LAD levels. In order to preserve the confidentiality of the data on individual census respondents, the NSAs are forced to make a trade-off between the level of detail provided by a dataset in terms of the univariate or multivariate structure of the table concerned and the level of geographical detail. Thus, in general, interaction datasets that provide a high level of variable detail or where cells may contain small numbers (e.g. commuting flows by ethnic group) are only available at higher geographical output levels, while interaction datasets that do not provide as much detail about the population are available at all geographical output levels. This relationship between the detail of the output geography and the detail of the extractable data extends to the variable categories available within the different interaction datasets.

Level 1 is the highest geographical output level, with a geography that has relatively less detail than levels 2 and 3. However, this low level of detail means that more tables and variables are available at the LAD level than at the Ward/MSOA or OA levels. Level 2 is the middle census-based geographical output level. The Ward/MSOA level has a geography that is more detailed than the LAD level but less detailed than the OA level and has available datasets that are more detailed than at the OA level but less detailed than at the LAD level. Level 3 is the lowest geographical output level, with a relatively detailed geography. Fewer data and datasets are available at the OA level than at the LAD or Ward/MSOA level.

Table 3.1 presents a summary of the number of tables and variable counts from the 2001 SWS and 2011 SWS and SRS for the different geographical output levels used by ONS. Table 3.1

shows that as the level of detail of the output geography increases; that is moving down from Level 1 to Level 3, the number of available tables and variable counts from the SWS and SRS datasets generally decreases.

Table 3.1: Table, univariate and multivariate variable counts for the 2001 and 2011 SWS and the 2011 SRS by geographical output level

Datasets	Level 1	Level 2	Level 3
2001 SWS	Tables: 9 Univariate: 8 Multivariate: 6	Tables: 7 Univariate: 7 Multivariate: 2	Tables: 2 Univariate: 1 Multivariate: 0
2011 SWS	Tables: 40 Univariate: 13 Multivariate: 0	Tables: 42 Univariate: 13 Multivariate: 0	Tables: 9 Univariate: 1 Multivariate: 0
2011 SRS	Tables: 32 Univariate: 11 Multivariate: 0	Tables: 10 Univariate: 2 Multivariate: 0	Tables: 8 Univariate: 0 Multivariate: 0

Source: WICID (2016).

In 2001, the SWS dataset was subjected to a number of Statistical Disclosure Control (SDC) measures, including suppression, imputation and adjustment methods, in order to minimise the risk of disclosing sensitive individual level data. These suppression and imputation methods included: over-imputation, record swapping, the Small Cell Adjustment Method (SCAM) and imposing population thresholds (Duke-Williams, 2010).

Over-imputation and record swapping are pre-aggregation SDC methods, meaning that they were applied to individual census records before they were aggregated into the SWS dataset. Over-imputation was the process by which whole records, or some variables within records, were deleted and then replaced with imputed values, while record swapping was a process in which two census records, from two different geographical areas, were exchanged with each other. ONS (2003) reports that the national imputation rates for the workplace postcode data and the mode of transport data were 6.4% and 5%, respectively.

SCAM and population thresholding are both forms of post-aggregation SDC, meaning that they were applied to the SWS datasets after they had been created from the individual census records. Although SCAM was not explicitly outlined by ONS, it is apparent that it involves the adjustment of values of 1 and 2 in the original SWS interaction datasets to take the values of 0 or 3, with a 1 more likely to become a 0 than a 3 and a 2 more likely to become a 3 than a 0, albeit with the exact probabilities of the different numerical modifications being unknown. A simpler but cruder post-aggregation approach to SDC for the 2001 Census was the imposition of population thresholds for those geographical output areas for which data were to be released, with the data for areas which had populations below the pre-defined threshold not being released.

SCAM was a particularly contentious SDC method due to its far-reaching effects, but also due to the lack of consultation regarding its implementation. Furthermore, it was not applied to the STS with origins in Scotland at levels 1 or 2, but all SWS commuting flow data at all geographical levels in England and Wales and Northern Ireland and all STS commuting flow data at OA level in Scotland were subjected to SCAM (Stillwell and Duke-Williams, 2007), with the result that the vast majority of the original commuting data for the UK were profoundly altered. The data alterations caused by SCAM were particularly acute for the SWS and STS commuting interaction datasets at the OA level due to values of 1 and 2 being widely prevalent in the large and sparsely populated origin-destination matrices at that level (Stillwell and Duke-Williams, 2007). In addition to the concerning effect of SCAM on the raw SWS and STS counts, there are also effects on all the marginal, and subsequently final, totals. The transformation of 1s and 2s into 0s and 3s means that the SWS interaction data flows are dominated by 3 or multiples of 3, particularly at OA level (Duke-Williams, 2010). Additionally, although individual SWS tables are consistent, as marginal and final totals were recalculated using the data that had been ‘SCAMed’, there are inconsistencies between different SWS tables (Duke-Williams, 2010). These inconsistencies between different tables exist because individual tables were SCAMed independently. As the 2011 Census interaction data have not been subject to the SCAM, the 2011 SWS and SRS are more reliable and accurate than the 2001 SWS. However, this inconsistency must be kept in mind when analysing the 2001 and 2011 SWS together.

SCAM was not used on interaction data from pre-2001 censuses. In order to avoid problems of confidentiality in 1981 and 1991, the Office of Population Censuses and Surveys (OPCS) extracted a 10% sample of the total commuting flows from the 1981 and 1991 census databases. While this approach means that the original data have not been adversely altered, they only consist of a 10% sample which somewhat limits their use from a spatial analysis perspective since the numbers may be very small in the majority of cells in the origin-destination matrix. However, the 1991 SWS data can be seen as representative of the whole UK working population at the time and would therefore be appropriate for a statistical analysis of commuting behaviour and patterns.

In addition to the problems that are likely to be caused by different SWS interaction datasets with different variables being available for different geographical output levels, despite the time, money and effort that go into producing the origin-destination data, they do have other shortcomings. Critiques of the census interaction data are available in Rees *et al*. (2002i), Rees *et al*. (2002ii) and Cole *et al*. (2002). The latter point out that the quality of the origin-destination flow data in the pre-2001 censuses may have been compromised by inaccuracy in the processing of the postcode system. A review of the accuracy of postcodes by the OPCS in the 1980s found that the translation of postcodes into wards was only accurate in 93% of cases and that only 72% of grid references contained within postcodes were accurate to within 100 metres (Raper *et al.*, 1992). These problems regarding the accuracy of the underlying census data areas, particularly for the earlier censuses, mean that the final releases of both the interaction datasets may not be particularly accurate.

The analytical usefulness of the SWS is brought into question since the only way to measure the distance that commuters travel is to calculate the Euclidean distance between the centroids of an individual's zone of residence and zone of employment. As Cole *et al.* (2002) explain, this is less likely to be a problem when analysing commuting in urban areas, where geographical output zones are relatively small and compact, but is likely to be more of a problem in more rural areas, where population densities are lower and geographical output areas are consequently larger and sparser.

One of the key problems with using data from different censuses is the boundary changes that hinder the comparison of flows and the identification of changes that might have taken place in commuting patterns over time. In response to this, the 1981 SWS at ward level were re-estimated to allow comparisons to be made between the 1981 and 1991 data and the 1981 and 1991 data were re-estimated to be consistent with 2001 boundaries (Boyle and Feng, 2002). This re-estimation was carried out in order to address the problem that, due to changes in the boundaries of small areas over time, very little academic work had attempted to investigate local-level commuting flows. These re-estimated 1981 and 1991 datasets have been made available through WICID (Stillwell and Duke-Williams, 2001).

3.2.3 The microdata

Census microdata are currently available directly from the UKDS[5]. The UKDS currently provides access to 1991, 2001 and 2011 census microdata. The I-SARs, Household Sample of Anonymised Records (H-SARs), SAM, Individual Controlled Access Microdata Samples (I-CAMs) and Household Controlled Access Microdata Samples (H-CAMS) constitute the main microdata products extracted from recent censuses. They provide a range of individual level variables for a large random sample of the UK population (Boyle and Dorling, 2004) and are created from samples of microdata for both households and individuals (Tranmer *et al.*, 2005). They are a useful addition to the aggregate and interaction data as they have a great deal of variable detail at the expense of having little geographical detail (Tranmer *et al.*, 2005).

The microdata from the 1991 Census include the I-SAR and the H-SAR. The 1991 I-SAR was produced from a 2% sample of the population and made available at LAD level, while the 1991 H-SAR was produced from a 1% sample of households and made available at region level.

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[5] https://www.ukdataservice.ac.uk/

The microdata products from the 2001 Census include: the Individual Licensed Sample of Anonymised Records (referred to as the 2001 I-SAR) and the Special License Household Sample of Anonymised Records (referred to as the 2001 H-SAR). The 2001 I-SAR was produced from a 3% sample of the population, but unlike the 1991 I-SAR, was only available at region level, and not made available at LAD level (Tranmer *et al.*, 2005), while the 2001 H-SAR was produced from a 1% sample of households and contains no geographical detail. In 2001, the microdata products from the 2001 Census were augmented with the production of the SAM, I-CAMS, and H-CAMS (Cathie Marsh Institute for Social Research, 2013). The SAM was produced from a 5% sample of the population, the I-CAMS were produced from a 3% sample of the population, and the H-CAMS were produced from a 1% sample of households. The SAM, I-CAMS and H-CAMS were all made available at LAD level.

The 2011 microdata consists of a Public SAR, two safeguarded I-SARs and a secure I-SAR and H-SAR. The Public SAR was produced from a 3% sample of individuals and contains no geographical detail. The two safeguarded I-SARs were produced from a 5% sample of individuals, with the first to be released being made available at region level and the second being made available at LAD level. The secure I-SAR and H-SAR were produced from 10% samples of individuals and households, respectively, and are available at LAD level.

Unlike with the aggregate data, use of the microdata is affected by a complex set of licence agreements and differing availabilities due to concerns regarding confidentiality and disclosure, related to their differing sample sizes and geographical output levels. While access to the 2011 public SAR is completely open and access to the 1991 I-SAR, 1991 H-SAR, 2001 I-SAR and 2001 SAM are all downloadable after an End User Licence agreement, access to the other microdata products is more complicated. The 2001 H-SAR is only downloadable after a Special Licence agreement, while the 2001 I-CAMS and H-CAMS are only available at ONS offices in London, Newport and Titchfield after an application for Approved Researcher Status has been reviewed and approved by the Census Research Access Board (CRAB) at the ONS. The three different 2011 microdata access tiers used by the ONS are: ‘Public use files’, ‘Safeguarded files’, and ‘Virtual Microdata Laboratory files’ (ONS, 2013i). The only public use dataset is the Public I-SAR, which is made available by an Open Government Licence, while the two 5% I-SARs are safeguarded and only available after a Special User agreement, and the two 10% are only available at an ONS office after being granted Approved Researcher status. Table 3.2 summarises the microdata products available from the 1991, 2001 and 2011 censuses and the sample size, geographical output level, licence requirements and availability of each product.

Table 3.2: Size, coverage and availability of 1991, 2001 and 2011 census microdata

File Name	Sample Size	Geographical Output Level	Licence	Availability
1991 I-SAR	2%	LAD	End User Licence agreement	Downloadable
1991 H-SAR	1%	Region	End User Licence agreement	Downloadable
2001 I-SAR	3%	Region	End User Licence agreement	Downloadable
2001 H-SAR	1%	None	Special Licence agreement	Downloadable after Special Licence agreement
2001 SAM	5%	LAD	End User Licence agreement	Downloadable
2001 I-CAMS	3%	LAD	CRAB approval	Secure environment
2001 H-CAMS	1%	LAD	CRAB approval	Secure environment
2011 Public SAR	3%	None	Open Government Licence	Downloadable
2011 I-SAR (Region)	5%	Region	Safeguarded	Downloadable after Special User agreement
2011 I-SAR (LA)	5%	LAD	Safeguarded	Downloadable after Special User agreement
2011 I-SAR	10%	LAD	Approved Researcher	Secure environment
2011 H-SAR	10%	LAD	Approved Researcher	Secure environment

Source: UKDS (2016).

Due to differences in geographical output levels and availability, the research in this thesis only makes use of the 1991, 2001 and 2011 I-SARs and the 2001 SAM. These four microdata datasets provide distance and mode of transport variables that contain a number of different categories depending on the dataset and year.

The 1991 I-SAR has 11 distance categories: ‘not applicable’; ‘not stated’; ‘at home nfp’; ‘work outside GB’; ‘0-2km’; ‘3-4km’; ‘5-9km’; ’10-19km’; ’20-29km’; ’30-39km’ and ‘40km and over’, and 12 mode of transport categories: ‘not applicable’; ‘not stated’; ‘works at home’; ‘B.R. train’; ‘other rail’; ‘bus’; ‘motor cycle’; ‘car-driver’; ‘car-passenger’; ‘pedal cycle’; ‘on foot’ and ‘other’.

The 2001 I-SAR distance variable has 12 categories: ‘not applicable’; ‘less than 2km’; ‘2km to less than 5km’; ‘5km to less than 10km’; ‘10km to less than 20km’; ‘20km to less than 40km’; ‘40km and over’; ‘at home’; ‘no fixed place’; ‘work outside Great Britain but within UK (England, Scotland and Wales only)’; ‘work outside Northern Ireland but within UK (Northern Ireland only)’ and ‘work outside UK’. The 2001 I-SAR mode of transport variable has 13 categories: ‘not applicable’; ‘mainly work at or from home’; ‘underground, metro, light rail, tram or tube’; ‘train’; ‘bus, minibus or coach’; ‘motorcycle, scooter or moped’; ‘driving a car or van’; ‘passenger in a car or van’; ‘taxi or minicab’; ‘bicycle’; ‘on foot’; ‘other’ and ‘car or van pool (Northern Ireland only)’. The 2001 SAM distance variable has six categories: ‘not applicable’; ‘less than 5km’; ‘5 and less than 20’; ‘20 and over’; ‘at home’ and ‘no fixed place’, and eight mode of transport categories: ‘not in work’; ‘work mainly at or from home’; ‘train, including underground, metro, light rail, tram etc.'; 'bus, minibus, coach'; 'motor cycle, scooter or moped'; 'car'; 'bicycle' and 'on foot/other'.

The 2011 I-SAR has 13 distance categories: 'not applicable'; 'less than 2km'; '2 to < 5km'; '5 to <10km'; '10 to < 20km'; '20 to <40km'; '40 to <60km'; '60km or more'; 'at home'; 'no fixed place'; 'work outside England and Wales but within UK'; 'work outside UK' and 'works at offshore installation (within UK)', and 12 mode of transport categories: 'not applicable'; 'work mainly at or from home'; 'underground, metro, light rail, tram'; 'train'; 'bus, minibus or coach'; 'taxi'; 'motorcycle, scooter or moped'; 'driving a car or van'; 'passenger in a car or van'; 'bicycle'; 'on foot' and 'other'.

3.2.4 Homeworking data issues

It should be noted that, in addition to individual issues with the aggregate data, interaction data and microdata, there are further issues and discrepancies when comparing the three datasets against each other in 1991, 2001 and 2011. These discrepancies are caused by the treatment of individuals who 'work at or from home' being different in the three years.

In 2001, individuals who worked at or from home were automatically assumed to have the same place of work as place of residence and were included in the SWS totals. However, in 2011, individuals who worked at or from home were excluded from the SWS totals. This exclusion of individuals who worked at or from home from the 2011 SWS totals means that the default 2001 SWS tables and the default 2011 SWS tables are not directly comparable. If comparable datasets for 2001 and 2011 are required, with both including individuals who worked at or from home, one must download the relevant 2011 aggregate homeworking data and combine it with the 2011 SWS data.

However, after rectifying this initial problem, it also became apparent that the way in which homeworkers are defined and recorded varies by census and dataset. Table 3.3 contains the definitions of homeworking used by each source. In 1991, no SWS data on homeworking were available and the aggregate data and the I-SAR (mode variable) data counted homeworkers as those working at home whereas the I-SAR (distance variable) counted those at home or with no fixed place of work. In 2001, the count of homeworkers in the aggregate data and in the I-SAR (mode) changed to 'mainly at or from home' and this definition was also used in the SWS. The same definitions were applied in 2011, except that the aggregate data were initially released with homeworkers defined as only those working at home, before subsequent aggregate data were released with homeworkers working at or from home, in order to facilitate comparisons with the 2001 aggregate data (see Section 3.3.1). In both the 2001 and 2011 I-SAR (distance variable), however, the definition 'at home (at home and no fixed place)' was used.

Table 3.3: Definitions of homeworkers from different census datasets in 1991, 2001 and 2011

	Aggregate Data (Mode)	I-SAR (Distance)	I-SAR (Mode)	SWS Data (Mode)
1991	Works at home	At home nfp	Works at home	-
2001	Work mainly at or from home	At home (At home and nfp)	Work mainly at or from home	Work mainly at or from home
2011	Work mainly at or from home	At home (At home and nfp)	Work mainly at or from home	Work mainly at or from home

Source: Derived from the 1991, 2001 and 2011 Census Aggregate Data, SWS and Microdata.

The 1991 aggregate data shown in Tables 3.4 and 3.5 suggest that 5% of commuters worked at home (see Table 3.6). This percentage increased substantially to 9.2% in 2001, but this is partly explained by the definition of homeworking changing to include those working from home as well as those working at home. When using the same definition as 2001 (from Table QS703EW), the 2011 aggregate data suggest that the percentage working mainly at or from home increased again to 10.3%. However, when using the initial 2011 definition (from Table QS701EW), the data show that only 5.4% worked at home.

The 1991 SWS data are not included as they were produced from a sample of the population (see Section 3.2.2). After correcting for the complete exclusion of homeworkers from the 2011 SWS, the 2001 and 2011 SWS data are directly comparable, as they use the same homeworking definition (see Table 3.3), with Table 3.6 showing that 9.4% and 11.4% of commuters were homeworkers in 2001 and 2011, respectively.

Because of the different definitions of homeworkers in the 1991 and 2001 I-SARs, we cannot say that there was an increase from 5.2% to 9.5% using the mode variable or from 11.9% to 13.9% using the distance variable between 1991 and 2001. However, although the distance and mode homeworking data from the 1991 I-SAR are not directly comparable with that from the 2001 and 2011 I-SARs due to the changing definitions of homeworkers (see Table 3.3), the 2001 and 2011 I-SARs are directly comparable. It is also possible to make the homeworking data from the distance variable in the 2001 and 2011 I-SARs comparable, if less useful, by aggregating homeworkers and those with no fixed place of work in 2001 and 2011.

The 2001 I-SAR distance and mode variables both indicate that 9.5% of commuters worked at or from home, with this proportion clearly comparable to the percentages shown by the aggregate data and SWS data in 2001. Similarly, the 2011 I-SAR distance and mode variables both indicate that 10.5% of commuters worked at or from home, which is comparable to the percentage shown by the aggregate data (10.3%) and not massively different to that shown by the SWS (11.4%).

Overall, Table 3.6 shows that there were largely consistent proportions of homeworkers in 2001 and 2011 across all the datasets. It is also clear that the differences between the different datasets in 1991 are due to differences in the definition of homeworkers, with the 1991 aggregate data and I-SAR mode variable indicating similar percentages while the I-SAR distance variable indicates a much higher percentage due to the inclusion of those with no fixed place of work.

What is not completely clear is the slight difference between the aggregate data and microdata percentages and the SWS percentage in 2011 (10.3% and 10.5% against 11.4%). However, given that the SWS are only used in Chapter 5, to examine commuting self-containment at LAD level across England and Wales, and in Chapter 7, to examine in-commuting, out-commuting and commuting self-containment at MSOA level across the LCR, with homeworkers being excluded from the analyses in both cases, the above issue does not affect the data analyses in this thesis.

Table 3.4: Number of homeworkers in England and Wales aged 16-74 from different census datasets in 1991, 2001 and 2011

<table>
<tr><th></th><th colspan="2">Aggregate Data (Mode)</th><th>I-SAR (Distance)</th><th>I-SAR (Mode)</th><th>SWS Data (Mode)</th></tr>
<tr><td>1991</td><td colspan="2">105,715
(Table: 82 (10% Sample), Variable: 11)</td><td>47,879
with nfp</td><td>21,047</td><td>-</td></tr>
<tr><td>2001</td><td colspan="2">2,170,547
(Table: KS015, Variable: 2)</td><td>66,664
(98,053 with nfp)</td><td>66,664</td><td>2,139,677
(Table: SWS Level 1 Table 3, Variables: 19 and 22)</td></tr>
<tr><td rowspan="2">2011</td><td>‘Working At Home ONLY’</td><td>‘Working At Home AND From Home’</td><td rowspan="2">133,679
(237,952 with nfp)</td><td rowspan="2">133,679</td><td rowspan="2">2,778,019
(Table: WU03UK, Variable: 2)</td></tr>
<tr><td>1,422,708
(Table: QS701EW, Variable: F561)</td><td>2,724,010
(Table: QS703EW)</td></tr>
</table>

Source: Derived from the 1991, 2001 and 2011 Census Aggregate Data, SWS and Microdata.

Table 3.5: Number of commuters in England and Wales aged 16-74 from different census datasets in 1991, 2001 and 2011

	Aggregate Data (Mode)		I-SAR (Distance)	I-SAR (Mode)	SWS Data (Mode)
1991	2,097,054 (Table: 82 (10% Sample), Variables: 2-11)		402,456	402,456	-
2001	23,627,754 (Table: KS015, Variables: 2-12)		703,407	703,407	22,698,517 (Table: SWS Level 1 Table 3, Variables: 7 and 10)
2011	'Working At Home ONLY'	'Working At Home AND From Home'	1,275,946	1,275,946	24,403,079 (Table: WU03UK, Variables: 1 and 2)
	26,526,336 (Table: QS701EW, Variables: F561-F571)	26,526,336 (Table: QS703EW)			

Source: Derived from the 1991, 2001 and 2011 Census Aggregate Data, SWS and Microdata.

Table 3.6: Percentage of homeworkers in England and Wales aged 16-74 from different census datasets in 1991, 2001 and 2011

	Aggregate Data (Mode)		I-SAR (Distance)	I-SAR (Mode)	SWS Data (Mode)
1991	5.0%		11.9% with nfp	5.2%	-
2001	9.2%		9.5% (13.9% with nfp)	9.5%	9.4%
2011	'Working At Home ONLY'	'Working At Home AND From Home'	10.5% (18.6% with nfp)	10.5%	11.4%
	5.4%	10.3%			

Source: Derived from the 1991, 2001 and 2011 Census Aggregate Data, SWS and Microdata.

3.2.5 Alternative data

Given the coverage of the aggregate and interaction datasets, and the level of individual detail afforded by the census microdata datasets, they remain the primary sources for reliable and representative commuting data in the UK. However, there are a number of other census datasets and non-censal data sources that can be used to investigate commuting, including: the Longitudinal Studies (LSs), commissioned tables, the NTS; PTEs; LAs; and commercial organisations. Although it was judged that none of these datasets could rival the three datasets used, each can be used to gain different perspectives on commuting in the UK. It must be noted however, that data from non-censal sources are often overly simple, only available for larger aggregate spatial units and limited by their sample sizes (Stillwell *et al.*, 2010).

Like the I-SARs and SAM, the UK LSs provide variables at the individual level for a sample of the UK population (Boyle and Dorling, 2004). There are three UK longitudinal studies: the

ONS LS, which is available through the Centre for Longitudinal Study Information and User Support (CeLSIUS) based at University College London (Centre for Longitudinal Study Information and User Support, 2007), the Scottish LS, which is available through the Longitudinal Studies Centre Scotland (LSCS) based at the University of St Andrews (Longitudinal Studies Centre Scotland, 2013), and the Northern Ireland LS, which is available through the Northern Ireland Longitudinal Study Research Support Unit (NILS-RSU) based at Queens University Belfast (Northern Ireland Longitudinal Study Research Support Unit, 2008).

In addition to those aggregate and interaction datasets made available to all users by the ONS, it is possible for researchers to commission their own tables. Once these tables have been generated, they are then made publicly available as commissioned tables. To date, there have been 60 tables commissioned from the 1991 and 2001 censuses related to commuting. However, the 15 commissioned tables from the 1991 Census are no longer available from ONS due to technical problems with the discs on which they were stored (ONS, personal contact). Although there are a relatively large number of commissioned tables from the 2001 Census, they were not used for this research as only six of the commissioned tables provide UK-wide geographical coverage. In addition, as the 2011 Census data has been released relatively recently, there are currently no commissioned tables related to commuting (ONS, personal contact).

The NTS is a household survey that provides data on personal travel behaviour. The first NTS was commissioned by the Ministry of Transport in 1965/66 (Economic and Social Data Service, 2013) and has run continually since 1988 (Department for Transport, 2011). Since 2002, the NTS has surveyed about 16,000 households per year. The NTS data are collected through interviews with the participants and a travel diary that they keep for a week; the NTS tracks both short-term changes in travel behaviour and the evolution of long-term travel trends (Department for Transport, 2011). As the NTS is carried out annually, the data it produces allows for the analysis of seasonal and cyclical travel behaviour which is not possible with data from any other nationally representative source. It is also the case that the NTS provides more detailed information about the travel undertaken by individuals and households for employment purposes than the decadal national census does. The NTS not only collects information on where and how people travel, but also on why and when people travel as well as information on car availability and driving licence acquisition (Department for Transport, 2013).

Information and data from the NTS are available to download from DATA.GOV.UK, and are made available to the public through an open government license. The most recent, currently available, NTS data for 2014 were published in September 2015 (GOV.UK, 2015).

However, the NTS suffers from some of the same problems as the national census in that the survey and the methodology used over time have changed. These changes mean that time-series analyses of the data can be misleading and unreliable. Although there have been no major structural or sample size changes to the NTS since 1988 (Kershaw, 2001), changes in the number of people included in the survey over the 1965/66 to 2011/12 period mean that the data produced are not consistently representative. Furthermore, unlike the census, the NTS achieves nowhere near universal coverage. Even if the aim of including 20,000 people in the survey is achieved, this would only amount to 0.03% of the current UK population. This small potential sample size is further reduced by selected individuals and households refusing to take part in the survey, with the NTS only achieving a 64% response rate in 2000 (Kershaw, 2001).

The Local Transport Act 2008 (The National Archives, 2008) gave the ITAs and their respective PTEs across the UK the power to govern, review and propose their own local travel arrangements in order to support the coherent planning and delivery of transport at the local level (Department for Transport, 2012). The PTEs are responsible for governing, reviewing and proposing their own local travel arrangements and plan and deliver transport services at the local level (Department for Transport, 2012) and the practical delivery of integrated transport networks in the UK's main urban areas (Passenger Transport Executive Group, 2013ii). This means that the PTEs are now responsible for the delivery and running of local transport networks and the collection of any local travel data and information required for transport planning.

The PTEs of the West Midlands urban area (Centro), Merseyside (Merseytravel), Greater Manchester (TfGM), South Yorkshire (SYPTE), West Yorkshire (Metro) and Tyne and Wear (Nexus) are jointly represented by the Passenger Transport Executive Group (PTEG), with Bristol and the West of England, Leicester City Council, Nottingham City Council, Strathclyde Partnership for Transport (SPT) and TfL being associate members (Passenger Transport Executive Group, 2013i). TfL is the most prominent PTE in the UK, collecting data pertaining to London Underground passengers, Oyster Card journeys and user's origins and destinations, amongst other things (Transport for London, 2013ii).

As London is such a substantial part of the UK economy, accounting for 25% of UK GDP (EURIM, 2006) and 12.5% of the UK population (Greater London Authority, 2013), data from TfL have the potential to make a sizeable contribution to an investigation of UK commuting patterns. However, the information and data that TfL collects are specific to the parts of the Greater London transport network that it is responsible for and the people that use those parts. TfL is responsible for London Underground, London Rail and surface transport (which includes buses, river services and red-route roads), but is not responsible for motorways, which are the responsibility of the Highways Agency (Highways Agency, 2013), or for non-red-route roads within Greater London, which are the responsibility of the individual London Boroughs, which are in turn responsible for 95% of London's road network (London European Partnership for Transport, 2013). TfL does monitor the capital's road network, but does not collect information or data related to car usage within Greater London as it falls outside of its main remits, which are the implementation of the London Mayor's transport strategy and the management of the transport services for which the Mayor is responsible (Transport for London, 2013iii).

The Tyne and Wear PTE also collects data on travel by carrying out the Tyne and Wear Household Travel Survey (HTS). The current Tyne and Wear HTS was started in 2003 and is carried out in order to gather data and information about travel patterns to inform long-term planning strategies (Tyne and Wear Household Travel Survey, 2006). The HTS carried out by Nexus provides data pertaining to the sociodemographic and socioeconomic characteristics of the households surveyed, as well as data on the purpose and length of different trips and the modes of travel used. This PTE data could therefore be used like the SARs, providing the data for an in-depth statistical analysis of commuting behaviour and patterns within a major metropolitan area.

However PTE data were not judged to be appropriate for the research for a number of reasons. Given the focus that the PTEs have on transport policy and delivery and their limited geographical jurisdictions, the data they provide was unlikely to be detailed enough to make a substantial contribution to an in-depth investigation of commuting behaviour and patterns at the national level. The main weakness of the travel data and information provided by PTE surveys is that the surveys are only carried out within the jurisdictions of the PTEs in question. Thus, the surveys provide no data pertaining to the, often substantial, number of individuals and households whose travel behaviour is multi-jurisdictional in nature. From a commuting perspective this was an important weakness, as PTEs cover the main urban and metropolitan areas in the UK that are particularly likely to draw in a substantial number of commuters from outside the jurisdiction of the particular PTE that they are covered by.

Under certain circumstances, commuting data can be extracted from Local Education Authority (LEA) sources. An example of this is the extraction of commuting to school data from the PLASC by Harland and Stillwell (2007i). The PLASC contains data that are supplied to the Department for Education by the LEAs. Although Harland and Stillwell (2007i) point out that the PLASC data need to be thoroughly checked and cleaned, in order to resolve inconsistencies and errors and to impute missing data, the PLASC provides invaluable information regarding the daily movements of pupils between their homes and places of study.

Although the PLASC data are specifically for pupils commuting to their places of education, they could contribute in part to an analysis of employees commuting to work as the two commutes are often connected, with children with working mothers more likely to be taken to school by them rather than make their own way there by bike or on foot (McDonald, 2008). This means that a full understanding of commuting to work behaviour and patterns often requires an understanding of commuting to school behaviour and patterns, and *vice versa*.

However, the PLASC is not a perfect dataset for understanding the journey of pupils to their places of study. Harland and Stillwell (2007ii) point out that, as the journey to school is generally short, calculating the distances travelled by pupils from their homes to their schools can be particularly problematic when the exact location of their home or school is not known. In addition, Harland and Stillwell (2007ii) highlight the absence of a 'mode of transport' variable from the PLASC between 2001 and 2006. This means that the usefulness of the PLASC data, regarding investigating the relationship between parents commuting to work and children commuting to school, is somewhat limited, as it is not possible to distinguish between those pupils who made their own way to school by bike or on foot and those pupils who were taken to school by car.

There has been a relatively recent trend toward deriving travel and transport data from commercial sources. The collection and compilation of these datasets is undertaken by private, usually service-providing, companies for customer service reasons, and is justified by the assumption that the more a service provider knows about its customers, the better it can meet their demands (Telefonica, personal contact). Two examples of commercial data sources from which it is possible to extract travel and transport data from are the mobile phone tracking data of mobile network providers and the car tracking data of car insurance companies.

In the case of mobile phone tracking data, the data are available due to the presence of tracking devices in individual mobile phones. The ability to track mobile phones became more widespread after the United States Federal Communications Commission ruled that all wireless communications within the USA needed to be geo-locatable by 1st October, 2001 (Zhao, 2000). The mobile phone tracking data are useful from a commuting perspective, as in most developed countries many people now have their mobile phone on their person much of the time. This means that the tracking data can provide researchers with an extremely detailed view of when, how and where an individual is traveling.

In the case of car tracking data, the data are available when the insurance company has fitted a 'black box' to a car for insurance purposes. These black boxes are common with pay-as-you-drive (PAYD) car insurance, with all of the information used for billing being collected by the black box within the car and then transferred to the insurance company (Troncoso *et al.,* 2007). These car tracking data are useful from a transport and travel perspective as the box relays data regarding where the car has been, how fast it has been going and how far it has travelled. Although PAYD car insurance, and therefore the fitting of black boxes in cars, is still not common, this technology has the potential to provide researchers with a lot of detailed information and data related to car usage by individuals. It is also the case that this technology is likely to become more widespread as PAYD insurance is seen as having distinct advantages for both customers and car insurance companies (Litman, 2007; Zahid and Barton, 2004).

These two examples of the possibility of extracting travel and transport flow data from commercial sources are part of a broader trend towards individuals becoming more geographically traceable. With the modern proliferation of powerful computer systems and hand-held devices, many individuals are, often unwittingly, allowing many aspects of their lives to be temporally and geographically recorded. This trend is opening up new possibilities for the study of human movement, whether from a commuting or migration perspective.

However, these new datasets are not without their shortcomings; there are concerns regarding their representativeness, the ability to distinguish between different types of journeys and the privacy of users.

Concerns regarding the representativeness arise because, with mobile phones being a relatively recent invention, and geo-locatable mobile phones being an even more recent development, it is likely that young and wealthy individuals will be overrepresented in the population of people who own them, while elderly and poor individuals will be underrepresented. The possibility that using geo-locatable mobile phones to investigate transport and travel issues would provide a skewed sample population raises questions about the validity of any findings if this data were used. However, this concern regarding the homogeneity of mobile users may not have been a problem in practice, with some studies finding that the diversity of tracked mobile phone users is relatively high (Kiukkonen *et al.*, 2010).

Despite mobile phone tracking technology having the potential to provide researchers with information regarding when, how and where an individual is travelling, it is not possible to determine the purpose of a trip being made by an individual from the tracking data alone (Asakura and Hato, 2004). Therefore, it would not have been possible to filter out the mobile phone tracking data that were only related to commuting trips, as there would have been no way to distinguish between a journey an individual made from home to a place of work and a journey an individual made for leisure purposes, for example. Therefore, unless assumptions were made about the type of journeys the different data were referring to, the use of the data for an analysis of commuting behaviour and patterns was judged to be somewhat limited.

There are also concerns regarding the privacy of those individuals being tracked, with researchers having to ask whether or not it is ethically permissible to track every aspect of an individual's travel and transport behaviour. However, in practice, studies that have used mobile phone tracking data for monitoring traffic have managed to balance the requirements of collecting data with the privacy of participants (Herrera *et al.*, 2009). It therefore seems likely that, in time, if tracking data becomes more official, they will be seen in the same way that interaction data are now seen, with privacy concerns being dealt with through anonymisation and partial suppression.

It must be noted, however, that despite the current downfalls of commercial travel and transport data, as mobile communication technologies are rapidly improving, their ability to measure transport and travel behaviour and patterns is also likely to improve (Asakura and Hato, 2004). This means that this relatively new way of investigating and understanding the movement of individuals is very likely to become more important and widespread in the future.

3.3 Defining Commuting Indicators

This section is concerned with understanding different commuting propensities and assessing which population at risk (PAR) would be appropriate with different measures of commuting behaviour. Section 3.3.1 focuses on potential commuting numerators and defining the population that commutes while Section 3.3.2 focuses on potential commuting denominators and selecting an appropriate PAR. In order to calculate commuting intensities, one must first decide on both the commuting numerators and denominators to be used. Although this task may initially appear straightforward, the lack of a clear definition regarding what constitutes the commuting population (see Chapter 2) and the difficulties surrounding where one draws the line between individuals who have the potential to commute and those who do not, mean that the task is a more complicated one that ultimately has important implications for subsequent data analysis and thus the final conclusions of the research.

3.3.1 Commuting numerators: The commuters

Before any data analysis can take place, one must decide how to measure the number of commuters. Given the lack of agreement regarding what actually constitutes the commuting population, there are a number of options to choose from and a number of problems that must be confronted. Putting aside alternative measurements and data sources, and confining the data analysis to using the official UK census data, does not completely resolve the problems associated with defining the commuting population. While the census microdata are relatively flexible regarding the inclusion or exclusion of certain groups of individuals as commuters, the aggregate and interaction census data only capture people in formal employment. Therefore, the aggregate statistics and interaction data do not capture people who work but are not employed in a formal sense, such as carers and homemakers. Thus, there are good arguments for using alternative indicators of the number of commuters in the UK, especially if one considers 'work' or 'employment' in a broader sense to include all individuals who are carrying out necessary non-leisure responsibilities, on a daily basis, that have a benefit to the economy or society.

Carers are a particularly important case in point; the line between formal employment and caring responsibilities is blurred, with some individuals redefining their caring responsibilities as employment rather than seeing them as an extension of previous responsibilities (Gibbon, 2001). A widely quoted statistic that carers save the UK economy £57 billion every year (Lloyd, 2006) indicates the importance of carers and caring to the wider economy. Moreover, caring benefits society and has the potential to benefit society even more, especially if caring were to become more evenly shared across communities and between men and women (Higgins, 2007). It is easy to see, therefore, why a group such as carers, who spend so much time on non-leisure responsibilities and contribute so much to the UK economy and society, should not be excluded from an analysis of commuting behaviour just because the official aggregate and interaction commuting data fail to capture them.

However, even if one confines the data analysis to using the official aggregate and interaction commuting data from the census, and accepts that an analysis using this data will exclude people not in formal employment, there is a further question regarding whether to include or exclude homeworkers. This decision has implications for the underlying aims and objectives of the research; there are three approaches that can be taken in regard to homeworkers and the commuting numerator. The first is to include them entirely, the second is to exclude them completely, and the third is to include or exclude homeworkers depending on whether or not they are judged to be relevant to the research and data analysis being carried out.

The inclusion of all homeworkers in the commuting numerator, and therefore, by implication, the inclusion of all formally employed individuals in the analysis regardless of whether or not they leave their place of residence and travel to work in a traditional sense, means that the research is more focused on the relationship between commuting and employment patterns from a labour market perspective. This approach would likely be taken by economic geographers and those researchers interested in labour market practices and patterns and less interested in the physical movement of people from point A to point B for employment purposes.

Alternatively, excluding all homeworkers completely from the commuting numerator, and therefore excluding individuals who do not travel to work in a traditional sense, means that the research is implicitly more focused on the actual movement of people for employment purposes from a transport perspective. This approach would likely be taken by transport geographers and those more interested in the movement of individuals from point A to point B and less interested in individuals whose employment practices do not require them to travel from a place of residence to a place of work.

Under normal circumstances, including or excluding all homeworkers would be the only two options. However, given the release by ONS of both the original mode of transport table QS701 and a commissioned mode of transport table CT0015 in 2011, a third option regarding the inclusion or exclusion of homeworkers has become available. This option is to include those homeworkers who also have a mode of transport, while excluding those homeworkers who do not have a mode of transport. The data for this option are available due to the ONS making different assumptions when processing the 2001 and 2011 aggregate statistics on homeworking. In 2001, all census respondents that indicated that they were working mainly at or from home were categorised as such, regardless of whether or not they indicated another mode of transport, while in 2011, respondents to the census who indicated that they were working mainly at or from home but also indicated another mode of transport were categorised under that mode of transport, and not under homeworking. This means that, while in 2001 all homeworkers were included in one table, in 2011 the original mode of transport table QS701 only included those homeworkers without a mode of transport. It is this table, QS701, which can be used as a numerator that will include only those homeworkers who do not also have a mode of transport.

Furthermore, ONS produced commissioned table CT0015 in 2011, which included all homeworkers with and without a mode of transport, in order to provide a table comparable with KS015 from 2001. This release means that it is possible to extract further data from the 2011 mode of transport tables. By subtracting the number of homeworkers in the 2011 table QS701 from the number of homeworkers in the 2011 table CT0015 one can produce a table that shows the number of homeworkers in 2011 who also had a mode of transport. Therefore, there are three 2011 tables that show data related to homeworking: the original table, which shows the total number of homeworkers without a mode of transport; the commissioned table, which shows the total number of homeworkers with and without a mode of transport; and a derived table, which shows the total number of homeworkers with a mode of transport.

Although this latter option appears to offer an appropriate balance between the two original options of total inclusion and outright exclusion, the implementation of the third option would result in problems of comparison between the 2001 and 2011 data as the 2001 mode of transport table is only equivalent to the commissioned 2011 mode of transport table, with no 2001 table being equivalent to the original 2011 mode of transport table.

Overall, it was judged that homeworkers would be included when deemed relevant to the data analysis (such as when analysing national and regional commuting rates in Chapters 4 and 7) and excluded when deemed irrelevant (such as when analysing variations in commute distance, commuting self-containment and mode of transport in Chapters 5 and 6). The inclusion or exclusion of homeworkers was also partly driven by data constraints (see Section 3.2.4).

3.3.2 Commuting denominators: The population at risk

Once a suitable numerator has been agreed it is necessary to decide on the PAR. In many ways, the selection of an appropriate PAR denominator for the commuting data is both more difficult and more important than identifying an appropriate numerator. Selection is more complicated as there are more options to choose from, and more important since different denominators can have radically different effects on the same numerator.

Unlike with the case of commuting numerators, confinement to using the official census data does not greatly help in the selection of an appropriate denominator. Even when only using the official UK census data there is a multitude of potential commuting denominators. Six, each with inherent advantages and disadvantages, are listed below:

- Total population
- Population aged 16+
- Population aged 16-74
- Population aged 16-64
- Economically active population
- Population in employment

Using the total UK population as the PAR means that children and students under the age of 16 are included in the denominator. Given that the research is to focus exclusively on commuting for work purposes, including children and students under the age of 16 in the denominator would be inappropriate as this sub-group of the population is likely to be commuting to school rather than to work.

Taking children and students under the age of 16 out of the denominator and using the population aged 16+ as the PAR means that individuals over the age of 74 are included in the denominator. As most individuals over the age of 74 are likely to be retired and therefore economically inactive, as ONS statistics usually assume when computing economic activity rates (Heap, 2005), their inclusion in the commuting denominator is likely to provide an overestimate of the PAR.

Taking individuals over the age of 74 out of the denominator and restricting the PAR to the population aged 16-74 removes all of those individuals aged over 74 and assumed to be retired. However, as many individuals in the 65-74 age group are likely to be economically inactive due to retirement, their inclusion in the commuting denominator, like the inclusion of those aged over 74, is likely to provide a slight overestimate of the PAR of commuting.

Removing individuals aged 65-74 from the denominator and restricting the PAR even further to those in the population aged 16-64, means that economically inactive people between the ages of 16 and 64 are still included in the denominator. The economically inactive population includes early retirees, people who are long-term sick or disabled and those individuals no longer looking for work. As these people are no longer part of the labour force, arguably, they do not have the potential to commute and are unlikely to become commuters in the future.

Restricting the denominator even further, by removing those economically inactive individuals and only using the economically active population as the PAR, means that unemployed individuals are included in the denominator. As individuals are unlikely to be commuting during periods of unemployment, the inclusion of unemployed people in the commuting denominator is debatable. However, using only the population in employment as the PAR means that any national or subnational commuting rates that are calculated will all be approximately 100%. This is because, when homeworkers are included as commuters, every employed individual commutes to work in some way.

Table 3.7 illustrates the different 2001 and 2011 PAR numbers for the Yorkshire and The Humber Region that are provided by the different possible denominators.

Table 3.7: Different PAR numbers for the Yorkshire and The Humber region in 2001 and 2011

Denominator/PAR	2001 Count	% of 2001 population	2011 Count	% of 2011 population
Total population	4,964,833	100.0	5,283,733	100.0
Population aged 16+	3,949,285	79.5	4,285,941	81.1
Population aged 16-74	3,574,331	72.0	3,875,219	73.3
Population aged 16-64	3,150,634	63.5	3,411,370	64.6
Economically active population	2,328,541	46.9	2,649,975	50.2
Population in employment	2,196,033	44.2	2,462,220	46.6

Source: Derived from the 2001 and 2011 Census Aggregate Data.

Table 3.8 illustrates the importance of choosing an appropriate denominator by showing the different commuting rates for the Yorkshire and The Humber region that are produced by using the different possible denominators. The total number of commuters in Yorkshire and The Humber was 2,182,839 in 2001 and 2,428,074 in 2011.

Table 3.8: Different commuting rates for the Yorkshire and The Humber region using different PARs in 2001 and 2011

Denominator/PAR	2001 %	2011 %
Total Population	44.0	46.0
Population aged 16+	55.2	56.7
Population aged 16-74	61.1	62.7
Population aged 16-64	69.3	71.2
Economically active population	93.7	91.6
Population in employment	99.4	98.6

Source: Derived from the 2001 and 2011 Census Aggregate Data.

Overall it was judged that the population aged 16-74 would provide the most appropriate default denominator for this research, unless data constraints necessitated the use of another PAR. This was largely due to the research addressing both ‘transport issues’, such as spatial and sociodemographic variations in modal split, and ‘labour market issues’, such as spatial and sociodemographic variations in commuting rates, and the desire to capture a substantial proportion of those individuals aged over 65 who are still economically active in the research.

3.4 Spatial Frameworks

Although UK census geography has been mentioned throughout this chapter, mainly in relation to the availability or unavailability of different census data at different geographical output levels, for the purpose of clarity this section outlines the official UK census geography in some detail. UK boundary data are currently available from Edina[6].

Table 3.9 shows the three main levels of census geography for which data are published in 2001 and 2011 in England, Scotland, Wales and Northern Ireland. Levels 1, 2 and 3 refer to the LAD, Ward/MSOA and OA geographies respectively. OAs and MSOAs are now used consistently across the whole of the UK, with the exception of Northern Ireland, where MSOAs are not used. Although LADs are used across the UK, they come in different forms in the different countries. In England, LADs come in the form of Metropolitan Districts (MDs), Non-Metropolitan Districts (NMDs), Unitary Authorities (UAs) and London Boroughs (LBs). Council Areas (CAs) are used in Scotland, UAs in Wales and Local Government Districts (LGDs) in Northern Ireland.

Table 3.9: UK LADs, MSOAs and OAs in 2001 and 2011

UK Country	Level 1	Level 2	Level 3
England	LADs (MDs, NMDs, UAs and LBs) 2001: 354 2011: 328	MSOAs 2001: 6,781 2011: 6,791	OAs 2001: 165,665 2011: 171,372
Scotland	LADs (CAs) 2001: 32 2011: 32	MSOAs 2001: 1,235 2011: 1279	OAs 2001: 42,604 2011: 46,351
Wales	LADs (UAs) 2001: 22 2011: 22	MSOAs 2001: 413 2011: 410	OAs 2001: 9,769 2011: 10,036
Northern Ireland	LADs (LGDs) 2001: 26 2011: 11	MSOAs 2001: N/A 2011: N/A	OAs 2001: 5,022 2011: 4,537

Source: Derived from 2001 and 2011 Census Boundary Data.

It is these three geographical output levels for which the vast majority of 2001 and 2011 census data are produced and released. The fundamental geographical unit for the 2001 and 2011 censuses is the OA. OAs are the smallest and most numerous geographical units, numbering 223,060 in the UK in 2001. In Northern Ireland, 2001 Wards were replaced by Super Output Areas (SOAs) for 2011 and the 2001 OAs were reorganised to produce Small Areas (SAs) for 2011. OAs aggregate to form MSOAs, CAS wards and ST wards, with CAS wards being equivalent to electoral wards (ONS, 2013ii). However, neither CAS wards nor ST wards (in the same form as 2001) were used for the 2011 Census as they were replaced by wards that are equivalent to the 2001 ST wards, with higher minimum population thresholds and geographies that take into account ward changes that have occurred since 2001 (ONS, 2012ii).

Although SOA geography, in the form of MSOAs, is useful from a commuting perspective, and appears to be becoming more mainstream by replacing electoral wards as the primary units for

[6] https://census.edina.ac.uk/

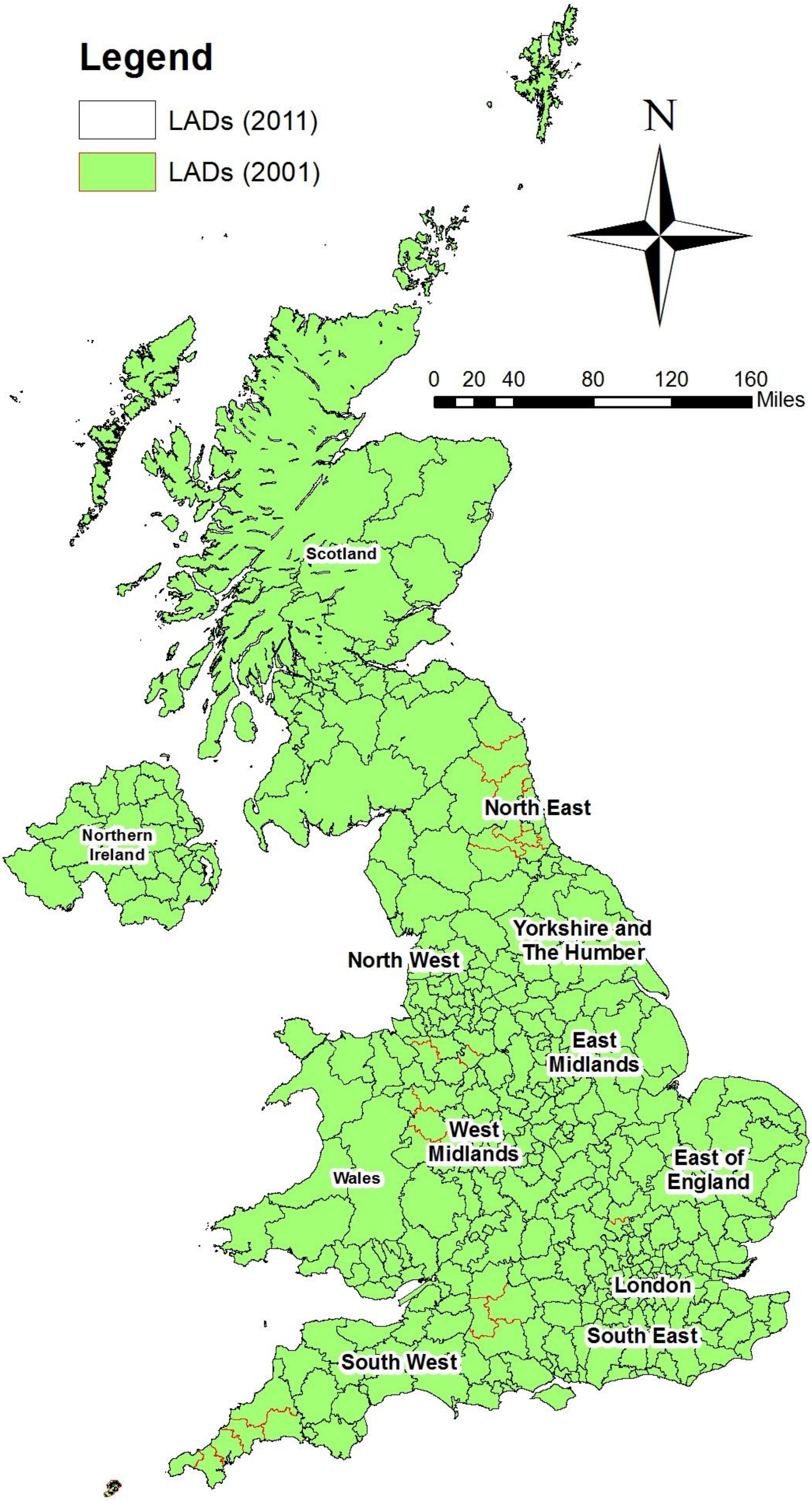
disseminating census data (GOV.UK, 2013), from an impact perspective, SOA geography is still not as widely used or recognised as ward geography, with neither MSOAs nor LSOAs carrying the same policy/political weight as wards. However, this lack of recognition may change as, in addition to being used for the publication of census data, SOA geography is also used for the collection and publication of non-census data, including deprivation scores (GOV.UK, 2011). Another advantage to using MSOAs, as opposed to Wards, is that SOA geography is supposed to be relatively stable over time, with MSOAs and LSOAs being designed to avoid the substantial boundary changes that were often seen with Ward geographies.

3.4.1 Regions and LADs in the UK

In 2001, there were 426 LADs in the UK. In 2011, there were 391 LADs in the UK (although updated Northern Ireland LAD boundary data has yet to be released by the UKDS), with the number of LADs decreasing between 2001 and 2011 due to the 2009 structural changes to English local government (see Figure 3.1). The 2009 structural changes to English local government included the aggregation of 36 2001 LADs, in the form of NMDs, into 9 2011 LADs, in the form UAs.

Figure 3.1 shows how the current 380 LADs aggregate up into the 12 regions in the UK and, in turn, how the 12 regions aggregate to the four constituent countries of the UK. An analysis of commuting behaviour and patterns using regions or LADs in 2001 is unlikely to encounter many data suppression issues associated with population thresholding or SCAM. However, it is also the case that a region or LAD level analysis would not uncover any complex small area commuting patterns. Thus, while the SWS commuting datasets are relatively robust at the region and LAD level, the opportunities for more detailed spatial analysis of the data are limited, since the vast majority of commuting flows will take place between small areas within regions and LADs, rather than between these larger spatial units.

Figure 3.1 also shows the changes to English LADs that took place on 1st April 2009, with changes to LAD boundaries in the North East, North West, West Midlands, East and South West regions. There have been no changes in LAD boundaries in Scotland and Wales.



Source: Derived from 2001 and 2011 Census Boundary Data.

Figure 3.1: LAD boundaries within the regions of the UK in 2001 and 2011

Table 3.10 tabulates the changes that took place as part of the 2009 structural changes to English local government. All of the changes, except those in the East Region, involved the aggregation of numerous small pre-2009 NMDs into fewer large post-2009 UAs. The changes that took place in the East Region involved replacing the pre-2009 Non-metropolitan LADs of Mid Bedfordshire and South Bedfordshire with two similar sized post-2009 UAs.

Table 3.10: 2009 structural changes to English local government

Region	Abolished Pre-2009 Non-metropolitan LADs	New Post-2009 Unitary Authorities
North East	Blyth Valley, Wansbeck, Castle Morpeth, Tynedale, Alnwick and Berwick-upon-Tweed	Northumberland UA
	Durham, Easington, Sedgefield, Teesdale, Wear Valley, Derwentside and Chester-le-Street	Durham UA
North West	Crewe and Nantwich, Congleton and Macclesfield	Cheshire East UA
	Ellesmere Port and Neston, Chester and Vale Royal	Cheshire West and Chester UA
West Midlands	North Shropshire, Oswestry, Shrewsbury and Atcham, South Shropshire and Bridgnorth	Shropshire UA
East	Mid Bedfordshire and South Bedfordshire	Bedford UA Central Bedfordshire UA
South West	Salisbury, West Wiltshire, Kennet and North Wiltshire	Wiltshire UA
	Penwith, Kerrier, Carrick, Restormel, Caradon and North Cornwall	Cornwall UA

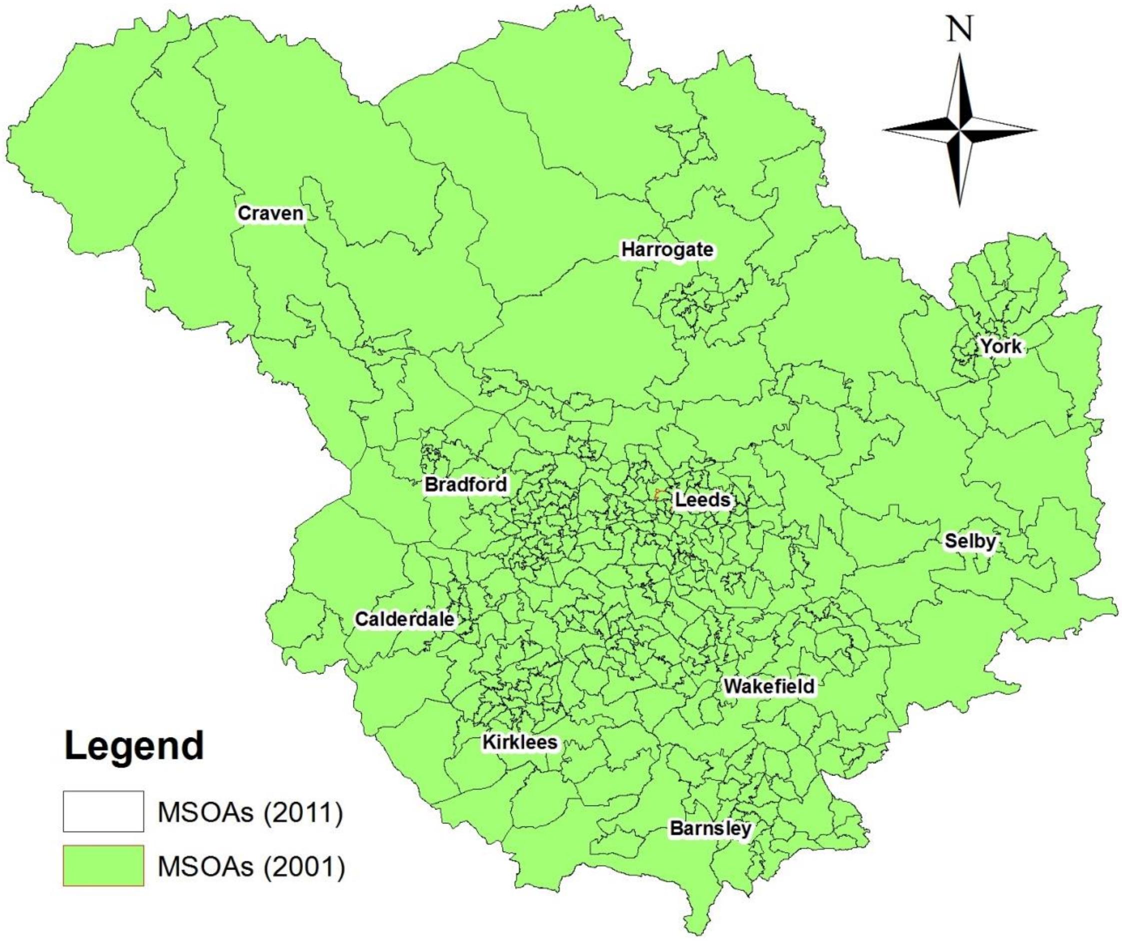
Source: Derived from 2001 and 2011 Census Boundary Data.

Overall, the importance of LADs is twofold. Firstly, when analysing data at the national level, LADs provide an appropriate level of geographical detail. Secondly, LADs are the primary political unit in the UK, with much local economic and transport policy being implemented by LADs. LADs are also important politically as they are building blocks of the new city regions being created as part of the UK Governments devolution agenda.

3.4.2 LADs and MSOAs in the Leeds City Region

In 2001, there were 393 MSOAs in the LCR and 392 MSOAs in 2011, a decrease of 1 MSOA. Figure 3.2 shows how the current 2001 and 2011 MSOAs aggregate up into the 10 LADs of the LCR.

Figure 3.2 shows the MSOA boundary changes that took place between 2001 and 2011 within the LCR. There were no changes in MSOA boundaries between 2001 and 2011 in nine of the ten LADs in the LCR. However, four 2001 MSOAs in North-West Leeds were aggregated up into two larger MSOAs in 2011 and one 2001 MSOA in Central Leeds was split into two smaller MSOAs in 2011.



Source: Derived from 2001 and 2011 Census Boundary Data.

Figure 3.2: MSOA boundaries within the LADs of the LCR in 2001 and 2011

Spatially, the MSOA geography sits between OA level geography, with its finer spatial scale, and LAD level geography, with its coarser spatial scale. This means that MSOA level geography allows one to gain a relatively good understanding of commuting behaviour and patterns at the sub-LAD level, without encountering as many issues surrounding SWS data suppression methods as one is likely to when using OA level geography.

In practice, MSOA geography is ideal for analysing commuting patterns within a city region or LAD, as there are too few MSOAs for analysing data for individual localities or neighbourhoods and too many for analysing data for the whole country. An analysis of commuting behaviour and patterns using MSOAs is advantageous due to the relatively high level of geographical and attribute data detail at MSOA level. Data suppression issues associated with population thresholding and SCAM are unlikely to cause many problems with the census interaction data at MSOA level. In addition, data obtained at MSOA level will provide a far more detailed picture of complex local commuting patterns. It is at the MSOA level that one can begin to investigate and understand commuting patterns within and across different urban and rural areas.

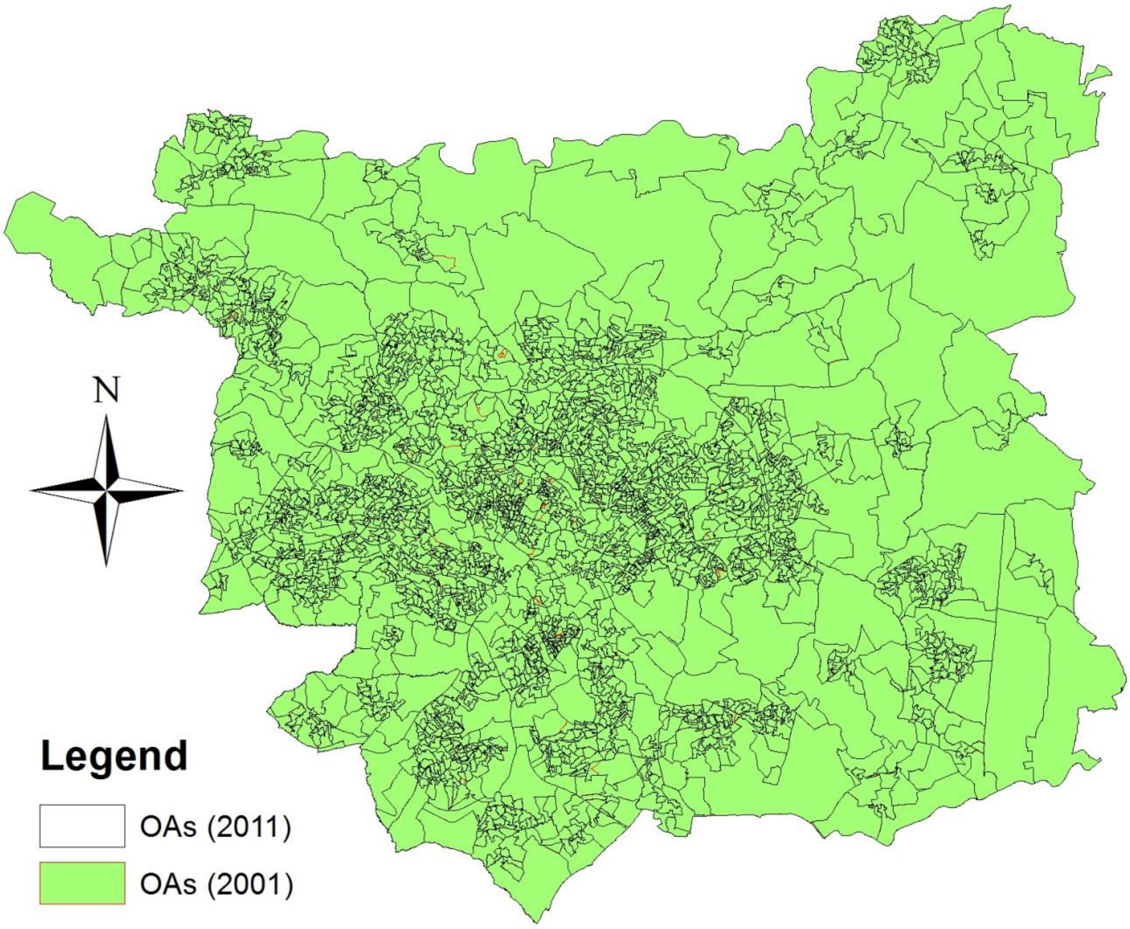
However, MSOA level geography and data are not without fault. First, MSOA level geography, and by extension the data associated with it, is still relatively coarse. Figure 3.2 shows that there are only 392 MSOAs in the LCR. That is 392 MSOAs covering a population of 3,004,900 people (Nomis, 2015). This means that, on average, each MSOA has a population of over 7,600 people. One must question the extent to which local commuting patterns and propensities can be investigated and understood when the spatial units being used have such large populations. Second, MSOAs do not aggregate up in to TTWAs, which are the most appropriate spatial units for an analysis of commuting patterns and propensities at the national level.

Overall, MSOAs are important when analysing data at the regional level, as they provide a good level of geographical detail, being much more numerous than LADs, while ensuring that any mapping output is not overly complicated, being much less numerous than OAs.

3.4.3 MSOAs and OAs in the Leeds LAD

In 2001, there were 2,440 OAs in Leeds LAD. In 2011 there were 2,543 OAs in Leeds LAD, an increase of 103 OAs. Although 2001 OAs aggregated into 2003 statistical wards (ONS, 2013v), the current 2,543 2011 OAs do not aggregate into the 33 wards of the Leeds LAD in 2011. This lack of alignment between 2011 OA and ward boundaries is because the 2011 OAs aggregate into the SOA geography framework, which, as stated previously, has no relationship with ward geography.

Figure 3.3 shows the few OA boundary changes that took place between 2001 and 2011 within the Leeds LAD. Most of the OA boundary changes were in dense and urban areas of northwest Leeds, in the Hyde Park, Woodhouse, Chapel Allerton, Headingley, Kirkstall and Weetwood areas. There were very few OA boundary changes in the more rural areas to the north and east of the Leeds urban area, in the Otley, Yeadon, Harewood, Wetherby, Kippax and Methley areas.



Source: Derived from 2001 and 2011 Census Boundary Data.

Figure 3.3: OA boundaries within the MSOAs of Leeds LAD in 2001 and 2011

OAs were the smallest geographies used for the 2001 and 2011 censuses, and therefore the geographical output level most sensitive to data suppression issues associated with population thresholding and SCAM. The trade-off made between MSOA level and OA level, giving up data detail for fine geographical detail is a difficult one to make from a commuting perspective. In order to greatly improve the level of geographical detail, by moving from the MSOA level to the OA level, one has to give up access to a host of variables while only maintaining access to the 'mode of transport' variable (Stillwell *et al.*, 2010).

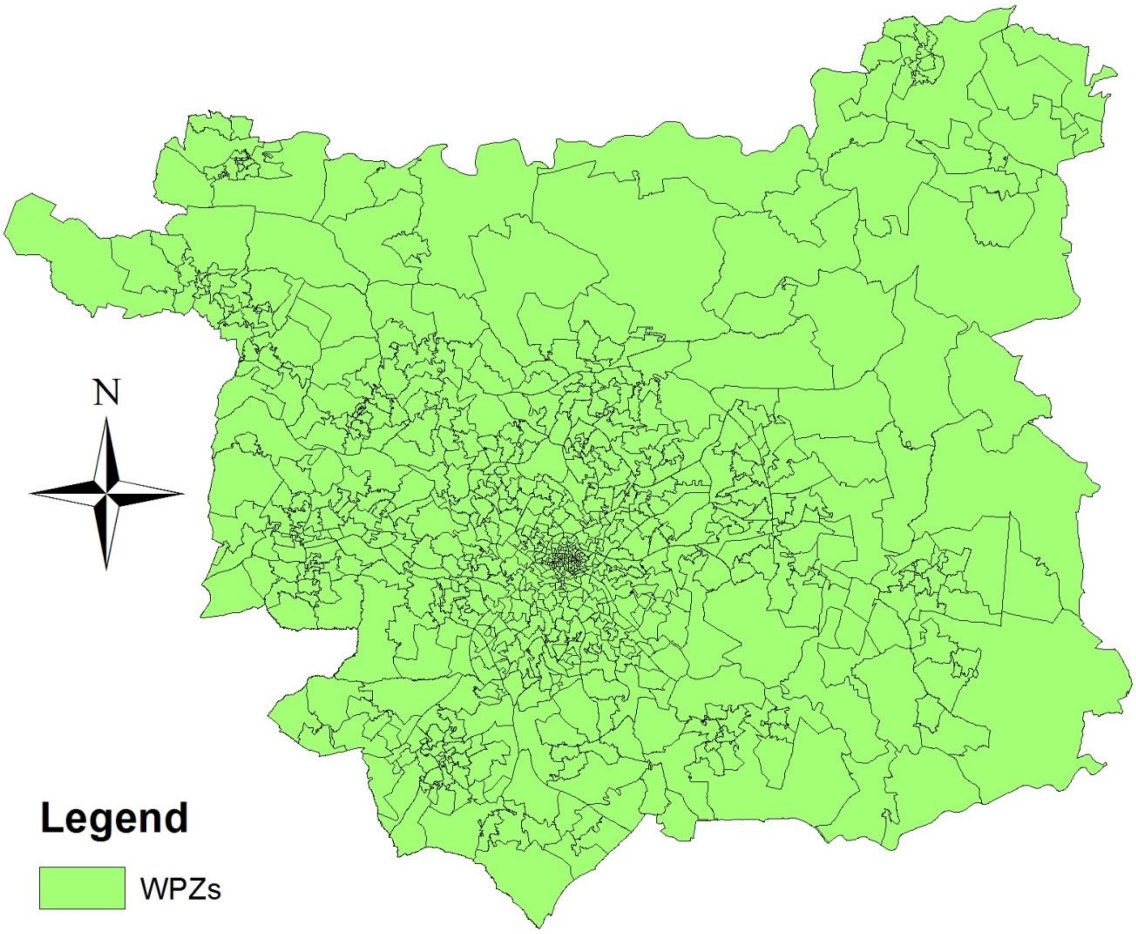
The presence of 2,440 OAs in the Leeds LAD means that each OA contains approximately 308 individuals, given the 2011 population of 751,500 (ONS, 2012iii). The availability of this relatively fine geographical output level permits the possibility of a detailed understanding of the movement of people at the local sub-ward level for employment purposes. However, given the relatively small number of people in each OA, it is unsurprising that the application of data suppression methods in 2001 is likely to render the SWS commuting interaction data largely unusable at this geographical output level. In practice, an analysis of commuting behaviour and patterns using OAs is only likely to be implemented for small areas, with OAs being too small, and the data associated with them to unreliable, to be used for a national or regional analysis of commuting behaviour and patterns.

3.4.4 MSOAs and WPZs in the Leeds LAD

Workplace Zones (WPZs) are a new geography, introduced for the 2011 Census. They are an attempt to provide a set of boundaries that are appropriate for analysing working populations, in that they are based on the locations at which people work rather than where they live. WPZs, therefore, provide a better division of space in dense urban areas (particularly city centres) that have a large number of workers but few residents (Duke-Williams, 2012).

The creation of WPZs for the 2011 Census data has important implications for spatial research in general, but is particularly noteworthy in regards to a spatial analysis of commuting to work patterns. Their creation opens up the possibility of more useful flow mapping at the small area level, as one now has the ability to use zones that take into account residential populations as zones of origin and zones that take into account workplace populations as destination zones.

Figure 3.4 shows how the 767 WPZs aggregate into the 107 MSOAs of the Leeds LAD. With OAs, WPZs are the geography for which the lowest level SWS flow data from the 2011 Census are to be made available (Duke-Williams, 2012).



Source: Derived from 2001 and 2011 Census Boundary Data.

Figure 3.4: WPZs within the MSOAs of Leeds LAD in 2011

Despite the spatial detail provided by OAs and WPZs, it was judged that LADs would provide the most appropriate spatial units for spatial analysis at the national level, while MSOAs would provide the most appropriate spatial units for spatial analysis at the region level. This is mainly due to the policy relevance of LADs and MSOAs providing a good level of geographical detail within a relatively large region like the LCR.

3.4.5 Alternative spatial frameworks

An alternative to official census geography is the use of a functional geography. In the UK, the need for functional geographies arises as the official UK census geography often bears no direct relation to the attribute data being analysed. Functional geographies are, therefore, an attempt to produce sets of boundary data that are relevant to the datasets they are produced for.

Although functional geographies can, if desired, be used for the analysis of multiple datasets covering a wide range of topics, they are not, unlike the official UK census geography with its policy relevance, considered to be multi-applicable. Functional geographies, by their very nature, are best used for analysing the spatial attribute data that was used to produce them. This section considers Larger Urban Zones (LUZs) and TTWAs as examples of functional geographies.

