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ETHNIC POPULATION PROJECTIONS FOR THE UK AND LOCAL AREAS, 2001-2051

Working Paper 10/02

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Project web pages:
http://www.geog.leeds.ac.uk/research/projects/migrants.html

Notes on the projection results

1. The results described in this report are both provisional and experimental and should be cited as such.
2. The data used derives from official sources (see the copyright notice under Acknowledgements), but the results are solely the authors' responsibility.
3. Disclaimer: the authors accept no responsibility for any consequences of the use of the data published in this report.
4. Full results from the projections will not be released until the project has delivered to ESRC, the sponsors of the research, the Final Report on the project and the data have been delivered to the UK Data Archive as required under the ESRC research contract.
5. We anticipate that full release of the data in flat file format will be announced at the ESRC Research Methods Festival, St. Catherine's College, Oxford on 6 July 2010.
6. We have submitted an ESRC Follow On Bid to disseminate the project's input and output data via a general database and web interface, which will be free to researchers and users who register their interest in the results. However, there is no guarantee that the results will in future be disseminated in this way.
7. Please report any errors in the results so that they can be corrected.

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EXECUTIVE SUMMARY

This report summarises the results of ESRC Research Award, RES-165-25-0032, *What happens when international migrants settle? Ethnic group population trends and projections for UK local areas,* 1 October 2007 to 31 March 2010. The principal aim of the project was to produce projections of ethnic group populations for local areas in the UK. The ethnic make-up of the UK's population is changing significantly at present and groups outside the White British majority are increasing in size and share, not only in the areas of initial immigration but throughout the country. This growth is driven by all the demographic components: immigration balanced by emigration, differences among ethnic groups in fertility levels and varying mortality experiences. Important spatial re-distribution of the population is taking place through internal migration. The ethnic make-up of local areas is therefore evolving. The composition of the population is also changing through the birth of children of mixed ethnic origins. We estimate all of these components of change for 16 ethnic groups and 352 local authorities in England together with estimates for Wales, Scotland and Northern Ireland. The most reliable estimates can be made for 2001, when the last decennial census was held. However, we extend these estimates to later in the decade, to the 2006-7 or 2007-8 mid-year to mid-year intervals, depending on component.

For the projections, we make assumptions about how component rates, probabilities and flows will develop in the next forty or so years and feed these into a projection model. This model is ambitious: we work with single years of ages to age 100+, a large number of areas and a large number of ethnic groups. To make projections of such a large set of population groups possible we designed an innovative bi-regional projection model. We report in detail on the results of five projections: two benchmark projections that explore what would have happened if the dynamics of 2001 had continued; a trend projection in which the assumptions for components beyond 2008 are adjusted in a general way to those adopted in the 2008-based National Population Projections; and two UPTAP projections that reflects the team's views on how component intensities will change in future.

We report on the outcomes of the projections using a variety of indicators and illustrations. The ethnic composition of all areas continues to change with the White British and Irish populations diminishing in numerical importance. The Mixed populations are the fastest growing, followed by the newer immigrant groups and then the traditional south Asian origin communities. All of these minority communities shift their distributions over the four projection decades so that by the end of the forecasting horizon they are significantly more dispersed than at the start. The projections yield a picture of the UK's demography which is both complex and fascinating. We can look forward to be being a more diverse nation but one that is more spatially integrated than at present.

The **key findings** of the research are as follows.

Model innovations

(1) We have designed an **innovative model** to project forward ethnic group populations for local areas in the UK simultaneously.

(2) The key innovative feature of the model is its **bi-regional structure** that captures the migration connections between areas and enables simultaneous projection of 355 zone populations.

(3) The model handles internal migration through **probabilities of out-migration conditional on survival within the country**. Such probabilities enable the proper separation of mortality and migration processes.

(4) The model design makes possible **different configurations of the international migration process** as gross or net flows or rates. We have explored two configurations: treating immigration and emigration as gross flows (the EF model) and treating immigration as gross flows and emigration as a product of emigration rates and populations at risk (the ER model).

(5) The model handles all **sixteen ethnic groups** recognised in the 2001 census.

(6) The model connects together ethnic groups by generating **births of mixed ethnic parentage**, using information from the 2001 census.

(7) The model handles explicitly **all population components** of change: fertility, mortality, immigration, emigration, internal in-migration and internal out-migration for each local area and for each ethnic group population.

(8) The model uses **single years of age** from 0 to 100+, which recognizes the need to know more about the distribution of the population of the very old, as the population ages.

(9) The model has been written as **a set of R scripts**. R is a general purpose statistical computer language/package, which has handles large arrays well and enables the projections to be run in a few hours.

Component estimates

(10) New **estimates of ethnic group mortality** have been prepared, which show moderate variation. The range in life expectancies between best and worst experience is 5 years, lower than in other countries where equivalent information is available such as the USA or New Zealand.

(11) Assumptions about mortality are driven by adopting annual percentage decline rates for age-sex-ethnic specific mortality which are converted into improvement rate for the survivorship probabilities used in the model. For the UPTAP projections we adopt a **decline rate of 2% per annum**, which is much lower than the decline in the last decade, about equivalent to the declines of the past 25 years and much higher than the 1% per annum assumed by National Statistics.

(12) Our fertility rate estimates are based on three sources: annual vital statistics, census populations (mothers and children) and LFS data for post-census information on ethnic fertility. The method is calibrated for 1991 and 2001. For 2006-11 the **total fertility rate estimates** range from 1.47 for the Chinese women to 2.47 for Bangladeshi women, with TFRs for White women estimated to be 1.88 and for Mixed women 1.74. Asian group fertility is estimated to be higher than Black group fertility. These estimates are higher than those of National Statistics but lower than those of Coleman.

(13) Our work on international migration has focussed on improving **local area estimates of immigration** using administrative sources. We combined this with the ethnic profile based on the 2001 Census immigrations. These estimates are different from the ONS and Coleman alternatives.

(14) Our internal migration estimates were based on a commissioned table from the 2001 Census which provided counts of total migrants (persons) moving between local authorities in the UK by ethnic group. From this information we computed the **total probabilities of out-migration (given survival within the UK)** and **the total probabilities of out-migration from the Rest of the UK to the local authority**. Uniform age profiles by age and sex were applied to these probabilities. After 2000-1 the migration probabilities were factored up or down depending of changes in the rate of out-migration from local authorities as monitored by the Patient Registration Data System.

(15) There is clear evidence in our projections that the internal migration probabilities are driving a **significant redistribution of the BAME populations**. They are spreading out from their clusters of concentration in 2001 to a wider set of residential locations by mid-century.

Projection results

(16) When we aligned our projection assumptions as closely as possible to the 2008-based National Population Projections (NPP), we obtain a comparable trajectory for the UK population as a whole. In 2051 in these TREND-EF projections, the UK population grows to 77.7 million compared with 77.1 million in the NPP. The gap of 0.6 million is **an estimate of the aggregation effect** in projection, being due to the difference between projecting four home country populations and projecting a large number (355 ×16 = 5680) of local authority-ethnic groups.

(17) Our BENCHMARK projections produced much lower projected populations than the NPP at 55.1 million (the ER model) and 63.0 million (the EF model) in 2051. The gaps of 20.0 and 14.1 million people demonstrate **the dramatic demographic shift** in the 2000s, that is, the combined impact in the 2001-2009 period of lower mortality (gains of 2.1 years in male life expectancy and 1.5 years in female for the UK 2000-7), higher fertility (gains of 0.33 of a child in TFR for the UK 2001-8) and higher net immigration (+154 thousand in 2000 and +217 thousand in 2007).

(18) The differences between our UPTAP-EF and UPTAP-ER projections demonstrate **the impact of a change in the model for emigration** can have. Modelling emigration as a fixed flow count rather than a flow produced by applying a fixed rate to a changing population at risk produces total populations in 2051 that differ by 9.1 millions.

(19) Our projections show **huge differences in the potential growth of the different ethnic groups**. Under the TREND-EF projection between 2001 and 2031 the White British group grows by 4%, the White Irish group by 10% and the Black Caribbean group by 31%. These are the low growth groups. The Mixed groups grow between 148 and 249%. The Asian groups increase between 95 and 153%. The Black African group grows by 179%, the Other Black group by 104%, the Chinese group by 202% and the Other Ethnic Group by 350%.

(20) As a result of these differences, **the ethnic composition of the UK will change** substantially over the period to 2051. Under the TREND-EF projection, the White share of the population shrinks from 92 to 79% and the BAME share increases from 8 to 21%. Two groups face loss in share: the White British population share shrinks from 87.1 to 67.1% and the White Irish share shrinks from 2.5% to 2.1%. The Black Caribbean share stays stable at 1.0%. The other BAME groups expand their population shares along with the Other White group share, which grows from 2.5% to 9.9% (the greatest gain). Mixed groups increase their share by 3%, Asian groups by 4.8%, Black groups by 2% and Chinese and Other ethnic groups by 2.6%.

(21) **All ethnic groups undergo population ageing**. The BAME groups in general increase the share of their population that is elderly so that the 2051 share (except the Mixed groups) is comparable with the White British share in 2001. The share of the White British population in 2001 that was 65 or over in age was 17%. The BAME (except Mixed) shares in 2051 range from 15 to 28% (TREND-EF projection). The Mixed groups still have smaller elderly shares at 8-10% in 2051. The White British share has risen from 17 to 27%. This ageing has important implications for social policy.

(22) **Changes in working age shares vary depending on ethnic group**. Only the Mixed groups and the Bangladeshi group increase their working age share. The other groups see falls in the working age share ranging from -1% for the Other Black and Pakistani groups to -13% for Black Caribbean group.

(23) There is **important regional and within region variation** in the changes in ethnic group population sizes, shares and concentration. Detailed accounts of regional and local variations in ethnic population change are provided in the paper.

(24) **Ethnic minorities will shift out of the most deprived local authorities and will move into the least deprived local authorities**. The distribution of ethnic minority populations shifts favourably over the projection horizon, while that of Whites remains stable. The percentage of the Mixed group population in the most deprived quintile of LAs reduces from 26% to 19%, while the percentage in the least deprived quintile increases from 22% to 29%. The corresponding shifts for Asian groups are from 25 to 18% for the most deprived quintile and from 9% to 20% for the least deprived quintile. For Black groups the most deprived quintile sees a decrease from 54% to 39% while the least deprived quintile sees an increase from 7% to 19%.

(25) There are **significant shifts to LAs with lower ethnic minority concentrations** by Mixed, Asian and Black populations from LAs with high ethnic concentrations, while the White and Chinese and Other group distributions remain in 2051 as they were in 2001.

(26) **Ethnic groups will be significantly less segregated** from the rest of the population, measured across local authorities, in 2051 than in 2001. The Indexes of Dissimilarity between each group and the rest of the population fall by a third over the projection period.

(27) **The UK in 2051 will be a more diverse society than in 2001** and this diversity will have spread to many more part of the country beyond the big cities where ethnic minorities are concentrated.

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Data sets

This research used census data obtained via MIMAS's CASWEB facility, the SARs support team at CCSR and interaction data from CIDER, Labour Force Survey data via ESDS Government and GIS boundary data via EDINA's UKBORDERS facility, services all supported by ESRC and JISC. Any census, survey, official Mid-Year Estimates and Vital Statistics data for England and Wales, Scotland and Northern Ireland used here have been provided by the ONS, GROS and NISRA and the digital boundary data by OSGB and OSNI. These data are Crown copyright and are reproduced with permission of OPSI.

Advice

We are very grateful to the following for their advice, discussions and encouragement over the 2007-2010 period. John Stillwell and Adam Dennett, who helped us in using the commissioned migration data from the 2001 Census for ethnic groups and for the PRDS and NHSCR time series that they developed for the Centre for Interaction Data Estimation and Research (http://cids.census.ac.uk/). Tom Wilson of the University of Queensland came over from Australia for a research visit in summer 2009 that helped us move our projection model forward to its present bi-regional form, helping us achieve a fast and feasible model design. Frans Willekens, Director of the Netherlands Interdisciplinary Demographic Institute, also visited in July 2009 to help in a Summer School in which we presented some of our work to a cohort of Europe's smartest young social science researchers and persuaded us that the shareware statistical programming language R was the right one to adopt to implement our new projection model. On a number of occasions we benefitted from attending workshops organised by James Raymer of the University of Southampton, from contributing to a book and a special journal issue that he organised. Several conversations with Ludi Simpson of the Universities of Manchester and Sheffield helped us clarify particular features of our work. David Coleman and Sylvie Dubuque kindly shared the progress of their parallel project on ethnic fertility and its implications for future ethnic populations. We benefitted very much from collaboration with John Hollis of Greater London, who kindly chaired our Stakeholder group and helped emphasise the potential demand for our work in the local government community. Roma Chappell, Emma Wright, Jonathan Swan and Chris Shaw of the Office for National Statistics have been supportive of our work along with their colleagues Robert Fry, Jonathan Smith, Pete Large and Richard Peirara. Luned Jones and Elinor Griffiths of the Welsh Assembly Government expressed an interest in our work and have committed to the production of ethnic group population estimates for Wales. David Marshall and colleagues at the Northern Ireland Statistics and Research Agency responded with incredible speed to many data requests. Cecilia Macintyre, formerly of the General Register Office Scotland and now at the UK Statistics Authority, always encouraged our research efforts with kind remarks and searching questions.

1. INTRODUCTION

This report provides a comprehensive account of the population projections for ethnic groups produced by a team of researchers at the University of Leeds. The research project, entitled, *What happens when international migrants settle? Ethnic group population trends and projections for UK local areas,* was funded by the Economic and Social Research Council (ESRC) under the Understanding Population Trends and Processes Programme (ESRC RES-162-25-0032).

The **aims** of the project were:

- to understand the demographic changes that the United Kingdom's local ethnic populations are presently experiencing and are likely to experience in the remainder of the 21st century
- to understand the impact that international migration and internal are having on the size and ethnic composition of UK local populations
- to understand the role that differences in fertility between the UK's ethnic groups plays in shaping current and future trends
- to understand the role that mortality differences between ethnic groups is playing in the changing demography of the UK's local populations
- to understand how the ethnic diversity of UK local populations is changing and likely to change in the future
- to deliver the projections as a resource for use by social science in the UK
- to build capacity in the analysis of demographic change through the development of young and middle career researchers
- to tap into the best practice internationally to benefit the UK social science community.

Why are these changes important? Because these demographic changes are altering the ethnic composition of the population, with many implications for the cohesion of UK society, for the nature of British culture, for the supply of and demand for labour and the way in which the UK will cope with the challenges of ageing over the 21st Century.

To achieve the project aims, the **objectives** were to build projections of the populations of ethnic groups for UK local areas and to use the population projection model to explore alternative futures.
The **ingredients** needed to achieve these objectives required the project (1) to build estimates of and reliability measures for *ethnic group fertility* (about which there is not an agreed view) using alternative data sources, (2) to make estimates of and measures of reliability for *ethnic group mortality* through indirect modelling, (3) to build a *databank of international migration* for local areas by assembling relevant census, survey and administrative data sets and to develop estimates and measures of reliability for long-term and short-term immigration and emigration, (4) to build

estimates of and measures of reliability for *internal migration* for ethnic groups using both census and register based migration datasets.

At the heart of the project were the following **tasks**: (1) development of a population projection model that delivers projected ethnic populations for local areas that incorporates the best of current practice in projection modelling from different countries and prior work, (2) incorporation in that model of incorporates interactions between groups (in particular mixed unions leading to infants with mixed origins), (3) inclusion in the model of interactions between local areas (migration flows from origin areas to destination areas) and (4) a method that handles different ethnic group classifications in the countries of the UK. We decided not to handle identity shifts in ethnic group membership (at say age 18 when individuals become adults) as the Longitudinal Study information was inadequate (Simpson and Akinwale 2007, Simpson *et al.* 2005).

The plan for reporting on these tasks and projection results is as follows. Section 2 reviews approaches to ethnic population projection in the literature and selects a model for use in the UK. Section 3 spells out the "state-space" of the projection model: that is, which population groups, spatial zones, age groups and time intervals will be used in the estimates and in the projections. Section 4 gives a formal description of the projection model in both words and equations. Section 5 of the report provides a guide to the software implementation of the projection model in which the statistical language/package R was used. Sections 6 to 9 spell out the data, methods and assumptions employed to estimate ethnic specific rates, probabilities or flows needed to estimate an historical time series of changes from mid-year 2001 to mid-year 2007 and the assumptions needed to drive the projection forward from the jump off year of 2007. Section 6 tackles the fertility component, section 7 the mortality component, section 8 the international migration component and section 9 the internal migration component. Section 10 describes the scheme adopted for our five projections and the assumptions used in each projection. Section 11 provides an overview of the results of five projections: two Benchmark projections, a Trend projection and two UPTAP projections. The outcomes are explained in terms of total numbers and age distributions for the 16 ethnic groups used in the projection for the UK, organizing the description for groups with roughly the same futures. Then we analyse the results using different spatial aggregations, which provide strong clues to the processes of differential population change and re-distribution: we use Government Office Region (GOR) in England plus the other Home Countries, a set of metropolitan and non-metropolitan regions, a local authority (LA) classification (Vickers *et al.* 2003), a population density LA classification, LAs sorted into deprivation quintiles based on Townsend scores and an LA classification into ethnic concentration classes. We present selected LA results from the 355 zones by presenting results for the most diverse districts in each GOR.

2. A REVIEW OF ETHNIC POPULATION PROJECTIONS

2.1 Aim of the review

The aim of this section of the report is to review the field of ethnic population projection, building on an earlier review by Coleman (2006b) but looking at the alternative methods rather than outcomes. Why might we want to project the population of the ethnic groups of a developed country? The first reason is that if demographic intensities (either rates or probabilities) vary substantially across sub-groups of the population, then that heterogeneity needs to be taken into account in constructing projections. There is plenty of evidence of such heterogeneity (ONS 2004a). The second reason for projecting ethnic group populations is so that we can plan for the future more intelligently, to reach social goals (greater equality of opportunity across ethnic groups), economic goals (to assess the future labour supply in terms of size and skills and determine what policy is needed to improve skills of the resident population) and community goals (the provision of the right schooling, the right mix of goods and services). You might object that the future is likely to be uncertain, so that projections will always turn out to be wrong. But the range of uncertainty can be estimated either by running many projections under different variants or scenarios or by sampling from error distributions of summary indicators of the main component drivers, fertility, mortality and migration.

There are, however, a number of challenges involved in carrying out ethnic population projections. How should ethnic groups be defined? How should they interact demographically? How do we estimate the key ingredients – fertility, mortality, internal and international migration by ethnic group – in the face of inadequate data? What kind of projection model should be employed? What assumptions should we adopt for future fertility, mortality or migration differences? How do we validate our projections?

2.2 Context

Developed world populations are being changed by three interacting trends: below replacement fertility for three to four decades, steadily improving life expectancies, particularly at older ages and significant inflows of migrants to the richest countries. These trends mean fewer children than in the baby boom years (circa 1946 to 1975) and a greater number of older people, with population ageing about to accelerate as baby boomers born in the years 1946 to 1975 cross various old age thresholds. Population ageing is mitigated in part and over the medium term by international immigration to developed countries from developing countries. Because the ethnic make-up of the immigrant stream is different from that of the already settled population, the ethnic composition of European country populations has been moving away from dominance by white Europeans towards both greater diversity of groups and a larger population of mixed parentage. The main demographic consequence of sustained flows of international migrants into a country and its regions is the growth of the populations of immigrants and their descendants and, if the settled or native population has low rates of growth, the subsequent changes in ethnic composition of the population. This, in turn, leads to changes in national identity and culture. Coleman (2006a, 2006b) has labelled this sequence of events the *Third Demographic Transition*.

Countries need to have a view of their future, under different scenarios. One aspect of that future will be the size, age structure and ethnic composition of the national population, given various assumptions. These demographic features are likely to change substantially for developed countries such as the United Kingdom over the next 50 years. What demographers normally do to explore the future is to carry out projections of the population. So far, these projections have taken into account the age and sex structure of the population and its spatial distribution at country, region and local levels (ONS and GAD 2006, ONS 2008a), but ethnic composition has not so far been included routinely in projections.

2.3 An example of changing ethnic composition: the case of the UK population

The population of the United Kingdom is continuing to grow at a moderate pace, 0.54% per annum in 2001-8 but this has accelerated from 0.37% in 2001-02 to 0.65% in 2007-8 (ONS 2010a, Table 1.1). There are several factors promoting continued growth: the remaining demographic momentum of high fertility in the 1960s and early 1970s, the recent rise (catch-up) in fertility levels, the continuing improvement of survival of people to and within the older ages and the ongoing high level of net immigration (ONS 2008b). Births have risen from 663 thousand in 2001-2 to 791 thousand in 2007-8, while deaths have decreased from 601 thousand to 570 thousand. Natural increase has risen since 2001 to contribute 54% to population change in 2007-8 from only 30% in 2001-2. Immigration has grown in the same period from 491 thousand in 2001-2 to 571 thousand in 2007-8 (ONS 2010b, Table 2.11). Emigration has also increased from 342 thousand (2001-2) to 375 thousand (2007-8). Net migration was 148 thousand in 2001-2 and 196 thousand in 2007-8 but had been 260 thousand in 2004-5 in the period of highest immigration from the new EU member states.

This population growth varies considerably from place to place (Dunnell 2007). Growth is highest in the East of England (6.1%), East Midlands (5.8%), South West (5.4%) and Northern Ireland (5.1%) between 2001 and 2008 but each region has a few local authorities that have experienced decline.

Against this back cloth of demographic change, the ethnic composition of the population is changing quite fast. ONS estimates for England for 2001-7 show a 3.2% increase in the total population, a 0.4% decrease in the White British group and a 22.0% increase in not-White British group (ONS 2010c). In 2001 the White British made up 87% of the England population and ethnic minorities 13%. By 2007 this had shifted to 84% White British and 16% ethnic minorities. Both immigration and natural increase of the not-White British contribute to substantial population change, which varies considerably across the local authorities of the UK. Profound change in the size and composition of the UK's local populations is in prospect.

2.4 Ingredients for projecting of ethnic group populations

To carry out a population projection we need to define the state space within which the projection is made operational, that is the classifications of the population into groups. Then we need to adopt a model form that represents the processes of population change that occur. To drive the model we need a set of benchmark component data sets and in the case of ethnic populations this may involve a considerable effort of estimation. Finally, we need a set of assumptions about how those components will develop in the future. Here we discuss the first of these ingredients, the state space. A full account of our modelling choices is given in Section 3 of the report.

2.4.1 Ethnic groups: what are they and how do people change ethnicity?

Here we discuss the various meanings of the term ethnic group and whether and how people change their ethnicity. In terms of its etymology, "ethnic" means belonging to a nation, an "ethnos" (Greek). Belonging to a nation may be defined using one or more variables that can be measured in surveys or censuses or recorded on registers. In general, persons are born into an ethnic group and tend to remain in that group for the rest of their lives. This contrasts with age and family/household status which change as a person's life course proceeds. It also differs from social class, linked to occupation, which can change through the working part of the life course through upward or downward social mobility. The variables used to define ethnicity include: country of birth, country of citizenship/nationality, country of family origin, racial group (defined mainly in terms of skin colour or facial features), language, religion or through self-identification.

However, many of these statuses used to define ethnicity do change over time and lead to problems in identifying groups. For example, use of a country of birth different from that of current residence applies most usefully to groups that have immigrated recently. Their children and grandchildren born in the country to which they migrated no longer share this characteristic. Nationality changes through the acquisition of citizenship through application. The criteria for eligibility include, depending on country, residence for a period of time in the host country, testimonials from citizens about the standing of applicants, the absence of a criminal record, a language test, a knowledge test and family connections to citizens. People whose ethnicity is defined by religion may change through conversion of religious belief. Where a person's ethnicity is defined by self-identification, they may change their identification over time. Rees (2002) made suggestions about how these might be incorporated into a projection when adolescents become adults. However, robust empirical evidence on the extent of changes in ethnic self identification is lacking (Simpson *et al.* 2005, Simpson and Akinwale 2007).

2.4.2 An example of the complexity of ethnic classification: the case of the UK

Ethnic classifications in the United Kingdom are based on self-reporting through census or social survey questionnaires. A full guide to ethnic classifications used in UK official statistics is provided in *Ethnic Group Statistics* (ONS 2003a). Considerable consultation and debate goes into the formulation of the question. The resulting categories are a compromise between the demands of pressure groups interested in counting and promoting their own group and a need to make the question one that the whole population can understand. Ethnic classifications change over time recognising the evolution of groups as a result of migration from the outside world and as a result of marriage/partnership of people from different groups resulting in children of mixed ethnicity.

Table 2.1 shows the ethnic group classifications adopted in the 2001 Census of the UK, which differ from those in the 1991 Census in recognizing several mixed groups. There are different classifications, specific to each home country within the UK. In the main published tables in England and Wales 16 groups are used; in Scotland, 5 groups are used; in Northern Ireland 12 groups are used. The classifications are based on two concepts: race and country of origin (either directly through migration or through ancestry). Many studies (e.g. Rees and Parsons 2006, Rees 2008, Parsons and Rees 2009) used a collapsed version of the classification (e.g. White, Mixed, Asian, Black, Chinese & Other) but these amalgamated classes hide huge differences in terms of timing of migration to the UK, age-sex structures, population dynamics and socio-economic and cultural characteristics.

Table 2.1: Ethnic groups in the 2001 Census of the UK (broad groups)

England and Wales	Scotland	Northern Ireland
White: British	White	White
White: Irish	Indian	Irish Travellers
White: Other White	Pakistani and Other South Asians	Mixed
Mixed: White and Black Caribbean	Chinese	Indian
Mixed: White and Black African	Others	Pakistani
Mixed: White and Asian		Bangladeshi
Mixed: Other Mixed		Other Asians
Asian or Asian British: Indian		Black Caribbean
Asian or Asian British: Pakistani		Black African
Asian or Asian British: Bangladeshi		Other Black
Asian or Asian British: Other Asian		Chinese
Black or Black British: Black Caribbean		Others
Black or Black British: Black African		
Black or Black British: Other Black		
Chinese or other ethnic group: Chinese		
Chinese or other ethnic group: Other Ethnic Group		

Most studies (e.g. Coleman and Scherbov 2005, Coleman 2006b, Rees and Butt 2004) drop the Mixed group. Since the 2001 Census revealed this to be the fastest growing group such an omission is regrettable. The omission occurs particularly when comparing 1991 and 2001 Census results. For example, Rees and Butt (2004) adopted the 1991 Census classification as the common classification for their analysis of ethnic population change in England and reallocated the mixed groups proportionally back to their parent groups (Table 2.2). Most authors allocate each of the mixed groups back to their non-White parent group (Table 2.3 shows how the GLA researchers do this).

Table 2.2: Example of harmonization of ethnic groups in the 1991 and 2001 Censuses, England

1991 census ethnic category	Component 2001 census ethnic categories
White	White British + White Irish + White Other + 0.5(Mixed White and Black Caribbean) + 0.5(Mixed White and Black African) + 0.5(Mixed White and Asian)
Black Caribbean	Black Caribbean + 0.5(Mixed White and Black Caribbean
Black African	Black African + 0.5(Mixed White and Black African)
Black Other	Black Other
Indian	Indian + 0.5(Mixed White and Asian) × Proportion Indian
Pakistani	Pakistani + 0.5(Mixed: White and Asian) × Proportion Pakistani
Bangladeshi	Bangladeshi + 0.5(Mixed: White and Asian) × Proportion Bangladeshi
Chinese	Chinese
Other Asian	Other Asian
Other Groups	Other Ethnic Group + Other Mixed

Source: Rees and Butt (2004)

Table 2.3: The aggregated ethnic groups used in the GLA ethnic projections

GLA Aggregated Ethnic Group (AEG)	**ONS 2001 Census Ethnic Groups**
White	White: British, White Irish, White Other
Black Caribbean	Black or Black British: Caribbean
Black African	Black or Black British: African
Black Other	Black or Black British: Other Black Mixed: White & Black Caribbean, Mixed: White & Black African
Indian	Asian or Asian British: Indian
Pakistani	Asian or Asian British: Pakistani
Bangladeshi	Asian or Asian British: Bangladeshi
Chinese	Chinese or Other: Chinese
Other Asian	Mixed: White & Asian, Asian or Asian British: Other Asian
Other	Mixed: Other Mixed, Chinese or Other: Other

Source: Klodawski (2009), Table 1

The proposals for the 2011 Census questions on ethnicity and a new question on national identity are set out in Table 2.4 (Cabinet Office 2008, White and McLaren 2009). The broad (and race-based) groups from 2001 are retained but some details will change. The first category under White recognizes the complexity of national identity for this group. The Chinese group has been relocated under the Asian/Asian British grouping. Arab ethnicity is recognized for the first time. It should be relative easy to aggregate the results of the projections described in this report to the new 2011 classification.

Table 2.4: Proposed ethnic classification in the 2011 Census (England)

Aggregate ethnic group	Ethnic group
White	English/Welsh/Scottish/Northern Irish/British Irish Gypsy or Irish Traveller Any Other White
Mixed/multiple ethnic groups	White and Black Caribbean White and Black African White and Asian Any other Mixed/multiple ethnic background
Asian/Asian British	Indian Pakistani Bangladeshi Chinese Any other Asian background
Black African/Caribbean/Black British	African Caribbean Any other Black/African/Caribbean background
Other ethnic group	Arab Any other ethnic group

Source: the proposed 2011 Census Questionnaire (Cabinet Office 2008)

In our work we have adopted the full set of 16 ethnic groups used in the 2001 Census for England and Wales and made estimates of the Scotland and Northern Ireland population of these groups using ancillary information (custom tables supplied by GROS and NISRA).

2.4.3 Sexes/genders in ethnic population projection models

Most variables in projection models are classified by sex/gender. The sexes only interact in the fertility process, where a female dominant fertility model is normally adopted. The one special ingredient that is needed in an ethnic projection model is a fertility module for generating mixed births. Mothers of one ethnic group may have husbands or partners of another ethnic group and their children will be of mixed ethnicity. If there is information on the birth registration record about the ethnicity of mother and father, then it is straightforward to compute the probabilities that mothers of one ethnic group will give birth to children of mixed ethnicity. Such classifications are not used on UK birth registration records although country of birth is recorded. However, in a substantial fraction of birth records the details of the father are missing (this is why fertility models are female-dominant). In that situation, researchers resort to using proxy variables from large household surveys or household microdata samples from censuses. Within each family household it is possible to identify children under one year of age or under five years of age together with their mothers and fathers (if present). Children will have been assigned an ethnicity by the household representative completing the census form. It is therefore possible to tabulate the ethnicity of the child against his/her mother's ethnicity. We use a commissioned table from the 2001 Census to estimates these mixing probabilities.

