Working Paper 13/1

Commuting to Work in the United Kingdom: Definitions, Concepts, Trends and Patterns

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April 2013

Abstract

Commuting to work is a hugely important activity that is carried out relatively frequently, usually daily, by the vast majority of those who are economically active in the UK. In its simplest form, commuting to work is the movement of an individual from his or her place of residence to his or her place of work and back again using some mode of travel. However, commuting to work often involves more complex forms of journey, occurs in more complicated ways, and is driven by a combination of different geographic and socio-economic forces.

This paper attempts to plug a substantial gap by providing a review of the extant literature relating to commuting, with particular emphasis on the United Kingdom. No such comprehensive review of the commuting-related literature appears to have been carried out in recent times, with most studies tending to be discipline-specific. The paper provides a context for the potential analysis of forthcoming commuting data from the 2011 Census.

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1. Introduction

Commuting plays an important role in modern economies, such as the United Kingdom (UK), at both macro and micro levels. At the macroeconomic level commuting can, through the daily movement of people for economic purposes, have an impact on levels of national and regional employment, unemployment and economic productivity and output (Owen, 2012). At the microeconomic level, changes in individual commuting behaviour can have sizeable impacts on household disposable income and spending power (BBC, 2012a). In the USA, the economic turmoil following the 2008 global financial collapse has given rise to so-called 'extreme commuters' (USA Today, 2012), 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 it has also been revealed that commuting is the daily activity that has the least positive effects 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.

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 many less developed and developing countries (BBC, 2012b; 2012c). Mass commuting is therefore a global phenomenon and the worldwide experience of commuting-related problems means that the improvement of transport networks is now no longer the reserve of wealthy western nations (BBC, 2012d).

The BBC (2003) reported that, according to the 2001 UK Censuses, there were nearly 26 million cars on the road in the UK, with 62% of the 24.2 million workers in the UK travelling to work by car. In addition, in 2001, the mean number of cars per household in England & Wales was 1.1, while by 2011 the average had increased to 1.2 cars per household, as reported in The Guardian (2012). Although this increase in cars per household may not appear particularly large, one must bear in mind that the increase took place at the same time as the largest decadal increase in population ever recorded in England & Wales, with the population increasing by 7% from 52.4 million in 2001 to 56.1 million in 2011 (ONS, 2012a). The number of households in the UK grew equally fast over the same period, at 7%, to reach 26.3 million in 2011 (ONS, 2012b). When these population and household growth figures are taken into account, the slight increase in the number of cars per household over

the inter-censal period begins to look more concerning because these figures suggest that there were 5 million more cars on the roads 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 London at the centre of this dense flow network (Gargiulo *et al*., 2012). In 2007, on average, 23.8 million trips were made within, to and from London every day (Transport for London, 2009). A substantial number of these trips will have been commutes, with London drawing commuters from all over the South East and further afield. Birmingham, Bristol, Cardiff, Leeds, Manchester and Newcastle, as important regional centres (Tickell, 1993; 1996), are also key commuting nodes in England & Wales. Glasgow and Edinburgh are by far the most important cities in Scotland in terms of Gross Domestic Product (GDP) and are important hubs of 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 *et al*., 2004). 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.

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 paper 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 spatial dimension as manifest in geographical patterns of commuting behaviour in the UK. Both functions serve to identify gaps where further research might be profitable.

The review of the literature on commuting behaviour is divided into broad sections relating to: the history of commuting patterns and how they have changed over time (Section 4); the geography of commuting patterns including both the spatial and socio-demographic elements (Section 5); and the subsequent policy debates that arise in particular from the problems caused by commuting and the utility of commuting data in defining labour market areas (Section 6). However, we begin with a consideration in Section 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 3.

2. Commuting Behaviour: Definitions and Concepts

2.1 Definitions: What is commuting?

According to the Oxford Dictionary (2012a), 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. However, some research (e.g. 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 workroom for those who work from home (so-called 'homeworkers'). One key aspect of the above definition is that the travel to work must take place on a regular basis, implying that irregular or one-off trips are not seen as commutes, even if carried out for employment purposes.