LUZs were produced by the EU Urban Audit, which was ordered by the Directorate-General for Regional Policy at the European Commission (Eurostat, 2006). LUZs across the EU were created in order to provide appropriate boundaries for capturing data on phenomena that cross city boundaries, such as economic activity and environmental pollution (Feldmann, 2008). LUZs were created using commuter flows and include cities and their surrounding commuter belts, and thus provide boundaries of functional urban areas (Feldmann, 2008). In this respect, the boundary data provided by LUZs could be seen to be much more appropriate for an analysis of commuting to work patterns than official UK census geography.

However, LUZs are not without limitations. Firstly, although not an issue when restricting data analysis to a single country, the collection and compilation of data for LUZs is done by the NSAs of the different countries in partnership with Eurostat, not by Eurostat alone (Eurostat, 2006). This means that the data for LUZs are likely to have issues with comparability. Secondly, some cities are excluded from the LUZs framework, due to the equivalence of their administrative boundaries and their would-be LUZ boundaries. Although a technicality, this means that not all cities are part of the LUZs dataset (Eurostat, 2006). The use of LUZs for research within the UK is also brought into question as the UK already has a tried and tested functional geography for the analysis of labour markets and commuting behaviour: TTWAs.

The first set of TTWAs was produced by Smart (1974). These were later computerised by Coombes and Openshaw (1982), while the latest set of TTWAs was defined by Coombes and Bond (2008). TTWAs have been created following every decadal UK census since and the methodology for constructing the 2001-based TTWAs is outlined in Coombes *et al*. (2005). They are particularly important as they are created from commuting data. As Coombes (2010, p.228) states: "*the core objective of the TTWA definitions is to identify patterns in the commuting data as a means of consistently defining a set of labour market area boundaries*". It is these boundaries that are then deemed appropriate for the analysis of commuting data and related local labour market statistics.

The definition of TTWAs is based on two key statistical criteria, which were first identified by Goodman (1970): 'commuting self-containment' and 'commuting integration'. The former refers to the statistical requirement that as few as possible commutes to or from areas within a TTWA boundary should cross the boundary of that TTWA, while the latter refers to the statistical requirement that there should ideally be a substantial number of commutes between most of the areas within a TTWA boundary. These two key statistical criteria are put into practice through the statistical requirements used to define TTWAs. Thus, the two criteria used to define TTWAs are: at least 75% of the economically active population of a TTWA must work within that TTWA, and at least 75% of everyone working in the TTWA must live within that TTWA (ONS, 2013vi).

It should be noted, however, that the two key statistical criteria asserted by Goodman (1970), and put into practice through the criteria used to define TTWAs, have become more difficult to satisfy over time. With the continuing rise of long-distance commuting, and the subsequent increases in the average length of commutes, achieving high levels of both commuting self-containment and commuting integration has become more difficult. The overall result of these problems is that individual TTWAs have had to become larger in order to internalise the same proportion of commuters that they did in the past (Coombes, 2010). There has been a subsequent reduction in the number of TTWAs over time. While there were 243 TTWAs in 2001, this number had declined from 334 in 1981and 314 in 1991.

The appropriateness of TTWAs for the analysis of commuting stands in stark contrast to that of LADs. The boundaries of LADs do not have the statistical properties required of local labour market boundaries as they have been defined and constructed to meet different, mostly political, criteria (Coombes, 2010). Thus, from a functional perspective, the findings of an analysis using TTWAs will be more meaningful.

However, despite their functionality, this research did not employ TTWA boundary data for a number of reasons. From a theoretical perspective, labour markets are too complex to allow for the perfect delineation of labour market 'areas' on a map (Peck, 1997); most places draw in workers from different parts of the country depending on the occupation or industry-type involved and the flows to other areas. This means that TTWAs can never be a truly realistic representation of travel to work patterns. Ideally, each economic/employment sector would have its own TTWA mapped and it is likely that different sociodemographic or occupational groups will experience different levels of self-containment and commuting integration for the TTWAs, given that the TTWAs are created using the commuting patterns of the total working population. From a policy perspective, while TTWAs are functional and appropriate for an analysis of commuting behaviour and patterns, LADs are the primary political units of the UK political system. Therefore, research using them is likely to have more policy impact than research using TTWAs. Finally, from a practical perspective, at the time of the research being carried out the ONS had plans to update the TTWAs in the UK using the 2011 Census data (ONS, 2013vi), but the new TTWAs did not become available until late 2015.

3.5 Methods and Methodological Approaches

Spatial and statistical methods are used in this thesis to examine the geographic and sociodemographic variations in commuting propensities, patterns and behaviours. Choropleth mapping is used to analyse spatial variations and temporal changes in different commuting indicators across England and Wales (in Chapters 4, 5 and 6) and across the LCR (in Chapter 7). BLR is used to analyse sociodemographic variations and temporal changes in different commuting behaviours across England and Wales (in Chapters 4, 5 and 6) and across the LCR (in Chapter 7). With this in mind, the remainder of this section is split into two major sub-sections. Section 3.5.1 outlines the spatial analyses used in the research, while Section 3.5.2 outlines the statistical analyses used.

3.5.1 Spatial analyses

This section outlines the spatial analysis techniques used in this research, the attribute and boundary data used and the different spatial scales they are used at.

3.5.1.1 Choropleth mapping

The spatial analyses included in this research were carried out using Microsoft Excel 2010, MapInfo Professional 11.0 and ArcMap 10. Excel was used for data sorting and exploration. MapInfo was used for spatial data exploration, although it was not used for any final spatial outputs. ArcMap was used for spatial data exploration and producing the final spatial outputs.

Choropleth maps have been used to visualise spatial variations in rates throughout this research, and to visualise absolute numbers in Chapter 7. The ranges used to classify rates and numbers in to five categories were produced using the quantile classification method in ArcMap which was also used to classify changes in rates and numbers, but with slight adjustments in each case to ensure that the classification split at zero, such that the lower two categories represented negative change and the upper three categories represented positive change.

When mapping 2001 and 2011 variables at LAD level across England and Wales, it was necessary to standardise the LADs, such that both the 2001 and 2011 data were presented using the 2011 LADs (see Section 3.4.1 for LAD changes). This standardisation was done by merging the boundary data and attribute data for the 2001 LADs into the 2011 LADs for the areas affected. An analogous process was required when mapping 2001 and 2011 variables at MSOA level across the LCR, when it was it was necessary to standardise the MSOAs, such that both the 2001 and 2011 data were presented using the 2011 MSOAs (see Section 3.4.2 for MSOA changes).

3.5.2 Statistical analyses

This section outlines the statistical analysis techniques used in this research, the data used and the different spatial scales they are used at.

3.5.2.1 Descriptive statistics

The descriptive statistics included in this research were carried out using Microsoft Excel 2010 and IBM SPSS Statistics 22. As with the spatial analyses, Excel was used for data sorting and quantitative data exploration. Excel was also used for the production of the final table and graph outputs. SPSS was used for quantitative data exploration and the production of frequency and crosstabulation tables.

Although Sections 3.3.1 and 3.3.2 outlined the commuting numerators and denominators used when computing overall commuting rates, different numerators and denominators were required when computing rates of commuting self-containment, out-commuting and in-commuting. Different numerators and denominators were required as the total commuting population was split according to their commuting behaviour; that is whether they commuted within an area, out of an area or in to an area.

Therefore, the analysis of commuting self-containment in zone *i*, where zone *i* is a LAD or MSOA, required the commuting population in zone *i* (*COMPOPi*) to be the PAR, such that the self-containment rate for zone *i* (scr_i) in percentage terms is defined as:

$$scr_i = (SCOCOM_i \,/\, COMPOP_i) * 100 \qquad (3.1)$$

where $SCOCOM_i$ is the number of commuters who commute within zone *i*.

The analysis of out-commuting from zone *i* also required the commuting population in zone *i* to be the PAR, such that the out-commuting rate for zone *i* (ocr_i) in percentage terms is defined as:

$$ocr_i = (OUTCOM_i \,/\, COMPOP_i) * 100 \qquad (3.2)$$

where $OUTCOM_i$ is the number of commuters who commute out of zone *i*.

The analysis of in-commuting to zone *i* is somewhat more complicated as there is no obviously correct denominator. However, in order to illustrate the magnitude of commuting inflows into an area relative to the total number of commuters in that area, in this research, the analysis of in-commuting to zone *i* again required the commuting population in zone *i* to be the PAR, such that the in-commuting rate to zone *i* (icr_i) in percentage terms is defined as:

$$icr_i = (INCOM_i \,/\, COMPOP_i) * 100 \qquad (3.3)$$

where $INCOM_i$ is the number of commuters who commute in to zone *i*.

3.5.2.2 Binary logistic regression (BLR)

The statistical modelling included in this research was carried out using IBM SPSS Statistics 22. This section outlines the BLR models used in the thesis and the datasets and variables used by them. The thesis contains six BLRs in total, with two in Chapter 4, two in Chapter 5, one in Chapter 6 and one in Chapter 7. These BLRs were carried out in IBM SPSS Statistics 22 and are used to examine the relationships between dependent variables (such as commute distance and mode of transport) and independent variables (such as sex, age and ethnicity). The nature and calculation of a BLR model is explained by Garson (2016), which the following outline is based on.

Commuting behaviours can be simplified in to dichotomous outcomes which can be modelled using BLR. BLR models with multiple predictor variables have been used for this analysis as BLR allows one to predict one of two possible outcomes of a binary categorical dependent variable, given the values of one or more predictor variables. BLR quantifies the relative likelihood, in the form of an odds ratio (OR), of predefined behavioural patterns (such as commuting long-distances and using public transport) for a selection of sociodemographic and geographic variable categories in relation to a set of corresponding reference categories. Thus, BLR allows direct comparison of the behaviour of men and women, younger people, middle-aged people and older people or White and BME individuals. The configuration of the categorical response and predictor variables is discussed in sections 3.5.2.2.2 and 3.5.2.2.3.

Formally, when y is the binary dependent variable (with 0 or 1 indicating absence or presence), x_1 to x_n are a set of independent variables and p is the probability that y is equal to 1, the model can be written as:

$$logit(p) = log(p/(1-p)) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n + \varepsilon \quad (3.4)$$

where $log(p/(1-p))$ is the log odds of an event (a response) occurring; with the OR being the proportion of successes (p) divided by the proportion of non-successes (1-p), and the β values represent the intercept on the Y axis (β_0) and the regression parameters or slopes of the regression lines relating to each x variable ($\beta_1, \beta_2 ... \beta_n$), when there are n independent variables. The final term, ε, is the random error term.

The statistics produced by the BLR analyses include the ORs, β values and significance scores (p-values). The OR is a measure of the relationship between an independent variable category and an outcome or response, relative to a reference variable category. In the commuting context, the OR represents the relative likelihood that an outcome (e.g. an individual commuting long-distance) will occur given the individual belongs to a certain variable category (e.g. sex = female), when compared to the reference category (e.g. sex = male). ORs can range from 0 to infinity, with an OR of less than 1 meaning that the category in question is associated with a lower relative likelihood of the outcome occurring, compared to the reference category and an OR of greater than 1 meaning that the category in question is associated with a higher relative likelihood of the outcome occurring, compared to the reference category. An OR of 1 means that the category in question does not affect the relative likelihood of the outcome occurring when compared with the reference category. The β values are the regression coefficients, with the β value for an independent variable category indicating the magnitude and direction of the effect that that independent variable category has on the dependent variable, relative to the reference variable category. A positive β value shows that having the characteristic or characteristics indicated by that variable category is associated with an increased probability of displaying the behaviour being modelled (such as commuting very long-distance or commuting by public transport), while a negative β value shows a decreased probability, with numbers further from zero indicating stronger effects, whether positive or negative. The constant (β_0) is the odds of commuting a certain distance (e.g. long-distance) or commuting using a certain mode of transport (e.g. public transport) when the possible values of the non-reference variable categories are set to 0. In practice, the constant can be seen as the underlying likelihood of an individual commuting a certain distance or commuting using a certain mode of transport when their characteristics are indicated by all the reference categories. The significance score indicates whether or not the OR and β value for the variable category are statistically significant. A significance score of less than 0.05 means that there is a less than 5% chance that the true values of the respective OR and β value are outside of 95% confidence interval.

3.5.2.2.1 Intersectionality and interaction effects

While intersectionality refers to a way of understanding variations in behaviour from a purely qualitative theoretical perspective (see Chapter 2), and is often seen as an ambiguous term (Nash, 2008), interaction effects (IEs) are part of a statistical approach to understanding variations in behaviour from a quantitative perspective, and are mathematically unambiguous (Rosnow and Rosenthal, 1989). Statistically, IEs refer to that part of any variation in behaviour which cannot be explained by an individual's characteristics alone, but is instead explained by the interrelationships between an individual's characteristics. The analysis of IEs employed in this thesis is analogous to that employed by Boyle *et al*. (2002). BLR IEs are explained in detail by Jaccard (2001), which the following outline is based on.

The BLR model shown in equation (3.4), which does not take into account any possible IEs, only includes primary effects (PEs). These PEs refer to that part of any variation in behaviour which is explained by an individual's individual characteristics alone, and not explained by the interrelationships between the individual's individual characteristics. However, BLR models can be calibrated with independent variables with or without IEs. While a predictor variable with no IE will have the same effect on the dependent variable regardless of the other predictor variables in the model, a predictor variable with an IE will have different effects on the dependent variable depending on the values that one or more other predictor variables take.

Thus, a model with a single dependent variable, two predictor variables (x_1 and x_2), and IEs between x_1 and x_2 can be written as:

$$log(p/(1-p)) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3(x_1 * x_2) \quad (3.5)$$

with the $\beta_3(x_1*x_2)$ term indicating the IE between the two predictor variables, x_1 and x_2.

The model can be extended to include many predictor variables, such that a model with a single dependent variable, three predictor variables (x_1, x_2 and x_3), and IEs between x_1, x_2 and x_3 can be written as:

$$log(p/(1-p)) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4(x_1 * x_2) + \beta_5(x_1 * x_3) + \beta_6(x_2 * x_3) \quad (3.6)$$

with the $\beta_4(x_1*x_2)$ term, as in equation 3.5, indicating the IE between the two predictor variables, x_1 and x_2, the $\beta_5(x_1*x_3)$ term indicating the IE between the two predictor variables, x_1 and x_3, and the $\beta_6(x_2*x_3)$ term indicating the IE between the two predictor variables, x_2 and x_3.

Given equation 3.4 and the relationship between odds (O) and probability (P), with:

$$O = P / (1 - P) \quad (3.7)$$

and:

$$P = O / (1 + O) \quad (3.8)$$

it is possible to calculate the probabilities that certain groups will express certain behaviours from the log odds values. For example, the probability (p) that females aged 65-74 will commute long-distance can be defined as:

$$p = (exp(z) / (1 + exp(z))) * 100 \quad (3.9)$$

where z is the log odds, with:

$$z = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3(x_1 * x_2) \quad (3.10)$$

in the case of two independent variables, or:

$$z = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4(x_1 * x_2) + \beta_5(x_1 * x_3) + \beta_6(x_2 * x_3) \quad (3.11)$$

in the case of three independent variables, where $\beta_1 x_1$ is the PE of the first variable, $\beta_2 x_2$ is the PE of the second, $\beta_3 x_3$ is the PE of the third, and $\beta_4(x_1*x_2)$, $\beta_5(x_1*x_3)$ and $\beta_6(x_2*x_3)$ are the IEs between the three variables.

Collinearity between independent variables can be a problem (Naes and Mevik, 2001). The Cramer's V statistic was employed to check the levels of association between the different independent variables in the different BLR models and showed that there was a very low association between most of the independent variables. The highest association was seen between the age group and dependent children variables, with a Cramer's V of 0.243. However, this low-to-medium level of association is not enough to warrant the removal of one of the variables from the BLR model; a Cramer's V of 0.3 or more, indicating a medium level of association, would be required to consider removal (Zaiontz, 2016). Furthermore, although skewness is a concern in some statistical analysis, with data having to be weighted in order to avoid the problems associated with it, as the I-SARs and SAM are created from a large random sample of the population, we can assume that the data are representative of the overall population and, therefore, not skewed. Finally, although BLR does not benefit from one basic measure of model fit, such as R^2 in linear regression, this is not particularly important due to BLR modelling being employed to examine variations in ORs rather than for explaining variations in commuting behaviours. It should also be noted that BLR models generally suffer from low R^2 values, with R^2 not usually exceeding 0.6 (Gujarati, 2004). Ultimately, BLR was selected as the main statistical method for this research as it is excellent for analysing census microdata (Dale *et al*., 2000).

3.5.2.2.2 The dependent variables

Since BLR modelling involves using a dependent variable expressed in binary form, it was necessary to recode each dependent variable into one of two categories, for example 'short distance' (coded 0) and 'very long-distance' (coded 1).

For the travel to work BLR in Chapter 4, the dependent variable indicates whether or not an individual travels to work, with those who 'do not travel to work' coded '0' and those who 'travel to work' coded '1'. For the homeworking BLR in Chapter 4, the dependent variable indicates whether or not a commuter works at or from home, with 'non-homeworkers' coded '0' and 'homeworkers' coded '1'.

For the commute distance BLR in Chapter 5, the dependent variable indicates whether or not a commuter has a very long-distance commute. In this BLR, the distance cut-point is 40km, with those commuting a distance of less than 40km having 'short distance' commutes (coded 0) and those commuting a distance of greater than 40km having 'very long-distance' commutes (coded 1). For the commuting self-containment BLR in Chapter 5, the dependent variable indicates whether or not a commuter works inside their LAD of residence, with the 'work outside LAD of residence' category coded '0' and the 'work inside LAD of residence' category coded '1'. This BLR used the 1991 I-SAR, the 2001 SAM and the 2011 I-SAR. It was necessary to use the 2001 SAM, instead of the 2001 I-SAR, as the 2001 I-SAR did not have any LAD level geography and therefore did not contain a variable indicating whether an individual commuted outside or inside their LAD of residence.

For the national and regional mode of transport BLRs in Chapters 6 and 7, the dependent variable indicates whether or not a commuter commutes to work using public transport, with commuters who ‘do not use public transport’ being coded ‘0’ and commuters who ‘use public transport’ being coded ‘1’. Commutes that do not use public transport have been defined as those using cars (driver or passenger), bicycle, on foot, and other modes of commuting, while commutes using public transport have been defined as those using trains, buses, underground and trams.

3.5.2.2.3 The independent variables

The eight BLR models each contain a number of appropriate predictor variables, including: sex, age group, ethnic group, limiting long-term illness (LLTI), dependent children, occupation, region of usual residence, commute distance and mode of transport. All of the predictor variables have been included in the BLR models given that previous research has found that each is likely to have an impact on individuals commuting behaviour (see Chapter 2).

The categories in the sex variable are ‘Male’ (0) and ‘Female’ (1). It was not necessary to recode any of the sex variables as they were all compatible in their original form.

The categories in the age group variable are ‘16-24’ (0), ‘25-44’ (1), ‘45-64’ (2) and ‘65-74’ (3), with the only exceptions being the age groups in the national self-containment BLR and the regional public transport BLR, where the age group categories are ‘16-24’ (0), ‘25-39’ (1), ‘40-64’ (2) and ‘65-74’ (3). This discrepancy is due to the use of the 2001 SAM in conjunction with the 1991 and 2011 I-SARs, with the original age groupings in the SAM necessitating a different set of recoded age groups. In the 1991 I-SAR, the original age data was given for 1 year age bands. Thus the relevant age bands were aggregated in order to form the recoded 16-24, 25-44, 45-64 and 65-74 age groups. The 2001 I-SAR provided some aggregated age groups; however, these categories were aggregated further such that the 16-19 and 20-24, the 25-29 and 30-44, the 45-59 and 60-64, and the 65-69 and 70-74 age groups were recoded to form 16-24, 25-44, 45-64 and 65-74 age groups consistent with those in 1991. The 2011 I-SAR age data were given in 1 year age bands up until the age of 70, from which point the data were given for 5 year age bands. The 1 year age bands from 16 to 69 and the one 5 year age band (70-74) were aggregated to be compatible with the age bands from the 1991 and 2001 I-SARS.

The ethnic group categories are ‘White’ (0), ‘Indian’ (1), ‘Pakistani’ (2), ‘Bangladeshi’ (3), ‘Black’ (4), ‘Chinese’ (5) and ‘Other’ (6). For the 1991 I-SAR, the ‘White’, ‘Indian’, ‘Pakistani’, ‘Bangladeshi’ and ‘Chinese’, ethnic group categories correspond to their respective original ethnic group categories, while the original ‘Black Caribbean’, ‘Black African’ and ‘Black other’ categories have been combined into a ‘Black’ category and the ‘Other Asian’ and ‘Other’ categories have been combined into a ‘Other’ category. For the 2001 I-SAR and SAM, while the ‘Indian’, ‘Pakistani’, ‘Bangladeshi’ and ‘Chinese’ ethnic group categories again correspond to their respective original ethnic group categories and the original ‘Black Caribbean’, ‘Black African’ and ‘Black other’ categories have again been combined into a ‘Black’ category, the ‘Other’ category has been created by combining the ‘White and Black Caribbean’, ‘White and Black African’, ‘White and Asian’, ‘Other Mixed’, ‘Other Asian’ and ‘Other’ categories and the ‘White’ category has been created by combining the ‘British’, ‘Irish’ and ‘Other White’ ethnic group categories. For the 2011 I-SAR, the ‘Indian’, ‘Pakistani’, ‘Bangladeshi’ and ‘Chinese’ groups did not need to be recoded. The ‘White’ group was created by aggregating the ‘White: English/Welsh/Scottish/Northern Irish/British’, ‘White: Irish’, ‘White: Gypsy or Irish Traveller’ and ‘White: Other White’ categories, the ‘Black’ category was created by aggregating the ‘African, Black/African/Caribbean/Black British’, ‘Caribbean, Black/African/Caribbean/Black British’ and ‘Other Black, Black/African/Caribbean/Black British’ categories, and the ‘Other’ category was created by aggregating the ‘White and Black Caribbean Mixed/multiple ethnic group’, ‘White and Black African Mixed/multiple ethnic group’, ‘White and Asian Mixed/multiple ethnic group’, ‘Other Mixed’, ‘Other ethnic group: Arab’, ‘Other Asian’ and ‘Other ethnic group: Any other ethnic group’ categories.

The two LLTI categories are ‘LLTI’ (0) and ‘No LLTI’ (1). The LLTI data in the 1991 I-SAR and the 2001 I-SAR and SAM have not been recoded in any way. In any tables and graphs produced using the LLTI data, the category titles of ‘Yes’ and ‘No’ have been changed to ‘LLTI’ and ‘No LLTI’ for the purpose of clarity. For the 2011 I-SAR, the ‘LLTI’ category was created by aggregating the ‘limited a lot’ and the ‘limited a little’ categories from the ‘Long-term health problem’ variable, while the ‘No LLTI’ category was derived from the original ‘not limited’ category.

The two dependent children categories are ‘No Dependent Children’ (0) and ‘Dependent Children’ (1). The 2001 dependent children variable has been recoded in two ways. Firstly, the ‘no children in family’ and ‘non-dependent children only’ categories have been combined into a ‘No Dependent Children’ category and the ‘dependent children only’ and ‘dependent and non-dependent children’ categories have been combined into a ‘Dependent Children’ category. Secondly, as single person households do not have any dependent children data attached to them, as the dependent children variable is a family variable, it has been necessary to change the dependent children data for all single person households from ‘Not applicable (not in a family / student living away / not in a household)’ to ‘No Dependent Children’. The 1991 dependent children variable has also been recoded in the same two ways. Firstly, the ‘.00’ category has been recoded into a ‘No Dependent Children’ category and the ‘1 or more’ category into a ‘Dependent Children’ category. Secondly, as with the 2001 I-SAR, the dependent children variable in the 1991 I-SAR is a family variable and, therefore, the dependent children data for all single person households has been changed from ‘Not in hhold’ to ‘No Dependent Children’.

For the 2011 I-SAR, all of the categories other than the ‘No dependent children’ category in the ‘Family dependent children’ variable were aggregated to form the ‘Dependent Children’ category and the ‘No dependent children’ category of the ‘Family dependent children’ variable became the ‘No Dependent Children’ category.

The two occupation categories are ‘Professional and Managerial’ (0) and ‘Non-Professional and Non-Managerial’ (1). The 1991 occupation variable was created by combining the ‘Managers/admnst’, ‘Prof occupations’ and ‘Assoc prof/tech’ categories from the ‘Occupation: SOC Major groups’ variable into the ‘Professional and Managerial Occupations’ category, with the other occupation categories combined to form the ‘Non-Professional and Non-Managerial Occupations’ category. The 2001 occupation variable was created by aggregating 11 categories, ranging from the ‘Employers in large organisations’ category to the ‘Lower managerial’ category, from the ‘NS-SEC Socio-Economic Classification’ variable into the ‘Professional and Managerial Occupations’ category and aggregating 24 categories, ranging from the ‘Higher supervisory’ category to the ‘Routine agricultural’ category, into the ‘Non-Professional and Non-Managerial Occupations’ category. The 2011 occupation variable was created by aggregating 11 different categories from the ‘National Statistics Socio-Economic Classification’ variable, ranging from the ‘Employers in large organisations’ category to the ‘Lower managerial and administrative occupations’ category, into the ‘Professional and Managerial Occupations’ category, while the ‘Non-Professional and Non-Managerial Occupations’ was an aggregation of 24 different categories, ranging from the ‘Higher supervisory occupations’ category to the ‘Routine occupations: Routine agricultural’ category. The incompatibility of the 1991 occupation variable with the 2001 and 2011 occupation variables is because there is no consistent variable indicating occupation used in 1991, 2001 and 2011. Both the 1991 and 2001 microdata included an occupation classification variable (‘Occupation: SOC Major Groups’ in 1991 and ‘International Standard Classification of Occupations’ in 2001), while both the 2001 and 2011 microdata included a socioeconomic classification variable (‘NS-SEC 8 Classes’ in 2001 and ‘National Statistics Socioeconomic Classification’ in 2011), but no consistent variable is available for all three years. The aggregation of different ‘occupation’ variables in 1991, 2001 and 2011 causes some problems with data compatibility and comparability. These issues are highlighted where necessary.

After the exclusion of Scotland and Northern Ireland, the region of usual residence categories for the national BLRs did not need to be recoded and are ‘North East’ (0), ‘North West’ (1), ‘Yorkshire and The Humber’ (2), ‘East Midlands’ (3), ‘West Midlands’ (4), ‘East of England’ (5), ‘South East’ (6), ‘South West’ (7), ‘Inner London’ (8), ‘Outer London’ (9) and ‘Wales’ (10). The only exceptions to this categorisation are for the travel to work BLR in Chapter 4 and for the self-containment BLR, when the ‘Inner London’ and ‘Outer London’ categories are replaced by a ‘London’ category. This difference is due to the use of the regional 2011 I-SAR in the former BLR and the use of the 2001 SAM in the latter.

The LAD of residence categories for the regional BLR are ‘Bradford’ (0), ‘Calderdale’ (1), ‘Kirklees’ (2), ‘Leeds’ (3), ‘Wakefield’ (4), ‘Barnsley’ (5), ‘Harrogate’ (6) and ‘York + Selby’ (7). The Craven LAD, despite being part of the LCR, was excluded from the LCR BLR due to data consistency issues (see Section 3.5.2.3.6).

The commute distance categories when the 1991 and 2011 I-SARs have to be made comparable with the 2001 SAM are ‘<5km’ (0), ‘5km-20km’ (1) and ‘>20km’ (2), while they are ‘<2km’ (0), ‘≥2-<5km’ (1), ‘≥5km-<10km’ (2), ‘≥10km-<20km’ (3), ‘≥20km-<40km’ (4) and ‘≥40km’ (5) when the 2001 I-SAR is used. For the commute distance variable categories, the ‘<2km’ category is equivalent to the ‘0-2km’ 1991 category and the ‘less than 2km’ 2001 category, the ‘≥2km-5km’ category is equivalent to the ‘2-4km’ 1991 category and the ‘2km to less than 5km’ 2001 category, the ‘≥5km-10km’ category is equivalent to the ‘5-9km’ 1991 and the ‘5km to less than 10km’ 2001 category, the ‘≥10km-20km’ category is equivalent to the ’10-19km’ 1991 category and the ‘10km to less than 20km’ 2001 category. The ‘≥20km-40km’ used in the analyses was created by aggregating the ’20-29km’ and ’30-39km’ 1991 categories and is equivalent to the ‘20km to less than 40km’ 2001 category, whereas the ‘≥40km’ category is equivalent to the ‘40km and over’ categories in both 1991 and 2001. Most of the distance categories in the 2011 I-SAR were already appropriate. However, the ‘40 to <60km’ and the ‘60km or more’ categories of the ‘Distance travelled to work’ variable were aggregated to form the ‘≥40km’ category.

The mode of transport categories when the 1991 and 2011 I-SARs have to be made comparable with the 2001 SAM are ‘Train, Underground and Tram’ (0), ‘Bus’ (1), ‘Car’ (2), ‘Bicycle’ (3) and ‘Other’ (4), while they are ‘Train, Underground and Tram’ (0), ‘Bus’ (1), ‘Car (Driver)’ (2), ‘Car (Passenger)’ (3), ‘Bicycle’ (4), ‘On Foot’ (5) and ‘Other’ (6) when the 2001 I-SAR is used. For the mode of transport variable categories, the ‘Train, Underground and Tram’ category was created by aggregating the ‘B.R. train’ and ‘Other rail’ 1991 categories and aggregating the ‘Underground metro light rail(EWandS) or tram(EandW) or tube(S)’ and ‘Train’ 2001 categories, the ‘Bus’ category is equivalent to the ‘Bus’ 1991 category and the ‘Bus minibus or coach’ 2001 category, the ‘Car (Driver)’ category is equivalent to the ‘Car – driver’ 1991 category and the ‘Driving a car or van’ 2001 category, the ‘Car (Passenger)’ category is equivalent to the ‘Car – passenger’ 1991 category and the ‘Passenger in a car or van’ 2001 category, and the ‘Bicycle’ category is equivalent to the ‘Pedal cycle’ 1991 category and the ‘Bicycle’ 2001 category. The ‘On Foot’ category is equivalent to the ‘On foot’ categories in both 1991 and 2001. Finally, the ‘Other’ category was created by aggregating the ‘Motorcycle’ and ‘Other’ 1991 categories and aggregating the ‘Motor cycle scooter or moped’, ‘Taxi or minicab' and 'Other' 2001 categories. As with the distance categories, most of the mode of transport categories in the 2011 I-SAR were already appropriate. However, the 'Underground, metro, light rail, tram' and the 'Train' categories from the 'Travel to work' variable had to be aggregated to form the 'Train, Underground and Tram' category, while the 'Taxi', 'Motorcycle, scooter or moped' and 'Other' categories were aggregated to form the 'Other' category.

3.5.2.2.4 The reference variable categories

As previously stated, BLR allows one to quantify the relative likelihood of predefined behavioural patterns for a selection of sociodemographic and geographic variable categories in relation to a set of corresponding reference categories. These reference categories can be selected automatically by SPSS (for the first or last categories of each variable) or customised by altering the SPSS BLR syntax. For each BLR predictor variable, whether using PEs or IEs, the automatic selection procedure in SPSS was used with the first category of each variable being used as the reference category.

3.5.2.2.5 National binary logistic regression population

The five BLRs in Chapters 4, 5 and 6 are national in scope and therefore include commuters and individuals in England and Wales. All five national BLRs exclude individuals in Scotland and Northern Ireland, those younger than 16, older than 74, full-time students and those with 'no fixed place' of work. The BLR modelling travel to work excludes homeworkers in order to calculate the relative likelihoods of an individual travelling to work, while the BLR modelling homeworking excludes non-commuters in order to calculate the relative likelihoods of a commuter working at or from home. The BLRs modelling very long-distance commuting, commuting self-containment and mode of transport all exclude both homeworkers and non-commuters in order to calculate the relative likelihoods of a commuter commuting very long-distance, commuting inside their LAD of residence and commuting using public transport.

3.5.2.2.6 Regional binary logistic regression population

The BLR in Chapter 7 (the LCR public transport BLR) is regional in scope and therefore only includes commuters resident in the LCR. Like the England and Wales BLRs, the LCR BLR excludes those younger than 16, older than 74, full-time students and those with 'no fixed place' of work. However, unlike the England and Wales BLRs, the geographical scope of the LCR BLR is not perfect. Due to the merging of some LADs in the 2011 I-SAR (presumably due to data confidentiality issues), it cannot be configured to only include those individuals resident in the LCR. The 2011 I-SAR has the Craven, Hambleton and Richmondshire LADs merged into one. As Craven is part of the LCR while Hambleton and Richmondshire are not, it is not possible to create a perfect 2011 I-SAR for the LCR.

There were three options for dealing with this inconsistency. First, Craven, Hambleton and Richmondshire could be excluded from both the 2001 and 2011 LCR microdata analyses. This would mean that the 2001 and 2011 'LCR' areas were directly comparable. However, it would also mean that neither was politically or geographically the same as the 'true' LCR. Second, Hambleton and Richmondshire could be included in both the 2001 and 2011 LCR microdata analyses. This would also mean that the 2001 and 2011 'LCR' areas were directly comparable. However, as above, it would also mean that neither was politically or geographically the same as the 'true' LCR. Third, Hambleton and Richmondshire could be excluded from the 2001 LCR microdata analyses, but included for the 2011 LCR microdata analyses. This would mean that the LCR area in 2001 would be a perfect representation of the 'true' LCR, while the LCR area in 2011 would not be a perfect representation. This option would also have the added disadvantage of meaning that the findings from the 2001 and 2011 LCR microdata analyses would not be directly comparable (albeit with only relatively small differences in populations). Ultimately, due to the relatively small population of the Craven LAD, the first option was chosen, with the Craven, Hambleton and Richmondshire LADs being excluded in both 2001 and 2011. Therefore, care should be taken when interpreting the results of the LCR BLR in Chapter 7, albeit with only a small difference existing between the actual LCR and the modelled LCR.

3.5.2.3 Simple linear regression (SLR)

This section outlines the SLR models used in the thesis and the datasets and variables used by them. The thesis contains several SLRs in chapter 4 and 7. These SLRs were carried out in IBM SPSS Statistics 22 and are used to examine the correlations, and potential relationships, between independent variables (such as the economic activity rate) and dependent variables (such as the commuting rate). The nature and calculation of a linear regression model is explained by Moore *et al.* (2009), which the following outline is based on. Reference is being made to SLR, as opposed to linear regression in general, because the linear regression models only contain one predictor variable at a time.

SLR minimises the sum of the squared residuals of the model such that it produces a straight line through a set of n data points. It is the slope of this straight line that indicates the correlation between the dependent and independent variables.

In SLR, the model involves a single continuous dependent variable (y) and a single continuous independent variable (x) and can be written as:

$$y = \beta_0 + \beta_1 x + \varepsilon \qquad (3.10)$$

where y is the value of the dependent variable, β represents the intercept on the Y axis (β_0) and the regression coefficient (β_1), or the slope of the regression line relating to the x variable. The final term, ε, is the random error term.

The statistics used in the SLR analyses include the coefficient (β_1), the significance scores (p-values) and the model fit (R^2). The β_1 coefficient is a measure of the correlation between the dependent variable and the independent variable. In the commuting context, the β_1 coefficient represents the change that can be expected in the dependent variable (e.g. the commuting rate of an area) given a one standard deviation increase in the independent variable (e.g. the economic activity rate of an area). A positive β_1 coefficient indicates that there is a positive correlation between the dependent and independent variables; while a negative β_1 coefficient indicates the correlation is negative. As with the BLRs, the significance score (p-value) of a SLR indicates whether or not the β value in question is statistically significant. A significance score of less than 0.05 means that there is a less than 5% chance that the true values of the respective OR and β value are outside of 95% confidence interval. Finally, the R^2 indicates the percentage of the variation in the dependent variable that is explained by the SLR model. With a SLR, as used in this thesis, an R^2 of 1 would indicate that 100% of the variation in the dependent variable had been explained by the independent variable, while an R^2 of 0 would indicate that the independent variable did not explain any of the variation in the dependent variable.

3.6 Conclusions

This chapter has introduced the data and spatial frameworks used in this thesis. A systematic review of the attribute and boundary data available for an analysis of commuting to work patterns in the UK has been carried out. The chapter has reviewed commuting data from the decadal census and boundary data in the form of the official census geographies.

Every dataset has advantages and disadvantages, but the research is going to make use of aggregate data, interaction data and microdata from the census, at both the national and city region levels. The national analysis of commuting propensities and patterns and modal split will make use of LAD level attribute and boundary data, while the city region level analysis of commuting patterns within the LCR will make use of MSOA level attribute and boundary data.

This chapter has also introduced the methods used in this thesis. The spatial and statistical methods used were systematically reviewed and justified. Although the methods in question have advantages and disadvantages, it was judged that the chosen approaches were the most suitable for the research, given its applied nature and policy focus.

Overall, the research has employed a range of different attribute and boundary data and methods in order to make sure that the research findings are reliable and robust. Where it is appropriate, more in-depth discussions of the data and methods have been provided in Chapters 4, 5, 6 and 7.

While alternative data and methods are available, the discussions in this chapter have illustrated that the chosen data and methods are suitable for achieving the thesis aims and objectives set out in Chapter 1. Alternative data and methods will be revisited in Chapter 8, particularly when identifying potential future research options.

4. Spatial, Sociodemographic and Temporal Commuting Patterns: Local Authority Variations

4.1 Introduction

Over the decade between the censuses of 2001 and 2011, the UK experienced substantial economic, demographic, social and political changes including the continuing tertiarisation of the economy (ONS, 2013vii), increasing fuel costs (BBC, 2013i, 2013iii, 2014, 2015vi, 2015ix), urban regeneration (Seo, 2002; Ogden and Hall, 2000), relatively high levels of immigration and population growth (ONS, 2012iv), increased female participation in the labour force (Scheiner and Kasper, 2003; ONS, 2013viii), further political devolution (BBC, 2015i, 2015ii) and increased environmental awareness in line with international trends (Lorenzoni *et al.*, 2007). These changes, together with a number of policy and infrastructure initiatives, such as the introduction of the congestion charge in London and developments of the road or rail networks across the nation, are likely to have had implications for commuting propensities, patterns and behaviours. Given this dynamic context, this chapter addresses the first broad research question set out in Chapter 1: What variations exist in commuting propensities and patterns both spatially and between sociodemographic groups and how did they change between 2001 and 2011?

To begin with, national and regional commuting rates in England and Wales are presented and the changes between the censuses are identified to establish whether national rates have increased due to the factors mentioned above, all of which are likely to have encouraged commuting in an era of increasing hypermobility (Gössling *et al.*, 2009). Variations in commuting rates at LAD level are examined to determine whether the highest commuting rates are found in southern England and the lowest commuting rates are evident in northern England and Wales reflecting the economic disparities between the north and the south. After taking account of the homeworking data issues outlined in Chapter 3, the proportions of homeworkers in LADs are analysed to establish whether or not working at or from home has become more prevalent, as suggested by the ONS (2014ii), and which sociodemographic groups are most likely to work at or from home. Attention is then given to modes of travel to work with variations at the national level and across LADs in England and Wales being investigated to see how the usage of the different modes has changed and how mode varies by LAD.

This chapter makes use of the census aggregate statistics and microdata introduced in Chapter 3. In Sections 4.2 the 2001 and 2011 aggregate data are used to analyse spatial variations in overall commuting rates and spatial variations in commuting rates by sex and age group. The microdata and aggregate data are using in section 4.3 and 4.4 to analyse sociodemographic and spatial variations in travel to work rates and homeworking rates. The analyses by modal split and the spatial variations in the different modes of transport at LAD level in Section 4.5 are based on further use of aggregate data. Section 4.6 presents some policy recommendations based on the analyses and draws some conclusions.

4.2 Commuting in England and Wales

Table 4.1 shows that the number of commuters, including homeworkers, in England and Wales increased between 2001 and 2011 from 23.6 million to 26.6 million, an increase partly due to population growth of more than 3.5 million in England and Wales. When the number of commuters is divided by the population at risk, the standardised commuting rate (see Chapter 3) indicates that there was a 3.8% increase in the overall commuting rate.

Table 4.1 also shows that the numbers of residents and commuters in each sex and every broad age group also increased over the period. The group which saw the largest increase of 10.8 percentage points in the commuting rate is those aged 65-74. This represents an increase of 129% but from a relatively low rate of 8.4 per 100 population in 2001. In contrast, the 16-24 age group saw its commuting rate decrease by 6.6 percentage points or 12% over the same period.

Table 4.1: Commuting numbers and rates for all individuals (including homeworkers) in England and Wales aged 16-74 in 2001 and 2011 and the percentage point changes between 2001 and 2011 by sex, age group, ethnic group, LLTI and dependent children (see Chapter 2 for variable choice justification)

Variables and Categories		Number of Commuters		Population 16-74		Commuting Rate (%)		% Point Change
Variables	Categories	2001	2011	2001	2011	2001	2011	01-11
England and Wales*		23,627,881	26,526,336	37,607,437	41,126,540	62.8	64.5	1.7
Sex*	Male	12,791,648	14,116,119	18,504,582	20,391,391	69.1	69.2	0.1
	Female	10,836,233	12,565,449	19,102,855	20,735,149	56.7	60.6	3.9
Age Group*	16-24	3,253,699	3,378,570	5,677,810	6,658,636	57.3	50.7	-6.6
	25-64	20,006,534	22,213,889	27,562,595	29,615,071	72.6	75	2.4
	65-74	367,648	933,877	4,367,032	4,852,833	8.4	19.2	10.8
Ethnic Group**	White	656,413	1,172,529	1,067,755	1,787,288	61.5	65.6	4.1
	Indian	13,572	36,756	23,902	55,824	56.8	65.8	9.1
	Pakistani	5,207	17,578	14,259	36,877	36.5	47.7	11.1
	Bangladeshi	1,772	6,679	5,349	14,316	33.1	46.7	13.5
	Black	13,280	38,365	25,540	65,686	52.0	58.4	6.4
	Chinese	2,750	8,714	5,674	17,944	48.5	48.6	0.1
	Other	7,525	30,329	15,373	54,757	48.9	55.4	6.4
LLTI**	LLTI	48,513	94,013	234,789	330,780	20.7	28.4	7.8
	No LLTI	654,894	1,236,307	1,085,663	1,734,383	60.3	71.3	11
Dependent Children**	No Dependent Children	320,811	585,196	465,957	907,481	68.8	64.5	-4.4
	Dependent Children	269,430	497,549	593,939	708,547	45.4	70.2	24.9

Source: Derived from the 2001 and 2011 Census Aggregate Data (*) and Microdata (**).

Whilst the increases seen in the absolute numbers of commuters in England and Wales between 2001 and 2011 reflect demographic growth (ONS, 2012v), the commuting rates suggest that a higher proportion of the population at risk was commuting. One reason for this may be increased female participation in the workforce (Scheiner and Kasper, 2003) with female commuting rates rising by nearly 7% in comparison with male commuting rates which showed only a very marginal increase. However, the increase in the total commuting rate may also be due to a larger proportion of those aged 65-74 working, possibly due to people working to a later age and retiring later (ONS, 2012vi). The increase may also be as a consequence of convergence between the different ethnic groups, with the commuting rates of all the BME groups, except the Chinese ethnic group, converging with the White ethnic group over the decade. Table 4.1 also shows that the commuting rates of those with a LLTI and without a LLTI both increased between 2001 and 2011, although the difference in the commuting rates between the two groups widened over the decade. Interestingly, while the commuting rate for those with dependent children increased substantially between 2001 and 2011, the commuting rate for those without dependent children decreased.

It is unfortunate that the data available from aggregate sources do not allow consistent comparison between more disaggregated age groups or a cross-classification of males and females by age group but spatial patterns of commuting by sex and broad age at LAD level are explored in Section 4.2.3. However, it is informative at this stage to understand spatial changes in aggregate commuting rates taking place at a more macro, regional scale.

4.2.1 Regional variations in commuting

The regional variation in aggregate commuting rates changed over the decade (Table 4.2), with the largest regional increase of 702,647 commuters taking place in the London region, an increase of 21.2% between 2001 and 2011. In contrast, the smallest increase in the number of commuters was in the North East, at only 124,798 or 11.6%. The lowest percentage increase of 9.3% occurred in the West Midlands. In both 2001 and 2011, the highest commuting intensities were seen for the South East, East of England and South West regions, with 2011 commuting rates of 67.9%, 67.1% and 66.4% respectively, and the lowest intensities were seen in the North East, Wales and North West regions, with commuting rates of 59.9%, 60.7% and 62.3% in 2011. Table 4.2 also shows some convergence in commuting intensities between the regions, with the highest 2001-2011 percentage point increases, of 3.6, 3.5 and 2.7 in commuting rates being seen in Wales, North East and London and the lowest of 0.5, 0.6 and 0.7 percentage points in the South East, West Midlands and East of England.

Table 4.2: Commuting numbers and rates for all individuals (including homeworkers) in the regions of England and Wales aged 16-74 in 2001 and 2011 and the percentage point changes between 2001 and 2011 by region

England and Wales and Regions	Number of Commuters		Population 16-74		Commuting Rate (%)		% Point Change
	2001	2011	2001	2011	2001	2011	01-11
England and Wales	23,627,754	26,526,336	37,607,438	41,126,540	62.8	64.5	1.7
Wales	1,186,256	1,363,615	2,075,347	2,245,166	57.2	60.7	3.6
North East	1,032,968	1,152,970	1,831,354	1,924,206	56.4	59.9	3.5
North West	2,900,020	3,228,744	4,839,669	5,184,216	59.9	62.3	2.4
Yorkshire and The Humber	2,182,839	2,428,074	3,574,331	3,875,219	61.1	62.7	1.6
East Midlands	1,917,728	2,146,541	3,020,752	3,336,532	63.5	64.3	0.8
West Midlands	2,334,567	2,536,876	3,780,784	4,067,119	61.7	62.4	0.6
East of England	2,579,378	2,849,512	3,884,104	4,245,544	66.4	67.1	0.7
London	3,319,134	3,998,897	5,300,332	6,117,482	62.6	65.4	2.7
South East	3,888,756	4,260,723	5,766,307	6,274,341	67.4	67.9	0.5
South West	2,286,108	2,560,384	3,534,458	3,856,715	64.7	66.4	1.7

Source: Derived from the 2001 and 2011 Census Aggregate Data.

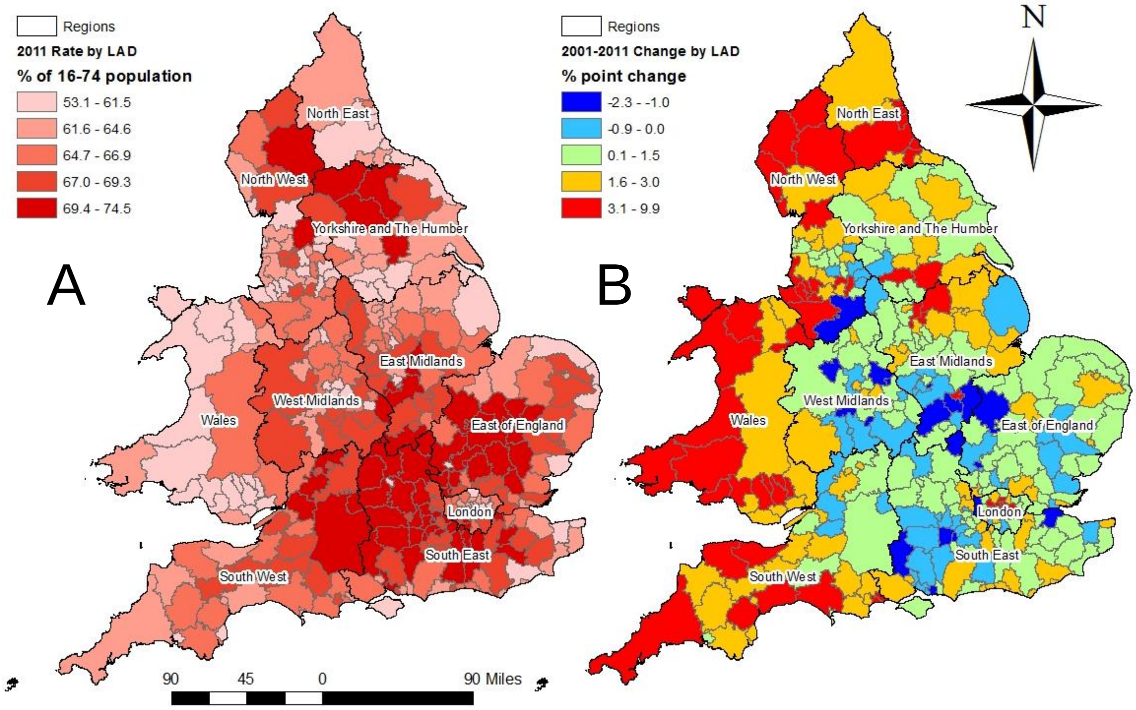
The regional differences in commuting rates, with higher commuting rates in those regions that constitute southern England and lower rates in the regions of northern England and Wales, reflect the north-south economic divide in the UK (Martin, 1988), with economic activity rates generally being lower in northern England and Wales than in southern England (Anyadike-Danes, 2004). Therefore, these northern regions are likely to have relatively smaller numbers of commuters and lower commuting rates as Table 4.2 suggests.

The convergence shown in Table 4.2, with higher percentage point changes in those regions with relatively low commuting rates and lower percentage point changes in those regions with relatively high commuting rates, may be due in part to London experiencing high economic growth and further consolidating its place as a global city during the decade (Pain, 2008) and urban regeneration that has taken place since the late 1990s in some of the cities in the peripheral regions (Tallon, 2013) which has led to job creation and therefore increases in the commuting rates of these areas and their surroundings.

4.2.2 LAD variations in commuting

When mapped (Figure 4.1(A)), the commuting rates at the district level provide a more detailed picture of a core-periphery pattern in 2011 than was apparent from the regional data. The highest commuting rates (>69.4%) are predominantly seen across the home counties in southern England and in some rural areas in northern England such as Ribble Valley, Richmondshire, Harrogate and Selby. These commuting rates include homeworkers and the LAD with the highest commuting rate in England and Wales (81%) is the Isles of Scilly, where population numbers are very small and where homeworking is very important. The lowest commuting rates (<61.5%) are seen in the conurbations of northern England, across Wales, some coastal areas of southern England and several urban LADs in the Midlands and southern England such as Leicester, Coventry, Oxford and Luton.

When changes in commuting rates between 2001 and 2011 are mapped (Figure 4.1(B)), an inverse core-periphery pattern is observed where the largest increases (>3.1 percentage points) have generally been in LADs in more peripheral areas, such as those in the South West, Wales, North West and North East. Increasing commuting rates are not a ubiquitous phenomenon and decreases have generally been confined to South East England, East Anglia and parts of the Midlands. However, there have also been large increases in the LADs of Inner London and decreases in some LADs of northern England, specifically those Pennine LADs between Leeds and Manchester.



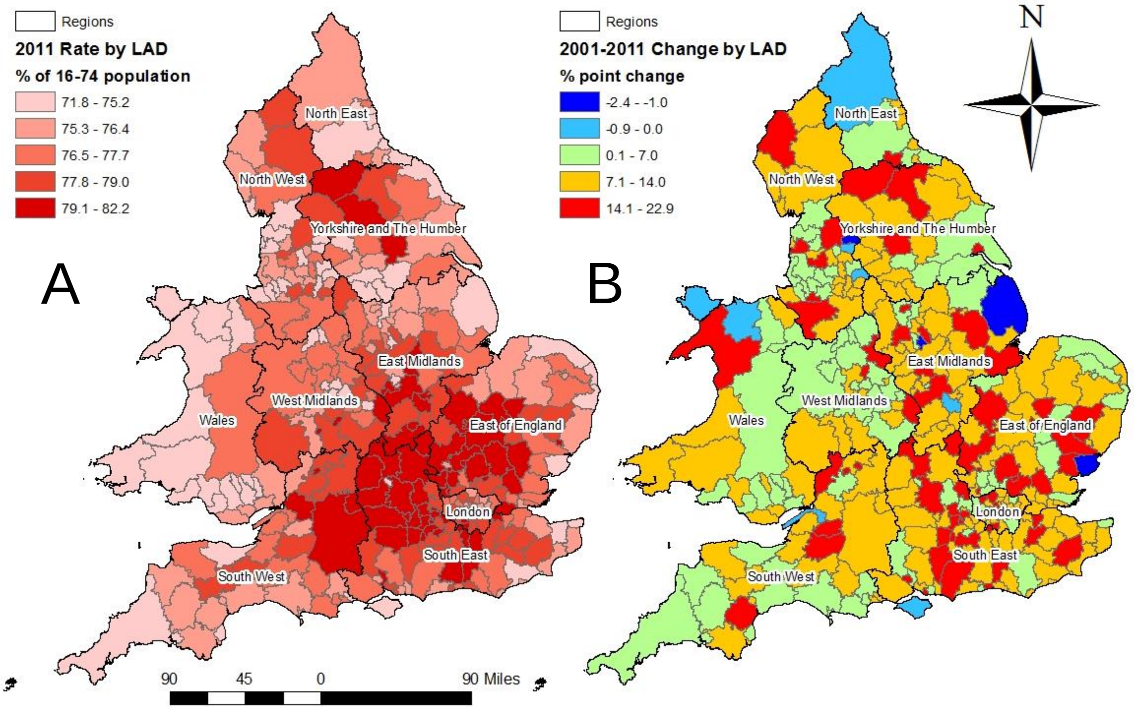
Source: Derived from the 2001 and 2011 Census Aggregate Data.

Figure 4.1: Commuting rates for all individuals (including homeworkers) in England and Wales aged 16-74 in 2011 (A) and the percentage point changes between 2001 and 2011 (B) by LAD

Given that commuting rates essentially measure those in employment, the spatial variations evident in Figure 4.1(A) are likely to reflect the economic inequalities between the core and the more peripheral parts of the country with lower rates of economic activity generally in northern England and Wales and higher rates generally in southern England, apart from London. However, the north-south divide is also accompanied by differentials apparent between urban and rural areas, regardless of whether or not these areas are in the 'north' or 'south'. This urban-rural divide (Scott *et al.*, 2007), is likely to be important in explaining the relatively low commuting intensities seen in the very rural LADs of Wales and northern England. As commuting is an inherently economic activity, these divisions are likely to play some part in producing the spatial variations in commuting rates.

In order to develop a better understanding of the spatial variation in commuting rates, it is helpful to consider the extent to which commuting patterns reflect underlying variation in rates of economic activity, employment and those of working age. Rates of economic activity differ from commuting rates by including all people participating in the labour market, which is those in employment and those actively seeking employment, regardless of whether or not they commute to work. Employment rates include all people who are in employment and are therefore very similar to commuting rates. Finally, the working age population rate is a measure of the proportion of the total population accounted for by people aged 16-64.

The maps in Figure 4.2 confirm that the spatial patterns evident in Figure 4.1 may be partially due to economic activity rates and changes in them between 2001 and 2011. A SLR indicated that the LAD economic activity rate and the commuting rate are highly correlated (R^2=0.908, $p<0.05$). The slope parameter of the OLS regression is 1.174, indicating that a one standard deviation increase in the economic activity rate will lead to a 1.174 standard deviation increase in the commuting rate.



Source: Derived from the 2001 and 2011 Census Aggregate Data.

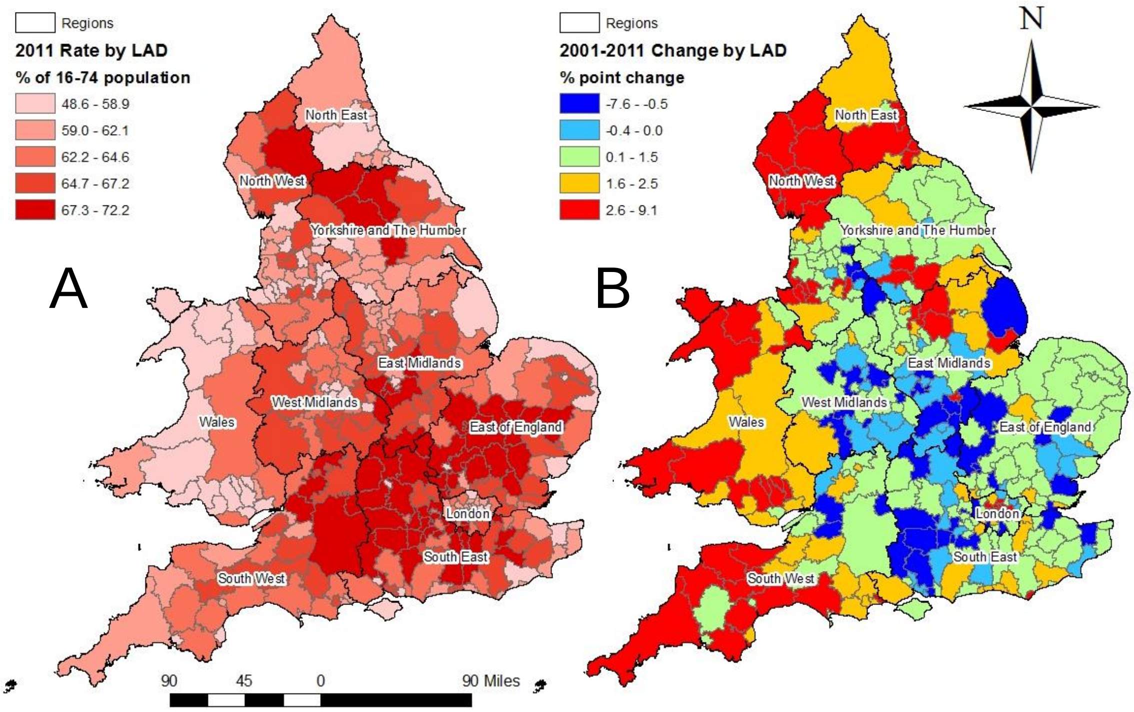
Figure 4.2 Economic activity rates for all individuals in England and Wales aged 16-74 in 2011 (A) and the percentage point changes between 2001 and 2011 (B) by LAD

After the election of the New Labour Government in 1997, many of the urban areas of northern England and Wales experienced a period of regeneration which often attracted increased investment by both the public and private sectors (Adair *et al.*, 2000). It is likely that this regeneration and investment was partly responsible for the increases in commuting rates seen in those areas by increasing economic activity levels through the provision of more employment opportunities. The urban regeneration seen in peripheral cities was also apparent in parts of London (Imrie *et al.*, 2009). However, it is likely that the high economic growth experienced in Central London, after regeneration began in the 1980s, was more important in increasing the number of employment opportunities that are likely to have driven the increase in commuting rates seen in many of the London boroughs. The increase in economic activity may be due, to a large extent, to increased female participation in the workforce (Scheiner and Kasper, 2003).

Figure 4.3 shows a strong core-periphery pattern in employment rates, with the highest employment rates seen across the home counties and some LADs in central and northern England such as Harborough, Eden and Harrogate, and the lowest seen in the coastal areas of southern England, the conurbations of northern England and across Wales. Moreover, the same inverse core-periphery pattern is evident in Figure 4.3 in relation to changes in employment rates that was seen in Figure 4.1 in relation to changes in commuting rates. The largest increases in employment rates have generally been in LADs in the peripheral areas of the South West, Wales and northern England, while the decreases in employment rates have mostly been confined to central and southern England. However, as with commuting rates, this inverse core-periphery pattern is not perfect, as there have been large increases in the employment rate in the LADs of Inner London and decreases in some LADs of northern England, specifically those LADs between Leeds and Manchester.

SLR showed that employment rates and commuting rates at LAD level are highly correlated (R^2=0.971, $p<0.05$) and the regression parameter indicates that a one standard deviation increase in the employment rate will lead to a 0.938 standard deviation increase in the commuting rate. LADs with high employment rates, such as Harrogate, West Oxfordshire and South Cambridgeshire, are those LADs with high commuting rates and LADs with low employment rate, such as Nottingham, Manchester and Liverpool, are those LADs with low commuting rates. In addition, those LADs which have experienced large increases in their employment rate, such as Hackney, Tower Hamlets and Merthyr Tydfil, are those LADs which have experienced high increases in their commuting rate.

This close correlation is unsurprising given that commuting patterns are a product of where people live and work. In this analysis of commuting rates anyone who is employed, regardless whether or not they make a journey from a place of residence to a place of work, is classified as a commuter (see Chapter 3). Given the employment rate is only concerned with whether or not individuals are in employment, the two are going to show similar spatial patterns.



Source: Derived from the 2001 and 2011 Census Aggregate Data.

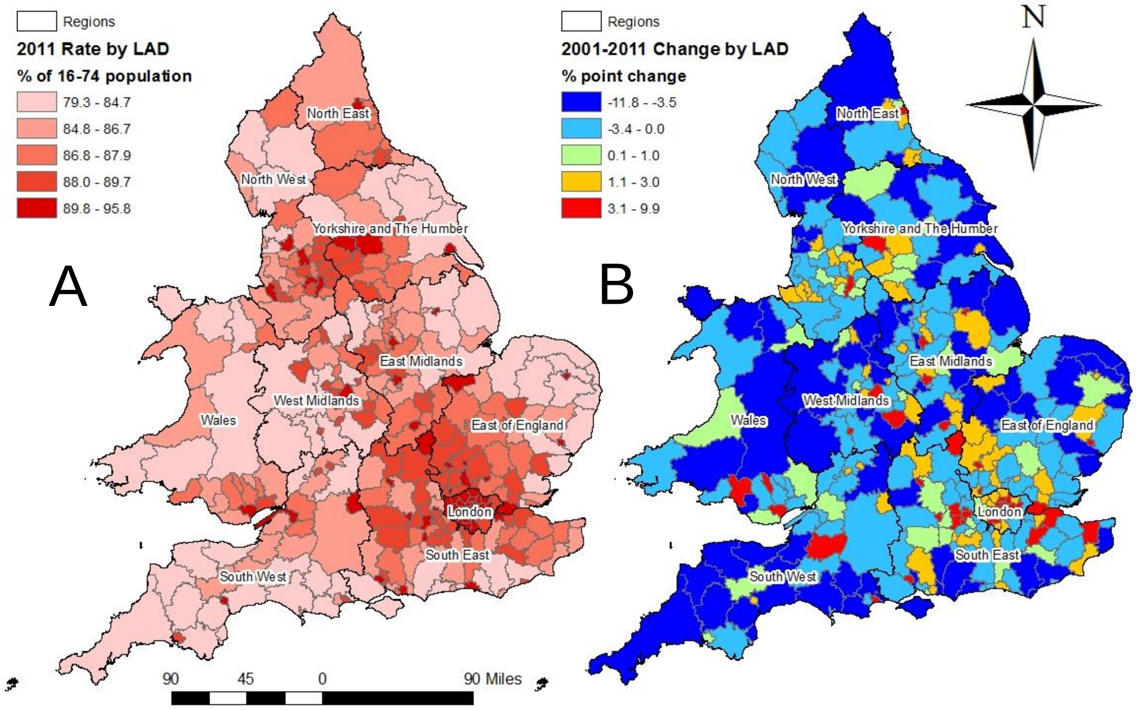
Figure 4.3: Employment rates for all individuals in England and Wales aged 16-74 in 2011 (A) and the percentage point changes between 2001 and 2011 (B) by LAD

It is likely that the 2008 financial crisis contributed to some of the decreases in employment rates seen in southern England as the majority of financial service companies are based in Central London (Keeble and Nachum, 2002), with most of their employees subsequently based in Greater London and southern England. Although the UK economy was recovering from the 2008 financial crisis at the time of the 2011 Census, it is likely that the decreases are partly attributable to many individuals in those areas losing their jobs between 2008 and 2011 during the subsequent 'Great Recession'.

Although spatial variations in economic activity and employment partially explain spatial variations in commuting rates, the changes seen in Figure 4.1 could also reflect more fundamental and long-term demographic changes, in addition to these 'one-off' economic circumstances, such as changes in the proportion of working age individuals.

Figure 4.4(A) shows that urban LADs generally have higher percentages of working age population than rural LADs, with the LADs of Tower Hamlets, Newham and Hackney having the highest percentages of working age population and the LADs of West Somerset, North Norfolk and Christchurch having the lowest percentages. Figure 4.4(B) shows that this divide between urban and rural LADs became more pronounced over time, with the urban LADs of Southampton, Lambeth and Luton experiencing the largest increases in the percentage of working age population between 2001 and 2011 and the rural LADs of East Devon, East Lindsey and East Dorset experiencing the largest decreases.

However, unlike with the economic activity and employment rates, a SLR revealed that the percentage of the population that is working age is not correlated with the commuting rate, as the regression showed a very low R^2 value of 0.001.



Source: Derived from the 2001 and 2011 Census Aggregate Data.

Figure 4.4: Percentage of individuals in England and Wales of working-age (16-64) in 2011 (A) and the percentage point changes between 2001 and 2011 (B) by LAD

The increases seen in some of the urban LADs of northern England, such as Newcastle, Manchester and Liverpool, may be partly due to urban regeneration (Seo, 2002), while the decreases in some rural LADs, such as East Lindsey, Huntingdonshire and Babergh may reflect these areas having a higher proportion of retired people in the 65-74 age bracket living in them. Overall, despite the SLR results, Figure 4.4 confirms that the spatial patterns evident in Figure 4.1 may partially reflect changes in working age populations between 2001 and 2011.

Table 4.3 shows that the highest commuting, economic activity and employment rates in 2011 were generally seen in southern England, with the Bracknell Forest LAD having the highest rate for all three. Conversely, the lowest rates were generally seen in the urban areas of northern England and in Wales, with the Nottingham LAD featuring in the bottom five for all three. All five LADs with the highest percentage of working age population are London boroughs, while those LADs with the lowest percentage of working age population are all rural coastal LADs.

Table 4.4 shows that the largest increases in commuting, economic activity and employment rates between 2001 and 2011 were generally seen in the urban LADs of northern England, London Boroughs and Wales, while the largest decreases were generally seen in the rural LADs of southern and central England, with the exception of the London Borough of Hillingdon, which experienced the largest decrease in employment rates.

When taken together, Tables 4.3 and 4.4 illustrate the general core periphery and convergence patterns seen in Figures 4.1, 4.2 and 4.3.

Table 4.3: Highest and lowest rates of commuting, economic activity, employment and working age population in 2011 by LAD

Rank	Commuting Rate (%)	LAD	Economic Activity Rate (%)	LAD	Employment Rate (%)	LAD	Working Age Population (%)	LAD
1	74.5	Bracknell Forest	78.4	Bracknell Forest	72.2	Bracknell Forest	95.8	Tower Hamlets
2	74.2	West Oxfordshire	77.9	Wandsworth	72.1	West Oxfordshire	95.0	Newham
3	73.4	South Cambridgeshire	77.7	Rushmoor	71.1	South Northamptonshire	94.8	Hackney
4	73.4	South Northamptonshire	77.1	Lambeth	71.1	South Cambridgeshire	94.7	Lambeth
5	73.3	Rushmoor	76.9	Basingstoke and Deane	70.9	Basingstoke and Deane	94.7	Southwark
Mean	65.4		70.1		63.0		87.3	
342	55.7	Birmingham	62.0	Blaenau Gwent	51.3	Middlesbrough	80.5	East Devon
343	55.1	Liverpool	61.7	Tendring	51.1	Newcastle upon Tyne	80.0	East Lindsey
344	54.6	Blaenau Gwent	61.3	Nottingham	51.1	Liverpool	80.0	Christchurch
345	54.2	Middlesbrough	61.1	Ceredigion	50.7	Manchester	79.5	North Norfolk
346	53.1	Nottingham	60.8	East Lindsey	48.6	Nottingham	79.3	West Somerset

Source: Derived from the 2011 Census Aggregate Data.

Table 4.4: Largest rates of change in commuting, economic activity, employment and working age population between 2001 and 2011 by LAD

Rank	Commuting Rate (% Point Change)	LAD	Economic Activity Rate (% Point Change)	LAD	Employment Rate (% Point Change)	LAD	Working Age Population (% Point Change)	LAD
1	9.9	Tower Hamlets	10.7	Tower Hamlets	9.1	Hackney	3.4	Barking and Dagenham
2	9.3	Hackney	9.8	Merthyr Tydfil	8.5	Tower Hamlets	3.2	Tower Hamlets
3	7.9	Merthyr Tydfil	9.6	Hackney	7.3	Merthyr Tydfil	3.1	Crawley
4	7.5	Knowsley	8.6	Knowsley	7.0	Knowsley	3.0	Manchester
5	7.1	Newham	8.5	Newham	6.0	Southwark	2.7	Nottingham
Mean	1.5		2.9		1.2		-0.6	
342	-1.7	Rushmoor	-0.4	Cheshire East	-2.0	Test Valley	-3.5	South Staffordshire
343	-1.7	Milton Keynes	-0.5	Lichfield	-2.0	Portsmouth	-3.9	Maldon
344	-1.8	Daventry	-0.6	Test Valley	-2.1	Daventry	-4.2	Wyre Forest
345	-1.9	Test Valley	-0.9	Daventry	-2.2	Wyre Forest	-4.4	Lichfield
346	-2.3	Wyre Forest	-0.9	Wyre Forest	-2.2	Hillingdon	-4.5	Cheshire East

Source: Derived from the 2001 and 2011 Census Aggregate Data.

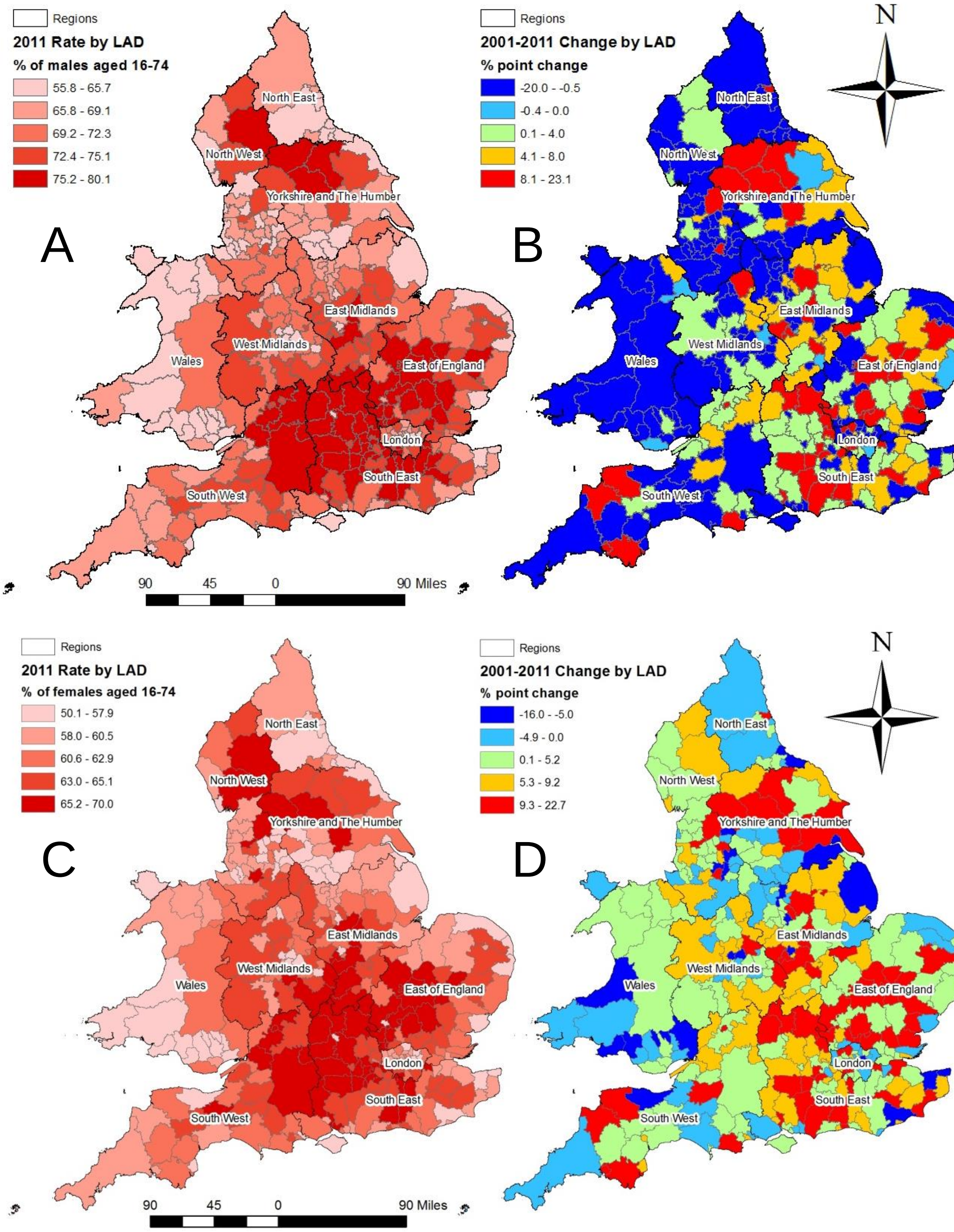
4.2.3 Sociodemographic variations in commuting

This section compares spatial variations in commuting rates by sex and broad age group in 2011 and illustrates how these changed between 2001 and 2011.

