Preface

HUMAN SPATIAL INTERACTION

Moving house is an event that most people experience at some stage during their lifetimes whereas going to work or to study are part of daily activities for the majority of the pre-retirement population living in the United Kingdom (UK). For many individuals, both these activities can be amongst the most stressful experiences in their lives, much more so than other mobility behaviour such as going shopping, visiting friends or going on holiday, although the latter can be extremely challenging if travel arrangements break down! Much more time is spent on daily travel to work than on the relatively infrequent process of moving from one home to another, but the time invested in migrating can be considerable when the hours spent finding a suitable property are taken into account along with those used up deciding whether to move in the first place.

The statistics from the last census of population in 2001 tell us that migration and commuting are remarkably important phenomena in contemporary times, as they have been throughout modern history. Over 6.2 million people in the UK changed their place of usual residence in the 12 month period before 29th April 2001, representing around 10% of the total population of the UK. As shown in the table below, 5.15 million of these migrants moved within England, with relatively small numbers moving across national boundaries within the UK. In addition, a further 467,000 immigrants arrived from outside the UK in the same period and 406,800 individuals moved but we do not know where from because their origins were unstated on their census forms.

Table 1. Migrants and commuters in the UK

Destinations	England	Wales	Scotland	Northern Ireland
Origins	Migrants in 2000-01			
England	5,153,436	48,248	43,675	7,899
Wales	42,614	243,851	1,546	325
Scotland	42,831	1,396	473,789	2,633
Northern Ireland	8,812	360	2602	127,999
	Commuters in 2001			
England	22,310,327	35101	19424	954
Wales	63,764	1,117,481	921	79
Scotland	14,566	200	4,066,398	175
Northern Ireland	3,030	51	450	674,511

In comparison, over 28.3 million people were recorded by the 2001 Census as commuting to work, around two fifths of the total population, although 2.1 million flows involved people whose home and workplace locations were the same. The commuting flows originating in Scotland shown in the table also include the movements of students aged 16 and over to their places of study whereas the flows for the other nations are all associated with journeys to work. Recent studies have shown how commuting patterns vary for people in different occupations and people who use different means to travel to work (Littlefield and Nash, 2008) and how distances travelled vary spatially for those in part-time and full-time work (Dent and Bond, 2008). The aggregate figures for migrants and commuters in the UK indicate that we are dealing with two forms of human behaviour that are very substantial in numerical terms as well as being hugely significant activities from an individual point of view.

Studies of both aggregate flows and individual experiences have been carried out by researchers from a wide range of academic disciplines. At one end of the spectrum are the transport planners and regional scientists who seek to model interaction behaviour, usually in aggregate form, often using sophisticated quantitative techniques once empirical analyses of the data have been undertaken. This type of research may result in very practical applications: a new road is built to reduce commuting congestion or new housing is created in response to the pressure of demand from potential in-migrants. At the other end, sociologists and social psychologists carry out interviews and apply their more qualitative skills to understand the decision-making processes involved, usually at an individual or micro level, and to develop their causal models. Studies like these may provide much better understanding of phenomena like 'road rage' or lead to new methods of reducing stress or making better decisions about optimum locations for living and working. In between these perspectives there are, of course, a whole range of disciplinary approaches, including important contributions from theoretical and applied human geographers, both quantitative and qualitative. This book reflects the interests of quantitative human geographers with most of the authors based in departments of Geography in the UK. Hence, the book primarily focuses on the technologies that geographers use to capture, extract, manipulate, analyse, model and display migration and commuting data.

It is perhaps worth reflecting for a moment on the historical importance of migration and commuting since both phenomena have served to transform societies in major ways and to influence how settlements and landscapes have developed over time. We might consider, for example, the mass migration of individuals away from the countryside and towards the centres of industrial and demographic growth in nineteenth century Britain, drawn by the opportunities of jobs in the new mills and factories built as a consequence of the Industrial Revolution. In twentieth century Britain, particularly in the post-war years when car ownership became a reality for many families, suburbanisation became a characteristic feature of most large towns and cities in common with the urban sprawl evident in North America. This shorter-distance, intra-urban residential mobility was directly responsible for the growth in commuting that occurred in the 1950s and 1960s and illustrates the interdependence between the two phenomena, migration and travel to work. In the 1970s and thereafter, attention has turned from suburbanisation to new processes of population redistribution. One of these processes has been counterurbanisation, the movement of individuals and families away from major metropolitan centres and down the urban hierarchy to increasingly rural areas as documented by Fielding (1982) and Champion (1989), amongst others. Whilst the process of suburbanisation involved breadwinners whose place of work before and after the change of house remained the same, counterurbanisation also included those migrating away from the cities, severing their commuting to work ties and adopting a less urban style of living. In some cases, these individuals were those deciding to work locally or from home; in other cases, they involved those seeking unconventional lifestyles; the pioneers of the counterurbanisation movements were actually those reaching retirement age who, when becoming economically inactive, no longer required to maintain their ties to a place of work. The major losses from the big conurbations have continued in the twenty-first

century, causing policy makers to fear implications of urban neighbourhoods being abandoned whilst rural areas come under increasing house-building pressures (Bate *et al*., 2000).