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 the fact 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 and vice versa (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 Britain are undertaking longer travel times justified by greater financial rewards and better employment opportunities. This long-distance travel has been facilitated by the development of faster and easier to use transport systems. Between the 1991 Census and the mid-2000s, the number of commuters travelling more than 30 miles to work increased by a third to 800,000 (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). 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. 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. 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 (Green *et al*., 1999). 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.

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 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 behaviours and 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 is brought about by the fact that commuting is not always seen as travel in the context of work. Commuting behaviours and patterns 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 agreement as to what constitutes commuting and where to draw the line 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 those data are collected, compiled and adjusted. 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 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 Office for National Statistics (ONS) in England & 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 of population and thus the data collected on commuting flows 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 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 of households and individuals resident in England & Wales and is, through the national statistician, directly accountable to the Westminster Parliament (House of Commons, 2006). The two key questions asked by the ONS in 2011 in order to measure commuting behaviour in England & 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 or more jobs, if they have any. This is important as there are increasing numbers of people in the UK with second jobs. 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 often 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, with the same weaknesses inherent in them.

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 the 2011 Census 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 of households and individuals resident in Northern Ireland and is responsible to the Northern Ireland Assembly through the Department of Finance and Personnel (NISRA, 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 & 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?".*

Thus, 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 Census Special Workplace Statistics (SWS) in England & 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 the fact 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 (NPD), 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, 2007a). 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, 2007b).

The Census Act 1920 provided the legal framework for conducting all subsequent censuses in England, Wales and Scotland (The National Archives, 2012a), with the first census to make enquiries from which commuting data could be derived being held in 1921. Despite the fact that the censuses of England & Wales and Scotland have been under the same legal framework for almost a century, they have always been separate censuses and census questions related to commuting have not remained consistent over time. Changes in the questions asked mean that a consistent analysis of the data over the time period 1921-2011 is not 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, 2012b). Before the 1920 legislation, it was necessary to deal with the England & 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. 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 & 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 slightly different sets of 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, 2011a). 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 over time in the imputation and adjustment methods used on the data by the different NSAs also mean that time-series data comparisons are difficult to draw.

Further compounding the aforementioned consistency and continuity problems as well as changes in the imputation and adjustment methods used on the data over time, is the fact that the 1981 and 1991 SWS were derived from a 10% sample of the UK population. Although the data being obtained from a 10% sample 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 (in the future) 2011 censuses, as the 2001 and 2011 SWS are calculated using the whole

UK population. Moreover, detailed spatial analysis becomes impossible with a relatively small sample size.

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 actually 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 as straightforward as one might initially think, with the data for Scotland having substantial differences to the data for England & Wales and Northern Ireland.

Methodologically, it is important to note that the usual way of computing commuting distances from the census is to calculate the straight-line distance between the postcode centroids of an individual's place of residence and an individual's place of employment (Parkin *et al*., 2008). The assumption that an individual's commute distance is equal to the Euclidean distance between the two postcodes is not realistic. This means that the commute distances produced from the census are not the actual real-world commute distances of individuals. Given the complex and non-linear nature of the UK transport network, every individual commute is likely to be noticeably longer than 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 the fact that the NSAs are concerned with commute distance and not commute time. Using an individual's commute time may be more relevant, given the fact that differences in commute time 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 each morning and *vice versa* each evening. Asking about commute time would have the added advantage of giving some information about different levels of network congestion, as congestion affects commuting time rather than distance.

In summary, the key weaknesses of the census data are two-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; and the changes to the questions asked and the methods used over time mean that an analysis of commuting time-series data is not straightforward.

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 must be taken account of.

In an anonymised and currently unpublished paper on commuting flows and commuting intensity in Greece, the unknown author(s) defines commuting as travel to work when an employee resides in one spatial unit and is employed in a workplace contained in a different spatial unit (the spatial units used in this particular research were Local Administrative Units (LAUs)). In this case an employee's journey from residence to workplace must intersect the boundary between two LAUs in order to be counted as a commute. This definition of commuting as being required to cross an administrative boundary is paralleled by a similar distinction used by some researchers who consider internal migration to be different from residential mobility because the former involves movement across a border.