Figure 4.5 shows commuting rates disaggregated by sex and these patterns should be interpreted in the context of increasing female participation in the labour force and decreasing male economic activity rates in the wake of the 2008 financial crisis, with Walby (2009) noting that the effects of the financial crisis were gendered.

Maps A and C in Figure 4.5 show that the spatial variation in commuting rates for males and females is very similar and mirrors the aggregate pattern. Maps A and C show both north-south and urban-rural divides in commuting rates for both males and females, with commuting rates for both groups generally being higher in southern and rural areas and lower in northern and urban areas.

Maps B and D show how commuting rates for males have declined in many LADs across all parts of England and Wales, whereas the declines in female commuting rates have largely been confined to peripheral areas. The largest increase and decrease in commuting rates for males were in the Broxbourne and Blaenau Gwent LADs, with an increase of 23.1 percentage points and a decrease of 20.0 percentage points, respectively, whereas the greatest changes in commuting rates for females were in Selby, with an increase of 22.7 percentage points, and in Newham where a decrease of 16.0 percentage points occurred. These change figures suggest that the urban-rural and core-periphery divides in commuting rates for both males and females have become more pronounced over time, with urban and peripheral LADs generally experiencing decreases in their already low commuting rates and rural and core LADs generally experiencing increases in their already high commuting rates. Overall, maps B and D in Figure 4.5 indicate, spatially, the convergence shown in Table 4.1.



Source: Derived from the 2001 and 2011 Census Aggregate Data.

Figure 4.5: Commuting rates for male (A) and female (C) commuters (including homeworkers) in England and Wales aged 16-74 in 2011 and the percentage point changes between 2001 and 2011 (B and D) by LAD

The similar spatial variations in male and female commuting rates are likely to reflect the north-south and urban-rural economic divides in the UK (Martin, 1988; Scott *et al.*, 2007). Both males and females are more likely to be in employment if they live in southern England and in rural or suburban areas and are less likely to be employed if they live in northern England or Wales and in urban areas.

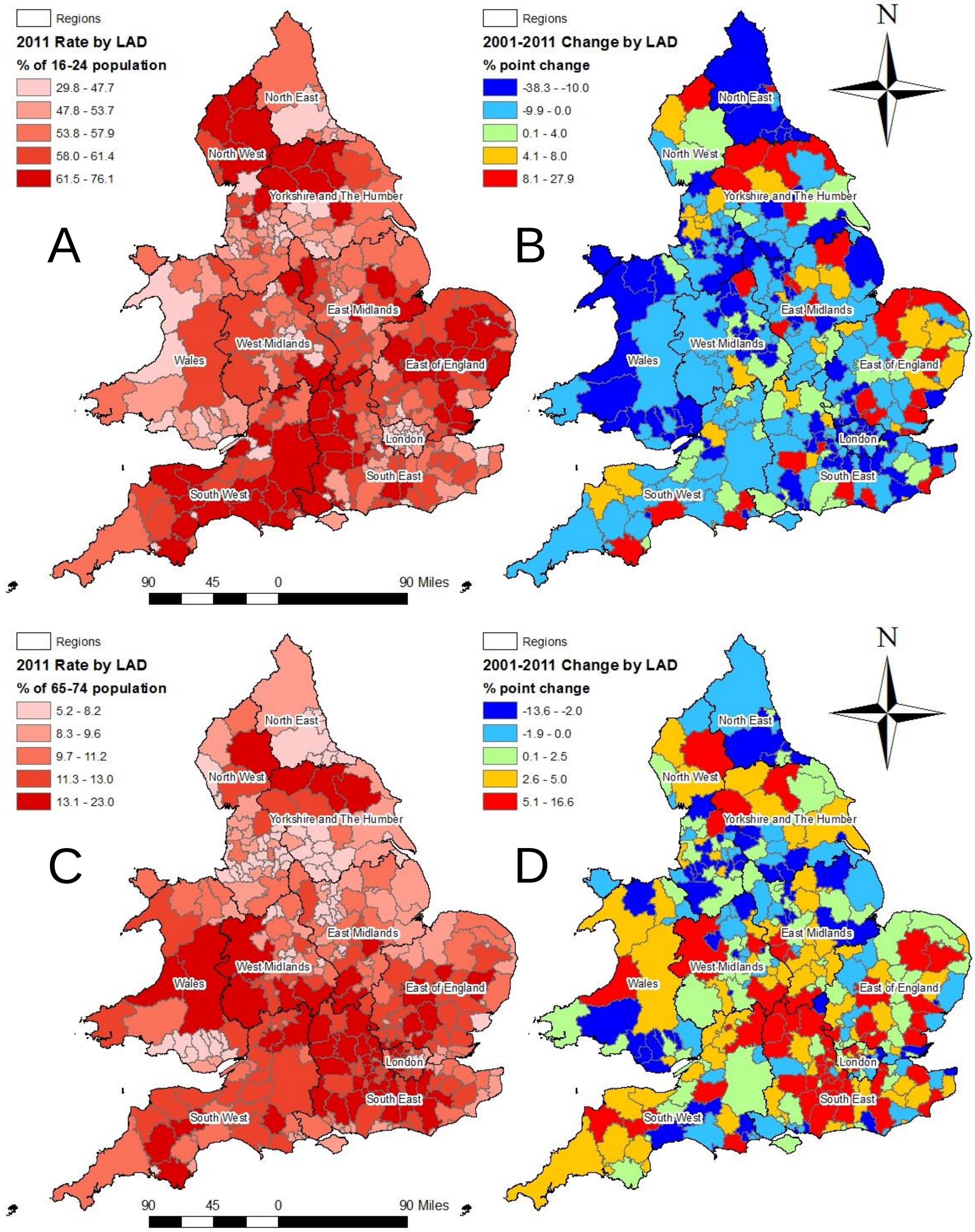
The location of most banking and financial service companies in London (Keeble and Nachum, 2002) may account for very high male commuting rates in the home counties around London, as men are over-represented in these industries in Central and Inner London (Metcalf and Rolfe, 2009). Conversely, given that the female workforce is not concentrated in banking and finance, high female commuting rates are slightly more dispersed throughout southern, central and northern England.

Any decreases in male commuting rates in southern England may be due to the 2008 financial crisis and subsequent recession, with males being more likely to have lost jobs in the banking and financial services sector. The general increases in female commuting rates are likely to reflect increasing female participation in the workforce over the decade (Scheiner and Kasper, 2003). This increased participation may be due to increased childcare subsidies and child benefits, paid maternity leave and tax incentives (Jaumotte, 2003).

For both males and females, those decreases seen in coastal areas and LADs in the South West may reflect an increased proportion of the population being retired people in the 65-74 age group. The widespread decreases in male and female commuting rates in the urban and former mining and industrial areas in Wales and northern England may reflect labour force changes in these areas. With mining and heavy industry being more concentrated in these areas, the continued decline of these activities is likely to have adversely affected the employment opportunities for people in these areas (Fothergill, 2001).

Figure 4.6 shows commuting rates for the 'younger' (16-24) and 'older' (65-74) populations; the pattern for the intervening 25-64 age group is largely responsible for defining the all-age patterns shown in Figure 4.1. Maps A and C in Figure 4.6 show a somewhat similar spatial variation in commuting rates for 'younger' and 'older' commuters, with higher rates generally being seen in rural areas and lower rates generally being seen in urban areas. The highest commuting rates for 'younger' commuters were seen in the rural LADs of Richmondshire (76.1%), Forrest Heath (69.3%) and Eden (68.1%), while the lowest rates for 'younger' commuters were seen in the urban LADs of Cambridge, Oxford and Nottingham, with rates of 29.8%, 29.9% and 32.3%, respectively. The highest commuting rates for 'older' commuters, on the other hand, are found in the Central London LADs of Kensington and Chelsea, City of London and Westminster, with rates of 23.0% and 21.6%, while the lowest rates for 'older' commuters were seen in the urban LADs of South Tyneside (5.2%), Sunderland (5.2%) and Hartlepool (5.3%).

The two age groups experienced rather different changes over the decade (Table 4.1), with the national commuting rate of the younger group decreasing by 6.6 percentage points while that for the 65-74 age group increased by 10.8 percentage points. Maps B and D in Figure 4.6 show that, while commuting rates for 'younger' commuters declined in many parts of England and Wales, declines in the commuting rates for 'older' commuters were mostly confined to urban areas and former industrial and mining areas. The largest increases in commuting rates for 'younger' and 'older' commuters were seen in the Staffordshire Moorlands and Camden LADs, with increases of 27.9 and 16.6 percentage points, respectively. The largest decreases in commuting rates for 'younger' and 'older' commuters were seen in the Kensington and Chelsea and Liverpool LADs, with decreases of 38.3 and 13.6 percentage points, respectively.



Source: Derived from the 2001 and 2011 Census Aggregate Data.

Figure 4.6: Commuting rates for 'younger' (16-24) (A) and 'older' (65-74) (C) commuters (including homeworkers) in England and Wales in 2011 and the percentage point changes between 2001 and 2011 (B and D) by LAD

The spatial variation in the commuting rates for the 'younger' commuters may in part reflect the urban-rural economic divide in the UK (Scott *et al.*, 2007), with the group experiencing higher commuting rates in rural areas and lower commuting rates in urban areas. However, this pattern may also be due to the student population in the UK being concentrated in the large urban areas of northern and central England such as Newcastle, Leeds, Sheffield, Manchester, Liverpool, Nottingham, Leicester and Birmingham. Given that the 16-24 age group accounts for a larger proportion of the populations of these cities, with many of them being students and not counted in the commuting statistics, those in this age group who do commute will be a smaller proportion of the 16-24 population in these cities than elsewhere. The particularly high commuting rate (76.1%) for the 16-24 age group in the Richmondshire LAD may reflect the presence of the army base at Catterick Garrison, where a high proportion of commuters will be young military personnel.

The spatial variations for the 'older' population may reflect the north-south economic divide in the UK (Martin, 1988), with the group generally experiencing higher commuting rates in central and southern England and lower commuting rates in northern England. However, this distinction for the 65-74 age group commuting rates is very generalised. In fact in South Wales and many coastal areas of southern England, the group's commuting rates are very low, whilst in some rural areas of northern England and Mid Wales, they are very high. These anomalies may be accounted for by differences in homeworking rates. As commuters in this age group are more likely to work at or from home (Table 4.4), areas with particularly high homeworking rates, which include Mid Wales and rural northern England (see Figure 4.10(A)), are likely to have higher commuting rates for this group. The particularly high commuting rates for the 65-74 age group in the Central London boroughs may reflect the concentration of banking and finance professionals in those areas and many 'older' individuals working in these sectors choosing to work longer and retire later.

The widespread decreases in the commuting rates of the 'younger' population may reflect the effects of the recession of the late 2000s (Choudhry *et al.*, 2012). However, the large decreases seen in the northern cities of Leeds, Sheffield, Manchester, Liverpool and Nottingham may reflect increases in the student populations of these cities, leading to a lower proportion of the 16-24 populations of these cities commuting to work.

Any increases in the commuting rates of the 'older' population may reflect a larger proportion of those in the 65-74 age group working, possibly due to people working longer and retiring later (ONS, 2012vi). Conversely, any decreases for this age group, particularly in Wales and northern England, may reflect labour force changes. This age group may have been particularly affected by the continued decline of mining and heavy industry activities in these areas (Fothergill, 2001), with employment in these sectors being replaced by unemployment, economic inactivity or retirement.

4.3 Travel to Work in England and Wales

So far, the patterns of commuting in 2011 and the changes between 2001 and 2011 that have been presented and discussed in this chapter have included people who work at or from home.

This section uses census aggregate data and microdata to examine the spatial and sociodemographic variations in commuting rates when homeworkers are excluded; referred to as travel to work rates.

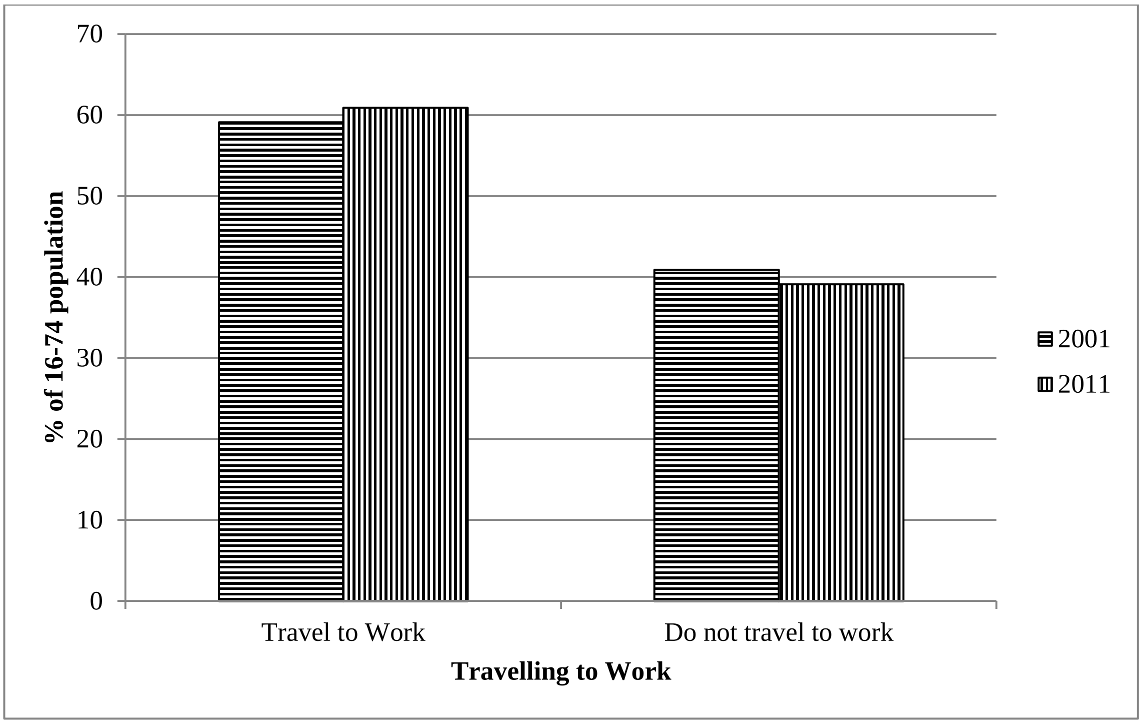
The aggregate data presented in Table 4.5 show that there was a 0.8 percentage point increase in the travel to work rate in England and Wales over the decade. There appears to be a core-periphery divide in travel to work, with the highest travel to work rates in the South East and East of England regions and the lowest rates in the North East and Wales. However, the changes suggest that this divide narrowed between 2001 and 2011, as both the South East and East of England regions experienced percentage point decreases in their travel to work rates, while the North East region and Wales experienced the largest increases.

Table 4.5: Travel to work numbers and rates for all individuals (excluding homeworkers) in England and Wales aged 16-74 in 2001 and 2011 and the percentage point changes between 2001 and 2011 by region

England and Wales Regions	Number Travelling to Work		Population 16-74		Travel to Work Rate (%)		% Point Change 01-11
	2001	2011	2001	2011	2001	2011	
England and Wales	21,457,207	23,802,326	37,607,438	41,126,540	57.1	57.9	0.8
Wales	1,070,933	1,221,437	2,075,347	2,245,166	51.6	54.4	2.8
North East	953,660	1,060,634	1,831,354	1,924,206	52.1	55.1	3.0
North West	2,657,546	2,937,761	4,839,669	5,184,216	54.9	56.7	1.8
Yorkshire and The Humber	1,998,658	2,203,272	3,574,331	3,875,219	55.9	56.9	0.9
East Midlands	1,744,420	1,930,768	3,020,752	3,336,532	57.7	57.9	0.1
West Midlands	2,125,744	2,290,865	3,780,784	4,067,119	56.2	56.3	0.1
East of England	2,335,893	2,544,623	3,884,104	4,245,544	60.1	59.9	-0.2
London	3,033,199	3,618,232	5,300,332	6,117,482	57.2	59.1	1.9
South East	3,502,454	3,758,139	5,766,307	6,274,341	60.7	59.9	-0.8
South West	2,034,700	2,236,595	3,534,458	3,856,715	57.6	58.0	0.4

Source: Derived from the 2001 and 2011 Census Aggregate Data.

The microdata presented in Figure 4.7 confirm the overall pattern shown in Table 4.5, with an increase in the percentage of individuals travelling to work between 2001 and 2011.



Source: Derived from the 2001 and 2011 I-SARs.

Figure 4.7: Percentage of individuals (excluding homeworkers) who travel to work in England and Wales aged 16-74 in 2001 and 2011

It is likely that the increase in travelling to work seen in Table 4.5 and Figure 4.7 is due to economic growth over the decade as well as increased female participation in the workforce (Scheiner and Kasper, 2003) and many people retiring later (ONS, 2012vi).

4.3.1 Sociodemographic variations in travel to work

In this and the next section, the 2001 and 2011 I-SARs are used to quantify the prevalence of travelling to work by a number of sociodemographic and geographic variables and to explore changes between 2001 and 2011. Table 4.6 indicates that travelling to work is more prevalent amongst males, the 25-44 age group, the Indian ethnic group, those without a LLTI, those with dependent children and those who live in London.

Males are substantially more likely to travel to work than females. However, convergence took place as the prevalence of travelling to work amongst men decreased, while increasing amongst women, with women experiencing a 3.7 percentage point increase in travelling to work between 2001 and 2011. Individuals in the 25-44 age group are the most likely to travel to work, closely followed by individuals in the 16-24 age group, with commuters in the 65-74 age group being the least likely to travel to work. As was the case with sex, there does appear to have been some convergence taking place between the age groups, as the prevalence for the 45-64 and 65-84 age groups increased substantially between 2001 and 2011. Convergence between the ethnic groups also appears to be taking place, as Bangladeshis experienced the largest increase in travelling to work, while the White ethnic group, which had the third highest prevalence, saw the smallest increase. Unsurprisingly, individuals without a LLTI are far more likely to travel to work than individuals with a LLTI. Table 4.6 shows that individuals with dependent children are far more likely to travel to work than individuals without dependent children. Although this may seem surprising, this may be due to the inclusion of individuals in the 65-74 age group in the analysis as many individuals in this age group will no longer have dependent children and are less likely to be commuters (Table 4.1). Table 4.6 confirms the north-south divide evident in Table 4.8, with commuters living in the regions of southern England being more likely to travel to work than those in northern England and Wales.

Table 4.6: Percentages and percentage point changes in travelling to work for all individuals (excluding homeworkers) in England and Wales aged 16-74 in 2001 and 2011 by sociodemographic and geographic characteristics

Sociodemographic and Geographic Characteristics		Travel to Work (%)		% Point Change
Variables	Categories	2001	2011	01-11
All	All	59.1	60.9	1.8
Sex	Male	64.7	64.5	-0.2
	Female	53.7	57.4	3.7
Age Group	16-24	72.3	69.2	-3.1
	25-44	72.9	74.2	1.3
	45-64	57.5	61.7	4.2
	65-74	6.1	11.7	5.7
Ethnic Group	White	59.6	61.2	1.6
	Indian	58.5	65.6	7.1
	Pakistani	39.1	48.1	9.0
	Bangladeshi	32.9	45.4	12.5
	Black	56.9	60.3	3.4
	Chinese	56.5	61.7	5.2
	Other	54.9	59.7	4.8
LLTI	LLTI	21.3	24.7	3.4
	No LLTI	67.6	68.4	0.8
Dependent Children	No Dependent Children	54.9	57.0	2.0
	Dependent Children	67.4	69.1	1.8
Region of Usual Residence	North East	54.2	58.1	3.9
	North West	56.8	59.6	2.9
	Yorkshire and the Humber	58.2	59.7	1.5
	East Midlands	59.7	60.9	1.2
	West Midlands	58.1	59.4	1.3
	East of England	61.7	62.6	0.9
	South East	62.6	62.6	0.0
	South West	58.9	60.4	1.5
	London	60.4	63.5	3.1
	Wales	53.9	57.2	3.3

Source: Derived from the 2001 and 2011 I-SARs.

4.3.2 Modelling travel to work

This section presents the results of a BLR model for travelling to work. As outlined in detail in Chapter 3, the BLR model predicts one of two possible outcomes for the dependent variable, given the values of one or more predictor variables. The BLR can therefore be used to explore how the dependent variable varies across the predictor variables. The BLR quantifies the prevalence of predefined behavioural patterns (in this case travelling to work) for a selection of sociodemographic and geographic variable categories in relation to a set of corresponding reference categories.

The first two columns of Table 4.7 contain the sociodemographic and geographic variables included in the regression and their categories. The third and fourth columns show the 2001 and 2011 odds ratios (ORs) with an asterisk (*) used to indicate significance at the 95% confidence level. The final row of the BLR table shows the constant values for the 2001 and 2011 BLRs. The OR for each non-reference variable category indicates the relative likelihood that an outcome will occur, compared to the reference variable category, given the individual belongs to that non-reference variable category. A significance score of less than 0.05 means that one can be 95% confident that the relationship between the independent and dependent variables did not occur by chance.

The model presented in Table 4.7 shows that most of the sociodemographic and geographic variations illustrated by Table 4.6 remain when controlling for the different variables. Table 4.7 indicates that, even when controlling for the other variables, males, those aged 25-44, those without a LLTI and those who live in Southern England are more likely to travel to work. However, while Table 4.6 indicated that those in the Indian ethnic group and those with dependent children were most likely to travel to work, Table 4.7 shows that, when controlling for all the variables, it is those individuals in the White ethnic group and those without dependent children that are most likely to travel to work. This may reflect one of the other variables, possibly age group, influencing the variation in the ethnic group and dependent children variables, with those in the Indian ethnic group and those with dependent children are more likely to be in the 25-44 age group and are, therefore, more likely to travel to work. This difference between Table 4.6 and 4.7 highlights the importance of the BLR model in controlling for all the different variables.

Finally, the regression analysis shows that the value of the constant decreased between 2001 and 2011, from 0.625 to 0.582. This means that, when controlling for all the variables in the model, the relative likelihood of the reference individual travelling to work decreased between 2001 and 2011.

Table 4.7: BLR model results for individuals travelling to work for all individuals (excluding homeworkers) in England and Wales aged 16-74 in 2001 and 2011 by sociodemographic and geographic characteristics

Sociodemographic and Geographic Characteristics		2001 OR		2011 OR	
Variables	Categories				
Sex	Male	1.000		1.000	
	Female	0.558	*	0.712	*
Age Group	16-24	1.000		1.000	
	25-44	1.176	*	1.437	*
	45-64	0.645	*	0.896	*
	65-74	0.029	*	0.074	*
Ethnic Group	White	1.000		1.000	
	Indian	0.776	*	0.924	*
	Pakistani	0.299	*	0.404	*
	Bangladeshi	0.213	*	0.346	*
	Black	0.672	*	0.695	*
	Chinese	0.580	*	0.644	*
	Other	0.543	*	0.631	*
LLTI	LLTI	1.000		1.000	
	No LLTI	6.389	*	5.239	*
Dependent Children	No Dependent Children	1.000		1.000	
	Dependent Children	0.795	*	0.885	*
Region of Usual Residence	North East	1.000		1.000	
	North West	1.132	*	1.076	*
	Yorkshire and the Humber	1.184	*	1.049	*
	East Midlands	1.224	*	1.105	*
	West Midlands	1.181	*	1.068	*
	East of England	1.295	*	1.147	*
	South East	1.325	*	1.128	*
	South West	1.181	*	1.077	*
	London	1.185	*	1.124	*
	Wales	1.014		0.992	
	Constant	0.625	*	0.582	*

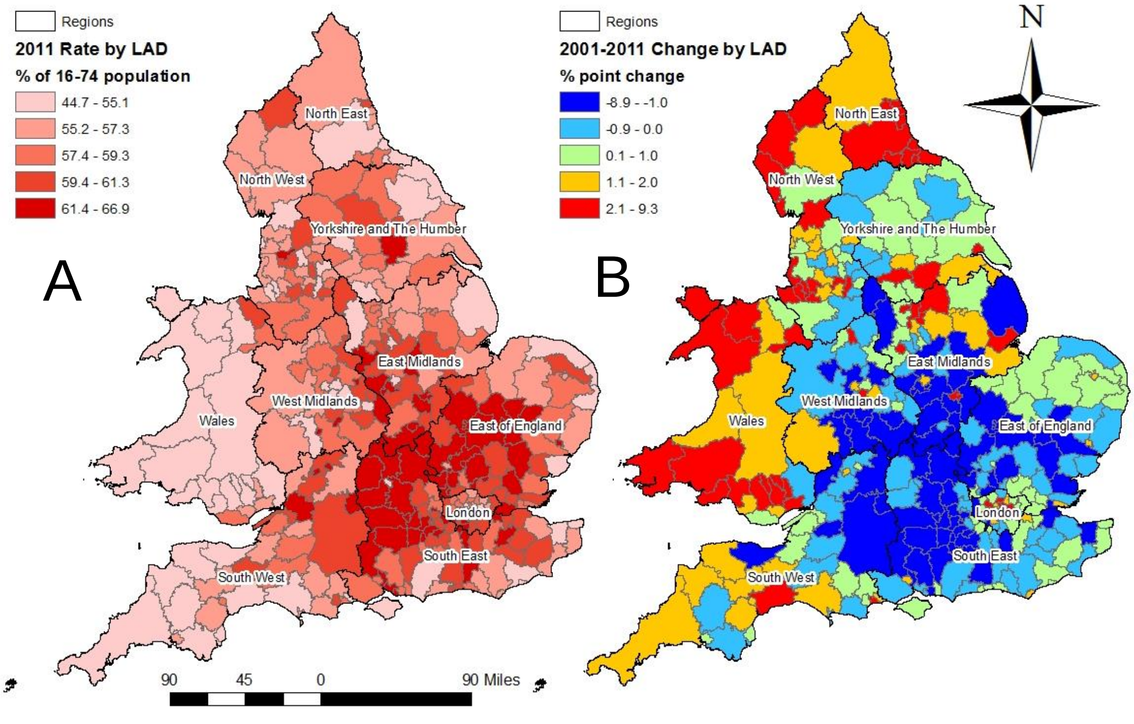
Source: Derived from the 2001 and 2011 I-SARs. (*=OR is statistically significant ($p<0.05$)).

Males may be more likely to travel to work due to them being more likely to work in heavy industy and manufacturing (Cowling and Taylor, 2001). However, the convergence between males and females is likely due to increased female participation in the workforce (Scheiner and Kasper, 2003). It is likely that the increased ORs for the 45-64 and 65-74 age groups are due to many individuals in these age groups retiring later in 2011 than they would have in 2001 (ONS, 2012vi) in part due to the change in state pension age. At the other end of the age spectrum, the relatively lower OR for the 16-24 age group is likely due to the 2008 financial crisis and subsequent recession, which particularly affected younger individuals (Choudhry *et al.*, 2012). The general convergence in ORs for the BME groups may be due to the processes of assimilation and integration, as the commuting propensities, patterns and behaviours of BME individuals become more similar to the established White population. Unsurprisingly, those without dependent children are more likely to travel to work as many individuals with dependent children may take advantage of homeworking opportunities in an effort to balance their childcare and work responsibilities. However, the convergence seen between the two groups between 2001 and 2011 may be due to the effects of childcare policies, making it easier for parents to work while their children are young (Jaumotte, 2003).

4.3.3 LAD variations in travel to work

As was the case with the overall commuting rate, Figure 4.8(A) shows a core-periphery pattern in travel to work rates at LAD level. The highest travel to work rates are seen in the home counties surrounding London and in some areas of central and northern England, while the lowest travel to work rates are seen in the urban LADs of northern England, across Wales and the coastal areas of southern England. The highest travel to work rate is seen in the Crawley LAD at 66.9%, while the lowest rate is seen in the Ceredigion LAD at 44.7%. The exclusion of homeworkers accounts for the much lower rates in rural northern England and Wales in Figure 4.8(A), compared to Figure 4.1(A).

Figure 4.8(B) shows the same inverse core-periphery pattern in the changes in travel to work rates as shown in Figure 4.1(B). The highest increases in travel to work rates have generally been in the peripheral areas of the South West, Wales and northern England, while decreases in travel to work rates have largely been confined to central and southern England. However, there have been large increases in many Central London LADs and decreases in some northern England LADs in North Yorkshire and between Leeds and Manchester.



Source: Derived from the 2001 and 2011 Census Aggregate Data.

Figure 4.8: Travel to work rates for all individuals (excluding homeworkers) in England and Wales aged 16-74 in 2011 (A) and the percentage point changes between 2001 and 2011 (B) by LAD

As was the case with overall commuting rates (Figure 4.1(A)) the spatial patterns seen in Figure 4.8(A) are likely a reflection of the economic north-south divide in the UK. The spatial variation in changes seen in Figure 4.8(B) may reflect labour market changes since the 2008 financial crisis. The decreases seen in much of southern and central England may be because of the many people who lost their jobs in banking and finance. Conversely, the increases seen in northern England and Wales may reflect urban regeneration and the rise of city centre living as more young and working age individuals move to urban areas.

4.4 Working At or From Home in England and Wales

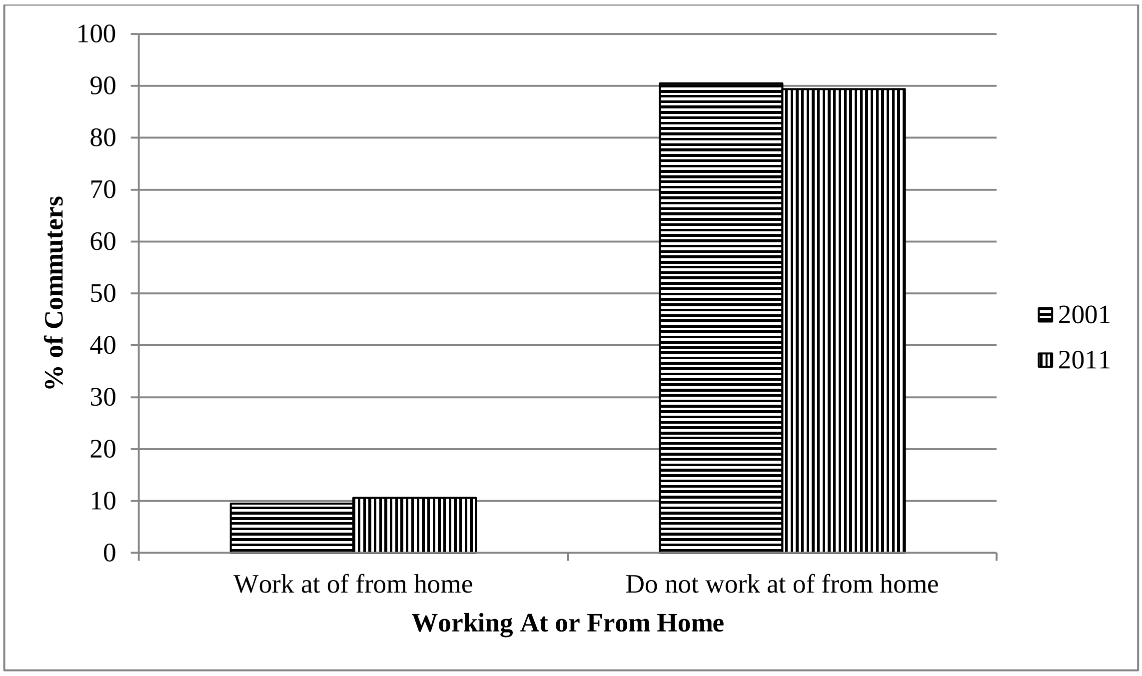
The aggregate data presented in Table 4.8 show that there was an increase in homeworking in England and Wales, with the overall rate of homeworking increasing by 1.1 percentage points between 2001 and 2011. There appears to be a north-south divide in homeworking, with the lowest homeworking proportions found in the North East, North West and Yorkshire and the Humber regions and the highest proportions recorded in the South East, South West and East of England regions. The percentage point changes suggest that this divide is becoming more prominent, as the three southern regions have also experienced the largest percentage point increases in homeworking, while the North East and North West regions have experienced the smallest increases.

Table 4.8: Homeworking numbers and rates for all commuters in England and Wales aged 16-74 in 2001 and 2011 and the percentage point changes between 2001 and 2011 by region

England and Wales Regions	Number of Homeworkers		Number of Commuters 16-74		Homeworking Rate (%)		% Point Change
	2001	2011	2001	2011	2001	2011	01-11
England and Wales	2,170,547	2,724,010	23,627,754	26,526,336	9.2	10.3	1.1
Wales	115,323	142,178	1,186,256	1,363,615	9.7	10.4	0.7
North East	79,308	92,336	1,032,968	1,152,970	7.7	8.0	0.3
North West	242,474	290,983	2,900,020	3,228,744	8.4	9.0	0.7
Yorkshire and The Humber	184,181	224,802	2,182,839	2,428,074	8.4	9.3	0.8
East Midlands	173,308	215,773	1,917,728	2,146,541	9.0	10.1	1.0
West Midlands	208,823	246,011	2,334,567	2,536,876	8.9	9.7	0.8
East of England	243,485	304,889	2,579,378	2,849,512	9.4	10.7	1.3
London	285,935	380,665	3,319,134	3,998,897	8.6	9.5	0.9
South East	386,302	502,584	3,888,756	4,260,723	9.9	11.8	1.9
South West	251,408	323,789	2,286,108	2,560,384	11.0	12.6	1.6

Source: Derived from the 2001 and 2011 Census Aggregate Data.

The microdata presented in Figure 4.9 confirm the overall pattern shown in Table 4.8, with a slight increase in the percentage of commuters working at or from home between 2001 and 2011.



Source: Derived from the 2001 and 2011 I-SARs.

Figure 4.9: Percentage of commuters who work at or from home in England and Wales aged 16-74 in 2001 and 2011

The increased prevalence of homeworking seen in Table 4.8 and Figure 4.9 may reflect the demise of mining and heavy industry in the UK (Fothergill, 2001). Many of the skilled manual workers who previously worked in these sectors may have responded to the prospect of unemployment or economic inactivity by becoming self-employed. Increases may also be linked to counter-urbanisation (Champion, 1989), with rural residents choosing to set up businesses instead of making long commutes to jobs in urban areas, and as homeworking is most prevalent within the agricultural and construction industries (ONS, 2014iii).

4.4.1 Sociodemographic variations in homeworking

Table 4.9 indicates that homeworking is more prevalent amongst males, those aged over 45, the Chinese ethnic group, those with a LLTI and those who live in southern England outside of London.

Males are substantially more likely to be homeworkers than females, with 11.8% of men working at or from home, compared to only 9.2% of women. It is also the case that the prevalence of homeworking amongst men increased more than amongst women, with a 1.4 percentage point increase between 2001 and 2011. ‘Older’ commuters are much more likely to work at or from home than ‘younger’ commuters, with 13.2% and 26.9% of commuters aged 45-64 and 65-74 being homeworkers, compared to only 4.3% and 8.7% of commuters aged 16-24 and 25-44, respectively. However, there does appear to be some convergence taking place between the age groups, as the prevalence for the 16-24, 25-44 and 45-64 age groups increased, while the proportion of homeworkers amongst the 65-74 age group decreased by 1.1 percentage points. Commuters of Chinese ethnicity are considerably more likely to be homeworkers than commuters in any other ethnic group, with 15.1% of Chinese commuters working at or from home. At the opposite end of the spectrum, only 8.2% of Black commuters are homeworkers. However, convergence between the ethnic groups does appear to be taking place, as the homeworking proportion amongst Chinese commuters decreased by 2.5 percentage points between 2001 and 2011, while that amongst White and Black commuters increased by 1.3 and 0.6 percentage points, respectively, over the same period. A commuter with a LLTI is more likely to work at or from home than a commuter without a LLTI, with no convergence taking place as the prevalence amongst both groups increased by 1.1 percentage points. Commuters with no dependent children and non-professional and non-managerial occupations are slightly more likely to be homeworkers than commuters with dependent children and professional and managerial occupations, with differences of 0.1 and 0.4 percentage points, respectively. Table 4.9 confirms the north-south divide evident in Table 4.8, with commuters living in the regions of southern England being more likely to work at or from home than those in northern England and Wales.

Table 4.9: Percentages and percentage point changes in commuters working at or from home for all commuters in England and Wales aged 16-74 in 2001 and 2011 by sociodemographic and geographic characteristics

Sociodemographic and Geographic Characteristics		Work At or From Home (%)		% Point Change
Variables	Categories	2001	2011	01-11
All	All	9.5	10.6	1.1
Sex	Male	10.4	11.8	1.4
	Female	8.3	9.2	0.9
Age Group	16-24	4.1	4.3	0.2
	25-44	8.0	8.7	0.7
	45-64	12.4	13.2	0.8
	65-74	28.0	26.9	-1.1
Ethnic Group	White	9.4	10.7	1.3
	Indian	11.8	9.2	-2.6
	Pakistani	9.8	9.6	-0.2
	Bangladeshi	17.3	10.0	-7.3
	Black	7.6	8.2	0.6
	Chinese	17.6	15.1	-2.5
	Other	10.0	9.3	-0.7
LLTI	LLTI	13.0	14.1	1.1
	No LLTI	9.2	10.3	1.1
Dependent Children	No Dependent Children	9.8	10.6	0.8
	Dependent Children	9.2	10.5	1.3
Occupation	Professional and Managerial	9.2	10.3	1.1
	Non-Professional and Non-Managerial	9.6	10.7	1.1
Region of Usual Residence	North East	7.9	8.3	0.4
	North West	8.6	9.3	0.7
	Yorkshire and the Humber	8.7	9.5	0.8
	East Midlands	9.3	10.3	1.0
	West Midlands	9.3	10.1	0.8
	East of England	9.7	11.1	1.4
	South East	10.2	12.0	1.8
	South West	11.5	13.1	1.6
	Inner London	9.0	10.3	1.3
	Outer London	8.8	9.5	0.7
	Wales	10.0	10.6	0.6

Source: Derived from the 2001 and 2011 I-SARs.

4.4.2 Modelling homeworking

Table 4.10 shows that most of the sociodemographic and geographic variations illustrated by Table 4.9 remain when controlling for the different variables. The model presented in Table 4.10 indicates that, even when controlling for the other variables, males, those aged 45-64 and 65-74, the Chinese ethnic group, those with a LLTI, those with a non-professional and non-managerial occupation and those who live in southern England outside of London are more likely to work at or from home.

However, while Table 4.9 indicated that those with no dependent children were more likely to be homeworkers, Table 4.10 shows that, when controlling for all the variables, it is those commuters with dependent children that are more likely to be homeworkers. This may reflect one of the other variables, possibly age group, influencing the variation in the dependent children variable when not controlled for. This may be because older commuters, who are possibly less likely to have dependent children, are more likely to be homeworkers.

Finally, the regression analysis shows that the value of the constant decreased slightly between 2001 and 2011 from 0.043 to 0.040. This means that, when controlling for all the variables, the relative likelihood of the reference individual working at or from home decreased slightly between 2001 and 2011.

Table 4.10: BLR model results for commuters working at or from home for all commuters in England and Wales aged 16-74 in 2001 and 2011 by sociodemographic and geographic characteristics

Sociodemographic and Geographic Characteristics		2001 OR		2011 OR	
Variables	Categories				
Sex	Male	1.000		1.000	
	Female	0.794	*	0.768	*
Age Group	16-24	1.000		1.000	
	25-44	2.009	*	2.067	*
	45-64	3.287	*	3.402	*
	65-74	8.742	*	8.089	*
Ethnic Group	White	1.000		1.000	
	Indian	1.407	*	0.926	*
	Pakistani	1.228	*	1.013	
	Bangladeshi	2.456	*	1.050	
	Black	0.866	*	0.772	*
	Chinese	2.231	*	1.632	*
	Other	1.239	*	0.962	
LLTI	LLTI	1.000		1.000	
	No LLTI	0.817	*	0.862	*
Dependent Children	No Dependent Children	1.000		1.000	
	Dependent Children	1.086	*	1.164	*
Occupation	Professional and Managerial	1.000		1.000	
	Non-Professional and Non-Managerial	1.070	*	1.061	*
Region of Usual Residence	North East	1.000		1.000	
	North West	1.078	*	1.134	*
	Yorkshire and the Humber	1.102	*	1.164	*
	East Midlands	1.166	*	1.265	*
	West Midlands	1.156	*	1.243	*
	East of England	1.224	*	1.361	*
	South East	1.293	*	1.490	*
	South West	1.467	*	1.625	*
	Inner London	1.183	*	1.403	*
	Outer London	1.086	*	1.194	*
	Wales	1.264	*	1.297	*
	Constant	0.043	*	0.040	*

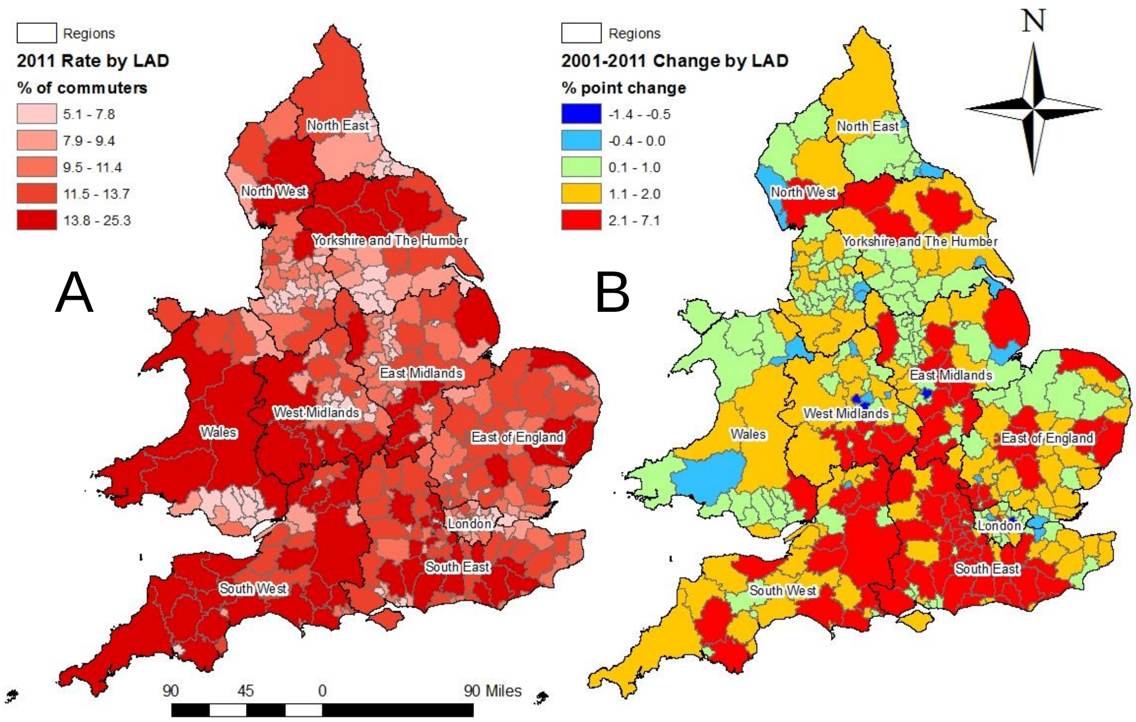
Source: Derived from the 2001 and 2011 I-SARs. (*=OR is statistically significant ($p<0.05$)).

Males may be more likely to work at or from home than females due to the higher prevalence of manual skilled jobs amongst the male population (Cowling and Taylor, 2001). As many of these manual skilled workers have been adversely affected by deindustrialisation, they may have chosen to set up their own home-based businesses making use of their manual skills and new technologies (Allen and Wolkowitz, 1987). It is likely that the higher proportion of homeworking amongst 'older' individuals is linked to the higher prevalence amongst those with a LLTI, with 'older' individuals potentially having health conditions which discourage commuting to a place of work or necessitate working at or from home. Homeworking may be more prevalent amongst Chinese individuals due to the high rate of small business ownership amongst this ethnic group compared to others (Uneke, 1996), with many of these small businesses potentially being run or managed from home. It is perhaps unsurprising that those with dependent children are more likely to work at or from home as many individuals with dependent children may take advantage of homeworking opportunities in an effort to balance their childcare and work responsibilities (Allen and Wolkowitz, 1986). Those with non-professional and non-managerial occupations may be more likely to work at or from home for the same reason that males are, as individuals with manual skilled jobs are included in the non-professional and non-managerial occupation category. Homeworking may be most common amongst those living in the South West and least common amongst those living in the North East because of the nature of the two regions. As the South West is a largely rural and relatively sparsely populated region those living there may take advantage of homeworking opportunities to avoid long and costly commutes to relatively distant towns and cities. Conversely, as the North East is a largely urban and relatively densely populated region, with lots of manufacturing and heavy industry, there is less need for those living there to work at or from home and less opportunity to take advantage of homeworking practices.

4.4.3 LAD variations in homeworking

Figure 4.10 shows the spatial variation in homeworking rates and in the changes between 2001 and 2011 based on aggregate data. Figure 4.10(A) indicates that homeworking rates are generally higher in rural LADs and lower in urban LADs. The highest homeworking rates are seen for the rural LADs of Isles of Scilly, West Somerset and Powys, where over one fifth of commuters are homeworkers. Conversely, the lowest homeworking rates are seen for the urban LADs of Hull, Knowsley and Blaenau Gwent, whose rates are between 5 and 6%.

Figure 4.10(B) also shows an urban-rural divide in changes between 2001 and 2011 in the proportion of commuters who are homeworkers, with large increases mainly being seen in the rural LADs of central and southern England and some rural LADs in northern England and decreases being mainly confined to urban LADs. The largest increases in the prevalence of homeworking were seen for the Isles of Scilly and West Somerset LADs, with increases of 9.5 and 7.1 percentage points, while the largest decreases were seen in the Newham and Sandwell LADs, with decreases of 1.4 and 0.7 percentage points, respectively. These change figures suggest that the urban-rural divide in homeworking became more pronounced over the decade, with urban LADs generally experiencing decreases in their already low homeworking proportions and rural LAD generally experiencing increases in their already high homeworking proportions.



Source: Derived from the 2001 and 2011 Census Aggregate Data.

Figure 4.10: Percentage of commuters in England and Wales aged 16-74 in 2011 that work at or from home (A) and the percentage point changes between 2001 and 2011 (B) by LAD

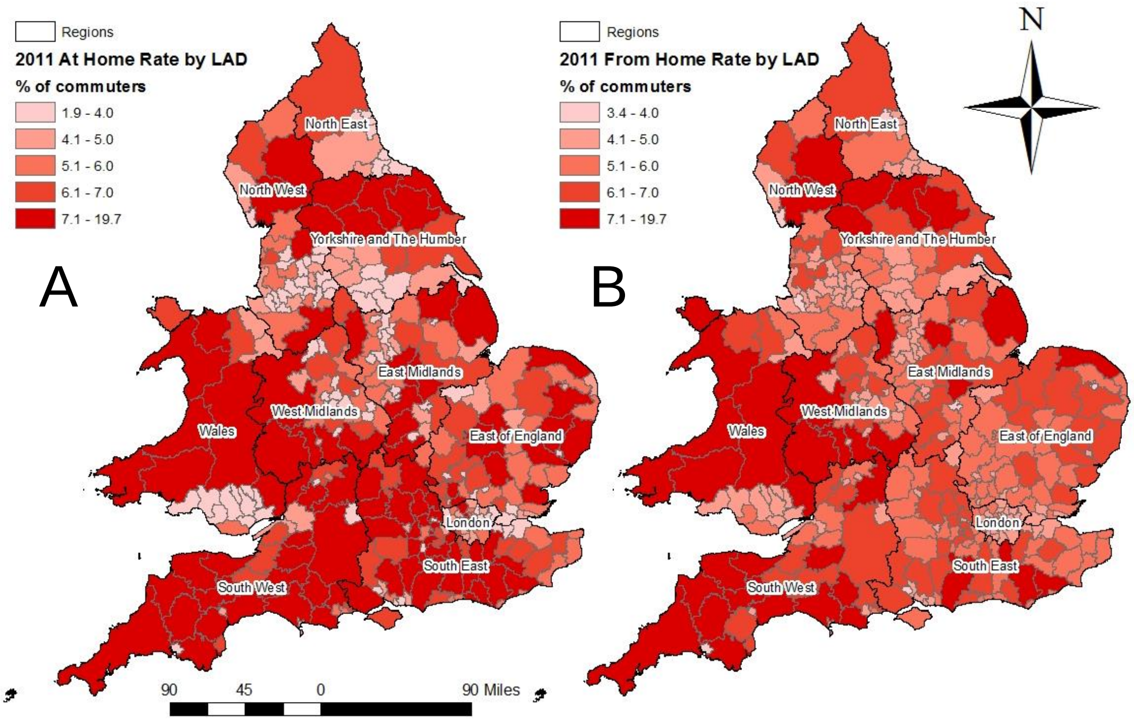
The spatial variation in homeworking rates (Figure 4.10(A)) is likely due to individuals living in rural areas living further away from employment opportunities than their urban counterparts. Many of these rural dwellers may choose to set up their own businesses instead of making long and expensive commutes to the nearest urban area.

The spatial variation in changes seen in Figure 4.10(B) may be partly due to the effects of the 2008 financial crisis. The high rates of increase seen in South East England may reflect many people who lost their jobs in the banking and finance sectors setting up their own businesses instead of becoming unemployed or economically inactive or looking for new banking and finance jobs in Central London. In a similar way, the increases seen in central and northern England may reflect their being fewer employment opportunities in manufacturing and heavy industry in these areas.

4.4.4 Working at home and working from home

Due to issues of comparability between the 2001 and 2011 data, the ONS released data in 2011 for those working at home and for those working at or from home, thus creating the opportunity to examine spatial variations in working 'at home' and working 'from home' separately (see Chapter 3).

Figure 4.11(A) shows a strong urban-rural divide in the prevalence of working at home, with many rural areas having very high rates (>7.1%) and many urban areas having very low rates (<4.0%). Figure 4.11(B) shows a similar urban-rural pattern in the prevalence of working from home, albeit with the divide being less extreme. The highest rates for working at home and from home were seen in the LADs of Powys (13.1%), West Somerset (12.8%) and West Devon (12.7%) and West Somerset (13.2%), Eden (9.4%) and Ceredigion (9.3%), respectively. Conversely, the lowest rates for working at home and from home were seen in the LADs of Hull (1.9%), Blaenau Gwent (2%) and Knowsley (2.1%) and Hull (3.4%), Corby (3.8%) and Liverpool (3.9%), respectively.



Source: Derived from the 2011 Census Aggregate Data.

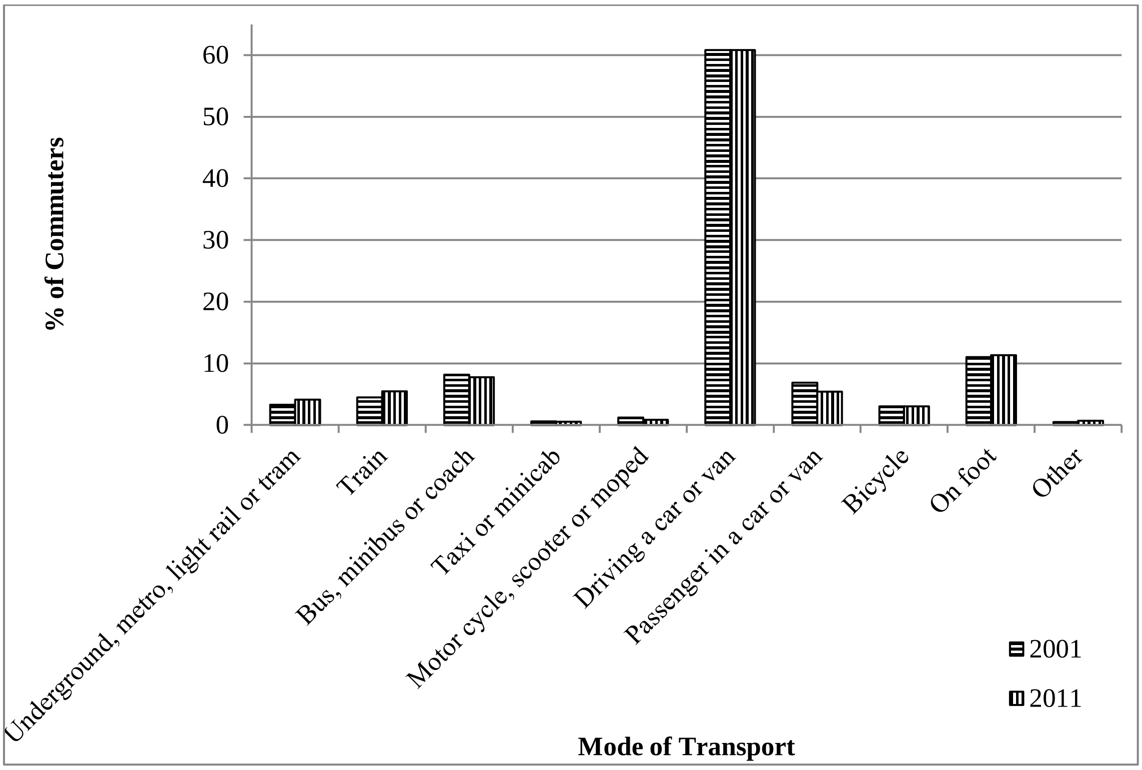
Figure 4.11: Percentage of commuters in England and Wales aged 16-74 in 2011 that work at home (A) and work from home (B) by LAD

As was the case with working at or from home, the spatial variations in working at home and working from home are likely mainly due to variations in proximity to employment opportunities. Individuals in rural LADs may be more inclined to take advantage of homeworking practices or set up their own home-based business instead of making long and expensive commutes to the nearest employment opportunities.

4.5 Spatial and Temporal Variations in Modal Split in England and Wales

The split between modes of travel to work in 2001 and 2011 in England and Wales and the spatial variations and changes in the different modes at LAD level are examined in this section using aggregate data. This modal split does not include homeworkers, as working at or from home is not a mode of transport.

Figure 4.12 shows that the proportions of individuals travelling to work using different modes of transport did not change radically in England and Wales between 2001 and 2011. In both years 'driving a car or van' accounted for 60.8% of commuters. The small percentage of commutes taking place by 'taxi or minicab' and by 'motorcycle, scooter or moped' declined slightly, while the proportion using the 'other' category increased marginally. However, there were some noteworthy changes in the modal split. The percentage of commutes that were made by 'underground, metro, light rail or tram', by 'train' and 'on foot' all increased, while the percentage of people traveling to work by 'bus, minibus or coach' and as a 'passenger in a car or van' both decreased. The largest increases were for 'underground, metro, light rail or tram', rising from 3.3% to 4.1%, and 'train', from 4.5% to 5.5%, while the most noteworthy decreases were for 'bus, minibus or coach', falling from 8.1% to 7.8%, and 'passenger in a car or van', decreasing from 6.9% to 5.4%.



Source: Derived from the 2001 and 2011 Census Aggregate Data.

Figure 4.12: Commuting modal split in England and Wales in 2001 and 2011 for all commuters (excluding homeworkers) aged 16-74

The changes in the modal split between 2001 and 2011 are likely to reflect underlying economic and social changes as well as alterations to the transport networks or new transport policies. These drivers include high economic growth in Central London, rising incomes, urban regeneration and the rise of city-centre living and changes in transport infrastructure which include improvements and extensions to the rail and underground networks, and new metro, light rail and tram networks.

As previously mentioned, the 2001-2011 period saw several large cities in England and Wales undergo extensive urban regeneration and high economic growth in Central London. This 'back to the city' movement (Laska and Spain, 1980) could explain the increases in commuting by underground, metro, light rail, tram and walking, and the stability in commuting to work by car or van, as those living in city centres and inner city areas are likely to have easier access to underground, metro, light rail and tram networks, are likely to live in close proximity to their workplace and, therefore, are less likely to need a car to commute. Closely linked to urban regeneration is the rise of city centre living in the UK (Tallon and Bromley, 2004). The increasing populations of city centre and inner city areas may account for some of the increase in commuting to work on foot, as individuals living in these locations have easy access to city centre employment opportunities, as documented for Leeds by Unsworth (2005; 2007). It is also the case that many modern inner city and city centre developments do not have allocated parking facilities, further discouraging city centre residents from driving.

The 2001-2011 period also saw rising individual and household incomes in the UK, with nominal wages increasing over the decade (Levy, 2013). Increasing incomes may account for the decrease in commuting as a passenger in a car or van and the stability of commuting by driving a car or van as more people became able to afford cars and chose to commute using them (Dargay, 2007). However, income cannot be used to easily explain changes when using real wages, as real wages in 2011 were similar to those in 2002 due to substantial decreases in the wake of the 2008 financial crisis (Levy, 2013), and it must be noted that not all income is accounted for by wages.

Developments of existing transport infrastructure took place over the 2001-2011 period, with extensions and improvements to the London Underground and Docklands Light Railway networks in London, the Tyne and Wear Metro, the Manchester Metrolink, the Sheffield Supertram and the Midland Metro. In addition, the decade also saw the opening of two new tram networks in England and Wales: the Croydon Tramlink network and the Nottingham Express Transit network. The UK railways also experienced some improvements between 2001 and 2011, with the renovation of many major railway stations. These improvements, extensions and openings are likely to account for the increase in the percentage of commuters travelling by underground, metro, light rail, tram and train and may also partly account for decreases in commuting by bus, minibus or coach, by providing some commuters with a wider range of transport options and by making travel on them more efficient, accessible and comfortable.

Some of the changes may be partially explained by local authorities and public transport operators attempting to influence the commuting behaviour of individuals; encouraging travel by train and bus through advertisements and promotions. From a policy perspective, it should also be noted that the decrease in the prevalence of commuting by bus has taken place in the wake of the deregulation of many bus services in 1986 and the subsequent restructuring of the industry (Fairhurst and Edwards, 1996), while the increasing prevalence of commuting by train has occurred at the same time as rail fares have increased (BBC, 2013i, 2013iii, 2014, 2015vi, 2015ix).

The decade also saw substantial changes in the cost of commuting, with costs of motoring, train travel and bus travel all changing in both nominal and real terms. The stability seen in the proportion of commutes taking place by driving a car in the face of improved transport networks may be because, although the nominal costs of owning and running a car have increased over the past 20 years, the real costs decreased between 1988 and 2008 by 18%, when fuel costs are included, and by 28%, when fuel costs are excluded (Royal Automobile Club, 2015). However, as the Royal Automobile Club figures suggest, while the real cost of buying a car decreased, fuel costs increased substantially. The high and increasing cost of petrol in the UK over the 2001-2011 period was due to both relatively high oil prices and the imposition of high taxes on petrol and other road fuels by central government (Smith, 2000).

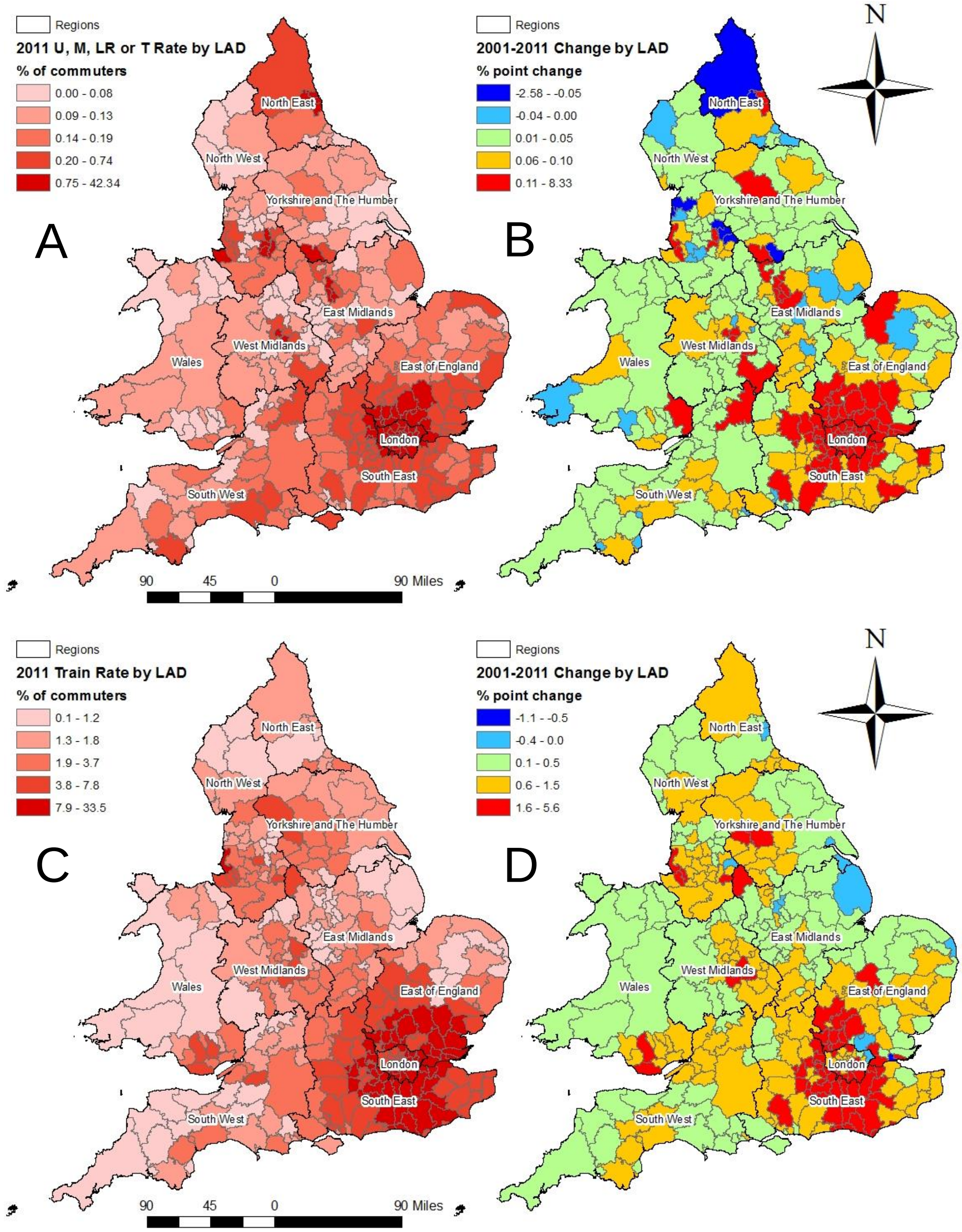
4.5.1 LAD variations in rail transport

Figure 4.13(A) shows that commuting to work by underground, metro, light rail or tram is concentrated in the LADs of Greater London, the London commuter belt and certain metropolitan LADs in the Midlands and northern England that have transport systems of this type, with the highest share (42.3%) being seen in the Hammersmith and Fulham LAD. Conversely, the lowest shares (<0.08%) of commuting by underground, metro, light rail or tram are seen in many of the more rural LADs outside of the South East. There appears to be a distance-decay effect of patronage around each area that has an underground, metro, light rail or tram system. This suggests that many commuters may travel a certain distance by bus or car before using the underground, metro, light rail or tram networks for the main part of their journeys.

The largest increases (>0.19 percentage points) in commuting to work by underground, metro, light rail or tram have occurred in those LADs with high shares of commuting to work by these modes (Figure 4.13(B)). The similarity of the two is unsurprising given that spatial variations in commuting by this mode of transport are likely to be driven by access to the different underground, metro, light rail or tram networks, which still remain relatively concentrated in certain areas. Any increases in commuting by underground, metro, light rail or tram may reflect extensions to existing networks, such as extensions to the London Underground network, to the Tyne and Wear Metro to Sunderland and Newcastle International Airport, and to the building of new networks, such as the tram networks in Croydon and Nottingham.

Figure 4.13(C) shows an extremely strong core-periphery pattern in the prevalence of commuting to work by train, with the highest shares (>7.9%) in Greater London and the home counties and the lowest shares (<1.2%) in the peripheral regions, especially in the East Midlands, Wales and the South West. However, an urban-rural contrast is also apparent, with higher shares for urban areas, such as the Bradford and Sefton, and lower shares for very rural areas, such as the Powys and East Lindsey.

The urban-rural contrast is retained in the pattern of changes in commuting to work by train (Figure 4.13(D)). The largest increases (>1.6 percentage points) have generally been in metropolitan LADs, such as Leeds and Birmingham, while the decreases (<0.0 percentage points) and smallest increases (0.1-0.5 percentage points) have generally been confined to more rural areas, such as East Lindsey and Northumberland. However, this urban-rural divide is not ubiquitous, as some urban LADs, such as Hull, North Tyneside, Sunderland and Gedling have experienced decreases in the proportion of train commuters.



Source: Derived from the 2001 and 2011 Census Aggregate Data.

Figure 4.13: Percentage of commuters (excluding homeworkers) in England and Wales aged 16-74 in 2011 that commute to work by underground, metro, light rail or tram (U, M, LR or T) (A) and train (C) and the percentage point changes between 2001 and 2011 (B and D) by LAD

The pattern of commuting by rail is likely to be closely linked with the availability of rail modes of transport. Areas with better developed railway networks, such as London, the South East and the North West have higher shares of commuting by train than areas with less dense railway networks, such as Mid Wales and the South West. Over the past 20 years, the number of train journeys in the UK increased from 735 million at the time of privatisation in 1994 to 1.7 billion in 2014 (BBC, 2015xi). This general increase in train travel is likely to go some way towards explaining the patterns of change seen in Figure 4.13(B). Although there were no major improvements or extensions to the railway network between 2001 and 2011, many major railway stations were rebuilt or improved, making train travel more attractive to commuters.

However, increases in the proportion of persons commuting by rail may also be explained by increased road traffic congestion and, in southern England, by the implementation of the London congestion charge. The 2001 and 2011 censuses showed that the number of cars in the UK increased from 23.9 million to 27.3 million between 2001 and 2011, implying increased traffic congestion on the roads since the end of the 'Predict and Provide' policy in the 1990's (Goulden *et al.*, 2014). This increased road congestion may well have encouraged many commuters to switch from driving to commuting by underground, metro, light rail, tram or train. In part as a reaction to increased road traffic (Leape, 2006), the London congestion charge was introduced in February 2003 (Litman, 2006), and many car drivers will have switched to commuting to work by underground or train instead.

The decreases in commuting by underground, metro, light rail, tram or train could be explained by increasing incomes leading to greater levels of car ownership and usage (Dargay, 2007), with people choosing the convenience and comfort of their car over their local rail networks. However, some of the declines may also reflect the promotion of cycling and walking to work (Fraser and Lock, 2010). An increase in cycling to work may explain declines in commuting by underground, metro, light rail or tram, as cycling in small and densely populated LADs such as Newcastle, Darlington and Exeter, where cycling to work is likely to be relatively easy, increased over the same time period. Similarly, an increase in walking to work may explain the declines in commuting by train in LADs such as Hull and North East Lincolnshire, where walking is easy due to the topographic nature of these areas. Maps B and D in Figure 4.15 confirm that the declines in the proportion of commuters by rail in the aforementioned LADs may have been paralleled by increases in the prevalence of commuting by bicycle and walking.

4.5.2 LAD variations in road transport

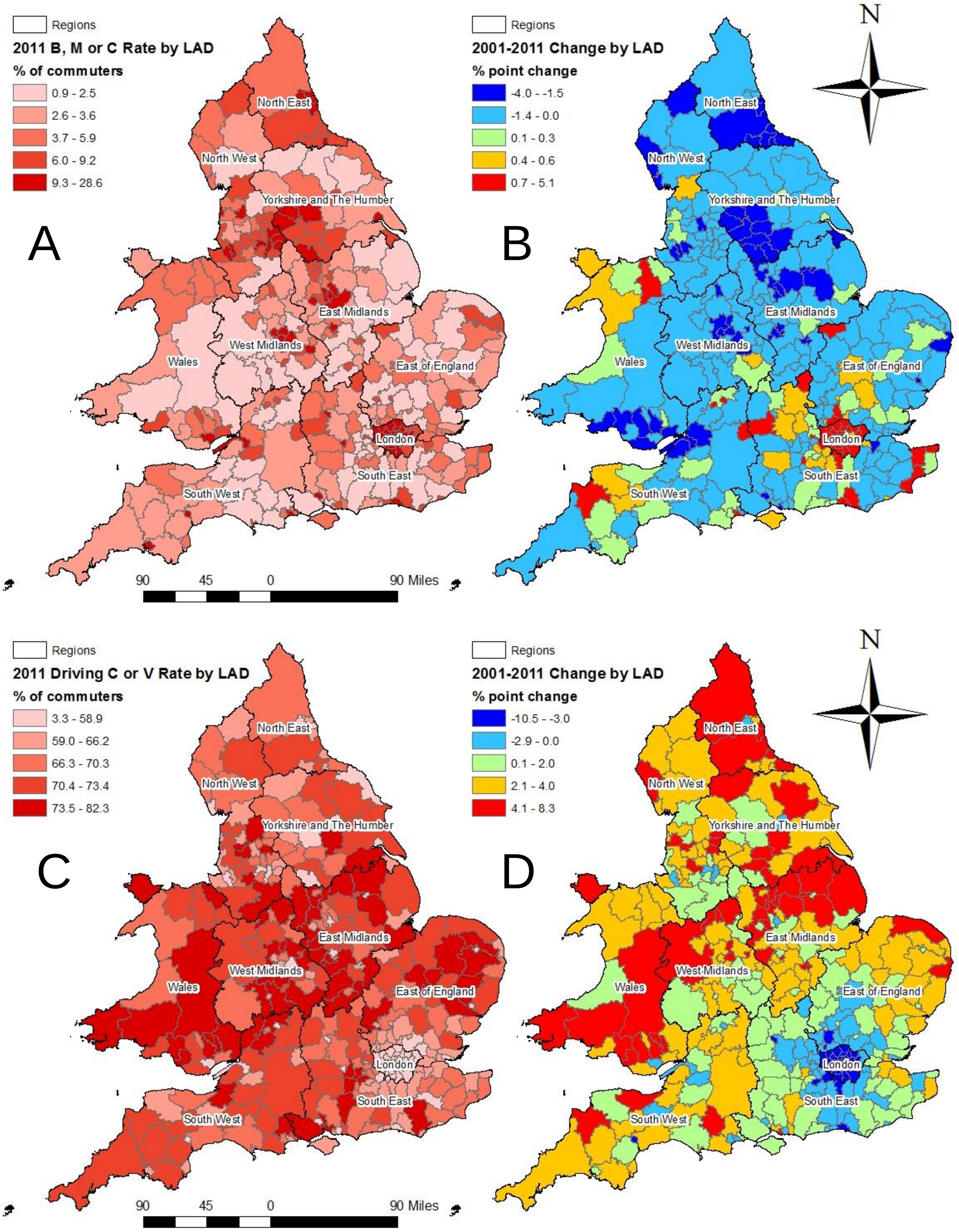
It should be noted at this point that, although the taxi or minicab and motorcycle, scooter or moped modes of transport could be included in this section on road transport, the absolute numbers of commuters using these two modes and their shares of the modal split are so small that they have been excluded in order to focus on the more important modes.