Recent decades have seen the emergence of new streams of migration and commuting. Whilst the decline in the cost of travel and the preference for a higher quality of living environment has resulted in the rise of the long-distance commuter (Green and Owen, 1999; Nielson and Hovgesen, 2008), processes of gentrification have been taking place in inner city neighbourhoods that have attracted new residents as well as retaining those who might previously have considered moving out. Flats now form a greater proportion of new housing developments than ever before and many cities have experienced new trends in reurbanisation or 'city living' (Unsworth, 2007), encouraged by the policies of central and local government to promote urban renaissance and by the increasing numbers of students attending higher education institutions and requiring accommodation relatively close to their place of study. These trends in internal population redistribution have been occurring at a time when London and many large provincial cities in the UK, whilst losing migrants in considerable quantities to the rest of the UK, have experienced large influxes of immigrants from overseas. Asylum seekers and refugees have become a major stream of newcomers in the last decade, locating initially in London and the South East but moving to provincial locations under the dispersal arrangements put in place by the Home Office and living in National Asylum Support Service (NASS) accommodation. Most recently, attention has been drawn to the increasing number of economic migrants, new migrant workers who are living and working, often temporarily, in different parts of Britain, some of whom have entered the country illegally but who provide a source of cheap labour. International net immigration over the past decade has been at an unprecedented scale, reaching a peak of 244,00 in 2004, and this has led to proposals from an all-party group of politicians for a 'balanced migration' target policy (Migration Watch, 2008).

All these migration and commuting trends, and the patterns of flows that occur as a consequence, raise many questions about the explanatory factors that lie behind the behaviour we observe and about how things will change in the future, leading to a wide range of theoretical, empirical and model-based research looking at historical change but also offering prediction and speculation about what might happen in the future. Some scenarios, particularly associated with immigration, make regular headline news and define new socio-political agendas. Key questions resurface time and time again: Are people currently more or less likely to migrate than in the past? How many new immigrants can we expect from overseas? Do people nowadays commute over longer distances than in the past? What variations in migration propensity exist between different sub-groups of the population? Do more people travel to work by car or by public transport? What are the motivations behind the changes that have occurred in the patterns of migration and commuting? What will be the impact of particular changes in migration or commuting propensities or patterns?

SECTION 1: THE DATA IMPERATIVE

In order to investigate the patterns, processes and drivers of mobility, there is a requirement for comprehensive and reliable data. Where have these data come from historically and why is the Census of Population revered as such a key source of information in the UK? What are the alternative sources of data on migration and commuting? The importance of understanding and using the data that are available to analyse these forms of human interaction provides the rationale for the first half of this book, which contains a series of seven chapters that cover data availability from different sources, online access to census data, confidentiality issues and disclosure constraints, generic analysis and mapping tools, and

spatial and temporal consistency, together with more detailed accounts of reconciling data on international migration from different sources and of using census micro data for investigation of migration and health and deprivation.

The contents and issues presented in the chapters that constitute Part 1 are particularly pertinent at the time of writing since much public and governmental concern has been expressed about the limitations of current sources of both UK internal and, in particular, international migration. In the Foreword of a report by an Interdepartmental Task Force on Migration in 2006, Karen Dunnell, the National Statistician, states that "there is broad recognition that available estimates of migrant numbers are inadequate to meet all the purposes for which they are now required. They are the weakest component in population estimates and projections in the United Kingdom, both nationally and at local level" (National Statistics, 2006, p. 3). The report contained 15 recommendations which have been the focus of an initiative, led by the Office of National Statistics (ONS) for 'Improving Migration and Population Statistics' (IMPS) resulting in various changes to the collection of international migration data and creation of sub-national immigration and emigration estimates that are critically important in the production of annual mid-year population estimates and biennial population projections. In 2008, a Parliamentary committee reviewed issues raised by local authorities and others about the inadequacy of official population statistics and its report (House of Commons Treasury Committee, 2008) resulted in a cross-government programme – the 'Migration Statistics Improvement Programme' (MSIP) – that is responsible for delivering the Task Force recommendations between 2008 and 2012. A Report by the UK Statistics Authority (UKSA, 2009) reviews progress on MSIP and the adequacy of co-operation across government to deliver the planned improvements, whilst commissioned research by Rees *et al.* (2009) published in the same UKSA report, provides a concise summary of migration statistics, a critique of MIPS and a review of migration estimation methods.