2.4.4 Ages: dealing with age-time space properly

Period-cohorts are the key age-time concept used in cohort-component projection models. A period-cohort is the space occupied by a birth cohort in a time period and shows how persons aged x at the start of year t, born in year t-x, age forward over one year to be aged x+1 at the start of year t+1. We recognise two different classifications: period-age and period-cohort. Many vital statistics are classified using the period-age scheme, but for projection models it is essential to use the period-cohort age-time-plan. Note that in many projection models the ageing process is implemented after the component population processes (survival, migration and fertility) have been implemented. We use a period-cohort scheme in our projections (Section 3 has details).

It is advantageous to use single years of age in a projection model wherever the data allow so that projections for each year can be produced and so that aggregate age groups can be flexibly constructed. There is a strong argument that the age range of the population should be extended to 100 and over, recognising the higher rates of survival into the older old ages that are now present in the population and recognising the important demands for care generated by the older old population. Many national statistics offices are now extending their statistical tables to include populations at greater ages than 100. But such an extension is probably too ambitious currently for ethnic groups or for sub-national populations and certainly for the combination.

Handling the last period-cohort in a projection model usually requires some assumption. In order to project the population aged 100+, the researcher needs to estimate survivorship probabilities for an additional period cohort (100+ to 101+), in the absence of good data on events for the 100+ population. To overcome this absence, one solution is to assume that the survivorship probabilities in the 99 to 100 and 100+ to 101+ period-cohorts are equal to the survivorship probability for the 99+ to 100+ cohort which can be estimated. This assumption is not unreasonable as in very old populations we observe a slowing down of the increase of mortality with age.

The age-time classification used to compute fertility rates is often a period-age plan. Most researchers convert these period-age fertility rates into period-cohort rates by averaging successive period-age rates within the fertility model of the projection model. However, this is not necessary if the fertility computations are placed after the computations for the existing populations at the start of the period.

If this is done, then the start of year and end of year populations by age will be known and so period-age fertility rates can be multiplied by the average female population in an age group to produce the projected births for that year. If the fertility computations are placed first in the projection calculations, then some approximations are employed.

2.4.5 Regions and migration

Most ethnic population projections produced to date are for national populations (Coleman 2006), though the US Bureau of the Census (Campbell 1996) produces state projections for five race/ethnicity populations (Table 2.5). Where sub-national units are used, then consideration must be given to how migration between them is handled. There are two general approaches: (1) to treat each sub-national unit as a single unit with streams of in- and out-migration or (2) to handle all sub-national units together and to represent migration as flows or rates between them. The former single region approach is easier to compute. The latter multiregional approach is more elegant theoretically but more difficult to compute if there are a large number of sub-national units.

Table 2.5: Population change in regions by race and Hispanic origin: 1995-2025 (millions)

Region	Total	Non-Hispanic origin				Hispanic origin
		White	Black	American Indian	Asian	
U.S.	72.3	15.6	11.9	0.8	12.0	32.0
Northeast	5.9	2.1	1.5	0.03	2.3	4.2
Midwest	7.3	1.8	1.9	0.2	1.1	2.3
South	29.6	10.4	7.6	0.2	1.8	9.5
West	29.5	5.4	0.9	0.4	6.7	16.0

Source: Campbell (1996), Table 3.

For **single region models**, it is customary to introduce migration as a total net migration addition or subtraction to the population. This is unsatisfactory as this gives no insight into which of the many migration streams are producing the net result. It is better to clearly recognize four separate migration streams, even though it may be difficult to estimate these for ethnic groups. The four streams are: (1) immigration to the sub-national unit from outside the country, (2) emigration from the sub-national unit to the outside world, (3) in-migration from the rest of the country to the sub-national unit and (4) out-migration from the sub-national unit to the rest of the country. There is then a choice about whether to handle the migration streams using a migration rate and population at risk or using an estimated migration flow. In a projection of the ethnic group populations for 13 regions in the UK, Rees and Parsons (2006), emigration and internal out-migration were modelled using rate and populations at risk for the origin region, while immigration and internal in-migration were represented in the model as flows.

The **multi-region** model form recognizes that in-migrants to a sub-national unit are, in fact, out-migrants from other sub-national units (Rogers 1990) and that the migration flows are best modelled simultaneously. Immigration and emigration are handled as flows and rates respectively. The form of the multiregional model depends on the way in which the migration data used are measured. There are two types of measure: transition and movement. Transition migration results from comparison of a person's location at two points in time. If they are different, a transition has occurred. Movement migration results from a recording of sub-national unit to sub-national unit migrations that occur in an interval. The count of moves/migrations is equal to or greater than the count of transition/migrants.

A compromise between the large size and estimation difficulties of the multi-region model and the failure of the single region model to allow proper interaction between regions is the **bi-region model**. This was originally suggested by Rogers (1976) and has been thoroughly tested by Wilson and Bell (2004b) for a set of Australian regions. They found that the bi-region model gave results which were close to those of the multi-region model. In the bi-region model, an N region population system is modelled as N sets of two regions, the first set consists of individual regions and the second set consists of the results of subtracting the region population from the country population. The definition of the rest of the country changes region by region. The data requirements of such a model are much smaller than the multi-region model: it uses 2N probabilities rather than N^2 and the input probabilities are more reliably measured. The bi-regional model needs an additional step at each time interval – adjustment of total of projected in-migration to match the total of out-migration.

2.4.6 Dealing with uncertainty

Ethnic population projections also need to provide the user with some idea of the uncertainty associated with the projections.

Traditionally, this has been done through high and low **variant projections** around a principal projection (see ONS and GAD 2006, ONS 2008a for national examples). The number of variant projections can become large if all combinations of high, middle and low assumptions for each component were selected. There are also decisions to be made about the ways in which the high, middle and low variants work themselves out across the sub-national units and the ethnic groups. We need to worry about whether mortality and fertility are converging to or diverging from a national mean trend or whether sub-national and ethnic group distributions of immigration and emigration, for example, are changing.

One solution is to design **scenario projections** which combine particular variants to produce a coherent picture of the alternative future. Such a set of scenarios are being developed for NUTS2 regions across Europe in the DEMIFER project (ESPON 2009). Another solution to uncertainty is the development of **stochastic/probabilistic projections** (see Wilson and Rees 2005 and Booth 2006 for reviews). An example of stochastic methods applied to ethnic group projections is given in Coleman and Scherbov (2005) for the UK population.

2.5 Population projection models adapted for ethnic groups

Do we need to develop new models for handling ethnic population projections? Could not existing models and associated software be used to produce the projections? We consider the advantages and disadvantages of current models and software. Table 2.6 provides a summary of work over several decades in the UK that has produced either population estimates by ethnicity or population projections by ethnicity. The methodologies used in the reports are listed in the final column of the table and these are discussed in this section of the report.

2.5.1 Single-region models: POPGROUP, JRF Model

Simpson, Andelin Associates and colleagues (CCSR 2009) have developed a suite of spreadsheet macros called POPGROUP that implement a single-region cohort-component model with net migration, which is widely used by Local Governments and has been applied to ethnic forecasts for Birmingham, Oldham, Rochdale and Leicester (Simpson 2007a, 2007b, 2007c; Simpson and Gavalas 2005a, 2005b, 2005c; Danielis 2007). Rees and Parsons (Rees and Parsons 2006, Parsons and Rees 2009) in work for the Joseph Rowntree Foundation (JRF) used a single-region cohort-component model for UK regions which used four migration streams: internal out-migration and emigration as intensities (probabilities) and immigration and internal in-migration as flows.

These models have the key advantage of being relatively easy to implement and use for a large number of sub-national units and ethnic groups. They suffer from an important disadvantage of neglecting the important nexus in multistate population dynamics: that the out-migrants from one region become the in-migrants to other regions (Rogers 1990). If we wish to introduce a model of migration rather than just the assumed migration rates, then this is best accomplished through the framework of a multi-regional or bi-regional projection.

2.5.2 Multi-region models: LIPRO, UKPOP

Since the 1970s various programs have been developed to implement the multi-regional cohort-component model. In the early 1990s a general version was developed at NIDI by van Imhoff and Keilman (1991) for use with household projections but in a form in which other state definitions could easily be introduced. The software is made available (NIDI 2008) though no longer supported as a licensed package. There is some uncertainty about the capacity of this software for handling

Table 2.6: Summary of UK work on ethnic population estimates and projections

Source (Author, Year)	Coverage	Spatial unit(s)	Ethnic groups (source)	Time horizon	Output	Model
OPCS and ONS Projections						
OPCS (1975)	Great Britain	Great Britain	NCWP (1971 Census)	1966-1974	Estimates	CCM
OPCS (1977a)	Great Britain	Great Britain	NCWP (1971 Census)	1976-1986	Projections	CCM
OPCS (1977b)	Great Britain	Great Britain	NCWP (1971 Census)	1971-1986	Projections	CCM
OPCS (1979)	Great Britain	Great Britain	NCWP (1971 Census)	1976-1991-2001	Projections	CCM
OPCS (1986a, 1986b)	England and Wales	England and Wales	5 groups (1981 Census)	1981, 1983, 1984	Estimates	LFS
Schumann (1999)	Great Britain	Great Britain	11 groups (LFS)	1992-1997	Estimates	LFS
Large and Ghosh (2006a), Large and Ghosh (2006b)	England	Local authorities	16 groups (2001 Census)	2002-2005	Estimates	CCM
ONS (2009b)	England	Local authorities	16 groups (2001 Census)	2007	Estimates	CCM
Local authority projections						
Bradford (1999)	Rochdale	Rochdale	Groups (1991 Census)	1999-2021	Projections	POPGROUP
Bradford (2000)	Bradford	Bradford	Groups (1991 Census)	1999-2021	Projections	POPGROUP
Simpson and Gavalas (2005a), Simpson and Gavalas (2005c)	Oldham	Oldham	6 groups (2001 Census)	2001-2021	Projections	POPGROUP
Simpson and Gavalas (2005b), Simpson and Gavalas (2005c)	Rochdale	Rochdale	6 groups (2001 Census)	2001-2021	Projections	POPGROUP
Simpson (2007a), Simpson (2007b) , Simpson (2007c)	Birmingham	Birmingham	8 groups (2001 Census)	2001-2026	Projections	POPGROUP
Danielis (2007)	Leicester	Leicester	8 groups (2001 Census)	2001-2026	Projections	POPGROUP

Table 2.6 (Continued)

Source (Author, Year)	Coverage	Spatial unit(s)	Ethnic groups (source)	Time horizon	Output	Model
Greater London projections						
London Research Centre (1999)	Greater London	London Boroughs	10 groups (1991 Census)	1991-	Projections	MRM-GL
Storkey (2002)	Greater London	London Boroughs	10 groups (1991 Census)	1991-	Projections	MRM-GL
Hollis and Bains (2002)	Greater London	London Boroughs	10 groups (1991 Census)	1991-	Projections	MRM-GL
Bains and Klodawski (2006)	Greater London	London Boroughs	10 groups (2001 Census)	2001-2026	Projections	MRM/BRM-GL
Bains and Klodawski (2007)	Greater London	London Boroughs	10 groups (2001 Census)	2001-2026	Projections	MRM/BRM-GL
Bains (2008)	Greater London	London Boroughs	10 groups (2001 Census)	2001-2026	Projections	MRM/BRM-GL
Klodawski (2009), Hollis and Chamberlain (2006)	Greater London	London Boroughs	10 groups (2001 Census)	2001-2031	Projections	MRM/BRM-GL
Academic projections						
Coleman and Scherbov (2005), Coleman (2006b)	United Kingdom	United Kingdom	4 groups (2001 Census)	2001-2100	Projections	CCM
Coleman (2010)	United Kingdom	United Kingdom	12 groups (2001 Census)	2006-2056	Projections	CCM
Rees and Parsons (2006), Rees (2006), Rees (2008), Parsons and Rees 2009	United Kingdom	GORs, Wales, Scotland and Northern Ireland	5 groups (2001 Census)	2001, 2010, 2020	Projections	SRM-R&F
Stillwell, Rees and Boden (2006)	Yorkshire & The Humber	Local authorities	5 groups (2001 Census)	2005-2030	Projections	SRM-R&F

Notes: GOR = Government Office Region, Wa = Wales, Sc = Scotland, NI = Northern Ireland,
CCM = Cohort Component Model, POPGROUP= Single region projection software, licensed to users, MRM-GL = Multiregional Model-Greater London for projection,
MRM/BRM-GL=Combined multi-regional and bi-regional model for ethnic projection, Greater London
SRM-R&F = Single Region Model, Rates & Flows (rates for out-migration and emigration, flows for in-migration and immigration)

"transition data" (e.g. census migration), having been designed for inputs of "movement data" (e.g. register events). It is still intensively used at NIDI and by Eurostat for various projections and by some researchers in the UK.

In the UKPOP model (Wilson 2001, Wilson and Rees 2003) the accounts based model developed by Rees (1981) is developed for a full set of UK local authorities. The accounts based model relies on iteration to make consistent the relationship between observed deaths in a region (the variable generally available) and the deaths to the population in the region at the start of the interval (who die in that region and elsewhere). Efforts by Parsons and Rees to re-apply this model met with difficulties in achieving convergence in the iterative procedure. The model could generate for older ages negative probabilities of survival within a region, for example. The reason for this was that populations, deaths and migration come from different data sources (e.g. census and vital register) which may be inconsistent and in error at the oldest ages. Wilson and Bell (2004a) and Wilson *et al.* (2004) have used simpler versions of the multi-regional model in important work in Australia with either much smaller numbers of spatial units or using a sequence of bi-regional models. This work builds on experiments by Rogers (1976). Wilson and Bell (2004b) establish that a set of bi-regional models gives results close to a full multiregional model. Wilson (2008) has also developed a model for the indigenous and non-indigenous population of the Northern Territory, Australia, which has a number of very useful features.

2.5.3 Multiregional models: ONS Sub-national model for England, GLA model for London Boroughs

Both these models have a long pedigree and are in continued use. The ONS Sub-national model for Local Authorities in England is implemented by the Office for National Statistics in collaboration with outside contractors. A broad outline of the methodology is in the public domain (ONS 2008c) though the details are not provided.

As the local government body with the largest ethnic minority population, Greater London has a longstanding interest in understanding the trends in its ethnic group populations. Ethnic projections were prepared by Storkey (London Research Centre 1999, Storkey 2002), which incorporated ethnic fertility estimates and linked to the all group projection model for London Boroughs. The model was revised by Hollis and colleagues and the 2002-2009 decade saw ethnic population projections become a regular publication that followed the main London Borough projections (e.g. Hollis and Chamberlain 2009) and were constrained to them (Hollis and Bains 2002, Bains and Klodawski 2006, Bains and Klodawski 2007, Bains 2008, Klodawski 2009). Considerable care was taken to estimate ethnic specific fertility rates using Hospital Episode Statistics gathered by the London Health Observatory.

2.5.4 Nested multi-region models (MULTIPOLES)

Kupiszewski and colleagues at CEFMR (Kupiszewska and Kupiszewski 2005, Bijak *et al.* 2005, Bijak *et al.* 2007) have developed a model from an idea by Rees *et al.* (1992) that uses several layers. For example, in a projection study of 27 EU states (Bijak *et al.* 2005) three layers are recognised: inter-region migration within states, inter-state migration within the EU and extra-EU migration. This approach enables different models to be used in the different layers within a consistent accounting framework.

2.5.6 The design of a projection model for ethnic groups in the UK

This review informed the design of our projection model for ethnic groups. The model uses a **transition** framework because the vital internal migration information derives from the decennial census. The model can be adapted where similar migration data sets are available.

Every projection model has an explicit or implicit accounting framework, which must be consistent. Table 2.7 provides a picture of the population accounting framework used in the model. The multi-region framework (Table 2.7A) consists of a matrix of population flows to which are added a column of row totals and a row of column totals to constitute an accounts table. The row totals contain births (in the case of the first, infant period-cohort) or start populations (for other period-cohorts) and totals of (surviving) immigrants. The column totals contain deaths (non-survivors) and final populations in an interval. Table 2.7B sets out the bi-regional accounting framework for local authorities within England, with Wales, Scotland and Northern Ireland being handled as single zones. In our model there are 355 such tables, one for each zone. The table variables are for a typical period-cohort, gender and ethnic group combination.

What are the key features of this framework?

The first feature is that the table holds transition data rather than events data. Transition data derive from censuses in which a question is asked about a person's usual residence at a fixed point in the past (one year before the 2001 Census, in the current analysis). Events data derive from registration of the demographic events such as birth or death or migration from one place to another. The variable $SM^{i,j}$ represents the number of surviving migrants resident in zone *i* on 29 April 2000 who live in zone *j* on 29 April 2001. Note that, in principle, migration data for the years from 2001-2 onwards are also transition data based on comparison of NHS patient register downloads one year apart but they are adjusted to agree with movement flows from the NHSR Central Register. The variables in the principal diagonal, $SS^{i,i}$, are persons present in zone *i* at both the start of the year and the end of the year (surviving stayers). These counts include migrants who moved within the zone.

Table 2.7: Multi-region and bi-region accounts for sub-national populations using migration (transitions) data from the UK census

A. Multi-regional accounts for zones 1 to 355

		Destinations (survival at end of time interval)								
Origins (start of time interval)	Zone	City of London & Westminster		Isle of Wight	Wales	…	N Ireland	Rest of World	Deaths	Totals
Zone	#	1	…	352	353	…	355	R	D	
England	1	$SS^{1,1}$	…	$SM^{1,352}$	$SM^{1,353}$	…	$SM^{1,353}$	SE^{1}	DE^{1}	SP^{1}
	:	:	…	:	:	…	:	:	:	:
	352	SM^{352}	…	$SS^{352,352}$	$SM^{352,353}$	…	$SM^{352,355}$	SE^{352}	DE^{352}	SP^{352}
Wales	353	$SM^{353,1}$	…	$SM^{353,352}$	$SS^{353,353}$	…	$SM^{353,355}$	SE^{353}	DE^{353}	SP^{353}
…	:	:	...	:	:	...	:	…	…	…
N Ireland	355	$SM^{355,1}$	…	$SM^{355,352}$	$SM^{355,353}$	…	$SS^{355,355}$	ES^{355}	DE^{355}	SP^{355}
Rest of World	R	SI^{1}	…	SI^{352}	SI^{353}	…	SI^{355}	0	0	TI^{*}
Totals	D	EP^{1}	…	EP^{352}	EP^{353}		EP^{355}	TE^{*}	TD^{*}	TF^{**}

B. Bi-regional accounts for zone i

		Destinations at end of time interval					
Origins (existence at start of time interval)	Zone	Same zone		Rest of the UK	Rest of World	Deaths	Totals
Zone	#	i	…	(UK-i)	R	D	
Local authority	i	SS^{i}	…	SM^{UK-i}	SE^{i}	DE^{i}	SP^{i}
Rest of UK	UK-i	:	…	:	:	:	:
Rest of World	R	SI^{i}	…	SI^{UK-i}	0	0	TI^{*}
Totals	D	EP^{i}	…	EP^{UK-i}	TE^{*}	TD^{*}	TF^{**}

Key to cells:

SS	Surviving stayers	DE	Deaths (non-survivors)	TE	Total surviving emigrants
SM	Surviving migrants	SP	Start population	TD	Total deaths (non-survivors)
SI	Surviving immigrants	TI	Total surviving immigrants	TF	Total flows (transitions)
SE	Surviving emigrants	EP	End population	0	Not relevant

Notes:
The accounting framework applies to each period-cohort/sex combination from age 0/age 1 to age 100+/age101+. A similar framework also applies to the first period-cohort from birth to age 0, except that births replace the starting population and the flows occur within a period-age-cohort.

From the start population are subtracted the deaths (non-survivors) from zone *i* population, the emigrant survivors from the zone *i* population, the sum of out-migrant survivors to other zones in the country. Then we add the sum of in-migrant survivors from other zones within the country and surviving immigrants from the rest of the world. The stayer survivor terms, $SS^{i,i}$, do not appear in this accounting equation. However, we do need to estimate these $SS^{i,i}$ variables. This is because in the projection model we will use probabilities of migration conditional on survival within the country. These are the sum of elements in the rows of the matrix from City and Westminster to Northern Ireland, including the stayer survivor terms. We estimate these terms by subtracting from the 2001

Census population aged 1+ the total number of in-migrant survivors and the total immigrant survivors.

Given the number of zones, ages and ethnic groups represented in our projection model, we should not expect to find reliable data to count directly the flows and transition probabilities needed for the projection model. Instead we will need to estimate these flows using a variety of sub-models which use more aggregate and reliable data together with a set of assumptions, some testable, some merely plausible in the absence of statistical evidence.

3. ETHNIC GROUPS, ZONES, AGES, TIME INTERVALS FOR PROJECTION

We discuss next the state-space in terms of the population classifications we use.

3.1 The state space: ethnic classifications

We have discussed the issues affecting and alternatives for ethnic classifications in Section 2.4. Ethnic classifications are based on self-reporting though census or social survey questionnaires. Considerable consultation and debate goes into the formulation of the question. The resulting categories are a compromise between the demands of pressure groups interested in counting and promoting their own group and a sensible desire to make the question understandable to the whole population. Here we adopt the definition that an ethnic group is a set of people with a common identity based on national origin and race. We use the 16 group classification adopted in the 2001 Census for England and Wales, set out in Appendix A.1, which differs from the 1991 Census in recognizing several mixed groups.

3.2 The state space: countries

Our projections are for the United Kingdom as a whole. The United Kingdom is made of four countries. The constitutional arrangements are complicated: Scotland has its own Parliament and government (formerly the Scottish Executive, now The Scottish Government) in Edinburgh. Wales has its National Assembly for Wales and its Welsh Assembly Government in Cardiff. Northern Ireland has its own Northern Ireland Assembly and government, the Northern Ireland Executive. England has no specific assembly or government arrangements. We divide up England for forecasting purposes into local government areas (with a couple of mergers detailed below). Wales, Scotland and Northern Ireland are treated as whole zones in the projections, because they have low percentages of non-White ethnic groups, which made attempts to estimate local area component rates and probabilities for ethnic groups difficult.

3.3 The state space: local areas

England is divided into local authority areas using the lowest tier of authority. The Local Authority Districts (LADs) are of the following types: 33 London Boroughs, 36 Metropolitan Districts, 46 Unitary Authorities and 239 County Districts. We have merged two pairs of English local authorities because one of each pair has a very small population. The City of London is merged with Westminster, a neighbouring London Borough. The Isles of Scilly in Cornwall are merged with Penwith, the nearest county district on the mainland. The 354 LADs in England are reduced to 352 zones in our projections with the addition of the three home countries, making 355 zones in total. A full list of LADs, codes (2001 Census) and names is given in Appendix A.2.

The Office of National Statistics provides outline maps of UK LADs. We have used the definitions in force from April 1998 to March 2009 (see ONS 2010d). These are the LADs we use for our ethnic population estimates and projections. In April 2009 the number of LADs was reduced by merging county districts into single unitary authorities (e.g. in Northumberland). Where changes have occurred, unitary authorities have been created through amalgamation of previous authorities. Our projection results can therefore be easily aggregated to the new authorities. Other administrative geographies, such as counties, the GLA or Government Office Regions, can be built from these bottom tier local authorities. We have also used a number of local authority classifications to help analyse the projection results. The look up table is provided in Appendix A.2.

3.4 The state space: ages

The classifications of age we will use recognise single years of age. They are set out in Appendix A.3. It is essential to use single years of age in a projection model so that projections for each year can be produced and so that aggregate age groups can be flexibly constructed. We extend the age range to 100 and over, recognising the higher rates of survival into the older old ages that are now present in the population and recognising the important demands for care generated by the older old population. We use a period-cohort classification which is the appropriate age-time-plan for projection. Note that to project the population aged 100+, we need to estimate survival probabilities for an additional period cohort (100+ to 101+). The age classification used for fertility rates is shown in Appendix A.3. Fertility rates are reported by period-age. The method for handling these in the projection model is explained later.

3.5 The state space: sexes/genders

Most variables in the projection model are classified by sex/gender. Appendix A.4 conventionally lists males and females in that order. The sexes only interact in the fertility process, where we adopt a female dominant fertility model.

3.6 Time intervals for estimation and projection

The time framework for the analysis is as follows. We project populations from mid-year (June 30/July 1) in one year to mid-year in the next year. This enables us to compare our estimates and projections with those of the Office for National Statistics, which are produced for mid-years. Sometimes statistics for the demographic components are published for mid-year to mid-year intervals but more frequently they are published for calendar years. Where this was the case we averaged successive calendar rates or flows to estimate mid-year to mid-year interval variables. This should not lead to much error.

We define the starting point of our projection (the jump off point) to be mid-2001. We use the projection model for all subsequent mid-year to mid-year intervals. For the first few years, from 2001-2 to 2006-7 the outputs are estimates rather than projections because we use some published data to estimate the inputs to the projection. In 2007-8 we have employed as inputs updated estimates for the fertility and internal migration components and assumptions for the mortality and international migration components. From 2008-9 onwards the inputs are set by assumption (e.g. using the latest mid-year to mid-year rates on a constant basis or adjusting those rates to a new leading indicator). Table 3.1 illustrates these arrangements.

Table 3.1: Times and time intervals used in the projections

Stocks and flows (Components)	Jump off time point	Estimates			Estimates & Assumptions		Assumptions
	2001 my	2001-2 my-my	…	2005-6 my-my	2006-7 my-my	2007-8 my-my	2008-51 my-my
Start Populations			…				
Mortality			…				
Fertility			…				
International Migration			…				
Internal Migration			…				
End Populations							

Notes

	ONS my estimates of ethnic groups based on the 2001 Census used in all projections
	Project estimates of rates, probabilities and flows for first period used in all projections and throughout for the BENCH-EF and BENCH-ER projections
	Project estimates of rates, probabilities and flows used in Trend-EF, Trend-ER, UPTAP-EF and UPTAP-ER projections
	Project assumptions
	Generated by the projection model

my = mid-year= 30 June/1 July

One feature of our estimates in the period 2001-2 to 2005-6 is that they are independent and distinct from the ethnic population estimates for local authorities produced by ONS (Large and Ghosh 2006a, 2006b). We chose to do this because ONS estimates make no attempt to estimate ethnic specific mortality, have very flat ethnic fertility estimates and constrain to immigration estimates with which we believe are flawed. We will therefore have an opportunity to compare estimates for the period 2001-2007.

4. THE PROJECTION MODEL

This section presents the demographic equations of the projection model. Readers unfamiliar with demographic modelling theory may find this presentation difficult to follow and may wish to skip to later sections, 6 and beyond, which describe the empirical estimation of the inputs to the projection model.

4.1 A notation

It is useful to develop a general notation for the variables used in the model. We have several choices of approach. The first alternative is to adopt a single letter, e.g. *K*, to represent all population groups. This is the approach adopted in the transition population models defined by Rees and Wilson (1977). Variables are distinguished by their attached subscripts (*sensu lato*), e.g. $K^{e(i)s(j)}$ are persons who exist in zone *i* at the start of the time interval and who survive in zone *j* at the end of the interval. This notation is consistent and logical but not widely understood. The second alternative is to use letters based on the well known life table model, e.g. ${}_1L_x$, = the stationary population in the age group from exact age *x* to *x+1*. There are two problems with such a notation: the use of prescripts leads to some algebraic confusion: it is preferable to list subscripts in a time sequence, e.g. $L_{x,x+1}$ instead of ${}_1L_x$. Secondly, the use of upper case (e.g. *M*, *L*) and lower case (e.g. *q*, *p, l*) conflicts with the convention that uses upper case letter to represent stocks or flows of population and lower case letters to represent intensities of transition (probabilities) or events (occurrence-exposure rates). A third, popular alternative is to adopt different letters for the different transitions or events that change populations (e.g. *M* = migrants (internal), *I* = immigrants (external), *m* = probability of migration, *d* = death (mortality) rate). This is what we do but have to extend our variables to double letters to clarify meanings, though this is not liked by mathematicians.

Table 4.1 sets out the building bricks of the notation and then builds the variables that are needed. We try to use single letter variables as far as possible, but double or triple letter variables are needed. Refer to Table 4.1 to check the meaning of variables. Note that we use lower case letters to refer to intensities (rates or probabilities), and upper case letters to counts of populations, migrants or cohorts, improving upon conventional notation.

Table 4.1: A notation for an ethnic population projection model

Variable	**Description**
Stocks	*Counts of people*
EP	End Population in a time interval (count)
SP	Start Population in a time interval (count)
L	Stationary population (equivalent to the Life years variable in a Life table model)
Flows	*Transitions from one state to another*
BI	Births
DE	Non-Survivors (deaths to persons in a region at the start of an interval)
TS	Total Survivors (transitions, survivors from persons in a zone at the start of the interval)
NS	Non-Survivors (deaths to persons in a region at the start of an interval)
SS	Surviving Stayers (transitions)
SM	Surviving Migrants (inter-country or inter-zone, internal migrants)
SE	Surviving Emigrants (migrants to rest of world, external migrants)
TE	Total Emigrations (count of migrations to rest of world, external migrants)
SI	Surviving Immigrants (migrants from rest of world, external migrants)
TI	Total Immigrations (count of migration from rest of world, external migrants)
Intensities	*Either probabilities or occurrence-exposure rates*
f	fertility rates (occurrence exposure rates)
fc	fertility rates for period-cohorts
fp	fertility rates for period-ages
d	death rates or mortality rates (occurrence-exposure rates)
s	survivorship probabilities
ns	Non-survivorship probabilities = 1 – survivorship probabilities
sm	migration probabilities conditional on survivorship
se	emigration probabilities conditional on survivorship
v	sex proportion at birth
Indexes	*Subscripts or superscripts*
x	age index (used for period-ages and period-cohorts)
g	gender index (values = 0, 1)
e	ethnic group (index values = 1 to 16, 1 to 18
i	zone index (see Appendix A. 2 for a list), used for origin zones
j	zone index (see Appendix A. 2 for a list), used for destination zones
t	for stocks: a point in time; for flows: an interval in time from t to t+1

4.2 The accounting framework and population components equations

Every projection model has an implicit or explicit accounting framework, which must be consistent. The accounting framework consists of a matrix of population flows to which are added a column of row totals and a row of column totals to constitute an accounts table. The row totals contain births (in the case of the first, infant period-cohort) or start populations (for other period-cohorts) and totals of (surviving) immigrants. The column totals contain deaths (non-survivors) and final populations in an interval. Table 2.5 sets out the accounting framework that we use. We can by attempting to complete the multi-regional version shown in the top panel but the arrays were so sparse that we switched to a bi-regional approach shown in the bottom panel. A bi-regional model employs N sets of two regions, the region of interest and the rest of the country. It is thus a highly simplified version of the multi-regional model.