Figure 4.14(A) shows a very strong urban-rural contrast in commuting to work by bus, minibus or coach, with the high shares (>9.3%) being exclusively seen in metropolitan LADs, such as Newcastle, Leeds, Manchester, Sheffield, Nottingham, Birmingham, Cardiff, Bristol and

Greater London, and the low shares (<2.5%) in rural LADs, such as South Lakeland, Hambleton, North Norfolk and West Dorset.

There appears to be a suggestion of a north-south pattern evident in the changes in commuting to work by bus, minibus or coach (Figure 4.14(B)). The larger increases in proportions travelling by this mode (>0.5 percentage points) have generally been in LADs in southern England, such as Isle of Wight, Torridge and the Greater London boroughs, while the larger decreases (<-1.3 percentage points) have generally been seen in LADs in metropolitan areas of northern England, such as Leeds, Sheffield and Liverpool. Again, however, this division of LADs between the north and the south is not exact as some northern LADs, such as Lancaster, Gwynedd and Denbighshire have experienced large increases and some southern LADs, such as Southampton, Reading and Gravesham have experienced large decreases.

Figure 4.14(C) shows an inverse urban-rural pattern in commuting to work by driving a car or van, with the lowest shares (<58.9%) mostly confined to urban LADs, such as Newcastle, Leeds, Manchester and the Greater London boroughs, and the highest shares (>73.5%) mostly confined to rural LADs, such as West Lindsey, Pembrokeshire and Breckland. North-south and urban-rural contrasts are again evident in the changes in commuting to work by driving a car or van (Figure 4.14(D)). The decreases and smallest increases (0.1-1.3 percentage points) in proportions using these modes have been confined to urban LADs, such as Newcastle, Manchester and Liverpool, and southern LADs, such as South Cambridgeshire, South Somerset and the Greater London boroughs. Conversely, the largest increases in shares (>4.0 percentage points) have been confined to rural LADs, such as North Norfolk, West Somerset and Torridge, and northern LADs such as Sunderland, Wakefield and Fylde.



Source: Derived from the 2001 and 2011 Census Aggregate Data.

Figure 4.14: Percentage of commuters (excluding homeworkers) in England and Wales aged 16-74 in 2011 that commute to work by bus, minibus or coach (B, M or C) (A) and by driving a car or van (Driving C or V) (C) and the percentage point changes between 2001 and 2011 (B and D) by LAD

Spatial variations and changes in the prevalence of commuting by bus, minibus or coach are likely to be partly explained, economically at least, by bus travel being an inferior good (Dargay and Pekkarinen, 1997; Chyi and Yang, 2009), with a negative relationship between bus travel and income. Conversely, the patterns seen for driving a car or van are likely to be influenced by the fact that car travel is a normal good, with the ownership and usage of cars increasing with income (Dargay, 2007). However, in addition to these broad relationships with income, it is likely that the spatial changes in the prevalence of commuting by road have been affected by some specific economic, social and transport network changes. Thus, where increases in the prevalence of commuting by bus, minibus or coach have taken place, these may be partly explained by the improved provision of bus networks and bus routes, with many major cities in England and Wales now having extensive park and ride bus networks (Meek *et al.*, 2010), at the same time as many urban areas are experiencing increased road traffic congestion.

The large increases in commuting by bus and large decreases in commuting by car in and around Greater London are likely to be due to the introduction of the London congestion charge in 2003. The introduction of this charge on motorists entering the congestion charge zone, increasing from £5 at the time of introduction to £10 in 2011, is likely to have encouraged many individuals commuting into Central London from surrounding areas by car to commute by some form of public transport, which would have become relatively more financially attractive.

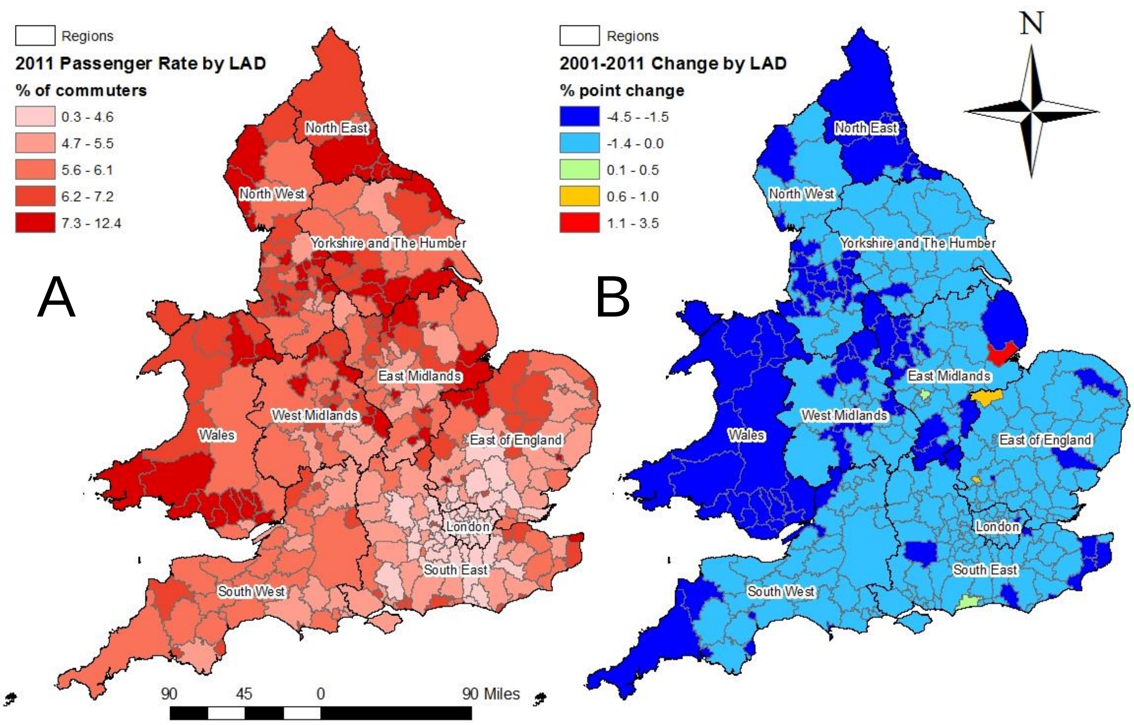
Conversely, increases in commuting by car in many parts of northern England, the Midlands and Wales may reflect increases in the cost of public transport, especially train travel (BBC, 2013i, 2013iii, 2014, 2015vi, 2015ix), making commuting by car relatively more financially attractive. Increases in car travel may also reflect the reduction and withdrawal of bus services in many rural areas due to budget constraints and government attempts to reduce subsidies (Gray *et al.*, 2006).

However, the specific instances of increased commuting by bus and decreased use of the car may also reflect increased environmental awareness (Lorenzoni *et al.*, 2007), re-urbanisation and the rise of city living (Seo, 2002). These changes are likely to have occurred as public transport is more environmentally friendly than car travel and individuals living in city centre and inner-city areas are likely to have better access to bus networks than those living in suburban and rural areas.

Decreases in commuting by bus and car may reflect the building of new tram networks in Nottingham and Croydon, extensions to existing tram networks in Newcastle, Manchester and Sheffield and improvements to train networks in parts of West Yorkshire, Merseyside and southern Wales. Maps B and D in Figure 4.13 confirm that the decreases in commuting by bus and car in the aforementioned areas are likely to have been due to increases in commuting by metro, light rail, tram and train.

Two possible explanations for the increases in commuting by car occurring at the same time and in the same places as decreases in commuting by bus are suburbanisation and urban-rural migration. Continued suburbanisation and urban-rural migration in many areas between 2001 and 2011 (Grey *et al.*, 2003) means that in those areas an increasing number of individuals are living in areas where the easiest way to commute is by car, as they are unlikely to live close to their place of work and may have little or no access to existing or new bus networks. Furthermore, even if they do have access to a bus network, it is likely to be very time inefficient to commute that way.

Figure 4.15(A) shows a core-periphery pattern in the prevalence of commuting to work as a passenger in a car or van, with the highest shares (>7.3%) generally being seen in northern England, the midlands and Wales and the lowest shares (<4.6%) being seen in London and the home counties. Although Figure 4.15(B) shows that the prevalence of commuting as a passenger in a car or van decreased in all but five LADs (Boston, Peterborough, Luton, Leicester and Arun), there is an inverse core-periphery pattern in the percentage point changes, with the increases and smaller decreases generally being seen in southern England and the largest decreases generally being seen in northern England and Wales.



Source: Derived from the 2001 and 2011 Census Aggregate Data.

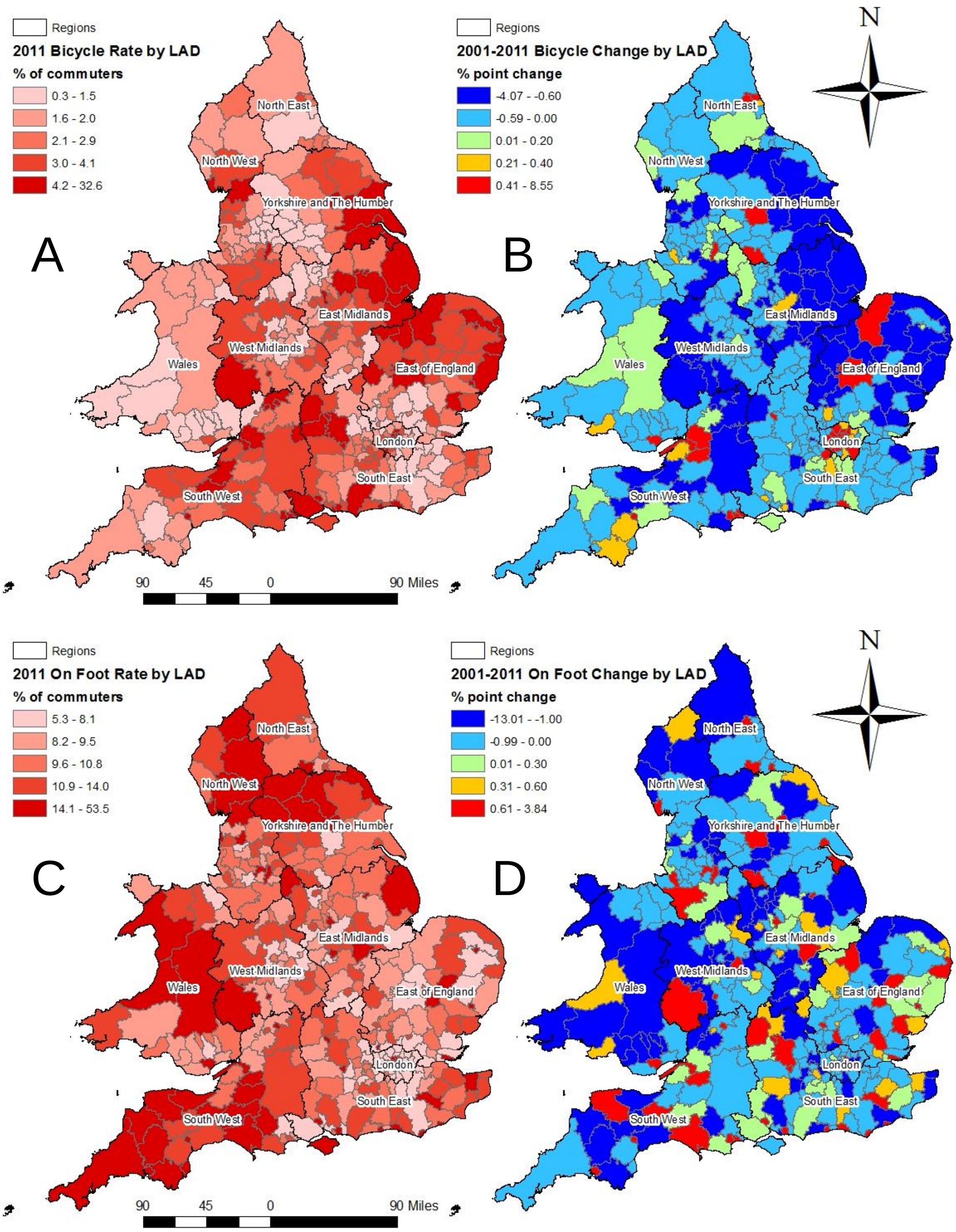
Figure 4.15: Percentage of commuters (excluding homeworkers) in England and Wales aged 16-74 in 2011 that commute to work as a passenger in a car or van (A) and the percentage point changes between 2001 and 2011 (B) by LAD

As was the case with bus travel, the spatial variations and changes in the prevalence of commuting as a passenger in a car or van are likely due to the ownership and usage of cars increasing with income (Dargay, 2007). As the decade saw the regeneration of many urban areas in northern England and Wales, it is likely that this increased public and private investment led to increased incomes in many of these areas, with people choosing to use this increased income to purchase cars of their own.

4.5.3 LAD variations in cycling and walking

Although cycling and walking are two distinct modes of transport and have different spatial patterns, there are also some notable similarities between the two. Maps A and C in Figure 4.16 show higher shares for both modes (>4.2% and >14.1%) in dense urban LADs, such as Manchester, Nottingham and the Inner London boroughs, and in those LADs classified as small cities or large towns such as York, Cambridge, Oxford, Brighton and Exeter, while low shares for both modes (<1.5% and <8.1%) are seen in some of the boroughs of Outer London and in LADs in semi-rural areas surrounding Greater London. Maps B and D in Figure 4.16 also show that while commuting to work by bicycle and on foot have both increased in the metropolitan LADs of northern England, such as Newcastle, Leeds, Sheffield and Manchester, and in the urban LADs of southern England, such as Oxford, Cambridge, Southampton and Brighton, they have both experienced decreases in the more suburban and rural LADs throughout England and Wales, but especially in some of the very rural LADs such as Richmondshire, Ryedale, Selby, East Lindsey and North Norfolk.

However, there are also spatial differences between the patterns of cycling and walking to work. Maps A and C in Figure 4.16 indicate that while commuting to work on foot is decidedly prevalent in the very rural LADs of the peripheral regions of Yorkshire and The Humber, the North West, Wales and the South West, commuting to work by bicycle does not enjoy the same popularity in these areas. Conversely, while commuting to work by bicycle is popular in the very rural LADs in the East Midlands and the East of England, commuting to work on foot is much less prevalent in these areas. Maps B and D in Figure 4.16 also illustrate that while commuting to work by bicycle increased in some urban and semi-rural LADs, such as North Tyneside, Calderdale, Stroud and Winchester, commuting to work on foot did not experience similar increases in these areas. Instead, commuting on foot increased in some urban LADs, such as Barrow-in-Furness, Hull and Lincoln, where commuting by bicycle decreased. However, perhaps the most interesting difference in the changes is for the Greater London boroughs, where commuting to work by bicycle generally increased between 2001 and 2011, while commuting to work on foot generally decreased over the same period.



Source: Derived from the 2001 and 2011 Census Aggregate Data.

Figure 4.16: Percentage of commuters (excluding homeworkers) in England and Wales aged 16-74 in 2011 that commute to work by bicycle (A) and on foot (C) and the percentage point changes between 2001 and 2011 (B and D) by LAD

In LADs where increases in commuting by cycling or on foot have occurred, this may reflect increased environmental awareness amongst the commuting population (Lorenzoni *et al.*, 2007). With much focus on the link between carbon dioxide emissions from road transport and global warming and climate change (Chapman, 2007), some commuters may have consciously changed their mode of transport in order to reduce the environmental impact of their commute; with some individuals walking or cycling instead of driving.

In addition to environmental awareness, health awareness and the promotion of walking and cycling as modes of transport may have played a part in increasing walking and cycling to work. Much recent research has focused on the link between sedentary lifestyles, which include commuting to work by car (Wener and Evans, 2007), and negative health outcomes (Hamer and Chida, 2008), with the promotion of 'active commuting' being seen as one way of addressing the problems of obesity and the associated health problems (Vuori *et al.*, 1994).

Walking and cycling may also have benefited from any increases in the costs of motoring or public transport, with fuel costs and rail fares increasing over the decade (RAC, 2015; BBC, 2013i, 2013iii, 2013iv, 2014, 2015vi, 2015ix). These increases in the cost of car and train travel may have encouraged some commuters to switch from commuting by car or train to cycling or walking. Moreover, increases in the prevalence of walking and cycling to work in the large urban LADs, such as Newcastle, Leeds, Bradford, Sheffield, Manchester, Liverpool and Birmingham, are likely due to changes in the urban structure of these cities over the decade, with the process of re-urbanisation leading to increases in the city centre and inner city populations of these LADs through the rise of city living (Seo, 2002). With proportionally more people living in city centre and inner city areas, commuting by walking and cycling will increase as these people live closer to their places of work in city centre areas. The increases in cycling to work seen in the Greater London boroughs, on the other hand, are likely due to the introduction of the London congestion charge, which may have encouraged many individuals commuting into Central London from other parts of Greater London to commute by cycling as commuting by car became relatively less financially attractive for these individuals.

Any decreases in commuting by walking or cycling may reflect increasing incomes over the decade leading to increased car ownership and usage (Dargay, 2007). As more people are financially able to own and use cars, many of these individuals may choose the comfort and convenience of their cars over walking and cycling. The fall in walking and cycling to work proportions seen in LADs such as Walsall, Selby and Fylde, may reflect the processes of suburbanisation and urban-rural migration occurring in the UK (Grey *et al.*, 2003). In areas where proportionally more individuals are choosing to live in outer-suburban and semi-rural areas, while still commuting into city centre areas, it is likely that the prevalence of commuting by walking and cycling will decrease due to increases in commute distance, as discussed in Chapter 5.

4.6 Policy Implications and Conclusions

This chapter set out to examine variations in commuting propensities and patterns and how they have changed using aggregate data and microdata from the 2001 and 2011 UK censuses. The analyses in this chapter help to address the need for evidence based policy recommendations in the UK at the local level, which is becoming increasingly important due to the devolution of some economic and transport policy to city regions, with the recent announcement of the devolution of a number of policy areas to Greater Manchester (BBC, 2015i) and to other combined local authorities (BBC, 2015ii) and the implementation of the 'Northern Powerhouse' initiative by the UK Government (BBC, 2015iii). These changes may in turn lead to a greater divergence of commuting patterns across the country in future as local and regional authorities become increasingly able to pursue policies suited to local needs and demands.

The chapter has shown that there have been increases in the number of commuters and commuting rates in England and Wales and every macro region, driven by increases in female participation and high levels of immigration as increasing numbers of women and immigrants are now part of the commuting population as well as the population at risk. Whilst these increases continue a trend observed by Neilson and Hovgesen (2008) of increased commuting throughout much of England and Wales between 1991 and 2001, the census data also suggest that there was convergence in commuting rates between males and females and between 'older' (65-74) and 'middle-aged' (25-64) commuters. However, at the same time there was divergence between 'younger' and 'middle-aged' commuters, with a substantial (and perhaps worrying) fall in the commuting rate of the 16-24 age group.

At the LAD level, much of England and Wales experienced substantial increases in commuting rates. As these trends show no sign of going into reverse, and as the total UK population is expected to continue to increase (ONS, 2011ii), those authorities responsible for the provision of transport networks should be considering substantial improvements and additions to existing transport networks. As the era of 'Predict and Provide' in relation to road transport has fallen out of favour with policy makers (see Chapter 2), it is likely that any substantial improvements in capacity to meet demand will have to be made to the existing underground, metro, light rail, tram, train and bus networks. Focusing on improving, extending and building new public transport networks would be likely to have positive outcomes in terms of ridership. As Section 4.5 showed, when commuters have easy access to these public transport networks, they will use them.

The chapter has also shown that the number of homeworkers and the prevalence of homeworking both increased between 2001 and 2011 and that homeworking is more common amongst males, those aged 65-74, the Chinese ethnic group, those with a LLTI, those with dependent children and those in non-professional and non-managerial occupations. Spatially, homeworking is more common in rural areas and in central and southern England. The increased prevalence of homeworking potentially presents policy makers with both opportunities and problems. The rise of homeworking is a potential opportunity as it creates an opportunity to tackle traffic congestion, and the associated economic, social and environmental problems. However, the increased prevalence of homeworking is a potential problem as it may negatively affect the ridership and, therefore, financing of existing and new public transport networks.

Finally, the chapter indicated that there was a general increase in the percentage of those commuting to work by underground, metro, light rail and tram, train and on foot. In contrast, there was a general decrease in the percentage of those commuting to work by bus, minibus or coach and as a passenger in a car. In addition to these national changes in modal split, the chapter has shown that continual infrastructure developments and changing preferences also lead to LAD variations in modal split due to spatial variations in transport networks and commuting preferences. Increasing fuel costs and environmental awareness may have led to many commuters choosing to travel to work by public transport rather than driving in order to reduce their commuting costs and the environmental impact of their commuting behaviour and urban regeneration may have led to an increase in walking and cycling to work as increasing numbers of people live in city centres and inner-city areas close to their places of work.

However, many of the explanations for changes in the modal split are fundamentally linked to changes in urban structure, such as urban regeneration, suburbanisation and urban-rural migration. Therefore, if the relevant national, regional and local authorities seek to encourage the use of public transport it would be advisable for them to start by prioritising certain types of development, urban or otherwise, over others. For instance, the building of a new suburb or industrial estate far from a city centre, with little or no access to existing public transport networks, is unlikely to facilitate the use of public transport by those living or working there. Likewise, if authorities are aiming to increase walking and cycling to work it would be unwise for the same authorities to allow further residential or commercial developments on the rural-urban fringe; they should instead be increasing the density of urban development by prioritising high density mixed-use developments in city centres and inner-city areas where walking or cycling to work is more likely.

Overall, this chapter has shown that there were substantial changes in commuting composition and patterns between 2001 and 2011, has offered some explanations of the forces that are driving these changes, and has pinpointed some of the important implications of these changes for policy makers and the relevant authorities. One feature of commuting that has not been examined in this chapter is the distance over which commuters travel; this dimension is now considered in the next chapter.

5. A National and Regional Analysis of Sociodemographic Variations and Temporal Changes in Commute Distance and Self-Containment

5.1 Introduction

As discussed in Chapter 2, individual commuting propensities and patterns vary by a range of demographic, socioeconomic and household characteristics, including sex (Department for Transport, 2011; Pickup, 1981), age (BBC, 2015xii; Kamid, 1999), ethnicity (Thomas 1998), health status (Stutzer and Frey, 2008; Koslowsky *et al*., 1995), childcare responsibilities (McQuaid *et al*., 2001; Gibbons and Machin 2006) and occupation (Pickup and Town, 1983; Owen and Green, 2005). To take an extreme example, it is unlikely that younger, black females, in non-professional occupations, with dependent children living in the North East region will commute the same distance as older, White males, in professional occupations, with no dependent children who live in the South East region. If it is the case that these older more affluent White males are more likely to commute long-distance while the younger less affluent black females are more likely to commute short distance, this selectivity raises important issues about differing levels of access to economic and social opportunities and the provision (or lack) of certain transport networks in areas inhabited by particular groups.

For the purposes of this chapter and Chapter 6, it is important to note that commute distance varies by mode of transport usage. Past research has shown that, on average, those who travel to work by train have the longest commutes while those who commute by bicycle or on foot travel the shortest distances, with bus and car commuters between the two extremes (Lyons and Chatterjee, 2008). This variation is important as commute distance is the dependent variable in the following analyses, with mode of transport as an independent variable, while in Chapter 6 mode of transport is the dependent variable and commute distance is an independent variable.

Although some past research, as reviewed in Chapter 2, has attempted to establish how and why commuting propensities and patterns vary by sociodemographic characteristics (for example: Pickup, 1981; Thomas, 1998), it has not been systematic in nature; it has been conducted at different times, by different researchers and using different techniques and data. Furthermore, much of the past research is now rather dated. No research hitherto has systematically analysed quantitative variations in commute distance or commuting self-containment disaggregated by those variables which past research has suggested are important. In addition, whilst it is necessary to recognise how commute distance varies by sociodemographic variables independently, it is also important to understand how these variables interact with each other and what effect this interaction has. No research on commute distance has looked at intersectionality (see Chapter 2). It is envisaged that the exploration and analysis of the IEs will lead to a greater understanding of the sociodemographic drivers of commute distance.

Therefore, this chapter addresses the second broad research question set out in Chapter 1: How do commute distance and commuting self-containment vary between different sociodemographic groups and how did these variations change between 1991, 2001 and 2011?

The research in this chapter and Chapter 6 makes use of the 1991, 2001 and 2011 microdata introduced in Chapter 3. The microdata are being used for four main reasons. First, they are created from a large random sample of the UK population (Boyle and Dorling, 2004) (although the 2011 I-SAR is currently only for England and Wales), which means that they are statistically reliable and representative, and are therefore ideal for carrying out robust analyses. Second, they have a great deal of variable and category detail at the expense of having relatively little geographical detail (Tranmer *et al.*, 2005), which means that they are good for carrying out national-level analyses of commuting behaviour. Third, and most importantly, they are extremely flexible, providing the opportunity to combine different variable categories in different ways. Fourth, microdata can be used to make consistent comparisons over time.

In Section 5.2, the 1991, 2001 and 2011 I-SARs are used to analyse sociodemographic variations in commute distance and changes over the 20 year period, whilst in Section 5.3, they are used to analyse self-containment. The 2001 and 2011 interaction data are also used in Section 5.3 in order to map spatial variations and temporal changes in commuting self-containment at LAD level. Section 5.4 presents some policy recommendations based on the analyses and draws some conclusions.

5.2 Sociodemographic Variations in Commute Distance

The distances that individual commuters travel to work have important implications for society, the economy, the environment and the individuals themselves. First, regarding society and the economy, variations in the distances that commuters travel to work may reflect the ease with which those commuters can access new or different employment opportunities (Shuttleworth and Green, 2011; Owen *et al.*, 2012). If certain groups of commuters on average commute longer distances than others, it suggests that some have better access to employment opportunities than others or that some are unable to find jobs locally. If this is indeed the case, differences in commute distance are likely to be reflected in wage levels and, therefore, levels of economic inequality in the UK. This social and economic inequality is likely to be further exacerbated because commuting behaviour also varies by socioeconomic classification, education and sex, with managerial and professional workers commuting longer distances than unskilled manual and low grade non-manual workers (Pickup and Town, 1983; Owen and Green, 2005), graduates being more mobile than non-graduates (Gibbons and Machin, 2006) and males traveling 23% further on average than females (Department for Transport, 2011). Although it should be noted that, according to the Department for Transport (2011), the differences between the distances travelled by males and females have narrowed over time, with the average distance travelled annually by men declining by 17% but increasing by 21% for women over the 1995-2010 period. It is also the case that longer commutes may reduce time spent at work (Zenou, 2008) and that workers with long commutes may be less productive (Zenou and Smith, 1995), leading to lost economic output from workers with very long commutes. This lost economic output could potentially lead to workers having lower total and disposable incomes, which could also be seen as contributing to social and economic inequality.

Second, regarding the environment, there is a relationship between distance travelled and energy/fuel usage and costs to the environment (Frank, 1989; Camagni *et al.*, 2002). This issue is particularly pressing given current national and international concerns about greenhouse gas emissions, global warming and climate change and the UK's domestic commitment to cut carbon dioxide emissions by 60% by 2050 (Department for Trade and Industry, 2003). Given that transport accounts for 25% of the UK's greenhouse gas emissions (Department of Energy and Climate Change, 2014), relatively small changes in the distances that commuters travel could have a substantial impact on the UK's contribution to the processes of global warming and climate change.

Finally, regarding the individual commuter, research has shown that those commuting long-distance to work report lower subjective well-being (Stutzer and Frey, 2008). Furthermore, commuting long-distance by car is associated with back problems, possibly caused by car vibrations (Kelsey and Hardy, 1975; Kelsey *et al*., 1990), cardiovascular stress, possibly linked to the inhalation of air pollutants by drivers (Aronow *et al*., 1972), and some types of cancer (Gubrean *et al*., 1992). Therefore, changes in the distances that commuters travel to work could have an impact on the general health of the commuting population and, therefore, their usage of health and health-related public and private services. It is also the case that commuting long-distance may reduce an individual's family time and leisure opportunities, which may have a negative impact on their quality of life, with some research going as far as labelling a commuting lifestyle one of chronic strain and stress (Rhodes and Rhodes, 1984).

5.2.1 Introduction: sociodemographics and commute distance

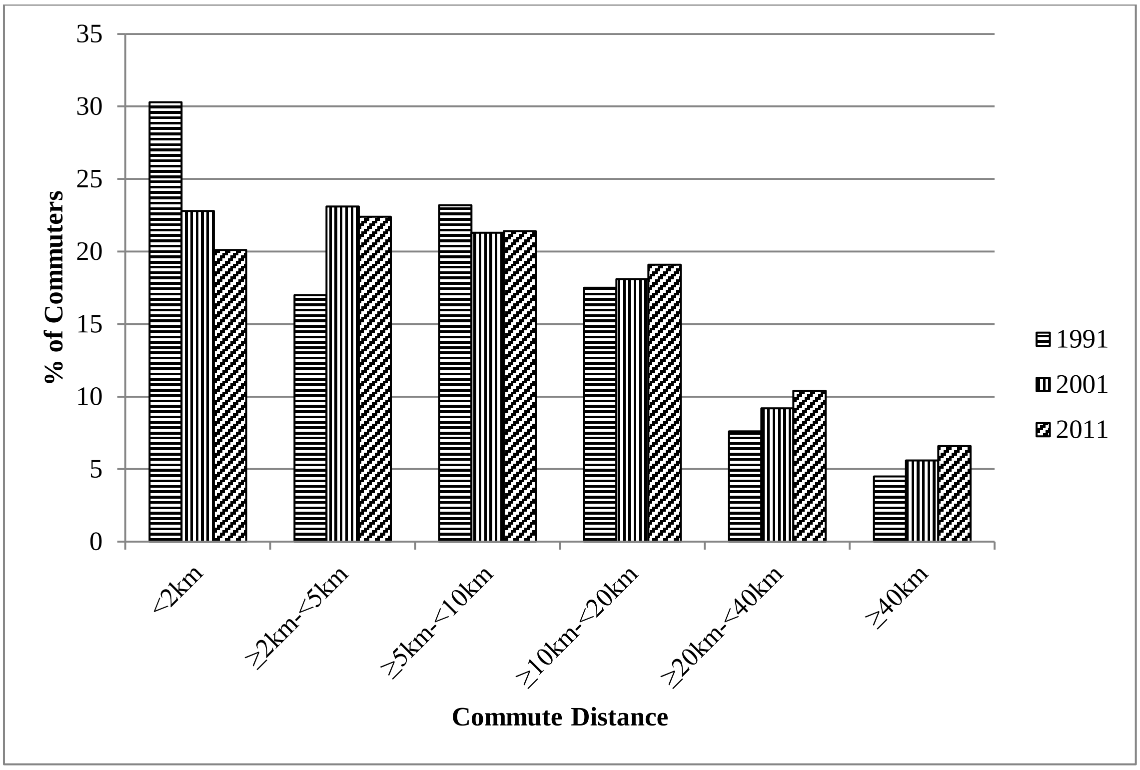
As outlined in Section 5.1 and in Chapter 2, previous research has shown a relationship between commute distance and a host of different sociodemographic variables, including occupation, sex and mode of transport. This Section builds on previous research by using the 1991, 2001 and 2011 I-SARs to quantify how likely commuters are to commute very long-distance (≥40km), given a host of variables, and how this likelihood changed over the 20 year period from 1991 to 2011.

The likelihood of commuting very long-distance is explored due to the policy relevance of commute distance, with long commutes being more economically, socially and environmentally damaging than short commutes (Brueckner, 2001; Kageyama *et al.*, 2007). Facilitating short commutes is seen as a way of encouraging walking and cycling to work (Maibach *et al.*, 2009) and, therefore, reducing greenhouse gas emissions and improving the well-being of commuters (Stutzer and Frey, 2008). If policy makers are going to be successful in facilitating shorter commutes, it is necessary to understand which individuals are more likely to commute very long-distance so that national, regional or local policies can focus on them and encourage them to change their behaviour.

Very long-distance commutes have been defined as those commutes over a distance of 40km or greater due to the classification used in the I-SARs, with the ≥40km category being the longest distance category in the 1991, 2001 and 2011 I-SARs (see Chapter 3). It is therefore the ideal distance category for analysing very long-distance commuting. In addition, similar distance categories have been used by Sandow and Westin (2010), Sandow (2011) and Champion *et al.* (2009).

5.2.2 Changing commute distances between 1991, 2001 and 2011

Figure 5.1 shows that between 1991, 2001 and 2011 there was a general shift in the distribution of commute distances away from the very short (<2km), towards longer commute distances, especially the ≥20-<40km and ≥40km categories. While the most notable change was the decrease in the share of those commuting <2km, from 30.3% in 1991 to 20.1% in 2011, the share of those commuting ≥2-<5km increased by 5.4 percentage points over the same period. Other changes are less notable, with those commuting ≥5-<10km decreasing by 1.8 percentage points and those commuting ≥10-<20km, ≥20-<40km and ≥40km increasing by 1.6, 2.8 and 2.1 percentage points, respectively.



Source: Derived from the 1991, 2001 and 2011 I-SARs.

Figure 5.1: Percentage of commuters (excluding homeworkers) in England and Wales aged 16-74 in each commute distance band in 1991, 2001 and 2011

Although Figure 5.1 is useful, a more detailed picture of the changes between 1991 and 2001 and between 2001 and 2011 can be obtained by exploring commuting distances by the sociodemographic characteristics introduced in Chapter 2 and earlier in this chapter. Table 5.1 shows the distribution of commuters across the six commute distance bands in 2011, while Tables 5.2 and 5.3 show the percentage point changes in each of the sociodemographic variable categories against each of the categories of distance commuted.

Table 5.1 shows that commuting very short distance (less than 2km) was most prevalent amongst those aged 65-74, the Pakistani ethnic group and those with non-professional and non-managerial occupations. Geographically, commuting less than 2km was most prevalent amongst those living in the South West region, while commuting more than 40km was most prevalent for those living the East of England region. Unsurprisingly, the bicycle and on foot modes of transport had the highest prevalence of commuting less than 2km. Conversely, commuting more than 40km was most prevalent amongst males, those aged 25-44 and those with professional and managerial occupations.

Table 5.1: Percentage of commuters in each distance band by sociodemographic and geographic characteristics for all commuters (excluding homeworkers) in England and Wales aged 16-74 in 2011 (base table)

Sociodemographic and Geographic Characteristics		Distribution of Commuters across Distance Bands (%)					
Variables	Categories	<2km	≥2km-<5km	≥5km-<10km	≥10km-<20km	≥20km-<40km	≥40km
All	All	20.1	22.4	21.4	19.1	10.4	6.6
Sex	Male	16.4	20.4	20.9	20.6	12.6	9.0
	Female	23.9	24.3	21.8	17.7	8.3	4.1
Age Group	16-24	22.9	24.9	21.5	17.1	8.2	5.4
	25-44	18.6	21.6	21.6	19.9	11.2	7.0
	45-64	20.9	22.5	21.0	18.9	10.2	6.5
	65-74	25.6	24.0	20.5	16.7	8.2	5.0
Ethnic Group	White	20.2	22.2	21.2	19.1	10.7	6.7
	Indian	19.7	23.3	21.4	20.5	9.4	5.7
	Pakistani	25.5	25.7	19.6	16.7	7.6	5.0
	Bangladeshi	23.3	25.1	20.4	16.9	8.4	5.9
	Black	15.5	23.9	25.5	21.4	8.2	5.5
	Chinese	19.8	22.6	22.2	20.1	9.2	6.1
	Other	19.8	23.8	23.3	19.3	8.2	5.5
LLTI	LLTI	22.8	24.1	21.4	17.7	8.8	5.2
	No LLTI	19.9	22.2	21.4	19.2	10.6	6.7
Dependent Children	No Dependent Children	20.2	22.6	21.7	19.1	10.1	6.3
	Dependent Children	20.0	22.0	20.8	19.2	11.0	7.0
Occupation	Professional and Managerial	13.9	18.6	21.4	22.3	14.2	9.6
	Non-Professional and Non-Managerial	24.0	24.8	21.3	17.2	8.1	4.7
Region of Usual Residence	North East	20.5	23.9	22.7	20.1	8.1	4.7
	North West	21.4	24.8	22.6	17.7	8.8	4.8
	Yorkshire and The Humber	21.2	24.8	22.2	17.4	8.7	5.7
	East Midlands	21.0	22.6	19.5	18.6	11.1	7.2
	West Midlands	19.6	24.7	22.2	17.9	10.1	5.6
	East of England	20.1	19.1	15.8	18.5	16.2	10.2
	South East	20.4	20.1	18.0	17.5	13.8	10.1
	South West	24.7	22.3	18.9	17.5	9.2	7.5
	Inner London	15.7	27.0	37.6	14.4	2.8	2.4
	Outer London	14.1	19.0	23.2	32.9	8.3	2.4
	Wales	20.8	20.1	20.8	19.8	11.6	6.9
Mode of Transport	Train, Underground and Tram	3.0	8.5	24.4	31.8	16.6	15.6
	Bus	12.7	41.1	29.0	11.4	3.1	2.8
	Car (Driver)	13.4	22.1	23.1	22.0	12.7	6.7
	Car (Passenger)	19.5	30.4	22.2	15.5	7.9	4.4
	Bicycle	30.8	38.1	19.2	7.5	2.0	2.4
	On Foot	74.7	13.9	3.9	2.9	1.7	2.9
	Other	18.1	28.3	22.2	17.5	7.5	6.3

Source: Derived from the 2011 I-SAR.

Tables 5.2 and 5.3 show that there were decreases in the percentage of commuters commuting <2km to work in every sociodemographic category between both 1991 and 2001 and between 2001 and 2011, with the exception of travel by train, underground and tram which showed small increases of 0.6 and 0.5 percentage points between 1991 and 2001 and 2011, respectively.

It is noteworthy that Tables 5.2 and 5.3 show that while there were increases in the percentage of commuters commuting ≥5-<10km in all the sociodemographic categories between 1991 and

2001, there were decreases in commuting this distance in nearly all the sociodemographic variable categories between 2001 and 2011, with only the Bangladeshi ethnic group category and the bicycle, on foot and other modes of transport experiencing increases in the second time period.

For longer distances, there were increases in the share of those commuting ≥20-<40km between 1991 and 2001 and between 2001 and 2011, with only the train, underground and tram mode showing a decrease of 2.3 percentage points between 1991 and 2001. Similarly, there were increases in the share of commuters commuting ≥40km in both time periods, with the exception of commuters from the Bangladeshi and Chinese ethnic groups and those travelling by train, underground and tram which showed decreases of 1.7, 0.6 and 1.4 percentage points, respectively, between 1991 and 2001.

Table 5.2: Percentage point changes in the percentage of commuters in each distance band by sociodemographic and geographic characteristics for all commuters (excluding homeworkers) in England and Wales aged 16-74, 1991-2001

Sociodemographic and Geographic Characteristics		Commute Distance Bands (% Point Change)					
Variables	Categories	<2km	≥2km-<5km	≥5km-<10km	≥10km-<20km	≥20km-<40km	≥40km
All	All	-7.5	6.1	-1.8	0.6	1.5	1.1
Sex	Male	-5.2	5.1	-2.5	-0.4	1.4	1.5
	Female	-10.6	7.0	-1.1	1.9	1.9	0.9
Age Group	16-24	-4.8	7.2	-3.2	-1.0	0.6	1.1
	25-44	-7.6	5.9	-1.5	0.6	1.5	1.1
	45-64	-8.6	6.2	-1.6	1.2	1.7	1.1
	65-74	-10.5	5.2	0.2	1.9	1.9	1.4
Ethnic Group	White	-7.5	6.0	-1.9	0.6	1.6	1.2
	Indian	-6.9	6.3	-1.8	0.0	1.2	1.3
	Pakistani	-10.5	9.0	-1.8	0.5	1.6	1.1
	Bangladeshi	-12.7	11.5	3.6	-2.3	1.7	-1.7
	Black	-9.5	5.6	-1.5	3.1	1.5	0.8
	Chinese	-2.2	8.0	-3.3	-2.0	0.2	-0.6
	Other	-3.7	8.4	-2.1	-3.4	0.6	0.2
LLTI	LLTI	-8.9	6.6	-2.1	1.5	1.6	1.2
	No LLTI	-7.6	6.0	-1.8	0.6	1.6	1.2
Dependent Children	No Dependent Children**	-7.1	5.9	-2.0	0.6	1.5	1.1
	Dependent Children**	-8.0	6.3	-1.7	0.7	1.5	1.2
Occupation	Professional and Managerial	-5.3	4.8	-1.7	-0.5	1.3	1.5
	Non-Professional and Non-Managerial	-8.1	7.0	-1.9	0.9	1.3	0.7
Region of Usual Residence	North East	-11.2	6.9	0.1	1.7	1.4	1.2
	North West	-7.8	6.9	-2.6	0.8	1.7	1.0
	Yorkshire and The Humber	-7.5	5.9	-3.1	1.0	2.0	1.6
	East Midlands	-8.5	5.9	-2.8	1.3	2.1	1.9
	West Midlands	-7.6	7.0	-3.1	0.3	1.8	1.6
	East of England	-9.6	2.5	-2.6	0.8	5.3	3.5
	South East	-5.4	6.0	-0.9	0.2	0.2	0.0
	South West	-7.7	6.3	-2.2	0.3	1.9	1.5
	Inner London	-8.4	8.1	0.4	-0.8	0.3	0.4
	Outer London	-6.1	5.0	-0.1	1.0	0.0	0.2
	Wales	-8.8	6.0	-2.5	1.0	2.4	1.9
Mode of Transport	Train, Underground and Tram	0.6	3.8	2.6	-3.3	-2.3	-1.4
	Bus	-10.7	11.3	-2.8	0.8	0.6	0.7
	Car (Driver)	-5.4	5.8	-3.0	-0.2	1.7	1.1
	Car (Passenger)	-8.0	9.2	-3.2	0.0	1.1	1.0
	Bicycle	-15.8	12.5	1.2	1.2	0.4	0.6
	On Foot	-9.7	6.1	1.3	1.1	0.5	0.6
	Other	-2.2	5.9	-6.2	-1.6	1.6	2.6

Source: Derived from the 1991 and 2001 I-SARs. (**=1991 category is not exactly consistent with 2001 category).

Table 5.3: Percentage point changes in the percentage of commuters in each distance band by sociodemographic and geographic characteristics for all commuters (excluding homeworkers) in England and Wales aged 16-74, 2001-2011

Sociodemographic and Geographic Characteristics		Commute Distance Bands (% Point Change)					
Variables	Categories	<2km	≥2km-<5km	≥5km-<10km	≥10km-<20km	≥20km-<40km	≥40km
All	All	-2.6	-0.7	0.0	1.1	1.3	1.0
Sex	Male	-1.8	-0.6	-0.4	0.6	1.2	1.1
	Female	-3.9	-0.9	0.5	1.7	1.5	1.0
Age Group	16-24	-1.7	-0.8	-0.3	0.7	1.0	1.1
	25-44	-2.1	-0.6	0.0	0.8	1.1	0.8
	45-64	-4.0	-0.9	0.3	1.7	1.7	1.2
	65-74	-6.2	-0.3	1.0	2.7	2.1	0.8
Ethnic Group	White	-2.6	-0.7	0.0	1.0	1.3	1.0
	Indian	-3.1	-2.8	-0.5	2.5	2.5	1.5
	Pakistani	-2.8	-2.5	-0.4	2.3	1.8	1.7
	Bangladeshi	-6.2	0.5	1.4	1.4	1.4	1.4
	Black	-1.6	-1.8	-1.8	0.6	2.6	2.1
	Chinese	-5.2	-0.2	0.2	1.8	1.5	2.1
	Other	-2.0	-0.1	0.5	-0.2	1.1	0.8
LLTI	LLTI	-3.1	-0.6	0.7	1.3	1.1	0.7
	No LLTI	-2.6	-0.7	0.0	1.1	1.3	1.0
Dependent Children	No Dependent Children	-2.2	-0.5	0.1	0.8	0.9	0.8
	Dependent Children	-3.3	-1.1	-0.1	1.4	1.8	1.2
Occupation	Professional and Managerial	-1.2	0.0	-0.1	0.3	0.6	0.4
	Non-Professional and Non-Managerial	-3.2	-0.9	0.1	1.4	1.5	1.1
Region of Usual Residence	North East	-1.3	-0.3	-1.1	1.0	1.6	0.1
	North West	-2.3	-0.7	0.2	0.7	1.3	0.8
	Yorkshire and The Humber	-2.1	-1.0	-0.4	1.1	1.3	1.1
	East Midlands	-3.2	-0.8	-0.8	1.5	1.9	1.5
	West Midlands	-3.0	-1.2	0.2	1.2	1.7	1.1
	East of England	-2.8	-0.5	-0.3	0.9	1.8	0.9
	South East	-3.1	-0.3	0.1	0.8	1.2	1.3
	South West	-3.6	-0.5	0.0	1.4	1.3	1.5
	Inner London	-1.9	-0.2	0.7	0.8	0.3	0.4
	Outer London	-1.3	-1.2	-0.3	1.8	0.7	0.4
	Wales	-2.7	-1.4	0.2	0.9	1.6	1.5
Mode of Transport	Train, Underground and Tram	0.5	-0.6	-0.3	-0.8	0.8	0.5
	Bus	-1.4	-1.9	0.9	1.2	0.6	0.7
	Car (Driver)	-1.8	-0.7	-0.4	0.8	1.3	0.7
	Car (Passenger)	-2.0	-1.8	-0.2	0.9	1.8	1.3
	Bicycle	-12.7	2.7	5.6	2.9	0.7	1.0
	On Foot	-6.8	3.5	0.7	0.8	0.6	1.2
	Other	-3.9	1.4	1.1	1.5	0.1	-0.1

Source: Derived from the 2001 and 2011 I-SARs.

The general trend seen in Figure 5.1 and Tables 5.2 and 5.3, with increases in long-distance commuting and decreases in short-distance commuting, could be partially explained by the 'death of distance' theory. The theory was first posited by Cairncross (1997) and suggests that the internet and improvements in communication technology have made distance a less important determinant of economic and social interaction. Therefore, it could be argued that any substantial increases in the prevalence of very long-distance commuting, and any substantial decreases in the prevalence of short-distance commuting, may be due to technology reducing the need for short commutes and facilitating long commutes, by allowing people to work and be economically productive on long train journeys, for example. However, it should be noted that the death of distance theory is refuted by Rietveld and Vickerman (2004), who argue that, despite enormous improvements in the performance of transport systems over time, economic activities have not become as detached from the constraints of distance as the theory would suggest.

It appears that these general increases in long-distance commuting may also be associated with changes to the modal split, with the analyses in Chapter 6 showing commuters switching from modes of transport that are associated with short-distance commuting, such as bus, to modes associated with long-distance commuting, such as train, underground and tram and car. As previously noted, this relationship between different commute distances and different modes of transport has been set out by Lyons and Chatterjee (2008) and is expounded further in this chapter and in Chapter 6.

5.2.3 Changes in very long-distance commuting

Table 5.4 shows the variation in the prevalence of very long commutes for the various sociodemographic categories in 1991, 2001 and 2011 and the decadal percentage point changes for each group.

Overall, Table 5.4 shows that there were general increases in the percentage of those commuting very long-distances between both 1991 and 2001 and 2001 and 2011 across the different sociodemographic categories. Only four sociodemographic categories showed a decrease in the percentage of commuters commuting very long-distances between 1991 and 2001; the Bangladeshi, Chinese and Other ethnic groups and the train, underground and tram mode of transport, while only one sociodemographic category showed a decrease in the percentage of commuters commuting very long-distances between 2001 and 2011; the Other mode of transport category. In all three years, males and those with professional and managerial occupations had the highest prevalence of very long-distance commuting, increasing over the 20 year period to 9.0% and 9.6%, respectively, in 2011.

There is some consistency in the sex, age group, LLTI, dependent children and occupation variables, in that those categories with the highest percentages of very long commutes in 1991 were the same in 2001 and 2011. In all three years, commuters in the male, 25-44, no LLTI, dependent children and professional and managerial categories experienced higher rates of commuting very long-distance, while commuters in the female, 65-74, LLTI, no dependent children and non-professional and non-managerial categories experienced lower rates of commuting very long-distance. However, the same level of consistency is not seen for the ethnic group variable. Although there was some consistency, with the Pakistani ethnic group being the least likely to commute very long-distance in all three years and the White ethnic group being the most likely to commute very long-distance in both 2001 and 2011, in 1991 it was the Bangladeshi ethnic group which was most likely to commute very long-distance.

Regarding geographic variations and changes, commuters resident in the East of England and South East regions were most likely to commute very long-distance in all three years, with the prevalence of very long-distance commuting increasing from 5.8% and 8.8% in 1991 to 10.2% and 10.1% in 2011, respectively. Conversely, those commuters resident in the Inner and Outer London regions were least likely to commute very long-distance in all three years, with only 2.4% of commutes in 2011 being very long-distance.

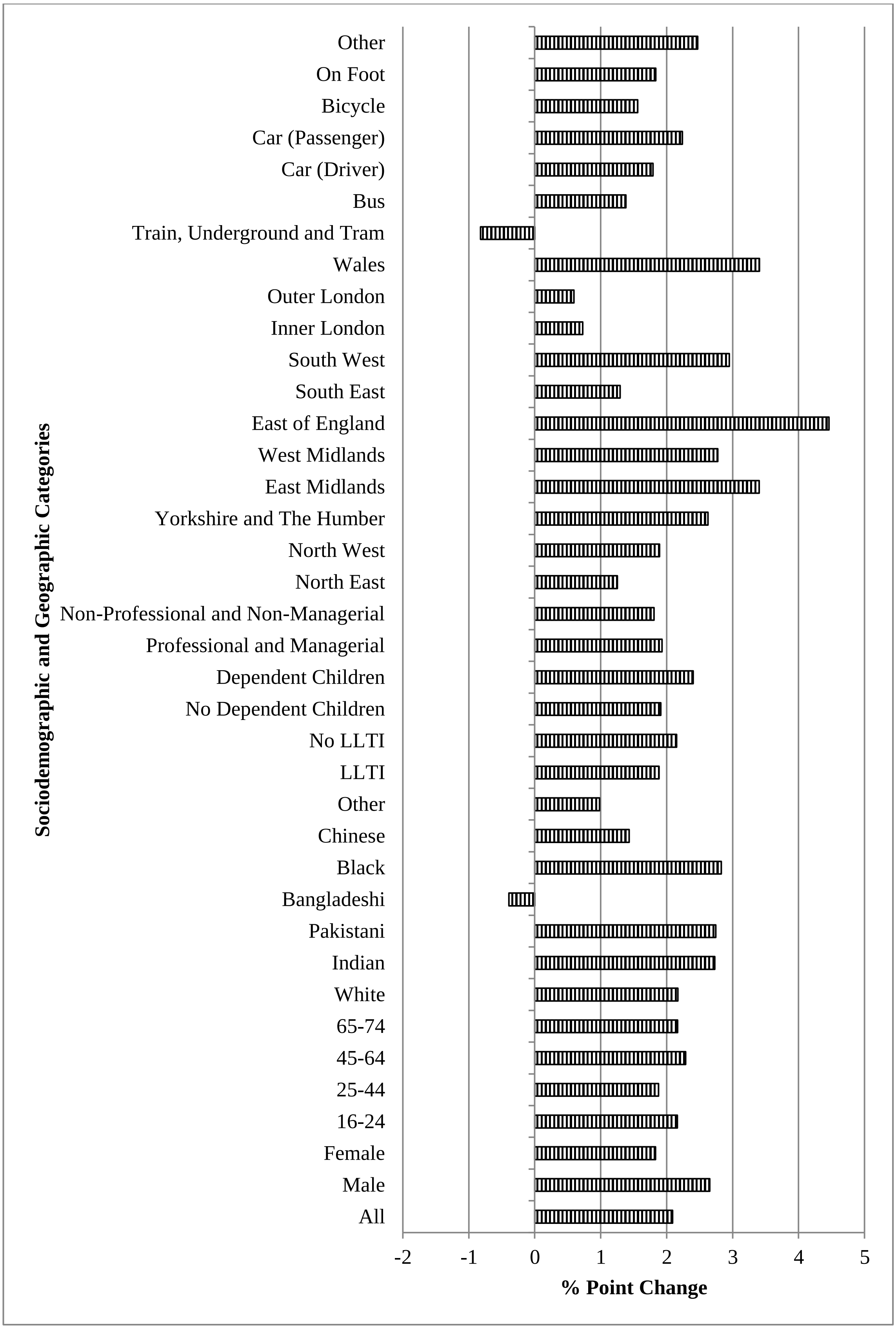
Finally, in all three years those commuting by train, underground and tram were most likely to commute very long-distance, albeit with the prevalence falling between 1991 and 2001, while those commuting by bicycle were the least likely, with only 2.4% of commutes by bicycle in 2011 being very long-distance.

Table 5.4: Percentages and percentage point changes in very long commutes (≥40km) by sociodemographic and geographic characteristics for all commuters (excluding homeworkers) in England and Wales aged 16-74, 1991, 2001 and 2011

Sociodemographic and Geographic Characteristics		Very Long Commute (%)			% Point Change	
Variables	Categories	1991	2001	2011	91-01	01-11
All	All	4.5	5.6	6.6	1.1	1.0
Sex	Male	6.4	7.9	9.0	1.5	1.1
	Female	2.3	3.1	4.1	0.9	1.0
Age Group	16-24	3.2	4.3	5.4	1.1	1.1
	25-44	5.1	6.2	7.0	1.1	0.8
	45-64	4.2	5.3	6.5	1.1	1.2
	65-74	2.9	4.3	5.0	1.4	0.8
Ethnic Group	White	4.6	5.7	6.7	1.2	1.0
	Indian	2.9	4.2	5.7	1.3	1.5
	Pakistani	2.2	3.3	5.0	1.1	1.7
	Bangladeshi	6.3	4.6	5.9	-1.7	1.4
	Black	2.6	3.4	5.5	0.8	2.1
	Chinese	4.7	4.1	6.1	-0.6	2.1
	Other	4.5	4.7	5.5	0.2	0.8
LLTI	LLTI	3.3	4.5	5.2	1.2	0.7
	No LLTI	4.5	5.7	6.7	1.2	1.0
Dependent Children	No Dependent Children	4.4	5.5	6.3	1.1	0.8
	Dependent Children	4.6	5.8	7.0	1.2	1.2
Occupation	Professional and Managerial	7.7	9.2	9.6	1.5	0.4
	Non-Professional and Non-Managerial	2.9	3.6	4.7	0.7	1.1
Region of Usual Residence	North East	3.4	4.6	4.7	1.2	0.1
	North West	3.0	4.0	4.8	1.0	0.8
	Yorkshire and The Humber	3.1	4.6	5.7	1.6	1.1
	East Midlands	3.8	5.7	7.2	1.9	1.5
	West Midlands	2.8	4.4	5.6	1.6	1.1
	East of England	5.8	9.3	10.2	3.5	0.9
	South East	8.8	8.9	10.1	0.0	1.3
	South West	4.5	6.0	7.5	1.5	1.5
	Inner London	1.7	2.1	2.4	0.4	0.4
	Outer London	1.9	2.1	2.4	0.2	0.4
	Wales	3.5	5.4	6.9	1.9	1.5
Mode of Transport	Train, Underground and Tram	16.4	15.0	15.6	-1.4	0.5
	Bus	1.4	2.1	2.8	0.7	0.7
	Car (Driver)	4.9	6.0	6.7	1.1	0.7
	Car (Passenger)	2.1	3.1	4.4	1.0	1.3
	Bicycle	0.8	1.4	2.4	0.6	1.0
	On Foot	1.0	1.6	2.9	0.6	1.2
	Other	3.9	6.5	6.3	2.6	-0.1

Source: Derived from the 1991, 2001 and 2011 I-SARs.

Figure 5.2 provides a graphical summary of the combined 1991-2001 and 2001-2011 percentage point changes in very long-distance commutes for commuters in each of the sociodemographic variable categories. Figure 5.2 indicates that there have been general increases in very long-distance commuting across the sociodemographic categories. The largest percentage point increases were for three different regions; Wales, the East of England and the East Midlands, with 3.4, 4.4 and 3.4 percentage point increases between 1991 and 2011, respectively. Only two sociodemographic categories experienced percentage point decreases for very long-distance commuting, the train, underground and tram mode of transport and the Bangladeshi ethnic group, with 0.9 and 0.3 percentage point decreases between 1991 and 2011, respectively.



Source: Derived from Table 5.4.

Figure 5.2: Percentage point changes in very long (≥40km) commutes by sociodemographic and geographic characteristics for all commuters (excluding homeworkers) in England and Wales aged 16-74, 1991-2011

5.2.4 Modelling very long-distance commuting

The results of the BLR models for very long-distance commuting based on the 1991, 2001 and 2011 census microdata are shown in Table 5.5, indicating that although there was some convergence in the ORs for males and females over the 20 year period, men were significantly more likely than women to commute very long-distances in all three years, as the ORs for females were 0.411, 0.419 and 0.448 in 1991, 2001 and 2011, respectively.

In all three years, it was the 25-44 age group that was most likely to commute very long-distance, while the 65-74 age group was the least likely. The changes in the ORs between 1991 and 2001 and 2001 and 2011 show that there is evidence of substantial convergence in the very long-distance commuting propensities across all age groups between 1991 and 2011, when controlling for the other sociodemographic variables. This convergence occurred in both directions, with the 25-44 and 45-64 age groups becoming less likely to commute very long-distance relative to the 16-24 age group and the 65-74 age group becoming more likely to commute very long-distance relative to the reference category. The ORs indicate that for every 100 commuters in the 16-24 age group commuting very long-distance in 1991, 136 commuters aged 25-44, 114 aged 45-64 and only 81 aged 65-74 commuted very long-distance. In 2001, the age profile of commuting had changed with 120 and 106 commuters in the working age groups commuting very long-distance for every 100 aged 16-24. By 2011, all four age categories had converged even further, with the 25-44 and 45-64 ORs decreasing from 1.103 and 1.062 in 2001 to 1.082 and 1.051 in 2011, respectively, and the 65-74 OR increasing from 0.808 in 1991 to 0.872 in 2011, albeit with all the convergence taking place between 1991 and 2001 and a small amount of divergence between 2001 and 2011.

The ORs for the different ethnic groups show that whilst Bangladeshi commuters were more likely to commute very long-distances than commuters in the White group in 1991, by 2011 commuters in both the Bangladeshi and Black ethnic groups were more likely to commute very long-distance, when controlling for the other variables. Pakistanis were the least likely to commute very long-distance in all three years, with ORs of 0.570, 0.692 and 0.831 in 1991, 2001 and 2011, respectively.

The ORs for LLTI for very long-distance commuting show that commuters with no LLTI were significantly more likely to commute very long-distance than commuters with a LLTI in 1991, 2001 and 2011.

Commuters with dependent children were significantly less likely to commute long-distance than commuters without dependent children in 1991, but significantly more likely in 2011. The finding for the dependent children variable in Table 5.5 differs from the finding in Table 5.4.

Table 5.4 indicated that, in all three years, the prevalence of very long-distance commuting was higher amongst commuters with dependent children than amongst commuters with no dependent children. This difference in the pattern between Tables 5.4 and 5.5 indicates the importance of controlling for the other sociodemographic variables, as the pattern seen in Table 5.4 may be because commuters with dependent children in 1991 and 2001 may have been more likely to also be in the 25-44 age group, not have a LLTI and commute to work by car, inflating the prevalence of very long-distance commuting amongst those with dependent children. However, Table 5.5 shows that even when controlling for the other variables, the 2011 data contradict the findings of McQuaid *et al*. (2001) and Gibbons and Machin (2006).

The ORs show that commuters with professional and managerial occupations were significantly more likely to commute very long-distance than commuters with non-professional and non-managerial occupations in all three years.

The ORs for the different regions show that commuters living in the East of England, South East and South West regions were the most likely to commute very long-distances in 1991, 2001 and 2011, whilst those in Inner London were the least likely. The high ORs for very long-distance commuting are in southern England, albeit in those regions outside of Greater London. This suggests that very long-distance commuters are likely to be those commuting in to London.

Table 5.5 shows that people commuting by train, underground and tram were most likely to commute very long-distances in 1991, 2001 and 2011, while commuters by bicycle were least likely to commute very long-distances in all three years, as might be expected. The ORs for the different modes of transport demonstrate substantial convergence in the relative likelihoods of commuting very long-distance, with the ORs for all mode of transport categories increasing between 1991 and 2011, relative to the train, underground and tram mode of transport category. The largest OR increase was seen for the other mode of transport, with the OR increasing from 0.115 in 1991 to 0.213 in 2011, albeit with all of the increase taking place between 1991 and 2001 and offsetting a small decrease taking place between 2001 and 2011.

It is worth noting at this point that, in reality, commuters may use more than one mode of transport to commute to work. It is likely that this multimodal commuting is more important when considering very long-distance commuters due to their higher usage of train, underground and tram modes, with most of those commuters having to get themselves from their place of residence to the nearest train, underground or tram station and from the subsequent train, underground or tram station to their place of work using other modes of transport. However, it is not possible to analyse this multi-modal commuting using the I-SARs or other data derived from the census as census respondents in England and Wales in 1991, 2001 and 2011 were only allowed to choose one mode of transport option in response to the question "*How do you* *usually travel to work?”*. This is a major weakness of the census data due to the importance of multimodal commuting. Multimodal commuting is particularly important when analysing the commuting behaviour of younger commuters, as individuals who are single are more likely to use multiple modes of transport (Kuhnimhof, *et al.*, 2006). Multimodal commuting is also important for individuals with families, with many commuters traveling in a carpool or ‘fampool’ to the train station before commuting by train for the rest of their journey to work (DeLoach and Tiemann, 2010). However, other datasets, such as local cohort studies as used by Goodman *et al*. (2012), that would likely be more advantageous for analysing multimodal commuting would be unlikely to provide the same levels of sociodemographic detail as the I-SARs.

Finally, the regression analysis shows that the value of the constant increased between 1991 and 2001 from 0.035 to 0.065 and then increased further between 2001 and 2011 to 0.089. This means that the relative likelihood of the reference individual commuting very long-distance increased between 1991 and 2001 and again between 2001 and 2011.

Table 5.5: BLR model results for commuters with very long commutes (≥40km) by sociodemographic and geographic characteristics for all commuters (excluding homeworkers) in England and Wales aged 16-74 in 1991, 2001 and 2011

Sociodemographic and Geographic Characteristics		1991 OR		2001 OR		2011 OR	
Variables	Categories						
Sex	Male	1.000		1.000		1.000	
	Female	0.411	*	0.418	*	0.448	*
Age Group	16-24	1.000		1.000		1.000	
	25-44	1.358	*	1.203	*	1.082	*
	45-64	1.140	*	1.062	*	1.051	*
	65-74	0.808	*	0.951		0.872	*
Ethnic Group	White	1.000		1.000		1.000	
	Indian	0.829	*	0.908		0.921	*
	Pakistani	0.570	*	0.704	*	0.831	*
	Bangladeshi	1.704	*	1.336	*	1.289	*
	Black	0.971		1.046		1.239	*
	Chinese	0.910		0.798	*	1.033	
	Other	1.070		1.008		1.035	
LLTI	LLTI	1.000		1.000		1.000	
	No LLTI	1.259	*	1.141	*	1.117	*
Dependent Children	No Dependent Children	1.000		1.000		1.000	
	Dependent Children	0.941	*	0.996		1.065	*
Occupation	Professional and Managerial	1.000		1.000		1.000	
	Non-Professional and Non-Managerial	0.506	*	0.455	*	0.540	*
Region of Usual Residence	North East	1.000		1.000		1.000	
	North West	0.822	*	0.844	*	1.014	
	Yorkshire and The Humber	0.954		1.044		1.255	*
	East Midlands	1.184	*	1.298	*	1.669	*
	West Midlands	0.815	*	0.949		1.189	*
	East of England	1.760	*	1.671	*	1.882	*
	South East	1.970	*	1.590	*	1.867	*
	South West	1.397	*	1.373	*	1.757	*
	Inner London	0.139	*	0.121	*	0.166	*
	Outer London	0.187	*	0.163	*	0.204	*
	Wales	1.069		1.234	*	1.574	*
Mode of Transport	Train, Underground and Tram	1.000		1.000		1.000	
	Bus	0.078	*	0.110	*	0.140	*
	Car (Driver)	0.143	*	0.186	*	0.211	*
	Car (Passenger)	0.093	*	0.128	*	0.167	*
	Bicycle	0.025	*	0.042	*	0.069	*
	On Foot	0.046	*	0.068	*	0.112	*
	Other	0.115	*	0.221	*	0.213	*
	Constant	0.367	*	0.473	*	0.385	*

Source: Derived from the 1991, 2001 and 2011 I-SARs. (*=OR is statistically significant ($p<0.05$)).

Males and those aged 25-44 being the most likely to commute very long-distance may be due to sex and age differences in caring responsibilities. As females and older individuals are more likely to have caring responsibilities than males and younger individuals (Buckner and Yeandle, 2006), they may choose to commute shorter distances in order to better balance their work and caring responsibilities.

Commuters in the Bangladeshi and Black ethnic groups may be most likely to commute very long-distance due to their status in the labour market and their concentration in inner city areas. This explanation is linked to the spatial mismatch hypothesis (Kain, 1968). It may be the case that ethnic minority populations in inner city areas are now quite distant from many employment opportunities that have tended to migrate with the White population to more suburban areas (Thomas, 1998), and therefore have no choice but to commute longer distances than their White counterparts.

That commuters without a LLTI are more likely to commute very long-distance than those with a LLTI is unsurprising as it is likely that those without a LLTI or disability are more capable of traveling very long-distances than those with a LLTI or disability. However, the finding that commuters with dependent children are more likely to commute very long-distance than those without dependent children is particularly interesting. Although the differences in the prevalence of very long commutes in Table 5.4 are only slight (0.2, 0.3 and 0.7 percentage points in 1991, 2001 and 2011, respectively) and that only in 2011 is the OR in Table 5.5 for those with dependent children higher than for those without dependent children, it means that the data contradict the findings of research based on earlier data, such as McQuaid *et al*. (2001) and Gibbons and Machin (2006), who found that commuters without dependent children were likely to commute further than those with dependent children.

The difference between professional and managerial commuters and non-professional and non-managerial commuters may be due to differences in income, with professionals and managers being more able to afford the financial costs of very long-distance commuting. It is unsurprising that there does not appear to have been any substantial convergence between the two occupation groups as. This lack of convergence may be because, although there have been recent falls in petrol prices (BBC, 2015v), the cost of fuel is still relatively high and train ticket prices are high and increasing (BBC, 2013i, 2013iii, 2014, 2015vi, 2015ix), restricting the ability of commuters in lower paid jobs to drive or take the train to work.

It is likely that the very low ORs for very long-distance commuting for the Inner and Outer London regions are due to many commuters living in those regions being relatively close to their places of employment in Central London. With an unrivalled concentration of employment opportunities, some commuters in London may make conscious decisions to minimise their commute distance by changing their employment. This ability to pick and choose employment opportunities is unlikely to be so freely available to commuters outside the London region.

The ORs for the different modes of transport go some way to confirming the findings of Lyons and Chatterjee (2008), who found commuting by train to be associated with long commutes and commuting by bicycle or on foot to be associated with short commutes, as one might have expected.

Table 5.6 shows the overall R^2 values and the individual R^2 values for the different sociodemographic variables in the model for the 1991, 2001 and 2011 very long-distance BLR models. The R^2 values of 0.174, 0.148 and 0.130 for 1991, 2001 and 2011, respectively, are relatively low. These R^2 values show that just 17.4%, 14.8% and 13.0% of the variations in very long-distance commuting are explained by the model using the chosen sociodemographic predictor variables in 1991, 2001 and 2011, respectively. The R^2 values indicate that the explanatory ability of the very long-distance BLR model is highest for 1991 and lowest for 2011.

Regarding the individual variables, in all three years the mode of transport variable contributed most to the models in terms of explaining any variations in very long-distance commuting, with R^2 values ranging from 0.080 in 1991 to 0.053 in 2001. The second and third most important variables are not the same for all three years. While in 1991 it was the region of usual residence and occupation that were second and third most important variables, in 2001 it was the occupation and sex variables and in 2011 it was the region of usual residence and sex. The ethnic group, LLTI and dependent children variables were the least important variables for explaining any variations in very long-distance commuting, with R^2 values of 0.001 or less in 1991, 2001 and 2011.

That the mode of transport variable was the most important independent variable in all three years further highlights the important relationship between mode of transport and commute distance. It is also the case that commute distance is one of the most important variables in explaining variations in commuting by public transport (see Chapter 6).

Table 5.6: R^2 results for the 1991, 2001 and 2011 very long-distance (≥40km) BLR models

Variable	1991 R^2	2001 R^2	2011 R^2
Sex	0.034	<u>0.032</u>	<u>0.026</u>
Age Group	0.004	0.002	0.001
Ethnic Group	0.001	0.001	0.001
LLTI	0.000	0.000	0.001
Dependent Children	0.000	0.000	0.001
Occupation	<u>0.036</u>	<u>0.037</u>	0.023
Region of Usual Residence	<u>0.043</u>	0.030	<u>0.030</u>
Mode of Transport	<u>0.080</u>	<u>0.053</u>	<u>0.043</u>
Model	0.174	0.149	0.130

Source: Derived from the 1991, 2001 and 2011 I-SARs.

These relatively low R^2 values may be due to sociodemographic variables that are excluded from the models having a particularly large and significant effect on the likelihood of an individual commuting very long-distance, such as personal or family income, transport network accessibility and rural/urban classification.

5.2.5 Commute distance interaction effects

This section deals with the IEs between some of the different sociodemographic variables used in the BLR modelling described previously. The IEs between the three most important variables are being analysed in addition to the PEs of the variables in order to gain a fuller understanding of the relationships between the different sociodemographic variables and commute distance, as intersectionality is important in determining the commuting behaviour of individual commuters (see Chapter 2). The following section builds on previous research and the preceding analyses by quantifying how likely an individual is to commute very long-distance given their sex, occupation and mode of transport.

The number of variables included in the IE BLR model has been limited to avoid the model becoming unwieldy and to concentrate on the most important variables. Any number of variables could potentially influence the relative likelihood that a commuter will commute a certain distance to work, and it is likely that some other important variables have not been included as they are not available from the microdata.

5.2.5.1 Sex, occupation and mode of transport

Past research discussed in Chapter 2 suggests that a commuter’s sex, occupation and mode of transport are particularly important in influencing how far they travel to work. Commuters who are male, in professional and managerial employment and commute to work by car or train, on average, travel further than females, those not in professional and managerial employment and those who travel to work by bicycle or on foot (Pickup and Town, 1983; Department for Transport, 2011; Lyons and Chatterjee, 2008). In addition, research has found that ethnicity and sex (McLafferty, 1997) and occupation and sex (Bostock, 2001), through the process of intersectionality, affect the commuting behaviours and patterns of commuters individually, as PEs, and together, as IEs. However, the ethnic group variable has been excluded from the following analysis in order to keep the number of IEs manageable and due to the extremely low R^2 values indicated in Table 5.6.

In addition to past research findings, the sex, occupation and mode of transport variables, and the interactions between them, are reported in Table 5.7 as they are particularly important in influencing variations in the prevalence of very long-distance commuting. Table 5.6 shows that they were the three most important variables for explaining very long-distance commuting, with all three variables having relatively high R^2 values in 1991 and 2001 and the highest R^2 values in 2011.

Table 5.7 shows the β-values, which were explained in Chapter 3, for the PEs of the sex, occupation and mode of transport variables and the IEs between the three individual variables. It is immediately clear from looking at the PE β-values that those in non-professional and non-managerial employment, females and those who commute by bicycle or on foot are substantially less likely to commute very long-distance than those in professional and managerial employment, males and those who commute by train or driving a car.