It is also the case that in the UK the Integrated Transport Authorities (ITAs), which are responsible to the Passenger Transport Executives (PTEs) and were previously called Passenger Transport Authorities (PTAs), collect information and data related to commuting 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 Greater London, respectively. These institutions collect their own information and data related to travel behaviour and patterns in their respective jurisdictions, and therefore have their own understandings as to what commuting is.

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). This means that the PTEs are now responsible for the delivery and running of local transport networks, including the Tyne and Wear Metro and the Sheffield Supertram, and the collection of any local travel data and information required for transport planning.

The Tyne and Wear PTE, which is accountable to the Tyne and Wear ITA, 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). Although the Tyne and Wear HTS is a specific case of a PTE collecting data and information on the travel patterns of individuals and households within its jurisdiction, other PTEs across the UK collect similar information.

The PTE data are a useful addition to the official ONS commuting statistics as they provide a rich variety of information relating to the individuals and households surveyed. The Tyne and Wear HTS provides data pertaining to the socio-demographic and socio-economic characteristics of the households surveyed, as well as data on the purpose and length of different trips and the mode of travel used. The PTE data could therefore be used like the Samples of Anonymised Records (SARs) that are derived from the census, providing the data for an in-depth statistical analysis of commuting behaviour and patterns within the major metropolitan areas of the UK.

However the PTE data are not without shortcomings. The main weakness of the travel data and information provided by PTE surveys is that the survey is only carried out within the jurisdiction of the PTE in question. Thus, the survey provides no data or information pertaining to the, often substantial, number of individuals and households whose travel behaviour is multi-jurisdictional in nature. From a commuting perspective, this is 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 their own jurisdictions.

It is therefore 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 commuting literature and commuting data, as they could have important implications on the applicability of research findings or data when the latter are used in a different context from that in which the research was originally conducted or data were originally collected.

2.4 Mode of travel to work, commuting distance and homeworking

People travel to work using different modes of transport over different distances. The 2011 Census in England & 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 the fact that respondents are 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 O2 Arena in Greenwich and the Royal Docks in east London (BBC, 2012e). With the possibility that it will be included as part of the Oyster Travelcard system (BBC, 2012f) and the fact that it carried over 1.3 million

people in its first year in operation (BBC, 2012g), 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, 2013). 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 homeworking such as teleworking, telecommuting or home-based business working. Even the use of data from other 2011 Census questions would only allow for 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 the fact that teleworking and telecommuting have been around since the early 1980s (Martino and Wirth, 1990) and that 59% of UK businesses are operated 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 the fact that both have distinctive geographies (Shen, 1999; Levie and Mason, 2009). Home-based businesses account for a substantial proportion of the economies of rural areas (Dwelly *et al*., 2006) and 12% of the rural workforce (Levie and Mason, 2009). Despite the fact that distinguishing between different types of teleworking and telecommuting and between teleworking and home working has been 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 perfectly clear. 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, 2013a), 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, 2013b).

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 locations (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 has 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 behaviour and patterns. There are problems 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 a large number of people use more than one mode of travel to work.

Despite the increasing focus of census questions over time, and the relatively detailed picture that the SWS and STS give of commuting in the UK, there is no consistent and widely accepted distinction between long-distance and short-distance commuting. The decision about where to draw the line is left to individual researchers and academics. 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, although the travel of workers to oil rigs out in the North Sea comes to mind as a similar example. However, the definition does raise the key issue that commuting does not necessarily take part on a daily basis and this criterion may therefore be used to define long-distance commuting.

The distinction between long-distance and short-distance commuting is an important one, not least due to the fact that 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 of trade-offs 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 thereafter 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.

Despite this apparent improvement in 2011 relating to the ownership of second homes, as of early 2013 the flow data are only beginning to be released and it remains uncertain whether the ONS will tabulate flows between first and second homes in the interaction data sets and therefore whether commissioned tables will

be required that provide data with the potential to contribute to a deeper understanding of commuting and related short-term migration patterns.

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 tolerate 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 impacted 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.