Concepts of space and time are critical in the understanding of migration and commuting since both involve the movement between two places and are measured over specified periods of time. Chapter 1 introduces the reader to some of the basic definitional and conceptual issues that underpin interaction data before providing a summary of data from the most important census, administrative and survey sources. The fundamental importance of population censuses in the UK is emphasized and 2001 Census variables are contrasted with those produced from the 1991 Census. In fact, census questions about migration have evolved from the earliest focus on place (county/parish) of birth (from 1851 Census) and country of birth (from 1841 Census) to place of residence five years previously (1971 Census) and one year previously (1961 to 2001 Censuses). Commuting flows are constructed by comparison of a place of work and a residential address and census questions focus on the mode of transport used. Census questions about place of work (1921, 1951-2001 Censuses) and journey to work (1966, 1971-2001 Censuses) are now commonplace but a question about 'occupation one year ago' was also asked in 1971.

Easy access to interaction data is critical because of the complexities of large origin-destination data matrices and Chapter 2 provides a technical guide to the Web-based Interface to Census Interaction Data (WICID), an online software system that has been developed by the Centre for Interaction Data Estimation and Research (CIDER) to allow users to build queries and extract data from the last three censuses quickly and easily. Equally important is knowledge of the ways in which data from these censuses have been adjusted and Chapter 3 presents the different methods used to reduce the risk of disclosure and maintain confidentiality. In particular, a new small cell adjustment method (SCAM) was introduced by the Office of National Statistics (ONS) when pre-processing the 2001 data that does not permit any of the data to be 'recovered' with methods similar to those used to 'unsuppress' the data that was suppressed in the 1991 Census tables. The impacts of adjustment on the flow counts at different spatial scales are evaluated in this chapter.

Once data sources have been identified, data have been extracted and downloaded and the characteristics of the data have been understood, the next challenge is to consider how the data are going to be analysed. Chapter 4 has been written with this in mind, introducing the reader to the 'interaction matrix' and the notation frequently used in the literature for origin-destination variables before explaining a number of different measures of interaction, reviewing popular statistical and modelling methods and offering a new way of visualising interaction flows through vector analysis. Chapter 5 confronts another major issue for those researchers interested in how migration or commuting changes over time: spatial and temporal consistency. The fact is that inconsistencies occur in a variety of ways and for different reasons. There are inconsistencies in the definition and measurement of variables from one census to the next; there are differences in the way that counts are categorised within particular themes and new standard classifications come into operation; there are variations in the counts that are released by the census authorities; and there are continuous changes between censuses in the geographical boundaries of the spatial units that comprise census areas. The issues of consistency are considered and a time series analysis of migration in Britain is presented based on a consistent annual time series of data obtained from National Health Service (NHS) patient registers from 1998 to 2006.

One of the most newsworthy phenomena in the twenty-first century has been the volume of immigrants of one form or another arriving in Britain in recent years, resulting in considerable press coverage and central government attention in terms of policy response as well as improving data integrity. As mentioned previously, there has been recognition that existing census, administrative and survey mechanisms for measuring both immigration and emigration flows have been inadequate and that better international migration statistics are required. Chapter 6 demonstrates one approach to this problem, explaining how data from the various sources of international migration might be integrated in a 'New Migrant Databank' so that authorities at national, regional and local level can monitor the different measures and attempt to explain the variations that appear in trends evident in data from different sources. Finally, in the last of the chapters in this first part of the book, Chapter 7 looks in more detail at two different sets of microdata that are produced from the census. The Samples of Anonymised Records (SARs) give researchers a valuable way of looking at the migration and commuting characteristics of individuals that are unavailable from other census products, whereas the Longitudinal Study (LS) is a sample of individuals that have been tracked from the 1971 Census through to the 2001 Census and therefore allow investigation of inter-censal change.

SECTION 2: CASE STUDIES

Several of the chapters in Section 1 contain analyses of migration and commuting but it is the nine chapters in the second half of the book which provide a series of case studies of migration and commuting in different contexts using different methods. The applications commence with what are essentially descriptive analyses of propensities and patterns before progressing to studies that use increasingly sophisticated methods and modelling techniques to understand mobility in the UK.