Table 5.7: PEs and IEs results from BLR model for commuters with very long commutes (≥40km) by sex, occupation and mode of transport for all commuters (excluding homeworkers) in England and Wales aged 16-74 in 1991, 2001 and 2011 (Reference Categories: Male, Professional and Managerial and Bus)

Effects	Sociodemographic Characteristics		1991 β		2001 β		2011 β	
	Variables	Categories						
Primary Effects	Sex	Male	0.000		0.000		0.000	
		Female	-0.935	*	-0.857	*	-0.789	*
	Occupation	Professional and Managerial	0.000		0.000		0.000	
		Non-Professional and Non-Managerial	-0.746	*	-0.726	*	-0.593	*
	Mode of Transport	Train, Underground and Tram	2.092	*	1.628	*	1.499	*
		Bus	0.000		0.000		0.000	
		Car (Driver)	0.853	*	0.798	*	0.753	*
		Car (Passenger)	0.402	*	0.387	*	0.431	*
		Bicycle	-1.006	*	-0.859	*	-0.567	*
		On Foot	-0.397	*	-0.328		-0.021	
		Other	0.580	*	0.819	*	0.562	*
Interaction Effects	Occupation, Sex and Mode of Transport	Male, Professional and Bus	0.000		0.000		0.000	
		Female, Non-Professional and Train, Underground and Tram	0.604	*	0.570	*	0.379	*
		Female, Non-Professional and Car (Driver)	-0.199	*	-0.251	*	-0.199	*
		Female, Non-Professional and Car (Passenger)	-0.054		-0.068		0.146	*
		Female, Non-Professional and Bicycle	0.884	*	1.044	*	0.735	*
		Female, Non-Professional and On Foot	0.189		0.123		0.125	*
		Female, Non-Professional and Other	0.609	*	0.084		0.311	*
		Constant	-3.162	*	-2.880	*	-2.729	*

Source: Derived from the 1991, 2001 and 2011 I-SARs. (*=OR is statistically significant ($p<0.05$)).

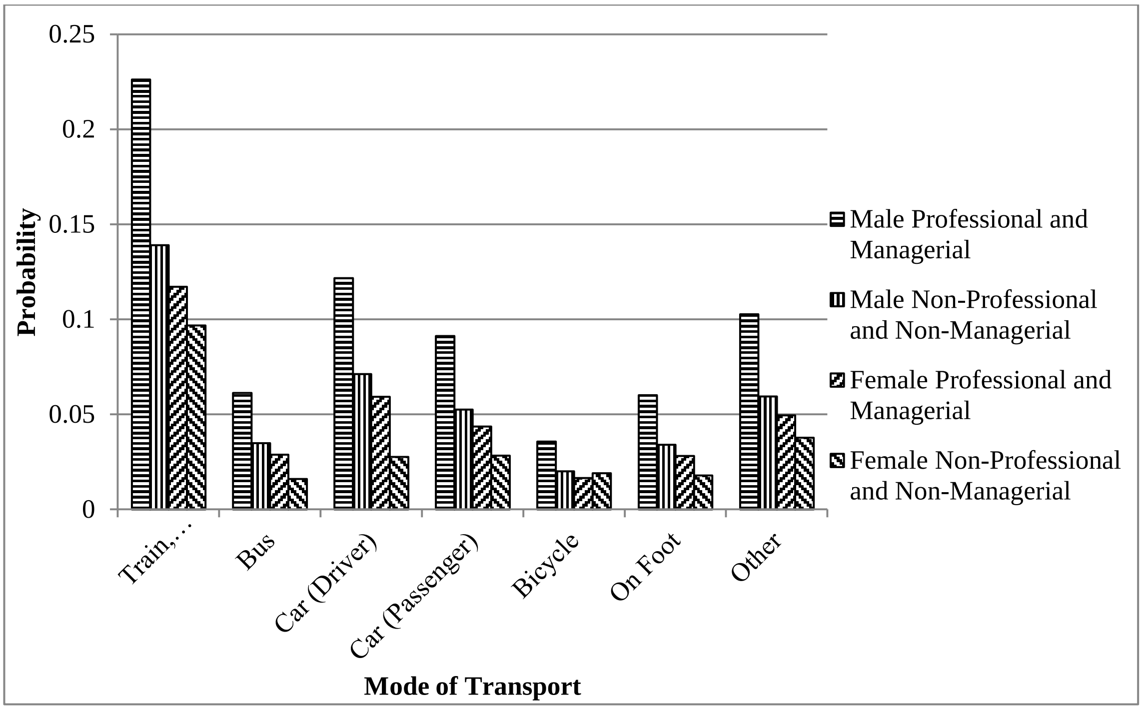
Although Table 5.7 clearly highlights the different β-values for the different variable categories, in order to examine the absolute probabilities of commuting very long-distance for the different combinations of the three variables it is necessary to calculate the probabilities of commuting very long-distance by taking both the PEs and IEs into account. The process of calculating probabilities using PEs and IEs was explained in Chapter 3.

Figure 5.3 is a graphical representation of the probabilities of commuting very long-distance in 2011 for the sociodemographic groups in question taking into account both the PEs and IEs in Table 5.7. This shows that the highest probabilities for commuting very long-distance are for all groups commuting by train, underground and tram and for men working in professional and managerial occupations who commute to work by car. The highest probabilities range from

0.122, for professional and managerial males who commute to work driving a car, to 0.226, for professional and managerial males who commute to work by train, underground and tram. Conversely, the lowest probabilities for commuting very long-distance are seen for women in non-professional and non-managerial roles who commute to work by bus (0.016) and women in professional and managerial occupations who commute to work by bicycle (0.017). These probabilities go some way to confirming the findings of previous research and suggest that very long-distance commuting is generally undertaken by professional men who drive or take the train to work.

However, the differences in the probabilities are not quite as clear cut as might be expected. First, non-professional and non-managerial men who commute by train, underground and tram are more likely to commute very long-distance than professional and managerial men who commute to work by driving a car. This means that, when comparing these two specific sociodemographic groups, it is mode of transport, rather than occupation, which is most important in determining their probability of commuting very long-distance. Second, both women in professional and managerial roles and those in non-professional and non-managerial occupations who commute by train, underground and tram have relatively high probabilities of commuting very long-distance, similar to those of professional and managerial males who commute by car (as a driver or passenger). This means that the mode of transport a commuter uses is particularly important in influencing the probability of them commuting very long-distance.

Overall, it is clear that all three variables, occupation, sex and mode of transport, and the IEs between them, are important in explaining variations in the probability of commuting very long-distances. There are substantial differences in probabilities between the two occupation categories across the different sex and mode of transport categories, between males and females across the different occupation and mode of transport categories and between the seven mode of transport categories across the different occupation and sex categories.



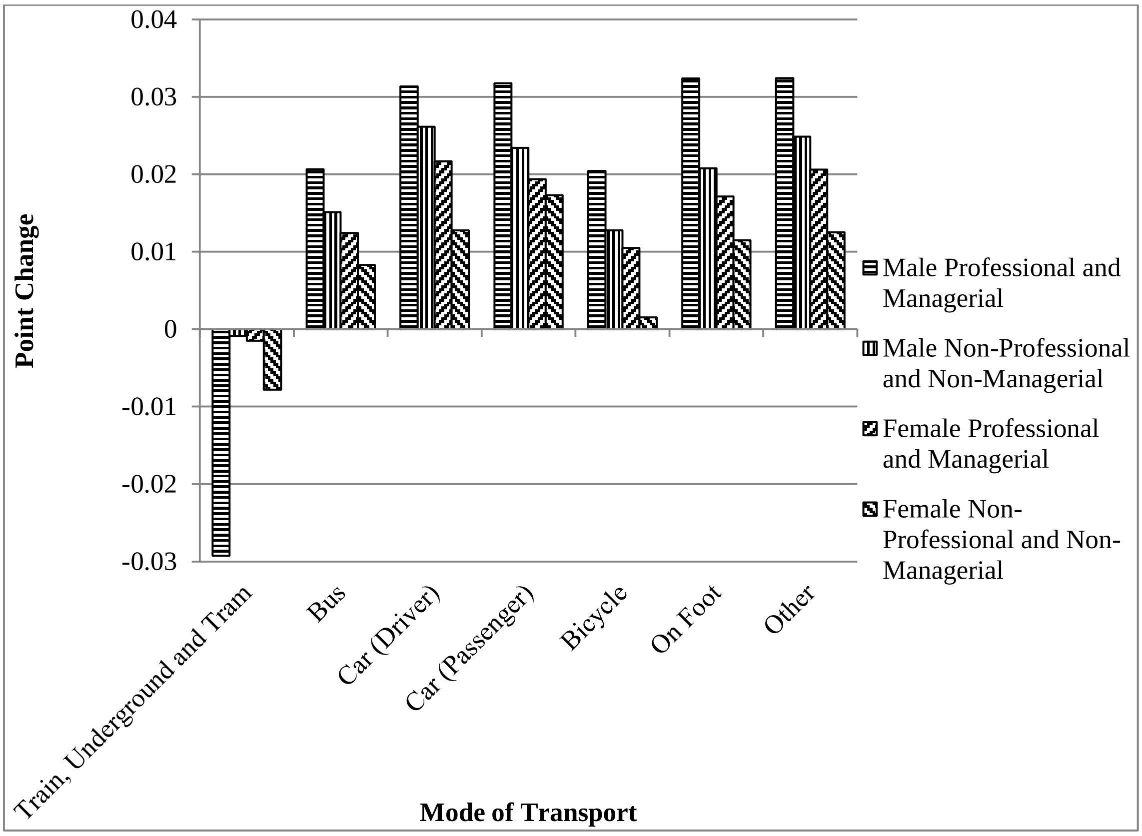
Source: Derived from Table 5.7.

Figure 5.3: Probabilities of commuters commuting very long-distance (≥40km) by sex, occupation and mode of transport for all commuters (excluding homeworkers) in England and Wales aged 16-74 in 2011

Males commuting by train, underground and tram may experience the highest probabilities of commuting very long-distance while non-professional and non-managerial females who commute to work by bus and professional and managerial females who commute to work by bicycle may experience the lowest probabilities of commuting very long-distance due to differences in income, caring responsibilities and working practices. Males commuting by train, underground and tram are more likely to be able to afford the cost of long commutes and may have jobs and incomes that justify a very long commute. Conversely, as females are more likely to have caring responsibilities (Buckner and Yeandle, 2006), females commuting by bus or bicycle may have childcare or other caring responsibilities that restrict their ability to commit to a very long commute. Similarly, as females are more likely to work part-time and be in low income and low skilled jobs (Grant *et al.*, 2005; Hurrell, 2005), they may not be able to justify a long commute to work.

Figure 5.4 is a graphical representation of the changes in the probabilities of commuting very long-distance between 1991 and 2011 for the different sociodemographic groups. Taken with Figure 5.3, it shows that there was no general convergence in the probabilities of commuting very long-distance over the 20 year period, with professional and managerial males generally experiencing the largest increases in probability across all the modes of transport, except for train, underground and tram, and non-professional and non-managerial females experiencing the smallest increases in probability. The changes seen in Figure 5.4 confirm the trends seen in

Figure 5.2 and Table 5.5, with nearly all groups experiencing increases in the prevalence of commuting very long-distance.



Source: Derived from Table 5.7.

Figure 5.4: Changes in probabilities of commuters commuting very long-distance (≥40km) between 1991 and 2011 by sex, occupation and mode of transport for all commuters (excluding homeworkers) in England and Wales aged 16-74

It is likely that those commuting by train, underground and tram have experienced decreases in the probability of commuting very long-distance due to the already high probabilities they were experiencing. Conversely, it is likely that the increase in probabilities seen for males and females and professional and managerial and non-professional and non-managerial workers across all the other modes of transport are a direct reflection of the general trend toward longer commutes seen in Figure 5.1 and Tables 5.2 and 5.3.

5.3 Sociodemographic and Spatial Variations in Commuting Self-containment

Changes in commuting self-containment at LAD level have important policy implications in the UK. With LADs being the primary spatial units used for the formulation and implementation of local economic and transport policies, any variations and changes in the extent to which LADs represent TTWAs or LLMAs will have implications for their relevance and usefulness in relation to policy.

5.3.1 Introduction: commute distance and self-containment

Table 5.8 shows the statistically significant relationships between commute distance and commuting self-containment in 1991 (x^2=151588.814, df=5, p<0.05) and 2011 (x^2=456218.047, df=5, p<0.05). Table 5.8 does not include the 2001 data as the 2001 SAM only has three commute distance categories (<5km, 5km-20km and >20km), while the 1991 and 2011 I-SARs have six distance categories. Table 5.8 illustrates the clear relationship between commute distance and commuting self-containment, with the percentage of commuters commuting outside their LAD of residence increasing as commute distance increases. The relationship is the same in both 1991 and 2011 but is even clearer in 2011.

Table 5.8: Variations in commute distance and commuting self-containment for all commuters (excluding homeworkers) in England and Wales aged 16-74 in 1991 and 2011

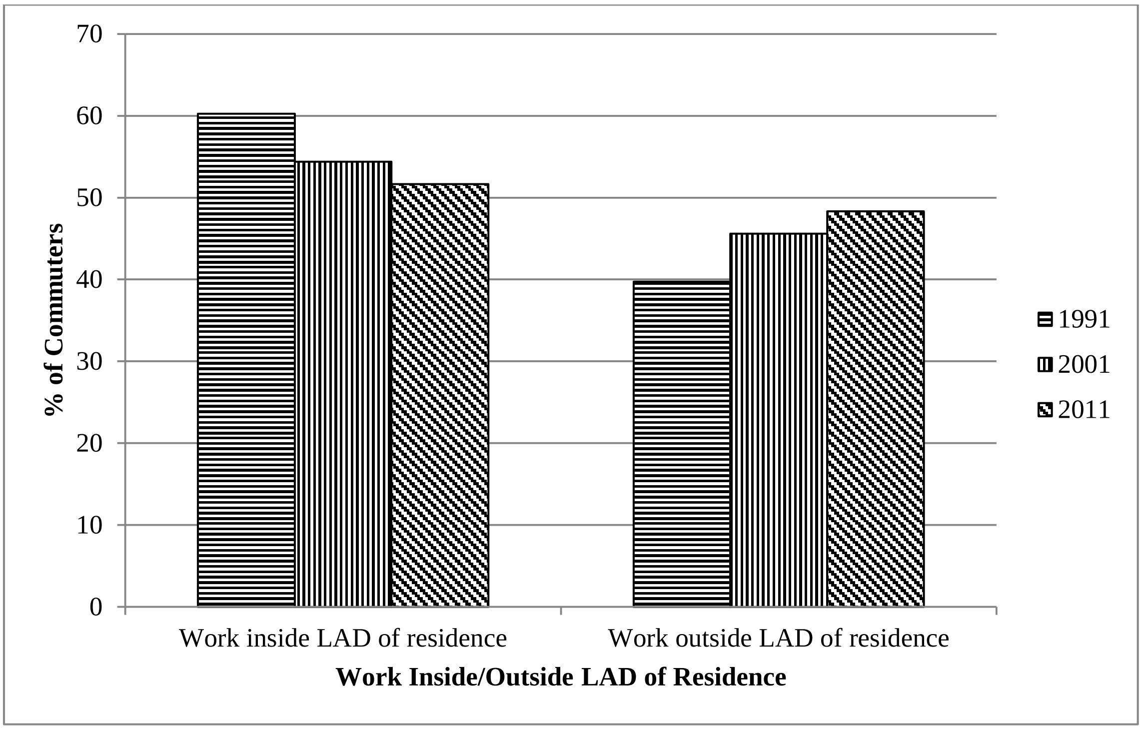
Variable	Categories	Work inside LAD of residence (%)		Work outside LAD of residence (%)	
		1991	2011	1991	2011
Commute Distance	<2km	95.4	96.0	4.6	4.0
	≥2km-<5km	81.0	78.8	19.0	21.2
	≥5km-<10km	54.6	46.2	45.4	53.8
	≥10km-<20km	24.5	20.6	75.5	79.4
	≥20km-<40km	7.8	7.8	92.2	92.2
	≥40km	2.8	1.2	97.2	98.8

Source: Derived from the 1991 and 2011 I-SARs.

The relationship between commute distance and commuting self-containment is hardly surprising. For an individual to commute <2km and work outside their LAD of residence they need to either live in an extremely small LAD, such as the City of London, or live on the edge of their LAD of residence and work on the edge of the LAD in which their workplace is located. Conversely, for an individual to commute ≥40km and work inside their LAD of residence they have to live in an extremely large LAD, such as the Powys LAD.

5.3.2 Changing self-containment between 1991, 2001 and 2011

Figure 5.5 shows that the percentage of commuters commuting within their LAD of residence decreased substantially between 1991 and 2011, with a decrease of 5.8 percentage points between 1991 and 2001 and 2.7 percentage points between 2001 and 2011. These decreases mean that while a substantial majority of commuters commuted within their LAD of residence in 1991, by 2011 only just over half of all commuters stayed within their LAD, with 48.3% commuting into another LAD for work.



Source: Derived from the 1991 and 2011 I-SARs and the 2001 SAM.

Figure 5.5: Percentage of commuters (excluding homeworkers) who commute inside/outside their LAD of residence in England and Wales aged 16-74 in 1991, 2001 and 2011

The trend seen in Figure 5.5 is a reflection of the trend seen in Figure 5.1 and the relationship seen in Table 5.8. The relationship between commute distance and self-containment (seen in Table 5.8) means that general increases in commute distance (seen in Figure 5.1) are likely to lead to the general decreases in commuting self-containment seen in Figure 5.5.

With the relationship between distance and self-containment in mind, decreases in self-containment could be driven by extensions of and improvements to road and rail transport networks in the UK, which facilitate and encourage more individuals to commute to work by car or train; the modes most associated with long-distance commuting (Lyons and Chatterjee, 2008). The declines may also be due to changes in the urban structure, counter-urbanisation and urban-rural migration. With relatively fewer people living in inner-city areas and relatively more people living in suburban areas (Grey *et al.*, 2003), and with economic activity becoming less concentrated in city centres and industrial areas with the development of peripheral industrial and commercial estates, commuters are now more likely to cross LAD boundaries on their way to work than they were in the past.

5.3.3 Changes in commuting self-containment

In addition to the region of usual residence geographical variable and the commute distance and mode of transport commuting variables, the findings of this section have been broken down by sociodemographic variables of sex, age group, ethnic group, LLTI, dependent children and occupation as these are variable which past research has suggested are important in influencing commuting behaviour (see Chapter 2). Table 5.9 shows the variation in the prevalence of commuting self-containment for the various sociodemographic categories in 1991, 2001 and 2011 and the decadal percentage point change for each group.

Overall, Table 5.9 shows that there were general decreases in the percentage of those commuting inside their LAD of residence between both 1991 and 2001 and 2001 and 2011 across the different sociodemographic categories. Only two sociodemographic categories showed an increase between 1991 and 2001, the Other ethnic group and the train, underground and tram mode of transport, and only four categories showed an increase between 2001 and 2011, the North East region, the ≥5-<20km and ≥20km distance categories and the train, underground and tram mode of transport category.

In all three years, females were more likely to commute inside their LAD of residence than males, those aged 65-74 were more likely to than any other age group, and those with a LLTI, with dependent children and with a non-professional and non-managerial occupation were more likely to than those without a LLTI, without dependent children and with a professional and managerial occupation. However, the variations and changes in the ethnic group categories have been less consistent. While in 1991 it was commuters in the Other ethnic group that were least likely to commute inside of their LAD of residence, by 2011 it was the Black and Chinese ethnic groups which were least likely to do so, with 38.0% of Black commuters and 41.8% of Chinese commuters living and working in the same LAD. At the other end of the spectrum, Pakistani and White commuters have consistently experienced the highest rates of commuting inside their LADs of residence, with 64.5% and 60.8% of Pakistani and White commuters in 1991 and 54.8% and 52.7% of Pakistani and White commuters in 2011 commuting inside their LAD of residence, respectively.

Regarding geographic variations and changes, commuters in London were consistently the least likely to commute inside their LAD of residence while commuters in the Yorkshire and the Humber region were consistently the most likely to, with both regions experiencing similar decreases in the prevalence of commuters commuting inside their LAD of residence between 1991 and 2001 and between 2001 and 2011.

The variations and changes seen for the commute distance categories reinforce the variations and changes seen in Figures 5.1 and 5.5 and the relationships shown in Table 5.8. However, Table 5.9 shows some interesting changes, with the prevalence of those commuting inside their LAD of residence increasing between 2001 and 2011 by 0.6 percentage points for those commuting ≥5-<20km and by 2.2 percentage points for those commuters commuting ≥20km.

Finally, in all three years, those commuting by train, underground and tram were least likely to commute inside their LAD of residence, albeit with the prevalence rising over the 20 years, while those commuting by bicycle were the most likely, albeit with the prevalence decreasing substantially over the period.

Table 5.9: Percentages and percentage point changes in commuters commuting inside their LAD of residence by sociodemographic and geographic characteristics for all commuters (excluding homeworkers) in England and Wales aged 16-74 in 1991, 2001 and 2011

Sociodemographic and Geographic Characteristics		Work inside LAD of residence (%)			% Point Change	
Variables	Categories	1991	2001	2011	91-01	01-11
All	All	60.2	54.4	51.7	-5.8	-2.7
Sex	Male	53.3	48.2	45.7	-5.1	-2.5
	Female	68.4	61.1	57.7	-7.3	-3.4
Age Group	16-24	62.3	61.1	57.9	-1.2	-3.2
	25-39	57.7	49.5	46.9	-8.2	-2.6
	40-64	63.0	56.2	53.2	-6.8	-3.0
	65-74	69.3	62.5	60.3	-6.8	-2.2
Ethnic Group	White	60.8	55.0	52.7	-5.8	-2.3
	Indian	50.1	47.4	43.4	-2.7	-4.0
	Pakistani	64.5	59.2	54.8	-5.3	-4.4
	Bangladeshi	53.4	48.3	45.8	-5.1	-2.5
	Black	46.4	38.0	38.0	-8.4	0.0
	Chinese	47.2	46.4	41.8	-0.8	-4.6
	Other	44.7	46.9	43.4	2.2	-3.5
LLTI	LLTI	65.5	59.4	57.9	-6.1	-1.5
	No LLTI	60.1	54.1	51.2	-6.0	-2.9
Dependent Children	No Dependent Children	59.3	52.6	51.3	-6.7	-1.3
	Dependent Children	61.7	57.0	52.3	-4.7	-4.7
Occupation	Professional and Managerial	47.1	41.0	39.8	-6.1	-1.2
	Non-Professional and Non-Managerial	67.0	63.2	59.1	-3.8	-4.1
Region of Usual Residence	North East	67.4	55.2	59.4	-12.2	4.2
	North West	61.6	58.3	56.2	-3.3	-2.1
	Yorkshire and The Humber	75.8	72.0	69.1	-3.8	-2.9
	East Midlands	61.7	53.0	49.9	-8.7	-3.1
	West Midlands	64.4	59.1	55.8	-5.3	-3.3
	East of England	73.4	52.0	48.7	-21.4	-3.3
	South East	55.0	51.5	48.1	-3.5	-3.4
	South West	71.6	65.6	65.0	-6.0	-0.6
	London	32.6	29.0	25.4	-3.6	-3.6
	Wales	73.1	68.4	65.7	-4.7	-2.7
Commute Distance	<5km	90.2	87.9	86.9	-2.3	-1.0
	≥5km-<20km	41.7	33.5	34.1	-8.2	0.6
	≥20km	5.9	3.1	5.3	-2.8	2.2
Mode of Transport	Train, Underground and Tram	7.5	8.9	9.2	1.4	0.3
	Bus	70.7	63.5	58.2	-7.2	-5.3
	Car	56.4	51.0	50.1	-5.4	-0.9
	Bicycle	84.7	78.6	66.8	-6.1	-11.8
	Other	90.3	86.0	84.1	-4.3	-1.9

Source: Derived from the 1991 and 2011 I-SARs and the 2001 SAM.

Figure 5.6 is a graphical summary of the combined 1991-2001 and 2001-2011 percentage point changes in commuting self-containment for commuters in each of the variable categories. There have been general decreases in the percentage of those commuting inside their LAD of residence across the sociodemographic categories. The largest percentage point decreases were for the East of England region and the bicycle and bus modes, with 24.7, 17.9 and 12.5 percentage point decreases between 1991 and 2011, respectively. Only the train, underground and tram mode category experienced a 1.7 percentage point increase between 1991 and 2011.

Source: Derived from Table 5.9.

Figure 5.6: Percentage point changes in commuters commuting inside their LAD of residence by sociodemographic and geographic characteristics for all commuters (excluding homeworkers) in England and Wales aged 16-74, 1991-2011

5.3.4 Modelling commuting self-containment

The results of the BLR models for commuting self-containment based on the 1991, 2001 and 2011 census microdata are shown in Table 5.10. The relative likelihoods for the different variable categories shown in Table 5.10 are similar to the variations for the different variable categories shown in Table 5.9, except for the ethnic group categories. Table 5.10 shows that males, those aged 25-39, those with no LLTI, those with no dependent children, those with professional and managerial occupations, those living in London, commuting ≥20km and commuting by train, underground and tram are relatively less likely to commute inside their LAD of residence.

However, while Table 5.9 showed that in 2011 it was the Black and Chinese ethnic groups which had the lowest prevalence of commuting inside their LAD, in Table 5.10 this is no longer the case, as Black commuters are not significantly more or less likely to commute inside their LAD of residence than White commuters (the reference category). This discrepancy between Tables 5.9 and 5.10 could be due to Table 5.10 controlling for the region variable, as the Black ethnic group is particularly concentrated in London, where commuters are less likely to commute inside their LAD of residence regardless of their ethnicity.

Table 5.10: BLR model results for commuters commuting inside their LAD of residence by sociodemographic and geographic characteristics for all commuters (excluding homeworkers) in England and Wales aged 16-74 in 1991, 2001 and 2011

Sociodemographic and Geographic Characteristics Variables	Categories	1991 OR		2001 OR		2011 OR	
Sex	Male	1.000		1.000		1.000	
	Female	1.325	*	1.251	*	1.272	*
Age group	16-24	1.000		1.000		1.000	
	25-39	0.942	*	0.888	*	0.848	*
	40-64	1.024		1.003		0.978	*
	65-74	1.147	*	1.094	*	1.177	*
Ethnic group	White	1.000		1.000		1.000	
	Indian	0.843	*	0.943	*	1.000	
	Pakistani	1.106		1.033		0.983	
	Bangladeshi	0.975		0.924		1.133	*
	Black	0.891	*	0.906	*	1.014	
	Chinese	1.038		0.932		0.915	*
	Other	0.980		0.933	*	1.003	
LLTI	LLTI	1.000		1.000		1.000	
	No LLTI	0.927	*	0.925	*	0.911	*
Dependent Children	No Dependent Children	1.000		1.000		1.000	
	Dependent Children	1.089	*	1.074	*	1.086	*
Occupation	Professional and Managerial	1.000		1.000		1.000	
	Non-Professional and Non-Managerial	1.306	*	1.382	*	1.377	*
Region of usual residence	North East	1.000		1.000		1.000	
	North West	0.680	*	1.132	*	0.763	*
	Yorkshire and The Humber	1.842	*	3.434	*	2.024	*
	East Midlands	0.687	*	0.848	*	0.567	*
	West Midlands	0.853	*	1.282	*	0.825	*
	East of England	2.038	*	1.226	*	0.775	*
	South East	0.756	*	1.064	*	0.661	*
	South West	1.335	*	1.892	*	1.488	*
	London	0.179	*	0.250	*	0.143	*
	Wales	1.776	*	3.247	*	2.046	*
Commute Distance	<5km	1.000		1.000		1.000	
	≥5km-<20km	0.088	*	0.071	*	0.075	*
	≥20km	0.007	*	0.004	*	0.007	*
Mode of Transport	Train, Underground and Tram	1.000		1.000		1.000	
	Bus	4.822	*	3.323	*	2.898	*
	Car	4.061	*	2.963	*	2.773	*
	Bicycle	6.378	*	4.379	*	3.157	*
	Other	10.218	*	7.625	*	6.535	*
	Constant	2.080	*	1.717	*	2.816	*

Source: Derived from the 1991 and 2011 I-SARs and the 2001 SAM. (*=OR is statistically significant ($p<0.05$)).

The variations between the sex, age group and LLTI variable categories may be due to males, those aged 25-39 and those without a LLTI being more able to commute very long-distance, with females, those aged 65-74 and those with a LLTI being less able to commute long-distance. Table 5.5 showed this, with females, those aged 65-74 and those with a LLTI being relatively less likely to commute very long-distance than males, those aged 25-39 and those without a LLTI. These differences are also supported by past research by McCarthy *et al*. (1968), who found that women workers are more interested in moving jobs in order to work in their local area, and by Roberts *et al*. (2011), who found that long-distance commuting is dominated by people with better health.

The differences between the different ethnic groups may be due to BME groups, especially the Black ethnic group, being concentrated in London (see Table 6.8 in Chapter 6). As individuals in London are more likely to commute outside their LAD of residence due to the London region being split into 33 LADs (City of London and the London boroughs), it is not surprising that the Black and Chinese ethnic groups experience the highest prevalence of out-commuting.

The relatively lower rates of out-commuting for those with dependent children, compared to those without dependent children, may be due to these individuals choosing to live close to where they work in order to better balance their work and childcare responsibilities, as commuting long-distance is a time-consuming activity that many commuters with dependent children may not feel able to commit to. This explanation is supported by previous research by McQuaid *et al*. (2001), who found that the presence of dependents influences the distance that people are prepared to commute, with people without dependents being prepared to travel further than those with dependents.

Commuters with professional and managerial occupations may have a lower rate of commuting inside their LAD of residence as they may be more able to afford to commute long-distances, compared to those with non-professional and non-managerial occupations. Lyons and Chatterjee (2008) found that those commuting by train were most likely to commute long-distance and, as train commuting is more prevalent amongst those with professional and managerial occupations (see Chapter 6), this may explain why professional and managerial commuters are less likely to commute inside their LAD of residence.

As previously mentioned in relation to ethnic group variations, the low levels of commuting inside LADs of residence in the London region are likely to be due to the London region, which is geographically small, being split up into 33 LADs. As London and its commuter belt act as a TTWA covering a large part of southern England, it is unsurprising that the London region experiences a high prevalence of cross-boundary commuting. Conversely, the high levels of commuting inside LADs of residence in the Yorkshire and the Humber region may be because LADs in the region tend to be large and are often good representations of TTWAs. The LADs of York, Leeds, Bradford, Doncaster and Sheffield are relatively large and completely cover the urban areas associated with them.

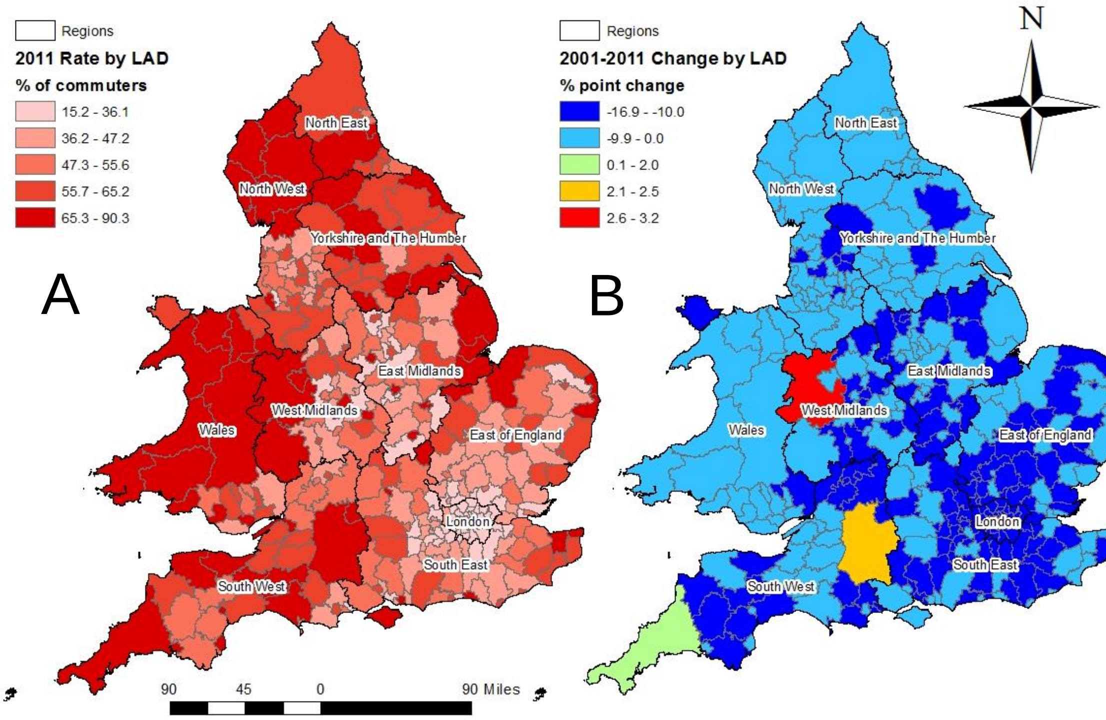
The low prevalence of commuting inside LADs of residence amongst commuters travelling by the train, underground and tram and car modes of transport is likely to be due to very long-distance commuting being relatively most likely for these two modes (see Table 5.5). Conversely, the high prevalence of commuting inside LADs of residence amongst bicycle commuters may be due to most commutes by bicycle taking place over relatively short distances (see Table 5.1).

5.3.5 Spatial variations in commuting self-containment

So far in this chapter the 1991, 2001 and 2011 microdata have been used to gain a detailed understanding of sociodemographic variations in commute distance and self-containment. However, these microdata are unable to provide a detailed understanding of any spatial variations. Although spatial variations in commute distance at LAD level cannot be analysed due to the lack of 2011 commute distance aggregate data (see Chapter 3), this section uses 2001 and 2011 interaction data to map spatial variations and temporal changes in commuting self-containment at LAD level.

Map A in Figure 5.8 shows that commuting self-containment is generally higher for large rural LADs and LADs that cover whole cities, such as Bradford, Leeds and Sheffield. Conversely, commuting self-containment is generally lower in LADs that only cover part of a wider urban area, such as the London boroughs, and in LADs that are adjacent to larger urban centres, producing ‘donut’ patterns of self-containment around cities such as Chesterfield, Nottingham, Birmingham and Norwich.

The vast majority of LADs experienced decreases in commuting self-containment between 2001 and 2011 (map B in Figure 5.8). There appears to be a north-south pattern to these changes, with the largest decreases being seen for LADs in south east England, with the largest decrease of 16.9 percentage points being for the Kensington and Chelsea LAD, and the smallest decreases being seen for LADs northern England and Wales.



Source: Derived from the 2001 and 2011 Census SWS.

Figure 5.8: Percentage of commuters (excluding homeworkers) in England and Wales aged 16-74 in 2011 that commute inside their LAD of residence (A) and the percentage point changes between 2001 and 2011 (B) by LAD

The spatial variations in commuting self-containment seen in map A of Figure 5.8 may reflect spatial variations in the prevalence of different modes of transport. Many of the LADs that experience high levels of commuting self-containment are LADs with high prevalence of commuting to work by bicycle and on foot, such as the York, Oxford, Cambridge, Bristol, Southampton and Exeter LADs (see Chapter 4). Conversely, many of the LADs that experience low levels of commuting self-containment are LADs with high prevalence of commuting to work by train and car, such as the Rushcliffe, Broxtowe and Gedling LADs and many of the LADs surrounding Greater London (see Chapter 4).

The spatial variation in changes seen in map B of Figure 5.8 may be partly due to general increases in commute distance (see Section 5.2.2), changes in urban structure and the effects of local, regional and national policy changes. Table 5.11 showed that those who commute short distances are more likely to work within their LAD of residence, while commuters who commute long-distances are less likely to work within their LAD of residence, therefore, a direct result of increases in the prevalence of very long-distance commuting will be a reduction in commuting self-containment at LAD level. Linked to this increase in very long-distance commuting are changes in urban structure, such as counterurbanisation and suburbanisation. Continuing suburbanisation (Grey *et al.*, 2003) means that many people are living further away from their places of work, and are therefore more likely to live and work in different LADs. Policies such as the introduction of Government Office Regions, which have now been abolished, and then city regions and Local Economic Partnerships could be seen as products of longer commutes and more intra-LAD commuting as geographically smaller LADs are being replaced as the primary centres of local economic and transport policy making by geographically larger, city regions.

5.4 Policy Implications and Conclusions

This chapter has explored sociodemographic variations and temporal changes in commute distance and commuting self-containment over the 1991-2011 period, a period during which the UK experienced substantial economic, social and transport network changes that are likely to have had implications for where people work and the distances that they commute. Therefore, the analyses in this chapter have important policy implications. If national, regional and local policy makers wish to decrease the prevalence of very long-distance commuting then policies need to be targeted at certain groups. The above analyses have clearly shown which sociodemographic groups are most likely to commute very long-distance. Therefore, the findings could easily be used to inform targeted transport policies.

The findings of this chapter indicate that if the relevant authorities wish to decrease the prevalence of very long-distance commuting they should implement policies focused on men, aged 25-44, with professional and managerial occupations, who live in southern England and commute to work by train, underground and tram. The analysis of Section 5.2.5 showed that professional and managerial men, who commute to work by train, underground and tram or by car (as a driver or passenger) should be of particular concern to policy makers. However, given that policy makers are unlikely to wish to reduce the prevalence of commuting very long-distance amongst those commuting by train, underground and tram, as this is a relatively environmentally friendly way of doing so and the probability of this group commuting very long-distance has been falling anyway, they are likely to want to focus on the same sociodemographic group but for those who commute by car.

Overall, although the analyses could be used to inform policy, it should be noted that the extent to which entrenched commuting distance patterns can be changed using policy remains questionable. However, this does not negate the need for policy makers to try and decrease the prevalence of very long-distance commuting, particularly amongst those sociodemographic groups showing the most room for improvement.

This chapter has also shown that many LADs in England and Wales are not good representations of TTWAs or LLMAs. The problem is particularly pressing in areas such as Greater Manchester and Greater London. With current proposals to devolve more central government powers, including transport, to local authorities and city regions, it would seem sensible for the relevant authorities to investigate whether or not the current configuration of many LADs is appropriate.

However, it is also clear that LADs serve as representations of TTWAs for some populations better than others, as certain population groups, such as men and those with professional and managerial occupations, are far more likely to commute outside their LAD than others, such as women and those with non-professional and non-managerial occupation. Therefore, the relevant authorities would also need to question whether or not only one set of TTWA/LAD boundaries could be used to inform all transport policy decisions, even when a specific transport policy may be aimed at a specific sociodemographic group.

The findings of this analysis are not unexpected given past research. However, as mentioned above, there has previously been no attempt to systematically quantify the likelihood that individual commuters will commute very long-distance or outside their LAD of residence given their sex, age, ethnicity and other characteristics. Therefore, the analyses provide new insights into commuting behaviours and patterns of individual commuters with different sociodemographic characteristics living in different parts of England and Wales.

6. A National and Regional Analysis of Sociodemographic Variations and Temporal Changes in Commuters' Mode of Travel

6.1 Introduction

As outlined in Chapter 5, there is a relationship between commute distance and mode of transport (Lyons and Chatterjee, 2008). The analyses in this chapter can be seen as an extension of the analyses in the previous chapter, by examining the effect that commute distance has on chosen mode of transport. In addition to further understanding the variations in commute distance, it is also important for both academic and policy reasons to understand sociodemographic variations in the use of different modes of transport because of the important implications for society, the economy, the environment and individual commuters. Therefore, this chapter addresses the third broad research question set out in Chapter 1: How does mode of transport vary between different sociodemographic groups and how did these variations change between 1991 and 2011?

As mentioned in previous chapters, commuting behaviours, propensities and patterns vary by a host of different sociodemographic variables. For example, it is unlikely that older commuters, in non-professional occupations, with dependent children living in Wales, with its sparse public transport networks, will commute using the same mode of transport as younger commuters, in professional occupations, with no dependent children who live in Greater London, with its highly developed public transport networks. If it is the case that these younger more affluent commuters are more likely to commute using public transport than the older less affluent commuters, important issues are raised about the quantity and quality of public transport networks in areas inhabited by older, less affluent commuters.

However, as was the case with commute distance, the relationship between access to different modes of transport and economic and social opportunities is likely to work in both directions. Although variations in mode of transport usage may be a product of different economic and social circumstances, it may also be the case that variations in the propensity to commute using certain modes of transport affect access to economic and social opportunities. If it is accepted that economic and social inequalities in mode of transport are socially unjust and are not economically ideal, then any future local, regional or national policies made in relation to the different modes of transport need to be designed with these sociodemographic and spatial variations in mind.

As outlined in Chapter 2, some previous research has investigated sociodemographic variations in the usage of different modes of transport (for example, Kamid, 1999; Witte *et al.*, 2008). However, previous research has been carried out on an *ad hoc* basis and there has been no research systematically analysing quantitative variations in the usage of different modes of transport disaggregated by key sociodemographic variables, such as age, sex and ethnicity.

As in Chapter 5, the research in this chapter makes use of the 1991, 2001 and 2011 microdata introduced in Chapter 3. In Section 6.2, the 1991, 2001 and 2011 I-SARs are used to analyse sociodemographic variations in mode of transport and changes over the 20 year period. The 2001 and 2011 aggregate data are also used in Section 6.2.5 in order to map spatial variations and temporal changes in commuting by public transport at LAD level. Section 6.3 presents some policy recommendations based on the analyses and draws some conclusions.

6.2 Sociodemographic and Spatial Variations in Modal Split

The different modes of transport that people use to commute to work have different economic, social and environmental advantages and disadvantages. Certain types of transport can be economically exclusionary; with the high financial cost of using some modes of travel effectively excluding some individuals from lower socioeconomic groups from using them, forcing them to use cheaper options (Dodson *et al.*, 2004). This issue becomes particularly acute during periods when train fares (BBC, 2013i, 2013iii, 2014, 2015vi, 2015ix) and petrol prices (BBC, 2013iv) are increasing. Therefore, increases in the prevalence of certain modes of transport, such as the car and train, suggest that commuting to work is becoming increasingly segregated along socioeconomic lines.

Different modes of transport are more efficient, in terms of energy usage, at transporting commuters from their places of residence to workplaces than others and are, therefore, better for the environment. While commuting to work by car is environmentally damaging (van Vugt *et al.*, 1996; Lowe, 1990), travelling to work by public transport (bus or train) is less damaging (Joireman *et al.*, 2004), while using a bicycle or walking has even fewer negative environmental impacts. As previously mentioned, transport accounts for 25% of the UK's greenhouse gas emissions (Department of Energy and Climate Change, 2014), therefore changes in the modes of transport that people use to commute to work could have a substantial impact on the UK's domestic commitment to cut carbon dioxide emissions by 60% by 2050 (Department for Trade and Industry, 2003).

Research has suggested that getting people to commute to work by bicycle or on foot can help tackle the obesity epidemic (Howard, 2012) and therefore, the mode of transport that commuters use can have a direct impact on their physiological health. Furthermore, the commute impedance model (Novaco *et al.*, 1979) proposes that commuting causes stress, which is a function of the ease of a commute, with slow speed and congestion increasing the stress level. Given that the mode of transport used is likely to affect the speed of a commute and the congestion experienced, the way commuters travel to and from work can have an indirect impact on their stress levels and, therefore, on their psychological health.

6.2.1 Introduction: sociodemographics and mode of transport

Although previous research has not systematically quantified variations in the usage of public transport by sociodemographic characteristics, such as sex, age, ethnicity and region of residence, Hamilton and Jenkins (2000) showed that women are more likely to use public transport than men (10% compared with 7%, respectively). Age is also related to mode of transport in that middle-aged commuters are more likely to own and use a car than younger and older commuters (Witte *et al.*, 2008; Dargay, 2007), and recent research has also suggested that many individuals aged over 65 rarely use public transport (BBC, 2015xii). Despite the convergence in commuting propensities and patterns between different ethnic groups that appears to be taking place, difference still persists (Thomas, 1998). Region of residence is also important, with individuals resident in London being twice as likely to commute using public transport as those living elsewhere in the UK (Choudhary, 2015).

The likelihood of using public transport (trains, mass-transit systems and buses) is explored in this chapter due to its current policy importance, with the promotion of public transport and discouragement of the use of private road transport being seen as a way of reducing carbon emissions (Wegener, 1996; Woodcock *et al.*, 2009) and tackling traffic congestion (Mackett and Edwards, 1998). If policy makers are going to be successful in getting more people to use public transport, it is necessary to understand which individuals are more likely to use these modes so that any national, regional or local policies, which are often designed to encourage commuters traveling by car to change their mode of transport (O'Fallon *et al.*, 2004), can be implemented in a targeted, systematic and effective manner.

This chapter builds on previous research by using data from the 1991, 2001 and 2011 censuses to quantify how likely commuters are to travel to work using different modes of transport, specifically public transport, given their sex, age, ethnicity, occupation and other characteristics and how this changed in the two inter-censal periods between 1991 and 2011.

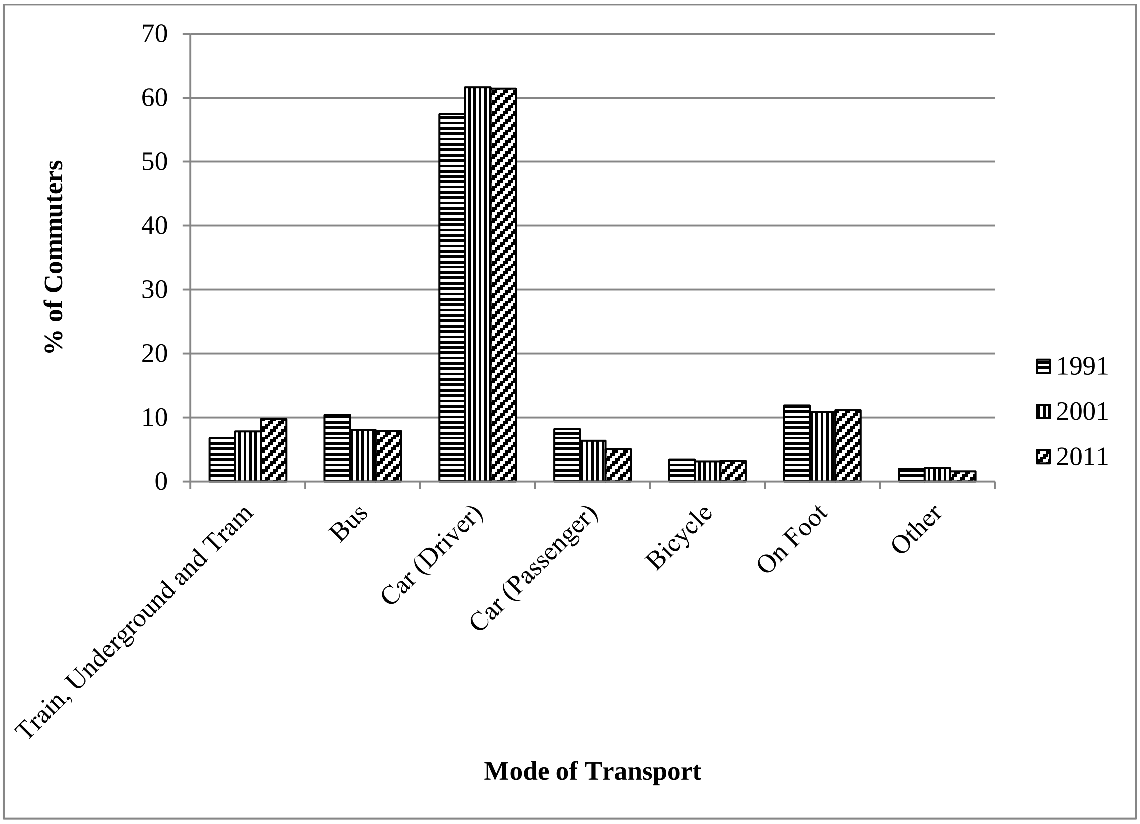
6.2.2 Changing modes of transport between 1991, 2001 and 2011

To understand how the prevalence of public transport use varies between different sociodemographic groups and over time, it is necessary to explore how the overall modal split varies. This is because public transport, in this analysis, is regarded as a combination of the 'Train, Underground and Tram' and 'Bus' categories, and any changes in the prevalence of these two categories will be mirrored by increases or decreases in the prevalence of the other five modes of transport: 'Car (driver)', 'Car (passenger)', 'Bicycle', 'On foot' and 'Other'.

Figure 6.1 shows the changes in prevalence of the seven different categories of transport in 1991, 2001 and 2011. Overall, it can be seen that the percentage of commuters travelling to work by bus, bicycle, on foot and as a passenger in a car all declined between 1991 and 2011, while the percentage commuting by train, underground and tram and by driving a car increased over the same time period.

The regularity of some of the trends in Figure 6.1 is also worth noting. There was a steady increase in the prevalence of commuting to work by train, underground and tram, mirrored by a decrease in the prevalence of commuting to work as a passenger in a car. However, the overall trends mask some interesting variations within and between the modes of transport. Firstly, although the percentage driving to work increased between 1991 and 2011, it peaked in 2001 at 61.6% before falling back slightly to 61.4% in 2011. Secondly, the percentage of those commuting to work by train, underground or tram saw the biggest increase over the period from 6.8% in 1991, to 7.9% in 2001 and 9.7% in 2011. Thirdly, while the percentage of those commuting to work by bicycle or on foot decreased slightly over the 20 year period, from 3.4% to 3.2% and from 11.9% to 11.1%, respectively, the percentage of those commuting to work by bus or as a passenger in a car decreased much more substantially over the same period, from 10.4% to 7.9% and from 8.2% to 5.1%, respectively.

Despite these changes, Figure 6.1 also indicates a remarkable stability in the prevalence of the seven mode of transport categories over the 20 year period. Car driving accounted for vast majority of commuting to work in 1991, 2001 and 2011, while at the same time there was a persistently low prevalence of commuting to work by bicycle.



Source: Derived from the 1991, 2001 and 2011 I-SARs.

Figure 6.1: Percentage of commuters (excluding homeworkers) in England and Wales aged 16-74 using each mode of transport in 1991, 2001 and 2011

The patterns and changes shown in Figure 6.1 are confirmed by the aggregate data presented in Table 6.1. In addition, Table 6.1 shows that while the percentage of commuters travelling by bus decreased, the absolute number of people travelling by bus to work increased between 2001 and 2011. The only mode of transport that experienced a decrease in both percentage and absolute terms was car (passenger), with the number of people commuting by this mode decreasing by 119,931 over the decade.

Table 6.1: Mode of transport numbers and rates for all commuters (excluding homeworkers) in England and Wales aged 16-74 in 2001 and 2011 and the percentage point changes between 2001 and 2011

Mode of Transport	Number of Commuters		Percentage of Commuters		% Point Change (01-11)
	2001	2011	2001	2011	
Train, Underground and Tram	1,674,725	2,399,825	7.8	9.6	1.8
Bus	1,747,683	1,949,442	8.1	7.8	-0.4
Public Transport (Total)	3,422,408	4,349,267	15.9	17.3	1.4
Car (Driver)	13,050,529	15,264,527	60.8	60.8	0.0
Car (Passenger)	1,477,211	1,357,280	6.9	5.4	-1.5
Bicycle	650,977	762,334	3.0	3.0	0.0
On Foot	2,364,633	2,846,588	11.0	11.3	0.3
Other	491,449	523,632	2.3	2.1	-0.2
Total	21,457,207	25,103,628	100.0	100.0	

Source: Derived from the 2001 and 2011 Census Aggregate Data.

These figures appear to reinforce some of the findings by Dargay and Hanley (2007), who found that each year in the UK, while 4.2% of commuters switch from commuting to work by car to other modes, 5.2% of commuters switch from commuting to work using other modes to commuting by car. Although the analysis by Dargay and Hanley (2007) only included three aggregate categories, 'public transport', 'car or van' and 'walk or cycle', this pattern of switching could go some way to explain both the general decrease in commuting to work by bus, bicycle and on foot, which may have been caused by those commuters switching to commuting by car, and the general increase in commuting to work by train, underground and tram, which may have been caused by car commuters switching.

Although Figure 6.1 is useful in showing the broad trends, it does not shed any light on any sociodemographic variations in the modal split. A more detailed picture of the changes between 1991 and 2001 and between 2001 and 2011 can be obtained by exploring the modal split by the sociodemographic characteristics introduced in Chapter 2 and earlier in this chapter. Table 6.2 is a base table showing the distribution of commuters across the seven modes of transport in 2011, while Tables 6.3 and 6.4 show how changes in prevalence of the seven different categories of transport varied sociodemographically between 1991, 2001 and 2011.

Table 6.2 shows that the prevalence of commuting by train, underground and tram is highest amongst the Indian, Bangladeshi, Black and Chinese ethnic groups, those with professional and managerial occupations and the 25-44 age group. Perhaps unsurprisingly, the highest rates of commuting by train, underground and tram are seen in Inner and Outer London; 44.5% of commuters in Inner London commute to work using this mode of transport. Commuting by bus is most prevalent amongst the Black and Bangladeshi ethnic groups, the 16-24 age group and those with a LLTI. As with train, underground and tram, commuting by bus is particularly prevalent in Inner and Outer London. Sociodemographic variations in the prevalence of driving to work can be seen to be the opposite of the train, underground and tram and bus variations, with this being most prevalent amongst the older age groups (45-64 and 65-74), the White ethnic group and commuters outside of Greater London, particularly amongst those in Wales and the Midlands. Commuting to work on foot is most prevalent amongst females, those in the 16-24 age group and those with non-professional and non-managerial occupations.

Table 6.2: Percentage of commuters using each mode of transport by sociodemographic and geographic characteristics for all commuters (excluding homeworkers) in England and Wales aged 16-74 in 2011 (base table)

Sociodemographic and Geographic Characteristics		Distribution of Commuters across Modes of Transport (%)						
Variables	Categories	Train, Underground and Tram	Bus	Car (Driver)	Car (Passenger)	Bicycle	On Foot	Other
All	All	9.7	7.9	61.4	5.1	3.2	11.1	1.6
Sex	Male	10.6	5.9	63.6	4.3	4.8	8.6	2.3
	Female	8.8	9.9	59.2	5.9	1.7	13.6	0.9
Age Group	16-24	9.5	13.4	45.2	10.0	2.8	16.8	2.3
	25-44	12.7	7.5	59.8	4.4	3.7	10.5	1.5
	45-64	6.4	6.8	67.8	4.5	2.9	10.2	1.5
	65-74	4.7	8.2	65.9	5.9	1.9	12.1	1.3
Ethnic Group	White	8.4	6.8	63.5	5.2	3.4	11.1	1.6
	Indian	19.0	11.6	51.8	4.8	1.0	10.8	1.0
	Pakistani	10.7	10.2	56.7	6.6	0.7	12.7	2.3
	Bangladeshi	20.2	14.5	42.4	6.7	1.0	13.4	1.7
	Black	23.6	25.0	37.1	2.2	2.0	8.9	1.2
	Chinese	24.1	11.4	42.6	4.4	3.0	13.5	0.9
	Other	19.4	15.1	43.7	4.4	3.1	12.8	1.6
LLTI	LLTI	6.1	10.3	60.6	6.7	2.5	11.4	2.4
	No LLTI	10.0	7.7	61.5	5.0	3.3	11.1	1.5
Dependent Children	No Dependent Children	10.7	8.7	58.5	5.5	3.3	11.8	1.6
	Dependent Children	8.1	6.5	66.3	4.4	3.1	10.0	1.5
Occupation	Professional and Managerial	15.1	4.9	65.6	2.8	3.2	7.1	1.2
	Non-Professional and Non-Managerial	6.3	9.7	58.7	6.5	3.3	13.6	1.9
Region of Usual Residence	North East	3.6	10.0	64.8	7.2	2.1	10.8	1.5
	North West	3.7	8.6	66.3	6.0	2.4	11.3	1.7
	Yorkshire and The Humber	3.0	9.1	64.9	6.4	2.9	12.0	1.7
	East Midlands	1.7	6.8	69.9	5.9	3.2	11.1	1.4
	West Midlands	3.1	8.2	68.9	6.0	2.3	10.2	1.4
	East of England	9.5	4.0	65.7	4.9	4.0	10.4	1.4
	South East	8.6	4.8	65.7	4.6	3.5	11.2	1.6
	South West	1.7	5.2	67.5	5.2	4.1	14.4	1.8
	Inner London	44.5	18.7	13.7	0.8	7.4	12.7	2.1
	Outer London	34.6	12.2	39.8	2.1	2.3	7.4	1.6
	Wales	2.2	4.9	72.2	7.0	1.6	10.7	1.2
Commute Distance	<2km	1.5	5.0	41.0	4.9	5.0	41.3	1.4
	≥2km-<5km	3.7	14.4	60.6	6.9	5.5	6.9	2.0
	≥5km-<10km	11.1	10.7	66.3	5.3	2.9	2.0	1.7
	≥10km-<20km	16.2	4.7	70.6	4.1	1.3	1.7	1.5
	≥20km-<40km	15.5	2.3	74.7	3.9	0.6	1.8	1.1
	≥40km	23.0	3.3	62.8	3.4	1.2	4.8	1.5

Source: Derived from the 2011 I-SAR.

Tables 6.3 and 6.4 show that the most substantial increases in the percentage of those driving to work were for females between 1991 and 2001, with a 10.1 percentage point increase, and for the 65-74 age group between 2001 and 2011, with a 8.9 percentage point increase. Conversely, the percentage of those commuting to work by driving a car for the 16-24 and 25-44 age groups increased by 0.8 percentage points and decreased by 1.7 percentage points over the 20 year period, respectively. This means that while in 1991 it was the 25-44 age group that had the highest prevalence of commuting to work by car, by 2011 the same age group had the second lowest prevalence of commuting to work by car, with only the 16-24 age group having a lower prevalence. Between 1991 and 2011, every age group experienced a decrease in the prevalence of commuting to work by bus, with the magnitude of the decrease increasing with age, from a 0.9 percentage point decrease for the 16-24 age group to a 3.3 percentage point decrease for the 65-74 age group. Similarly, between 2001 and 2011 every age group experienced a decrease in the prevalence of commuting to work as a passenger in a car, ranging from a decrease of 0.1 percentage points for the Chinese ethnic group to a decrease of 2.5 percentage points for those commuters resident in Wales.

Tables 6.3 and 6.4 show that the prevalence of commuting to work by car amongst those in professional and managerial occupations decreased substantially between 1991 and 2001, and between 2001 and 2011 (by 2.6 percentage points and 3.5 percentage points, respectively). Thus, while the percentage of those commuting to work by car amongst commuters with professional and managerial occupations fell between 1991 and 2011, for commuters with non-professional and non-managerial occupations the proportion increased, meaning that the difference between the two occupation categories decreased substantially to 6.9 percentage points over the 20 year period. While the increases in commuting by car seen for the non-professional and non-managerial category have been paralleled with decreases in the percentages commuting by bus and as a passenger in a car, the decreases in commuting seen for the professional and managerial groups have been paralleled by increases in the percentage commuting by train, underground and tram. These changes mirror the general trends seen in Figure 6.1, with decreases in commuting by bus and as a car passenger and increases in commuting by train, underground and tram.

Table 6.3: Percentage point changes in the percentage of commuters using each mode of transport by sociodemographic and geographic characteristics for all commuters (excluding homeworkers) in England and Wales aged 16-74, 1991-2001

Sociodemographic and Geographic Characteristics		Mode of Transport (% Point Change)						
Variables	Categories	Train, Underground and Tram	Bus	Car (Driver)	Car (Passenger)	Bicycle	On Foot	Other
All	All	1.1	-2.3	4.2	-1.8	-0.3	-1.0	0.1
Sex	Male	1.3	-0.9	-0.5	-0.3	0.3	0.3	0.0
	Female	0.9	-4.1	10.1	-3.6	-0.9	-2.7	0.3
Age Group	16-24	1.1	-0.9	-3.3	0.2	0.0	2.4	0.4
	25-44	2.1	-1.6	2.1	-1.7	0.0	-1.1	0.2
	45-64	-0.1	-3.0	8.0	-2.0	-0.8	-2.1	0.0
	65-74	-0.3	-3.3	6.5	-0.4	-0.8	-2.9	1.4
Ethnic Group	White	0.8	-2.5	4.6	-1.8	-0.3	-1.1	0.1
	Indian	1.3	-3.3	3.5	-3.0	0.1	0.4	1.0
	Pakistani	0.3	-3.8	1.9	-0.1	0.4	-0.8	2.1
	Bangladeshi	-1.0	-1.3	4.6	0.9	0.6	-5.4	1.5
	Black	2.3	-4.4	5.3	-1.5	-0.1	-2.3	0.6
	Chinese	-3.3	3.6	-2.6	-3.1	1.0	3.2	1.2
	Other	-4.2	-1.2	1.9	0.0	0.7	2.2	0.7
LLTI	LLTI	0.1	-4.6	8.4	-2.0	-0.5	-1.8	0.4
	No LLTI	1.2	-2.3	4.2	-1.8	-0.3	-1.0	0.1
Dependent Children	No Dependent Children	1.3	-2.4	3.8	-2.0	-0.3	-0.5	0.1
	Dependent Children	0.6	-2.2	5.0	-1.4	-0.3	-1.9	0.1
Occupation	Professional and Managerial	2.7	0.0	-2.6	-1.3	0.2	0.5	0.4
	Non-Professional and Non-Managerial	-0.1	-3.3	7.2	-1.8	-0.5	-1.5	0.0
Region of Usual Residence	North East	0.0	-3.6	8.0	-1.7	-0.1	-3.4	0.8
	North West	-0.1	-4.0	6.6	-1.8	-0.2	-1.0	0.5
	Yorkshire and The Humber	0.7	-4.6	6.4	-0.9	-0.4	-1.2	0.0
	East Midlands	0.2	-2.4	7.0	-2.1	-0.6	-1.8	-0.2
	West Midlands	0.3	-3.4	6.4	-1.5	0.0	-1.7	0.0
	East of England	6.2	-1.2	3.9	-2.9	-4.5	-0.2	-1.4
	South East	-1.5	-0.8	3.9	-1.7	-0.3	0.2	0.1
	South West	0.2	-1.1	4.1	-2.4	-0.3	0.2	-0.7
	Inner London	6.3	-1.1	-5.3	-1.0	0.9	-1.1	1.4
	Outer London	3.6	-0.5	-1.3	-1.3	0.0	-1.0	0.6
	Wales	-0.1	-3.0	7.8	-2.2	-0.3	-2.4	0.1
Commute Distance	<2km	0.4	-3.5	2.2	-1.9	-0.7	3.1	0.4
	≥2km-<5km	1.0	-4.3	3.4	-2.1	0.2	1.9	0.0
	≥5km-<10km	2.6	-3.2	2.4	-2.3	0.2	0.7	-0.3
	≥10km-<20km	0.2	-1.0	1.9	-1.7	0.1	0.6	-0.2
	≥20km-<40km	-2.6	-0.3	3.4	-1.1	0.0	0.4	0.2
	≥40km	-3.7	-0.2	3.0	-0.3	0.2	0.4	0.7

Source: Derived from the 1991 and 2001 I-SARs.

Table 6.4: Percentage point changes in the percentage of commuters using each mode of transport by sociodemographic and geographic characteristics for all commuters (excluding homeworkers) in England and Wales aged 16-74, 2001-2011

Sociodemographic and Geographic Characteristics		Mode of Transport (% Point Change)						
Variables	Categories	Train, Underground and Tram	Bus	Car (Driver)	Car (Passenger)	Bicycle	On Foot	Other
All	All	1.9	-0.2	-0.2	-1.3	0.1	0.2	-0.5
Sex	Male	2.2	0.5	-2.4	-0.8	0.4	0.7	-0.6
	Female	1.6	-1.1	2.3	-1.9	-0.1	-0.5	-0.2
Age Group	16-24	-0.3	-2.0	4.1	-2.4	-0.6	1.7	-0.6
	25-44	3.2	0.7	-3.8	-0.9	0.4	0.9	-0.6
	45-64	1.5	-0.6	1.6	-1.5	0.0	-1.0	-0.2
	65-74	-0.2	-1.5	8.9	-1.5	-1.5	-3.1	-1.1
Ethnic Group	White	1.3	-0.7	0.8	-1.3	0.1	0.2	-0.5
	Indian	4.2	-0.3	-2.5	-1.4	0.5	-0.3	-0.2
	Pakistani	2.2	-2.0	2.9	-1.6	0.0	-1.3	-0.2
	Bangladeshi	2.3	0.7	2.8	-1.7	0.1	-3.9	-0.4
	Black	-0.9	1.6	-2.2	-0.3	0.7	1.0	0.1
	Chinese	3.9	2.2	-7.2	-0.1	1.1	1.0	-0.9
	Other	-0.4	2.0	-2.1	-0.7	0.7	0.8	-0.2
LLTI	LLTI	0.6	-0.2	1.8	-0.8	-0.4	-0.6	-0.5
	No LLTI	2.0	-0.2	-0.4	-1.3	0.1	0.3	-0.5
Dependent Children	No Dependent Children	1.5	-0.2	-0.2	-1.2	0.2	0.4	-0.4
	Dependent Children	2.4	-0.2	0.0	-1.5	-0.1	-0.1	-0.6
Occupation	Professional and Managerial	2.7	0.1	-3.5	-0.7	0.9	0.9	-0.4
	Non-Professional and Non-Managerial	1.1	-0.2	1.4	-1.5	-0.4	0.1	-0.5
Region of Usual Residence	North East	0.8	-1.8	3.8	-2.4	0.2	-0.1	-0.5
	North West	1.2	-0.5	1.2	-1.6	-0.2	0.4	-0.4
	Yorkshire and The Humber	1.1	-2.2	2.8	-1.3	-0.4	0.4	-0.3
	East Midlands	0.5	-0.9	2.5	-1.1	-0.4	-0.1	-0.5
	West Midlands	1.2	-1.3	2.4	-1.5	-0.3	-0.2	-0.3
	East of England	1.6	-0.2	-0.1	-0.8	-0.4	0.5	-0.4
	South East	1.9	0.1	-0.8	-0.9	0.0	0.2	-0.5
	South West	0.6	-0.4	0.7	-1.1	0.1	0.7	-0.6
	Inner London	2.6	2.7	-7.9	-0.8	3.3	0.9	-0.7
	Outer London	4.5	2.5	-6.0	-1.0	0.5	0.0	-0.5
	Wales	0.9	-0.7	3.1	-2.5	0.2	-0.5	-0.6
Commute Distance	<2km	0.6	0.0	-0.2	-1.1	-1.0	2.3	-0.6
	≥2km-<5km	0.6	-0.6	-0.3	-2.0	0.7	2.0	-0.4
	≥5km-<10km	2.0	0.1	-1.5	-1.4	0.9	0.4	-0.4
	≥10km-<20km	2.0	0.1	-1.6	-1.0	0.5	0.4	-0.4
	≥20km-<40km	2.0	0.1	-1.8	-0.4	0.2	0.5	-0.5
	≥40km	2.0	0.3	-3.3	-0.2	0.4	1.7	-0.8

Source: Derived from the 2001 and 2011 I-SARs.

The substantial increase in the prevalence of commuting by train, underground and tram may be due to investment in the rail network leading to new routes (BBC, 2015 vii) and improvements to train stations (BBC, 2015 viii) making rail travel more attractive to commuters. The increases may also be due to the introduction of the London congestion charge meaning that commuting by underground in London became more financially attractive between 2001 and 2011.

The striking decreases in commuting by bus seen in Figure 6.1 and Tables 6.3 and 6.4 to the low levels seen in Table 6.2 may be a result of bus service deregulation (Glaister, 1986), the restructuring of the industry (Fairhurst and Edwards, 1996) and the cutting of bus subsidies (Gray *et al.*, 2006). At best, it is clear that these policies have done nothing to halt the decline in bus travel and at worst it could be postulated that these policies have led to the large decreases in bus travel.

The stability in the prevalence of commuting by car is also concerning. This means that no transport policy or economic or social changes over the past two decades have dented the popularity of driving to work. However, the 7.9 and 6.0 percentage point decreases in the prevalence of car commuting in the Inner and Outer London regions between 2001 and 2011 suggest that the imposition of the London congestion charge in 2003 is one transport policy which may have had a positive impact on the modal split in those areas.

The general increases in commuting by bicycle and on foot between 2001 and 2011 seen in Table 6.4 are likely due to the rise of city living and the re-urbanisation of many towns and cities in the UK (Seo, 2002). Many of these new city-dwellers may have taken advantage of the opportunity to commute to work by bicycle or on foot instead of spending time stuck in rush-hour traffic in a car or on a bus. With a larger proportion of the population living in city centre and inner city areas in 2011 than in 2001, it is therefore unsurprising that some groups, such as those aged 25-44, those without dependent children and those with professional and managerial occupations, have seen increases in the prevalence of commuting by bicycle and on foot.

6.2.3 Changing public transport usage

As Figure 6.1 showed, at the same time as there was a substantial increase in the percentage of those commuting to work by train, underground or tram, there was a corresponding decrease in the percentage of commuters commuting to work by bus. To explore the overall changes to public transport commuting by sociodemographic variables using BLR it is necessary to aggregate these two modes of transport. Table 6.5 shows the percentage of commuters commuting to work using public transport; that is commuting to work by train, underground and tram and bus, in 1991, 2001 and 2011 and the changes between the three years, while Figure 6.2 shows the overall percentage point changes between 1991 and 2011.

Table 6.5 and Figure 6.2 show that there was no overall trend, across the different sociodemographic categories, in the changes in commuting to work using public transport over the 20 year period. While some categories have seen notable increases in the percentage of those commuting to work using public transport, such as those aged 25-44, the Chinese ethnic group and the Inner and Outer London regions, other groups have seen notable decreases, such as the 65-74 age group and people in the Yorkshire and the Humber and North East regions.

The LLTI, dependent children and commute distance variables are particularly noteworthy in that all 10 categories within those variables experienced decreases between 1991 and 2001, and increases between 2001 and 2011, in the prevalence of commuting to work using public transport. In a similar vein, between 1991 and 2001 all of the ethnic groups, except Chinese, showed decreases in the prevalence of commuting to work using public transport, but increases between 2001 and 2011. Although none of the changes seen within the other variables are as clear cut as these, and despite no overall trend over the 20 year period, the general pattern is one of decreases in commuting by public transport between 1991 and 2001 and increases between 2001 and 2011.