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 (Gutierrez-Domenech and Bell, 2004). This general change in the role of females from homemakers to employees means that the commuting distance for the average woman has changed considerably since the middle of the twentieth century.

The rise of flexible employment practices and the dissolution of traditional time-regimes have also 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. These practices 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 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. The spreading out of land use 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 due to the fact that 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, 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 plane 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 employees to the commutes of unskilled employees and comparing the commutes of employees who work internationally to the commutes of employees who work in their local areas.

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. In the first instance, it is important to understand who commuters are and why they commute.

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' that come under the official measurement radar and which may involve some travel on a regular basis.

Despite the fact that commuting is 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 socio-demographic groups. Owner occupiers and highly educated 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. Specifically, time-consuming long-distance commuting in the UK tends to be particularly spatially concentrated, occurring mainly 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, 2012).

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 (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 the fact that conventional thinking holds 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 and thinking about (and sometimes carrying out) work for the day ahead.

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 proximity to 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, such as London. 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 of 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.

3.3 Explaining spatial commuting to work patterns

If we assume that the majority of commuters will be paid employees, 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 local labour market areas 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. Each local labour market has a spatial structure, with the places people live and the places people work defining the spatial extent of local labour market through the economic forces of 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, 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 preferences of workers and the hiring and firing preferences of employers are not completely dictated by the interaction of labour supply and demand.

Contrary to the assumptions of classical economics, the structure of a labour market can often impact directly on peoples' commuting behaviour. 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 cutback, 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).

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 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 (Cherry, 1996), 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. 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).

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).

Conversely, 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 and 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 economic system and temporary disequilibrium within it (Smith, 1982). 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) and will be discussed in more detail later in the paper.

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, Hoyt, Harris and Ullman, and Mann. 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), which 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 workingmen's homes. Further out from the zone of workingmen'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 to be developed using the Concentric Zone Model is bid rent theory, which was developed by Alonso (1964) 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 due to the fact that 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 of concentric land-use zones suggested by Burgess' Concentric Zone Model but 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 towards the centre of the city, 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 has important impacts on urban form that in turn have important impacts on 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 contribution to the theory of commuting behaviour and 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.

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). The gentrification and the 'back to the city' movements have been driven by the increasing economic and social costs of transport and travel, especially over long distances. The 'back to the

city' movement has mainly been property-led and has 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, sometimes with their families, to relatively desirable residential areas close to city centres and carrying out extensive home improvement works. 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.

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. Changes in commuting behaviour and transport networks will be dealt with in more detail in section 4.

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. 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 due to the fact that there are two different ways of trying to understand why, when and how people commute as they do.

The structure-agency debate has 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. Whilst the structure perspective appreciates the importance of factors outside of the individual's control in determining commuting behaviour, and the agency perspective takes account of the fact that some individuals live in places and commute 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 implications 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.

3.5 Modelling commuting behaviour

An investigation of commuting patterns not only requires an appreciation of past research and understanding of available data, but it also requires 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/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 aggregated or disaggregated. Although not always the case, a model representing more than one individual, which is more likely to use aggregate exogenous data, is usually referred to as an aggregate model, while a model representing individual behaviour, which is more likely to use disaggregated exogenous data, is usually referred to as a micro model. However, there are also issues related to cost, with the use of less detailed data 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, Daly (1982) goes as far as stating that, in many cases, there are essentially no differences between the different aggregate and disaggregate model types.

The second decision is whether to employ a cross-section or time series model. A cross-section model will rely on data for one point or period in time, with the census being a good source of cross-sectional commuting data, referring as it does to data

taken at one point in time at the start of each decade. Time series models, however, require time series data such as annual flows occurring over consecutive years, and while it is possible to make time series comparisons between censuses over a number of decades if the problems of inconsistency can be resolved, this situation is not ideal due to the length of the inter-censal periods. 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, the decision of whether to use revealed or stated preference techniques is also important. 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-section 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 or mathematical models have been proposed and calibrated in a range of transport contexts. Possibly the most famous model that is applicable to modelling origin-destination flows is the gravity model. Although the first gravity model ever developed was used by Ravenstein (1889) to model migration patterns in the UK in