Table 2.5 refers to each period-cohort-sex-ethnic group combination and so are repeated 102 ×2 × 16 = 3264 times in the model computations. The non-infant cohort (numbers 1 to 100 in Appendix A.3) and the infant period-cohort (number 0 in Appendix A.4) differ in their starting stocks: in the typical period-cohort these are the populations at the start of the time interval, while for the infant period-cohort the starting stocks are births during the period (by ethnic group of child). There are also some differences in treatment of the last period-cohort (100+ to 101+) which we describe later.

What are the key features of this framework? The first feature is that the table holds transition data rather than events data. Transition data derive from censuses in which a question is asked about a person's usual residence at a fixed point in the past (one year before the 2001 Census, in the current analysis). Events data derive from registration of the demographic events such as birth or death or migration from one place to another. So SM^{ij} represents the number of surviving migrants living in zone i at the start of a time interval and resident in zone j on 29 April 2001. The zones in our system are either local authorities (350 zones) or merged local authorities (2 zones) or home countries (3). Note that, in principle, migration data for the years from 2001-2 onwards are also transition data based on comparison of NHS register downloads one year apart. However, in practice, they are adjusted by the Office for National Statistics to be consistent with counts of record transfers between health authorities (much bigger zones than local authorities) to yield published counts of migration events. We therefore use this information to provide a dimensionless time series index adjusted so that the year prior to the census has a value of 1.

The table elements in the principal diagonal, SS^{ii}, are persons present in the country at both the start of the year and the end of the year (surviving stayers). These counts include migrants who moved within the zone as well as people who have resided continuously at the same address. Migrants from an origin zone *i* to a destination zone *j* are represented as SM^{ij}. We use a summary of the out-migration to all other zones in the system (region r):

$$SM^{ir} = \Sigma_{j\epsilon r} SM^{ij} \qquad (4.1).$$

We also use a summary of all out-migration from other zones in the system (region r) to the zone i of interest:

$$SM^{ri} = \Sigma_{j\epsilon r} SM^{ji} \qquad (4.2).$$

A key point about the accounting framework is that it should put together in a consistent fashion all the population flows required to connect the start population in a time interval to the finish population. So the end of interval population (for ethnic group *e*, age *x* and gender *g* in zone *i*) is given by:

$$EP^i = SP^i - DE^i - SE^i - SM^{ir} + SM^{ri} + SI^i \qquad (4.3).$$

From the start population are subtracted the deaths (DE^i) from the zone *i* start population, the surviving emigrants (SE^i) from the zone *i* population and the sum of out-migrants (SM^{ir}) to the rest of country *r*. Then we add the sum of in-migrants from the rest of the country, SM^{ri} and surviving immigrants, SI^i, from the rest of the world. The surviving stayer terms, SS^i, do not appear in this accounting equation. However, we do need to estimate these SS^i variables because of the method used to estimate the migrant flows (explained later).

Given the number of zones, ages and ethnic groups represented in our projection model, we should not expect to find reliable data to count directly the flows and transition probabilities needed for the projection model. Instead we will need to estimate these flows using a variety of sub-models which use more aggregate and reliable data together with a set of assumptions. We now convert the accounting equation into a projection model by substituting for each flow (set of transitions) a product of a probability and a population at risk and show how the probabilities are estimated.

4.3 Births, fertility rates, and mixed births

The fertility part of the projection model is sometimes placed after all period-cohorts present in the start population have been processed. This is usually done so that the start and end populations in a time interval of female populations in the reproductive ages is known. So we can estimate and use conventional period-age specific fertility rates for ethnic groups and use them as follows:

$$B_{eg}^i = v_g \sum_x f_{ex}^i \, 0.5(SP_{exF}^i + EP_{exF}^i) \qquad (4.4)$$

where v_g is the sex proportion at birth (0.513 for boys and 0.487 for girls), assumed constant over all ethnic groups, mothers' ages and time intervals, where f^i_{ex} are the age x specific period-age fertility rates for ethnic group e in zone i, and the start and end populations at risk are for females (subscript F) only. This is therefore a standard female dominant fertility model.

However, because of the computational demands of handling population for 355 zones, 16 groups, 2 sexes and 102 ages, we decided to calculate the births at the beginning of the projection computations, so that the infant cohort can be processed with all other computations. As we do not have the start and end population, we cannot apply equation (4.4) to calculate the number of births into an ethnic group. Instead, we estimate period cohort fertility rates from the period age fertility rates by averaging the period age fertility rate of an age group

$$fc_x^i(t) = 0.5 * (fp_{ex}^i(t) + fp_{e(x+1)}^i(t)) \quad (4.5)$$

where fc is the estimated period cohort fertility rate and fp is the period age fertility rate.

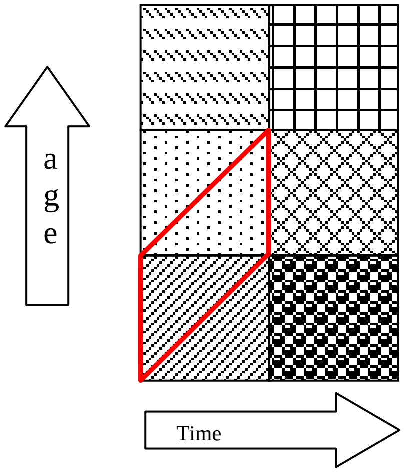


Figure 4.1: Age-time diagram showing a period-cohort space

In Figure 4.1 the filled squares represent the period-age spaces our fertility rates refer to. The red parallelogram represents the age time space we aim to achieve by applying equation 4.5 to the data.

We then apply estimated period cohort fertility rate to the fertile women at the beginning of the period, using the ages 10 to 49 to calculate the number of births into each ethnic group:

$$B_e^i = fc\,_x^i(t) * SP_{exF}^i \quad (4.6).$$

We then add one crucial ingredient to this model to achieve mixing of ethnicities at birth. The births in equation (4.6) are defined with respect to mother's ethnicity. If the father of the child is of a different ethnicity, the child will be of mixed origin. Mixed groups are recognised in the 2001 Census question. Parents may not necessarily decide to give their child a mixed label but to assign their offspring to the mother's or father's ethnic group. Rather than apply an arbitrary rule, we use detailed from the 2001 Census which classify infants aged 0 in the census by their mother's ethnicity and their own. From these tables we compute the probability that an infant has ethnicity *ie* given mother's ethnicity *me*, $P(ie|me)$ and apply it the projected births:

$$B_{ie}^{i} = B_{me}^{i} P^{I}(ie|me) \quad (4.7).$$

The probability is computed for a larger region I into which zone i of interest fits (usually the Government Office Region). Table 4.2 presents the conditional probabilities for England. The highest values occur in the principal diagonal of the table where the infants have the same ethnicity as their mothers. There are significant off-diagonal entries for some groups, for example, White Irish mothers, the majority of whose children are classified as White British. There is also much mixing among the mixed groups, the Asian groups and Black groups. A lot of children are born to non-White British mothers and White British fathers.

Table 4.2: A mixing matrix for England, 2001 Census

2001 Census, England			WHITE			MIXED				ASIAN				BLACK			CHINESE OR OTHER		
Ethnic group of mother: percentages		Totals	British	Irish	Other White	White and Black Caribbean	White and Black African	White and Asian	Other Mixed	Indian	Pakistani	Bangladeshi	Other Asian	Black Caribbean	Black African	Other Black	Chinese	Other Ethnic Group	% net gain or loss
	Totals	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0
WHITE	British	83.4	96.8	64.3	49.7	21.0	23.5	40.2	33.5	2.6	2.9	3.8	7.8	3.5	2.7	7.8	5.9	12.8	1.2
	Irish	0.4	0.1	25.4	0.3	0.0	0.0	0.3	0.2	0.1	0.0	0.0	0.2	0.1	0.1	0.0	0.1	0.1	-65.1
	Other White	2.2	0.4	4.4	40.1	2.2	4.9	3.0	6.1	0.3	0.2	0.2	1.7	0.6	0.6	1.9	0.8	3.1	12.9
MIXED	Caribbean	1.5	1.1	1.7	1.5	48.1	3.5	2.7	3.4	0.2	0.1	0.2	0.6	15.2	0.3	7.0	0.4	0.7	212.0
	African	0.5	0.3	0.7	1.6	2.0	38.9	1.1	1.7	0.1	0.1	0.1	0.4	0.3	5.5	1.1	0.0	0.4	151.0
	White and Asian	1.2	0.6	1.5	2.3	0.9	0.9	39.1	4.0	7.4	1.9	1.7	7.1	0.5	0.2	0.4	5.8	18.5	257.4
	Other Mixed	0.9	0.3	0.9	2.2	12.1	11.6	5.9	41.2	0.8	0.3	0.6	3.9	2.1	0.8	11.1	16.1	14.4	186.2
ASIAN	Indian	2.1	0.0	0.1	0.2	0.5	0.3	1.1	0.8	83.2	1.6	1.2	4.6	0.2	0.4	0.3	0.4	0.7	-10.4
	Pakistani	2.4	0.1	0.1	0.2	0.5	0.0	2.4	1.1	2.3	90.0	2.4	4.3	0.2	0.3	0.3	0.2	0.8	-1.8
	Bangladeshi	0.9	0.0	0.0	0.2	0.1	0.3	0.9	0.4	0.4	0.6	87.3	1.5	0.0	0.2	0.0	0.0	0.3	-4.7
	Other Asian	0.6	0.0	0.1	0.4	0.4	1.3	1.7	1.2	2.0	1.9	1.6	65.1	0.3	0.6	0.6	0.3	2.0	-4.3
BLACK	Black Caribbean	1.0	0.0	0.2	0.1	8.8	1.2	0.3	1.7	0.1	0.1	0.1	0.2	65.8	1.9	7.2	0.1	0.2	-23.0
	Black African	1.7	0.0	0.2	0.6	0.7	10.7	0.2	1.1	0.2	0.1	0.1	0.6	4.0	80.8	6.5	0.2	0.8	-9.8
	Other Black	0.4	0.0	0.1	0.2	2.6	2.4	0.2	1.7	0.0	0.0	0.1	0.4	7.2	5.6	55.4	0.1	0.5	68.6
OTHER	Chinese	0.4	0.0	0.1	0.1	0.0	0.0	0.3	0.7	0.1	0.1	0.1	0.1	0.1	0.0	0.0	68.3	1.1	-22.0
	Other Ethnic Group	0.4	0.0	0.2	0.3	0.2	0.6	0.6	1.3	0.2	0.2	0.5	1.6	0.0	0.1	0.4	1.2	43.6	-45.3

Key to percentage classes: >=80% | 50%-<80% | 25%-<50% | 1%-<25% | <1%

Source: Computed by the authors using a 2001 Census Commissioned table.
Notes: The table displays sending percentages, i.e. the percentages of children under one born to mothers of each ethnicity classified by the ethnicity they were assigned in the census. The mother's ethnicity is represented in the columns and the child's ethnicity in the rows.

In the Greater London ethnic group model this method is extended to bring in the potential influence of the male population by age and ethnicity on the ethnicity of the child (Baines, Hollis and Clarke 2005). The method uses the census distribution of men by ethnicity for a London Borough to modify the conditional probability of child's ethnicity given mother's ethnicity based on the population of a larger area. In a future projection, we may introduce this method, after testing it for robustness.

4.4 Survivors and non-survivors using survivorship and non-survivorship probabilities

We have specified the projection model using transition probabilities, because the most detailed migration data from the census come as transition variables. However, previous use of such data in projection models based on transition data has been difficult to implement for two reasons. The first is because migration probabilities and mortality probabilities at older ages may turn out to exceed one (leading to negative probabilities of being a surviving stayer). This is because we cannot guarantee that only non-survivors from our start population appear in the deaths count and because of errors in age reporting at very old ages. The second concerns the discrepancy between observed death rates that measure deaths using occurrence-exposure rates for an average population in a zone in a time interval and the required non-survival probability for start populations in origin zones. To convert the former to the latter requires use of either iteration or matrix inversion which can lead to convergence problems at older ages for systems with large numbers of zones, given the problem of estimating the migration and survivorship probabilities.

To solve these problems, we propose a simple assumption that survivorship probabilities derived from the standard life table produced using occurrence-exposure mortality rates based on zone of death, d_x^{*i}, are a reasonable estimate for non-survivorship probabilities for origin zone populations at the start of the period, d_x^{i*}:

$$d_x^{i*} = d_x^{*i} \qquad (4.8).$$

To estimate non-survivorship probabilities, we use the standard life table model equation for survivorship probabilities, s^i_x, for region *i*:

$$s^i_x = L^i_{x+1}/L^i_x \qquad (4.9).$$

We then compute non-survivorship probabilities as:

$$d^i_x = 1 - s^i_x \qquad (4.10)$$

Life tables have not, to date, been developed for ethnic groups although they are regularly produced for countries (full life tables using single year age intervals to 100+) and for local authorities (abridged life tables using five year age intervals with ages 0 and 1 to 4 to 85+). To estimate survivorship probabilities for local areas *i*, ethnic group *e*, period-cohort *x* and gender *g* we use a method that converts standardised illness ratios (SIRs) for ethnic groups into standardised mortality ratios (SMRs) and thence age-specific mortality rates and ethnic-specific life tables (see section 7 of the paper, Rees and Wohland 2008 and Rees *et al.* 2009). Using standard life tables to generate the survivorship probabilities has the advantage that it is relatively easy to introduce new projection assumptions based studies of mortality rate trends or future scenarios of the mortality rates.

Survivorship and non-survivorship probabilities are used to generate the total number of survivors, TS^i_x, from the start populations of origin zones, SP^i_x, and the total number of deaths experienced by members of those populations, DE^i_x (see Table 2.5). We project the total number of survivors of the starting population for each ethnic group and gender as follows:

$$TS^i_x = s^i_x \, SP^i_x \qquad (4.11).$$

Note that total survivors are the sum of surviving stayers, surviving (internal) out-migrants and surviving emigrants (Table 2.5):

$$TS^i_x = SS^i_x + SM^{ir}_x + SE^i_x \qquad (4.12).$$

Deaths are projected by multiplying the non-survivorship probabilities by the start populations by local area, ethnic group, period-cohort and gender:

$$DE^i_x = d^i_x \, SP^i_x \qquad (4.13)$$

so that the following holds:

$$DE^i_x = SP^i_x - TS^i_x \qquad (4.14).$$

Note that the deaths can occur anywhere and so include out-migrants who die. We don't attempt to estimate these.

4.5 Emigration and surviving emigrants using emigration rates and survivorship probabilities

The next terms we need to estimate and project are the emigration probabilities and emigrants. Because the accounting framework is built on transitions, we need to estimate surviving emigration probabilities. The statistics available on emigration derive almost exclusively from the International Passenger Survey (IPS) which estimates the number of emigrations occurring over a one year interval. The estimate is based on a question about intention to leave the country for 12 months. However, some of these emigrants may die before the year is out and we have already made an estimate of these non-surviving emigrants in the mortality/non-survivorship probabilities. The emigration counts must be converted to surviving emigrants by applying survivorship probabilities that reflect the reduced risk of exposure to dying (as emigrants exit the UK month by month during a year and can be assumed to spend half the year at risk of dying in the UK). We use the square root (geometric mean) of the survival probability, s^i_x, to estimate the surviving emigrant probability, se^i_x. Then we need to subtract from these survivors an estimate of the projected number of surviving emigrants. Emigration and immigration in the UK are measured as prospective events via a survey which asks about intentions over the next 12 months. So first we estimate the rate of emigration, re^i_x, from the total emigration count, E^i_x:

$$re^i_x = E^i_x / SP^i_x \tag{4.15}$$

The flow of people declaring an intention to emigrate is subject to mortality and must be survived to the end of the annual interval using a survivorship probability that reflects their average exposure in the interval. Here we use the geometric mean or square root of the survivorship probability to estimate the probability that emigrants will survive to the end of the projection interval and hence the probability of emigration and survival.

$$se^i_x = (s^i_x)^{½}\ re^i_x \tag{4.16}$$

The number of surviving emigrants, SE^i_x, is projected by applying the surviving emigrant probabilities to the starting population:

$$SE^i_x = se^i_x\ SP^i_x \tag{4.17}$$

In the model implementation this is done in one step:

$$SE^i_x = s^{i^{0.5}}_x re^i_x SP^i_x \tag{4.18}$$

4.6 Within country survivors as a stepping stone to internal migrant projection

Then we can compute the number of the starting population who survive within the country, WS^i_x, by subtracting surviving emigrants from total survivors:

$$WS^i_x = TS^i_x - SE^i_x \tag{4.19}$$

Substituting for TS^i_x we obtain

$$WS^i_x = SP^i_x - DE^i_x - SE^i_x \tag{4.20}$$

Then we can estimate surviving internal migrants within a country:

$$SM^{ir}_{x} = sm^{ir}_{x} \, WS^{i}_{x} \qquad (4.21)$$

where

$$sm^{ir}_{x} = SM^{ir}_{x} / WS^{i}_{x} \qquad (4.22).$$

How can we measure these probabilities of migration given survival within the country from the latest census? The surviving migrant variables are recorded directly in the census migration tables, but within region surviving stayers, SS^{i}_{x}, are not usually tabulated. We must therefore compute this variable from the census migrant data and the census population (the final populations of the year before the census for which migration is measured) by subtracting surviving (internal) in-migrants to a zone and surviving immigrants from abroad from the end population (the census population):

$$SS^{i}_{x} = EP^{i}_{x} - SM^{ir}_{x} - SI^{i}_{x} \qquad (4.23).$$

This enables the computation of the total survivors within the country:

$$WS^{i}_{x} = SS^{i}_{x} + SM^{ir}_{x} \qquad (4.24)$$

and thus the estimation of probability of migration within the country conditional on survival within a country using equation (4.17) above.

4.7 Internal surviving migrants using migration probabilities conditional on survival

What does this re-formulation of the bi-regional projection model achieve? Essentially, the re-formulation using internal migration probabilities conditional on survival de-couples the processes of mortality and migration and enables us to develop separate models for each component. We will use two sets of properly defined probabilities: the relevant aggregations of survivorship and non-survivorship probabilities will always add to one and the appropriate conditional probabilities of internal migration given survival within the UK will always add to one.

Using the probabilities of migration between zones conditional on survival within the country, we project the surviving internal migrants between zones within a country by multiplying the probabilities of migration given survival by the projected within country set survivors for zone i:

$$SM^{ir}_x = sm^{ir}_x \; WS^i_x \qquad (4.25)$$

and for zone r:

$$SM^{ri}_x = sm^{ri}_x \; WS^i_x \qquad (4.26).$$

These projected variables are used in two ways: as out-migration flows to be subtracted from the starting population and as in-migration flows to be added to the starting populations to yield the final populations.

4.8 The final populations

We can now bring together the equations defined above and boil down the projection into one statement of how the end population in a time interval, EP^i_x, is computed for the zone of interest:

$$\begin{aligned} EP^i_x = {} & SP^i_x - m^{ir}_x \,(SP^i_x - se^i_x\,SP^i_x - d^i_x\,SP^i_x) \; - se^i_x\,SP^i_x - d^i_x\,SP^i_x \\ & + m^{ri}_x\,([\Sigma_i\, SP^i_x - SP^i_x] - [\Sigma_i\, se^i_x\,SP^i_x - se^i_x\,SP^i_x] - [\Sigma_i\, d^i_x\,SP - d^i_x\,SP]) \\ & + SI^i_x \qquad (4.27). \end{aligned}$$

It is useful to spell out in words what each term in the projection equation means. This is accomplished in Table 4.3. These equations for a typical ethnic group, gender and period-cohort are repeated for all period cohorts except the last. In the first period-cohort from birth to age 0, projected births are substituted for the start population. We explain the fertility model that generates projected births above. Care is taken in the estimation for the terms for the first period-cohort to allow (either empirically or by assumption) for the shorter period of exposure to transitions for infants born during a year (see Sections 5.2.3, 5.2.5). We assume the exposure period is half a year on average. The last period-cohort is treated differently only when the projected end populations of a time interval are converted into the start populations of the next.

For a typical period-cohort this is achieved thus:

$$SP^i_{x+1}(t+1) = EP^i_x(t) \qquad (4.28)$$

where t and t+1 refer to successive time intervals. For the last period-cohort, this assignment combines the end populations of the last but one, age z-1period-cohort, and the last period-cohort, z:

$$SP^i_z(t+1) = EP^i_{z-1}(t) + EP^i_z\,(t) \qquad (4.29).$$

Table 4.3 Definitions of the terms in the equation for the end of time interval population

Algebraic term	**Definition**
EP^i_x	End of interval population in zone i, period-cohort x
SP^i_x	Start of interval population in zone i, period-cohort x
m^{ir}_x	Probability of migration from zone i to the rest of the country r for period-cohort x, conditional on survival within the country
$(SP^i_x - se^i_x SP^i_x - d^i_x SP^i_x)$	The population in zone i at the start of the time interval who survive within the country over the time interval (modelled)
$se^i_x SP^i_x$	Surviving emigrants (modelled) from zone i for period-cohort x
$d^i_x SP^i_x$	Non-survivors (modelled) from zone i start population for period-cohort x
$[\Sigma_i SP^i_x - SP^i_x]$	The population of the rest of the country for zone i and period-cohort x
$[\Sigma_i se^i_x SP^i_x - se^i_x SP^i_x]$	Surviving emigrants (modelled) from the rest of the country for zone i for period-cohort x
$[\Sigma_i d^i_x SP - d^i_x SP]$	Non-survivors (modelled) from the rest of the country for zone i start population for period-cohort x
SI^i_x	Surviving immigrants for zone i and period-cohort x

5. SOFTWARE FOR IMPLEMENTING THE PROJECTION MODEL

To implement the ethnic group and local area cohort component model for the UK we use the software R. From the beginning of the project until December 2009 version 2.7.0 was used. From January 2010 version 2.10.1 (released 14.12.2009) was employed.

The current version of the model implementation consists of four scripts.

- **Script 1**: reads in and arranges the data
- **Script 2**: runs the model for 2001-2 and computes the 2002 midyear populations
- **Script 3**: compiles R function to run the projection
- **Script 4**: runs the model and creates the output.

Scripts 1 and 4 can be specified for particular projections; scripts 2 and 3 are never changed. Source locations of the Scripts are given in Appendix A.5.

5.1 Script 1: reading and arranging the data

With the first script all input data are read in and arranged in the necessary way. For the benchmark projection, only data from 2001 are read in. These initial data are mid-2001 populations and component rates, probabilities and flows for 2001-2. For the other projections (Trend and UPTAP) estimates for fertility, migration and mortality are also needed for after 2001-2. Fertility and migration estimates are done in separate computations and the final comma separated variable file products are imported into the projection model. This approach was chosen, as it requires less RAM for running the projection model. Only survivorship probabilities are calculated "on the go" while data are read into the software. For easier implementation of the model, all input data have a final extent of 204 columns and 5680 rows. 5680 rows are the result of 355 zones by 16 ethnic groups. The first 102 columns are reserved for male data, the next 102 for female data, with some small differences in the array for the first, infant cohort. Table 5.1 shows the organisation of the standard array used.

Table 5.1: The standard array used for processing in R

Running number	Ethnic group	LA	Ages	Ages
1	1	1	Men	Women
:	:	:	:	:
355	1	355	Men	Women
356	2	1	Men	Women
:	:	:	:	:
710	2	355	Men	Women
:	:	:	:	:
5326	16	1	Men	Women
:	:	:	:	:
5680	16	355	Men	Women

Alongside the intensities and 2001 midyear population data, the mixing matrix (see also sections 2.4.3, 4.8. and Fig. 4.3), birth proportion factors (0.513 for boys and 0.487 for girls), a mortality trend matrix and lookup tables for ethnic groups and local areas are imported as well. In the TRENDEF projection, the TFR is kept constant at 1.84 from 2008/9 onwards. This is done by scaling the 2007/9 average TFR to 1.84. A detailed list of the input files for each of the projections is supplied in Appendix A.6. The projection pairs BENCHER and BENCHEF (see section 10), UPTAPER and UPTAPEF (see section 10), have each the same set of input data, as they only differ in the way future migration is computed.

5.2 Script 2: running the model for 2001-2 and creating the 2002 midyear populations

We describe the implementation of the model, step by step. As we use a standard array size (5680 rows and 204 columns) for the population data as well as all intensities, the implementation of the projections model in R is easy in most steps. For example, to calculate the number of Births as described below, one only needs to multiply the fertility rates array with the population array. This results in an array of the same extent as the input arrays, containing the number of children born into an ethnic group, by single year of age of the mothers and local authorities. Therefore, the equations describing the projection model in Section 4 are equivalent to the computation done in the model runs.

5.2.1 Births

The first step in the model is to calculate the number of births born in the given year. For 2001-2 the female population at risk is multiplied by the 2001-2 fertility rate (estimation described below) to calculate the number of births for 2001-2. For each of the consecutive years, we used an approximate fertility rate to calculate births in the given year, equation (4.5). Calculating the number of births in the first step enables the model to do all calculations in one stage, without having to treat the infants separately. After the number of births to mothers of an ethnic group is calculated (4.6), the mixing matrix is used to calculate the number of children born into an ethnic group (4.7). The number of total births into an ethnic group is then disaggregated into boys and girls by applying the male and female birth proportions. These are then added as the first column into the population array. The resulting population is the *start-population* of the projection.

5.2.2 Survivors

In the next step, *survivorship probabilities* are applied to the *start-population* to calculate the *total survivors* (equation 4.11) and *non-survivors* (equation 4.14) in the given time period.

5.2.3 Emigrants

In a first step we calculate the emigration rates for infants born in the course of the year (ages -1 to 0). We do this, by assuming the emigration rate to be half of the emigration rate of the 0 to 1 year olds:

$$re^{i}_{-1to0} = 0.5re^{i}_{0\ to\ 1} \qquad (5.1).$$

We then calculate the number of *surviving emigrants* as follows. We have two variations to compute the number of emigrants (see also Section 10 Assumptions). One version, EF - emigration flow, is based on the assumption of a set number of emigrants from the UK. In the second approach, ER - emigration rate, we "only" apply emigration rates to the population at risk, this means, the number of emigrants depends on the population size. If population increases, the number of emigrants will increase and vice versa.

The surviving emigrants are deducted from the total survivors in both approaches, ER and EF, to compute the within country survivors (equation 4.18).

5.2.4 Out-migrants from zone and into zones, using a bi-regional model

In this step, the numbers of *out-migrants* are calculated by multiplying the *surviving population* in an area by the *outmigration probability* out of an area. At the same time, a preliminary number of in-migrants into an area is calculated by multiplying population in the rest of the country (the total population of all zones minus the population of the zone in question) by the probability of migration from the rest of the country into an area. For each ethnic group the ratio of number of out-migrants to the number of preliminary in-migrants is calculated. This ratio is then used as a correction factor to scale the *preliminary in-migrants* so their total number is equal to the total number of *out-migrants* out of all areas for each ethnic group. Thus, the *final* number of *in-migrants* into an area is computed.

5.2.5 Immigration and final population

As the immigration flows are available for ages 0 to 100+, the number of immigrants born in this year, is also calculated in this step.

$$re^{i}_{-1to0} = 0.5re^{i}_{0\ to\ 1} \qquad (5.2).$$

The *final population* for an area is calculated in this second last step by adding the (surviving) *immigration flow* and the *final in-migrants* to the *surviving stayers* in an area. Survivorship probabilities are not applied to the immigration flow in the current model implementation; a trial run considering survivorship for immigrants ($s_x^{i^{0.5}}$) only showed a marginal difference in the projected population number. We decided mortality in immigrants is too marginal to be considered for two reasons: international migration takes place in ages when mortality is low; secondly, the healthy migrant effect will decrease mortality in immigrants even further.

5.2.6 Population ageing and new start population

In the last step the *final population* “ages” forward one year (equation 4.28). For the last, open-ended age group, this is done by adding the final populations for the last two ages, 99 years of age and 100+ year of age, together to become the 100+ group in the following year (equation 4.29). This “aged” final population is also the population which will start the next projection cycle.

5.2.7 Components

At the end of the script, total numbers of births, deaths, start populations, end populations, internal migrants, emigrants and immigrants for each ethnic group and for each local authority are calculated as well.

5.3 Script 3: compiling the model function

R allows the programmer to custom design functions for any sequence of calculations. This feature is used here; this script compiles the model function which is then used in the last script. Two functions are compiled, one for the ER, one for the EF approach.

5.4 Script 4: running the model and creating the output

Script 4 runs the model. Here we specify which intensity estimates (see Table 10.3) are used to compute a year’s mid-year population. R keeps the computed data in working memory. Further data analysis can be done at this stage without a need to write out the projected numbers in spreadsheet format first.

5.5 Data preparation scripts

Before the above model was run, several input files for the five population projections were produced. This was done outside the main projection, primarily to save working memory. The key tasks preparing input data were to convert the initial data into the correct time frame. Converting calendar year data into mid-year to mid-year data was necessary for the fertility data and survivorship probability data. Secondly, 2001 based data had to be extended. This was usually done in to steps. The 2001/2 data were extended from available estimates up to 2006/7 or 2007/8, depending on data availability. After this point in time assumptions were applied to the following years. In the next sections, data preparation is described for each of the intensities.