Table 6.5: Percentages and percentage point changes in commuting using public transport by sociodemographic and geographic characteristics for all commuters (excluding homeworkers) in England and Wales aged 16-74, 1991, 2001 and 2011

Sociodemographic and Geographic Variables		Public Transport (%)			% Point Change	
Variables	Categories	1991	2001	2011	91-01	01-11
All	All	17.1	15.9	17.6	-1.2	1.7
Sex	Male	13.4	13.8	16.5	0.4	2.7
	Female	21.5	18.3	18.7	-3.3	0.4
Age Group	16-24	24.9	25.2	22.9	0.2	-2.2
	25-44	15.7	16.2	20.1	0.5	3.9
	45-64	15.3	12.2	13.2	-3.1	0.9
	65-74	18.3	14.6	12.9	-3.7	-1.7
Ethnic Group	White	16.2	14.6	15.2	-1.6	0.6
	Indian	28.7	26.7	30.6	-2.0	3.9
	Pakistani	24.3	20.8	21.0	-3.5	0.2
	Bangladeshi	34.0	31.8	34.7	-2.2	3.0
	Black	50.0	47.9	48.6	-2.2	0.7
	Chinese	29.1	29.4	35.5	0.3	6.1
	Other	38.4	33.0	34.6	-5.5	1.6
LLTI	LLTI	20.5	16.0	16.4	-4.5	0.5
	No LLTI	17.0	15.9	17.7	-1.1	1.8
Dependent Children	No Dependent Children	19.2	18.1	19.3	-1.1	1.3
	Dependent Children	14.0	12.4	14.6	-1.6	2.2
Occupation	Professional and Managerial	14.4	17.2	20.1	2.7	2.9
	Non-Professional and Non-Managerial	18.5	15.2	16.0	-3.4	0.9
Region of Usual Residence	North East	18.3	14.7	13.6	-3.6	-1.1
	North West	15.7	11.7	12.3	-4.0	0.6
	Yorkshire and The Humber	17.2	13.3	12.1	-3.9	-1.2
	East Midlands	11.1	8.9	8.5	-2.2	-0.4
	West Midlands	14.5	11.4	11.3	-3.1	-0.1
	East of England	7.2	12.2	13.6	5.1	1.3
	South East	13.7	11.4	13.5	-2.2	2.0
	South West	7.7	6.8	7.0	-0.9	0.2
	Inner London	52.8	58.0	63.2	5.2	5.2
	Outer London	36.7	39.8	46.7	3.1	7.0
	Wales	10.0	6.9	7.2	-3.1	0.3
Commute Distance	<2km	8.9	5.9	6.4	-3.1	0.6
	≥2km-<5km	21.5	18.1	18.1	-3.3	0.0
	≥5km-<10km	20.3	19.7	21.8	-0.6	2.1
	≥10km-<20km	19.6	18.8	20.9	-0.8	2.1
	≥20km-<40km	18.7	15.8	17.8	-2.9	2.1
	≥40km	27.9	24.0	26.3	-3.9	2.3

Source: Derived from the 1991, 2001 and 2011 I-SARs.

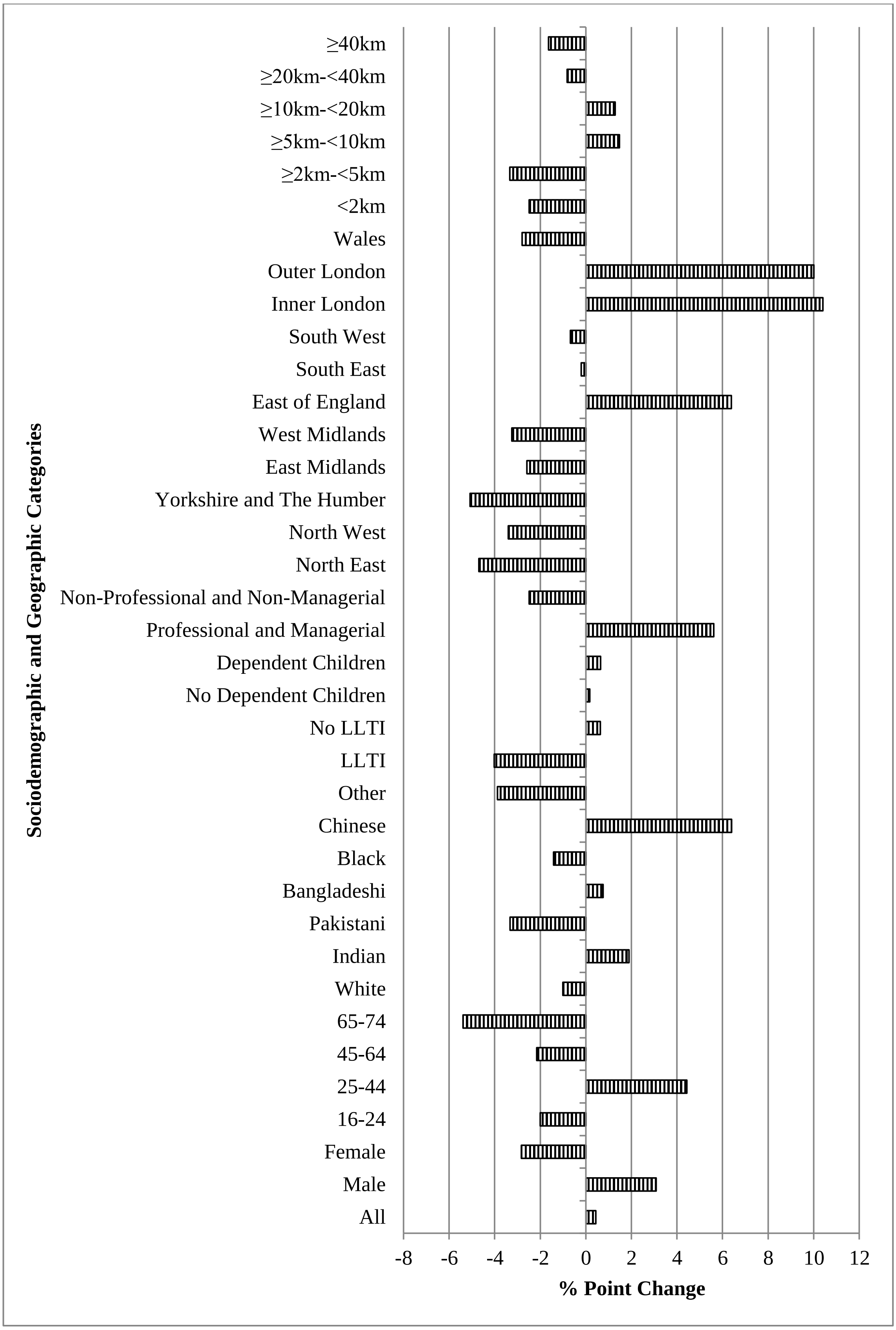
The general pattern seen in Table 6.5 may be due in part to changes in national, regional and local government policies over the 20 year period, especially those associated with the election of the New Labour Government in 1997. While both Labour and Conservative Governments, before 1997, were committed to a policy of 'Predict and Provide' (Goodwin, 1993), which resulted in increased investment in the road network throughout the 1960s, 1970s and 1980s (Terry, 2000), the New Labour Government, after 1997, moved away from this towards the principle of 'new realism' (Walton and Shaw, 2003), with the aim of implementing road pricing and influencing transport patterns through land-use planning (Owens, 1995).

This major change in government policy may go some way to explaining the general increases in public transport use between 2001 and 2011, particularly in Greater London. Logically, less investment in the road network, more investment in public transport systems and the linking of transport and land-use planning would lead to an increase in the percentage of those commuting to work using public transport. However, this explanation is questionable with Glaister (2002) producing a scathing review of the Government's transport policies between 1997 and 2001.

The general increase in public transport use between 2001 and 2011 may also have been due to recent changes in where and how commuters live. While the 'Predict and Provide' policy may have facilitated suburban sprawl up until the late 1990s, the period from 2001 to 2011 saw the implementation of urban regeneration policies (Jones and Evans, 2008) and the rise of city centre living (Tallon and Bromley, 2004), especially in London and the regional core cities. It is likely that commuters living in city centres and inner city areas have easier access to railway, bus and mass transit networks and are therefore more likely to use them to commute to work. It is also the case that many modern city centre residential developments have limited access to free car parking facilities, due to planning decisions in the late 1990s and early 2000s whereby planners were increasingly prioritising 'car-free' developments (Mittler, 1999). Furthermore, substantial increases in the real price of petrol in the UK after 2001 (BBC, 2008), due to market forces, government policy and the global financial crisis, means that it is likely to have been more expensive to commute by car in 2011 than it was in 2001, thus making public transport use relatively more financially attractive.

Another possible explanation for the increase in public transport use between 2001 and 2011 is the substantial increase in the UK's ethnic minority population over the 10 year period. The UK ethnic minority population increased from 14% in 2001 to 20% in 2011 (Jivraj, 2012). As ethnic minority populations tend to be concentrated in areas with better public transport connections, such as inner city areas, with particular concentrations in Greater London, it may be the case that ethnic minority commuters have more opportunities to commute using public transport.

Figure 6.2 provides a graphical summary of the combined 1991-2001 and 2001-2011 percentage point changes in commuting by public transport for commuters in each of the variable categories. This indicates that there was no consistent pattern of increase or decrease across the 20 year period. This lack of a trend is likely due to there being general decreases in commuting by public transport between 1991 and 2001 and general increases between 2001 and 2011. The largest percentage point increases were for the Inner London, Outer London and East of England regions and for the Chinese ethnic group, with 10.4, 10.0, 6.4 and 6.4 percentage point increases, respectively, between 1991 and 2011. Conversely, the largest percentage point decreases were for the 65-74 age group and the Yorkshire and The Humber and North East regions, with 5.4, 5.1 and 4.7 percentage point decreases, respectively, between 1991 and 2011.



Source: Derived from Table 6.5.

Figure 6.2: Percentage point changes in commuters using public transport by sociodemographic and geographic characteristics for all commuters (excluding homeworkers) in England and Wales aged 16-74, 1991-2011

6.2.4 Modelling the use of public transport

Although Table 6.5 and Figure 6.2 indicate how the prevalence of commuting by public transport changed between 1991 and 2011 across the selection of sociodemographic variables, they do not show how the relative likelihoods of commuting by public transport changed for each of the categories within the variables when controlling for the other variables. It is useful to know the relative likelihoods in addition to the percentages; because they indicate how more or less likely commuters in one sociodemographic category, such as females, are to commute to work using public transport compared to another category, in this case males. Knowing these relative likelihoods is important from a policy perspective so that policy makers tasked with promoting the usage of public transport know which subsections of the commuting population to target, with previous research suggesting that policy makers should target males in their early thirties who commute less than five miles to work (Curtis and Headicar, 1997).

Table 6.6 shows that the 25-44, 45-64 and 65-74 age groups were all less likely to commute using public transport, relative to the 16-24 age group, in 2011 than they were in 1991. This pattern was consistent in all three years. It is noteworthy that while the relative likelihoods of commuting by public transport for the 25-44 and 45-64 age groups decreased between 1991 and 2001 before increasing between 2001 and 2011, there was a constant trend seen for the 65-74 age group, with this age group becoming relatively less likely to commute using public transport over both time periods. The 2011 ORs indicate that the likelihood of commuting using public transport generally decreases as commuters get older, with the 2011 ORs decreasing across the age groups from 1.000 for the 16-24 age group to 0.427 for the 65-74 age group. These findings mirror those of Fiedler (2007), who found that older people were less likely to use public transport than younger people, especially if they own a car.

Commuters in all of the ethnic groups, with the exception of the Chinese group, were less likely to use public transport, relative to the White ethnic group, in 2011 than they were in 1991. The Chinese ethnic group became relatively more likely to commute using public transport, with the OR increasing from 1.464 in 1991 to 1.659 in 2011, albeit with a slight decrease to 1.436 in 2001. The most striking aspect of the ethnic group ORs is that in 1991, 2001 and 2011, commuters in all the BME groups were more likely to commute to work using public transport than commuters in the White ethnic group, with commuters in the Black ethnic group being the most likely to commute using public transport, with ORs of 2.683, 2.030 and 2.369 in 1991, 2001 and 2011, respectively. These ORs mean that commuters from Black ethnic groups were over twice as likely to commute using public transport as those from White ethnic groups in all three years. These findings are similar to those of Shen (2000), who found that commuters of Black ethnicity in the USA had longer commutes due to their greater dependence on public transport.

Commuters with non-professional and non-managerial occupations were more likely to commute using public transport than commuters with professional and managerial occupations in 1991, 2001 and 2011. The likelihood of commuters with non-professional and non-managerial occupations commuting using public transport decreased between 1991 and 2001 and also between 2001 and 2011, relative to commuters with professional and managerial occupations, with the OR decreasing from 1.638 in 1991, to 1.166 in 2001 and to 1.057 in 2011. This means that, while in 1991 commuters with professional and managerial occupations were relatively substantially less likely to commute using public transport, in 2011 they were only slightly relatively less likely to do so.

The ORs in Table 6.6 clearly indicate that in all three years commuters resident in the Inner and Outer London regions were far more likely to commute using public transport than commuters resident anywhere else, while commuters in Wales and the South West were amongst the least likely to commute using public transport in 1991, 2001 and 2011. The high ORs for those commuters resident in Greater London are likely due to the well-developed public transport networks available and the difficulty of commuting by car in that part of the UK, making commuting by public transport relatively easier and cheaper than anywhere else, while the low ORs for those commuters resident in Wales and the South West are likely to be due to the rural and sparse nature of these areas; with fewer dense urban areas than in the other regions, commuting by public transport is likely to be much less effective and affordable.

Finally, Table 6.6 shows a clear positive relationship between commute distance and the likelihood of commuting by public transport, with those commuting ≥40km the most likely to use public transport in 1991, 2001 and 2011 and those commuting <2km the least likely. The high ORs for those commuting ≥40km is likely driven by the high likelihood of commuting by train, as opposed to underground, tram or bus, amongst those commuting ≥40km (see Table 6.2). Conversely, the low ORs for those commuting <2km is likely driven by the high likelihood of commuting by bicycle or on foot amongst those commuting <2km.

Table 6.6: BLR model results for commuters commuting using public transport by sociodemographic and geographic characteristics for all commuters (excluding homeworkers) in England and Wales aged 16-74 in 1991, 2001 and 2011

Sociodemographic and Geographic Characteristics		1991 OR		2001 OR		2011 OR	
Variables	Categories						
Sex	Male	1.000		1.000		1.000	
	Female	2.164	*	1.715	*	1.432	*
Age Group	16-24	1.000		1.000		1.000	
	25-44	0.580	*	0.493	*	0.659	*
	45-64	0.581	*	0.388	*	0.447	*
	65-74	0.750	*	0.450	*	0.427	*
Ethnic Group	White	1.000		1.000		1.000	
	Indian	1.526	*	1.325	*	1.517	*
	Pakistani	1.754	*	1.323	*	1.240	*
	Bangladeshi	1.870	*	1.146	*	1.295	*
	Black	2.683	*	2.030	*	2.369	*
	Chinese	1.464	*	1.436	*	1.659	*
	Other	1.935	*	1.548	*	1.534	*
LLTI	LLTI	1.000		1.000		1.000	
	No LLTI	0.700	*	0.835	*	0.859	*
Dependent Children	No Dependent Children	1.000		1.000		1.000	
	Dependent Children	0.780	*	0.680	*	0.696	*
Occupation	Professional and Managerial	1.000		1.000		1.000	
	Non-Professional and Non-Managerial	1.638	*	1.166	*	1.057	*
Region of Usual Residence	North East	1.000		1.000		1.000	
	North West	0.819	*	0.769	*	0.874	*
	Yorkshire and The Humber	0.895	*	0.883	*	0.846	*
	East Midlands	0.521	*	0.548	*	0.542	*
	West Midlands	0.712	*	0.725	*	0.743	*
	East of England	0.306	*	0.750	*	0.884	*
	South East	0.619	*	0.709	*	0.892	*
	South West	0.351	*	0.423	*	0.460	*
	Inner London	5.026	*	7.943	*	9.966	*
	Outer London	2.389	*	3.630	*	4.908	*
	Wales	0.466	*	0.415	*	0.458	*
Commute Distance	<2km	1.000		1.000		1.000	
	≥2km-<5km	3.099	*	3.731	*	3.389	*
	≥5km-<10km	2.827	*	3.727	*	3.750	*
	≥10km-<20km	3.028	*	3.929	*	3.980	*
	≥20km-<40km	4.004	*	4.452	*	4.666	*
	≥40km	8.574	*	9.231	*	9.189	*
	Constant	0.106	*	0.095	*	0.081	*

Source: Derived from the 1991, 2001 and 2011 I-SARs. (*=OR is statistically significant ($p<0.05$)).

Any decreases in the prevalence of commuting by public transport may be due to increases in the cost of commuting by public transport; especially increases rail fares (BBC, 2013i, 2013iii, 2014, 2015vi, 2015ix). However, decreases may also be due to reductions in the cost of car transport, with the Royal Automobile Club (2015) showing that although, nominally, the costs of owning and running a car have increased over the past 20 years, the real cost decreased between 1988 and 2008 by 18% when fuel costs are included, and this was before the recent substantial decreases in the price of diesel and petrol (BBC, 2015v).

Conversely, any increases in the prevalence of commuting by public transport may be due to increased traffic congestion on the roads and the introduction of the congestion charge in London. It is likely that increased traffic congestion and congestion charging have persuaded many car commuters to switch to commuting by public transport, particularly if they have long commutes that they cannot cover by bicycle or on foot.

That the ORs for commuting by public transport generally decrease with age, with the 16-24 age group experiencing the highest OR in all three years, may be due to car ownership rates generally increasing with age (Prillwitz *et al.*, 2006), before decreasing later in life (Alsnih and Hensher, 2003). This means that as commuters age they are more likely to have access to a car and, therefore, less likely to be forced to use public transport to commute to work.

The high ORs for the ethnic minority groups seen in Table 6.6 may be due to low levels of car ownership amongst BME groups (Raphael and Stoll, 2001), meaning that many BME commuters have no choice but to commute to work by public transport. However, they may also be due to the BME population being concentrated in London, where there are dense and well developed public transport networks. The convergence seen in the ORs for many of the BME groups may be due to continued integration and assimilation into the White population, with the commuting behaviours of the BME groups becoming more similar to that of the White group over time.

Table 6.7 shows the overall R^2 values and the individual R^2 values for the different sociodemographic variables in the model for the 1991, 2001 and 2011 public transport BLR models. The R^2 values of 0.200, 0.238 and 0.271 for 1991, 2001 and 2011, respectively, are relatively low, but higher than those for the commute distance BLR models. These R^2 values show that just 20.0%, 23.8% and 27.1% of the variations in commuting using public transport are explained by the model using the chosen sociodemographic predictor variables in 1991, 2001 and 2011, respectively. In complete contrast to the commute distance model, these R^2 values indicate that the explanatory ability of the public transport BLR model is lowest for 1991 and highest for 2011.

Importantly, in all three years the same three variables, ethnic group, region of usual residence and commute distance, contributed most to the models in terms of explaining any variations in commuting using public transport. The sex, LLTI and occupation variables were the least important variables for explaining any variations commuting by public transport in 2001 and 2011, all having R^2 values of 0.006 or less.

It is notable that commute distance was the second most important independent variable in all three years, meaning that the relationship between commute distance and mode of transport is likely to work in both directions (see Chapter 5).

Table 6.7: R^2 results for the 1991, 2001 and 2011 public transport BLR models

Variable	1991 R^2	2001 R^2	2011 R^2
Sex	0.019	0.006	0.001
Age Group	0.013	0.018	0.016
Ethnic Group	0.020	0.029	0.046
LLTI	0.000	0.000	0.000
Dependent Children	0.008	0.010	0.006
Occupation	0.004	0.001	0.004
Region of Usual Residence	0.105	0.161	0.205
Commute Distance	0.041	0.048	0.047
Model	0.200	0.238	0.271

Source: Derived from the 1991, 2001 and 2011 I-SARs.

As was the case with the commute distance BLR models, these relatively low R^2 values may be due to sociodemographic variables that are excluded from the models having a particularly large and significant effect on the likelihood of an individual commuting using public transport, such as transport network accessibility, cost of travel and area type.

6.2.5 Mode of transport interaction effects

Whilst it is necessary to recognise how mode of transport usage varies by sociodemographic variables independently, it is also important to understand the interactions between the variables. No research on mode of transport usage has looked at intersectionality (see Chapters 2 and 5), the IEs between the different variables or what impact the interaction has on mode of transport usage. As with commute distance, it is envisaged that the exploration and analysis of these IEs will lead to a greater understanding of the sociodemographic drivers of variations in mode of transport usage.

This section deals with the IEs between some of the different sociodemographic variables used in the BLR modelling earlier in this chapter. The IEs between the most important variables are being analysed in addition to the PEs of the variables in order to gain a fuller understanding of the relationships between the different sociodemographic variables and the usage of public transport, as intersectionality is important in determining the behaviour of individual commuters (see Chapter 2). Section 6.2.5.1 builds on previous research and the preceding analyses by quantifying how likely an individual is to commute to work using public transport given their ethnic group, residential location and commute distance together.

As was the case in Chapter 5, the number of variables included in the IE analyses has been limited to three in order to concentrate on the most important variables. Any number of variables could potentially influence the relative likelihood that a commuter will commute to work using public transport, and it is likely that other important variables have not been included. For example, research by Hess (2001) found that commuters with professional and managerial occupations were more likely to benefit from free parking at work than commuters with other occupations. It is likely that whether or not a commuter benefits from free parking will have an impact on the likelihood that they will commute by car, as opposed to public transport.

6.2.5.1 Ethnic group, residential location and commute distance

Past research, which was expounded in Chapter 2, Chapter 5 and earlier in this chapter, has found that an individual's ethnic group, residential location and commute distance individually influence their commuting patterns and behaviours. However, as mentioned above, different combinations of these variables will interact with each other in different ways to jointly influence commuting patterns and behaviours. This interaction can be explained through the theory of intersectionality (see Chapter 2). In order to fully understand how these variables influence which mode of transport an individual will use to commute to work, it is necessary to take both the primary and interaction effects of these sociodemographic variables into account.

In addition to past research findings, the ethnic group, region of usual residence and commute distance variables, and the interactions between them, are reported in Table 6.8 as they are particularly important in influencing variations in commuting using public transport. Table 6.7 shows that they were the three most important variables for explaining commuting using public transport, with all three variables having the highest R^2 values in 1991, 2001 and 2011.

For the purpose of calculating probabilities from the primary and interaction effects, the ethnic group, region of usual residence and commute distance variable were recoded into binary variables. For the ethnic group variable, the White category remained the same, while all the other ethnic group categories have been combined to form a 'BME' category. For the region of usual residence variable, the Inner and Outer London categories were combined to make a 'London' category, while all the other regions were combined to make a 'Rest of England and Wales' category. For the commute distance variable the ≥40km category remained the same to become a 'very long-distance' category, while all the other distance categories were combined to make a 'short distance' category. This recoding was undertaken for practical reasons, to keep the number of interaction effects produced by the BLR as manageable as possible, and for research reasons, so it is possible to compare directly the commuting patterns and behaviours of people in the different categories.

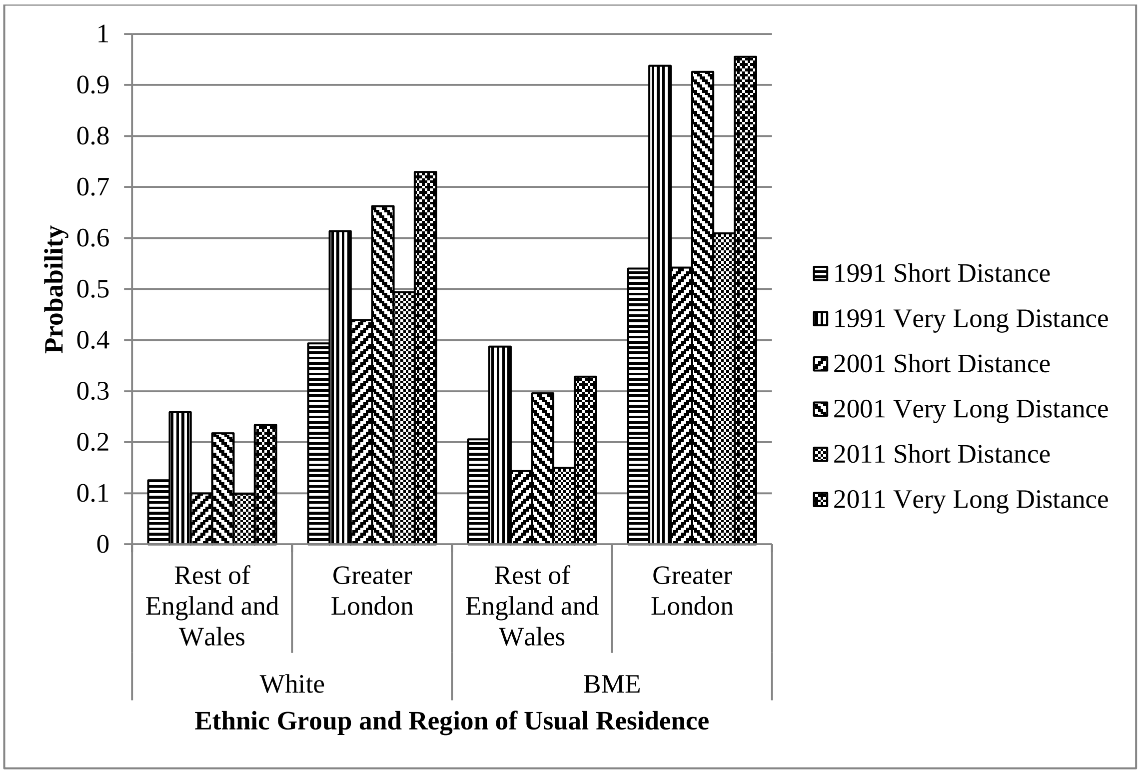
Table 6.8 shows the β-values, as aforementioned in Chapter 3, for the PEs of the ethnic group, region of usual residence and commute distance variables and the IEs between the three individual variables. It is immediately clear from looking at the PE β-values that BME commuters, those who live in Greater London and those who commute very long-distances to work are substantially more likely to commute using public transport than White commuters, those who live outside Greater London and those who commute short distances to work.

Table 6.8: PEs and IEs results from BLR model for commuters commuting using public transport by ethnic group, region of usual residence and commute distance for all commuters (excluding homeworkers) in England and Wales aged 16-74 in 1991, 2001 and 2011 (Reference Categories: White, Rest of England and Wales and Short Distance)

Effects	Sociodemographic and Geographic Characteristics		1991 β		2001 β		2011 β	
	Variables	Categories						
Primary Effects	Ethnic group	White	0.000		0.000		0.000	
		BME	0.593	*	0.412	*	0.469	*
	Region of usual residence	Rest of England and Wales	0.000		0.000		0.000	
		Greater London	1.512	*	1.954	*	2.178	*
	Commute distance	Short Distance	0.000		0.000		0.000	
		Very Long-distance	0.894	*	0.917	*	1.018	*
Interaction Effects	Ethnic group, Region of usual residence and Commute distance	White, Rest of England and Wales and Short Distance	0.000		0.000		0.000	
		BME, Greater London and Very Long-distance	1.656	*	1.433	*	1.598	*
		Constant	-1.944	*	-2.196	*	-2.203	*

Source: Derived from the 1991, 2001 and 2011 I-SARs. (*=OR is statistically significant ($p<0.05$)).

Figure 6.3 is a graphical representation of the probabilities derived from the multiple primary effects and interaction effects shown in Table 6.8, as explained in Chapter 3, and shows the probability of commuting using public transport given an individual's ethnic group, region of usual residence and commute distance. The probabilities show that for those inside and outside of Greater London, BME commuters and those commuting very long-distances are more likely to commute using public transport than White commuters and those commuting short distances.



Source: Derived from Table 6.8.

Figure 6.3: Probabilities of commuters using public transport by ethnic group, region of usual residence and commute distance for all commuters (excluding homeworkers) in England and Wales aged 16-74 in 1991, 2001 and 2011

The differences in the probabilities for White and BME commuters may be because BME individuals are more likely to live in major cities of the UK (Buckner *et al.*, 2007), and in the inner areas of these cities (Bromley *et al.*, 2007), than their White counterparts, who, due to post-war suburbanisation, are more likely to live in suburban and rural areas (Phillips, 1998). It is also the case that the BME population in the UK is generally younger than the White population (Lievesley, 2010) and, as younger individuals are more likely to live in urban areas (Glaeser, 1998), BME individuals are therefore more likely to live in inner city areas than suburban or rural areas. Furthermore, as public transport networks tend to be denser and more developed in city centre and inner city areas than in suburban and rural areas (Focas, 1998; Church *et al.*, 2000), BME commuters are likely to have ready access to these networks and are therefore more likely to use public transport to commute to work, regardless of other sociodemographic characteristics. However, it may also be because they are less likely to have access to a car (Raphael and Stoll, 2001) and are more likely to be low-paid (Low Pay Commission, 2013), and are therefore less financially able to run a car.

A different, but related, reason for this pattern may be because the BME population is concentrated in Greater London and BME individuals living in Greater London account for a substantial proportion of all BME individuals in the UK (see Table 6.9). As commuters living in Greater London are more likely to commute to work using public transport (see Table 6.6), due to the greater number of public transport options available and the presence of congestion charging, this will have more of an impact on the commuting behaviours and patterns of the BME population as a whole than the White population, which is more widely distributed.

Table 6.9: BME and total populations in England and Greater London in 2011

	BME Population	Total Population	% BME
Greater London	4,504,657	8,173,941	55.1
England	10,733,220	53,012,456	20.2
% of Population	42.0	15.4	

Source: Derived from the 2011 Census Aggregate Data.

Similarly, the difference between Greater London and the rest of England and Wales in the prevalence of commuting by public transport is likely explained by the well-developed public transport networks available in London and the necessity of commuting by car in many rural areas (Gray *et al.*, 2006).

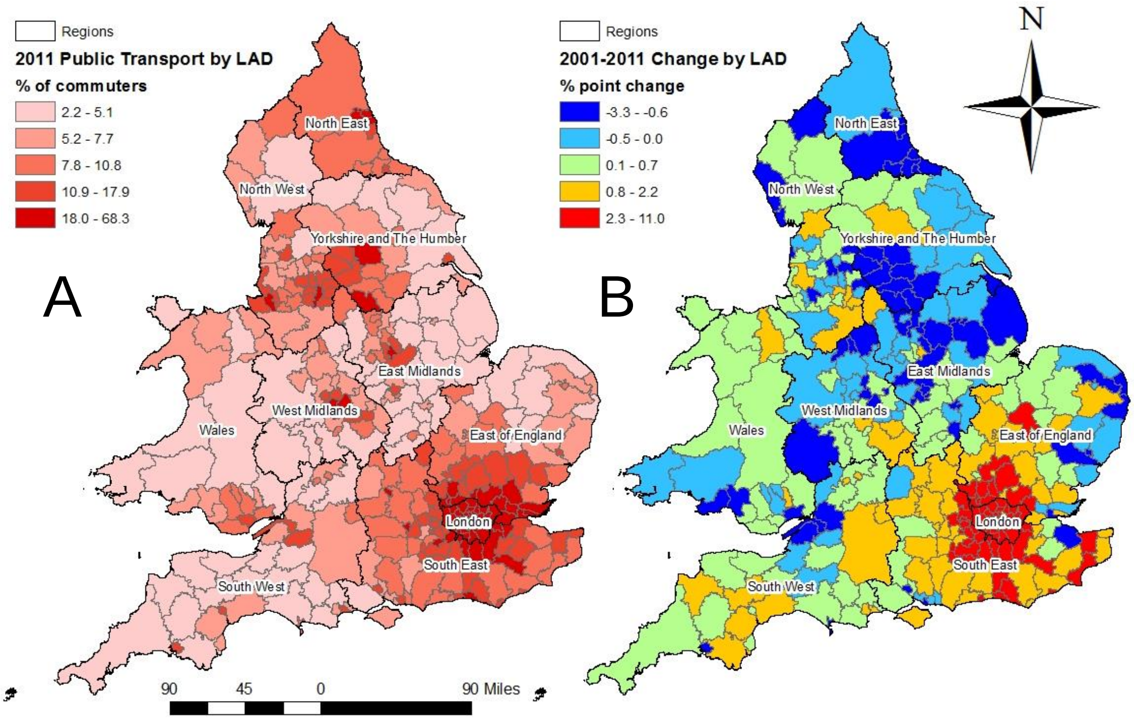
The higher probability of commuting using public transport amongst those commuting very long-distance may reflect the relatively high prevalence of commuting by train amongst those commuting more than 40km (see Table 6.2). Conversely, the lower probability of commuting using public transport amongst those commuting short distance may reflect the relatively high prevalence of commuting by bicycle and on foot amongst this group, particularly amongst those commuting less than 5km (see Table 6.2).

6.2.6 Spatial variations in commuting by public transport

So far in this chapter the 1991, 2001 and 2011 microdata have been used to gain a detailed understanding of sociodemographic variations in commuting by public transport. However, these microdata are unable to provide a detailed understanding of any spatial variations below the region level. This section uses 2001 and 2011 aggregate data to map spatial variations and temporal changes in commuting by public transport at LAD level.

Map A of Figure 6.4 shows that high rates of commuting by public transport are generally confined to urban areas, with the highest rates being seen in the Lambeth, Newham and Wandsworth LADs, with rates of 68.3%, 67.8% and 65.8%, respectively. Conversely, the lowest rates of commuting by public transport are seen in rural LADs in the South West, northern and central England and Wales, with the lowest rates being seen in the Powys, South Somerset and Sedgemoor LADs, with rates of 2.2%, 2.4% and 2.5%, respectively.

The spatial variations shown in map B of Figure 6.4 are similar to those in map A. Map B shows that the largest increases in commuting by public transport were in the London Boroughs and many of the LADs surrounding Greater London, with the largest percentage point increases of 11.0, 10.2 and 9.2 in Newham, Hounslow and Greenwich, respectively. The largest decreases in commuting by public transport were in some rural LADs and many of the urban LADs in northern and central England, with the largest percentage point decreases of 3.3, 2.9 and 2.7 in Rotherham, Darlington and Corby.



Source: Derived from the 2001 and 2011 Census Aggregate Data.

Figure 6.4: Percentage of commuters (excluding homeworkers) in England and Wales aged 16-74 in 2011 that commute to work by public transport (A) and the percentage point changes between 2001 and 2011 (B) by LAD

The spatial variation in the prevalence of commuting by public transport in map A is likely to be a reflection of the availability of public transport networks. Areas with dense and extensive train, bus, underground, light rail and tram networks are likely are likely to have higher rates of public transport usage than those areas with little or no access to public transport. This likely explains the clear divide between the urban areas of Greater London, Birmingham, Nottingham, Sheffield, Leeds, Manchester, Liverpool and Newcastle and many of the rural areas of the South West, Wales and central and northern England.

Increases in the proportion of people commuting by public transport in and around Greater London may be explained by increased road traffic congestion and the implementation of the London congestion charge, while increases in other areas may reflect the improved provision of bus networks and bus routes, with many major cities in England and Wales now having extensive bus networks and park and ride facilities (Meek *et al.*, 2010). It is also the case that increased commuting by public transport may reflect the process of re-urbanisation and the rise of city living (Seo, 2002) as well as increased environmental awareness amongst the public (Lorenzoni *et al.*, 2007).

Any decreases in commuting by public transport may reflect increasing incomes leading to greater levels of car ownership and usage (Dargay, 2007). Decreases may also reflect increases in the cost of public transport, especially train travel (BBC, 2013i, 2013iii, 2014, 2015vi, 2015ix), and the withdrawal of bus services in many rural areas due to budget constraints and reductions of subsidies (Gray *et al.*, 2006). However, some of the declines may also reflect the promotion of cycling and walking to work (Fraser and Lock, 2010).

6.3 Policy Implications and Conclusions

The analyses in this chapter have important policy implications. If national, regional or local policy makers wish to increase travel to work by public transport then policies need to be targeted at certain groups and in certain areas. The above analyses have clearly shown which sociodemographic groups are most likely to commute by public transport. Therefore, the findings could be used to inform targeted transport policies.

The findings of this chapter indicate that national, regional and local authorities would be wise to focus on promoting, possibly through targeted advertising and price concessions, the use of public transport amongst men, aged 45-74, of White ethnicity, who do not have a LLTI or any dependent children, and who work in professional and managerial occupations, as these are the sociodemographic characteristics of those commuters who were relatively less likely to commute by public transport in both 2001 and 2011. Particular attention should be paid to the White population, as opposed to the BME population, as the analysis has clearly shown that commuters from the White ethnic group are substantially less likely to commute using public transport than those from BME groups, regardless of age and occupation.

The high levels of commuting by public transport seen in Greater London and the low levels seen in Wales, the South West and the Midlands indicate that policy makers should prioritise dense mixed-use urban developments with good access to multiple public transport options and discourage low density residential development in rural areas and on the rural-urban fringe where there is little access to existing public transport networks.

Perhaps most importantly, in relation to both commute distance and mode of transport, although sociodemographic and geographic variations in distance and mode may be a product of differing access to employment opportunities, it may also be the case that the sociodemographic and geographic variations effect access to employment opportunities (Shuttleworth and Green, 2011; Owen *et al.*, 2012). If it is accepted that these inequalities in access to employment are economically suboptimal and socially unjust, then local, regional and national transport policies need to be designed with these sociodemographic and geographic variations distance and mode in mind.

The findings of this chapter generally align with those of previous research. However, as noted, there has previously been no attempt to quantify the likelihood that individual commuters will commute using public transport given their sex, age, ethnicity and other characteristics.

As with the analyses in Chapter 5, one must question the extent to which entrenched sociodemographic and geographic variations in commuting by different modes of transport can be changed using policy. However, policy makers should not be excused from trying to increase the prevalence of commuting by public transport, particularly amongst those sociodemographic groups and in those areas which these analyses have shown have the most potential for positive changes.

7. Changing Commuting Propensities, Patterns and Behaviours in the Leeds City Region

7.1 Introduction

City regions, such as the LCR, are becoming increasingly important spatial units with the devolution of certain economic and transport policy making from central UK Governments; with the recent announcement of the devolution of a number of policy areas to Greater Manchester (BBC, 2015i) and other combined LAs (BBC, 2015ii) and the implementation of the 'Northern Powerhouse' initiative (BBC, 2015iii). Given the political context, this chapter addresses the fourth broad research question set out in Chapter 1: How do commuting propensities and patterns vary spatially and by sociodemographic group in the LCR and what changes occurred between 2001 and 2011?

The analyses in this chapter aim to address the need for evidence based policy recommendations at the city region level and make use of all three types of data from the 2001 and 2011 censuses: aggregate statistics, interaction flows and microdata. To begin with, the self-containment of the LCR is examined in order to assess whether or not this spatial unit can be considered to be a functional city region, comparing the LCR self-containment rates with those applied when using TTWAs. Commuting inflows, outflows and intra-area flows within the LCR are then examined at MSOA level in order to identify which localities have seen the greatest changes in commuting propensities, to detect whether changes in the fabric of the LCR have occurred, to establish whether there have been changes in the relationship between places of residence and places of work between 2001 and 2011, and to identify variations in levels of self-containment within MSOAs. Commuting rates within the LCR are examined to see which sociodemographic subgroups experience the highest and lowest propensities for commuting and homeworking and what spatial variations are apparent. The chapter then examines the changes in modal split between 2001 and 2011 in the LCR as a whole, and spatial variations in modal split at MSOA level. Finally, sociodemographic and spatial variations in public transport usage are analysed to see which population subgroups and which localities experience the highest and lowest propensities to commute using public transport. Public transport has been singled out due to its importance from a policy perspective, with regional and local authorities seeking to increase the usage of public transport systems. Analysing data at a small area scale, in this case at MSOA level, is important when investigating commuting propensities, patterns and behaviours as most commuting takes place within the larger spatial units of LADs and TTWAs.

In Sections 7.2 and 7.3, the 2001 and 2011 microdata and interaction flow data are used to examine commuting self-containment rates in the LCR and commuting outflows, inflows and self-containment at MSOA level. The aggregate statistics and microdata are employed in

Section 7.4 in order to examine sociodemographic and spatial variations and temporal changes in commuting and homeworking rates at LAD and MSOA level. In Section 7.5, the ONS 2011 urban-rural classification is used to summarise variations and changes in the different commuting indicators for the LCR. In Section 7.6, changing variations in modes of travel to work are investigated at MSOA level using the aggregate statistics and in Section 7.7 microdata and aggregate statistics are used to examine changes in commuting by public transport at LAD and MSOA level. In Section 7.8, the urban-rural classification is used again to summarise variations and changes in the different modes of transport. Finally, some policy recommendations based on the analyses are presented in Section 7.9 and some conclusions are drawn.

Before embarking on these analyses, it is useful to examine which flow variables are available at each spatial scale in the 2001 and 2011 census datasets. It should be noted that while Sections 7.2, 7.4, 7.5, 7.6 and 7.7, when examining commuting self-containment, commuting rates and modal split, focus on rates and shares of commuters, Section 7.3, when examining commuting outflows, commuting inflows and commuting self-containment, also uses the absolute numbers of commuters. The absolute flows have been used in addition to the rates as they are important for local policy makers when improving existing transport networks and building new ones. This importance is exemplified by the fact that it is possible for an area to experience a substantial change in its commuting inflows or outflows without experiencing an equivalent change in its commuting inflow or outflow rate.

Table 7.1 identifies which origin-destination flow variables in the SWS are available at the LAD, Ward and OA levels in the 2001 dataset and at the LAD, MSOA and OA levels in the 2011 dataset. The geographic variations in variable availability in 2001 and 2011 indicate that only changes in total commuting flows and flows by mode of transport can be analysed at MSOA level, by virtue of aggregating the 2001 data from the OA level.

Table 7.1: Sociodemographic variables available for census interaction data in 2001 and 2011 SWS at different spatial scales

SWS Output Levels	2001 SWS Variables	2011 SWS Variables
District Level	Sex, Age, NS-SeC, Industry, Ethnic Group, Employment Status, Living Arrangements and Mode of Transport	Sex, Age, NS-SeC, Mode of Transport, Occupation, Family status, Economic Activity, Industry, Social Grade, Car or Van Availability, Country of Birth, Hours Worked
Ward Level	Sex, Age, NS-SeC, Employment Status, Occupation, Family Status and Mode of Transport	-
MSOA Level	-	Sex, Age, NS-SeC, Mode of Transport, Occupation, Family status, Economic Activity, Industry, Social Grade, Car or Van Availability, Country of Birth, Hours Worked
OA Level	Mode of Transport	Mode of Transport

Source: Derived from the 2001 and 2011 Census SWS.

The MSOA level has been chosen as an appropriate spatial scale for LCR data analysis as it provides a good level of spatial detail while keeping the amount of data needed manageable and the map outputs relatively clear and readable. This means that all of the analyses in this chapter have been carried out at either the LAD or MSOA levels. Although their use would be appropriate for analysing commuting data, WPZs were only developed for the 2011 Census and equivalent 2001 spatial units do not exist.

It should be noted at this point that there are some inconsistencies between the age groups used in 2001 and 2011. As outlined in detail in Chapter 3, due to inconsistencies in the classification of homeworkers in 2001 and 2011, it was necessary to extract 2011 Census interaction data from Nomis and 2001 Census interaction data from WICID, as only Nomis provided 2011 Census interaction data that were compatible with the 2001 Census interaction data when disaggregated by mode of transport. However, while WICID only provides 2001 Census interaction data for those aged 16-74, by extracting and aggregating census interaction data for the 16-17, 18-19, 20-24, 25-29, 30-44, 45-59, 60-64 and 65-74 age groups, Nomis only provides the consistent 2011 Census interaction data for those aged 16+. This means that in Section 7.2 there are slight inconsistencies when analysing commuting self-containment in the LCR in 2001 and 2011. Due to the same issues, it should also be noted that in Section 7.3 the census interaction data used for visualising commuting outflows, inflows and self-containment shows all commuters aged 16+, as opposed to those aged 16-74.

7.2 The Leeds City Region as a TTWA

In recent years, the LCR has acquired substantial powers over policies in the areas of housing, regeneration, skills and innovation, all of which affect commuting propensities and patterns (Leeds City Region Enterprise Partnership, 2015). However, the creation of the LCR, and other city regions, has mainly been driven by local and regional politics, not by an assessment of the potential ‘functionality’ or ‘self-containment’ of such a city region or whether or not it adequately serves as a macro TTWA (see Chapter 2). To this end, Table 7.2 uses 2001 and 2011 census interaction data to show levels of commuting self-containment experienced by the city region and, therefore, can be seen as showing the extent to which the LCR serves as a functional region. The commuting self-containment rate is the total commuting flows that have both their origin and destination within the city region (or LAD or MSOA) as a percentage of the total commuting flows that have origins within the geographical area in question.

Table 7.2 shows that, overall, the LCR experiences a high level of commuting self-containment, with 91.7% of commuters and homeworkers resident in the LCR aged 16 and over commuting to a workplace somewhere within the city region in 2011. However, the level of self-containment for those commuters aged 16-74 decreased by 1.7 percentage points since 2001, when 94.3% of commuters did not leave the city region. Importantly, Table 7.2 indicates that the extent to which the LCR represents a TTWA varies according to an individual's sex, age and district of residence. Women are more likely to commute within the LCR than men, with 10.3% of male commuters resident in the LCR commuting to workplaces outside the LCR. No convergence took place between men and women, with the self-containment rates falling by 3.0 and 2.4 percentage points, respectively, between 2001 and 2011. Commuters in the 65-74 age group are more likely to remain within the LCR that those in the 16-24 or 25-64 age groups, with 93.4% of commuters in the older age group commuting within the city region. However, there is some evidence of convergence between the age groups, with the self-containment rate for the 65-74 age group decreasing by 3.6 percentage points between 2001 and 2011 but by only 2.5 percentage points for the 25-64 age group.

There is substantial variation in self-containment within the LCR by LAD of residence, with commuters resident in the Leeds LAD most likely to stay within the city region (95.2% of commuters) and commuters resident in the Barnsley LAD least likely to stay within the city region (72.7% of commuters). There is also substantial variation in the percentage point changes by LAD, with the self-containment rate for commuters in the Bradford and Calderdale LADs only decreasing by 1.6 percentage points between 2001 and 2011, while the self-containment rate for commuters in the Barnsley LAD decreased by 5.8 percentage points.

The aggregate self-containment rates for the LCR, and those of the sociodemographic groups, mean that this city region is a good representation of a large TTWA in terms of being self-contained, with the self-containment rate of 91.7% comparing well to the 75% rate used by Coombes (2002) when configuring TTWAs from the 2001 UK census data. However, this is undoubtedly partly due to the LCR being geographically larger than nearly all TTWAs defined by Coombes (2002), with the LCR containing places as distant and different as York, Huddersfield, Harrogate and Barnsley.

Regarding the variations in commuting self-containment by sex and age group, these are likely to be due to variations in the distances commuted by these groups. On average, men commute further than women and people in the 25-64 age group commute further than people in the younger (16-24) and older (65-74) age groups (see Chapter 5). The variation in self-containment by LAD of residence is partly due to the locations of the different LADs within the LCR. The LADs with the highest rates of commuting within the LCR (Bradford and Leeds) are at the centre of the region, being surrounded by other LADs that are part of it. Conversely, the LADs with the lowest rates of commuting within the LCR (Barnsley, Craven and Selby) are on the edge of the LCR, bordering LADs that are not part of it and with which they will have a higher level of interaction.

Table 7.2: Numbers and rates for commuters (including homeworkers) within and out of the LCR aged 16-74/16+ in 2001 and 2011 and the percentage point changes between 2001 and 2011 by sex, age and LAD of residence

Sociodemographic and Geographic Characteristics		Total Commuters		Commute Inside LCR		Commute Outside LCR		Commute Inside LCR (%)		Commute Outside LCR (%)		Self-Containment % Point Change
Variables	Categories	2001	2011	2001	2011	2001	2011	2001	2011	2001	2011	01-11
Leeds City Region Total 16-74		1,179,336	1,276,130	1,111,857	1,180,800	67,479	95,330	94.3	92.5	5.7	7.5	-1.7
Leeds City Region Total 16+*		-	1,149,461	-	1,054,131	-	95,330	-	91.7	-	8.3	-
Sex*	Male**	636,199	571,635	589,953	512,698	46,246	58,937	92.7	89.7	7.3	10.3	-3.0
	Female**	543,137	577,826	521,904	541,433	21,233	36,393	96.1	93.7	3.9	6.3	-2.4
	Total**	1,179,336	1,149,461	1,111,857	1,054,131	67,479	95,330	94.3	91.7	5.7	8.3	-2.6
Age group*	16-24	134,239	165,833	127,702	152,176	6,537	13,657	95.1	91.8	4.9	8.2	-3.4
	25-64	1,030,502	957,630	970,003	877,680	60,499	79,950	94.1	91.7	5.9	8.3	-2.5
	65-74	14,595	22,072	14,152	20,611	443	1,461	97.0	93.4	3.0	6.6	-3.6
	Total	1,179,336	1,145,535	1,111,857	1,050,467	67,479	95,068	94.3	91.7	5.7	8.3	-2.6
LAD of residence	Barnsley	86,365	95,370	69,765	71,507	16,600	23,863	80.8	75.0	19.2	25.0	-5.8
	Bradford	184,005	203,963	179,554	196,487	4,451	7,476	97.6	96.3	2.4	3.7	-1.2
	Calderdale	85,452	90,113	79,815	83,527	5,637	6,586	93.4	92.7	6.6	7.3	-0.7
	Kirklees	166,947	179,501	159,287	169,353	7,660	10,148	95.4	94.3	4.6	5.7	-1.1
	Leeds	305,877	331,342	296,749	316,971	9,128	14,371	97.0	95.7	3.0	4.3	-1.4
	Wakefield	133,841	141,666	127,802	133,059	6,039	8,607	95.5	93.9	4.5	6.1	-1.6
	York	82,286	92,564	74,981	81,869	7,305	10,695	91.1	88.4	8.9	11.6	-2.7
	Craven	24,897	25,373	22,134	22,165	2,763	3,208	88.9	87.4	11.1	12.6	-1.5
	Harrogate	72,901	75,895	68,442	70,524	4,459	5,371	93.9	92.9	6.1	7.1	-1.0
	Selby	36,765	40,343	33,328	35,338	3,437	5,005	90.7	87.6	9.3	12.4	-3.1
	Total	1,179,336	1,276,130	1,111,857	1,180,800	67,479	95,330	94.3	92.5	5.7	7.5	-1.7

Source: Derived from the 2001 and 2011 Census Aggregate Data and Census SWS (*Excludes Homeworkers in 2011, **16+ in 2011).

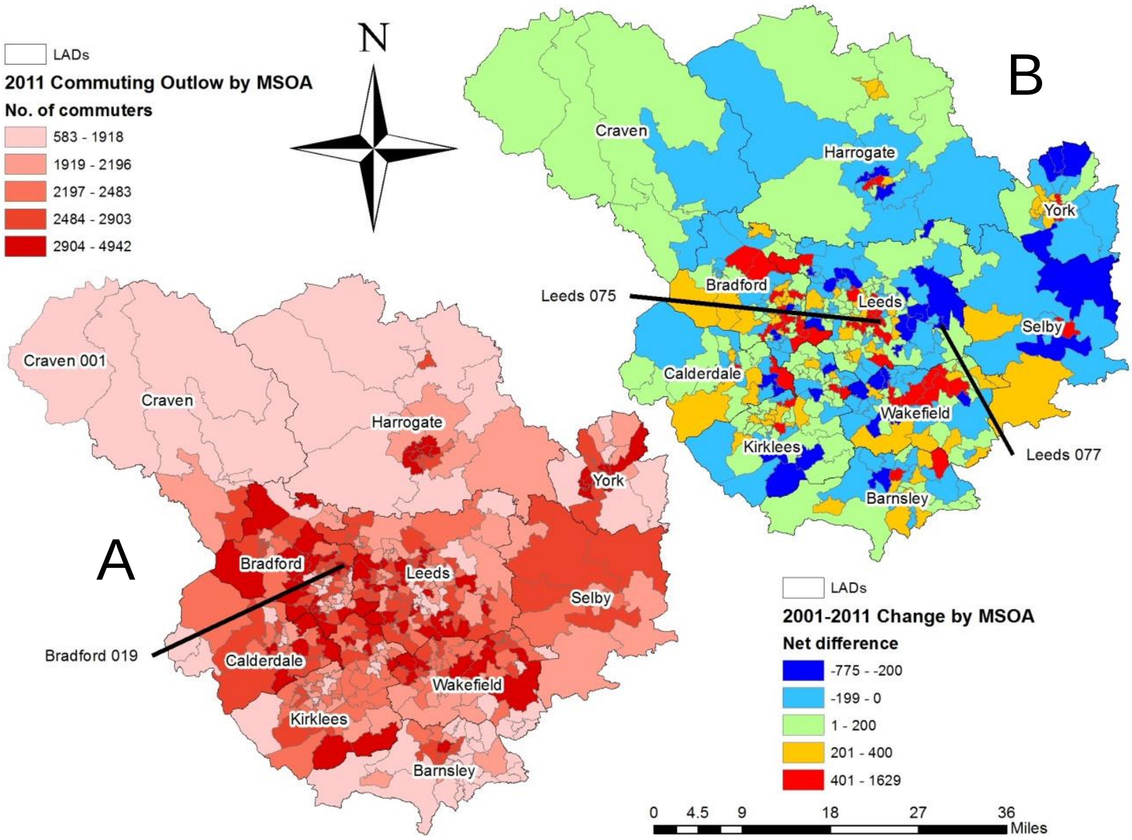
7.3 Out-commuting, In-commuting and Commuting Self-containment in the Leeds City Region

As Table 7.2 showed, the percentage of commuting within the LCR decreased between 2001 and 2011. However, due to spatial variations in the locations of residences and workplaces, changes in commuting outflows, inflows and self-containment will not have been uniform across the LCR. Understanding spatial variations in these measures at a relatively fine spatial scale across the LCR is important from a transport policy perspective, with substantial changes in commuting flows having implications for the development of existing networks and the supply of new transport infrastructure. Policy makers may also seek to encourage certain commuting behaviours, such as walking and cycling to work, while discouraging others, such as commuting to work by car, and may wish to tailor or focus their efforts in different areas. For instance, notwithstanding the possibility of long-distance commutes being self-contained within a geographically large LAD, those MSOAs with high levels of commuting self-containment are likely to be more receptive to the provision of cycle routes and the promotion of walking and cycling in general as commuters resident in those MSOAs are likely to be travelling shorter distances to work and therefore be more able to commute by bicycle or on foot (see Chapter 6). Therefore, this section uses 2001 and 2011 census interaction data to examine spatial variations and decadal changes in out-commuting, in-commuting and commuting self-containment in the LCR at MSOA level, with all commutes originating in the LCR being included in the analyses of outflows and inflows, regardless of their destination.

7.3.1 MSOA variations in out-commuting

Figure 7.1(A) shows the largest outflows of commuters are generally from MSOAs covering suburban areas of the LCR, such as those in Harrogate, York, north west and south east Leeds, north west Bradford and Ilkley. Conversely, the smallest outflows are generally from rural MSOAs and those covering city centres, such as those in Leeds, Bradford and Huddersfield. It is also noteworthy that the highest outflows appear to be concentrated in the West Yorkshire part of the LCR. The Bradford 019 MSOA, which is the MSOA covering Idle and Thorpe Edge in north-east Bradford, had the largest number of out-commuters in 2011, with 4,942 commuters leaving the MSOA. Conversely, the Craven 001 MSOA, which is the MSOA covering the villages of Bentham, Ingleton and Clapham, had the smallest number of out-commuters in 2011, with only 583 out-commuters.

Figure 7.1(B) shows that the largest increases in outflows have generally taken place in city centre and inner city MSOAs, particularly in two belts extending from south east to north west Leeds and from south east Bradford to north west Bradford. There have also been substantial increases in the central areas of Harrogate, York and Huddersfield and in the former mining and industrial areas of Normanton and Castleford in the Wakefield LAD. The largest decreases have been confined to more rural and suburban MSOAs in north York, east Leeds and along the M62 in north Wakefield, Batley, Mirfield and Brighouse. The largest increase in commuting outflows was for the Leeds 075 MSOA, which is the MSOA immediately to the east of Leeds City Centre covering Saxton Gardens, Richmond Hill and Cross Green, with the number of out-commuters increasing by 1,629 between 2001 and 2011. This increase is likely due to both the substantial number of city-living residential developments taking place in the area between 2001 and 2011 and the regeneration of nearby Leeds City Centre. Conversely, the largest decrease in commuting outflows was for the Leeds 077 MSOA, which is the MSOA covering East Garforth in east Leeds, with the number of out-commuters decreasing by 775 over the decade.

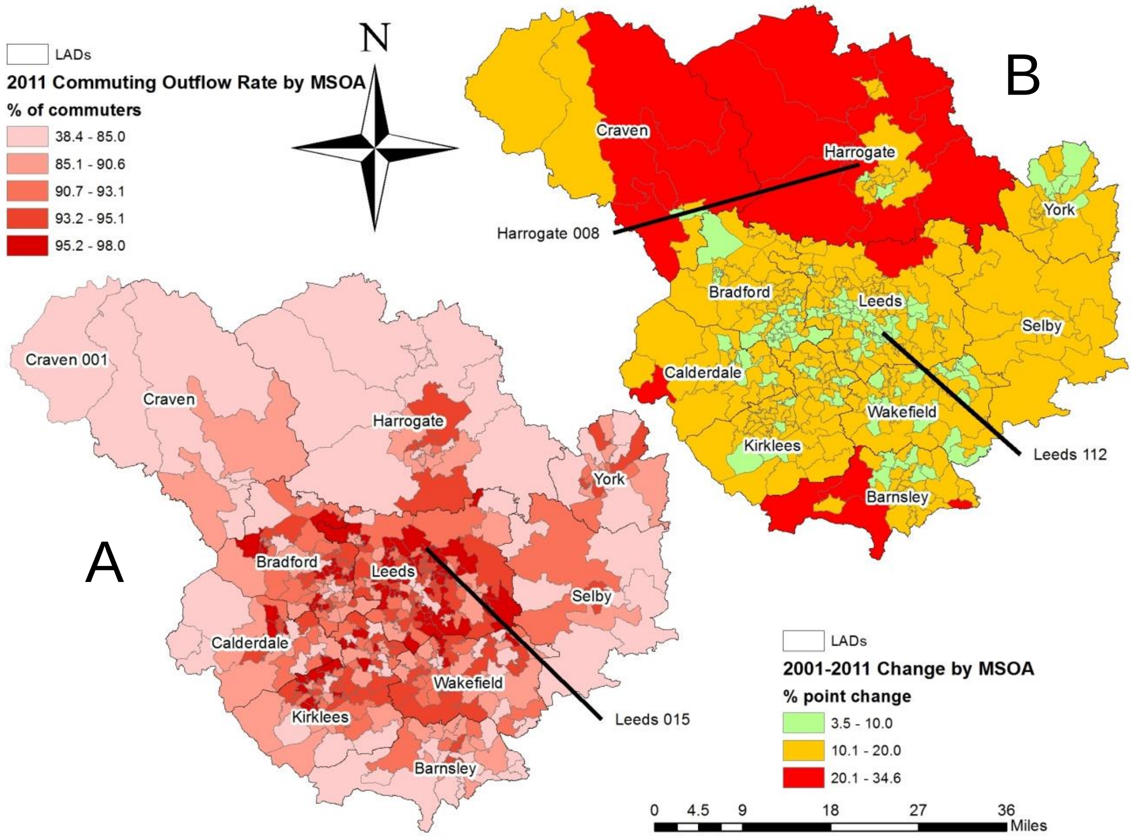


Source: Derived from the 2001 and 2011 Census SWS.

Figure 7.1: Number of commuters (excluding homeworkers) in the LCR aged 16+ in 2011 that commute out of each MSOA (A) and the changes between 2001 and 2011 (B) by MSOA

Figure 7.2(A) shows a largely similar pattern to that shown in Figure 7.1(A), with higher rates of out-commuting generally being seen in suburban areas and lower rates being seen in rural and city centre areas. The Leeds 015 MSOA, which is the MSOA covering the central and eastern parts of Alwoodley in north Leeds, had the largest percentage of out-commuters in 2011, with 98.0% of commuters commuting out of the MSOA. Conversely, the Craven 001 MSOA had the smallest percentage of out-commuters in 2011, with only 38.4% of commuters commuting out of the MSOA.

Figure 7.2(B) shows a very different overall pattern to that shown by Figure 7.1(B). While Figure 7.1(B) shows that there were increases and decreases in the absolute numbers of out-commuters across the LCR, Figure 7.2(B) shows that no MSOA experienced a decrease in its out-commuting rate between 2001 and 2011. This means that any decreases in the absolute numbers of out-commuters must have been driven by demographic change in an MSOA, as opposed to any change in the propensity of individuals in those MSOAs to out-commute. The largest percentage point increase in commuting outflows was for the Harrogate 008 MSOA, which is the MSOA covering the villages of Ripley, Nidd, Killinghall and Hampsthwaite to the north of Harrogate town centre, with the percentage of out-commuters increasing by 34.6 percentage points between 2001 and 2011. Conversely, the smallest percentage point increase in commuting outflows was for the Leeds 112 MSOA, which is the MSOA covering Hunslet and Stourton to the south east of Leeds City Centre, with the percentage of out-commuters increasing by only 3.5 percentage points over the decade.



Source: Derived from the 2001 and 2011 Census SWS.

Figure 7.2: Percentage of commuters (excluding homeworkers) in the LCR aged 16+ in 2011 that commute out of each MSOA (A) and the percentage point changes between 2001 and 2011 (B) by MSOA

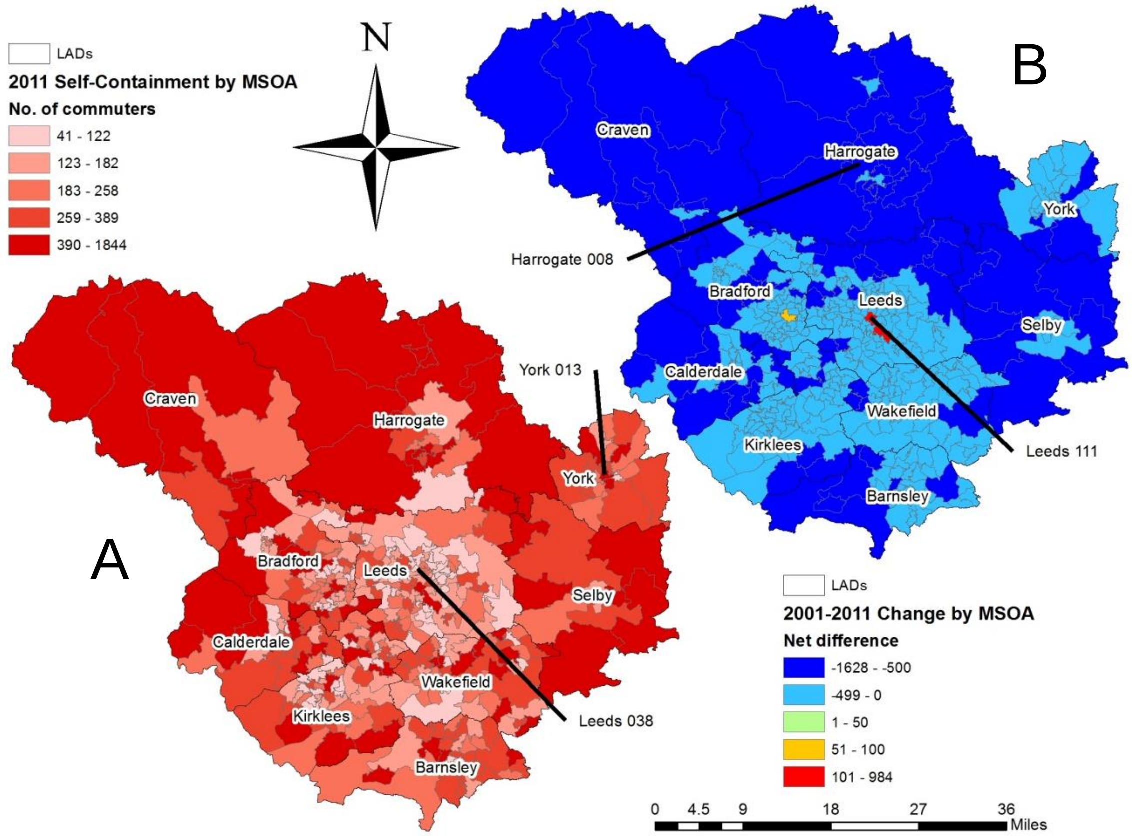
The patterns shown in Figure 7.1(A) and Figure 7.2(A) may be due to variations in age structure, employment rates, transport networks and land use. If an MSOA has a particularly large proportion of its population accounted for by working age individuals, then it is more likely to experience relatively high outflows as the population is more likely to be in employment. Conversely, if an MSOA has a particularly large proportion of its population accounted for by older or younger individuals, then it is less likely to experience a large outflow as many of its population will either be retired or in education. Similarly, if an MSOA has a high employment rate people in the MSOA are more likely to be commuting to work than people in an MSOA with a low employment rate. Variations in the availability and accessibility of transport networks may also affect outflows, with MSOA near or containing suburban train stations potentially experiencing larger outflows as the resident populations is more easily able to access relatively distant employment opportunities than those without easy access to the rail network. In the same way, MSOAs with easy access to motorways may experience larger outflows. Spatial variations in land use could potentially explain spatial variations in outflows as residents of MSOAs which also contain large industrial or commercial estates or cover city centre areas have more opportunities to live and work in the same MSOA than residents in MSOAs that cover largely residential areas.

Unlike with variations in commuting outflows, changes in the population sizes of MSOAs are a potential explanation for changes in commuting outflows between 2001 and 2011. Commuting outflow change and population change are correlated (R^2=0.637, $p<0.05$). The slope parameter of the OLS regression is 0.431 for population change, indicating that a one standard deviation increase in population change will lead to a 0.431 standard deviation increase in commuting outflow. However, in addition to population changes, if the patterns in Figure 7.1(A) and 7.2(A) are potentially explained by the aforementioned variables then the patterns shown in Figure 7.1(B) and Figure 7.2(B) are potentially explained by changes in these same variables. MSOAs that have seen increases in outflows may have experienced increases in their working population, either through demographic change or through changes in their employment rates, while decreases in outflows may be due to increases in the retired population or unemployment rate. Changes in transport networks and land use may also have had an effect on outflows, with the building of a new railway station, such as at Glasshoughton in Wakefield, or a new housing estate potentially increasing outflows and the building of a new industrial or commercial estate potentially decreasing outflows from the MSOA it is in, but also increasing outflows from MSOAs in the vicinity.

7.3.2 MSOA variations in commuting self-containment

Figure 7.3(A) shows that commuting self-containment, when excluding homeworkers, is generally higher for the geographically large and rural MSOAs in the western, northern and eastern parts of the LCR and for the small and urban MSOAs that cover the central areas of Leeds, Bradford, Huddersfield, Wakefield, York and Harrogate. Conversely, commuting self-containment is generally lower for the MSOAs covering suburban areas of Leeds, Bradford, Kirklees and Wakefield, producing an area of generally low self-containment in the West Yorkshire part of the LCR. The York 013 MSOA, which is the MSOA covering York City Centre, had the largest number of self-contained commuters in 2011, with 1,844 commuters commuting within the MSOA. Conversely, the Leeds 038 MSOA, which is the MSOA covering Potternewton to the north of Leeds City Centre, had the smallest number of self-contained commuters in 2011, with only 41 self-contained commuters.

Figure 7.3(B) shows that the vast majority of MSOAs experienced decreases in commuting self-containment between 2001 and 2011. There appears to be a slight urban-rural pattern to these changes, with the largest decreases generally being confined to very rural MSOAs in the Harrogate, Craven, Bradford, Calderdale and Barnsley LADs. The only MSOAs to experience a substantial increase in commuting self-containment are those covering the city centre areas of Leeds and Bradford. However, it must be kept in mind, when looking at Figure 7.3(B), that this self-containment data excludes homeworkers and therefore will not capture any increases in self-containment caused by increases in the number of individuals working at or from home. The largest increase in commuting self-containment was for the Leeds 111 MSOA, which is the MSOA covering Leeds City Centre, with the number of self-contained commuters increasing by 984 over the decade. This increase would be expected given the large number of riverside and city-living residential developments that have taken place in Leeds City Centre over the decade. Conversely, the largest decrease in commuting self-containment was for the Harrogate 008 MSOA, with the number of commuters commuting within the MSOA decreasing by 1,628 between 2001 and 2011.

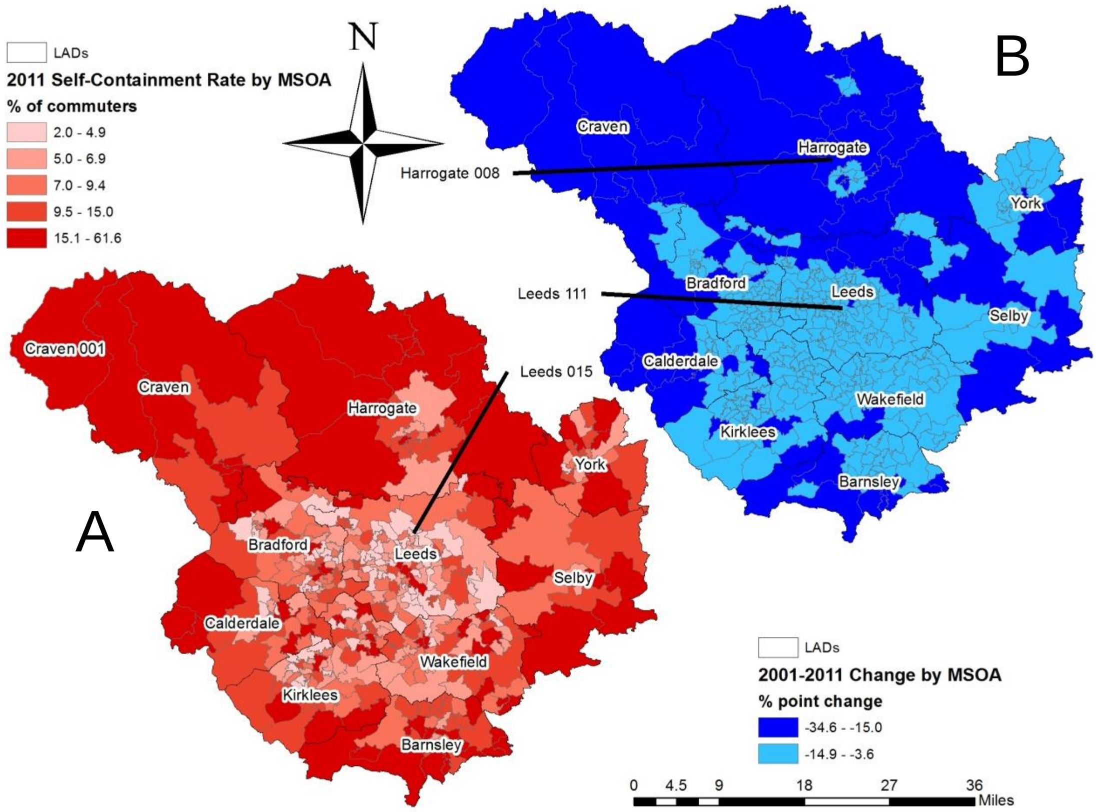


Source: Derived from the 2001 and 2011 Census SWS.

Figure 7.3: Number of commuters (excluding homeworkers) in the LCR aged 16+ in 2011 that commute within each MSOA (A) and the changes between 2001 and 2011 (B) by MSOA

As was the case with out-commuting, Figure 7.4(A) shows a largely similar pattern to that shown in Figure 7.3(A), with the highest rates of commuting self-containment generally being seen in city centre MSOAs and large rural MSOAs and the lowest rates of self-containment generally being seen in suburban MSOAs. The Craven 001 MSOA had the largest percentage of self-contained commuters in 2011, with 61.6% of commuters commuting within the MSOA. Conversely, the Leeds 015 MSOA had the smallest percentage of self-contained commuters in 2011, with only 2.0% of commuters commuting within the MSOA.

Figure 7.4(B) shows that every MSOA in the LCR experienced a decrease in its commuting self-containment rate between 2001 and 2011. Even the city centre MSOAs in Leeds and Bradford experienced decreases, meaning that any increase in the absolute numbers of self-contained commuters was driven by increases in the commuting population as opposed to any change in the propensity to commute within an MSOA. The smallest percentage point decrease in commuting self-containment was for the Leeds 111 MSOA, with the percentage of self-contained commuters decreasing by only 3.6 percentage points between 2001 and 2011. Conversely, the largest percentage point decrease in commuting self-containment was for the Harrogate 008 MSOA, with the percentage of self-contained commuters decreasing by 34.6 percentage points over the decade.



Source: Derived from the 2001 and 2011 Census SWS.