the 19th Century, the first modern gravity models were used by Converse (1949) and Casey (1955) to model retail gravitation and town and regional catchment areas for shopping trips, respectively. These gravity models were derived from Newton's gravitational law and were 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:

$$T_{ij} = W_i W_j / d_{ij}^{-\beta} \quad (1)$$

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 (1) into:

$$\log Tij = \alpha + b_1 \log W_i + b_2 \log W_j - b_3 \log d_{ij} \quad (2)$$

where α is the intercept and the b's are regression parameters that define the nature of the relationship between the dependent commuting variable and the explanatory variables, such that β in equation (1) is estimated as b_3 in equation (2).

Although the gravity model has stood the test of time and is still widely used in academia, it is not without weaknesses. As Senior (1979) notes, the early forms of gravity model had 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, the gravity model only works at the aggregate level and says nothing about how aggregate interactions relate to individual interactions. Third, the gravity model, as indicated above, cannot accurately predict interactions which are consistent with the known constraints on their number. Finally, the gravity model 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 the gravity model 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, $\exp^{-\beta dij}$. One 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:

$$T_{ij} = A_i B_j O_i D_j \exp^{-\beta d_{ij}} \quad (3)$$

where $\sum_j T_{ij} = O_i$, the total outflow from zone i, and $\sum_i T_{ij} = D_j$, the total inflow to zone j, and where A_i and B_j are balancing factors which are computed using an iterative procedure, as outlined by Furness (1965) and Senior (1979), as:

$$A_i = [\ \sum_j B_j D_j \exp^{-\beta d_{ij}}\ ]^{-1} \quad (4)$$

$$B_j = [\ \sum_i A_i O_i \exp^{-\beta d_{ij}}\ ]^{-1} \quad (5)$$

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

Although mathematical commuting models may seem very academic, there has been an ambitious implementation of a mathematical commuting 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 virtually observed 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. Boyle and Feng (2002) 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 done 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 Ireland using a bivariate logistic regression model. In this study, the distance variable was entered into a bivariate logistic regression model to predict mode choice (that is active versus inactive commuting to school), controlling for sex, population density, socio-economic status and population clustering. In a similar vein, Helminen and

Ristimaki (2007) used a bivariate logistic regression 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.

4. Commuting Trends and Patterns: Historical and Contemporary

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. As such, the movements of people, and the modes of travel 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 as indicated in section 3.3. 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).

It is arguable that modern commuting patterns are largely a product of the Industrial Revolution, which occurred in Britain between around 1760 and 1830 (Crafts, 1996), and the concomitant large-scale rural to urban migration that accompanied it. These two historical processes, industrialisation and rural to urban migration, were so radical and far-reaching that the consequences of them are still to be seen in the urban forms, the transport networks and the social and economic structures throughout Britain today. As these processes radically altered the social and economic structure of Britain, they also influenced 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. 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. 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 doubled over this time period, with most of this increase occurring before 1920. 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; although the processes of suburbanisation and counter-urbanisation have now been occurring for over half a century in many parts of the UK. Given that post-war suburban developments were often not developed in conjunction with peripheral commercial or industrial developments, the development of suburbs in the UK has corresponded with increases in the size of travel to work areas (TTWAs or labourshed) 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 complexity 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 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.

Therefore, as commuting patterns are driven by the locations of residences and workplaces, commuting is intrinsically linked to urban form, as indicated in section 3.3. The complex links that form the urban spatial structure are due to the processes of spatial interaction (Bourne, 1982), of which commuting is one, as noted in the previous section. In the 1970s, for example, before commuting by car became even more common, only 17% of commuting journeys in dense and urban Central London were by car, in comparison with 37% of commuting journeys in more sparse and suburban Outer London (Pickup and Town, 1983). Thus, commuting behaviour influences urban form, which in turn influences commuting behaviour, creating a self-perpetuating cycle of movements and spatial interactions.

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, led 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).