5.5.1 Survivorship probabilities

The first survivorship probability data were derived from life tables calculated by Rees *et al.* 2009. The population data were 2001 midyear estimates and the mortality data were 2001calendar year counts. The resulting survivorship probabilities therefore refer to the calendar year 2001. For our projection model, these data need to be transformed into mid-year to mid-year data and extended beyond the 2001/2 time interval. To achieve 2001/2 data and to extend survivorship probabilities up to 2006/7 we used a mortality time series of total population in each LA (this series had no ethnic information). In the course of studying life expectancies across the UK local areas we the constructed a 16 year time series of life expectancies in the UK, from 1991 to 2007 (Wohland *et al.* 2009). These abridged life tables also contain survivorship probabilities for all 432 UK local areas, the UK and each of the home countries. We used the information from 2001 onwards to extend our survivorship probability estimates until 2006/7. This was done by calculating the rate of change of survivorship probabilities of the total population of each local authority compared the total population survivorship probabilities in the year 2001. Starting with the year 2002 we calculated a change rate:

$$Rs_{x-1}^{i} = s_{x}^{i}/s_{2001}^{i} \qquad (5.3)$$

and used this as the scaling factor for each ethnic group:

$$s_{xe}^{i} = Rs_{x}^{i} * s_{e2001}^{i} \qquad (5.4)$$

where Rs is the scaling factor, x is the year, i the local area and *e* the ethnic group. In cases where this leads to survivorship probabilities of above one, the survivorship probabilities are capped at 1. To compute already the 2001/2 survivorship probabilities, the survivorship probabilities for 2001 calendar year (CY) by LA, SYA and ethnic group where scaled by the scaling factor calculated by dividing 2002 CY by 2001 CY data for the total population and so forth. As the scaling factors were derived from abridged life tables, factors computed for each five year (FY) age group are applied to the SYA data contained in a FY group. The extension of survivorship data beyond 2006/7 was done within in model run (see above).

5.5.3 Issues with the oldest ages

There are general issues with accurate measurements for the oldest ages. In our model survivorship probabilities in for the oldest ages (99, 100+) were overestimated by the JAVA script used to calculate the initial 2001 survivorship probabilities for each of the ethnic groups. To correct for this overestimation in the short term, we adjusted the oldest ages for all ethnic groups, by the percentage decline observed in the total population from ages 98 to ages 99 for each local authority.

5.5.4 Fertility input data generation

Fertility data supplied are 2001 CY data, ASFRs by SYA for the ages 10 to 49 by ethnic groups. These data need to be transformed into midyear to midyear data and extended for the TREND and

UPTAP projections beyond 2001. The extension is done in 2 steps: in the first step, data from 2001/2 to 2007/8 are computed. These are used in both, the UPTAP and the TREND projections. The 2001/2 file is also the fertility input file for the BENCH projections. For after 2007/8 the TFR of the total female population is fixed to 1.84 within the R script for the TRENDEF projection (see above). For the UPTAP projections files from 2008/9 to 2021/22 are generated in a second step. Thereafter, fertility rates are assumed to be constant at 2021/22 rates.

To compute 2001/2 to 2007/8 data, rates of change from 2001 CY FY ASFR to the following CY FY ASFR for each LA total population are calculated. These total population calendar to calendar year rates of change are than applied to each ethnic groups 2001 ASFR SYA data (each FY rate applied to the linked SYA contained in the FY group) to compute 2001/2, 2002/3 etc ASFR SYA by ethnic group and LA data. Beyond this time period, fertility rates for the TREND projection are calculated within in model run (see above). For the UPTAP projections, we extend the 2007/8 ASFR SYA data by ethnic group specific expected trends up to the year 2021/22.

5.5.5 Internal migration input data generation

Internal migration data origin from the 2001 Census and refer to transitions that took place between one year before the Census up to the Census day in 2001. We call this the 2000/01 time period. Our projections however have as a starting point the midyear population of 2001. For this reason we already needed to estimate the internal migration data for the jump off year (2001/2). To update SYA, LA by ethnic group internal migration data, the rate of change of total population outflow of a region as well the rate of change of the total population inflow into an area were calculated. The rate of change was calculated as the rate of change with respect to the first year, the 2000/1 time period and applied by multiplying the out-migration probabilities or in-migration probabilities by the mid-year to mid-year change factor.

5.5.6 International migration input data generation

5.5.6.1 Immigration

Immigration data were supplied as midyear to midyear data. For 2001/2 flows were supplied by SYA, LAs and ethnic groups. For 2002/3 to 2006/7 total flow data by LAs were supplied. These were disaggregated into SYA and ethnic groups by specific ethnic and age profiles derived from Census 2001 information (see Section 8). Data from 2007/8 to 2014/15 were derived from scaling the 2006/7 data by home country specific multipliers which were derived considering the anticipated net migration number for each time interval. Those scaling factors varied between the TREND and UPTAP projections, allowing for lower total immigration flows in the UPTAP projections compared to the TREND projections.

5.5.6.2 Emigration

Emigration data are midyear to midyear. Emigration data for 2001/2 were original supplied as emigrant flows by single year of age. As described in Section 10, we have two model variations, one which considers migration as a proportion of the population and requires emigration rates data, the other one considers a total emigration flow derived from and assumed yearly net migration flow. We calculated emigration rates for the first year (midyear 2001 to midyear 2002) by dividing the emigration flow data by the midyear population of 2001.

$$Emigration\ rate = \frac{Emigration\ flow}{Population\ at\ risk} \qquad (5.5)$$

This however can lead to a zero emigration rate, if the emigration flow was zero, or an undefined term, if the population at risk was zero. As the emigration flow by ethnic group, local area and single year of age were disaggregated from total emigration flows from local areas, in some instances the emigration flow was larger than the population at risk, which with the above calculation will lead to a emigration rate of above one. To avoid emigration rates above one, zero or not defined emigration rates, we substitute for the cell values concerned the national emigration rates by single year of age for each ethnic group.

This leads to an underestimation of emigrants by 7745 persons in the first year, if we calculate the emigration flow backwards, that is multiplying the 2001 mid-year population by the emigration rate. This is the result of how emigration rates are estimated. We apply national emigration rates areas with no people present. To estimate emigration rates for the 2002-03 up to 2006-7 we first calculated emigration rates for the total population for each local authority from the available total emigration flows and the midyear populations.

$$Em\_r_y^i = \frac{Em\_flow_y^i}{(MyPop_y^i + MyPop_{y+1}^i)/2} * 1000 \qquad (5.6)$$

Where Em_r is the emigration rate, Em_flow the emigration flow and $MyPop$ is the midyear population. Subscript *y* is the year and superscript *i* the area.

Data for the periods from 2007/8 to 2014/15 were derived in a similar way as described above for immigration flows in the same period of time. 2006/7 emigration rates were scaled with the same scaling factors/ multipliers as those for the immigration flows.

A list of all files used in data preparation can be found in Appendix A.6.

6. FERTILITY ESTIMATES, TRENDS AND ASSUMPTIONS

Age specific fertility rates (ASFRs) by ethnic group, as needed for our cohort component model, are not readily available in the UK. In the following section we describe the steps employed to estimate ethnic group specific ASFRs for local Authorities in the UK.

The overall fertility level in a population is summarised using a total fertility rate (TFR). Calculating a time-series of ASFRs and TFRs from the 1980s to 2006 has been achieved here for all women using vital statistics on births and official mid-year estimates as denominators with all data allocated to the LA geography by the national statistics agencies (see Tromans *et al.,* 2008 for trends in England and Wales). Figure 6.1 illustrates ASFRs in Bradford and in Leeds, both of which are multicultural, university LAs but evidently have rather different fertility trends since 1981. In both, the curves move down and to the right as fertility gradually falls over time and as women in general 'postpone' births to have children somewhat later in their childbearing years. Leeds overall has lower fertility than Bradford with the latter having a somewhat 'younger' ASFR profile. Both LAs experienced a rise in fertility between 2001 and 2006, which has continued to 2008.

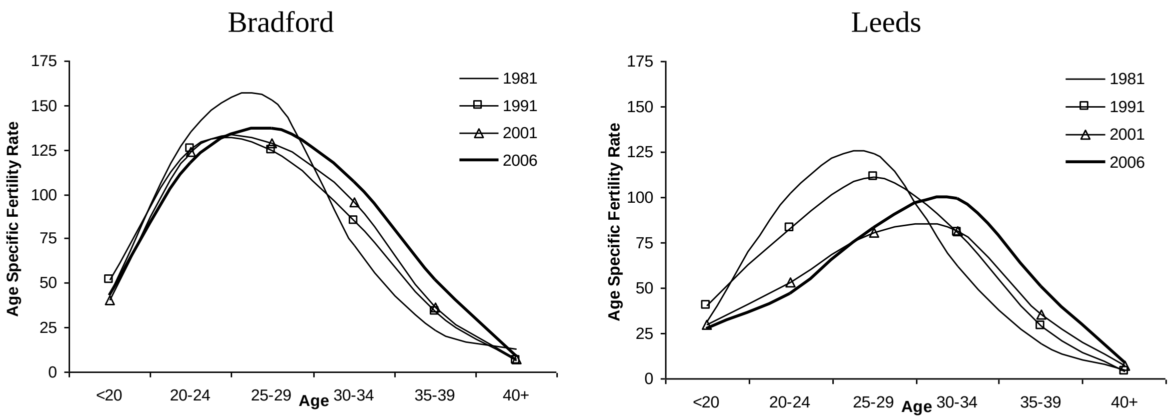


Figure 6.1: Age-specific fertility trends, Bradford and Leeds, 1981-2006
Source: Authors' calculations based on vital statistics and population data from ONS

The need in this research is to estimate ASFRs and fertility trends by ethnic group. Here a variety of population and sample data sources are used to estimate rates since the necessary ethnic group information is not necessarily available by time-point, data source and geography. Table 6.1 summarises the sources used here and outlines the relevant geographical and demographic detail which each provides. TFRs by ethnic group and LA are estimated from 1991 and 2001 Census data using child to woman ratios (CWRs) which are assumed to emulate family size by ethnic group (Sporton and White, 2002). Annual trends in national level ASFRs by ethnic group are derived from the Labour Force Survey (LFS) by modelling the probability of a woman having a child based on her age and ethnicity.

Table 6.1: Sources to estimate fertility by ethnic group

Source	Time point	Geography	Ethnicity	Fertility measure	Notes
Census Area Statistics	1991 2001	LAs LAs	10 groups 16 groups	Child to woman ratios to estimate TFRs by ethnic group	1991 Ethnic group categories can be aligned with the 2001 categories by assuming that eight are equivalent over time (Simpson, 2002, p. 77) 1991 data can be adjusted to the 2001 geography (Norman *et al.*, 2003) Children not directly linked with mothers
Census Samples of Anonymised Records	1991 2001	National National	10 groups 16 groups	Child to woman ratios to estimate TFRs by ethnic group	Provides national level fertility estimates by ethnic group and acts as a control for LA estimates Children are directly linked with mothers
Labour Force Survey	Annually from 1980s to date	National	A variety of different groups over time	Modelled probability of child provides ASFRs by ethnic group	Small numbers and changing ethnic information mean that information for only five broad ethnic group can be estimated reliably

Using CWRs in Bradford and Leeds, ethnic-specific TFRs have been estimated with examples illustrated in Figure 6.2. Higher fertility rates are shown for Pakistani and Bangladeshi women. Rates for Indian women are closer to the White group TFRs, particularly in Leeds. The local ASFRs for all women (Figure 6.3) have been adjusted for overall level using these TFRs by ethnic group and for shape of curve using the LFS-derived national estimate of each group's ASFR. In 2001 in Bradford, the Bangladeshi group have high fertility with the peak age of giving birth for women in their early 20s. The Pakistani curve is similar and a little lower. Whilst the TFR for Indian women is just a little lower than for the Pakistani group, the curve is somewhat older, resembling that of the White ethnic group. In Leeds, fertility levels for all groups are lower than in Bradford and the ASFR curves much flatter with the peak ages of fertility for women in their late 20s and early 30s. Figure 6.4 shows the broad ethnic group information and then the disaggregation to more detailed groups which used information for England in a commissioned table from ONS.

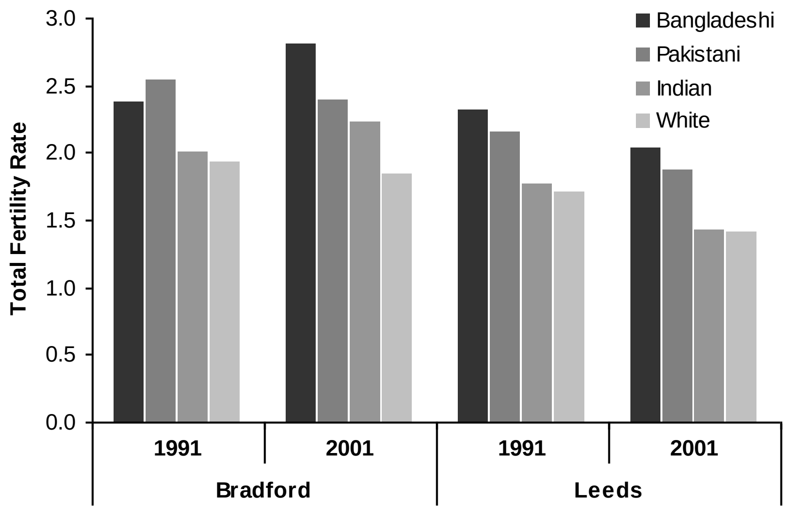


Figure 6.2: Estimated TFRs, Bradford and Leeds, 1991 and 2001

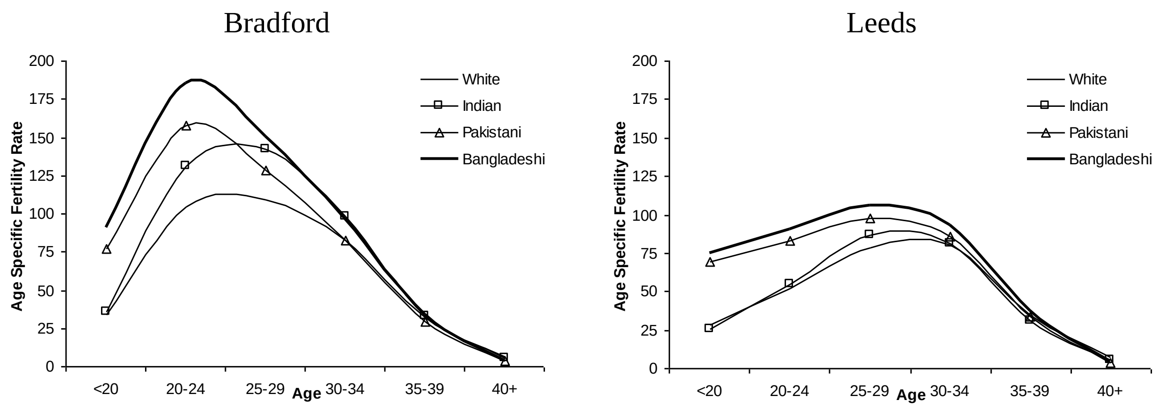


Figure 6.3: Estimated ASFRs by ethnic group, Bradford and Leeds, 2001
Source: Authors' calculations based on vital statistics, census, population and survey data from ONS

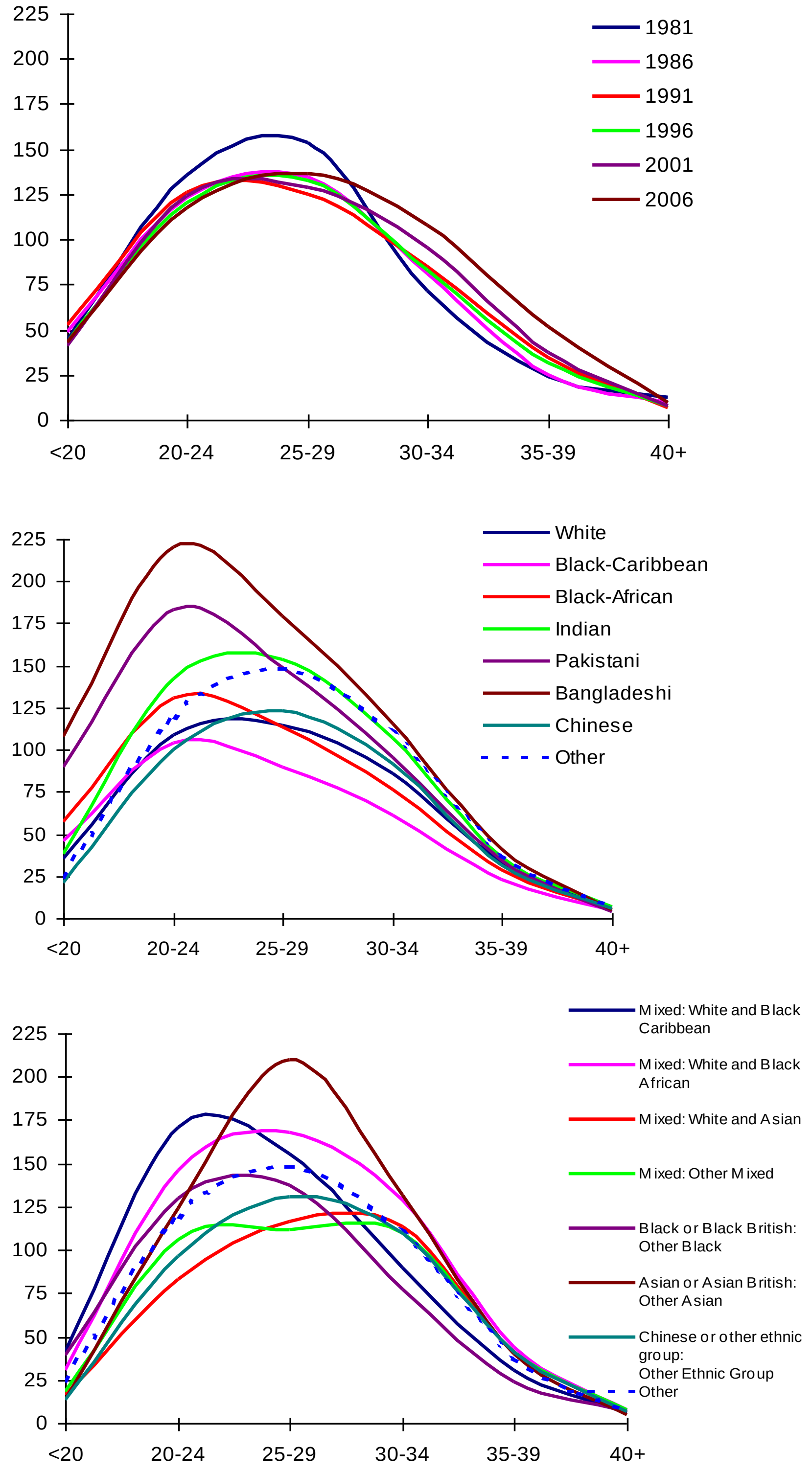


Figure 6.4: Estimated fertility rates for Bradford, all groups for selected years with eight and sixteen ethnic groups for 2001

The data sources are triangulated to provide the fertility estimates (Figure 6.5). For each year from the early 1980s to 2006, fertility trends for all women have been identified for each LA and by ethnic group at national level using the LFS. The UK's Census provides indicators of changes in family size by ethnic group between 1991 and 2001. In combination, these sources have underpinned the calculation of ASFRs and trends for all LAs across the UK by ethnic group, as appropriate to each country.

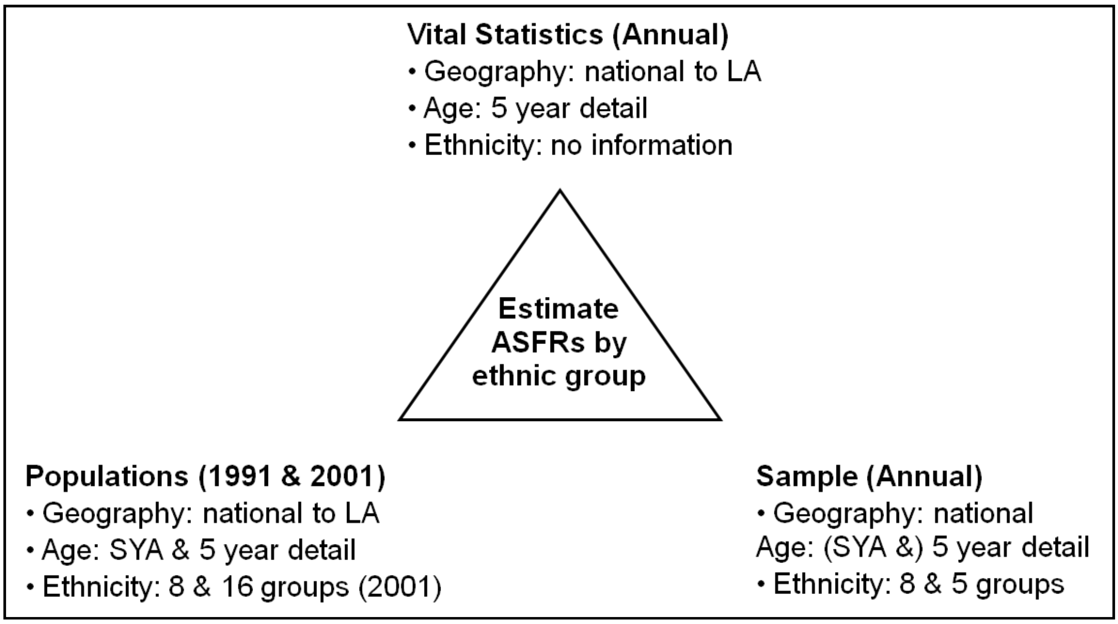


Figure 6.5: Sources for the estimation of ethnic fertility rates

For the projection model, the fertility rates originate from five year ASFRs and are disaggregated into single year of age ASFR in the following way. The national five year ASFRs for each ethnic group are estimated as single year of age rates using the Hadwiger function. For each ethnic group, the ratio of the five year rate to the relevant single year of age rate is applied to the local five year rate as an initial estimate which is then controlled so that TFRs by ethnic group and total births for each area are maintained. Figure 6.6 illustrates the five year and single year of age ASFRs for Bangladeshi women in Bradford.

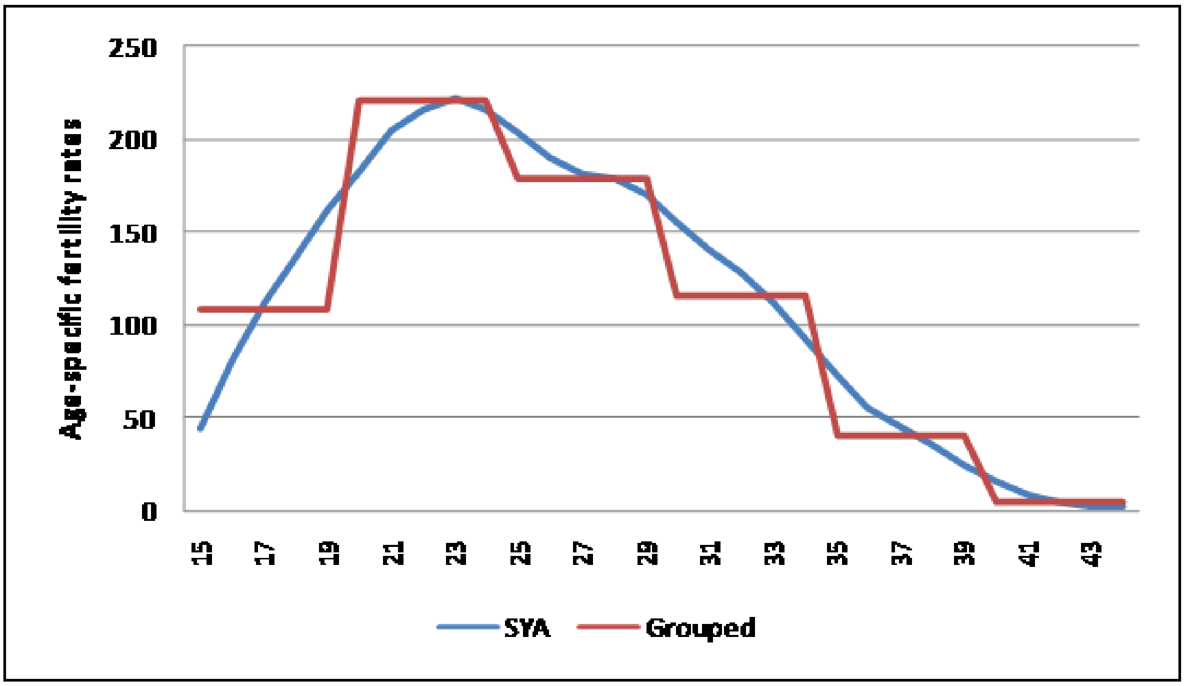


Figure 6.6: Estimated single year ASFRs from five year grouped information: Bangladeshi women in Bradford, 2001

Assumptions are needed on the direction of fertility in the future. Fertility rates have risen recently (Tromans *et al.*, 2008) from an all time low in 2001. Demographic momentum and social change will impact on the number of future births. Since we have information estimated from 1991 for ethnic groups assumed common across the 1991 and 2001 Censuses we can use a trend over this time period which encompasses both falling and rising fertility but differences by age of woman and by ethnic group. The trends for each age and broad ethnic group are modelled using curve fitting with the parameters of the curve applied to estimate future fertility rates up to the year 2021. The five year age-specific fertility rates resulting from this process are illustrated in Figure 6.7. Then, Figure 6.8 has the resulting TFRs by group. The general picture is of parallel curves across the groups with relative differences maintained but the White group shows less of a decline between 1991 and 2001 than the general trend and, after the current period, the fertility of the White and Other groups stays pretty constant whilst the fertility levels of all other ethnicities tend to decline.

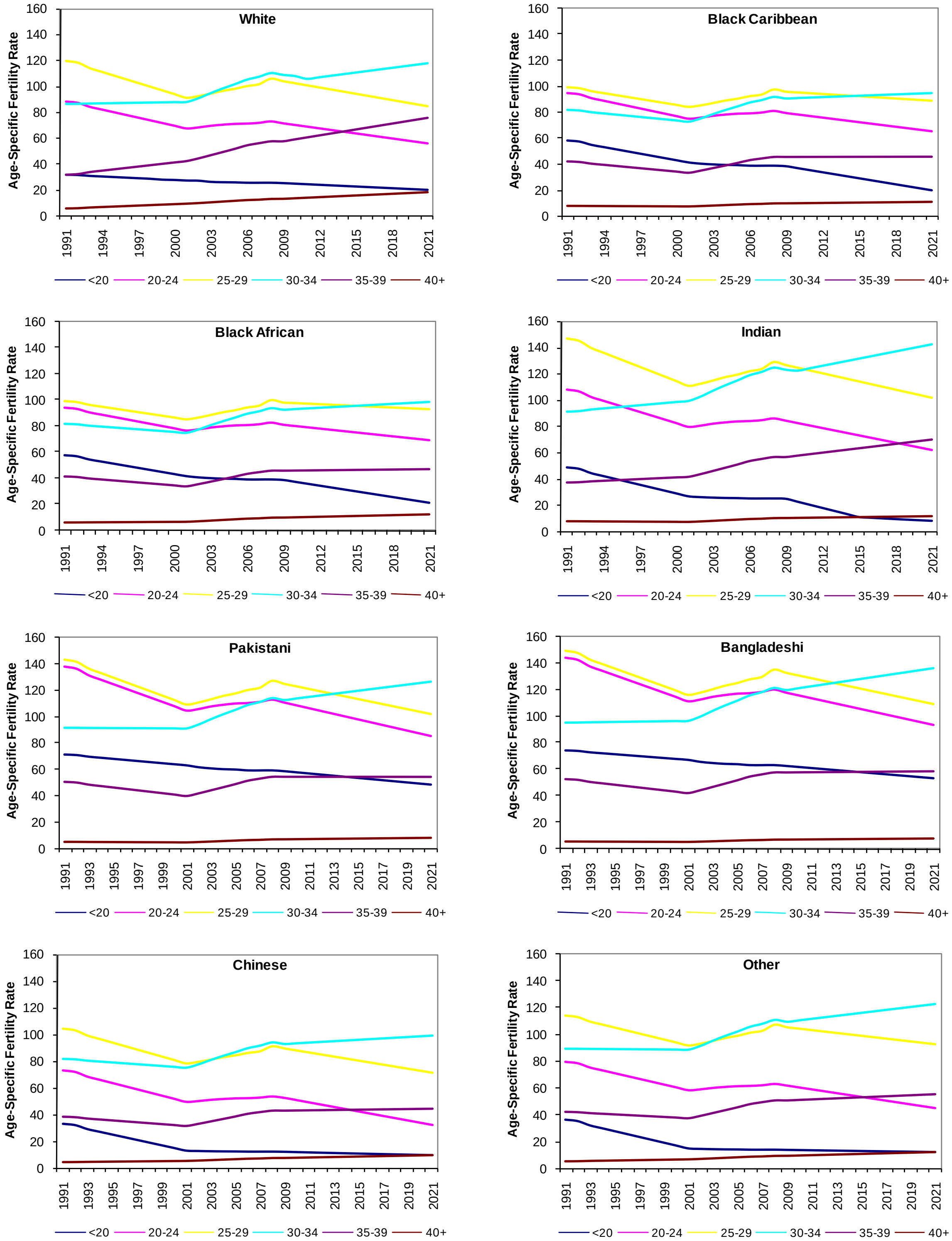


Figure 6.7 Estimated and projected five year of age fertility rates by broad ethnic group: 1991-2021 in England

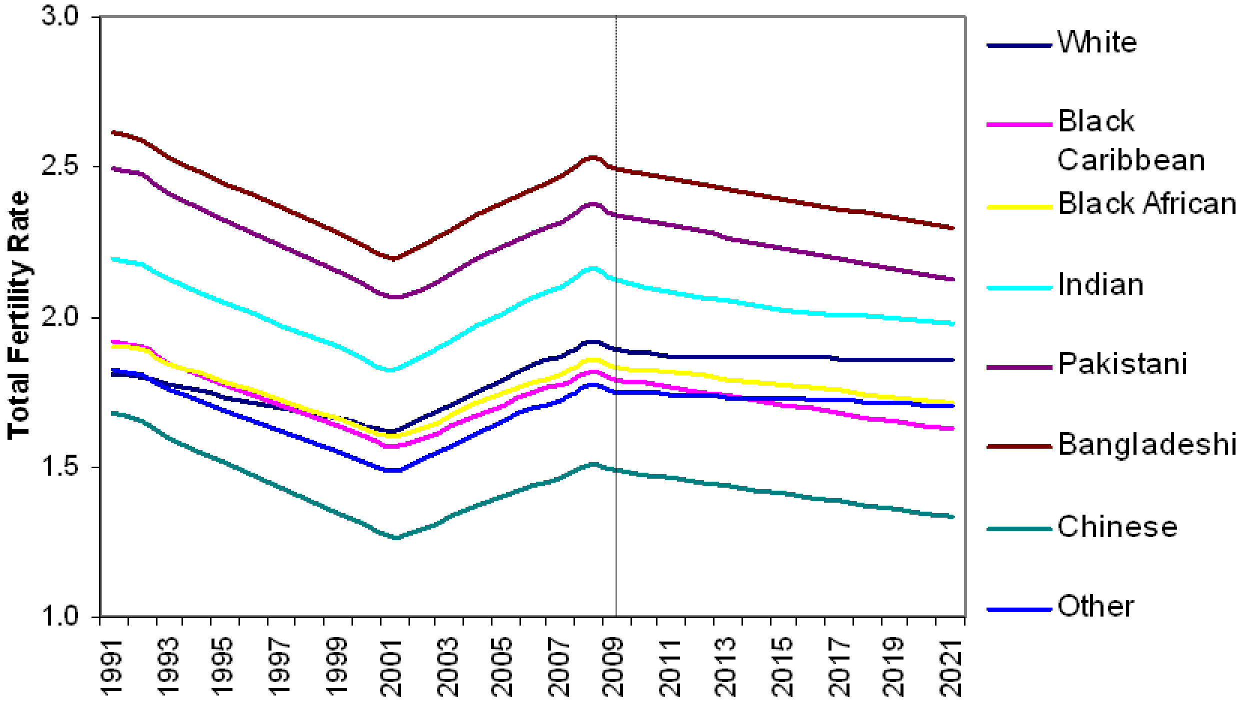


Figure 6.8: Fertility rate assumptions for the UPTAP projections

In the projection model, the decline (growth) rates from one year to the next by five year group are used to scale the single year information after the projection jump-off point. Taking these model based assumptions past 2021 is ill advised so the rates after that time point are assumed to stay constant. The trends for each broad group are applied to the sub-groups within each; i.e. White rates to White-British, to White-Irish and to White Other. Table 6.1 sets out the assumed TFRs.