Figure 7.4: Percentage of commuters (excluding homeworkers) in the LCR aged 16+ in 2011 that commute within each MSOA (A) and the percentage point changes between 2001 and 2011 (B) by MSOA

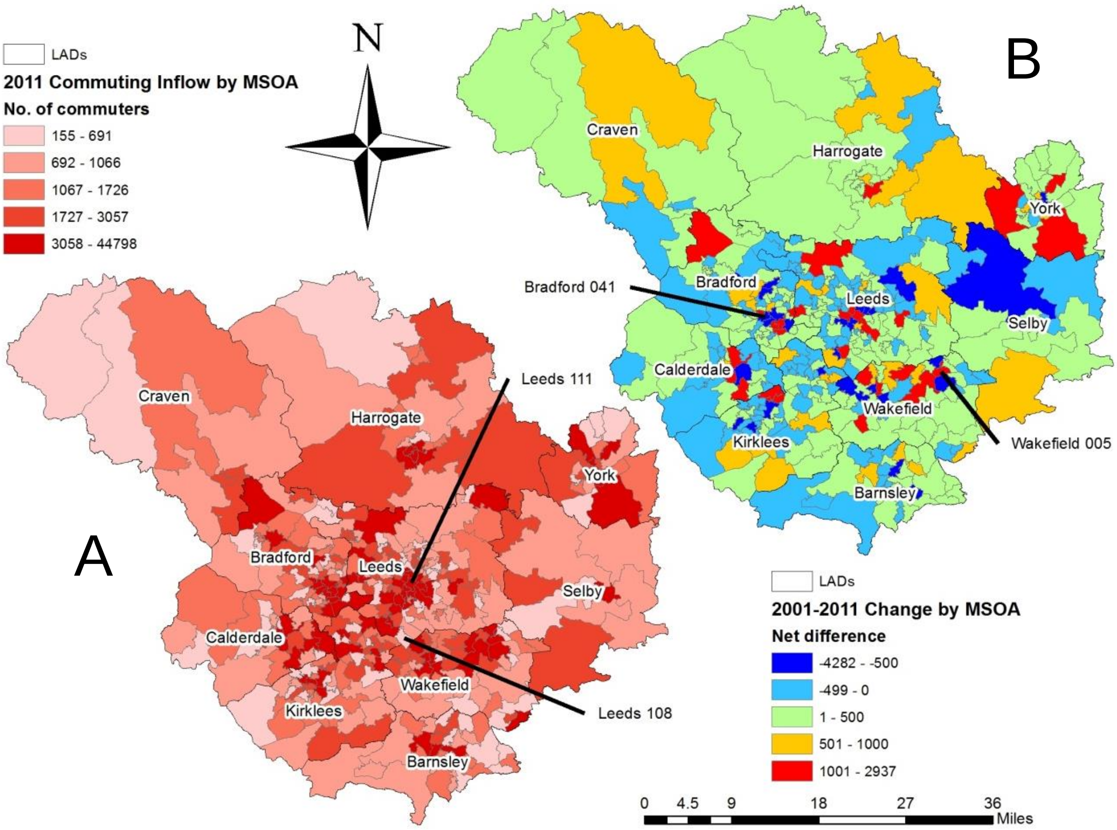
The patterns shown in Figure 7.3(A) and Figure 7.4(A) may be due to differences in the sizes of MSOAs, the locations of employment opportunities and variations in the prevalence of different modes of transport. Many of the larger MSOAs in the more rural areas of the LCR may have a large number of commutes within them as their larger size means that commuters would have to travel a longer distance to leave the MSOA than an equivalent commuter in one of the smaller MSOAs in the more urban areas. The MSOAs covering the city centre areas of Leeds, Bradford, Wakefield and York experience greater levels of self-containment as they are the locations of many employment opportunities, reducing the need for residents in those MSOAs to commute to other MSOAs for employment. Finally, many of the MSOAs that experience high levels of commuting self-containment are MSOAs with high prevalence of commuting to work by bicycle and on foot (see Figure 7.14), modes of transport which are associated with lower likelihoods of commuting long distances (see Chapter 5). Conversely, many of the MSOAs that experience low levels of commuting self-containment are MSOAs with high prevalence of commuting to work by train, bus and car (see Figures 7.11 and 7.12); modes of transport which are associated with higher likelihoods of commuting long distances (see Chapter 5).

The patterns shown in Figure 7.3(B) and Figure 7.4(B) may be partly due to general increases in commute distance (see Chapter 5), suburbanisation, urban regeneration and the rise of city centre living. Chapter 5 showed that those who commute short distances are more likely to work within their LAD of residence, while commuters who commute long distances are less likely to work within their LAD of residence, this same relationship can be applied at the MSOA level. Therefore, an increase in the prevalence of very long-distance commuting is likely to lead to a reduction in commuting self-containment at MSOA level. As was the case at the LAD level, continuing suburbanisation (Grey *et al.*, 2003) means that many people are living further away from their places of work, and are therefore more likely to live and work in different MSOAs. Urbanisation and the rise of city centre living (Tallon and Bromley, 2004) means that the MSOAs covering the city centres of Leeds and Bradford are likely to have seen both an increase in employment opportunities and an increase in working population between 2001 and 2011. It is likely that the increased levels of commuting self-containment seen for these MSOAs is due to more working age people living in them and more of these people having the opportunity to work in them. Commuting self-containment and the working age population are slightly correlated (R^2=0.072, $p<0.05$). The slope parameter of the OLS regression is 0.041 for the working age population, indicating that a one standard deviation increase in the working age population will lead to a 0.041 standard deviation increase in commuting self-containment.

7.3.3 MSOA variations in in-commuting

Figure 7.5(A) shows the largest commuting inflows from other MSOAs in the LCR are into those MSOAs covering city centre and inner city areas, with particular concentrations in central Leeds, Bradford, Harrogate, Wakefield, Huddersfield and Barnsley. However, there are some more suburban and rural MSOAs which also experience high inflows, such as those in York, Wetherby, Castleford, Normanton, Pontefract, the MSOA covering Steeton and Silsden and the MSOA containing Leeds-Bradford Airport. The Leeds 111 MSOA, which is the MSOA covering Leeds City Centre, had the largest number of in-commuters in 2011, with 44,798 commuters commuting into the MSOA. Conversely, the Leeds 108 MSOA, which is the MSOA covering Tingley and West Ardsley, had the smallest number of in-commuters in 2011, with only 155 in-commuters.

Figure 7.5(B) shows that the largest increases and decreases in commuting inflows have been seen in MSOAs relatively close to each other in central Leeds, central Bradford, Halifax, Wakefield, Normanton, Castleford and Pontefract. In central Leeds, the MSOAs covering the city centre, universities and further education colleges have seen substantial increases in inflows, while those MSOAs covering the surrounding areas have seen substantial decreases in inflows. Interestingly, this pattern is reversed in central Bradford, with the MSOAs covering the city centre, university and further education college experiencing substantial decreases in commuting inflows while some neighbouring MSOAs have seen substantial increases in inflows. There have also been substantial increases in inflows for MSOAs in outer York, south Harrogate, the MSOA covering Steeton and Silsden and the MSOA covering Leeds-Bradford Airport. The largest increase in commuting inflows was for the Wakefield 005 MSOA, which is the MSOA covering Glasshougton to the south of Castleford, with the number of in-commuters increasing by 2,937. Conversely, the largest decrease in commuting inflows was for the Bradford 041 MSOA, which is the MSOA covering Brown Royd and parts of Black Abbey, Lidget Green and Listerhills in west Bradford, with the number of in-commuters decreasing by 4,282.

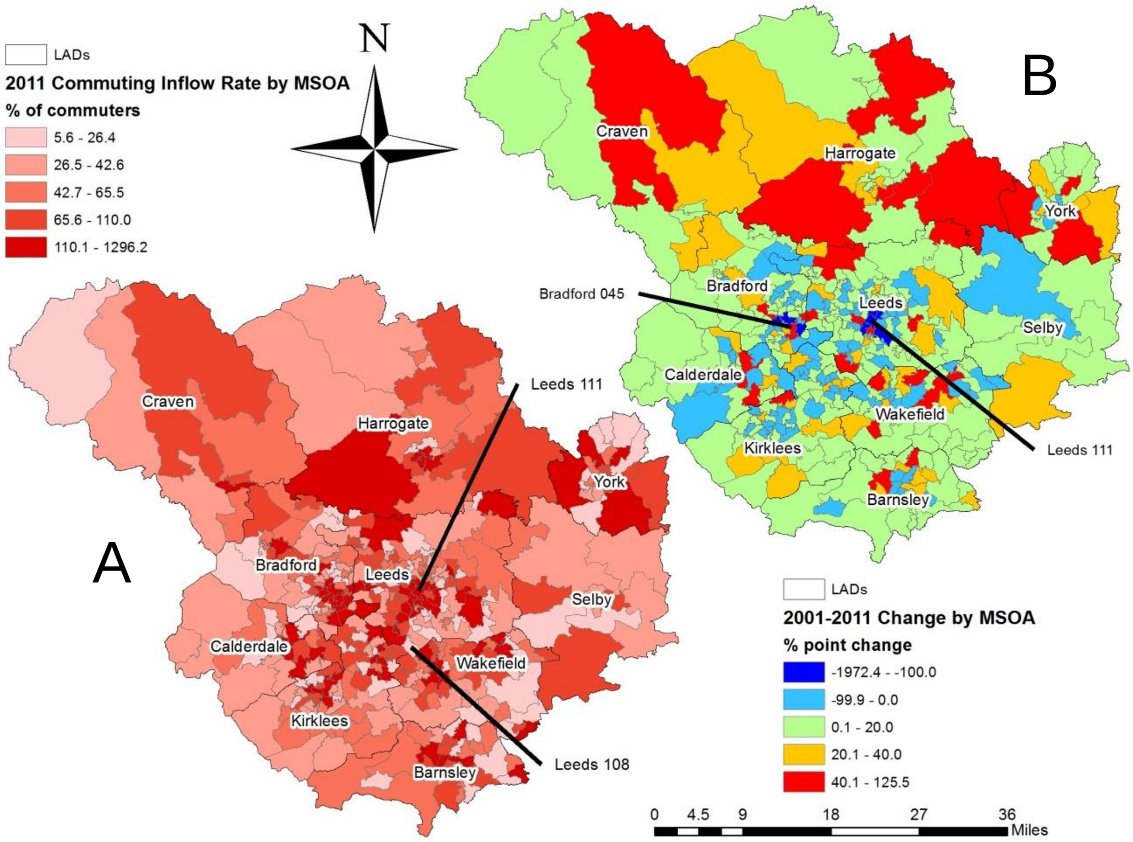


Source: Derived from the 2001 and 2011 Census SWS.

Figure 7.5: Number of commuters (excluding homeworkers) in the LCR aged 16+ in 2011 that commute into each MSOA (A) and the changes between 2001 and 2011 (B) by MSOA

As was the case with out-commuting and commuting self-containment, Figure 7.6(A) shows a largely similar pattern to that shown by Figure 7.5(A), with the highest rates of in-commuting generally being seen in city centre and inner city MSOAs and the lowest rates generally being seen in MSOAs further away from city centres. The Leeds 111 MSOA had the highest rate of in-commuting in 2011, with a rate of 1,296.2%. Conversely, the Leeds 108 MSOA had the lowest rate of in-commuting in 2011, with a rate of 5.6%.

Figure 7.6(B) shows a substantially different overall pattern to that shown by Figure 7.5(B). While Figure 7.5(B) showed that the MSOAs in central Leeds experienced large increases in absolute numbers of in-commuters, Figure 7.6(B) shows that those central MSOAs experienced the largest decreases in in-commuting rates between 2001 and 2011. This means that the resident commuting populations of those central MSOAs increased much more substantially than the number of commuters commuting into them. The largest percentage point increase in the rate of in-commuting was for the Bradford 045 MSOA, which is the MSOA immediately to the south east of Bradford City Centre covering Broomfields, New Leeds and East Bowling, with the in-commuting rate increasing by 125.5 percentage points between 2001 and 2011. Conversely, the largest percentage point decrease in the rate of in-commuting was for the Leeds 111 MSOA with the in-commuting rate decreasing by 1,972.4 percentage points over the decade.



Source: Derived from the 2001 and 2011 Census SWS.

Figure 7.6: Number of commuters (excluding homeworkers) in the LCR aged 16+ in 2011 that commute into each MSOA as a percentage of commuters in that MSOA (A) and the percentage point changes between 2001 and 2011 (B) by MSOA

Given the nature of commuting, the patterns shown in Figure 7.5(A) and Figure 7.6(A) are likely to be due to the location of major employment centres, with MSOAs with large inflows being more commercial or industrial in nature and containing many employment opportunities, and MSOAs with small inflows being more suburban or rural in nature and containing fewer places of employment. The areas of central Leeds and Bradford experiencing large inflows is due to the location of major hospitals, universities, further education colleges and a concentration of finance, retail and leisure facilities in these areas, and the resultant number of employment opportunities these provide. However, outside of the central urban areas, there are some specific anomalies, with MSOAs outside of urban areas having large commuting inflows, to take account of. The MSOAs in north west Bradford and Wetherby contain Airedale General Hospital and Thorpe Arch Estate, respectively. The MSOAs in the eastern part of Wakefield LAD contain the Hopetown industrial estate and Glasshoughton retail park, which are both located adjacent to the M62 motorway. Finally, the MSOAs in north west, north east and south York contain Clifton Moor Retail Park, Monks Cross Shopping Park and the University of York, respectively.

The patterns shown in Figure 7.5(B) and Figure 7.6(B) are likely due to changes in the locations of workplaces between 2001 and 2011, with both physical changes of location and changes in the importance of different industries contributing to the changes. Increases in inflows to MSOAs that contain commercial, retail and leisure centres, such as those in central Leeds, could be explained by the continued tertiarisation of the economy (ONS, 2013vii), while decreases in inflows to MSOAs that contain mining or manufacturing industry, such as those in south east Leeds, Huddersfield and Wakefield, could be explained by the continued decline of low-value and low-productivity manufacturing (Fothergill and Gore, 2013). The decreases in central Bradford may be due to stalled urban regeneration, as old commercial and industrial developments were demolished and not replaced with the Broadway shopping centre until 2015 (BBC, 2015x).

7.4 Commuting in the Leeds City Region

The LCR has experienced major economic growth and urban development in recent years, with Leeds being part of the 'Core Cities Group' (Core Cities, 2016). However, Table 7.3 shows that commuting rates have remained stable at 64.6% in 2001 and 64.7% in 2011. This means that the LCR compares favourably with England and Wales overall (see Chapter 4), with the LCR commuting rate being 1.8 percentage points higher than the national average in 2001 and 0.2 percentage points higher in 2011, albeit with the LCR commuting rate increasing much less than the national commuting rate over the decade.

7.4.1 Sociodemographic variations in commuting

Although the commuting rate in the LCR increased marginally between 2001 and 2011, this increase was not uniform across different sociodemographic groups due to on-going economic and social processes. Understanding these sociodemographic variations is important as LCR policy makers may wish to target economic and transport policies towards the specific sociodemographic groups that show the most room for improvement.

Table 7.3: Commuting numbers and rates for all individuals (including homeworkers) in the LCR (excluding Craven LAD) aged 16-74 in 2001 and 2011 and the percentage point changes between 2001 and 2011 by sex, age group, ethnic group, LLTI and dependent children

Sociodemographic Variables and Categories		Number of Commuters		Population 16-74		Commuting Rate (%)		% Point Change
Variables	Categories	2001	2011	2001	2011	2001	2011	01-11
Leeds City Region*		59,037	62,064	91,371	95,929	64.6	64.7	0.1
Sex	Male	32,120	32,532	44,993	46,836	71.4	69.5	-1.9
	Female	26,917	29,532	46,378	49,093	58.0	60.2	2.1
Age Group	16-24	6,724	6,872	9,315	9,872	72.2	69.6	-2.6
	25-64	51,597	53,898	70,943	73,540	72.7	73.3	0.6
	65-74	716	1,294	11,113	12,517	6.4	10.3	3.9
Ethnic Group	White	55,932	55,677	84,929	84,623	65.9	65.8	-0.1
	Indian	828	1,129	1,298	1,718	63.8	65.7	1.9
	Pakistani	1,160	2,298	3,138	4,810	37.0	47.8	10.8
	Bangladeshi	85	180	229	384	37.1	46.9	9.8
	Black	392	989	634	1,486	61.8	66.6	4.7
	Chinese	116	230	184	360	63.0	63.9	0.8
	Other	429	1,087	741	1,781	57.9	61.0	3.1
LLTI	LLTI	4,134	4,404	17,856	17,519	23.2	25.1	2.0
	No LLTI	54,903	57,660	73,515	78,410	74.7	73.5	-1.1
Dependent Children	No Dependent Children	33,618	38,672	57,383	64,676	58.6	59.8	1.2
	Dependent Children	25,419	23,392	33,988	31,253	74.8	74.8	0.1

Source: Derived from the 2001 and 2011 I-SARs.

As was the case for England and Wales (see Chapter 4), the age group which saw the largest increase in commuting rate was those aged 65-74, with an increase of 3.9 percentage points, while the 16-24 age group commuting rate decreased by 2.6 percentage points over the same period. The only ethnic group to experience a decrease in the number of commuters, number of residents and commuting rate between 2001 and 2011 was the White ethnic group, with the commuting rate decreasing slightly to 65.8%. However, this means that the White ethnic group still had the second highest commuting rate of all ethnicities, being slightly lower that the 66.6% seen for the Black ethnic group in 2011. Despite substantial increases and convergence in commuting rates, the Pakistani and Bangladeshi ethnic groups continued to experience the lowest commuting rates of 47.8% and 46.9%, respectively, in 2011. However, these same two groups experienced major increases in their commuting rates over the decade. There was also some convergence between the groups with and without a LLTI between 2001 and 2011. While the commuting rate for those with a LLTI increased by 2 percentage points, the rate for those without a LLTI decreased by 1.1 percentage points, although the commuting rate for those with a LLTI (25.1%) remains substantially lower than for those without a LLTI (73.5%). The commuting rates for those with and without dependent children increased, albeit only slightly for those with dependent children.

Overall, there are some similarities and some differences with the national commuting rates, and changes in them, seen in Chapter 4. The major differences are seen for the male, White, no LLTI and no dependent children and dependent children sociodemographic groups. While males in the LCR experienced a decrease in commuting rate between 2001 and 2011, the rates for males across England and Wales increased, albeit only slightly, by 0.1 percentage points. This relatively slight difference may be due to the LCR containing substantial former mining and industrial areas, with males in the LCR potentially seeing a decrease due to disproportionate job losses in manufacturing and mining as a result of continued deindustrialisation (Cumbers *et al.*, 2006).

While the commuting rate for White individuals in the LCR decreased slightly over the decade, their commuting rate across England and Wales increased by a substantial 4.1 percentage points. This major difference may be due to demographic differences between the LCR 'White' population and the England and Wales 'White' population with the former containing a lower proportion of 'Other White' individuals, while England and Wales as a whole experienced a substantial increase in this 'Other White' population between 2001 and 2011 due to immigration from A8 EU countries (ONS, 2007). 2011 Census data shows that while 5.2% of the England and Wales 'White' population is classed as 'Other White', the proportion in LCR is only 3%.

Although the commuting rate for those without a LLTI in the LCR decreased by 1.1 percentage points between 2001 and 2011, the same group saw an 11.0 percentage point increase across England and Wales. This difference may be due to differences in age structure, with the decrease in the LCR possibly being accounted for by proportionately more retired individuals in the population. 2011 Census data shows that while 13.8% of the England and Wales 16-74 population is retired, a slightly higher 14% of the LCR 16-74 population is retired.

Whereas those with no dependent children in the LCR saw a 1.2 percentage point increase in their commuting rate, the same group experienced a 4.4 percentage point decrease at the national level. A similarly substantial difference, albeit in the opposite direction is seen for those with dependent children, with those in the LCR experiencing a 0.1 percentage point increase over the same period that those across England and Wales experienced a 24.9 percentage point increase. These differences may be due to urban regeneration (Tallon, 2013), gentrification and the rise of city centre living (Tallon and Bromley, 2004), with the LCR containing a number of large and medium sized urban areas that experienced these processes between 2001 and 2011.

7.4.2 LAD variations in commuting

In addition to sociodemographic variations in commuting rates, due to the economic and geographic processes of urban regeneration, gentrification and migration, the changes in commuting rates will not have been uniform across the LADs and MSOAs that constitute the LCR. Understanding these geographic variations is also important for LCR policy makers when planning and implementing economic and transport policies as it will highlight those areas most in need of economic development or high quality and high capacity transport networks.

Table 7.4 shows that the LAD variation in aggregate commuting numbers changed over the decade, with the largest increase of 32,394 commuters taking place in Leeds, an increase of 10.0% between 2001 and 2011. In contrast, the smallest increase in the number of commuters was in Craven, with an increase of only 1,884 or 7.3%. In both 2001 and 2011, the highest commuting intensities were seen for Harrogate, Selby and Craven, with 2011 commuting rates of 71.4%, 70.0% and 68.9% respectively, and the lowest intensities were seen for Barnsley and Bradford, with commuting rates of 60.8% and 59.8% in 2011. Kirklees was the only LAD to experience a decrease in its commuting rate between 2001 and 2011, with the rate decreasing slightly to 62.6%. The largest increase was seen for the Barnsley LAD, with an increase of 4.5 percentage points, meaning that by 2011 it had overtaken Bradford and no longer had the lowest commuting rate in the LCR.

Table 7.4: Commuting numbers and rates for all individuals (including homeworkers) in the LCR aged 16-74 in 2001 and 2011 and the percentage point changes between 2001 and 2011 by LAD

LCR LADs	Number of Commuters		Population 16-74		Commuting Rate (%)		% Point Change
	2001	2011	2001	2011	2001	2011	01-11
Leeds City Region	1,229,571	1,369,620	1,984,536	2,160,142	62.0	63.4	1.4
Barnsley	88,760	103,579	157,569	170,405	56.3	60.8	4.5
Bradford	191,252	218,937	326,778	366,217	58.5	59.8	1.3
Calderdale	88,034	96,645	136,731	148,766	64.4	65.0	0.6
Kirklees	174,021	192,397	277,601	307,194	62.7	62.6	-0.1
Leeds	322,831	355,225	520,479	560,849	62.0	63.3	1.3
Wakefield	138,020	151,828	228,151	240,997	60.5	63.0	2.5
Craven	25,716	27,600	38,146	40,056	67.4	68.9	1.5
Harrogate	75,757	81,402	109,225	114,038	69.4	71.4	2.0
Selby	37,878	43,286	55,309	61,831	68.5	70.0	1.5
York	87,302	98,721	134,547	149,789	64.9	65.9	1.0

Source: Derived from the 2001 and 2011 Census Aggregate Data.

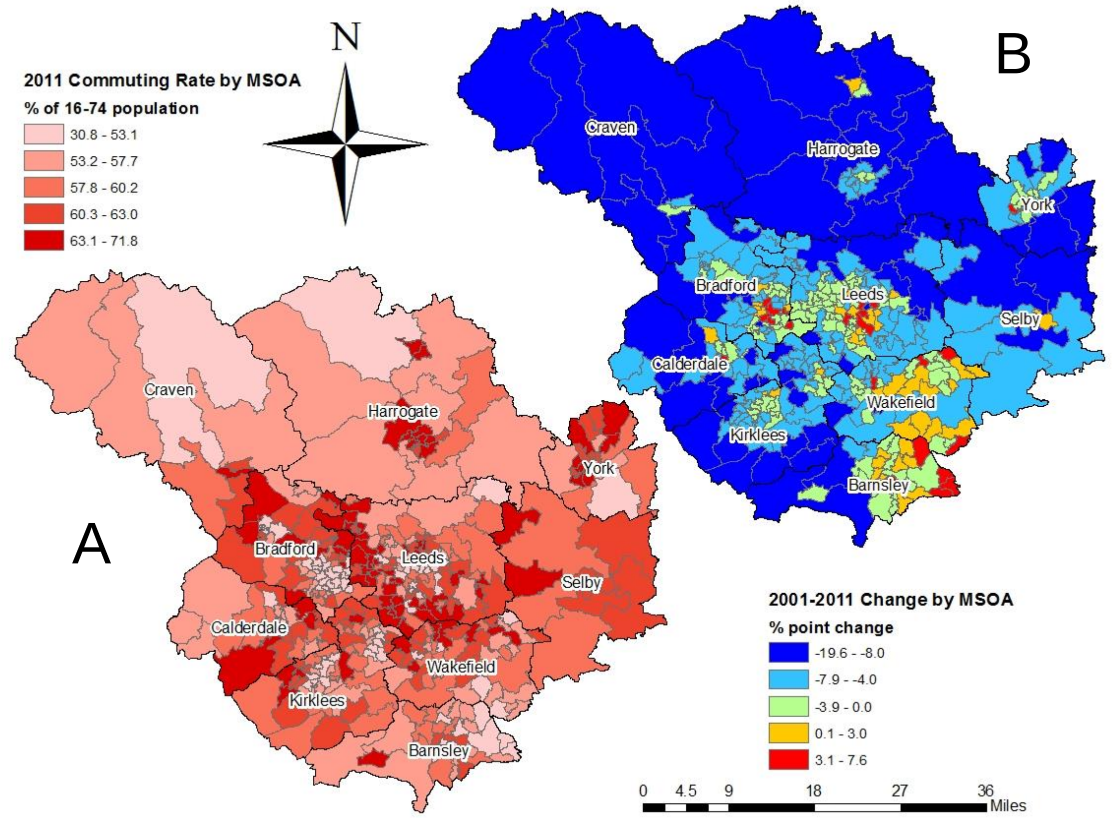
The overall increase in commuting rates between 2001 and 2011 may be due to general economic growth over the decade. With the UK economy experiencing increases in productivity, falling unemployment and overall growth during the decade (Corry *et al.*, 2011), it is likely that the LCR economy benefited from these trends and an increase in the commuting rate as a result. The specific increases in Leeds and Bradford could be due to urban regeneration (Tallon, 2013). The physical and economic regeneration experienced by Bradford and Leeds city centres is likely to have increased the number of employment opportunities in the affected areas and, therefore, reduced unemployment and economic inactivity.

Continued suburbanisation (Champion, 2001) may explain the increases in Harrogate, Selby, Barnsley and Wakefield. With a general increase in distances travelled to work (see Chapter 5), it is likely that LADs such as Harrogate, Selby, Barnsley and Wakefield have benefited from urban regeneration in Leeds and Bradford, with individuals in these more suburban and rural LADs taking advantage of the new employment opportunities available. The anomaly of Kirklees, with the number of commuters increasing by less than the total population, could potentially be explained by demographic change between 2001 and 2011. A large increase in the number of retired people in the 65-74 age group could explain the fall in the commuting rate. However, it could also be due to a disproportionate increase in the ethnic minority population, particularly the Pakistani and Bangladeshi populations, as these ethnic groups experience far lower commuting rates than the White ethnic group (see Table 7.3).

7.4.3 MSOA variations in commuting

Figure 7.7(A) shows the highest commuting rates (>62.1%) are generally seen in suburban areas and especially in a band stretching from north Wakefield through south, south west, west and north west Leeds to north Bradford. There are also clusters of MSOAs with high commuting rates in Ripon, Harrogate and York. The lowest commuting rates (<53.1%) are seen in the central areas of Bradford, Huddersfield and Dewsbury and the inner city areas of Leeds. There is also a cluster of MSOAs with low commuting rates in the east part of the Barnsley LAD and the south east part of the Wakefield LAD.

When changes in commuting rates between 2001 and 2011 are mapped (Figure 7.7(B)), a strong urban-rural divide is evident, with the largest increases (>3.1 percentage points) generally being seen in very urban MSOAs, especially in central Leeds and Bradford. The largest decreases (<-8.0 percentage points) have generally been seen in the more rural MSOAs on the edge of the LCR. This urban-rural divide in commuting rates is supported by Table 7.5, which shows that those areas classed as ‘rural’ by the ONS in the LCR generally have higher commuting rates than those areas classed as ‘urban’, ranging from 66.9% in ‘rural town and fringe’ areas to 70.2% in ‘rural village and dispersed’ areas. However, Table 7.5 also shows that commuting rates in urban areas generally increased more substantially over the decade, ranging from a 1.0 percentage point increase in ‘urban major conurbation’ areas to a 4.5 percentage point increase in ‘urban minor conurbation’ areas.



Source: Derived from the 2001 and 2011 Census Aggregate Data.

Figure 7.7: Commuting rates for all individuals (including homeworkers) in the LCR aged 16-74 in 2011 (A) and the percentage point changes between 2001 and 2011 (B) by MSOA

Given that commuting rates essentially measure those in employment, as was the case at the national level, the spatial variations in commuting rates evident in Figure 7.7(A) are likely to reflect differences in economic activity and employment rates. Within the LCR, the economic activity rate (R^2=0.945, $p<0.05$) and employment rate (R^2=0.885, $p<0.05$) of an MSOA are highly correlated with the commuting rate. The slope parameter of the OLS regression is 1.14 for the economic activity rate, indicating that a one standard deviation increase in the economic activity rate will lead to a 1.140 standard deviation increase in the commuting rate, while it is 0.629 for the employment rate, indicating that a one standard deviation increase in the employment activity rate will lead to a 0.629 standard deviation increase in the commuting rate.

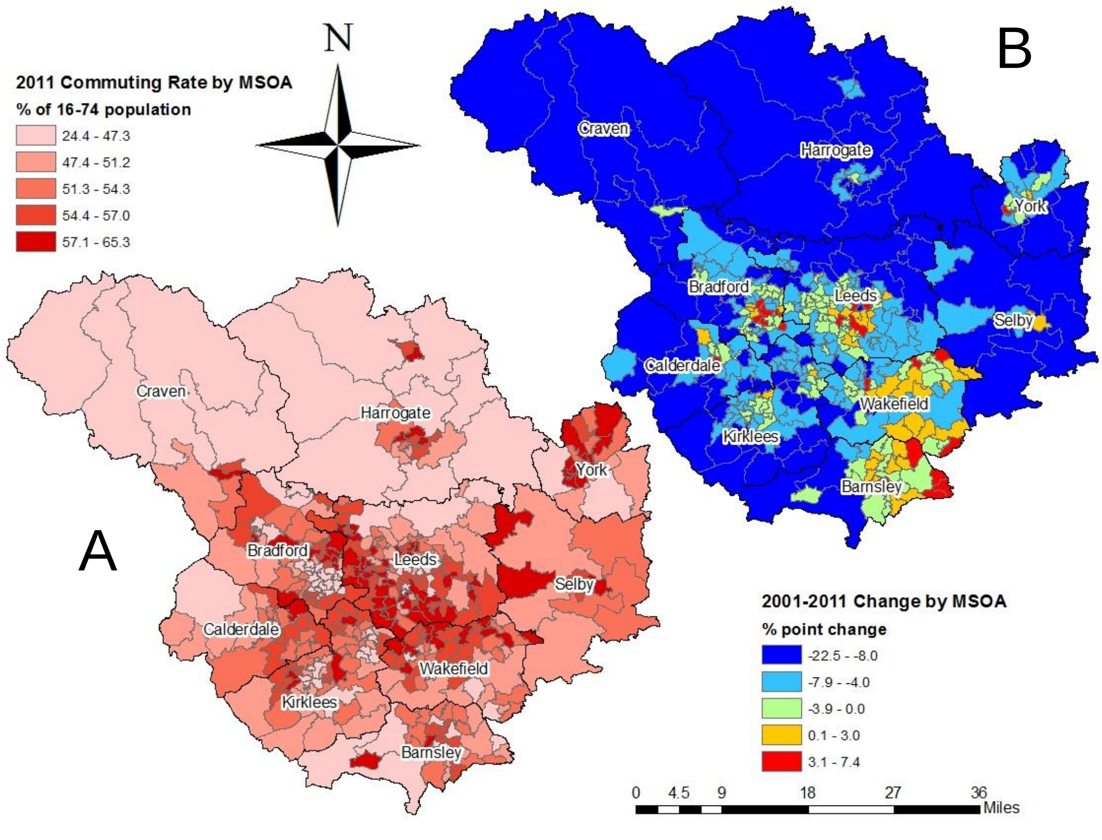
The urban-rural divide (Scott *et al.*, 2007), and changes in it, is likely to be important in explaining the patterns of change seen in Figure 7.7(B), with re-urbanisation, urban regeneration and the rise of city living potentially explaining the increases seen in city centre and inner city areas. Table 7.5 shows that while rural areas in the LCR generally experienced higher commuting rates in 2011 than urban areas, urban areas experienced a 2.1 percentage point increase in the commuting rate between 2001 and 2011 while rural areas experienced a 2.9 percentage point decrease.

7.4.4 MSOA variations in travel to work

As was the case with the rates for all commuters in Figure 7.7(A), Figure 7.8(A) shows that the highest travel to work rates (>57.1%) are seen in suburban areas and in the same band from north Wakefield to north Bradford. The exclusion of homeworkers accounts for the much lower commuting rates (<47.3%) in the rural MSOAs in the Craven and Harrogate LADs.

Figure 7.8(B) shows the same urban-rural divide in the changes in travel to work rates as shown in Figure 7.7(B). The highest increases in travel to work rates (>3.1 percentage points) have generally been in the city centre and inner city areas of Leeds and Bradford and the former mining and industrial areas of east Wakefield and east Barnsley.

This urban-rural divide in travel to work rates is supported by Table 7.5, which shows that the highest travel to work rate (59.6%) is seen for ‘urban city and town’ areas while the lowest rate (52.4%) is seen for ‘rural village and dispersed in a sparse setting’ areas. Table 7.5 also shows that while the three ‘urban’ areas all experienced percentage point increases in travel to work rates between 2001 and 2011, all three ‘rural’ areas experienced percentage point decreases.



Source: Derived from the 2001 and 2011 Census Aggregate Data.

Figure 7.8: Commuting rates for all individuals (excluding homeworkers) in the LCR aged 16-74 in 2011 (A) and the percentage point changes between 2001 and 2011 (B) by MSOA

As was the case with overall commuting rates (Figure 7.7(A)), the spatial patterns in travel to work rates seen in Figure 7.8(A) are likely due to spatial variations in economic activity and employment rates. The economic activity rate (R^2=0.852, $p<0.05$) and employment rate (R^2=0.713, $p<0.05$) of an MSOA are correlated with the travel to work rate. The slope parameter of the OLS regression is 0.977 for the economic activity rate, indicating that a one standard deviation increase in the economic activity rate will lead to a 0.977 standard deviation increase in the travel to work rate, while it is 0.510 for the employment rate, indicating that a one standard deviation increase in the employment rate will lead to a 0.510 standard deviation increase in the travel to work rate.

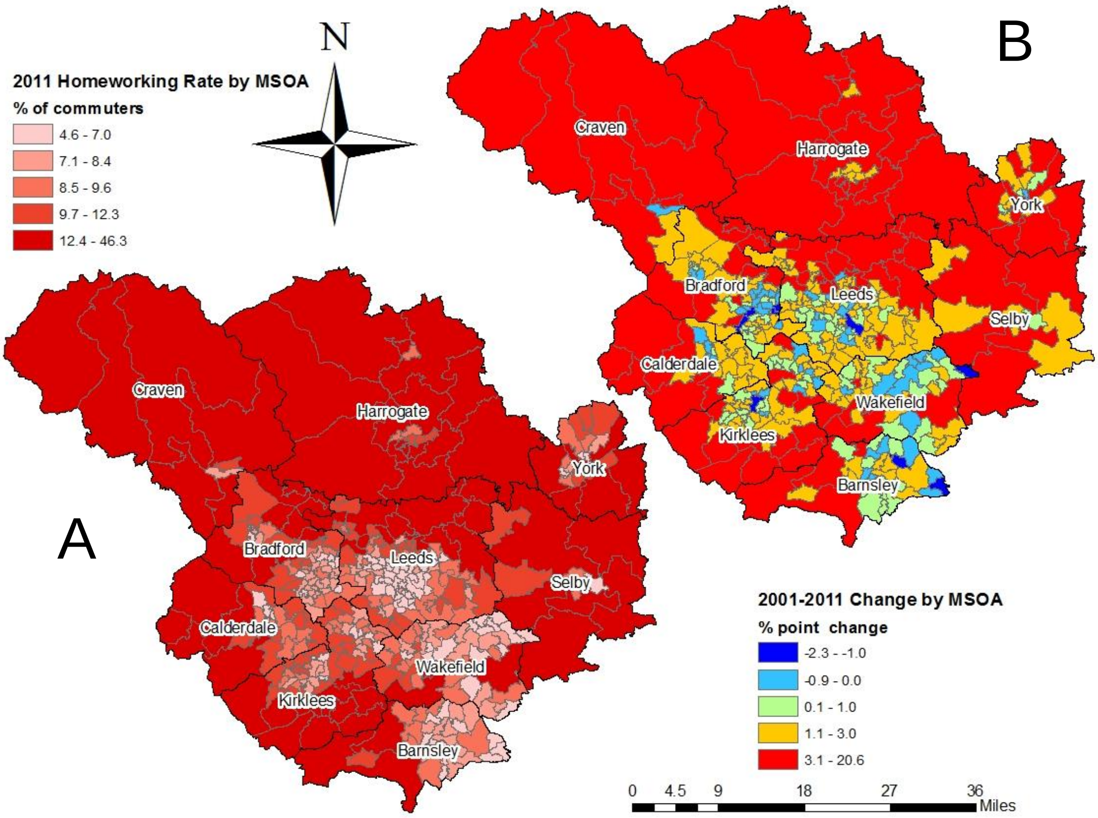
The spatial variations in change seen in Figure 7.8(B) are likely to reflect labour market changes. The decreases seen in the suburban and rural MSOAs may be due to demographic changes, with a larger proportion of the population being aged over 65 and retired. The percentage of retired people and an MSOAs travel to work rate are correlated (R^2=0.106, $p<0.05$). The slope parameter of the OLS regression is -0.448 for the percentage of retired people, indicating that a one standard deviation increase in percentage of retired people will lead to a 0.448 standard deviation decrease in the travel to work rate. Conversely, the increases seen in the central and inner city areas of Leeds and Bradford may reflect urban regeneration and the rise of city centre living as more young and working age individuals move to urban areas.

7.4.5 MSOA variations in homeworking

Figure 7.9 shows the spatial variation in homeworking rates in the LCR and the changes in homeworking rates between 2001 and 2011. Mirroring the divide at the national level (see Chapter 4), Figure 7.9(A) shows that homeworking rates are generally higher in rural MSOAs and lower in urban MSOAs.

Again reflecting the changes across England and Wales in Chapter 4, Figure 7.9(B) also shows an urban-rural divide in changes between 2001 and 2011 in the proportion of commuters who are homeworkers, with large increases mainly being seen in the rural MSOAs around the edges of the LCR and decreases being mainly being seen in the urban MSOAs. As was the case at the national level, it appears that the urban-rural divide in homeworking became more pronounced in the LCR over the decade, with urban MSOAs generally experiencing decreases in their already low homeworking rates and rural MSOAs generally experiencing increases in their already high homeworking rates.

This urban-rural divide in homeworking rates is again highlighted by Table 7.5, which shows that rural areas in the LCR generally have higher homeworking rates than urban areas, ranging from 12.0% in ‘rural town and fringe’ areas to 24.1% in ‘rural village and dispersed in a sparse setting’ areas. Table 7.5 also shows that homeworking rates in rural areas have increased more substantially over the decade, ranging from a 1.7 percentage point increase in ‘rural town and fringe’ areas to a 2.7 percentage point increase in ‘rural village and dispersed’ areas.



Source: Derived from the 2001 and 2011 Census Aggregate Data.

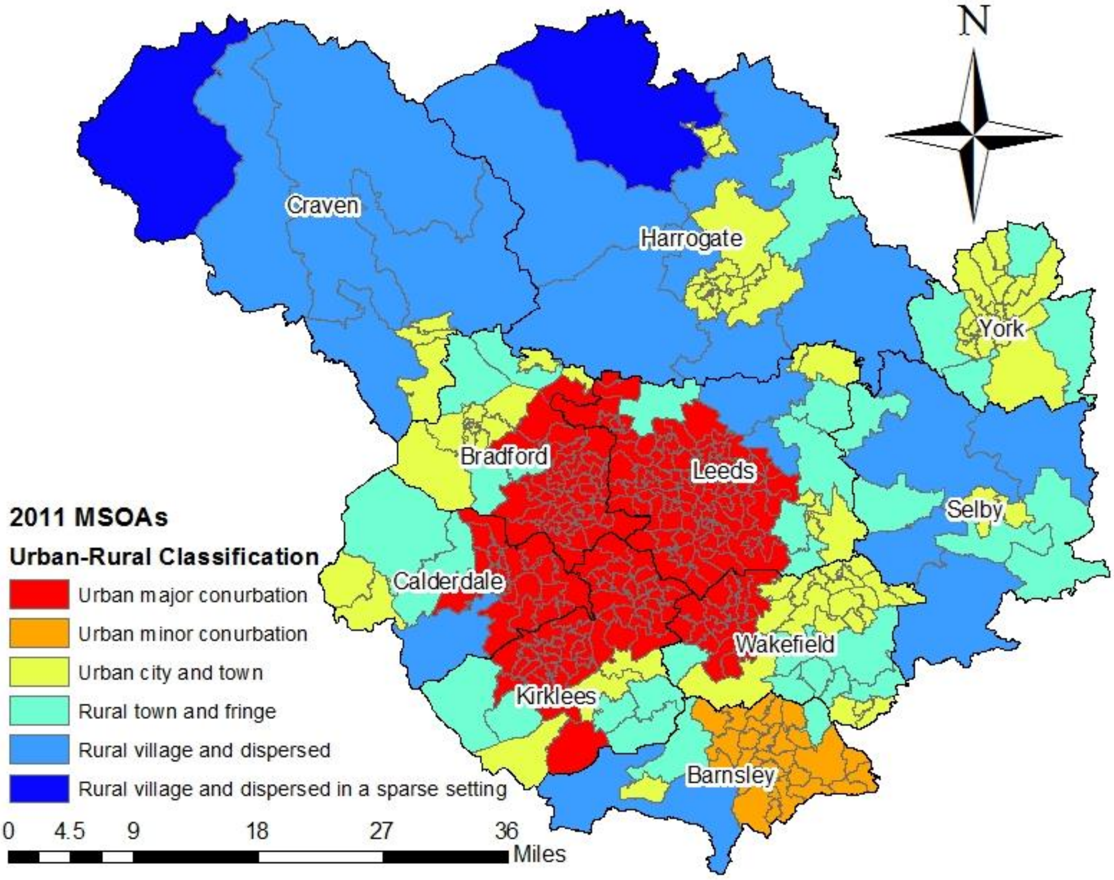
Figure 7.9: Percentage of commuters in the LCR aged 16-74 in 2011 that work at or from home (A) and the percentage point changes between 2001 and 2011 (B) by MSOA

The patterns shown in Figure 7.9(A) are likely to be due to the relative remoteness of the rural MSOAs, with individuals living in the rural MSOAs being further away from city centre employment opportunities than those living in the urban MSOAs. As a result of this relative remoteness, many rural dwellers in the LCR may choose to set up their own home-based businesses instead of making long and expensive commutes to Leeds or Bradford.

The patterns shown in Figure 7.9(B) may be partly due to demographic changes and urban regeneration. Those MSOAs which have experienced large increases in homeworking rates may have experienced an increase in the proportion of their population accounted for by those aged 65-74, who are more likely to work at or from home than younger workers (see Chapter 4). The proportion of people aged 65-74 is correlated with the homeworking rate in an MSOA (R^2=0.407, $p<0.05$). The slope parameter of the OLS regression is 0.541, indicating that a one standard deviation increase in the percentage of people aged 65-74 will lead to a 0.541 standard deviation increase in the homeworking rate. Conversely, those MSOAs which have experienced decreases in the homeworking rate may have experienced regeneration between 2001 and 2011 and, therefore, may have experienced an increase in non-homeworking employment opportunities as a result.

7.5 The Urban-Rural Divide in Commuting

Throughout this chapter, reference is made to the urban-rural divide when describing and explaining spatial variations in the different commuting rates and the modal split. Figure 7.10 shows the spatial distribution of urban and rural areas at MSOA level in the LCR according to the official 2011 ONS Rural-Urban Classification. This MSOA classification is built from the OA classification. According to the ONS (2011iii), an OA is ‘urban’ if it is allocated to a 2011 built-up area with a population of 10,000 or more, while an OA is ‘rural’ if it is not allocated to such an area. In the case of the LCR, with only six different categories, ‘urban’ areas are those classified as ‘urban major conurbation’, ‘urban minor conurbation’ and ‘urban city and town’, while ‘rural’ areas are those classified as ‘rural town and fringe’, ‘rural village and dispersed’ and ‘rural village and dispersed in a sparse setting’.



Source: Derived from the 2011 ONS Rural-Urban Classification.

Figure 7.10: The 2011 urban-rural classification in the LCR by MSOA

Table 7.5 summarises the 2011 commuting rates and the 2001-2011 changes in them using the 2011 MSOA urban-rural classification. Table 7.5 shows that the overall commuting rate is slightly higher in rural areas, albeit with substantial convergence between urban and rural areas taking place between 2001 and 2011. Conversely, the travel to work rate is higher in urban areas than rural areas and declined substantially in rural areas over the decade while increasing in urban areas. However, the opposite is the case for the homeworking rate, with the prevalence of homeworking being much higher in rural areas and also increasing much more substantially over the ten years.

Table 7.5: LCR MSOA commuting rates by the 2011 urban-rural classification

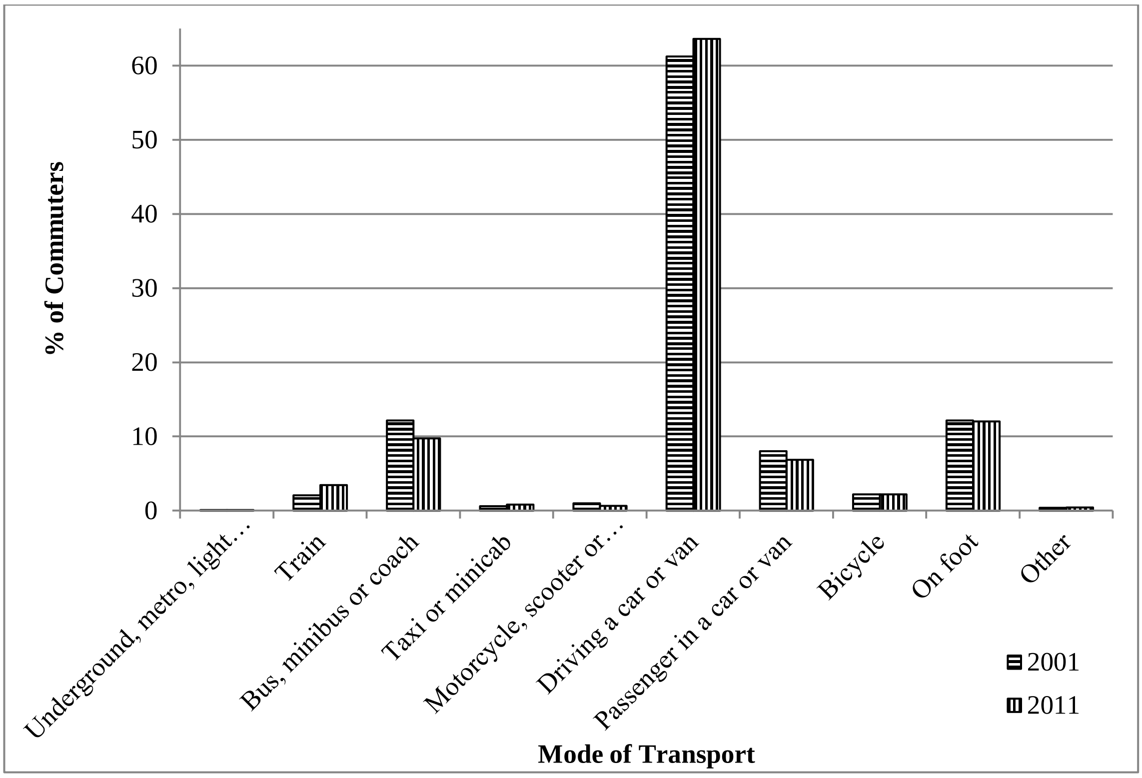
Commuting Rates and Modal Split Shares		2011 MSOA Urban-Rural Classification					
		Urban major con-urbation	Urban minor con-urbation	Urban city and town	Rural town and fringe	Rural village and dispersed	Rural village and dispersed in a sparse setting
Commuting Rate	2011%	61.9	60.2	65.7	66.9	70.2	69.0
	2001-2011 Change	1.0	4.5	1.9	1.0	1.1	0.7
Travel to Work Rate	2011%	56.8	56.0	59.6	58.8	57.2	52.4
	2001-2011 Change	0.5	4.1	1.0	-0.3	-1.0	-1.2
Homeworking Rate	2011%	8.2	7.0	9.3	12.0	18.5	24.1
	2001-2011 Change	0.7	0.1	1.1	1.7	2.7	2.5

Source: Derived from the 2001 and 2011 Census Aggregate Data.

7.6 Spatial and Temporal Variations in Modal Split in the Leeds City Region

The split between modes of travel to work in 2001 and 2011 in the LCR and the spatial variations and changes in the different modes at MSOA level are examined in this section using census aggregate data. As with the data at the national level (see Chapter 4), this modal split does not include homeworkers. Understanding spatial variations in the usage of different modes of transport and how these have changed over time is important for local and regional policy makers when making decisions about building new transport networks and improving existing infrastructure. If commuters in a local area are heavily dependent on their cars as a means of travelling to work, this could indicate that the area in question is in need of new or improved public transport networks. Policy makers can then make informed decisions about re-routing existing bus networks, opening a new railway station, as happened in Kirkstall in 2016, or building a new mass transit system, such as the Leeds Supertram, which was planned but not implemented.

Figure 7.11 shows that the modal split in the LCR did not change radically between 2001 and 2011. As across England and Wales, ‘driving a car or van’ accounted for the vast majority of commutes in both years. The small percentage of commutes taking place by ‘motorcycle, scooter or moped’ declined slightly from 1.0% to 0.7%, while the proportion using ‘taxi or minicab’ increased slightly from 0.6% to 0.8% and the ‘other’ category held steady at 0.4% in both years. Furthermore, due to the lack of an underground, metro, light rail or tram network in the LCR, the percentage of commutes taking place using this mode was almost zero in 2001 and 2011, with the small numbers using this mode accounted for by commuters who are resident in the LCR but who commute outside of it to places with underground, metro, light rail or tram networks. However, there were some noteworthy changes in the modal split. The percentage of commutes that were made by 'train' and 'driving a car or van' increased substantially, while the percentage of people traveling to work by 'bus, minibus or coach', as a 'passenger in a car or van' decreased substantially. The percentage of commuters traveling to work by bicycle remained the same at 2.2% and those commuting on foot declined by 0.1 percentage points to 12.0% in 2011. This means that, other than the lack of commutes taking place by 'underground, metro, light rail or tram', the modal split in the LCR is largely similar to that seen for England and Wales overall (see Chapter 4).



Source: Derived from the 2001 and 2011 Census Aggregate Data.

Figure 7.11: Commuting modal split in the LCR in 2001 and 2011 for all commuters (excluding homeworkers) aged 16-74

As at the national level, the changes in the LCR modal split between 2001 and 2011 are likely to reflect underlying economic and social changes in the region as well as alterations to the transport network or new transport policies. These factors include rising incomes, urban regeneration and the rise of city-centre living, changes in transport policies and changes in transport infrastructure.

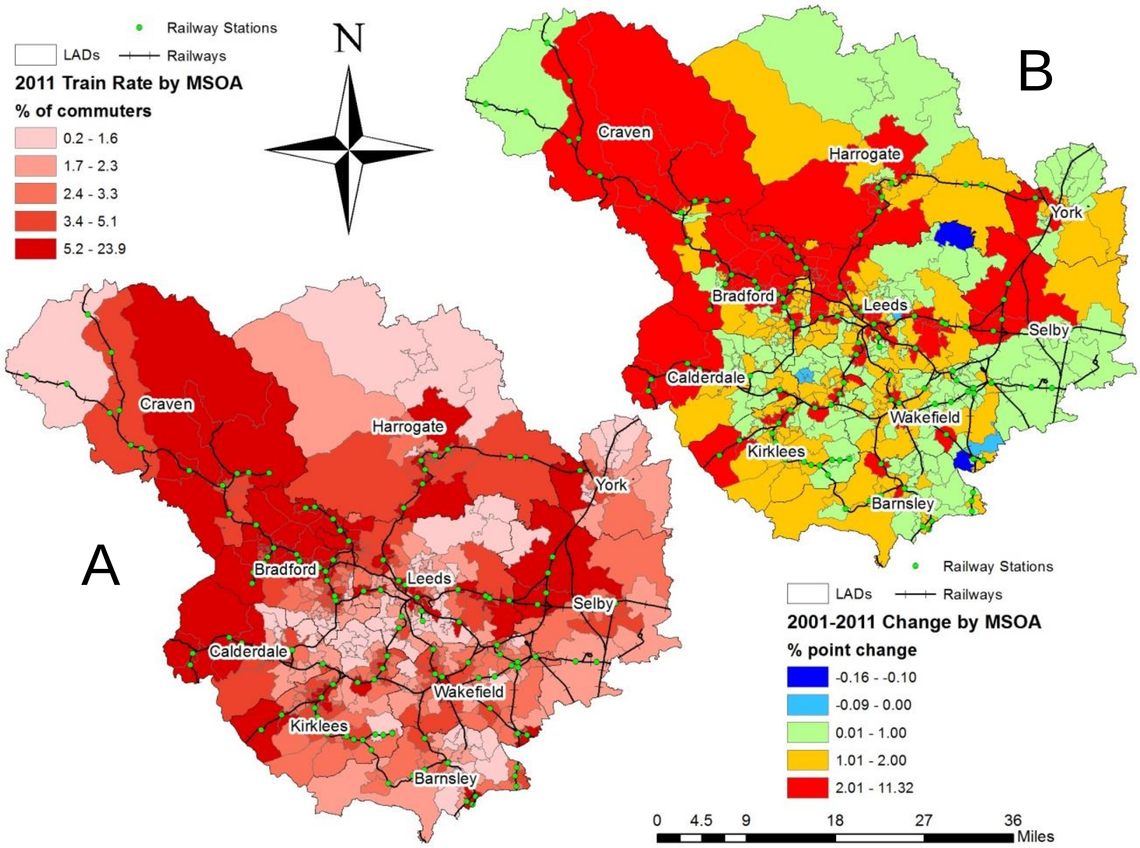
As outlined in Chapter 4, individual and household incomes increased between 2001 and 2011 (Levy, 2013). Higher personal incomes may account for the decrease in commuting as a passenger in a car or van and the increase in commuting by driving a car or van in the LCR as more people became able to afford cars and chose to commute using them (Dargay, 2007). The 2001-2011 period saw many of the urban areas of the LCR undergo extensive urban regeneration. This urban regeneration and accompanying rise in city centre living could explain the stability in commuting by bicycle and on foot, as those living in city centres and inner city areas are likely to live close to their workplace and, therefore, are more likely to cycle or walk to work. Improvements to the existing railway infrastructure in the LCR took place over the decade, with the renovation of Leeds railway station in 2002 (Network Rail, 2012) and many smaller stations throughout the region. Improvements like these may partly account for the increase in commuting by train. However, they may also partly account for decreases in commuting by bus, minibus or coach, by making commuting by train more attractive to those already using public transport.

It should be noted that national level policy changes and social trends, such as the promotion of walking and cycling and increased environmental awareness (Lorenzoni *et al.*, 2007), may have influenced commuting behaviour in the LCR. National changes in the cost of commuting, such as changes in rail fares (BBC, 2013i, 2013iii, 2014, 2015vi, 2015ix) and changes in the costs of owning and running a car and the price of petrol (RAC, 2015) may also have influenced commuting behaviour in the LCR, with reductions in the real cost of owning and operating a car potentially explaining the substantial increase in commuting by car in the LCR, especially when combined with increased personal and household incomes (Levy, 2013).

7.6.1 MSOA variations in rail transport

Commuting by train is most prevalent (>5.2%) in a band of MSOAs stretching from Leeds city centre, through north west Leeds and into north Bradford and the Craven LAD. There are other clusters of high prevalence in Huddersfield, Harrogate and east Leeds. Conversely, it is least prevalent (<1.6%) in a band of MSOAs from north east Leeds, through north, east, south and south west Leeds and into the eastern parts of the Kirklees and Calderdale LADs.

The spatial pattern of changes shown in Figure 7.12(B) largely follows the same spatial patterns in Figure 7.12(A), with the largest increases (>2.0 percentage points) in commuting to work by train generally being seen in those MSOAs with the highest prevalence of commuting by train. Decreases in the prevalence of commuting by train have been confined to a handful of MSOAs in Wetherby, Cleckheaton and south east Wakefield.



Source: Derived from the 2001 and 2011 Census Aggregate Data.

Figure 7.12: Percentage of commuters (excluding homeworkers) in the LCR aged 16-74 in 2011 that commute to work by train (A) and the percentage point changes between 2001 and 2011 (B) by MSOA

As was the case at the national level, the pattern of commuting by rail in the LCR appears to be closely linked to proximity to the railway network, as shown in Figure 7.12. The parts of the LCR with a better developed rail network, such as north west Leeds and north Bradford, experience a substantially higher prevalence of commuting to work by train than those areas lacking access to the rail network, such as north, north east and south Leeds.

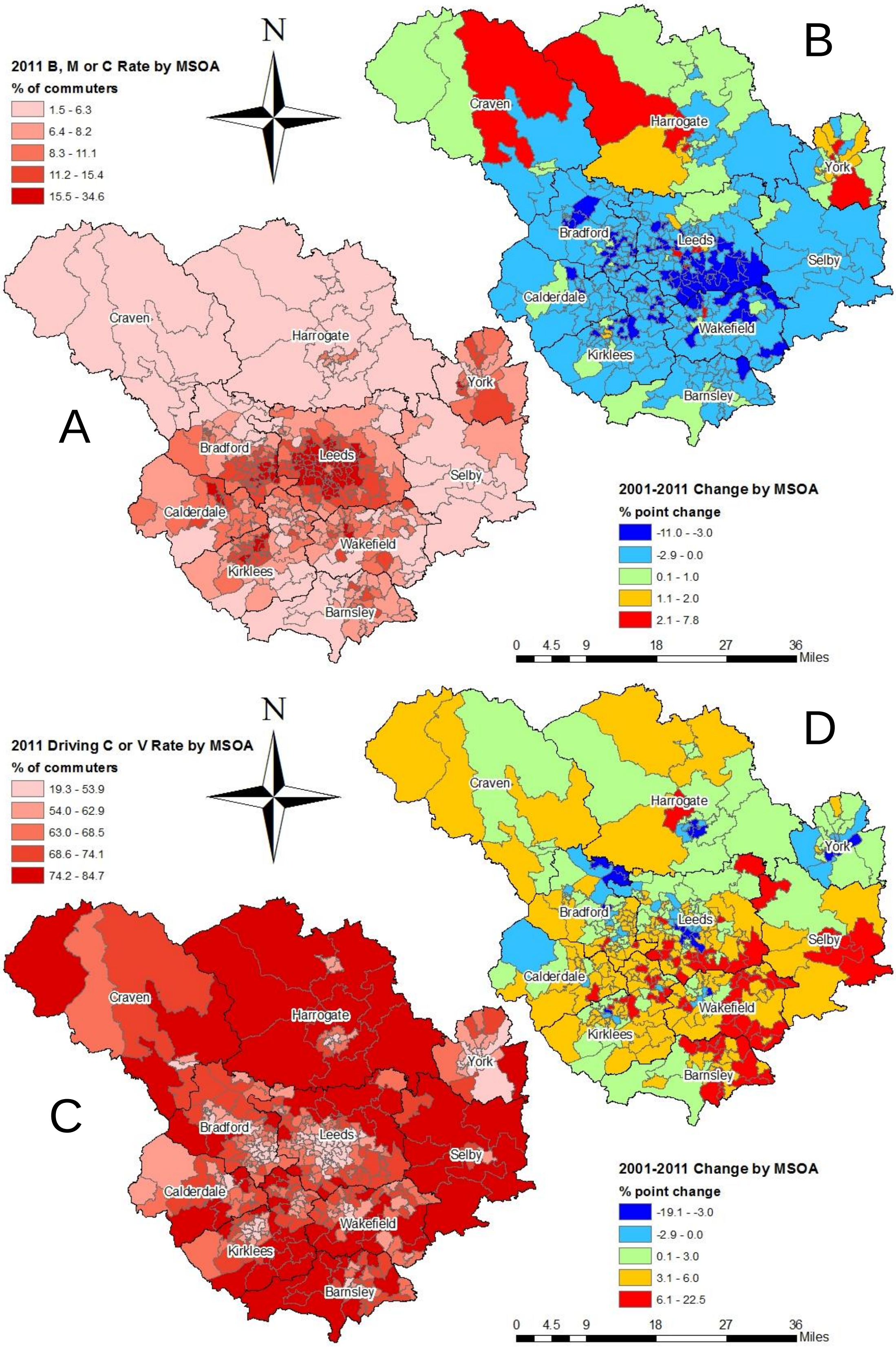
The general increase in train travel over the past 20 years (BBC, 2015iii) is likely to explain the general pattern of increase seen in Figure 7.12(B). Although the rail network in the LCR saw no extensions over the decade, as previously mentioned, Leeds railway station and many smaller stations were rebuilt or improved, potentially making train travel more attractive. Many commuters in the LCR may also have switched to commuting by train as it became relatively more attractive in terms of travel time (Kamba *et al.*, 2007), due to increased road traffic congestion resulting from the increased ownership and usage of cars. The prevalence of commuting by driving a car in an MSOA is negatively correlated with the prevalence of commuting by train (R^2=0.236, $p<0.05$). The slope parameter of the OLS regression is -0.255 for the prevalence of commuting by driving a car, indicating that a one standard deviation increase in the prevalence of commuting by driving a car will lead to a 0.255 standard deviation decrease in the prevalence of commuting by train.

7.6.2 MSOA variations in road transport

Figure 7.13(A) shows a very strong urban-rural contrast in commuting to work by bus, minibus or coach, with the highest shares (>15.5%) being exclusively seen in the urban MSOAs covering Leeds and the central areas Bradford, Halifax, Huddersfield and Wakefield. the lowest shares (<6.3%) are generally seen in rural MSOAs in the Craven, Harrogate, Selby and Barnsley LADs. Figure 7.13(B) indicates that there was a general decrease in the prevalence of commuting to work by bus across the LCR. The most substantial decreases (<-3.0 percentage points) are concentrated in east, south east and south Leeds and the northern part of Wakefield LAD. There are also clusters of substantial decreases in Keighley, central Bradford, Huddersfield and Dewsbury. Substantial increases in commuting by bus (>2.1 percentage points) have been confined to a very small number of rural MSOAs in Craven and Harrogate and suburban and urban MSOAs in York, Leeds and Wakefield.

Figure 7.13(C) shows the opposite urban-rural pattern in commuting to work by driving a car or van. The lowest shares (<53.9%) are confined to urban MSOAs in Leeds, Bradford, Keighley, Skipton, Harrogate, York, Selby, Wakefield, Barnsley, Huddersfield and Halifax, while the highest shares (>74.2%) are confined to more rural MSOAs, especially in the Harrogate and Selby LADs. A similar urban-rural divide is evident in the changes in commuting to work by driving a car or van in Figure 7.13(D). Decreases have generally been confined to city centre MSOAs in Leeds, Wakefield and York, while the largest increases (>6.1 percentage points) have been seen in the more suburban and rural MSOAs on the edge of the Leeds LAD and in the Selby, Wakefield and Barnsley LADs.

These urban-rural divides in commuting by bus, minibus or coach and driving a car or van are highlighted by Table 7.8. This table shows that urban areas generally have higher rates of commuting by bus, minibus or coach, ranging from 6.5% in 'urban city and town' areas to 12.5% in 'urban major conurbation' areas, while rural areas generally have higher rates of commuting by driving a car or van, ranging from 74.4% in 'rural town and fringe' areas to 79.8% in 'rural village and dispersed' areas. However, Table 7.8 also shows that the smallest percentage point decrease (-0.6) in commuting by bus, minibus or coach was seen for rural areas classed as 'rural village and dispersed', while the largest percentage point increase (5.6) in commuting by driving a car or van was seen for urban areas classed as 'urban minor conurbation'.



Source: Derived from the 2001 and 2011 Census Aggregate Data.

Figure 7.13: Percentage of commuters (excluding homeworkers) in the LCR aged 16-74 in 2011 that commute to work by bus, minibus or coach (B, M or C) (A) and by driving a car or van (Driving C or V) (C) and the percentage point changes between 2001 and 2011 (B and D) by MSOA

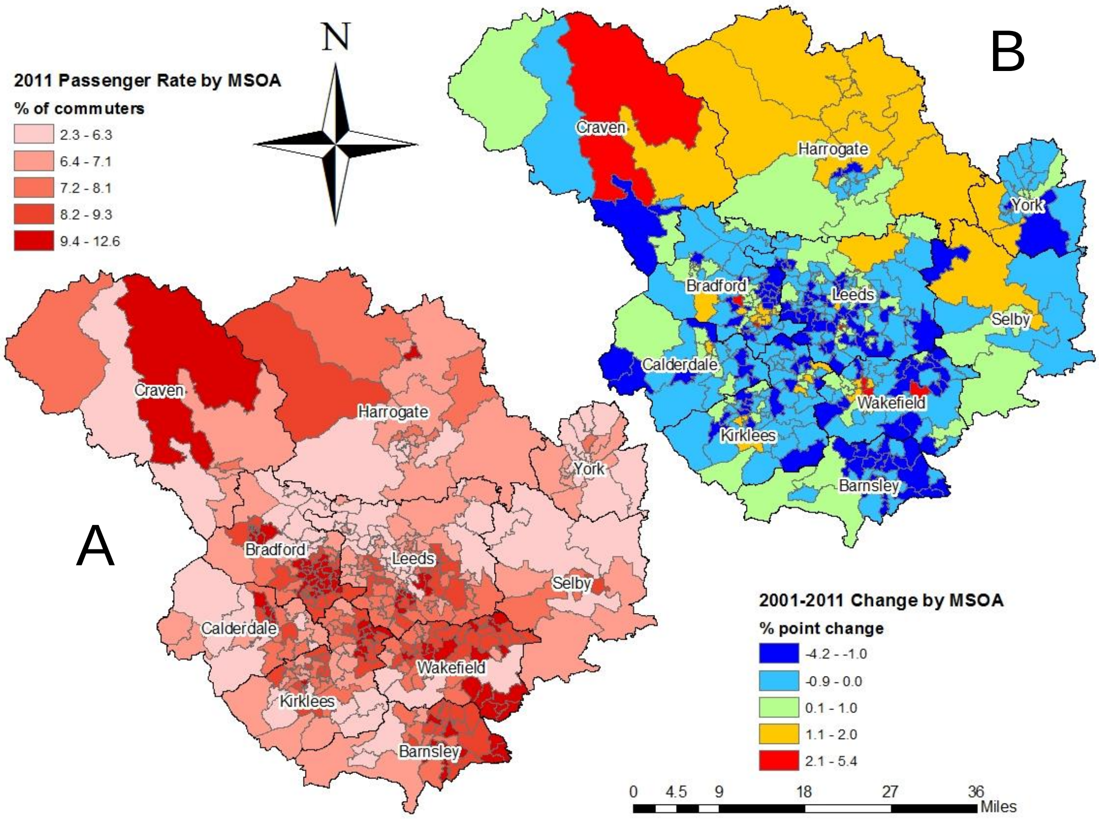
General decreases in the prevalence of commuting by bus and general increases in commuting by car may be due to increases in personal incomes (Levy, 2013), leading to increasing car ownership and usage (Dargay, 2007), or changes in local bus provision. However, as at the national level, any increases in commuting by bus and decreases in commuting by car potentially reflect greater environmental awareness amongst the population (Lorenzoni *et al.*, 2007), re-urbanisation and the rise of city living (Seo, 2002). These changes are likely to have occurred as bus travel is more environmentally friendly than car travel and individuals living in dense urban city centre and inner-city areas are likely to have better access to bus networks than those living in suburban and rural areas.

The general increase in commuting by car throughout the LCR may be due to increases in the cost of public transport, especially train travel (BBC, 2013i, 2013iii, 2014, 2015vi, 2015ix), making commuting by car relatively more financially attractive. Any decreases in commuting by bus and any increases in car travel in the more rural areas of the LCR may be due to the reduction and withdrawal of bus services subsidies in many rural areas (Gray *et al.*, 2006).

Despite these potential explanations for general trends, specific instances of increases or decreases in prevalence may also be due in part to local transport policies. The increased prevalence of bus travel in the York LAD may be due to the development of the extensive 'park and ride' network over the decade, with all major routes into York city centre now being served by park and ride facilities. Increases in commuting by bus in the handful of MSOAs in the Leeds and Wakefield LADs may be due changes in bus routes and changes in the provision of bus services.

Figure 7.14(A) shows a complex spatial distribution of commuting as a passenger in a car or van. There appears to be a slight urban-rural divide, with high shares (>9.4%) in Bradford, Dewsbury, Wakefield, Barnsley and East Leeds, and low shares (<6.3) in more rural areas, especially in the York and Selby LADs. However, this urban-rural divide is not exact, as there low shares in central York, Harrogate and north west Leeds. Map B in Figure 7.14 shows that the prevalence of commuting as a passenger in a car or van decreased in most MSOAs. However, there have been notable increases (>1.1 percentage points) in parts of Wakefield and Bradford and in some of the most rural MSOAs in the Craven and Harrogate LADs.

This urban-rural divide in commuting as a passenger in a car or van is supported by Table 7.8 which shows that urban areas generally have higher rates of commuting as a passenger in a car or van, ranging from 6.5% in 'urban city and town' areas to 8.1% in 'urban minor conurbation' areas. Conversely, the lowest rate (5.1%) of commuting as a passenger in a car or van is seen for 'rural village and dispersed' areas. However, Table 7.8 suggests that this urban-rural divide may be closing, with the largest percentage point decrease (-2.0) in commuting as a passenger in a car or van being seen for ‘urban minor conurbation’ areas and the smallest percentage point decrease (-0.2) being seen for ‘rural village and dispersed’ areas.



Source: Derived from the 2001 and 2011 Census Aggregate Data.