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 the nature of commuting being dependent on the characteristics of different localities. For instance, the mode of commuting in Central London, with the high usage of its well-developed railway and underground networks (ONS, 2011a), is very different to the mode of commuting in other British cities, with their higher dependence on car usage (ONS, 2011a). In turn, the differences in the nature of commuting between London and other British cities seem minor in comparison to the differences in the nature of commuting between London and very rural areas of Britain, 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).

Commuting patterns are also linked to the prevailing political and economic ideologies that countries subscribe to. Liberal and capitalist countries, such as the USA and Canada, generally have more extensive and better developed road networks, which subsequently promote the private car often at the expense of public transport systems. The socialist and communist states of the eastern bloc, on the other hand, 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 and, as such, are considered relatively sustainable societies (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 credentials 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).

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 linked to economic changes. Present transport and travel issues are no exception. The general rise in real incomes over time leads to higher car ownership. Since 2000, there have been more households in Britain 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 without a car. 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 Britain 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 the

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 in 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 the fact 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. The analysis of commuting and general traffic patterns is important from a policy perspective. As journeys to work account 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.

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. In Canada, for example, the census captures commuting interactions (Statistics Canada, 2010) whilst in the USA, the census collects no information whatsoever on a person's workplace or travel mode (US Census Bureau, 2010).

As far as international comparisons are concerned, there is a general lack of extant research or literature. One study of commuting which was international in nature was carried out by Banerjee *et al*. (2007). The study 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. The study found that commuters in the USA and Switzerland were prepared to spend three hours every day on average commuting to work, while commuters in India were only prepared to spend two and a half hours commuting to work every day. Although Banerjee *et al*. (2007) argue that these findings have important policy implications, two problems 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. These two points, the difference between the theoretical maximums and the actual distances and the subjective nature of the data, are likely to limit the study's policy impacts somewhat.

Schafer (2000) also carried out research at an international level and found that time and money budgets for travel are largely similar across time and space for all the countries that were examined in his study, both developed and less developed. 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. However, comparability problems are likely to affect the findings, 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 in different countries.

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. 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 (IRF, 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.

5 Commuting Composition: Socio-demographic 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 that, in addition to, and in combination with, the spatial commuting patterns outlined above, commuting propensities and patterns vary by socio-demographic group. This variation is due to the different preferences and circumstances of individuals within those socio-demographic groups. The rise of flexible employment practices and the dissolution of traditional time-regimes mean that 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.

5.1 Commuting and personal circumstances: gender, age, ethnicity and health

It is important to note, before remarking on the correlations between different socio-demographic groups and different commuting behaviours and patterns, that the causal relationships between the different socio-demographic characteristics and the different commuting behaviours and patterns are not completely clear. As the spatial distribution of some socio-demographic 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 commuting behaviours observed are due to the different preferences of the different socio-demographic groups, and thus directly related to the characteristics of the group, or if the commuting behaviours observed are due to the different spatial distributions and spatial clustering of the different socio-demographic groups, and thus only indirectly related to the characteristics of the group.

The Department of 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), meaning that while males generally make long trips but fewer of them, 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 (Department for Transport, 2011).

The average commuting distance travelled by women depends on the stage they are at in the family life cycle, 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. This variation in commuting distance by gender has also been observed in other European countries (European Commission, 1980), which means 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. Differences in commuting behaviour between young and old 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 may explain the higher prevalence of public transport usage by older commuters. 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). Hence, individual commuting propensities and patterns are linked to the stage that an individual is at in the life cycle. However, the link is not as simple as it may at first appear. Changes in commuting behaviour over an individual's life cycle 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. 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*.

As well as differences in commuting propensities and patterns, different age groups often display different commuting behaviours. 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). 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 socio-demographic groups (Laflamme and Vaez, 2007).

Using data from the 1980s, Thomas (1998) found that ethnic minorities 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 non-white individuals have lower propensities to commute and migrate than white individuals 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 white people. 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 by the fact that not all non-white groups have the same migration propensities, with South Asians having the lowest propensities and Chinese having the highest propensities (Stillwell and Hussain, 2008), and the fact that convergence is taking place over time (Stillwell *et al*., 2008).