Table 6.2: The fertility assumptions of the UPTAP projections

Ethnic group	2006-11 average	2021 onwards	Ethnic group	2006-11 average	2021 onwards
WBR	1.90	1.88	PAK	2.32	2.12
WIR	1.75	1.73	BAN	2.47	2.29
WHO	1.71	1.69	OAS	1.74	1.70
WBC	1.82	1.78	BLC	1.78	1.62
WBA	2.05	2.01	BLA	1.82	1.71
WAS	1.56	1.53	OBL	1.74	1.70
OMI	1.62	1.58	CHI	1.47	1.33
IND	2.10	1.98	OTH	1.74	1.70
			Total	1.92	1.93

7. MORTALITY ESTIMATES, TRENDS AND ASSUMPTIONS

As for fertility data, mortality data by ethnic groups are are also not readily available in the UK since a person's ethnic group or race is not registered when they die. Even though a place of birth has been noted on English death certificates since 1969, this only indicates mortality for first generation immigrants and is potentially biased, for example, by White British born in India before independence. A direct source for ethnic group mortality is the ONS Longitudinal Study (LS) but this only represents 1% of the England and Wales population and has considerable loss to follow-up of LS members, up to 30% at older ages (Harding and Balarajan, 2002). The LS is not a reliable enough mortality source for ethnic groups and cannot provide local mortality information.

Various studies using panel or longitudinal data find that self-reported health is a strong predictor for subsequent mortality, for total populations as well as subgroups (e.g. Burström and Friedlund 2001, McGee *et al.* 1999, Heistaro *et al.* 2001; Helweg *et al.* 2003). Thus, with no adequate ethnic mortality data available, we use a proxy measure for which data existed by UK LA level and ethnic group: answers to the 2001 Census question, "Do you have any long-term illness, health problem or disability which limits your daily activities or the work you can do?"

To estimate mortality by ethnic group, we use a suite of census, official mid-year population estimates and vital statistics data to estimate ethnic group life expectancy. As outlined in Figure 7.1, first we calculated standardised illness ratios (SIRs) for each LA by sex with data from the 2001 Census. We also calculated standardised mortality ratios (SMRs) for all local areas and both sexes from mid-year population estimates and vital statistics mortality data. Next, we use these ratios to define all-person SMRs as a function of all person SIRs. This all-person function is then applied to each ethnic group's local area SIR to calculate an ethnic group-specific SMR. These ethnic group SMRs are used to adjust upwards or downwards age-sex specific mortality rates (ASMRs) for each local area. These ASMRs are fed into life tables to derive survivorship probabilities for our projection model. During this procedure, we found men reporting less illness than women but experiencing higher mortality. We also found different SIR/SMR relationships for the UK's constituent countries.

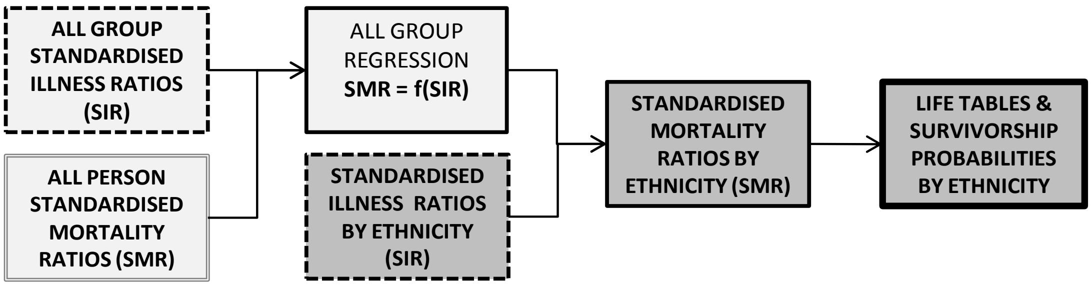


Figure 7.1 Method to estimate life tables and survivorship probabilities from self reported illness, combining 2001 Census data with mid-year estimates and vital statistics

Thus, we estimated life expectancies and survivorship probabilities for all ethnic groups defined in the UK 2001 Census for each local authority, by single year of age and sex. Below we present examples of life expectancies at birth in England. Table 7.1 shows a gender combined rank for each ethnic group in life expectancy at birth, together with the population weighted mean life expectancy for men and women of each ethnic group. Three groups are ranked above the national average, with the Chinese group on top, men and women both having the highest mean life expectancies. Within the White group, we estimate the White Irish group to occupy the lowest rank. This ranking is due to the rather low life expectancy for Irish men, whereas life expectancy of Irish women is expected to be close to that of White British women. The lowest life expectancies are for the Bangladeshi and Pakistani groups which have the poorest labour market positions (Simpson *et al.*, 2006). That the Other Asian and the Indian groups occupy moderate ranks shows the importance of having well-defined subgroups. We also find a strong contrast in the Black group, where the Black African group is one rank below the total population, in contrast to the Black Caribbean group which occupies rank 12. The Black African estimate is reasonable considering the so-called healthy migrant effect (Fennelly, 2005) whereby persons moving countries are advantaged in various ways (compared with their origin and/or their destination populations) including good health which thereby enables their move. The Black African group is a much younger – and therefore healthier – migrant community compared with the Black Caribbean group which is longer established in the UK.

Table 7.1: Mean life expectancies at birth for men and women by ethnic group, 2001

Rank	Ethnic group	Mean e_0	
		Women	Men
1	Chinese	82.1	78.1
2	Other White	81.3	76.9
3	Other Ethnic	81.5	76.2
	All groups	80.5	76.0
4	Black African	80.4	76.1
5	White British	80.5	75.9
6	White-Irish	80.3	74.9
7	White-Asian	80.0	75.1
8	Indian	79.3	75.5
9	Other Asian	79.5	75.2
10	Other Mixed	79.9	74.6
11	White-Black African	79.5	74.2
12	Black Caribbean	79.1	74.4
13	White-Black Caribbean	78.7	73.4
14	Other Black	78.5	73.4
15	Bangladeshi	77.7	72.7
16	Pakistani	77.3	73.1

Source: Rees *et al.* (2009)

We are cautious about the origins of the differences between the group estimates, though preliminary analyses suggest the most important socioeconomic influence is the level of higher education attainment in the group (Rees and Wohland, 2008). The healthy migrant effect is also likely to be important. Migration selects for individuals who are healthy because they have the resources and energy to move and because immigration rules prevent people with long term limiting illness from entry to a destination country. At older ages migration may be associated with the transition to various grades of disability, when older persons move to locations where health care or family support is better. This probably only affects the White British group (returning to the UK to benefit from NHS care) and the Black Caribbean group (older cohorts have retired back to the West Indies).

Spatial distributions of life expectancy for women from example ethnic groups (one from each racial group) are given in Figure 7.2. The dark shade on the maps denotes areas in the 25% highest life expectancies (81.2 years to 85.9 years), the light shade denotes the 25% lowest local areas (73.8 years to 78.9 years) and the mid-shade the 50% between these. We find pronounced differences between the ethnic groups. Most extreme differences are found between the Chinese women with most areas in the top 25% distribution and the Pakistani women with the largest numbers of areas in the bottom 25%. Most groups also reflect the North-South gradient mentioned above. Note that the Mixed group, Black and White Africans, has more areas in the bottom of the distribution compared to either of the separate ethnic groups, White British or Black African. A full account of methods and results is provided in Rees *et al.* (2009).

To establish recent trends, before ethnic mortalities are introduced into the population projection, they are updated to 2007. Since there is no comprehensive source of local ethnic illness data beyond the 2001 Census, we will update ethnic mortality in line with the mortalities for all groups.

As with internal migration, we have no means of updating our ethnic mortality estimates based on proxy illness data from the 2001 Census (Rees *et al.* 2009). We therefore use abridged life tables for local areas for 2001 (2000-2) to 2007 (2006-8) to update the survivorship probabilities needed for the projection model. For each ethnic group and local area, we multiply the survivorship probability from 2001 by the year y to 2001 ratio:

$$s_{xg}^{ei}(y) = s_{xg}^{ei}(2001)\frac{s_{Xg}^{*i}(y)}{s_{Xg}^{*i}(2001)} \qquad (7.1)$$

where $s_{xg}^{ei}(y)$ is the survivorship probability for ethnic group e, area i, single age x, gender g in year y, $s_{xg}^{ei}(2001)$ is the same probability for 2001, $s_{Xg}^{*i}(y)$ is the survivorship probability for all groups,

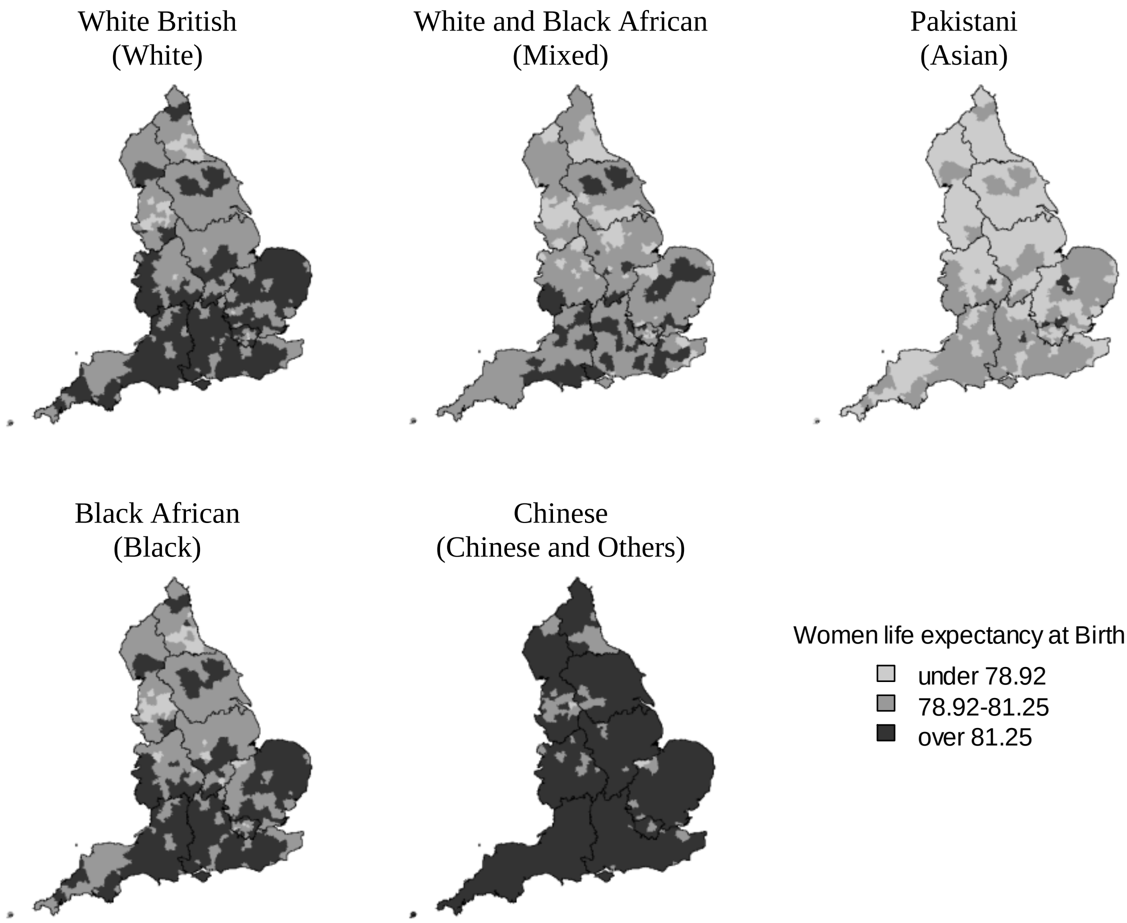


Figure 7.2 Spatial distribution of female life expectancy at birth for five example ethnic groups, England, 2001
Source: Authors' calculations based on vital statistics, census and population data from ONS, GROS and NISR

area i, five year age X, gender g in year y and $s_{Xg}^{*i}(2001)$ is the same probability in the year 2001.

For the trend projections, we implemented the assumptions built into the National Population Projections (2008 based). These involve adopting rates of percentage per annum decline in mortality rates for each age and sex. The declines start with the experience of recent years and then are converged to a uniform percentage decline across all ages and sexes within 25 years and held constant thereafter.

In our model we work with non-survivorship probabilities for period-cohorts rather than mortality rates for period-ages and, after trending, convert them back into survivorship probabilities. For the Trend-EF projection we adopted the long-term rate of decline of 1% used by ONS. For our own UPTAP projections we adopted a higher (2%) rate of decline. Table 7.2 shows the period life expectancies associated with our 2% decline assumption.

Table 7.2: Projected life expectancies under 2% rate of decline of mortalities

Ethnic group	Men			Women			Difference: women-men	
	2006-10	2046-50	Change	2006-10	2046-50	Change	2006-10	2046-50
WBR	80.2	84.7	4.6	82.6	86.7	4.1	2.5	1.9
WIR	81.0	85.5	4.5	83.0	86.8	3.8	2.0	1.3
WHO	82.4	86.6	4.2	84.2	87.9	3.8	1.7	1.3
WBC	78.1	82.6	4.5	81.5	85.4	3.9	3.3	2.7
WBA	79.3	83.8	4.4	82.2	86.0	3.8	2.9	2.3
WAS	79.7	84.1	4.4	82.4	86.3	3.8	2.7	2.1
OMI	79.4	83.8	4.4	82.5	86.2	3.8	3.1	2.5
IND	79.9	84.3	4.4	81.9	86.0	4.0	2.0	1.6
PAK	78.6	83.1	4.5	80.3	84.4	4.1	1.7	1.4
BAN	78.2	82.5	4.4	80.5	84.4	3.9	2.3	1.9
OAS	80.3	84.6	4.3	82.3	86.0	3.7	2.0	1.5
BLC	80.3	84.6	4.3	82.6	86.2	3.6	2.3	1.5
BLA	82.7	86.8	4.1	83.6	87.2	3.6	0.9	0.4
OBL	78.8	83.3	4.4	81.9	85.5	3.6	3.1	2.2
CHI	83.9	87.8	4.0	84.7	88.4	3.7	0.9	0.5
OTH	82.2	86.3	4.1	84.3	88.0	3.7	2.1	1.6
Stan Dev	1.7	1.6	-0.1	1.2	1.1	-0.1	-0.5	-0.4

8. INTERNATIONAL MIGRATION ESTIMATES, TRENDS AND ASSUMPTIONS

International migration is a significant driver of population change in the UK and as such is a crucial component in a sub-national projection model. The methods available to estimate its true impact on local areas are constrained, however, by inadequate systems of measurement and data capture since there is no single data collection instrument for the measurement of international migration. There are various alternative sources which provide intelligence about the movement of population into and out of the UK (Rees *et al.* 2009). These sources include census, survey, administrative and 'composite' datasets with each having its limitations depending upon the question asked, purpose of data collection and the population covered (for more details see Rees and Boden, 2006 and Green *et al.*, 2008).

The UK's official source of data on immigration and emigration is the Total International Migration (TIM) statistics (ONS, 2008e). The TIM statistics are primarily based on the International Passenger Survey's question on each migrant's 'intentions' to stay or leave the UK. For immigration estimation the Labour Force Survey (LFS) is part of the sub-national calibration process with 2001 Census data used for the proportional allocation of flows to local authority areas. Emigration estimation cannot be informed by the LFS or Census so incorporates a 'migration propensity' model to estimate the distribution of flows from each local authority. At ONS, an ongoing programme of improvement to international migration statistics includes an evaluation of the explicit use of administrative statistics (ONS 2009a; Rees *et al.* 2009, Bijak 2010). The results of this work are subject to consultation during 2009 with any methodological revisions to be implemented in 2010 with the release of 2008 mid-year estimates.

Here a 'New Migrant Databank' (NMD) originally recommended to the Greater London Authority to measure international migration at a local level (Rees and Boden, 2006) has been developed to produce a repository of UK-wide migration statistics from national to local authority level (Boden and Rees, 2008, 2009, 2010). The NMD provides a single source of migration statistics for each LA and has facilitated the development of alternative migration estimation methods. Using the NMD repository in parallel with the ONS improvement programme, we have developed a number of alternative methods for sub-national estimation incorporating intelligence from administrative datasets. An alternative methodology for distributing immigration flows has been derived combining TIM statistics at a national level with sub-national statistics from three administrative sources: National Insurance Number (NINo) registrations by migrant workers, the registration of international migrants with a local GP and Higher Education Statistics Agency (HESA) data on international students (Boden and Rees, 2009). The methodology uses flow 'proportions' to distribute national TIM totals to sub-national areas. The specification of this allocation process is as follows:

$$M_j = \left[\sum_k M \; r_k \; q_{Jk} \right] S_{(j|J)} \qquad (8.1)$$

where

j	=	local authority district
J	=	Government Office Region (GOR)
k	=	reason for immigration (1 formal study, 2 definite job or looking for work, 3 other)
M	=	Total International Migration (TIM) immigration estimate for the UK
M_j	=	Immigration estimate by local authority district j
r_k	=	(M_k / M) = TIM immigration proportion by migrant type k
q_{Jk}	=	$\frac{H_{Jk}}{\sum_J H_{Jk}}$ = the proportion of the administrative dataset count, *H*, for GOR J and migrant type k of UK total of migrant type k
$S_{(j\|J)}$	=	$H_{3j} / \sum_{j \in J} H_{3j}$ = the proportion of the GP registration count for local authority district j in GOR J, where, H_{3J} = count of migrants of type 3 for GOR J and H_{3j} = count of migrants of type 3 for local authority j

The alternative model results in a very different distribution of immigration flows to that recorded in official statistics (Figure 8.1). This redistribution of immigration flows reflects the differences that exist between immigration counts derived from administrative sources and those produced from ONS estimates which combine IPS and LFS sample data with census counts at a local level.

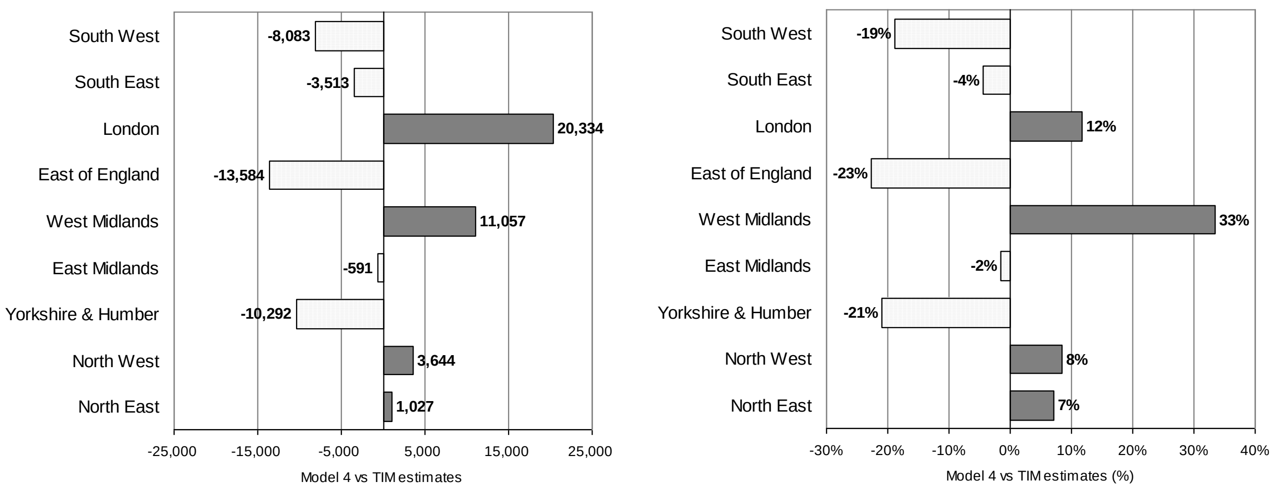


Figure 8.1: Immigration estimation: impact of an alternative methodology

At this local level the impact of the alternative estimation model is even more significant. Figure 8.2 illustrates the impact of the new estimates upon immigration flows to Yorkshire and the Humber, for example. There is an overall reduction of 10,292 immigration flows to the region. North

Lincolnshire, Wakefield and Selby experience the largest percentage gains. In South Yorkshire, Rotherham, Doncaster and Barnsley all have marginal gains, whereas Sheffield has a 29% reduction in its immigration flow total. The largest percentage reductions are associated with small absolute changes in the rural authorities of North Yorkshire. The largest overall reduction is in Leeds, the economic focus of the region, losing almost 5,000 from its TIM immigration estimate, a 36% fall.

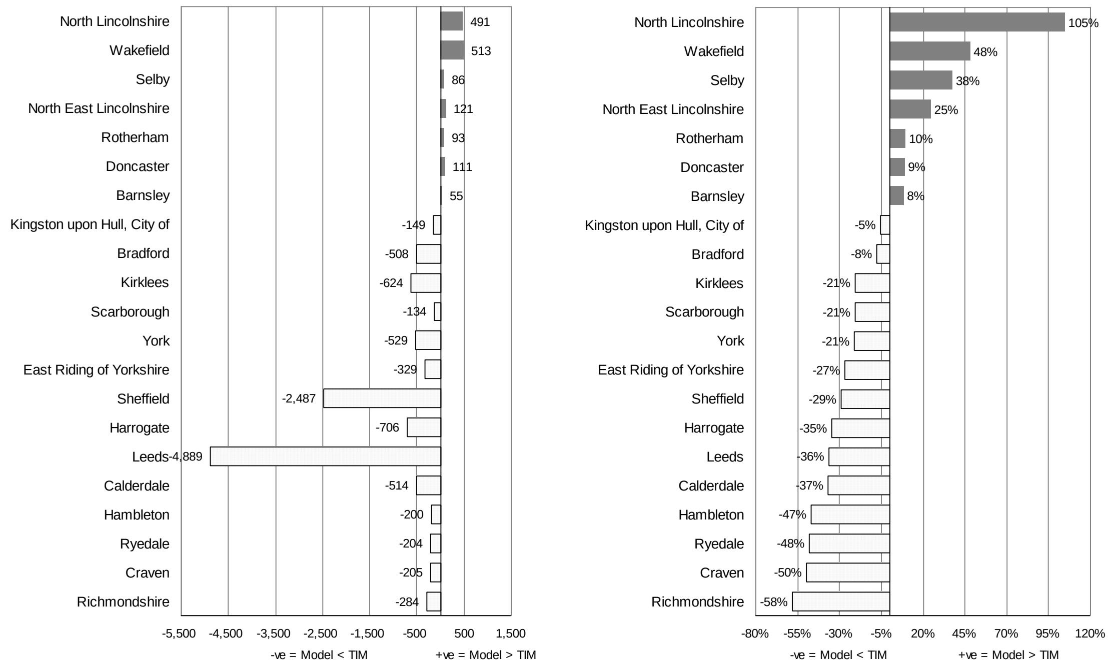


Figure 8.2 Immigration estimation: TIM versus alternative estimates, Yorkshire and the Humber

These are clearly very significant differences from the 'official' estimates of immigration but our analysis of immigration flows from a range of alternative sources suggests that a distribution of flows based on administrative data is likely to be more robust than an estimation process which relies upon a relatively small national sample (IPS) in combination with the census to produce its local authority estimates.

The accuracy of the local estimates of immigration is crucial to the robustness of population estimates, given the importance of international migration as a driver of population change since 2001. The research team has used its alternative immigration estimates to demonstrate the impact they would have upon population estimates since 2001 and population projections to 2026. Leeds is undoubtedly an extreme case, but using the alternative immigration estimates in the components of change since 2001 suggests that its mid-year population in 2007 may be too high by as much as 25,000. Its resulting population projection to 2026 could be too high by as much as 110,000;

significant numbers when trying to plan future service provision in housing, education and health care in a large metropolitan area like Leeds.

For our local authority estimates of international migration by ethnic group we have used our alternative immigration totals based on the ‘administrative data’ model. In the absence of further empirical evidence on emigration we have retained the existing emigration estimates produced by ONS for each local authority.

Given the challenge of accurately estimating international migration at all spatial scales, the robust calculation of an *ethnic group* dimension to these migration flows is also problematic. The 2001 Census provides the only direct source of data on ethnic flows and then only for immigration. The research team again experimented with the use of additional administrative data in an attempt to create alternative immigration profiles. The Department for Work and Pension’s NINo registration data were used here to derive ethnic profiles for immigration to each local authority area. Based on a commissioned 2001 Census table (C0880) linking ethnic group and country of origin, this allocated an ethnic group to each NINo registration using each registrant’s country of origin. Combining these sources produced an aggregation of NINo registrations by ethnic group for each local authority. There were shortcomings to this approach, however, as NINo statistics are associated with migrants whose length of stay is indeterminate and, in addition, they do not account for White-British migrants who do not require NINo registration.

As a result, our chosen disaggregation of immigration and emigration flows by ethnicity, age and sex has relied upon census information in combination with aggregate age-sex profiles from ONS’ published TIM statistics. A summary of the methodology is provided in Figure 8.3. For immigration, local authority totals have been disaggregated by ethnic group using local area profiles from the 2001 Census immigration tables. Decomposition by single-year of age and sex has then been applied using the national age-sex schedule in 2001. To make the age-sex profile consistent with the most recent evidence at a national level, the age-sex profile of immigration has been constrained to the TIM aggregate age-group totals recorded since 2001. This composite estimation process has produced an immigration profile by ethnicity, age and sex for each local authority area.

For emigration the process of ethnicity, age and sex disaggregation has required a more creative approach given the absence of census information on international outflows. Using TIM statistics at a national level, an estimate of the British – non-British split of emigration has been derived. Using this split at a local authority level, the ethnic profile of non-British emigration flows has been based upon the observed 2001 census *immigration* profile; the ethnic profile of British emigration flows has mirrored that of the 2001 census internal, out-migration profile. The same age and sex profiles were applied as for immigration, although the TIM aggregate age split for emigration provided an important additional weight to the profile of emigration flows. The emigration estimation is by no means a perfect solution but one which makes best use of the alternative sources that are available and which tries to reflect the different profiles of ethnicity-age-sex as robustly as possible.

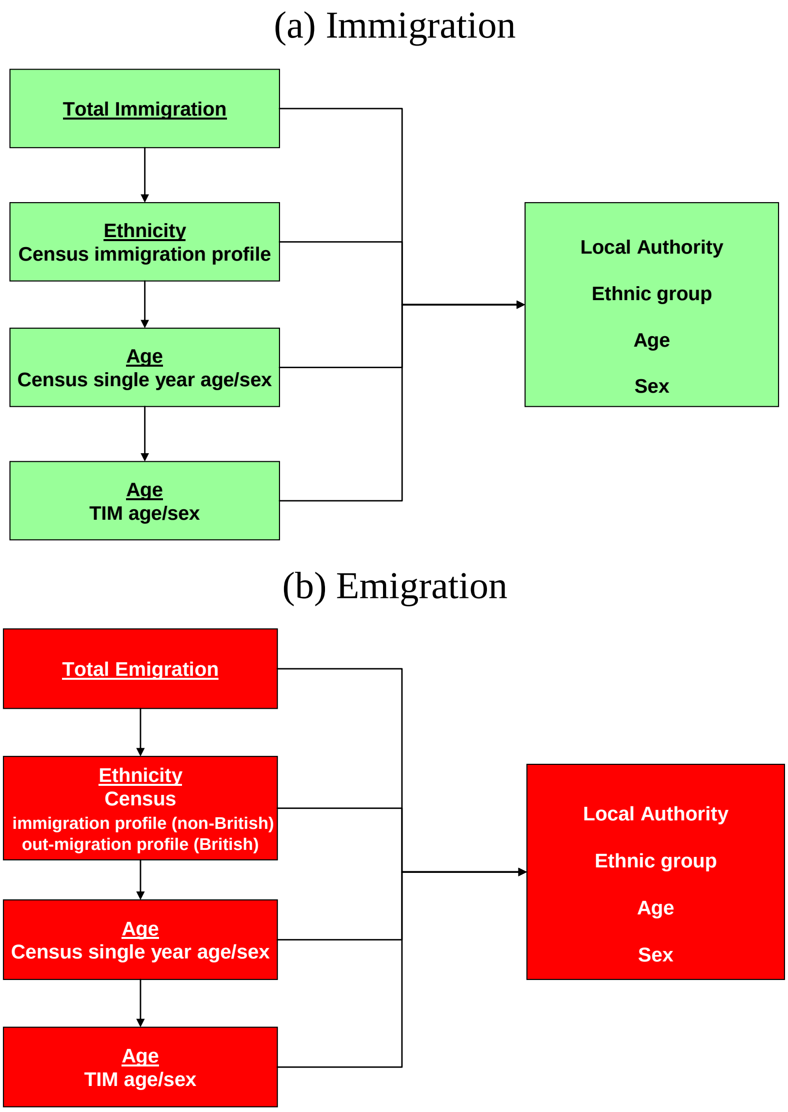


Figure 8.3: Estimating immigration and emigration by ethnicity, age and sex

The resulting age-profiles of immigration and emigration are summarised in Figure 8.4. There is a peak in immigration in the young adult ages contrasting with the higher levels of emigration in older adults. And, as an illustration of the resulting age and ethnicity impact of net international migration at a local level, Figure 8.5 illustrates three example profiles: Bradford, Birmingham and Newham, showing how significant net immigration is distributed across the sixteen ethnic groups.