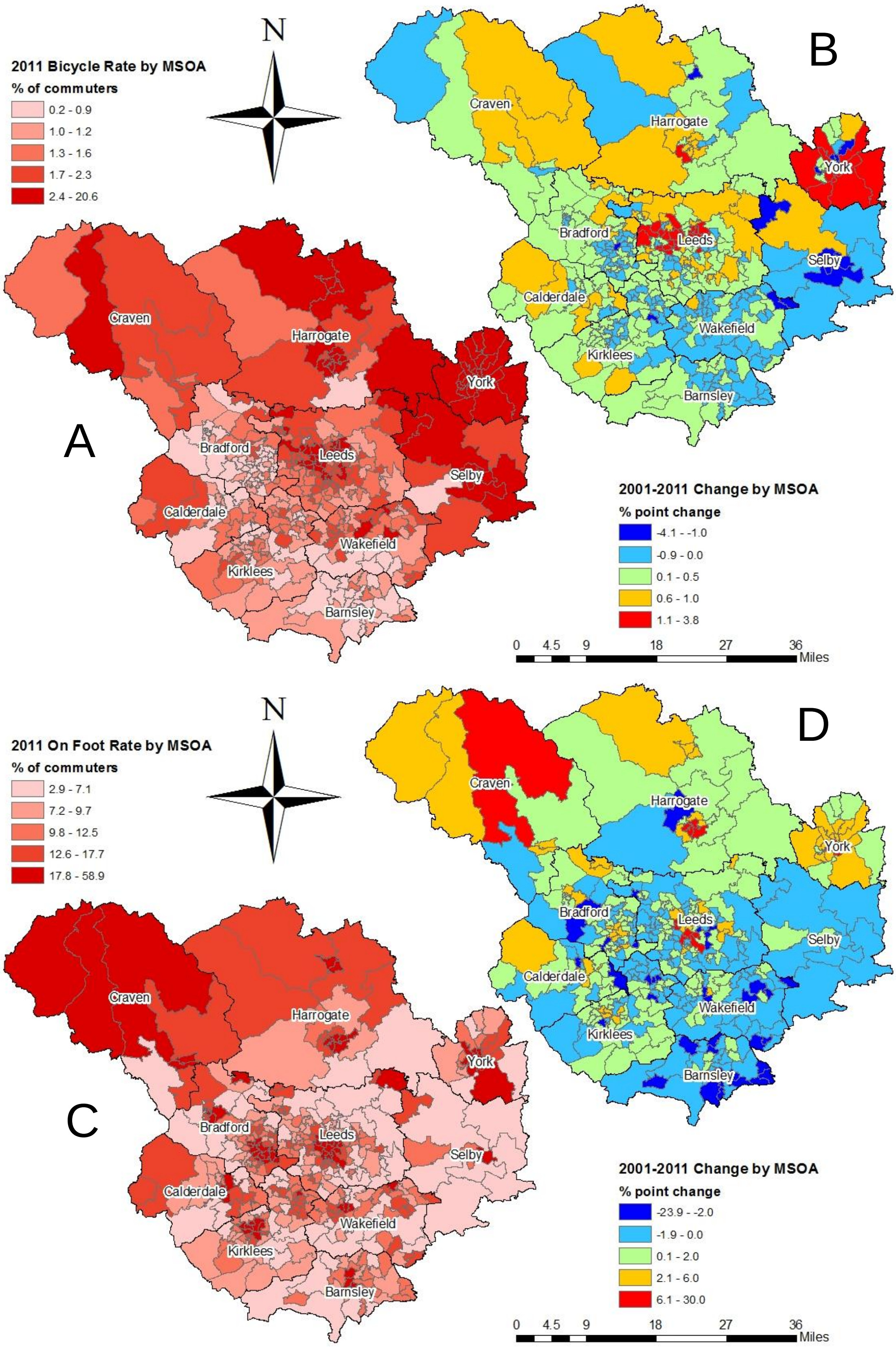
Figure 7.14: Percentage of commuters (excluding homeworkers) in the LCR aged 16-74 in 2011 that commute to work as a passenger in a car or van (A) and the percentage point changes between 2001 and 2011 (B) by MSOA

As with bus travel, changes in the prevalence of commuting as a passenger in a car or van are likely to be due to increases in personal incomes in the LCR leading to the ownership and usage of cars becoming more widespread (Dargay, 2007). As many of the urban areas in the LCR experienced regeneration between 2001 and 2011, it is likely that local incomes increased as a result, with many people choosing to use this increased income to purchase cars of their own rather than relying on commuting as a passenger in a car or van. As was the case in Chapter 4, although the taxi or minicab and motorcycle, scooter or moped modes of transport could be included in this section on road transport, the numbers of commuters in the LCR using these modes and their shares of the LCR modal split are so small that they have again been excluded in order to focus on the more prevalent modes.

7.6.3 MSOA variations in cycling and walking

There are some similarities between the spatial patterns of cycling and walking to work in the LCR. Figure 7.15(A and C) shows that cycling and walking to work are both highly prevalent (>2.4% and >17.8%) in the central areas of Leeds, Ripon, Harrogate, York and Selby. In contrast, cycling and walking to work are both rare (<0.9% and <7.1%) in the more suburban and rural MSOAs of Wakefield, Barnsley, Kirklees, Calderdale and Bradford. However, there are distinct differences between the spatial patterns of cycling and walking to work in the LCR. Maps A and C in Figure 7.15 indicate that while commuting to work on foot is prevalent in the MSOAs covering central Bradford, Keighley, Halifax, Huddersfield, Dewsbury and Barnsley, commuting to work by bike is far from prevalent in those same MSOAs. Conversely, while commuting to work by bicycle is popular in rural MSOAs in the Selby, Harrogate and York LADs, commuting to work on foot is much less common in these areas.

Maps B and D in Figure 7.15 show the spatial patterns of change in cycling and walking to work in the LCR are quite different. Decreases in commuting on foot have been far more widespread than decreases in cycling. While the largest increases in commuting to work by bicycle (>1.1 percentage points) have occurred in north and north west Leeds and York, the largest increases in commuting to work on foot have taken place in central Leeds, Harrogate and York. Decreases in walking and cycling to work have also happened in different areas, with the largest decreases (<-1.0 percentage points) in cycling to work being largely confined to Selby and York, while large decreases (<-2.0 percentage points) in walking to work have occurred across the LCR.



Source: Derived from the 2001 and 2011 Census Aggregate Data.

Figure 7.15: Percentage of commuters (excluding homeworkers) in the LCR aged 16-74 in 2011 that commute to work by bicycle (A) and on foot (C) and the percentage point changes between 2001 and 2011 (B and D) by MSOA

Increases in commuting by cycling or walking to work may reflect increased environmental awareness (Lorenzoni *et al.*, 2007) at a more local level, with some commuters choosing to walk or cycle to work instead of driving. Improved awareness of health issues and the promotion of active commuting (Vuori *et al.*, 1994) may also be reflected in increased walking and cycling to work. Some commuters may have switched to walking or cycling to work due to increasing costs of motoring and public transport, with increases in fuel costs and rail fares occurring between 2001 and 2011 (RAC, 2015; BBC, 2013i, 2013iii, 2013iv, 2014, 2015vi, 2015ix).

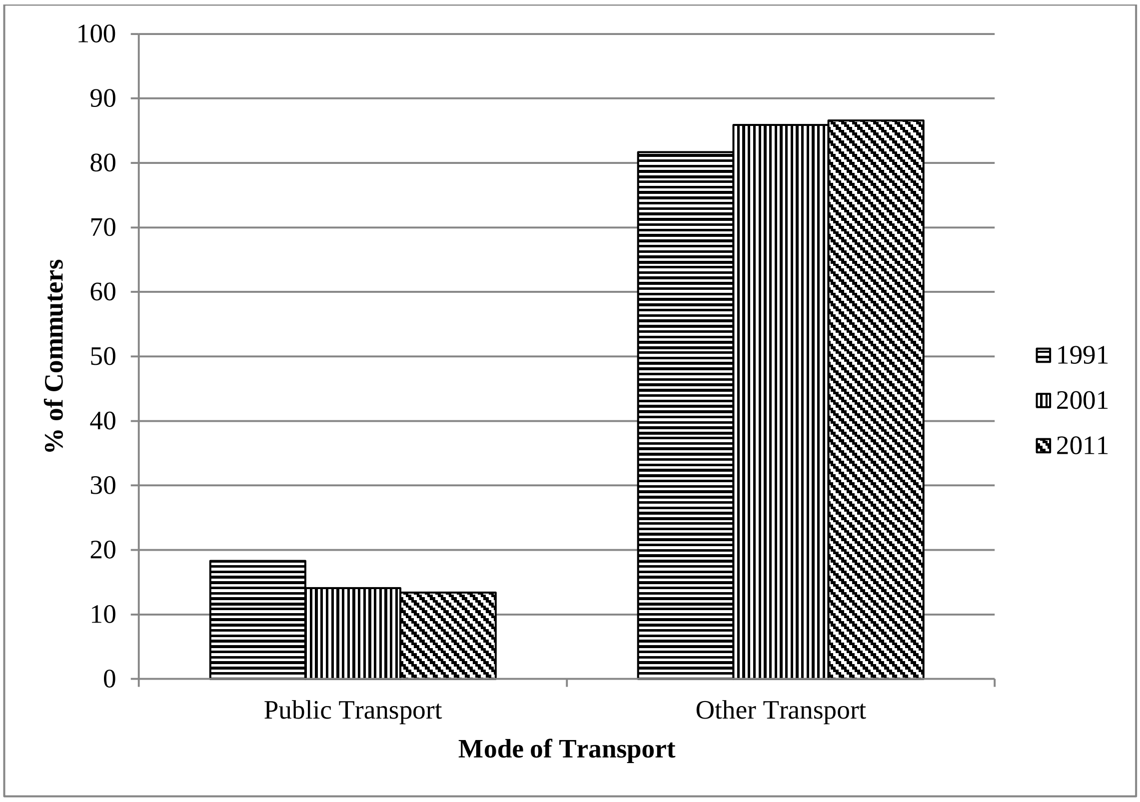
The increases in the prevalence of walking and cycling to work in central, north and north west Leeds are likely to be due to changes in the urban structure of Leeds over the decade, with the process of re-urbanisation leading to an increase in the city centre and inner city population, encouraged by the rise of city living (Seo, 2002). Commuters in these areas are more likely to live close to their places of work in central Leeds and are, therefore, more able to commute by walking and cycling. As with decreases in commuting by bus, decreases in commuting by walking or cycling may reflect increase personal incomes leading to increased car ownership and usage (Dargay, 2007). The fall in walking and cycling to work proportions seen in MSOAs away from town and city centres may also reflect the processes of suburbanisation and urban-rural migration within the LCR (Grey *et al.*, 2003).

7.7 Commuting Using Public Transport in the Leeds City Region

Whether or not the increases in commuting rates seen in the LCR have been fuelled by an increase in commuting using public transport is important, as commuting by train or bus is more economically, socially and environmentally desirable than commuting by car. In this section 1991, 2001 and 2011 census microdata are used to analyse sociodemographic variations in commuting by public transport in the LCR before 2001 and 2011 census aggregate data are used to analyse the spatial variations.

7.7.1 Changes in commuting using public transport between 1991 and 2011

Figure 7.16 shows a substantial decline in the prevalence of commuting by public transport in the LCR between 1991 and 2011, albeit with most of the decline taking place between 1991 and 2001. The percentage of commuters travelling to work by public transport declined from 18.3% in 1991 to 13.4% in 2011. This means that the LCR, after being in a better position in 1991, now compares unfavourably to England and Wales overall, which saw the percentage of commuters using public transport increase from 17.1% in 1991 to 17.6% in 2011, albeit with a decrease between 1991 and 2001 (see Chapter 6).



Source: Derived from the 1991 and 2011 I-SARs and the 2001 SAM.

Figure 7.16: Percentage of commuters (excluding homeworkers) in the LCR (excluding Craven LAD) aged 16-74 who commute using public transport in 1991, 2001 and 2011

7.7.2 Sociodemographic variations in commuting using public transport

Figure 7.11 showed that at the same time that there was a substantial increase in the percentage of those commuting to work by train in the LCR, there was also a substantial decrease in the percentage of commuters going to work by bus. In order to explore the overall changes in the prevalence of commuting by public transport in the LCR, it is necessary to aggregate these two modes of transport categories. Table 7.6 shows the percentage of commuters commuting to work using public transport in the LCR in 1991, 2001 and 2011 and the changes over the two decades. Table 7.6 and Figure 7.17 show a general trend of decline across the sociodemographic categories in the prevalence of commuting by public transport in the LCR over the 20 year period. Declines were almost universal between 1991 and 2001, while the picture was more mixed between 2001 and 2011.

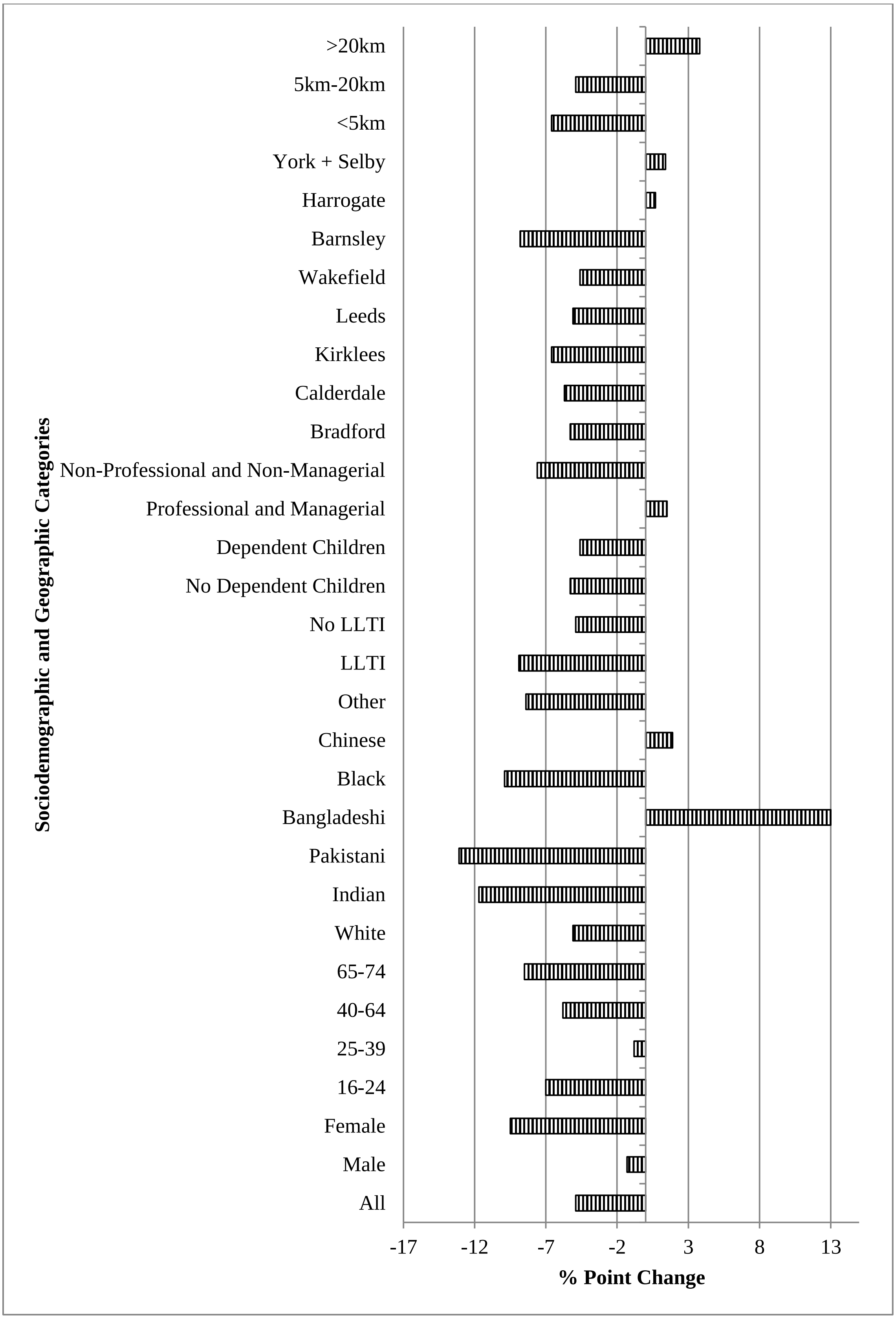
Despite the general trend, some commuting subgroups have seen notable increases in the percentage of those commuting to work using public transport, with the professional and managerial category experiencing a 1.3 percentage point increase between 1991 and 2001 and the 25-39, Black and Chinese categories experiencing 1.1, 1.9 and 7.0 percentage point increases between 2001 and 2011, respectively. Geographically, there is clear urban-rural divide in the changing prevalence (also see Table 7.7), with the most substantial decreases being seen in the more urban LADs in the West Yorkshire and South Yorkshire parts of the LCR and slight overall increases being seen in those more rural LADs in North Yorkshire. This geographical divide in changes may be linked with the changes in commute distance, with those with the longest commutes (>20km) experiencing increases in the prevalence of public transport commuting over the two decades and those with the shortest commutes (<5km) experiencing decreases over the same period.

Table 7.6: Percentages and percentage point changes in commuting using public transport by sociodemographic and geographic characteristics for all commuters (excluding homeworkers) in the LCR (excluding Craven LAD) aged 16-74 in 1991, 2001 and 2011

Sociodemographic and Geographic Characteristics		Commute Using Public Transport (%)			% Point Change	
Variables	Categories	1991	2001	2011	91-01	01-11
All	All	18.3	14.1	13.4	-4.2	-0.7
Sex	Male	12.6	10.7	11.3	-1.9	0.6
	Female	25.0	17.9	15.5	-7.1	-2.4
Age Group	16-24	29.9	27.7	22.9	-2.2	-4.8
	25-39	14.9	13.0	14.1	-1.9	1.1
	40-64	16.8	11.5	11.0	-5.3	-0.5
	65-74	18.6	15.8	10.1	-2.8	-5.7
Ethnic Group	White	18.0	13.8	12.9	-4.2	-0.9
	Indian	27.1	18.4	15.4	-8.7	-3.0
	Pakistani	24.0	15.1	10.9	-8.9	-4.2
	Bangladeshi	0.0	26.5	12.9	26.5	-13.5
	Black	40.6	28.8	30.7	-11.8	1.9
	Chinese	16.7	11.6	18.6	-5.1	7.0
	Other	28.6	22.0	20.3	-6.6	-1.8
LLTI	LLTI	24.9	15.3	16.0	-9.6	0.7
	No LLTI	18.1	14.0	13.2	-4.1	-0.8
Dependent Children	No Dependent Children	20.1	15.5	14.8	-4.6	-0.7
	Dependent Children	15.6	12.3	11.0	-3.3	-1.3
Occupation	Professional and Managerial	9.9	11.2	11.3	1.3	0.2
	Non-Professional and Non-Managerial	22.0	15.8	14.5	-6.2	-1.4
LAD of Residence	Bradford	20.8	15.6	15.5	-5.2	-0.1
	Calderdale	18.5	14.8	12.8	-3.7	-2.0
	Kirklees	17.8	12.6	11.2	-5.2	-1.4
	Leeds	23.8	19.9	18.7	-3.9	-1.2
	Wakefield	15.2	12.3	10.6	-2.9	-1.7
	Barnsley	17.7	9.7	8.9	-8.0	-0.8
	Harrogate	6.7	6.6	7.4	-0.1	0.8
	York + Selby	8.1	7.8	9.6	-0.3	1.7
Commute Distance	<5km	18.8	13.9	12.2	-4.9	-1.7
	5km-20km	19.3	15.2	14.4	-4.1	-0.8
	>20km	10.5	11.1	14.3	0.6	3.2

Source: Derived from the 1991 and 2011 I-SARs and the 2001 SAM.

Figure 7.17 provides a graphical summary of the combined 1991-2001 and 2001-2011 percentage point changes in commuting by public transport in the LCR for commuters in each of the variable categories. This graph reinforces the general pattern of decreases across the 20 year period. The largest percentage point increases were for the Bangladeshi ethnic group and for those commuters travelling >20km to work, with 13.0 and 3.8 percentage point increases, respectively, between 1991 and 2011. Conversely, the largest percentage point decreases were for the Pakistani, Indian and Black ethnic groups, with 13.1, 11.7 and 9.9 percentage point decreases, respectively, between 1991 and 2011.



Source: Derived from Table 7.6.

Figure 7.17: Percentage point changes in commuters commuting using public transport by sociodemographic and geographic characteristics for all commuters (excluding homeworkers) in the LCR aged 16-74, 1991-2011

7.7.3 Modelling public transport usage

Although Table 7.6 and Figure 7.17 indicate how the prevalence of commuting by public transport in the LCR changed between 1991 and 2011 across the selection of sociodemographic variables, they do not show how the relative likelihoods of commuting by public transport changed. As was the case at the national level, it is useful to know the relative likelihoods for those in the LCR as they indicate how more or less likely commuters in one sociodemographic category are to commute to work using public transport compared to another category. These relative likelihoods can be important for local policy makers when implementing targeted local or regional transport policies.

Table 7.7 shows that, in all three years, females were significantly more likely to commute to work using public transport than males. However, there was convergence between the sexes, with the female OR decreasing from 2.291 in 1991 to 1.562 in 2011. Unlike at the national level, where the 25-44 age group were most likely to commute using public transport, Table 7.7 shows that in the LCR the 16-24 age group is the most likely in all three years. By 2011, there was a clear trend across the age groups, with the relative likelihood of commuting by public transport decreasing with age, with the 65-74 age group having an OR 0.338.

Table 7.7 shows that commuters in the Black ethnic group were the most likely to commute by public transport in all three years, with the ORs remaining relatively stable over the two decades. While White commuters were the least likely to commute using public transport in 1991 and 2001 (with the lower ORs for the Bangladeshi and Chinese groups not being statistically significant), by 2011 it was commuters in the Pakistani ethnic group, with an OR of 0.779, who were the least likely. However, as the substantial number of non-significant results for the different ethnic groups indicates, the ORs for the BME groups need to be viewed with caution as the sample sizes are relatively small when dealing only with the LCR.

In all three years, those with no LLTI and those with dependent children were significantly less likely to commute by public transport than those with a LLTI and those with no dependent children, respectively. However, while there was some convergence between the two LLTI groups, with the OR for those with no LLTI increasing from 0.641 in 1991 to 0.710 in 2011, there was divergence between those with and without dependent children, with the OR for those with dependent children decreasing from 0.802 in 1991 to 0.696 in 2011.

As was the case at national level, commuters with non-professional and non-managerial occupations in the LCR were more likely to commute using public transport than commuters with professional and managerial occupations in the LCR in 1991, 2001 and 2011. The relative likelihood of commuters with non-professional and non-managerial occupations commuting using public transport was decreasing relative to commuters with professional and managerial occupations since 1991, with the OR decreasing from 2.317 in 1991, to 1.411 in 2011.

The ORs in Table 7.7 clearly indicate that in all three years commuters resident in the Leeds LAD were the most likely to commute using public transport, while commuters in Harrogate were the least likely to commute using public transport in 1991, 2001 and 2011. This urban-rural divide, which was also evident at the national level, is likely due to the better developed public transport networks available in Leeds, making commuting by public transport relatively easier than elsewhere in the region, while the low ORs for those in Harrogate are likely to be due to the relatively rural nature of the LAD, meaning commuting by public transport is likely to be much more difficult.

The OR for those commuting >20km increased by so much between 1991 and 2011 that, while in 1991 those commuting the longest distances were the least likely to commute by public transport, by 2011 there was a clear positive relationship between commute distance and the likelihood of commuting by public transport, with those commuting >20km the most likely to use public transport and those commuting <5km the least likely. As at the national level, the high OR for those commuting >20km is likely driven by the high likelihood of commuting by train, as opposed to bus, amongst those commuting long-distances, while the low OR for those commuting <5km is likely driven by the high likelihood of commuting by bicycle or on foot amongst those commuting short distances (see Chapter 6).

Finally, the regression analysis shows that the value of the constant remained relatively stable between 1991 and 2011. This means that, when controlling for all the variables, the relative likelihood of the reference individual commuting by public transport remained steady over the two decades.

Table 7.7: BLR model results for commuters commuting using public transport by sociodemographic and geographic characteristics for all commuters (excluding homeworkers) in the LCR (excluding Craven LAD) aged 16-74 in 1991, 2001 and 2011

Sociodemographic and Geographic Characteristics		1991 OR		2001 OR		2011 OR	
Variables	Categories						
Sex	Male	1.000		1.000		1.000	
	Female	2.291	*	1.921	*	1.562	*
Age Group	16-24	1.000		1.000		1.000	
	25-39	0.488	*	0.406	*	0.584	*
	40-64	0.518	*	0.333	*	0.417	*
	65-74	0.574	*	0.413	*	0.338	*
Ethnic Group	White	1.000		1.000		1.000	
	Indian	1.898	*	1.324	*	1.217	*
	Pakistani	1.690	*	1.017		0.779	*
	Bangladeshi	0.000		2.042	*	0.800	
	Black	2.982	*	2.399	*	2.918	*
	Chinese	0.920		0.806		1.410	
	Other	1.923	*	1.492	*	1.502	*
LLTI	LLTI	1.000		1.000		1.000	
	No LLTI	0.641	*	0.815	*	0.710	*
Dependent Children	No Dependent Children	1.000		1.000		1.000	
	Dependent Children	0.802	*	0.732	*	0.696	*
Occupation	Professional and Managerial	1.000		1.000		1.000	
	Non-Professional and Non-Managerial	2.317	*	1.461	*	1.411	*
LAD of Residence	Bradford	1.000		1.000		1.000	
	Calderdale	0.912		1.001		0.820	*
	Kirklees	0.813	*	0.779	*	0.673	*
	Leeds	1.201	*	1.349	*	1.180	*
	Wakefield	0.674	*	0.762	*	0.614	*
	Barnsley	0.792	*	0.573	*	0.505	*
	Harrogate	0.288	*	0.391	*	0.423	*
	York + Selby	0.347	*	0.463	*	0.552	*
Commute Distance	<5km	1.000		1.000		1.000	
	≥5km-<20km	1.231	*	1.228	*	1.287	*
	>20km	0.980		1.197	*	1.637	*
	Constant	0.228	*	0.285	*	0.283	*

Source: Derived from the 1991 and 2011 I-SARs and the 2001 SAM. (*=OR is statistically significant ($p<0.05$)).

The general pattern of decreases in the prevalence of commuting by public transport in the LCR may be due to increases in the cost of commuting by public transport; with substantial increases in rail fares occurring annually (BBC, 2013i, 2013iii, 2014, 2015vi, 2015ix) and being defended by the UK Government (BBC, 2015iv). However, decreases may also be due to reductions in the cost of car transport (RAC, 2015) and increases in personal incomes (Levy, 2013).

The negative correlation between the prevalence of commuting by public transport and age may be due to higher rates of car ownership amongst older individuals (Prillwitz *et al.*, 2006). The high ORs for the Black ethnic group may be due to the Black population in the LCR being concentrated in inner city Leeds, where there are better developed public transport networks.

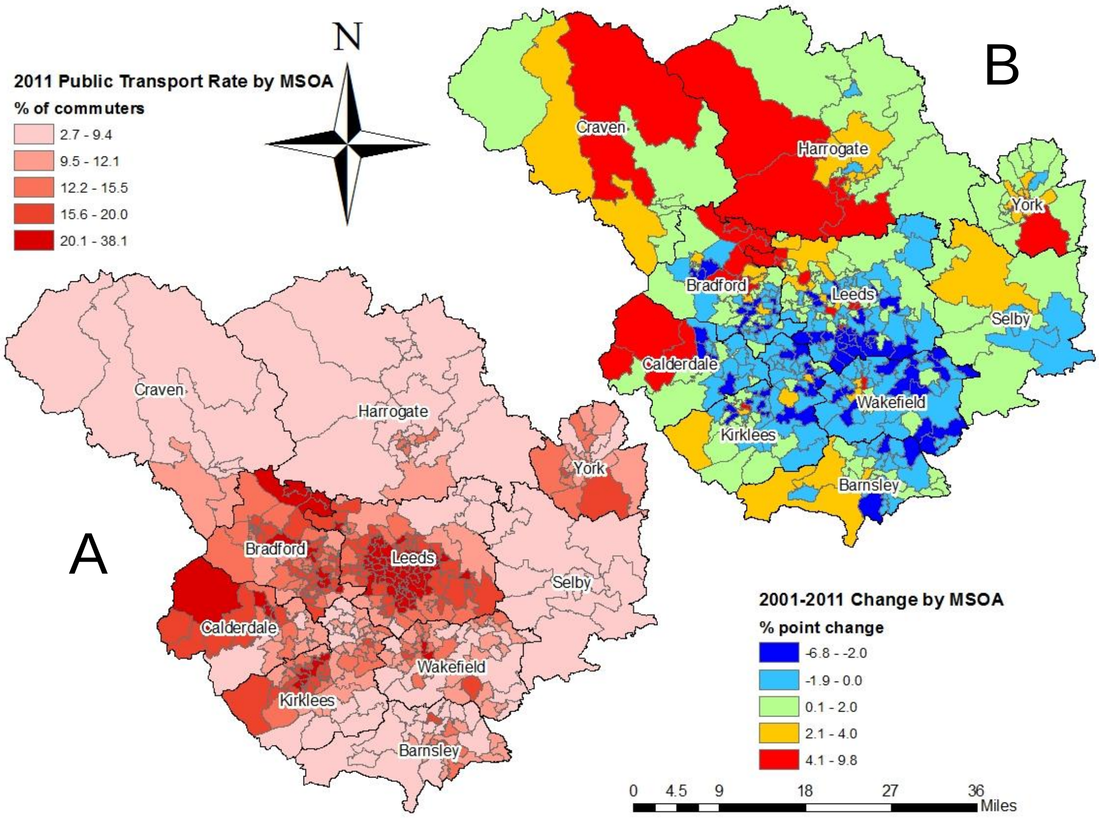
Conversely, the low OR for the Pakistani ethnic group may be due to this population being concentrated further away from central Leeds in areas of Bradford and Dewsbury, where there are less opportunities to commute by train or bus. It should be noted at this point that it is not possible to analyse OA or MSOA variations in commuting flows by ethnic group without a commissioned table.

7.7.4 MSOA variations in public transport usage

As was the case with changes in commuting rates, the general decrease in commuting by public transport was not uniform across the different areas of the LCR. Understanding these spatial variations at a relatively fine spatial scale is important for policy makers when planning the provision of public transport networks and encouraging their usage, as it will highlight those areas most in need of new or improved public transport networks.

Figure 7.18(A) shows a strong urban-rural divide in the prevalence of commuting using public transport. Commuting by public transport is most prevalent (>20.1%) in the urban and suburban areas of Leeds, Ilkley, Bradford, Halifax, Huddersfield and Wakefield and least prevalent (<9.4%) in the more rural MSOAs around the edge of the LCR, especially in the Craven, Harrogate, Selby and Barnsley LADs. Figure 7.18(B) shows a similar, but less definite, urban-rural divide in the changes in commuting by public transport. Decreases have generally been confined to urban areas in the Leeds, Bradford, Calderdale, Kirklees, Wakefield and Barnsley LADs, while increases have been seen in the more rural and suburban MSOAs in the Harrogate, Bradford and Calderdale LADs.

The urban-rural divide seen in Figure 7.18 is similar to that seen at the national level in Figure 6.4 (see Chapter 6). The LCR compares favourably to England and Wales when considering commuting by public transport, with only the largely rural LADs of Craven, Harrogate and Selby experiencing public transport usage rates of less than 7.7% and the Leeds, Bradford, Calderdale and Kirklees LADs all experiencing rates in excess of 10.9%. This urban-rural divide in commuting by public transport is supported by Table 7.8. Table 7.8 shows that urban areas generally have higher rates of commuting by public transport, ranging from 9.5% in ‘urban minor conurbation’ areas to 16.0% in ‘urban major conurbation’ areas. Conversely, the lowest rate (2.1%) of commuting by public transport is seen for ‘rural village and dispersed in a sparse setting’ areas. However, Table 7.8 suggests that this urban-rural divide may be closing, with two of the rural areas experiencing percentage point increases in commuting by public transport and the largest percentage point decrease (-1.5) being seen for ‘urban major conurbation’ areas.



Source: Derived from the 2001 and 2011 Census Aggregate Data.

Figure 7.18: Percentage of commuters (excluding homeworkers) in the LCR aged 16-74 in 2011 that commute to work using public transport (A) and the percentage point changes between 2001 and 2011 (B) by MSOA

The patterns shown in Figure 7.18(A) are likely to be a reflection of the availability of, and access to, bus and rail networks. MSOAs covering areas with dense and extensive train and bus networks are likely to have higher rates of public transport usage than those areas with little or no access to public transport. Any increases in the prevalence of commuting by public transport shown in Figure 7.18(B) may be explained by increased road traffic congestion, increased environmental awareness amongst the public (Lorenzoni *et al.*, 2007), or be linked to the improved provision of bus networks and bus routes, with York now having an extensive network of park-and-ride facilities. It is also the case that increased commuting by public transport in MSOAs in inner city Leeds may reflect the process of re-urbanisation and the rise of city living (Seo, 2002). Decreases in the prevalence of commuting by public transport in the urban areas of the LCR, and especially in the former mining and industrial areas, may reflect increasing incomes, which lead to increased car ownership and usage (Dargay, 2007). Decreases may also reflect increases in the cost of public transport (BBC, 2013i, 2013iii, 2014, 2015vi, 2015ix), and the ending of subsidised bus services (Gray *et al.*, 2006).

7.8 The Urban-Rural Divide in Mode of Transport

Table 7.8 summarises the 2011 modal split shares and the 2001-2011 changes in them using the 2011 ONS Urban-Rural Classification. It shows that commuting by bus, minibus or coach, as a passenger in a car, by bicycle and on foot are generally more prevalent in urban areas while commuting by driving a car or van is much more prevalent in rural areas. As was the case when examining Figure 7.11, there does not appear to be a substantial urban-rural divide in the prevalence of commuting by train. As previously mentioned, this is likely due to commuting by train being highly dependent on easy access to the rail network, which is gained by living close to a railway station as opposed to being in an urban or rural area. Finally, Table 7.8 shows that commuting by public transport is much more prevalent in urban areas than rural areas, which is largely due to the much higher prevalence of commuting by bus, minibus or coach in urban areas. However, both urban and rural areas in the LCR experienced decreases in the prevalence of commuting by public transport between 2001 and 2011, albeit with the decline being much more pronounced in urban areas.

Table 7.8: LCR MSOA modal split shares by the 2011 urban-rural classification

Commuting Rates and Modal Split Shares		2011 MSOA Urban-Rural Classification					
		Urban major con-urbation	Urban minor con-urbation	Urban city and town	Rural town and fringe	Rural village and dispersed	Rural village and dispersed in a sparse setting
Train	2011%	3.4	2.1	3.9	3.9	2.8	0.9
	2001-2011 Change	1.6	0.9	1.1	1.3	0.9	0.1
Bus, Minibus or Coach	2011%	12.5	7.3	6.5	5.6	3.0	1.1
	2001-2011 Change	-3.1	-1.8	-1.5	-2.2	-0.6	-0.2
Car or Van (Driver)	2011%	61.2	69.4	60.5	74.4	79.8	76.8
	2001-2011 Change	2.2	5.6	1.3	3.5	4.6	4.7
Car or Van (Passenger)	2011%	7.2	8.1	6.5	5.8	5.1	5.3
	2001-2011 Change	-1.2	-2.0	-1.1	-1.2	-0.8	-1.5
Bicycle	2011%	1.4	0.7	5.0	1.8	1.5	1.2
	2001-2011 Change	0.2	-0.2	-0.4	0.0	-0.2	-0.4
On Foot	2011%	12.0	10.5	15.7	7.1	6.3	12.7
	2001-2011 Change	0.2	-2.3	0.8	-0.9	-3.7	-2.5
Public Transport	2011%	16.0	9.5	10.5	9.6	6.0	2.1
	2001-2011 Change	-1.5	-0.9	-0.3	-0.9	0.4	0.0

Source: Derived from the 2001 and 2011 Census Aggregate Data.

7.9 Policy Implications and Conclusions

The analyses in this chapter have highlighted how the changing structure of the LCR has influenced the importance of certain MSOAs as origins and destinations of commuters. MSOAs covering city centre areas have become relatively more important as origins and destinations of commuters, with the rise of city centre living, re-urbanisation and urban regeneration likely to be driving this change. Conversely, MSOAs further away from city centre areas have become relatively less important as origins and destinations of commuters, with continued deindustrialisation and demographic changes likely to account for this.

The chapter has shown that there were increases in the number of commuters and commuting rates in the LCR and nearly every LAD in the region between 2001 and 2011. As at the national level, these increases are likely to have been driven by increases in female participation and high levels of immigration, with a greater number of women and immigrants now part of the commuting population as well as the population at risk. There was convergence in commuting rates between males and females and between 'older' (65-74) and 'middle-aged' (25-64) commuters, with both groups experiencing an increase in their commuting rate. However, as across England and Wales, there was a substantial and concerning fall in the commuting rate of 'younger' (16-24) commuters.

Most of the LCR experienced an increase in the overall commuting rate between 2001 and 2011. Due to changes in the overall population, it is unlikely that this increase will reverse in the near future. Therefore, the regional and local policy makers and transport authorities should be planning and implementing improvements and additions to the existing transport infrastructure. Given the social and environmental costs of road transport, it is likely that any substantial improvements in capacity to meet demand will have to be made to the existing train and bus networks or by the development of new metro, light rail or tram networks, such as the Leeds Supertram or Trolleybus system. The recent announcement that the plans for the Trolleybus system are to be abandoned is, therefore, disappointing.

The chapter has also highlighted the general increase in homeworking across the LCR between 2001 and 2011. As at the national level, homeworking in the LCR is more common in rural areas and the increased prevalence presents regional and local policy makers with opportunities and problems (see Chapter 4).

Finally, the chapter has shown that there was a general increase in the percentage of commuters getting to work by train and by driving a car or van in the LCR. In contrast, the LCR saw a general decrease in the percentage of commuters traveling by bus, minibus or coach and as a passenger in a car. Worryingly, the chapter has revealed a substantial decrease in the prevalence of commuting by public transport in the LCR between 1991 and 2011, with both decades experiencing an overall decrease. However, in addition to these regional changes in modal split, the chapter has shown that infrastructure developments and changing preferences lead to MSOA variations in modal split.

Many of the explanations for changes in the modal split and changes in the prevalence of commuting by public transport are fundamentally linked to changes in the urban structure of the LCR, with urban regeneration, the rise of city living, suburbanisation and urban-rural migration all playing a part. Therefore, if the regional and local authorities of the LCR wish to encourage the use of public transport, at the expense of less socially and environmentally friendly modes of transport, they must start to fundamentally question the types of development they are allowing to take place in the region. For instance, the building of new residential suburbs, such as those in Whinmoor or Middleton in the Leeds LAD, or new industrial estates, such as those at Normanton or Durkar in the Wakefield LAD, far from the existing city centres with little or no access to existing public transport networks, will not encourage the use of public transport by those living or working in those locations. Instead, the regional and local authorities should be promoting dense mixed-use developments in the existing city centres, such as the large Leeds South Bank development (Leeds City Council, 2013) in Leeds city centre, where there is less need for those living and working there to commute by car.

Overall, this chapter has shown that the LCR experienced substantial changes in commuting composition and patterns between 2001 and 2011, has attempted some explanations for these changes, and has identified some of the important implications of these changes for local and regional policy makers.

8. Summary, Evaluation and Conclusions

8.1 Introduction

Spatial and sociodemographic variations in commuting behaviours and patterns in the UK have largely been overlooked by academic researchers. Chapter 2 illustrated that there has been research carried out in relation to the importance of commuting in the UK and the issues it raises and the problems it creates, differences in commuting behaviour between different sociodemographic groups, the emergence of homeworking practices in the UK and historical and contemporary theories of urban development and form. However, Chapter 2 also illustrated that there is a dearth of research related to spatial variations in commuting propensities and patterns at the national level and spatial and sociodemographic variations in commuting propensities, patterns and behaviours in the context of a city region. There is also a complete lack of research comprehensively analysing variations in commuting behaviours and patterns across different sociodemographic groups using quantitative methods.

These gaps in existing research cannot be perpetually ignored. The research carried out for this thesis has contributed to filling these gaps by providing spatial and statistical analyses of different commuting behaviours and patterns at the national and regional levels in 1991, 2001 and 2011 and using the findings of these analyses to produce some evidence-based policy recommendations for the relevant national, regional and local authorities. The research presented in this thesis has progressed the knowledge and understanding of spatial and sociodemographic variations and changes in commuting to work in the UK using well-known spatial and statistical methods on existing datasets. However, what adds to the originality of this research is its systematic, quantitative and relatively comprehensive nature.

To accomplish the aims of this thesis, several research objectives were outlined in Chapter 1 which also signposted the chapters in which the different objectives would be addressed. This final chapter will synthesise the findings of the thesis in the context of the research objectives. This discussion will highlight what this thesis has achieved and how the different issues have been examined. In addition to outlining what has been accomplished, it is also necessary to consider future research possibilities that follow from what has been done. However, before presenting some recommendations for future research, it is necessary to take account of the limitations of the research and the alternative data, spatial frameworks and methods that could have been employed. It is only through an appraisal of the research findings, policy implications and research limitations that appropriate recommendations for future research can be made.

The remainder of this chapter is split into four main sub-sections. Section 8.2 summarises the research findings and policy implications, outlining how each of the research questions set out in Chapter 1 have been fulfilled. Section 8.3 outlines the limitations of the research. Section 8.4

makes some suggestions for future research given the findings and limitations of this research. Section 8.5 makes a final concluding remark.

8.2 Summary of Research Findings and Policy Implications

Research Question 1: What variations exist in commuting propensities and patterns both spatially and between sociodemographic groups and how did they change between 2001 and 2011?

The analyses in Chapter 4 illustrated that there had been substantial changes in commuting propensities and patterns between 2001 and 2011 across England and Wales. The aggregate data showed increases in commuting numbers and rates across all sex and broad age groups between 2001 and 2011, except for the 16-24 age group which experienced a concerning decrease in its commuting rate. In addition, the microdata showed increases in commuting rates across all ethnic, LLTI and dependent children groups, except for those without dependent children.

Spatially, commuting rates are generally higher in southern regions and lower in northern regions of England and Wales. However, there was substantial convergence between 2001 and 2011, with the commuting rates in northern England, Wales and London increasing more substantially than elsewhere. This north-south divide in commuting rates is replicated at LAD level, with rural LADs in southern England experiencing the highest commuting rates in 2011 and urban LADs in northern England and Wales experiencing the lowest commuting rates. The reverse core-periphery pattern was seen for change, with decreases in commuting rates largely being confined to southern England and the Midlands while the highest increases were seen in more peripheral areas.

Whilst spatial variations in commuting rates in 2011 for males and females and for 'younger' and 'older' individuals are similar, spatial variations in change between 2001 and 2011 are different. Firstly, while very few LADs experienced a decrease in the female commuting rate between 2001 and 2011, decreases in male commuting rates were widespread and seen across England and Wales. Secondly, while the pattern of change seen for younger individuals was one of general decreases with specific cases of increase, there was no obvious pattern of increases and decreases for older individuals.

As with overall commuting rates, travel to work rates (which exclude homeworkers) are generally higher in southern regions and lower in northern regions. However, there was substantial convergence between 2001 and 2011, with the patterns replicated at LAD level. BLR modelling indicated that, when controlling for the other variables, males, those aged 25-44, White individuals, those without a LLTI, those without dependent children and those who live in southern England were more likely to travel to work.

Homeworking rates are generally higher in southern regions of England and in Wales and lower in northern regions. Again, there was substantial convergence between 2001 and 2011. However, at the LAD level, there is a clear urban-rural divide, with homeworking rates being higher in rural areas and lower in urban areas. BLR modelling of this variable indicated that, when controlling for the other variables, males, those aged 45-64 and 65-74, the Chinese ethnic group, those with a LLTI, those with dependent children, those with a non-professional and non-managerial occupation and those who live in southern England outside of London were more likely to work at or from home.

Modal split remained remarkably stable between 2001 and 2011 in England and Wales, with the vast majority of commuting being accounted for by 'driving a car or van'. The largest increases were for 'underground, metro, light rail or tram', rising from 3.3% to 4.1% of commutes, and 'train', from 4.5% to 5.5%, while the most noteworthy decreases were for 'bus, minibus or coach', falling from 8.1% to 7.8% of commutes, and 'passenger in a car or van', decreasing from 6.9% to 5.4%. There was a clear core-periphery pattern for commuting by 'rail', with commuting by rail being more prevalent in southern England and a clear urban-rural divide in commuting by 'road', with commuting by 'bus' and commuting by 'driving a car or van' having opposite divides. There were similar spatial patterns for cycling and walking to work in 2011, with both experiencing higher shares in dense urban LADs, such as Manchester, Nottingham and the Inner London boroughs, and in those LADs classified as small cities or large towns such as York, Cambridge, Oxford, Brighton and Exeter, and both experiencing low shares in some of the boroughs of Outer London and in LADs in semi-rural areas surrounding Greater London.

Research Question 2: How do commute distance and commuting self-containment vary between different sociodemographic groups and how did these variations change between 1991, 2001 and 2011?

Overall, Chapter 5 showed that over the two decades from 1991 to 2011 considerable changes in the distances that commuters travel to work were evident. The census microdata showed a general increase in commute distance between 1991, 2001 and 2011, with a shift towards longer-distance categories across the different sociodemographic groups. When recoded, there was a near-universal increase in very long-distance commuting between 1991 and 2001 and between 2001 and 2011. BLR modelling in this context indicated that, when controlling for the other variables, males, those aged 25-44, Bangladeshi individuals, those without a LLTI, those with dependent children, those with professional and managerial occupations those who live in the East of England region and those who commute by train, underground and tram were more likely to commute very long distance. After computing primary and interaction effects, the microdata showed that the probability of commuting very long-distance increased for both sex and occupation categories across all the modes of transport, except for those commuting by train, underground and tram.

Chi-square testing indicated a correlation between the distance that an individual commutes to work and whether or not that individual works in their LAD of residence, with those individuals commuting longer distances being less likely to live and work in the same LAD, as logic suggests. The microdata showed a general decrease in commuting self-containment between 1991, 2001 and 2011, with near-universal decreases in commuting self-containment between 1991 and 2001 and between 2001 and 2011 across sociodemographic groups. BLR modelling indicated that, when controlling for the other variables, females, those aged 65-74, Bangladeshi individuals, those with a LLTI, those with dependent children, those with non-professional and non-managerial occupations and those who live in Wales were more likely to commute within their LAD of residence.

Mapping the prevalence of commuting self-containment using the SWS produced donut patterns around major urban areas outside London, with self-containment being high in dense urban LADs, such as Birmingham and Liverpool, and lower in the more suburban surrounding LADs. Unsurprisingly the prevalence of commuting self-containment was higher in those LADs which cover whole cities, such as Bradford, Leeds and Sheffield and lower in LADs that only cover part of a wider urban area, such as the London boroughs.

Research Question 3: How does mode of transport usage vary between different sociodemographic groups and how did these variations change between 1991 and 2011?

Chapter 6 found that although modal split remained relatively stable between 1991 and 2011, there were some noteworthy changes. Mirroring the findings from the aggregate data in Chapter 4, the microdata indicated a general stability in the modal split in 1991, 2001 and 2011, with commuting by driving a car or van accounting for the vast majority of commutes in all three years. When recoded, the microdata showed that the prevalence of commuting by public transport decreased between 1991 and 2001, before increasing between 2001 and 2011. This increase between 2001 and 2011 was supported by the findings from the aggregate data. There were near-universal decreases in public transport commuting between 1991 and 2001 and near-universal increases between 2001 and 2011 across the sociodemographic groups. BLR modelling indicated that, when controlling for the other variables, females, those aged 16-24, Black individuals, those with a LLTI, those without dependent children, those with non-professional and non-managerial occupations, those who live in London and those who commute over 40km to work were more likely to commute using public transport. After computing primary and interaction effects, the microdata showed the probability of commuting by public transport increased for all distance (short and very long), ethnic group (White and BME) and region (Greater London and rest of England and Wales) categories.

Mapping the prevalence of public transport commuting using the aggregate data showed an urban-rural divide, with commuting by public transport being higher in urban areas and lower in rural areas. Commuting by public transport is particularly prevalent in and around Greater London and in the urban areas of northern England and the midlands, such as Newcastle, Sunderland, Leeds, Sheffield, Manchester, Liverpool, Nottingham and Birmingham.

Research Question 4: How do commuting propensities and patterns vary spatially and sociodemographically in the LCR and how did they change between 2001 and 2011?

In order to examine commuting at a more local level, the analyses in Chapter 7 concentrated on understanding commuting propensities and patterns in the LCR using MSOA geography. The analyses showed that there had been noteworthy changes in commuting propensities and patterns across the LCR between 2001 and 2011. The LCR experienced a high level of commuting self-containment in both 2001 and 2011. However, the level decreased over the decade. Commuting self-containment within the LCR was higher for females, those aged 65-74 and those living in Bradford, while it was lower for males, those aged 25-64 and those living in Barnsley.

Analyses of the interaction data showed that there were substantial changes in out-commuting, commuting self-containment and in-commuting at MSOA level between 2001 and 2011. The largest increases in out-commuting numbers were seen in city centre and inner city MSOAs, while the only MSOAs to experience increases in commuting self-containment were those covering the city centre areas of Leeds and Bradford. The MSOAs covering the Leeds City Centre also experienced substantial increases in commuting inflows. In 2011, out-commuting rates were highest in suburban MSOAs and lowest rural and city centre MSOAs, commuting self-containment rates were highest in city centre MSOAs and large rural MSOAs and lowest in suburban MSOAs and in-commuting rates were highest in city centre and inner city MSOAs and lowest in MSOAs further away from city centres.

The LCR experienced a slight increase in its overall commuting rate between 2001 and 2011, with decreases only occurring amongst males, those aged 16-24, the White ethnic group and those without a LLTI. Within the LCR there is an urban-rural divide in commuting rates and homeworking rates, with both being higher in rural areas and lower in urban areas. However, there is not such clear divide in travel to work rates. An urban-rural divide is also evident in the prevalence of most modes of transport. Commuting by bus, as a passenger in a car or van and walking are particularly prevalent in urban areas, while commuting by driving a car or van is much more prevalent in rural areas. There is no clear urban-rural divide for commuting by train or bicycle, with commuting by train being highest in those areas close to a train station and commuting by bicycle being highest in the geographically flatter areas of the LCR.

The microdata illustrated a general decrease in the prevalence of commuting by public transport in the LCR between 1991 and 2011. After recoding, the microdata showed widespread decreases in commuting by public transport across the different sociodemographic groups. BLR modelling indicated that, when controlling for the other variables, females, those aged 16-24, Black individuals, those with a LLTI, those without dependent children, those with non-professional and non-managerial occupations, those who live in Leeds and those who commute over 20km to work were more likely to commute using public transport in the LCR.

Mapping public transport commuting in the LCR at MSOA level using the aggregate data showed an urban rural divide in the prevalence, with commuting by public transport being higher in urban areas and lower in rural areas. However, the pattern of change between 2001 and 2011 is quite the opposite, with decreases generally being seen in more urban areas and increases being confined to more rural areas.

Research Question 5: What are the policy implications of the variations in and dynamics of commuting propensities, patterns and behaviours as shown by the analyses of the preceding questions?

There is one major common policy implication that can be derived from the analyses presented in this thesis. In order to accommodate increases in commuting rates, reduce commute distances and encourage commuting by public transport or walking and cycling, national regional and local authorities must start prioritising high density, mixed-use developments in city centres and inner-city areas over further residential or commercial developments on the rural-urban fringe. However, some policy recommendations were specific to each of the analysis chapters.

The findings of Chapter 4, at the national level, suggested that in order to keep pace with increases in commuting, national, regional and local authorities should focus on improving the capacity of existing underground, metro, light rail, tram, train and bus networks and promoting homeworking, as it creates an opportunity to tackle traffic congestion. Policy makers have clearly already recognised the need for improved, extended and new public transport networks; the UK government is committed to the development of the High Speed 2 rail network between London, Birmingham, Manchester and Leeds, while the Greater London Authority and TfL have been developing Crossrail 1, linking west and east London, and planning and consulting for Crossrail 2, linking north and south London, and Manchester City Council and Transport for Greater Manchester are planning to extend the Manchester Metrolink tram network. However, despite these on-going developments, national, regional and local policy makers should look to the predict and provide policy of road transport in the 1980s and 1990s as providing a model for planning and developing the public transport networks of the future.

Chapter 5 suggested that if the relevant authorities wish to decrease the prevalence of very long-distance commuting, in order to reduce energy consumption and greenhouse gas emissions, they should implement policies focused on men, aged 25-44, with professional and managerial occupations, who live in southern England and commute to work by car. It is unlikely that policy makers would be concerned with those individuals commuting very long-distance by public transport, but encouraging those individuals commuting by car to reduce their commute distance could be achieved through the implementation of a national road pricing scheme. This would encourage individuals to keep their commutes as short as possible, either by changing their place of work or residence, and to only make trips that were necessary. It would also likely increase the prevalence of commuting by public transport, walking and cycling.

The analyses in Chapter 6 suggested that national, regional and local authorities would be wise to focus on promoting the use of public transport amongst men, aged 45-74, of White ethnicity, who do not have a LLTI or any dependent children, and who work in professional and managerial occupations. This promotion could entail increased subsidies for public transport networks in order to make it cheaper to travel by train, tram and bus or the implementation of congestion charging in the UK's major cities. As has been seen in Greater London, these policies would encourage individuals commuting by car to switch to commuting by public transport.

Finally, the findings of Chapter 7, at the regional level, suggested that if the regional and local authorities of the LCR wish to encourage the use of public transport, at the expense of less socially and environmentally friendly modes of transport, they must start to fundamentally question the types of development they are allowing to take place in the region. The planning authorities must stop allowing new residential, commercial and industrial developments on the rural-urban fringe and in out-of-town locations and instead focus on delivering high-density mixed-use developments on brownfield sites in city centre and inner city areas. Therefore, while it is encouraging to see the local authorities allowing so many new residential and commercial developments in Leeds, Bradford and Wakefield city centres, those same local authorities have not stopped new development elsewhere, such as new urban-rural fringe housing estates at Middleton in south Leeds, Crossgates in east Leeds and Dringhouses in York and the new out-of-town commercial centre at Glasshoughton. However, even if the authorities only allow future developments in city centre and inner-city areas, they must still plan to extend and improve existing public transport networks and build new ones in order to make sure that existing residential areas are well connected to employment centres. Therefore, while the recent improvements to the local rail network, including the opening of new train stations at Kirkstall and Glasshoughton, are welcome, the abandonment of plans for the Leeds Trolleybus network is less encouraging.

8.3 Research Limitations and Future Potential

8.3.1 Data

The aggregate data derived from the 2001 and 2011 censuses have been the least problematic of the three datasets. The main shortcoming of the aggregate data was the current lack of a commute distance variable available through InFuse for 2011. Although this has not negatively affected the research in any major way, the presence of such a variable in 2011 would have facilitated the use of the aggregate data, in addition to the microdata, when analysing sociodemographic and spatial variation in commute distance in Chapter 5. The only other issue with the aggregate data has been the inability to disaggregate the mode of transport variable, at the national or local levels, by variables that would have been of interest. For example, it was not possible to disaggregate mode of transport by ethnic group in either 2001 or 2011 and it was not possible to disaggregate it by occupation in 2011.

If releasing distance and mode of transport data disaggregated by individual ethnic groups poses too much risk of disclosure for the ONS, a release of distance and mode of transport data disaggregated by broad ethic groups, such as for White and BME groupings, would facilitate more detailed analyses. Even if only at LAD level, this data would have allowed an investigation of the commuting propensities, patterns and behaviours of the ethnic majority and minority groups in different parts of the country.

Despite not being included very much in the final thesis, the interaction data have been the most problematic of the three datasets. One of the main issues with the interaction data, as with the aggregate data, has been the inability to disaggregate flows by ethnic group at the MSOA or OA levels in 2001 and at any level in 2011. Although overcome, another small issue with the interaction data was inconsistency in the 2001 and 2011 LADs for which the flow data were made available. In 2001, WICID provided separate flows for the Isles of Scilly LAD, the six Cornwall LADs, the Westminster LAD and the City of London LAD, while in 2011 the flows were only available for a merged ‘Cornwall, Isles of Scilly’ area and a merged ‘City of London, Westminster’ area. This necessitated the merging of both attribute data and LADs that would otherwise have been kept separate.

However, the two major issues with the interaction data have been the complete removal of homeworkers from the interaction data in 2011, necessitating the use of both WICID and Nomis for the extraction of interaction data, and the subsequent inconsistencies in the denominator populations in 2001 and 2011 used by WICID and Nomis. The complete exclusion of those working ‘at home’ from the internal (LAD-to-LAD or MSOA-to-MSOA) commuting flows and the inclusion of those working ‘from home’ in the external commuting flows by WICID in 2011 necessitated the use of Nomis for extracting the 2011 interaction data. This is because Nomis provided 2011 commuting flows using the 2001 homeworking specification. However, Nomis also completely excluded homeworkers (both ‘at home’ and ‘from home’) from the 2011 LAD-to-LAD or MSOA-to-MSOA commuting flows, without releasing a table of 2011 homeworkers derived from the interaction data, necessitating the extraction of the 2011 homeworking ‘flows’ from the aggregate data before combining them with the 2011 commuting flows from the interaction data.

This necessary use of both WICID and Nomis caused an unavoidable inconsistency in the denominator populations as while WICID provides both 2001 and 2011 commuting flows for the 16-74 population, with no option to select those aged 75+, Nomis only provides 2011 commuting flows and these flows are for the 16+ population, with no option to only select those aged 16-74. This means that analyses using the interaction data where homeworkers were included (Table 7.2) are for the 16-74 population in 2001 and for the 16+ population in 2011.

The main shortcoming of the microdata has been the lack of geographical detail available. Although the 1991 I-SAR, 2001 SAM and 2011 I-SAR have LAD geography, the sample sizes are too small to permit the analysis of commuting patterns within an individual LAD, as was achieved with the aggregate and interaction data. A more specific shortcoming is the inconsistency of some variables, such as the occupation variable, over time. As outlined in Chapter 3, consistent occupation variables were available for the 1991 and 2001 microdata or for the 2001 and 2011 microdata, but not for all three microdata datasets. In a similar way, not all variables are included in all three years; this necessitates the exclusion of certain variables. For example, despite that it would ideally have been included in the analyses, the provision of care variable was excluded as it is only available for 2001 and 2011.

If the 1991 I-SAR, 2001 SAM and 2011 I-SAR were substantially larger samples of the population, such as 20%, it would have been possible to do the vast majority of data analyses using only the microdata. With a larger sample it would have been possible to use the three datasets to examine spatial and sociodemographic variations and temporal changes in commuting propensities, patterns and behaviours at LAD level, with the aggregate and interaction data only being used for the MSOA level analyses. With this in mind, the ONS would be wise to consider releasing a 20% I-SAR and 20% H-SAR in the future, as these would facilitate analyses without presenting any substantial risk of disclosure due to them being samples at LAD level.

The late release of the 2011 Census interaction data and microdata also had an impact on the research. It was envisaged that the vast majority of 2011 Census data would already have been released by September 2012, when the research started. However, this was not the case, with only the 2011 Census aggregate data being available as planned. This necessitated the cancelling of certain research plans, such as the merging of the 1991 and 2011 I-SARs and the

2001 SAM in to one large ‘super I-SAR’ in order that the year could be included in the BLRs as an independent variable.

Use of the England and Wales LS would have allowed the analysis of changes in commuting behaviour and patterns over time to be carried out for the same sample of individuals. Arguably, this would have made the findings of the BLR modelling more reliable and valid. However, as the research was primarily concerned with how the relative likelihoods of certain commuting behaviours varied across sociodemographic groups, as opposed to over time, the I-SARs and SAM were deemed to be more appropriate for the BLR analyses.

Mobile phone tracking data could have been used to further the aims of this research by providing an idiosyncratic representation of individuals’ journeys from origin to destination. Given that many people in the UK carry their mobile phone much of the time, mapping the data as flow maps could have provided an accurate and detailed view of when, how and where an individual was traveling. However, these data are not publicly available, so using them would have required an agreement with a network provider. More importantly, it would not have been possible to determine the purpose of a trip being made, rendering the data largely irrelevant to an analysis specific to commuting to work.

The Department for Transport collect and release three datasets related to street-level traffic: the Annual Average Daily Flow, the Annual Volume of Traffic and the Road Traffic Estimates (Department for Transport, 2016). These datasets, which provide data on the number of vehicles using a stretch of road per day, the number of vehicle miles per year and road traffic estimates by country, region, local authority, time of day, day and month, could have been used to analyse spatial variations and temporal changes in car usage at a relatively small spatial scale or on specific stretches of the road network. However the datasets do not improve on some of the weaknesses of the SWS data as they only provide traffic flow data for A-roads, which would largely prohibit an analysis of very local journeys, and, as with mobile phone tracking data, it would not be possible to restrict the analyses to work-related commuting journeys.

Data from TfL, such as the Public Transport Accessibility Levels (PTALs) data, could have been used for an in-depth case study of commuting behaviours, propensities and patters in Greater London. Given the PTAL data measure the accessibility of a point to the public transport network (Transport for London, 2016), these data could have been used in conjunction with the 2011 Census mode of transport data to examine the correlation between network accessibility and public transport usage in London. However, given the unique nature and status of London in the UK, it was judged that using Greater London as a case study area was not the best way of facilitating an understanding of regional and local commuting behaviours, propensities and patters in the UK.

Any number of commissioned tables could have been requested in order to facilitate the research. However, perhaps the most desirable would have been commute distance and mode of transport by ethnic group at LAD and MSOA levels in 2001 and 2011. These tables would have been necessary for the research to analyse spatial variations and temporal changes in the commuting propensities, patterns and behaviours of different ethnic groups. However, it is unlikely that these tables, especially at MSOA level, would have been made available due to the small numbers of individuals in certain groups and, therefore, the risk of disclosure.

8.3.2 Spatial frameworks

As was briefly outlined in Chapter 3, although the official UK census geography provides a consistent spatial framework for the analysis of census data, it is not necessarily best suited for the analysis of every census dataset. Given the complex nature of the commuting data, when compared to other census data products, analyses might arguably have been carried out using more functional spatial frameworks. The use of TTWAs to map spatial variations in commuting propensities and patterns would have facilitated making comparisons between functional 'commuting areas'. The commuting rates derived for TTWAs would have been better representations of spatial variations and more valid indications of the economic circumstances of different areas than those derived for LADs, given the arbitrary and political nature of LAD boundaries.

Sector and mode specific TTWAs would have been extremely useful when analysing spatial variations in different commuting indicators and modes of transport. These non-standard TTWAs are not available from the UKDS and could not have been derived from OA level SWS data, due to the lack of data disaggregated by sector or mode. However, the creation of sex, age, ethnic group, sector and mode specific TTWAs would clearly be advantageous to researchers and should be seen as a possibility for future research. Similarly, geographically smaller TTWAs, created using looser self-containment requirements than those used by Coombes *et al.* (2005), would have been ideal for visualising local variations in commuting propensities and patterns within the LCR. These smaller TTWAs could have been derived from the aggregate OA level SWS data and this is also a future research possibility.

WPZs could have been used when visualising spatial variations in commuting inflows in the LCR instead of MSOAs. Given how they are created, WPZs could have provided a better representation of the locations of major employment centres, such as city centres. However, despite their appropriateness for analysing commuting data and commuting inflows, respectively, TTWAs and WPZs were not used. TTWAs were not used due to there being no 2011 TTWAs available, while MSOAs, instead of OAs or WPZs, were used for LCR analyses as it was judged that their size and number were more appropriate for the regional analyses.

8.3.3 Methods

Choropleth mapping and BLR, as outlined in Chapter 3, are not without faults. Any choropleth mapping is susceptible to the EF and the Modifiable Areal Unit Problem (MAUP), while the BLR analyses are also vulnerable to the EF, as well as the omitted-variable bias, and results can be affected by changes in the aggregation of categories. The EF refers to making inferences about the characteristics of individuals based on the characteristics of the spatial or sociodemographic group that they are part of. In a commuting context, choropleth mapping and BLR modelling are susceptible to the EF as they can both give the impression that all individuals in a geographical area or in a sociodemographic group experience the same commuting propensities and patterns. In respect of choropleth mapping, the MAUP refers to the fact that the spatial patterns seen may be as much a result of the chosen spatial areas used to display the data as the attribute data themselves. In a commuting context, changes in the spatial characteristics of the LADs or MSOAs used could potentially alter the spatial commuting patterns seen. While the EF can be largely avoided by not making generalisations about individuals in a geographical area or sociodemographic group based on the average commuting propensities, patterns and behaviours of individuals in that area or group, overcoming the MAUP would require the use of different spatial and statistical methods.

In the case of BLR, the omitted-variable bias refers to a situation where the ORs, and any subsequently derived probabilities, are affected by the exclusion of a particularly important independent variable and the model compensates for this omission by overestimating or underestimating the effects of one or more of the other independent variables. This bias occurs when the omitted independent variable is correlated with the dependent variable and one or several independent variables. However, given that all the independent variables in the BLR analyses were included on the basis that previous research had shown them to be important in influencing commuting propensities, patterns and behaviours, the only way to reduce any further omitted-variable bias would have been to include more independent variables. Given that all variables which were previously found to be important and for which census data were available were included, using other influential variables would have necessitated the use and matching of non-censal data.

Different aggregations of sociodemographic categories could potentially lead to different findings when running BLR models using those categories, meaning that the statistical patterns seen for some variables may be as much a result of the chosen categorisation as the attribute data themselves. The use of census data meant that this weakness was unavoidable, as it was necessary to standardise data categories based on the official pre-existing categorisations in 1991, 2001 and 2011.

Despite their weaknesses, it was judged that choropleth mapping and BLR were the spatial and statistical methods most appropriate for the research. However, a number of other spatial and statistical methods, including heat mapping, cartograms and multilevel modelling, potentially could have been employed for the analyses of the aggregate, interaction and microdata datasets. Although none have been included in the final thesis, flow maps were used for data exploration at both the national and regional levels.

Inverse Distance Weighting could have been used to create heat maps in order to analyse spatial variations in commuting propensities and patterns. Heat mapping, using LAD and MSOA centroids, would have arguably been an improvement on choropleth mapping by removing LAD and MSOA boundaries and, therefore, reducing problems associated with the MAUP. However, not using LAD and MSOA boundary data could have reduced the policy relevance of the research as LADs are the primary political units of the UK and MSOAs are the standard spatial units within them. Removing LAD boundaries from the spatial analyses would have been a big sacrifice for this research given its policy focus and intent, and due to LADs remaining the primary spatial units for which the census data are released.

The use of population weighted cartograms for choropleth mapping would have arguably improved the choropleth maps from a visualisation perspective. Population weighted cartograms would have arguably made any choropleth mapping more accurate by giving different LADs or MSOAs appropriate representation, with densely populated but geographically smaller urban areas becoming a much more substantial part of the maps at the expense of less populated but geographically larger rural areas. However, the use of population weighted cartograms would have necessitated a debate about which ‘population’ the cartograms should be weighted by; the total population, those aged 16+, those aged 16-74 or the commuting population and more importantly would have negated the inherent advantages of using standard boundary data, which provide a much more understandable spatial representation of the areas in question. It is also the case that cartograms transform space, making it difficult to recognise where different spatial areas and locations are.

Space-time cubes, similar to those used by Gatalsky *et al.* (2004), could have been employed in order to analyse spatial variations and temporal changes in commuting propensities and patterns simultaneously, removing the need for multiple choropleth maps. Arguably, visualising spatial variations and temporal changes in the 1991, 2001 and 2011 census data using a space-time cube could facilitate an understanding of the links between commuting and time and space better than traditional two dimensional maps. However, space-time cubes would have been near-impossible to visualise properly using a two-dimensional medium, especially when used over relatively large areas such as England and Wales and the LCR. Therefore, any advantages gained by using a 3-dimensional GIS visualisation technique would have largely been lost when transferring the final output to the thesis.

Multilevel modelling could have been employed to analyse statistical variations in commuting behaviour. The more sophisticated nature of multilevel modelling would have arguably been better at revealing any causal relationships between the sociodemographic characteristics of individuals and their commuting behaviours, identifying the different effects of individual, household, neighbourhood and region on commuting behaviour. However, due to its more complex nature, the use of multilevel modelling would have potentially necessitated a greater focus on statistical modelling at the expense of any spatial analyses due to the time constraints of the research.

8.4 Recommendations for Future Work

The discussions in this chapter have already alluded to some possibilities for future research. However, other possibilities for research can be identified which would augment the findings of this thesis. These possibilities are related to addressing the gaps in this research, using future datasets in the same way as this research, using alternative existing datasets in the same way, conducting similar research at different spatial scales using different geographical output levels and conducting qualitative research to discover why certain commuting propensities, patterns and behaviours exist.

Firstly, although the lack of data is understandable, due to the lack of aggregate and interaction data disaggregated by ethnic group, this research has not been able to examine spatial variations in commuting propensities and patterns by ethnic group to the extent that would provide real insight into inter-ethnic differences. Therefore, future research using any dataset at a sub-LAD level geography to analyse the different commuting propensities and patterns of different ethnic groups would be extremely valuable given the different commuting propensities and patterns of different ethnic groups at the national level and the concerning low commuting rates of some BME groups, particularly the Pakistani and Bangladeshi groups, when compared to the majority White population. More research, both quantitative and qualitative, is also needed in relation to the two-way relationship between commuting propensities, patterns and behaviours and labour market engagement. Given that commuting is inherently linked to labour market activity, it would be useful for both economic and transport policy makers to know how changes in the structure of labour markets affect changes in commuting behaviour and how changes in transport networks affect the labour market activities of individuals. This thesis also recognised that the relationship between commuting and the labour market is two-way, but did not focus on the interaction between the two. If we accept that policy makers should combat unemployment and economic inactivity by promoting engagement with the labour market, then policy makers need to understand sociodemographic and geographic variations in commuting propensities, commute distance and access to different modes of transport in order to target their policies effectively. For example, facilitating commuting, particularly very long-distance commuting, through making transport networks more accessible is likely to increase the number of employment opportunities open to individuals not currently participating in the labour market. Similarly, promoting the use of certain modes of transport, such as train, bus, walking and cycling, through subsidising public transport fares or introducing congestion changing is likely to reduce greenhouse gas emissions and fuel consumption as individuals switch from commuting by car.

Secondly, this research could be updated if/when the 2021 Census data become available. If there is a 2021 Census in the same form as those in 2001 and 2011, the 2021 aggregate data, interaction data and microdata could be used to bring the findings of this research up to date.

Thirdly, alternative existing datasets, such as the LSs and TfL data, could be used to augment this research. As alluded to previously, the LSs could be used in much the same way as the I-SARs and SAM have been while ensuring that the same individuals are analysed over time, highlighting the changes that individuals have experienced in their commute distance and mode of transport. Given TfL's importance when it comes to providing public transport and monitoring its usage, TfL data may have the potential to contribute to future investigations of public transport use in London, with oyster card data indicating where the largest increases and decreases in commuting flows on the different transport networks have been. Mobile phone tracking data are an area of promising potential and, as the technology continues to develop, commuting research employing those datasets is likely to be of great academic and policy importance.

Fourthly, it is likely that this research would have made use of the 2011 TTWA boundary data if they had been available. With this in mind, much of the analyses in chapters 4 and 7 could be replicated using 2011 TTWAs, which are much more appropriate than LADs from an academic perspective. Similarly, given the substantial commuting changes that took place in city centre and inner city areas between 2001 and 2011 (see Chapter 7), an OA level analysis of commuting propensities and patterns within a city centre/inner city area would be likely to make a substantial contribution to the existing knowledge base.

Fifthly, the analyses in this thesis could be extended to Scotland and Northern Ireland. At the start of the project, it was envisaged that the research would cover the whole of the UK. However, concerns regarding the availability and compatibility of the different census datasets in the different parts of the UK necessitated the restriction of the research to just England and Wales. The inclusion of Scotland and Northern Ireland in future research would advance the understanding of national commuting propensities and patterns, especially given the rise of very long-distance commuting in the UK, which is likely to have increased commuting flows between parts of Scotland, such as Edinburgh, and London.

Finally, this research has been quantitative in nature and, as such, has been able to discover how, when and where commuting propensities, patterns and behaviours vary. However, being purely quantitative and predictive in nature, it has not discovered why commuting propensities, patterns and behaviours vary. For this, qualitative or explanatory quantitative research is required. Therefore, any future qualitative or explanatory quantitative research regarding why people commute to work, why people work at or from home, why people commute the distance that they do and why people commute using the mode of transport that they do would substantially enhance the findings of this thesis.

8.5 Concluding Remark

This thesis has achieved its initial aims and objectives, has addressed some of the gaps in existing research and has contributed to the knowledge of spatial and sociodemographic variations in commuting in England and Wales. By recognising the importance of commuting and clearly illustrating that commuting propensities, patterns and behaviours are not universal across different sociodemographic groups or geographical areas, the thesis has also demonstrated the need to continue investigating these variations.

By systematically analysing spatial variations in commuting propensities and patterns and quantifying sociodemographic variations in commuting behaviours, the research has built on the existing knowledge base and added to the evidence base required for evidence based policy and practice (Solesbury, 2001) as requested by Adrian Smith in his 1996 presidential address to the Royal Statistical Society (Smith, 1996).

9. References

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