The first three chapters in Section 2 are dedicated to analyses of migration data from the 2001 Census. Chapter 8 considers one of the most important selective influences of migration, age, by investigating the internal migration patterns of those in different age groups and making use of a national area classification as a framework for summarising flows at the district scale. Migration age schedules are compared across types of district for measures of migration turnover and churn. Whilst data from the 2001 Census Special Migration Statistics (SMS) are used for this investigation, Chapter 9 is based primarily on tables specially commissioned from the ONS that cross-classify age and ethnicity at ward level and

allow the analyses of variation in migration propensities for Britain's ethnic groups by broad age group. The analysis reported in this chapter focuses on wards in London, revealing distinctive spatial patterns of net migration when separating flows between wards within London from flows between London wards and the rest of England and Wales and confirming that migrants of all ethnic groups tend to move away from areas of higher deprivation. The third chapter in this mini-series, Chapter 10, also uses the SMS, but in this instance, the theme is migration and socio-economic polarisation and the data set used involves migrants with certain socio-economic characteristics. In fact, the counts for this variable are only available for 'moving group reference persons', a new category of migrants introduced in the 2001 Census for the first time. Moreover, the analysis is conducted for a set of 27 city regions, with London, Birmingham and Bristol being selected as three case studies for particular attention.

In contrast to these chapters on migration, the next two chapters are both concerned with commuting. Chapter 11 aims to provide an assessment of the suitability of 2001 Census data for analyses of commuting in rural England. Several of the problems with the census data are highlighted, not least that of the adjustment of small flows in order to reduce the risk of disclosure. This problem is avoided in the work reported in Chapter 12 which involved the definition of a new set of 2001 Travel-to-Work areas (TTWAs) for ONS based on flows unadjusted by SCAM between small areas known as lower level super output areas. TTWAs have been defined using commuting data from each of the last four censuses and the 2001 TTWAs have been generated from a much larger set of flows than previously. The chapter reports the method of definition and shows how these functional labour markets can be visualised at different stages of the definition process.

The four remaining chapters of the book each involves the application of a modelling approach to the data sets concerned with a different purpose in mind in each case. In Chapter 13, the aim is to generate sets of migration and commuting flows that can be compared between censuses. This addresses one of the major issues discussed in Section 1, that of spatio-temporal inconsistency, and the modelling approach that has been developed makes use of Poisson regression to estimate 1981 and 1991 inter-ward flows that are consistent with flows between 2001 Census wards. Poisson regression is also the statistical modelling style used in Chapter 14 to estimate the independent variables that might be used to predict inter-district migration in Britain. The chapter explains the methodology in detail and reports the results of a calibrating a series of models: a Poisson model that includes traditional gravity variables, the same model with an additional contiguity dummy, a negative binomial form of the model to allow for over-dispersion; and a zero-inflated Poisson model. Chapter 15, on the other hand, explains how a multiplicative component framework can be used to explore the age and ethnic structures on inter-regional migration in England using data from the 1991 and 2001 Censuses. Inter-regional matrices are disaggregated into a series of components that enable insights into the stability in the overall level of migration, the out-migration push component, the in-migration pull component, and the origin-destination component representing the distance between places. A multiplicative component model expressed as a log-linear model enables the effects of different components to be identified and described. Finally, in the last chapter of the book, Chapter 16, a new spatial interaction modelling framework is proposed which separates out the constraint equations in the spatial interaction model proposed by Wilson (1971) from the actual model equation and which uses a genetic algorithm to define the optimum form of model to be used. The modelling framework is demonstrated using flow data on the journey to school by pupils in Leeds.

There is no doubt that the developed world is witnessing fundamental shifts in social behaviour which include changes in the two forms of mobility with which we are interested: moving house and travelling to work. Furthermore, we must also acknowledge that research is also changing as we attempt to analyse and understand the huge quantities of data that are now being collected and made available on increasingly powerful computational facilities. This book is therefore aimed at students, researchers

and practitioners interested in contemporary migration and commuting patterns and the data sets that underpin our knowledge of this human behaviour. In particular, the chapters review, describe and analyse information known collectively as the interaction or origin-destination data sets and we have included three classroom exercises in the appendix to guide students through the extraction, processing and mapping of flow data. We recognise that there is huge popular interest in issues related to both migration – housing market pressures, gentrification, second and holiday home ownership, counterurbanization, and immigration, for example – and to commuting – urban traffic congestion, new road construction, environmental sustainability and public transport, politics of the 'school run' and definition of travel-to-work areas, for example. Despite the importance of understanding these phenomena, the data sets that exist to inform us about them remain under-used and under-exploited by researchers and policy makers, partially because of their huge size and complexity. This book attempts to demystify the data sets and to demonstrate how they can be used with modern computational processing and analysis tools to provide insights into the changing behaviour of individuals, households and moving groups in the twenty-first century.

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