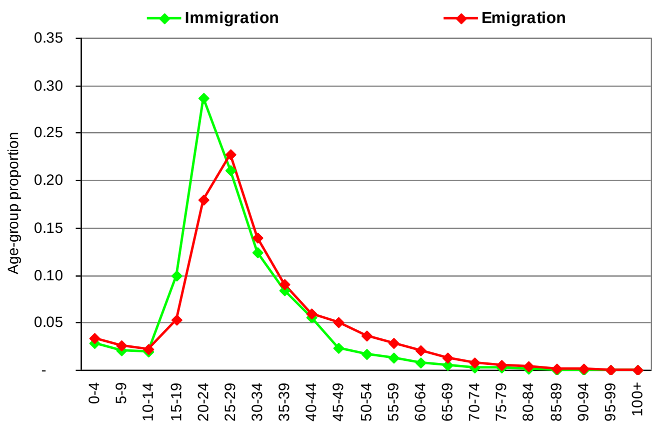
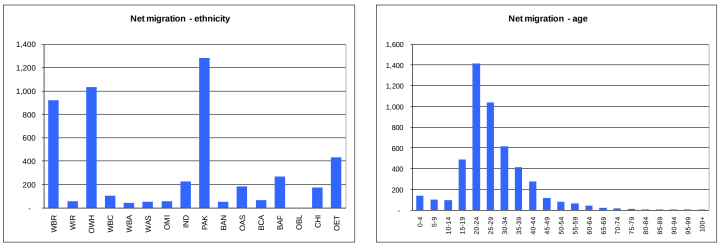
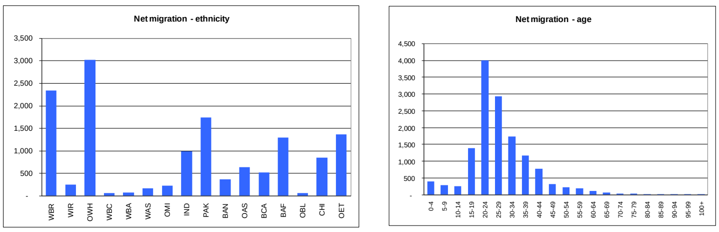


Figure 8.4 Age profile of immigration and emigration

(a) Bradford



(b) Birmingham



(c) Newham

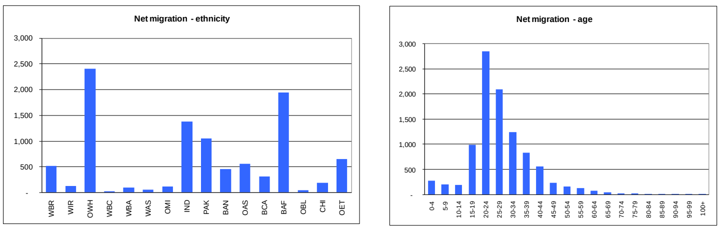


Figure 8.5 Example age ethnicity profiles, net international migration

In section 10 we explain how we construct five different projection scenarios. The first (BENCH-EF) and second (BENCH-ER) explore the impact of ethnic population dynamics at the start of the century; a third (TREND-EF) explores trends since 2001 and trends assumed by ONS in its national population projections; a fourth (UPTAP-EF) and fifth (UPTAP-ER) adopts different trends from 2006/7 that reflect the best judgement of the authors.

The EF versions of the BENCH and UPTAP projections input the flow totals for immigration and uses these as constraints to which the detailed immigration estimates are adjusted. Emigration is projected using emigration rates multiplied by populations at risk which are adjusted to add up to emigration totals as constraints. This version resembles what is done in the national population projections for net immigration.

The second versions, labelled ER, adopt an alternative model for emigration, recognizing that the populations at risk of emigration are known and that emigration can be projected by multiplying a UK population risk by an assumed emigration rate. The resulting flows are not adjusted to an assumed total but are free to change as the populations at risk change.

These two alternatives adopt different views of the international migration system. Use of flow totals is based on the assumption that immigration flows can be controlled through policy, e.g. by setting quotas on migration by particular groups or origins of migrants. Use of populations at risk and emigration rates assumes that migrants are free to move to other parts of the world like internal migrants because there is no policy constraint on emigration applied in the UK. Both views are only partially true. Some immigration streams are subject to legal control but other migration streams are not subject to such control. There are no constraints on the return of nationals who have moved overseas, the flow of migrants from the rest of the European Union, and the migration of family members who join immigrants with the right to reside permanently, for example. Conversely, while emigrants are free to migrate to some destinations such other European member states, other destinations have their own immigration controls which will affect emigration from the UK. In the projections reported in Section 11, we are able to measure what effect these alternative conceptualisations of international migration have on the projected population.

Table 8.1 sets out the net international migration result of our estimates and assumptions for the UPTAP projections for the current five year period leading up to the next census, a period 25 years hence and a period at the end of our projection horizon.

Table 8.1: Net international migration associated with the UPTAP assumptions

UPTAP Ethnic group	UPTAP assumptions EF 2006-11	2031-36	2046-51	UPTAP assumptions ER 2006-11	2031-36	2046-51
WBR	-31	-25	-25	-24	-16	-16
WIR	7	5	5	6	3	3
WHO	108	94	94	57	13	8
WBC	0	0	0	-2	-5	-7
WBA	2	2	2	1	-2	-2
WAS	2	2	2	0	-5	-7
OMI	3	3	3	1	-4	-6
IND	17	14	14	12	4	3
PAK	9	8	8	6	0	-3
BAN	1	1	1	0	-2	-2
OAS	7	6	6	4	0	-1
BLC	3	2	2	1	1	1
BLA	16	14	14	7	-4	-6
OBL	0	0	0	0	-1	-1
CHI	12	10	10	5	1	0
OTH	22	19	19	9	0	-2
Total	178	155	155	83	-17	-38

Notes: The figures are in 1000s and are the annual net international migration for the 5 year periods indicated.

9. INTERNAL MIGRATION ESTIMATES, TRENDS AND ASSUMPTIONS

To project the populations of 16 ethnic groups for 352 local authorities in England and three countries filling out the United Kingdom we need robust estimates of internal migration, which is a very important component of population change. Data on migration by ethnic group are collected in two sources: the decennial census and the annual Labour Force Survey and its successors, the Annual Population Survey and the Integrated Household Survey. The annual household surveys have been used to understand the structure of UK migration by ethnic groups by Raymer and Giulietti (2008; 2009) and Raymer *et al.* (2008), while Stillwell *et al.* (2008) have used information from the 2001 Census Small Area Microdata. Hussain and Stillwell (2008) and Stillwell and Hussain (2008) have analysed the spatial structure of inter-district migration using 2001 Census commissioned tables. However, the data sets used by these authors did not match the input requirements of our projection model – 16 detailed ethnic groups as well as a LA spatial scale (in England). Fortunately, a commissioned table was available from the 2001 Census (table CO528) which reports the inter-district flows in England by 16 ethnic groups. Inspection of the CO528 table indicated that further disaggregation by age and sex would generate very small numbers and therefore unreliable ethnic-age-sex specific migration rates. The decision was taken to focus analysis on table CO528 and to add age and sex as independent variables, using a national age-sex profile of migration from the 2001 Census.

The original intention was to use this information, an origin-destination-ethnic (ODE) array of migration flows between LAs in England (plus Wales, Scotland and Northern Ireland as single zones) with age-sex (AS) variables to generate multi-regional probabilities: in log-linear modelling terms an ODE+AS model. Further investigation revealed that most flows were either zero or small numbers (1, 2) which had been subject to disclosure control procedure (turning them into 0 or 3). Adopting advice in Wilson and Bell (2004b, p.157) that *"the POOL, BR and BR+N models were argued to provide forecasting frameworks with a balance between conceptual purity and practicality"*, we adopted a reduced model, the bi-regional (BR) cohort-component model.

The structure of the bi-regional model can be summarised as follows. Each region's population is projected in a two-region system consisting of that region and the rest of the country. The model projects flows from the region of interest to the rest of the country and from the rest of the country to the region of interest as products of out-migration probabilities multiplied by the population at risk in the respective origin region. It thus captures the essential advantage of the multiregional model over the single-region model (with net migration or gross flows), namely that the migration flows respond, *ceteris paribus*, to the changing size of origin populations. The model was found by Wilson and Bell

(2004b) to give projection results close to the outcomes of a multiregional model applied to the states and territories of Australia. A couple of adjustments are needed to the model to ensure consistency of the projected flows. The total of outflows from the regions may differ from the total of inflows (outflows from the rest of the country). In each time interval, these totals are reconciled by adjusting the inflows to agree with the total of outflows. The second adjustment is to compute the total country populations as the sum of all the regional populations for use in the next time interval.

Because we employ census migration data between LAs, there is an opportunity to separate the processes of survival from those of migration. Migration data from the 2001 census is generated from a question on location one year ago, asked (by definition) of those who have survived the year. So from these data we can compute the probabilities of re-location given survival within the country covered by the census. We can compute survival probabilities using life tables from local and national mortality data (described above) and thereby estimate the probability of emigration given survival. The advantage of computing the component probabilities in this way is that it ensures that they are all well behaved, being non-negative and not exceeding unity. So the flows of internal migrants in each period-cohort, sex and ethnic group are modelled using equations set out in Table 9.1.

Table 9.1: Equations used to estimate the out-migration probabilities for local areas by ethnicity

Variable		Constituent variables	Equation number
Total survivors	=	Survivorship probability × Start population of origin	(9.1)
Emigrant survivors	=	Square root (survivorship probability) × Emigration flow	(9.2)
Survivors within country	=	Total survivors – Emigrant survivors	(9.3)
Out-migrant survivors	=	Probability of out-migration given survival within country × Survivors within country	(9.4)
Surviving stayers	=	Census population – Total surviving in-migrants – Surviving immigrants	(9.5)
Total surviving in-migrants	=	Total migrants – Intra-zone migrant – Surviving immigrants	(9.6)
Total survivors within the UK	=	Surviving stayers + Total surviving out-migrants within the UK	(9.7)
Total surviving out-migrants within the UK	=	Total migrants within UK (with given origin) – Intra-zone migrants	(9.8)
Total probability of out-migration given survival within the UK	=	Total surviving out-migrants within the UK/Total survivors within the UK	(9.9)
Total survivors in rest of UK	=	Sum of total survivors within UK in each zone – Total survivors within UK	(9.10)
Total probability of out-migration from the rest of UK given survival in UK	=	Total surviving in-migrant to zone/total survivors in rest of UK	(9.11)

The projection begins with equation (9.1) in which the start population is multiplied by a survivorship probability derived from the local area life table (see Section 7). Then in equation (9.2) the model inputs the estimate of emigration from the local area and computed the number of emigrant survivors using the square root of the survivorship probability to reflect the shorter exposure to mortality in the UK of persons who emigrate. We then subtract emigrant survivors from total survivors to yield the survivors within the country (equation 9.3). The number of out-migrant survivors (people who migrate and survivor between local areas within the country) is projected by multiplying the total survivors within the country computed in equation (9.1) by the probability of out-migration given survival within the country in equation (9.4). These probabilities are estimated by converting the inter-area internal migration matrix from the census into a population accounting matrix. The way this is done is best explained through an example shown in Table 9.2.

Table 9.2 contains the matrix of flows for one ethnic group, Indians, showing three of the 355 origins/destinations. The top left sub-table shows the flows from origins (rows) to destinations (columns). These derive from census commissioned table but have been adjusted upwards by re-distributing the persons reporting 'No usual address one year ago' (NUA) using the reported migrants flows as weights (including intra-area migrants). This is a vital adjustment as NUA migrants make up 8% in the case of the Indian ethnic group. The diagonal terms in the matrix contain the intra-zone migrants (persons with a different address one year before the census which was in the same zone as that they lived at the time of the census). They are replaced for probability calculations by the surviving stayers within a zone (within zone migrants and non-migrants). This term is not provided in the census tables but can be computed as a residual by subtracting from the census population the total of internal in-migrants plus the international immigrants ('Address outside the UK one year ago'). This is equation (9.5). Total surviving in-migrants to a local area can be computed as a sum of the flows from all other areas or through subtracting intra-zone migrants and surviving immigrants from total migrants (equation 9.6).

Consider the migration flows into the first zone, City of London plus Westminster. There are a total of 1,772 in-migrants, 405 intra-zone migrants and 495 surviving immigrants, so that the total surviving in-migrants are 872. Subtract from the census population of 5,830 the 872 surviving in-migrants and the 495 surviving immigrants and the result is 4,463 surviving stayers. This population term is essential for the computation of the total of survivors within the UK, who are located in middle top panel of the table. They are computed as the sum of surviving stayers within the local area plus total surviving out-migrants within the UK (equation 9.7). Total surviving out-migrants within the UK are total migrants within UK (with given origin) less intra-zone migrants (equation 9.8). For the City of London plus Westminster, the total migrants are 1,015 and the intra-zone migrants 405, leaving 610 total surviving out-migrants within the UK. Add this number to the

Table 9.2: Sub-national migration flows for ethnic groups, Indian ethnic group, 2001 Census

ORIGIN		DESTINATION													
Zone #	Zone name	City of London + Westminster	:	Leeds	:	Northern Ireland	Total migrants within UK	Intra-zone migrants	Total surviving out-migrants within UK	Surviving stayers	Total survivors within UK	Total probability of out-migration from area*	Total surviving in-migrants	Total Survivors in Rest of UK	Total probability of out-migration from RUK*
1	City of London + Westminster	405	:	3	:	1	1,015	405	610	4,463	5,073	0.120226	872	990,070	0.000881
:	:	:		:		:	:	:	:	:	:	:	:	:	:
67	Leeds	10	:	1,134	:	1	1,671	1,134	537	11,322	11,859	0.045253	707	983,285	0.000719
:	:	:		:		:	:	:	:	:	:	:	:	:	:
355	Northern Ireland	3	:	4	:	205	385	205	180	1,399	1,579	0.055575	48	992,241	0.000157
	Address outside UK	495	:	274	:	122									
	Total migrants	1,772	:	2,115	:	375									
	Intra-zone migrants	405	:	1,134	:	205									
	Total surviving in-migrants	872	:	707	:	48									
	Total surviving in-migrants & immigrants	1,367	:	981	:	170									
	Total surviving stayers	4,463		11,322	:	1,394									
	2001 Census population	5,830	:	12,303	:	1,569									
	No usual address one year ago	140	:	138	:	0									

Notes: * given survival in the UK. **Figures may not sum precisely to column or row totals because of rounding for presentation purposes.

Source: Authors' calculations based on Commissioned Table CO528, 2001 Census, Crown Copyright and census migration statistics and population data from ONS, GROS and NISRA surviving stayers and we get 5,073 total survivors within the UK. We are now in a position to compute the migration probabilities needed in the projection model.

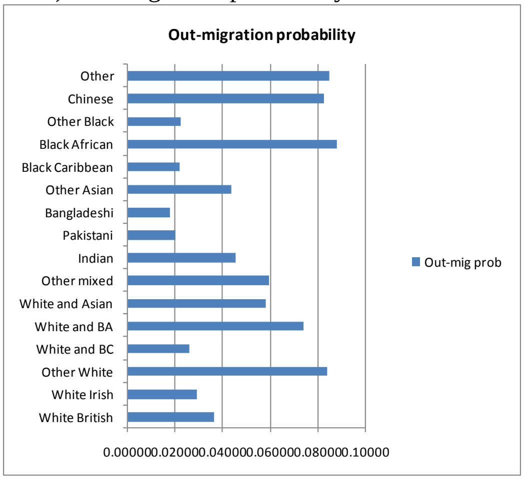
The total probability of out-migration given survival within the UK is computed as the total surviving out-migrants within the UK divided by total survivors within the UK (equation 9.9). In the case of the City of London plus Westminster, this probability for the Indian group is 610/5073 = 0.120226 or 12% for the Indian group. The out-migration probabilities are higher for London boroughs than elsewhere because they are parts of a much larger metropolitan housing and jobs market.

The rightmost panel in Table 9.2 reports the computation of the out-migration probabilities from the rest of the UK (the UK minus the zone of interest), which requires the computation of the total survivors in the rest of the UK. These are calculated as the sum of total survivors within UK in each zone less total survivors within UK (equation 9.10). The total probability of out-migration from the rest of UK given survival in UK is computed as total surviving in-migrant to zone divided by total survivors in rest of UK (equation 9.11). For the City of London plus Westminster, this probability is 872/990,070 or 0.00088.

Full versions of Table 9.2 have been developed for all 16 ethnic groups and all 355 zones in our analysis. Previous work used only broad ethnic groupings (Stillwell *et al.* 2008). The out-migration probabilities for ethnic groups in Leeds are plotted in Figure 9.1. Figure 9.1a plots the probabilities of out-migration from Leeds. Compared with the White British, the Other White, all of the Mixed Groups, the Indian, Black African, Chinese and Other Ethnic Group all exhibit higher probabilities whereas the White Irish, White and Black Caribbean, Pakistani and Bangladeshi and Other Black groups have lower probabilities. Thus, within four of the five broader groupings, there are detailed groups with low and with high migration probabilities. The picture is broadly similar in terms of highs and lows for out-migration from the rest of the UK (in-migration to Leeds), shown in Figure 9.1b.

The next piece in the jigsaw of internal migration estimation is to add age-sex detail. Here we converted single year of age profiles for men and women for UK migrants as a whole into ratios of the profile means. These ratios were then multiplied by the mean probabilities generated in the analysis illustrated in Table 9.2. This estimate assumes independence of the OD pattern of migration from the AS pattern. As a first approximation this is satisfactory but further analysis comparing with broad age migration data for seven ethnic groups (Stillwell *et al.* 2008) will be appropriate.

a) Out-migration probability from Leeds



b) Out-migration probability from the Rest of the UK

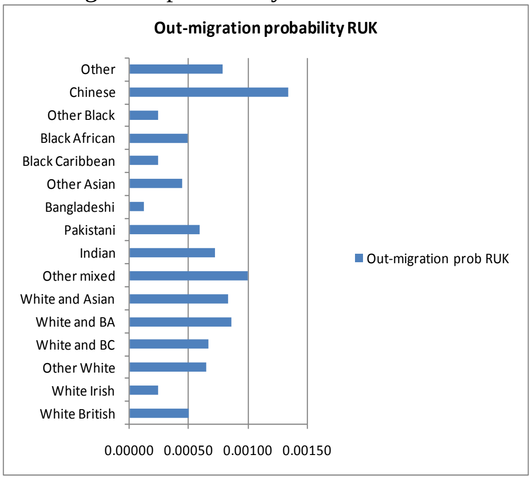


Figure 9.1: Migration probabilities for Leeds, by ethnic group, 2000-1
Source: Authors' calculations based on census migration and population data from ONS, GROS and NISRA

These conditional probabilities of migration by ethnicity are updated from their 2000/1 values derived from the 2001 Census using the time series of all group LA migration from 2001/2 to 2007/8 based on the PRDS and NHSCR migration data published by ONS. The LA to LA migration flows after 2000-1 were estimated for the whole of the UK by Adam Dennett using a method developed by Dennett and Rees (2010) for larger NUTS2 regions. Preliminary analysis of the time series at NUTS2 and lA scale did not reveal systematic trends in direction of internal migration, so we adopted the assumption that the estimated 2007/8 probabilities would remain constant to 2050/51, the end of our projection period. This assumption can be revisited when we develop further projection scenarios. Table 9.3 sets out the consequent total internal migration flows at the start and end of the projection period.

Table 9.3: Projected totals of inter-zone migration for 355 zones by ethnic group (1000s)

	UPTAP-EF		UPTAP-ER	
Ethnic group	2006-11	2046-51	2006-11	2046-51
WBR	2368	2679	2361	2503
WIR	33	37	32	30
WHO	283	485	270	304
WBC	26	56	25	47
WBA	14	39	14	29
WAS	30	80	30	59
OMI	28	72	27	51
IND	95	148	93	119
PAK	41	71	41	60
BAN	17	28	16	25
OAS	31	57	30	41
BLC	31	36	30	30
BLA	82	146	80	102
OBL	8	15	8	13
CHI	46	74	44	49
OTH	48	86	45	51
Total	3180	4109	3149	3515

10. PROJECTION ASSUMPTIONS

In this section of the report we describe the set of projections carried out and the assumptions which underpin each projection. The set of projections was computed in order to validate the projection model and to understand how assumptions changed the projected populations.

10.1 The schema of projections

Table 10.1 sets out the schema of projections that have been carried out to date using the model, software and component estimates described in earlier sections and which are here married with an account of the various assumptions made. The research has examined the projected change in ethnic group populations using five alternative scenarios.

10.1.1 The Benchmark-Emigration Flows (EF) and Benchmark Emigration Rates (ER) scenarios

We began our projection work with the production of a very basic projection, which is termed **Benchmark**. This was designed to test out the model and the associated R software, to discover any erroneous inputs and to adjust estimation methods if the results were implausible. The results were first presented at the Annual Conference of the Royal Geographical Society held at Manchester in August 2009 (Presentation 22 in Appendix A.8). We used as "jump-off" populations the 2001 mid-year ethnic group population estimates produced by the Office for National Statistics for local authorities in England supplemented by our own estimates of the ethnic group populations of Wales, Scotland and Northern Ireland adjusted to the England and Wales classification. By "jump-off" we mean the base populations beyond which further populations are either estimates or projections based on the components of change. We made our own estimates (described in earlier sections of the report) of the components of change in local ethnic populations. We did not use any further ONS ethnic group estimates because our methods and estimates of these components differ to a greater or lesser extent. The benchmark estimates uses component estimates for the mid-year to mid-year interval 2001-2, either derived directly or indirectly (see Sections 5.5.1 and 5.5.2). The only exception is internal migration for which the data source was the 2001 Census. The migration data derived from the census refer to the year prior to the census date (April 29, 2001), for our model we use an estimate updated for the 2001-2 period (see Section 5.5.3).

We then assumed that these benchmark component intensities (rates, probabilities or flows) continued unchanged into the future. Such projections are, of course, likely to be wrong but they serve as a comparator for later projections in which more recent information is introduced. What is remarkable about the two benchmark projections is how far they differ from later ones and the 2008-based ONS National Population Projection (NPP). These differences are due to radical rises in fertility and immigration in the decade after 2001 and the continued fall in mortality rates.

Table 10.1: The schema used for the ethnic population projections

Projection	Model	Benchmark inputs Fertility, International Migration	Mortality	Internal Migration	Estimates **2002-2007**	Assumptions **2007-2051**
BENCHMARK-EF	BRM with Emigration Flows	2001-2	2001-2	2001-2	Constant	Constant
BENCHMARK-ER	BRM with Emigration Rates	2001-2	2001-2	2001-2	Constant	Constant
TREND-EF	BRM with Emigration Flows	2001-2	2001-2	2001-2	Estimated	Aligned with 2008-based NPP
UPTAP-EF	BRM with Emigration Flows	2001-2	2001-2	2001-2	Estimated	UPTAP Project
UPTAP-ER	BRM with Emigration Rates	2001-2	2001-2	2001-0	Estimated	UPTAP Project

Notes: EF = emigration flow model, ER = emigration rates model, BRM = bi-regional model, UPTAP = Understanding Population Trends and Processes

There are two versions of the benchmark projections: in the EF version we project emigration as assumptions of the constant count of migration by zone, age, sex and ethnicity; in the ER version we project emigration as the product of a constant rate of emigration multiplied by the starting population at risk, by zone, age, sex and ethnicity. We introduced the EF version in order to match our projections assumptions with those of ONS. We employ the ER version because this method of modelling emigration is preferred. The assumptions for ER projections are in terms of the age-sex-ethnic specific emigration rates.

10.1.2 The Trend-EF scenarios

The third scenario we term the **Trend** projection. This title indicates we made estimates of the components of change for years subsequent to 2001-2 using published data with ethnic information (e.g. the fertility and international migration components) or by assuming that all group population trends applied to ethnic groups (e.g. the mortality and internal migration components). We were able to make such updated estimates for all years to 2006-7 and for the fertility and internal migration components for 2007-8. In 2011 the next census will take place and, of course, will offer a valuable check on the accuracy of our estimation work. From mid-year 2007 forward we continue the latest estimate rates, probabilities and flows forward at a levels aligned as far as possible to the assumptions made in the ONS 2008-based National Population Projections (ONS 2009c). The internal migration assumptions derive from the Sub-national Projections for England, which, in fact, assume continuation of redistribution effected in 2004-6 migration estimates. An analysis of internal migration trends (Dennett and Rees 2010) suggests a fair measure of stability. Raymer and Giulietti (2009) claim substantial rises in the ethnic minority migration but these are essentially size effects (the ethnic minority groups are growing) rather than changing pattern effects. However, as we shall see, even the application of a constant migration structure results in substantial changes in the distribution of populations across local areas and in our projection of ethnic group populations across the local areas of England.

10.1.3 The UPTAP-EF and UPTAP-ER scenarios

The fourth and fifth scenarios we call the **UPTAP** projections. UPTAP stands for Understanding Population Trends and Processes. This is the ESRC programme under which the current research was supported (see www.uptap.net for more details). Here we have applied our own judgements to the assumptions for the future from 2006 onwards, which may differ from or coincide with the official assumptions by ONS, GROS, NISRA and WAG. For ethnic fertility our assumptions are usually higher than those estimated by ONS in developing their 2001-7 ethnic population estimates though we adopt roughly the same view about long term fertility. Our long term mortality improvement assumption of 2% decline per annum is more optimistic than ONS's 1% decline. Our international migration assumptions are lower than the ONS assumptions in the UPTAP-EF (Emigration Flows) scenario and substantially below the ONS assumptions in the UPTAP-ER (Emigration Rates) scenario.

10.2 Assumptions for the projections

The assumptions adopted in each of the four projections are set out in general terms in Table 10.2. All projections use the same inputs for the first time interval, mid-year 2001 to mid-year 2002 and a base population of 2001 Census populations adjusted to local authority mid-2001 estimates. The populations have been estimated by single years of age by disaggregating ethnic populations by five year ages by the single year age distribution for all groups for each local authority. The exact time interval for the first inputs varies by component. Age-sex specific fertility rates are estimated for 2001 calendar year and converted into 2001/2 midyear interval (5.5.2). Life tables for each ethnic group, sex and local area are estimated using 2001 calendar year deaths before survivorship probabilities are computed, those survivorship probabilities are then moved into the 2001/2 time space (5.5.1). Internal migration probabilities by ethnic group for both sexes conditional on survival within the UK are computed directly from a commissioned 2001 Census migration table and adjusted to age and sex using national profiles of migration probabilities. Immigration flows for ethnic groups are computed from 2001 Census data adjusted to local immigration totals derived from administrative records, adjusted in turn to national totals. Emigration flows and hence rates are derived from a combination of national emigration totals and Census immigration profiles for the non-British and total out-migrants for the British. More details for each component have been given in earlier sections of the paper.

Table 10.3 sets out an overview of the assumptions we made in our own UPTAP projections. The assumptions for 2001/7 or 2001/8 (depending on component) follow those made for the TREND projections and are estimated from available demographic information. For the long term projection period a constant assumption is made. For the initial projection period (2007 to target year) we interpolate between the latest time interval and the long term projection period, differing between components.

The long term assumption (target year to 2051) for fertility is that the national total fertility rate will be 1.84 children per woman. Ethnic specific fertility rates are distributed above and below this long term assumption. For mortality the long term assumption is that age-sex-ethnic specific fertility rates will decline at 2% per annum. For internal migration we hold probabilities constant at 2007/8 levels over the whole projection period. For international migration we assume declines from peaks in 2006/7 to lower long-term levels in 2032-33 which remain constant to the end of the projection period. This assumption applies to both immigration and emigration and also to net international migration in the UPTAP-EF projection. The levels are shown in the last column of Table 10.3. In the UPTAP-ER model it is the emigration rates of 2006/7 which are held constant over the projection period. Emigration flows increase as a result because the ethnic group populations grow and the net international migration balances shrink to become negative (Table 8.1).