Despite these differences and the temporal convergence, the difference in commuting propensities between white and non-white individuals 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. 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 the job search efforts of ethnic minorities if local searches are more fruitful. Indeed, Rouwendal (1998) found that wasteful excess commuting occurs as a result of the maximising behaviour of individual workers as well as employers. 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, especially 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. The complex interplay between labour market status, health and commuting patterns and propensities is further 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). This is worrying from a public health perspective as, 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 directly correlated 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). It is therefore important to note that the relationship between health and commuting activity is not one way, with an individual's pre-existing health impacting on their commuting behaviour and their commuting behaviour impacting on their health.

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 telecommuters and their families (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 is 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 due to the fact that 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 a third dimension to it.

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 preferences 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 & Wales are now providing unpaid care (BBC, 2013c). Similarly, childcare commitments are likely to influence an individual's commuting preferences and behaviour. Gibbons and Machin (2006) found 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, ethnicity and commuting behaviour. Women are more likely than men to be carers (Arber and Ginn, 1994; Parker and Lawton, 1994) and provide childcare (EHRC, 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.

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

The pattern in Britain, 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). As with gender, this variation in commuting distance by employment status has also been observed in Ireland (Bannon *et al*., 1980) and other European countries (Ganser, 1969; Six, 1976). Occupation is highly correlated with income, with employees in professional and managerial positions earning substantially more than employees in unskilled jobs. Therefore, it is easier to economically 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).

As with occupation, an individual's level of qualification is likely to be correlated with income and occupation. Gibbons and Machin (2006) found that graduates are more mobile than non-graduates. As the 2005 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 actual differences in the commuting behaviours of the two groups, due to differences in characteristics, but also by differences in the spatial locations of the two groups. These two aspects interact to produce distinctive commuting patterns for full-time 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, with full-time workers spending 25.1 minutes commuting and part-time workers spending 17.9 minutes in transit. This disparity in commuting time between full-time and part-time workers is mirrored by a disparity in commuting distance, with MVA (2005) finding that while full-time workers in Scotland commuted 13km on average, part-time workers only travelled 7km. The differences in actual commuting behaviour between full-time and part-time workers may be due to part-time workers being less willing to pay commuting costs than full-time workers (Ermisch and Wright, 1993). This is due to the fact that work is likely to provide

greater financial rewards for full-time workers and therefore justifies longer and more complex commutes. It may also be due to the desire by 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 male and female part-time workers lead to short commuting distances, while part-time male workers are likely to both live and work in the inner city and city centre areas, women working part-time are unlikely to commute out of their local area for work. This difference along gender lines is backed up by research by the East Midlands Development Agency (2007). This research suggested that differences in commuting distance and commute time between full-time 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 by Shearmur (2006), it is important to note that there is a subjective and qualitative aspect to all commuting behaviour. When looking at the macro commuting patterns of different socio-demographic groups, one must be careful not to succumb to the ecological fallacy. 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 individuals' 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.

Furthermore, the above point reaffirms the importance of locality. It is important that locality is examined, in addition to the various socio-demographic variables, in relation to variations in behaviour (Buckner, 2009), as a local level analysis can highlight issues that are hidden in a macro level analysis (Buckner *et al.*, 2004). An understanding of how locality interacts with different socio-demographic 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). This point reaffirms the importance of government policy in

influencing the commuting behaviour of individuals and different socio-demographic groups. It is thus necessary to investigate government transport policy and the effect that is has, and has had, on commuting behaviour and patterns in the UK.

6. Commuting and Policy

Despite the fact that transport trends and transport systems have 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; although they have changed over time, and have been greatly exacerbated by the rise of car ownership and usage (Pucher and Lefevre, 1996). However, 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).

6.1 Commuting and transport policy

It is now half a century since the UK Government published two key reports that ignited the debate about road traffic that continues to 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 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, the reports 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 massively 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, 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 (Schaeffer 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 evidence 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 review, 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, including reduced car usage. 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 (DETR, 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 being 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).