Table 10.2: Projection Assumptions for Key Drivers

Projection title	Component	2001-2002	2002-2007	2007 to Target Year	Target Year 2051
BENCHMARK	Fertility	Estimated 2001-2 ASFRs	Constant from 2001-2	Constant from 2001-2	Constant from 2001-2
	Mortality	Estimated 2001-2 Survivorship Probabilities	Constant from 2001-2	Constant from 2001-2	Constant from 2001-2
	Internal migration	2000-1 Conditional Probabilities	Constant from 2000-1	Constant from 2000-1	Constant from 2000-1
	Immigration	2001-2 Immigration flows	Constant from 2001-2	Constant from 2001-2	Constant from 2001-2
BENCHMARK-EF	Emigration flows	2001-2 Emigration flows	Constant from 2001-2	Constant from 2001-2	Constant from 2001-2
BENCHMARK-ER	Emigration rates	2001-2 Emigration rates	Constant from 2001-2	Constant from 2001-2	Constant from 2001-2
TREND-EF	Fertility	Estimated 2001-2 ASFRs	Adjusted to all groups ASFRs 2002-7	Adjusted to ONS assumptions for TFRs	Adjusted to ONS assumptions for TFRs
	Mortality	Estimated 2001-2 Survivorship Probabilities	Adjusted to life tables for years	Adjusted to ONS assumptions for mortality decline	ONS mortality decline at 1% per annum
	Internal migration	2000-1 Conditional Probabilities	Local Time Series Indexes applied to 2000-2001 probabilities	Held constant at 2005-6 levels	Held constant at 2005-6 levels
	Immigration	2001-2 Immigration flows	Time series of total immigration used	Adjusted to ONS assumptions on total immigration	Adjusted to ONS assumptions on total immigration
	Emigration flows	2001-2 Emigration flows	Time series of emigration used	Adjusted to ONS assumptions on total emigration	Adjusted to ONS assumptions on total emigration
UPTAP	Fertility	Estimated 2001-2 ASFRs	Adjusted to all groups ASFRs 2002-7	New assumptions on TFR	New assumptions on TFR
	Mortality	Estimated 2001-2 Survivorship Probabilities	Adjusted to life tables for years 2002 to 2007	Adjusted to ONS assumptions for mortality decline	Mortality decline at 2% pa
	Internal migration	2000-1 Conditional Probabilities	Local Time Series Indexes applied to 2000-2001 probabilities	Held constant at 2005-6 levels	Held constant at 2005-6 levels
	Immigration	2001-2 Immigration flows	Time series of total immigration used	New assumptions on total immigration	New assumptions on total immigration
UPTAP-EF	Emigration flows	2001-2 Emigration flows	Time series of emigration used	New assumptions on emigration flows	New assumptions on emigration flows
UPTAP-ER	Emigration rates	2001-2 Emigration rates	Time series of emigration used	New assumptions on emigration rates	New assumptions on emigration rates

Note: Beyond the target year assumptions remain the same. Between 2007 and the target year short term trends are projected, ending in the long term assumptions.

Table 10.3: Details of the assumptions made for the component drivers in the UPTAP projections

Component	Indicator	Estimate period	Initial projection period	Long term projection period
		2001-2008	2008-2021	2021-2051
Fertility	Age specific fertility rates for eight ethnic groups	Estimates based on VS, LFS and Census data	Decline to long-term averages	Long-term assumptions approximate to a TFR of 1.84
		2001-2007	2008-2032	2032-2051
Mortality	Survivorship probabilities	Change in accordance to local authority time series 2001 to 2007	ONS 2008 NPP assumption on mortality applied to non survivorship probabilities decline	From 2032-3 onwards 2% decline in non-survivorship probabilities for all groups and ages
		2001-2008	2008-2032	2032-2051
Internal migration	Probabilities of migration conditional on survival within UK	2000-1 probabilities changed by time series multiplier based on PRDS and NHSCR migration data	Probabilities constant at 2007-8 levels	Probabilities constant at 2007-8 levels
		2001-2007	2007-2032	2032-2051
Immigration	Total flow (UK)	Estimates of total immigration ranging from 486,285 in 2001-2 to 604,656 in 2006-7	Total immigration declines from 2006-7 peak to long term level	Total immigration of 435,182
Emigration	Total flows converted into rates (UK)	Estimates of total emigration ranging from 339,475 in 2001-2 to 406,417 in 2006-7	Total emigration declines from 2006-7 peak to long term level	Total emigration of 292,520
Net Immigration	Net flow (UK)	Estimates of net international migration ranging from 146,810 in 2001-2 to 198,239 in 2006-7	Net international migration declines from 2006-7 peak to long-term level	Net international migration of 142,662

11. PROJECTION RESULTS

The aim of this section of the report is to present the results of our five projections. The volume of information which our projections have produced is huge. We will make available our raw input and output files of comma separated variable files via the UK Data Archive and our project website. The sets of files are described in Appendix A.6. We intend to deliver the results in web-accessible database format, provided ESRC Follow On Funding is provided. This section picks out the highlights from our results, concentrating on comparison between 2001 and 2051 populations. The plan for the section is as follows. Sub-section 11.1 presents the summary numbers for the UK as a whole, compares them with the official projected populations and discusses the reasons for the differences between projections. Sub-section 11.2 provides a systematic description of the projected populations of the sixteen ethnic groups, showing how each group fares in the five projections, how age-sex structures change and how the spatial distributions change between 2001 and 2051. Sub-section 11.3 returns to the national scale to look at the systematic ageing of the ethnic group populations over those fifty years. Under current and assumed demographic regimes no group escapes this process. Sub-section 11.4 views the patterns displayed in the maps through the lens of a number of geographical classifications that help establish the extent of spatial redistribution. Finally, in sub-section 11.5 we use a well-known index for comparing population distributions to measure the re-distribution implied by our preferred UPTAP-ER projection.

11.1 Projections for the United Kingdom

Table 11.1 presents the total populations for the United Kingdom while Figure 11.1 graphs these trajectories and adds the projected populations from the 2008-based ONS National Population Projections. A comparison of the benchmark projection which uses 2001-2 component rates, probabilities and flows with the other three projections we have produced show how profoundly the UK's demographic regime has changed in the 2000-09 decade with increased net inflows from outside the UK, increased fertility rates leading to higher numbers of new born and continued improvement in survival changes leading higher numbers of older people.

The UK population was 59.1 millions in 2001. Under the 2008-based NPP, the population grows steadily to 77.1 million by mid-century. If this level of growth comes to pass, it is likely that the UK will have Europe's largest population (Europa 2008, Rees *et al.* 2010b). Our projection, TREND-EF, with assumptions aligned with those of the 2008-based NPP produces slightly higher projected populations. The UPTAP-EF projection using a model that handles international migration as flows produces slightly higher numbers than the Trend projection.

Table 11.1: Total populations of the UK, 2001-2051: the 2008-based National Population Projections and five ethnic group projections (populations in millions)

Year	NPP 2008	BENCH-EF	BENCH-ER	TREND-EF	UPTAP-EF	UPTAP-ER
2001	59.1	59.1	59.1	59.1	59.1	59.1
2006	60.2	60.2	59.9	60.8	60.8	60.6
2011	62.6	61.1	60.4	63.5	63.6	62.8
2016	64.8	62.0	60.5	66.0	66.1	64.5
2021	67.0	62.8	60.5	68.2	68.4	66.0
2026	69.1	63.3	60.1	70.1	70.5	67.1
2031	70.9	63.6	59.5	71.9	72.3	67.9
2036	72.6	63.6	58.6	73.4	74.0	68.5
2041	74.2	63.5	57.5	74.9	75.6	69.0
2046	75.7	63.3	56.3	76.4	77.2	69.4
2051	77.1	63.0	55.1	77.7	78.8	69.7

Sources: ONS 2009c, authors' computations.

Notes:

Projection	Specifications
BENCH	Benchmark projection using constant 2001-2 component rates, probabilities and flows
TREND	Trend projection using estimated 2001-7 or 2001-8 component rates, probabilities and flows; component rates, probabilities and flows thereafter aligned to NPP 2008 assumptions
UPTAP	Understanding Population Trends and Processes projection using revised assumptions
EF	Emigration flows model
ER	Emigration rates model

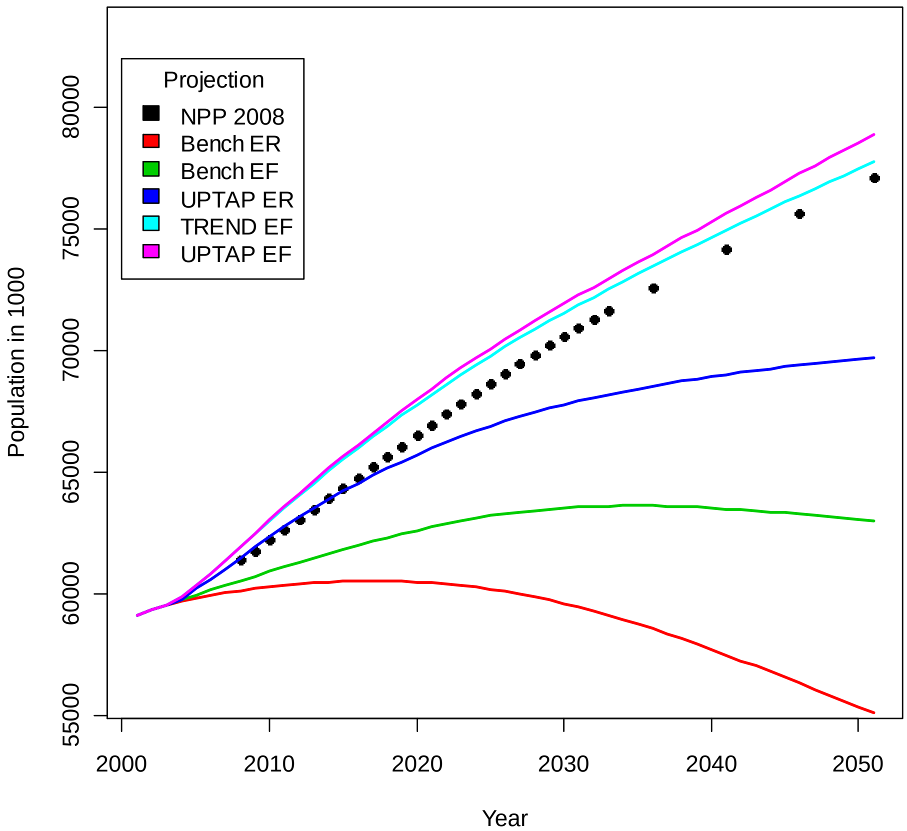


Figure 11.1: Trends in the UK population, ONS 2008-based projections and five ethnic group projections, 2001 to 2051

The NPP model is a set of four single region cohort-component models linked by a matrix of net migration flows between the four home countries. Our results come from summing the projected 16 ethnic group populations for 355 zones using a bi-regional cohort-component model that links zones through internal migration and ethnic groups through mixed ethnicity births. We can interpret the NPP-2008 and TREND-EF differences as a product of using linked local and ethnic group populations compared with four separate national populations, weakly linked though one net migration matrix.

The differences between the TREND-EF and UPTAP-EF projections can be interpreted as mainly due to the additional population surviving to older ages because of the more optimistic mortality assumptions.

The fifth projection in our set, the UPTAP-ER projection, shows projected populations that differ considerably from the NPP aligned projection (TREND-EF). The model for handling emigration is different: we use rates of emigration multiplied by populations at risk to project the numbers of emigrants. As the projected population grows so does the number of emigrants so the net contribution of international migration to population growth diminishes because immigration is assumed to be a set of constant flows. This asymmetry in the treatment of the immigration and emigration streams, which we argued earlier in the report better reflected the policy context, leads to 9.1 million fewer people in 2051 compared with the UPTAP-EF projection and 7.4 million fewer people than the NPP projection. The UPTAP-ER projection is our preferred future trajectory for the UK population.

In the analysis of our projection results that follow we always present results of the TREND-EF and UPTAP-ER projections, so that the reader can either agree with our view of the UK and the rest of the world or with the ONS view. Selected results from the other three projections are presented as appropriate.

11.2 Projections for the sixteen ethnic groups

Our analyses yield projected populations for 16 ethnic groups for the whole UK (summing the results for the individual zones). These sums are set out for our five projections in Table 11.2. In the Benchmark projections, we see that the White British and White Irish groups actually decrease in size by 2051, while the other ethnic group populations grow, in some cases substantially. The differences between groups are due mainly to the following factors: the favourable age structure for growth in many minority groups (concentrations in the fertile age range leading to a favourable demographic momentum), the higher fertility rates for some groups and the higher gains from international migration, counter-balanced for some groups by higher mortality.

How does the ethnic composition of the UK population change under the five projections? In 2001 87% of the UK population was White British (the host group) and 13% belonged to ethnic minorities. Some 92% of the population was White (the first three groups) and 8% non-White. In 2051 the White British share of the population falls to between 67 to 77% while the White share falls to between 79 to 84%. The difference between the White British and White shares is due mainly to the rapid growth of the Other White population, which gained from heavy immigration during the 2000-9 decade that is reflected in the TREND-EF and UPTAP-EF projections. The UPTAP-ER projection assumes that growing numbers of migrants from central and eastern Europe will return home. The latest international migration estimates suggest that this has begun. In the year to September 2008 100,000 A8 migrants entered the UK compared with 45,000 in the year to September 2009, while 57,000 A8 citizens emigrated in both periods. Emigration went from 57% of immigration to 127%.

To understand what is happening in our projections it is helpful to convert the absolute numbers into time series indicators. We have done this for the UPTAP-ER projection, our preferred projection, in Figures 11.2, 11.8, 11.13 and 11.18. We investigate what happens in our projections to each ethnic group under our UPTAP assumptions. The sixteen ethnic groups are arranged into four groups for presentation purposes:

(1) White and other groups that grow slow or to a limit over the projection horizon (Figure 11.2)

(2) Mixed groups that grow rapidly (Figure 11.8)

(3) South Asian and Other Asian (not China) groups which grow strongly (Figure 11.13)

(4) Various newer groups that grow strongly (Figure 11.18).

Note that we use an indicator of population change relative to 2009 to represent the group dynamics in a comparable way. Each figure also presents the age profile of the groups in 2009 compared with their profile in 2051. The shaded area on the age profile graphs shows the all group distribution, while the coloured lines show the respective groups. All age profiles show substantial changes. Note that the scales on the time series graphs differ between sets of graphs and the age profile numbers corresponding to the percentages plotted differ from group to group. The alternative would have been to use absolute numbers in the age-sex profiles but this is difficult to do in less than 16 separate graphs.

Table 11.2: Ethnic group projected populations for 16 ethnic groups, 2001-2051

Ethnic Group	2001	BENCH-EF projection 2011	2031	2051	BENCH-ER projection 2011	2031	2051	TREND-EF projections 2011	2031	2051
WBR	51469	50613	47290	41771	50621	47244	41788	52423	53668	52477
WIR	1451	1451	1389	1300	1437	1343	1235	1529	1601	1615
WHO	1465	2491	4529	6182	2182	2852	3088	2746	5307	7705
WBC	246	338	556	763	324	447	515	351	610	895
WBA	83	135	259	390	126	190	224	143	291	463
WAS	197	301	556	835	279	402	470	318	633	1013
OMI	162	260	503	766	236	344	400	276	566	915
IND	1070	1386	1980	2475	1336	1733	1960	1438	2150	2864
PAK	761	1011	1551	2049	979	1358	1625	1041	1655	2322
BAN	289	375	556	721	364	493	589	377	563	760
OAS	253	362	590	792	335	450	507	378	641	914
BLC	574	629	691	688	617	640	612	649	753	820
BLA	500	763	1317	1790	686	885	955	792	1393	2001
OBL	99	125	183	235	121	156	177	130	202	281
CHI	254	396	680	909	339	433	467	427	766	1084
OTH	238	473	948	1331	387	504	532	515	1072	1592
ALL	59111	61107	63579	62995	60367	59474	55142	63533	71872	77720

Group	2001	UPTAP-EF projections 2011	2031	2051	UPTAP-ER projections 2011	2031	2051	Ethnic Group	Name
WBR	51469	52599	54803	55015	52625	54697	54516	WBR	White British
WIR	1451	1529	1605	1633	1515	1549	1532	WIR	White Irish
WHO	1465	2679	4907	6982	2293	2998	3341	WHO	Other White
WBC	246	354	626	934	340	525	678	WBC	White & Black Caribbean
WBA	83	143	287	459	133	217	277	WBA	White & Black African
WAS	197	320	630	1006	296	474	603	WAS	White and Asian
OMI	162	276	558	901	250	398	502	OMI	Other Mixed
IND	1070	1432	2065	2672	1381	1841	2178	IND	Indian
PAK	761	1040	1622	2247	1008	1446	1829	PAK	Pakistani
BAN	289	378	562	757	368	505	629	BAN	Bangladeshi
OAS	253	375	617	869	346	479	568	OAS	Other Asian
BLC	574	649	743	798	636	693	710	BLC	Black Caribbean
BLA	500	785	1329	1873	705	930	1044	BLA	Black African
OBL	99	130	201	280	126	176	217	OBL	Other Black
CHI	254	420	716	985	358	472	529	CHI	Chinese
OTH	238	502	989	1438	400	521	562	OTH	Other Ethnic
ALL	59111	63609	72261	78848	62780	67921	69712	ALL	All groups

Notes: All figures are in 1000s.

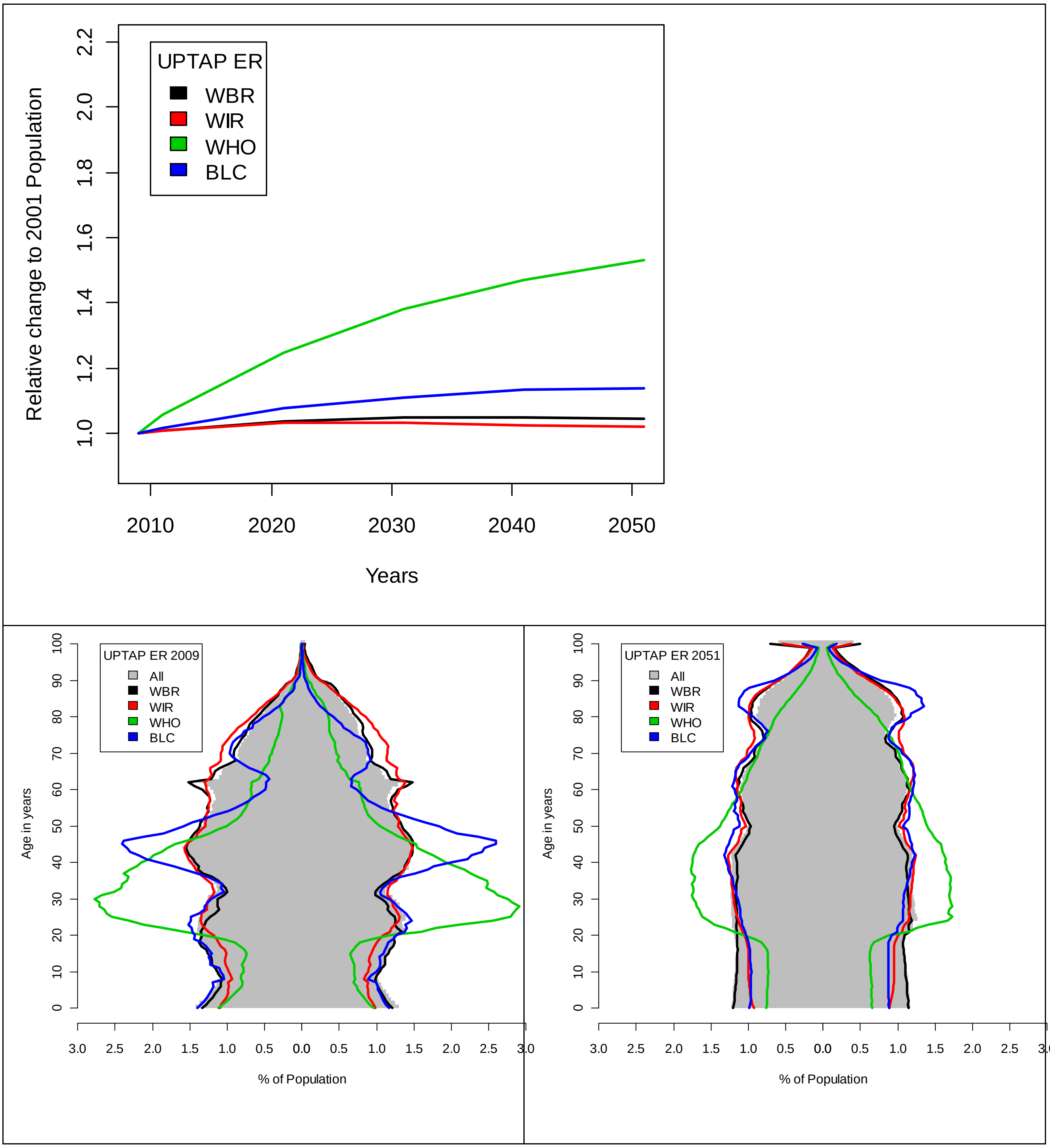


Figure 11.2: Time series indexes and population age-sex profiles for four lower growth groups, UPTAP ER projection, 2009-2051

11.2.1 Slow growing groups: the White British group

This group grows by 6% over the 50 years (Table 11.3). The age profile ages over the 42 years. Cohort waves move through the age profile so that the baby boomers in their 40s and 50s in 2009 constitute a major bulge in the 80s some 40 years later (Figure 11.2).

Table 11.3: Percentage shares and time series indices for the White British group

WBR	Mid-Year estimate 2001	TREND-EF projection 2051	UPTAP-EF projection 2051	UPTAP-ER projection 2051
% Share	87.1	67.5	69.8	78.2
Time series	100	102	107	106

The White British population loses 19.6% share under the TREND-EF projection, 17.3% under the UPTAP-EF projection and 8.9% under the UPTAP-ER projection.

The projections generate 355 local ethnic group populations, which are interesting to examine in cartographic form. To make the maps of the 16 ethnic groups as comparable as possible we did two things: first, we computed location quotients (LQs) for each group in each area and second, we plotted the LQs on a population cartogram base rather than a conventional geographic map.

A location quotient is the ratio of the share that a group has of the local population to its share of the national population. So, if a group makes up 20% of the local population but only 10% of the national population, then its LQ in that area is 200/100 or 2. LQs above 1 indicate that the group is more concentrated locally than nationally; LQs below 1 indicate the group is less concentrated locally than nationally. LQs enable us to compare distributions of groups with very different shares of the national population.

A conventional geographic map does not provide a good visual display for populations concentrated in the major urban centres such as most of the ethnic minority groups in the UK. The conventional map is dominated by low density rural populations. Therefore we use instead a population cartogram in which the area occupied by each local authority (LA) is proportional to the population of that LA. The population cartogram we adopt is that developed by Thomas and Dorling (2007) in which each LA is made up of an appropriate number of hexagons, each hexagon representing about 100,000 people. The population cartogram is designed to meet the following criteria: the hexagons for each LA must be contiguous, each LA must still be contiguous to the same LAs as in the conventional map; there should be a minimum displacement of the LA from its position on a conventional map and the shapes of LAs and the country as a whole should be preserved. It is possible to design the cartogram by hand or to write computer algorithms to achieve the best possible solution that satisfies these criteria. Some criteria are treated as absolute constraints (internal and external contiguity); others are treated as objective functions to be minimized or maximized.

One of the problems of such population cartograms is that they are unfamiliar to the reader. Figure 11.3 provides information to identify where government office region boundaries are located in the cartogram and where some of the principal cities are located. For a full key, refer to Thomas and Dorling (2007).

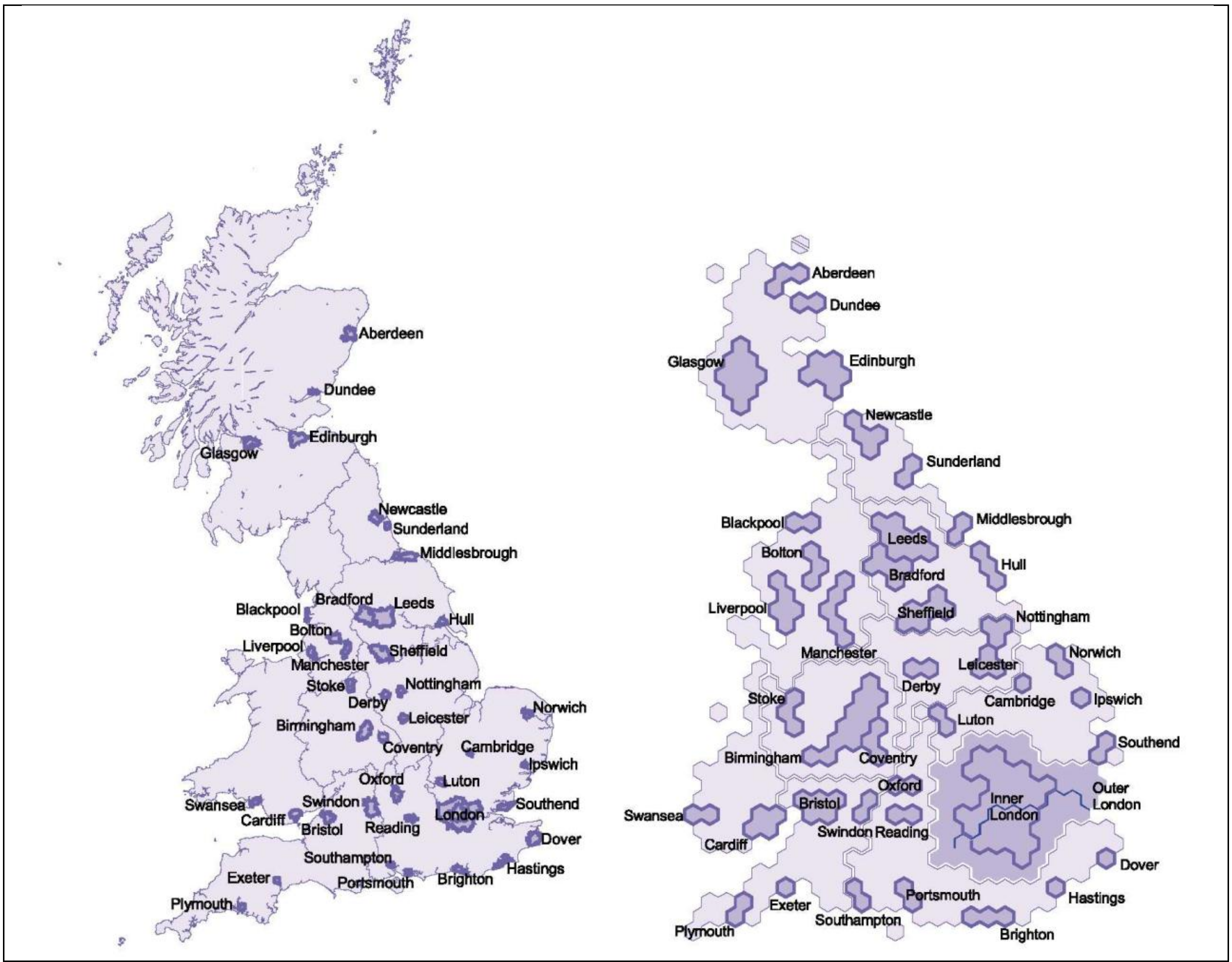


Figure 11.3: A standard geographic map and the population cartogram, with principal cities identified
Source: Thomas and Dorling (2007), Online at:
http://www.sasi.group.shef.ac.uk/publications/identity/towns_cities_locator_maps.pdf
For a map identifying Government Office Regions:
http://www.sasi.group.shef.ac.uk/publications/identity/regional_locator_maps.pdf

Figure 11.4 presents the location quotient maps for the White British. There are four maps in the diagram. The top LH map shows the LQ distribution at mid-year 2001. The top RH map shows the LQ distribution in 2051 according to the TREND-EF projection (the projection most closely aligned to the 2008 based NPP). The bottom LH map show the LQs for the UPTAP-EF projection, while the bottom RH map depicts the UPTAP-ER projection LQs. This arrangement of four maps is repeated for each of the sixteen ethnic groups.

The distinctive feature of the White British group is that the majority of LAs fall in the class with LQs slightly above 1 (coloured yellow) in 2001 and in 2051. It is the major metropolitan centres which show LQs below one: London, Birmingham, Luton, Leicester, Nottingham, Manchester, Kirklees, Bradford and NE

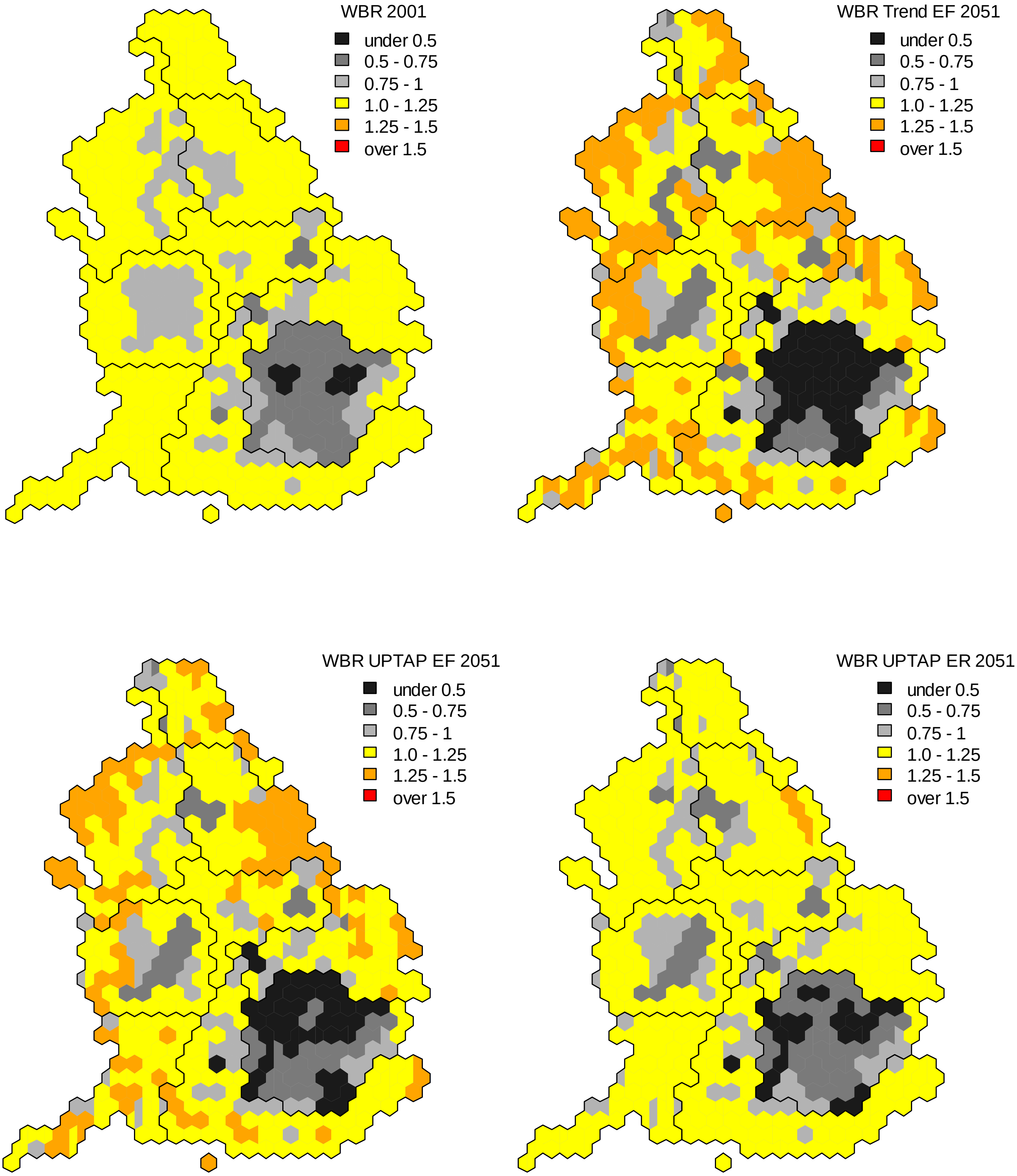


Figure 11.4: Location quotients in 2001 and 2051 for selected projections, White British

Lancashire but not Bristol, Leeds or Liverpool. The lowest LQs are found in Brent, Newham and Tower Hamlets in London. The map patterns do alter a little between 2001 and 2051. Comparing 2001 and the 2051 LQs according to the UPTAP-ER projection, we see small extensions of White British under-concentration in the east of London (Greenwich, Barking and Dagenham and Bexley) and to the north (St. Albans). Under-representation intensifies in Birmingham and appears in a few smaller towns in Northern England.