6.2 Commuting and the definition of local labour market areas

The creation of travel to work areas (TTWAs) is also important from a policy perspective. Indeed, TTWAs were first developed as functional regions in order to better understand spatial variation in variables measuring the state of local labour

market areas across the UK, particularly unemployment rates (Coombes, 2010). TTWAs were seen as providing more appropriate spatial units and boundaries than Local Authority (LA) areas for the analysis of unemployment and other socioeconomic variables.

TTWAs are functional regions derived from the analysis of commuting flow data. The development of TTWAs based on commuting data in order to define local labour market areas (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 per cent of the resident economically active population actually work in the area, and where at least 75 per cent of people working in the area are actually resident in the area (ONS, 2012). TTWAs are important for labour market analysis and planning (ONS, 2012), 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 necessary 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). Therefore, 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 therefore appear to be the ideal spatial units to use for the analysis of commuting. They are a set of boundaries that fulfil the requirement of having been as consistently and appropriately defined as possible (Coombes, 2002). However, TTWAs are not without problems. First, TTWAs are spatial manifestations of 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 social and labour market 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 of the spectrum. 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 pretty 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 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.

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). The fact that certain researchers see TTWAs as interchangeable with other functional regions raises important questions regarding the definition of TTWAs and LLMAs. We return to the discussion of TTWAs and LLMAs in the UK in the next chapter, since these areas are used as the basis of one of the area frameworks for examining spatial variations in commuting intensity across the UK.

7. Conclusions

The aim of this review has been to establish the state-of-the-art in terms of research on commuting and some important points can be drawn out. However, the review has also highlighted some gaps in the current research landscape, which will help inform the trajectory of the future research activity. Some of the important points from the paper and some of the important gaps in the research are set out below as concluding remarks.

First, past research as reported in the literature has highlighted the importance and magnitude of commuting in the UK, and the issues that it raises and the problems that 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. There are over 20 million commuters in the UK and they, and the transport networks that they use, are focused on London in south east England and the major regional cities spread throughout the rest of the UK. This recognition of importance is accompanied by an acknowledgement of the issues and problems that society and the environment face that are related to commuting. 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, 2013a) and petrol price rises (BBC, 2013b). 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 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.

Second, the review has exposed the paucity of data related to commuting behaviour, patterns and propensities. Although the decadal UK census has gathered data on commuting behaviour in the UK since 1921, these data only presents a snapshot of UK commuting propensities and patterns on a relatively infrequent basis. Outside of the census, 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 do not collect any widely useable or comprehensive 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 are somewhat questionable.

Third, the 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 socio-demographic makeup of the area in question. Likewise, the socio-demographic variations in commuting propensities are the product of micro level individual preferences and constraints.

Fourth, by extension of the above point, the review has provided an initial insight into the different commuting propensities and patterns of different population sub-groups. Thus the review has made clear that researchers have identified distinct differences in commuting behaviour and propensities between different socio-demographic groups. Some of the key differences are: between men and women, between young people and old people, between individuals from a minority ethnic background and those not, between healthy individuals and unhealthy individuals, between individuals with caring or childcare responsibilities and those without, between skilled professional employees and unskilled employees, between highly qualified individuals and unqualified individuals, and between full-time workers and part-time workers.

Fifth, the review has drawn attention to the emergence of homeworking practices in the UK. The relatively recent increase in homeworking is an important trend when considering spatial and socio-demographic commuting patterns and propensities. On the one hand, it can 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. On the other hand, 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. The review has covered historical and contemporary theories of urban development and urban form that have had 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.

Although a rich mix of conclusions has been drawn from this literature review, there are substantial gaps in the literature. There has been little or no research addressing:

- variations in aggregate commuting propensities and patterns across the UK (including homeworking);
- variations in commuting propensities and patterns across the UK, disaggregated by socio-demographic group, socio-economic group, and mode of transport;
- spatial variations in commuting propensities and patterns across the UK;
- variations in the frictional effect of distance on commuters in different sub-groups of the UK population;
- the relationship between commuting propensities and patterns and migration propensities and patterns since the beginning of the 21st Century; and
- the extent to which recent changes in urban form have created new patterns of commuting.

It is apparent that, with the release of a new set of commuting data from the 2011 census, the time is ripe to explore some of these issues.

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