The TREND-EF and UPTAP-EF projections have quite similar patterns, which differ from the UPTAP-ER pattern for 2051 in two ways. There is greater under-representation in many parts of London and greater over-representation in the more rural parts of northern England. Both these projections forecast higher net immigration to London Boroughs, resulting in lower representation of the White British. The higher ethnic minority share in these two projections pushes some White British dominated LAs into a higher concentration class.

11.2.2 Slow growing groups: the White Irish group

Migration between Ireland to the UK has a long history. As a result of the Irish famine triggered by the potato blight in the 1840s, large numbers of migrants moved not only to the USA but also to the UK. Irish migrants clustered in the cities of North West England, particularly Liverpool and Manchester together with London. In the 20th century the main Irish migration took place in 1945-1955 adding the West Midlands to the destination conurbations. These cohorts had reached retirement ages in 2001. By 2051 the older ages are made up of the children of the post-war wave of migrants from Ireland. Fertility levels of this group are forecast to be low. Inter-marriage and assimilation mean that offspring "move" into the White British group. There has been return migration to a previously booming Irish economy of younger migrants. Under the TREND-EF and UPTAP-EF projections the group grows by 11 or 13% and by only 6% under the UPTAP-ER projection, where more of the group return to the Irish Republic (Table 11.4).

Table 11.4: Percentage shares and time series indices for the White Irish group

WIR	Mid-Year estimate 2001	TREND-EF projection 2051	UPTAP-EF projection 2051	UPTAP-ER projection 2051
% Share	2.46	2.08	2.07	2.20
Time series	100	111	113	106

The group loses its share of the UK population under all projections from 2.46% in 2001 to 2.08-2.20% in 2051.

Figure 11.5 shows the LQ pattern for the group. The White Irish group is concentrated in the three largest metropolitan areas: Greater London, The West Midlands and Greater Manchester. Liverpool had lost White Irish migrants or they had assimilated to such an extent that the group was no longer over-represented

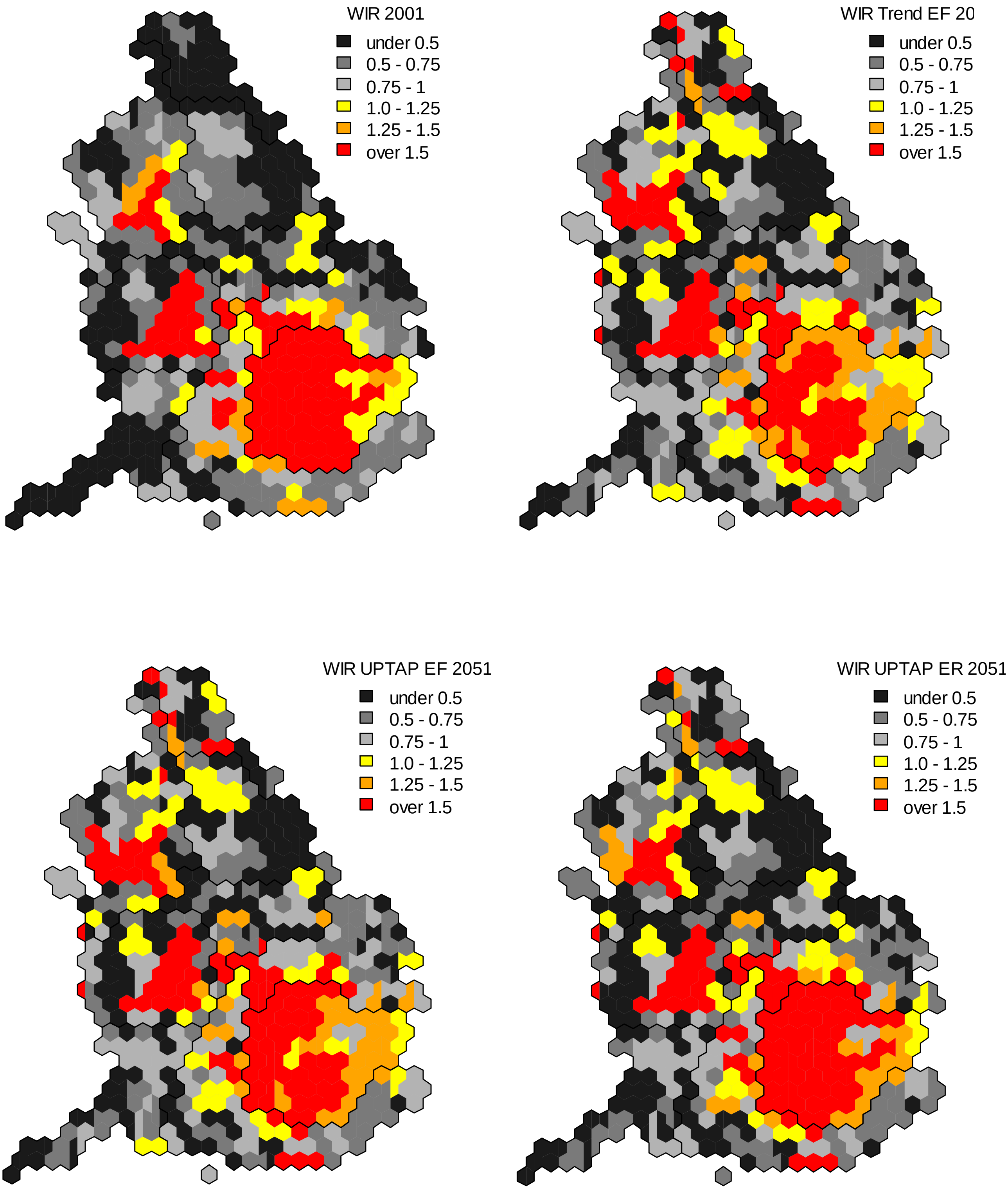


Figure 11.5: Location quotients in 2001 and 2051 for selected projections, White Irish

in 2001 or descendants of the original migrants has assimilated and re-identified as White British Scousers. By 2051 the distribution has shifted only marginally with gains in Liverpool, and some towns in London's outer-metropolitan ring.

11.2.3 Slow growing groups: the Other White group

This group grows strongly at first but then levels off (Figure 11.2). Because of the large influx of new migrants from central and east Europe, this ethnic group expands faster than the extra-European groups. Their fertility is, however, low, indicated in the small number of children in the 2051 age profiles. There is also evidence that there has been return migration to Poland (ONS 2010e). The over-representation at young adult ages turns into an age distribution close to that of the White British in 2051 but still shows the 2009 bulge aged by 42 years. Table 11.5 indicates substantial differences in growth and share depending on the model for emigration selected. Under the TREND-EF and UPTAP-EF projections the White Other population increases by over four to five times while the population only doubles under the UPTAP-ER projection. Under this scenario emigration rises so that fewer people are added to the group's population.

Table 11.5: Percentage shares and time series indices for the Other White group

WHO	Mid-Year Estimates 2001	TREND-EF Projections 2051	UPTAP-EF Projections 2051	UPTAP-ER Projections 2051
% Share	2.48	9.91	8.86	4.79
Time series	100	526	477	228

Figure 11.6 indicates that the Other White group in 2001 is London focussed and stays so through to 2051. This is a little surprising given that we know from analysis of the Worker Registration System (WRS) statistics that one component of the group, recent migrants from the Accession 8 countries has a wider spatial distribution than most other immigrant groups (Bauere *et al.* 2007). The reason is that we rely on the 2001 Census for the starting stock of the Other White population and then attempt to estimate the 2001-07 components from available indirect data, not including the WRS information. In a future projection we may need to revisit our estimates for 2001-07. Another issue is that we rely on the 2001 Census for internal migration probabilities by ethnicity. Updating is achieved by using a time series based on local authority out-migration and in-migration for all ethnic groups. Publication of population and migration data from the 2011 Census in 2012 and 2013 will enable these assumptions to be checked and revised. It will always be difficult to handle in a projection phenomena such as waves of migration from new origns, which were unknown at the time of design of the assumptions. However, migrants from central and eastern Europe only make up a minority of the Other White population. Large numbers of Other White migrants have come from France, Germany, other Western European countries, the United States, Canada, New Zealand and Latin America. All of these groups come predominantly to London.

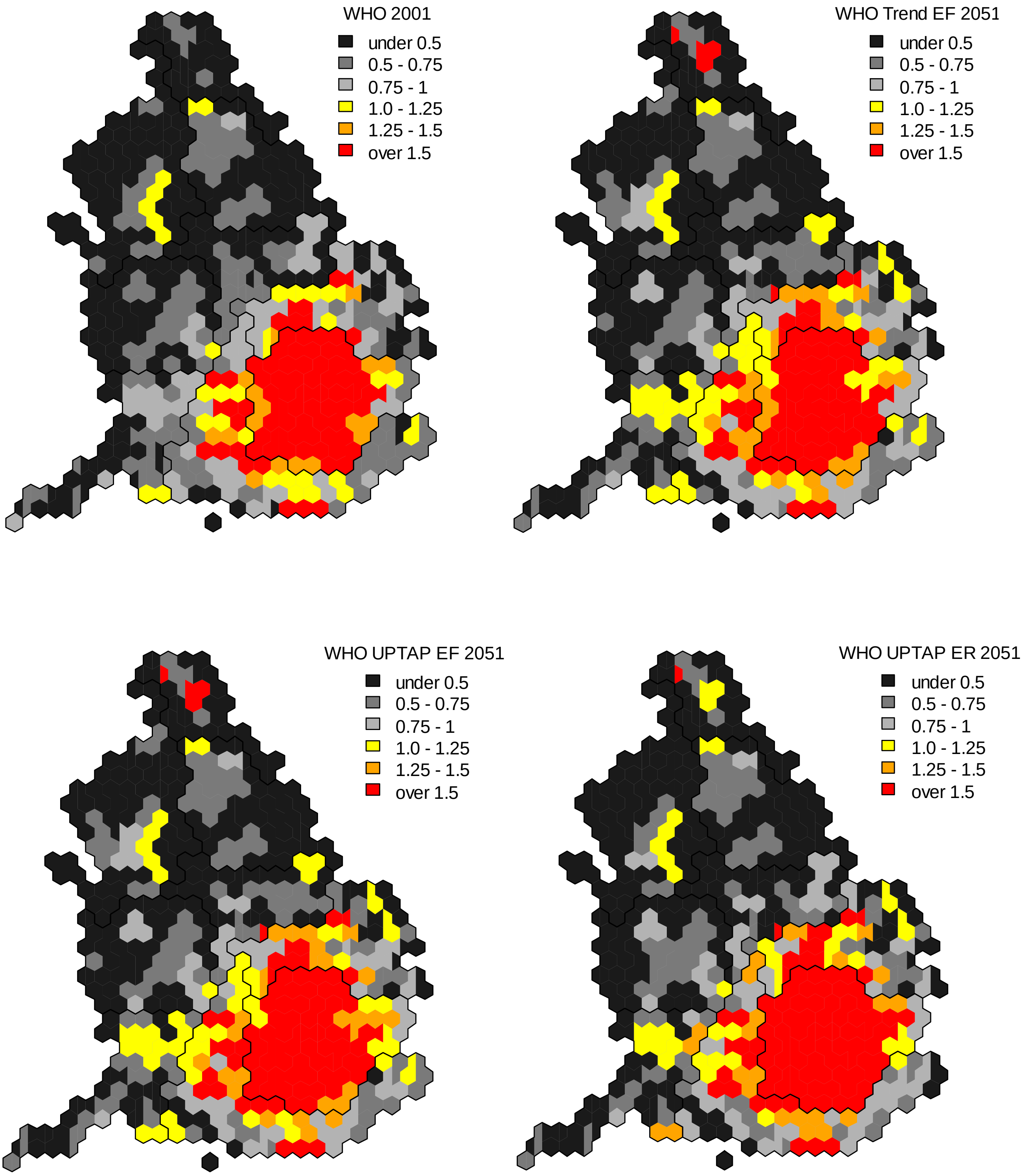


Figure 11.6: Location quotients in 2001 and 2051 for selected projections, White Other

11.2.4 Slow growing groups: the Black Caribbean group

The evolution of the Black Caribbean group's age profile is shown in Figure 11.2. In 2001 we find evidence of four immigrant generations represented as bulges in the age profile. The first generation of immigrants, who arrived in the 1950s and 1960s have aged into their late sixties and seventies. Their children, the second generation are in their forties. Their grandchildren (many fewer because of a decline in fertility) are aged 15 to 25. Their great grandchildren are beginning to be born and are aged 0-4 in 2001. By 2051, the first generation has died out, the second generation are aged in the eighties (many who would have been in their nineties will have died). The age bulge of the children of the migrants of the 1950s and 1960s almost disappears and the age profile comes to resemble that of the White British (Figure 11.2). The Black Caribbean population also experiences a high level of emigration back to their West Indies origins.

Table 11.6 indicates that the growth in the Black Caribbean group between 2001 and 2051 varies between 24% (UPTAP-ER projection) and 43% (TREND-EF projection). The UPTAP-ER projections applies emigration rates to the UK local populations which reflect high levels of return migration to the West Indies among older ages. Continuing low fertility and a high level of mixed marriages/unions mean the demographic momentum effect is subdued and return migration reduces ageing.

Table 11.6: Percentage shares and time series indices for the Black Caribbean group

BLC	Mid-Year estimate 2001	TREND-EF projection 2051	UPTAP-EF projection 2051	UPTAP-ER projection 2051
% Share	0.97	1.05	1.01	1.02
Time series	100	143	139	124

The spatial distributions of the Black Caribbean groups in 2001 and in 2051 under three projections are plotted in Figure 11.7. The group's population in 2001 is concentrated in Greater London, Birmingham, Manchester, Nottingham and some towns in the South East outside London. In the 2051 maps there has been de-concentration: fewer LAs fall in the bottom class (LQs less than or equal to 0.5) and more occupy the fifth and fourth bands from LQs of 0.5 to 1.0. Within Greater London LQs in the highest class (greater than 1.5) extend to the south east and south of Greater London. In the centre of the capital, in the boroughs of Kensington and Chelsea, Westminster and City of London LQs fall because of in-migration of White groups, while in Tower Hamlets the group is partly replaced by Bangladeshis. A little more de-concentration occurs in the two EF projections than in the ER projection.

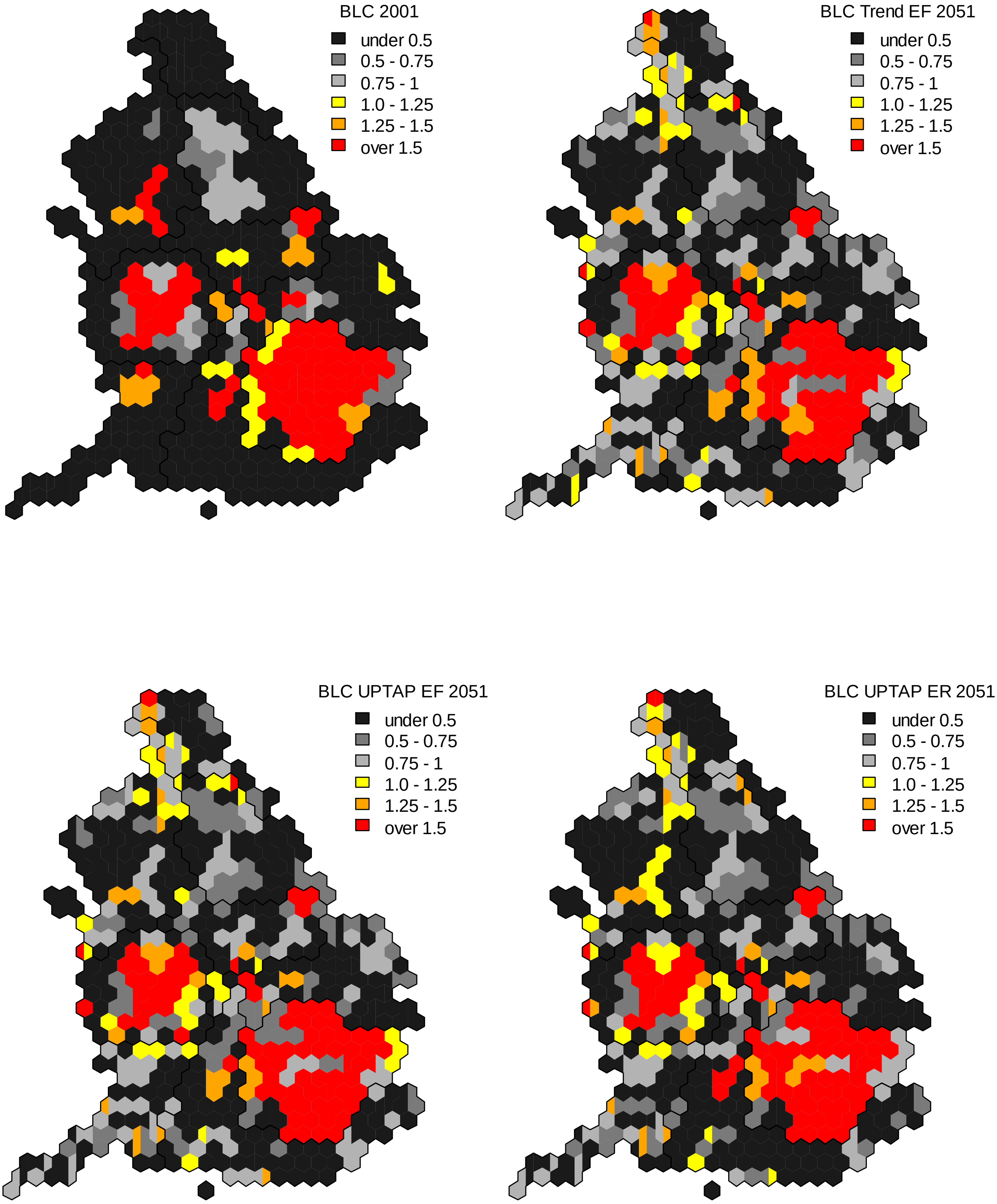


Figure 11.7: Location quotients in 2001 and 2051 for selected projections, Black Caribbean

11.2.5 Mixed groups: White and Black Caribbean

We now review the projection outcomes for the four mixed ethnicity groups, which are projected to grow most compared to the other ethnic groups under our preferred UPTAP-ER projection. The mixed groups all have a very young age structure in 2001 (true pyramids) and so have the potential to grow substantially as the children move into the family building ages (Figure 11.8, bottom panel). The White and Black African group grows fastest, followed by the White and Asian groups and Other Mixed group. The White and Black Caribbean grows slightly less. The age profiles of all the groups show progress towards an older structure by 2051 although the profiles are still very young compared with the whole population.

Table 11.7 presents the changes in shares and relative numbers between 2001 and 2051 for the White and Black Caribbean group. This group increases to between 2.7 and 3.8 times its 2001 population, depending on projection chosen. Its share of the population increases to around 1% of the population, about 2.3 times its 2001 share.

Table 11.7: Percentage shares and time series indices for White and Black Caribbean

WBC	Mid-Year estimate 2001	TREND-EF projection 2051	UPTAP-EF projection 2051	UPTAP-ER projection 2051
% Share	0.42	1.15	1.18	0.97
Time series	100	364	380	276

The location quotients for 2001 and the selected projections in 2051 are mapped in Figure 11.9 for the White and Black Caribbean group. There is substantial spatial de-concentration from its 2001 foci of Greater London, the West Midlands, Manchester, Kirklees, Sheffield, Bristol and smaller cities in the South East. By 2051 the intensity of concentration in these foci has decreased and LQs have increased outside these cities. The index of dissimilarity between the White and Black Caribbean group and the rest of the population, measured across 355 zones (England LAs and other home countries) shrinks from 39 in 2001 to 27 in 2051 (UPTAP-ER projection).

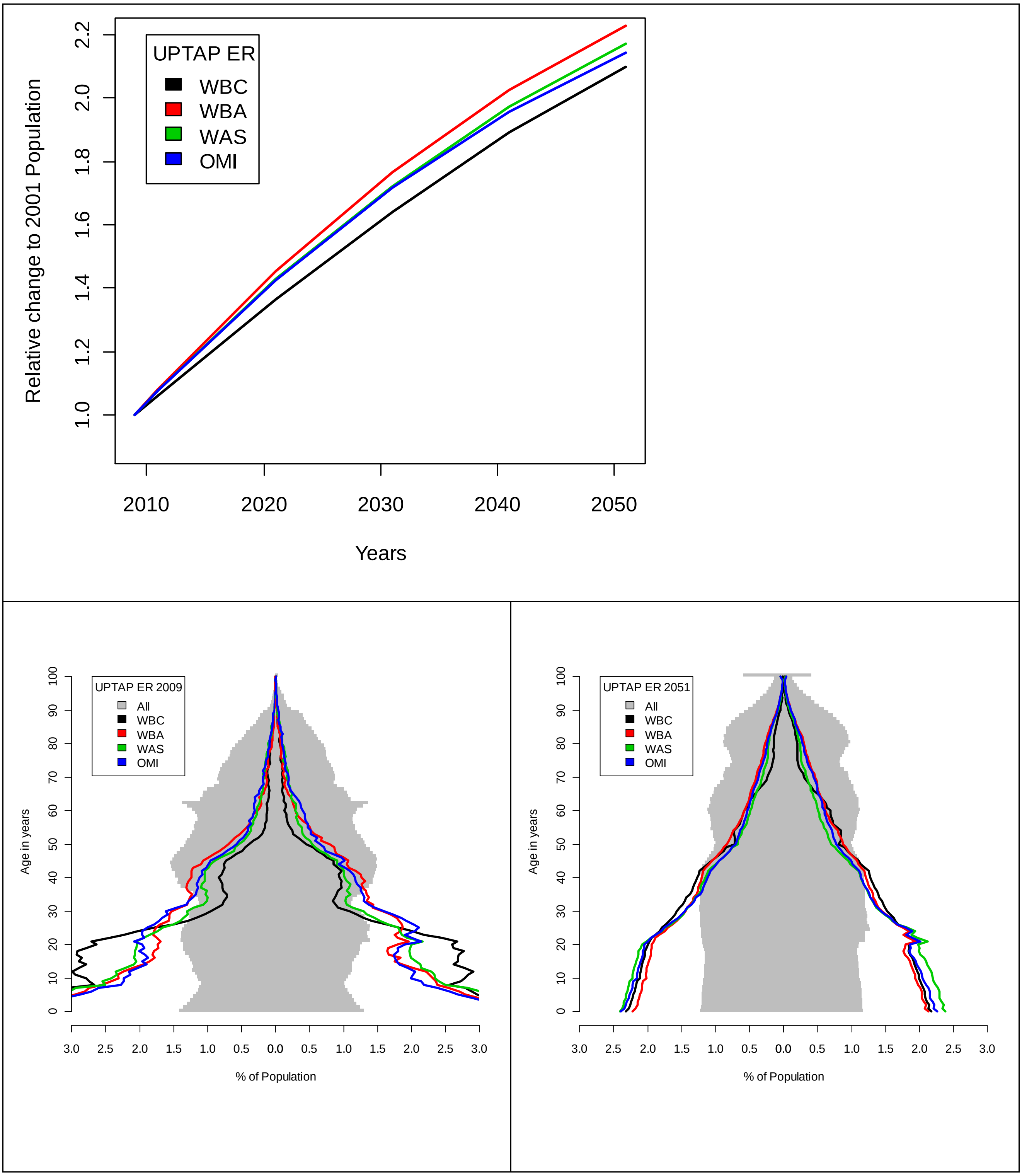


Figure 11.8: Time series indexes and population age-sex profiles for four mixed groups, UPTAP ER projection, 2009-2051

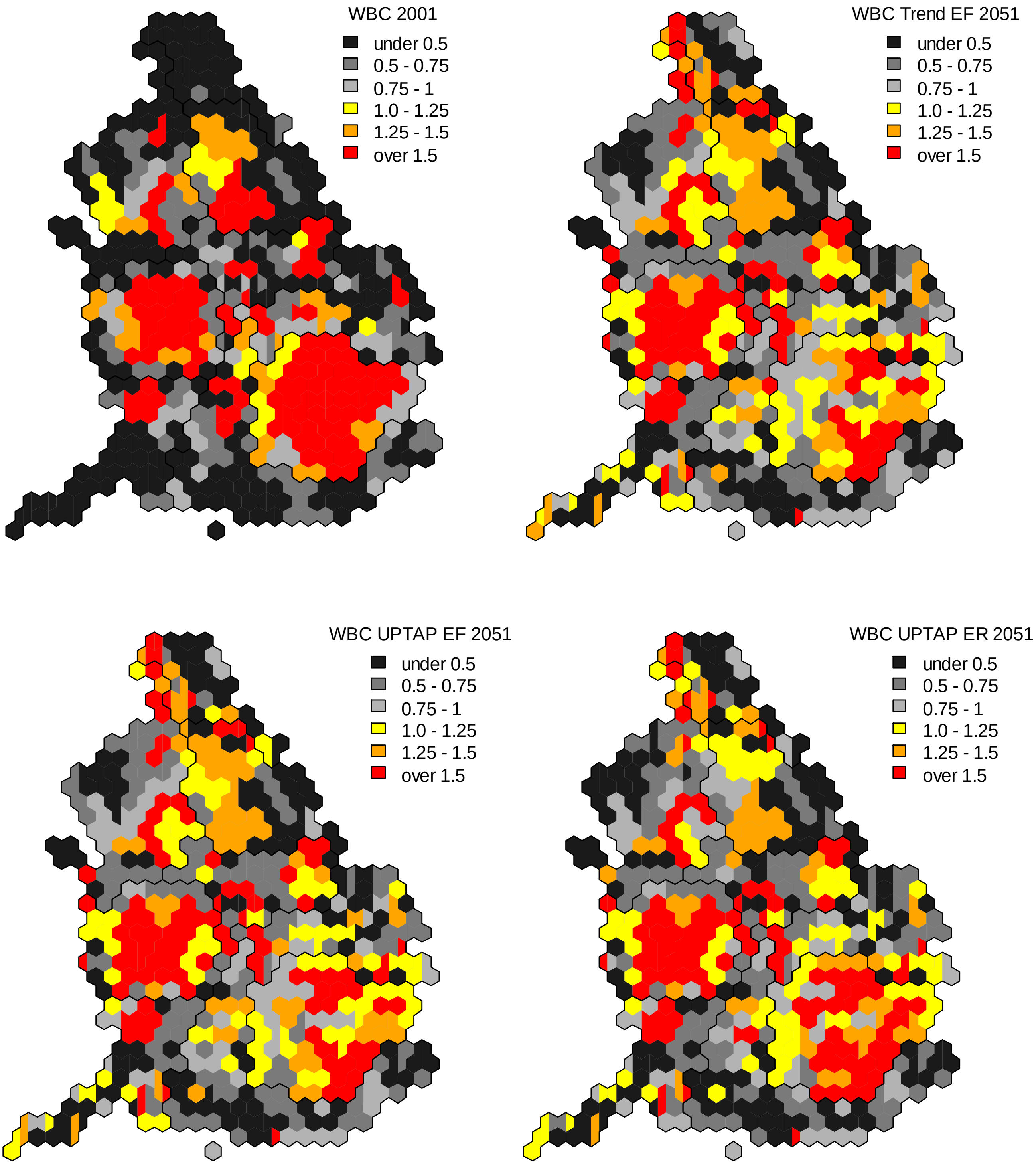


Figure 11.9: Location quotients in 2001 and 2051 for selected projections, White and Black Caribbean

11.2.6 Mixed groups: White and Black African

Table 11.8 presents the changes in shares and relative numbers between 2001 and 2051 for the White and Black African group. This group increases to between 3.3 and 5.6 times its 2001 population, depending on projection chosen. The Black African share of the population increases to around 0.4% of the population, about 3.1 times its 2001 share.

Table 11.8: Percentage shares and time series indices for the White and Black African group

WBA	Mid-Year estimate 2001	TREND-EF projection 2051	UPTAP-EF projection 2051	UPTAP-ER projection 2051
% Share	0.14	0.60	0.58	0.40
Time series	100	560	554	334

The location quotients for 2001 and the selected projections in 2051 are mapped in Figure 11.10 for the White and Black African group. There is substantial spatial de-concentration from 2001 foci of Greater London, Manchester and Liverpool. By 2051 the intensity of concentration in Greater London has decreased and LQs have increased outside the capital. The index of dissimilarity between the White and Black African group and the rest of the population shrinks from 39 in 2001 to 25 in 2051 (UPTAP-ER projection).

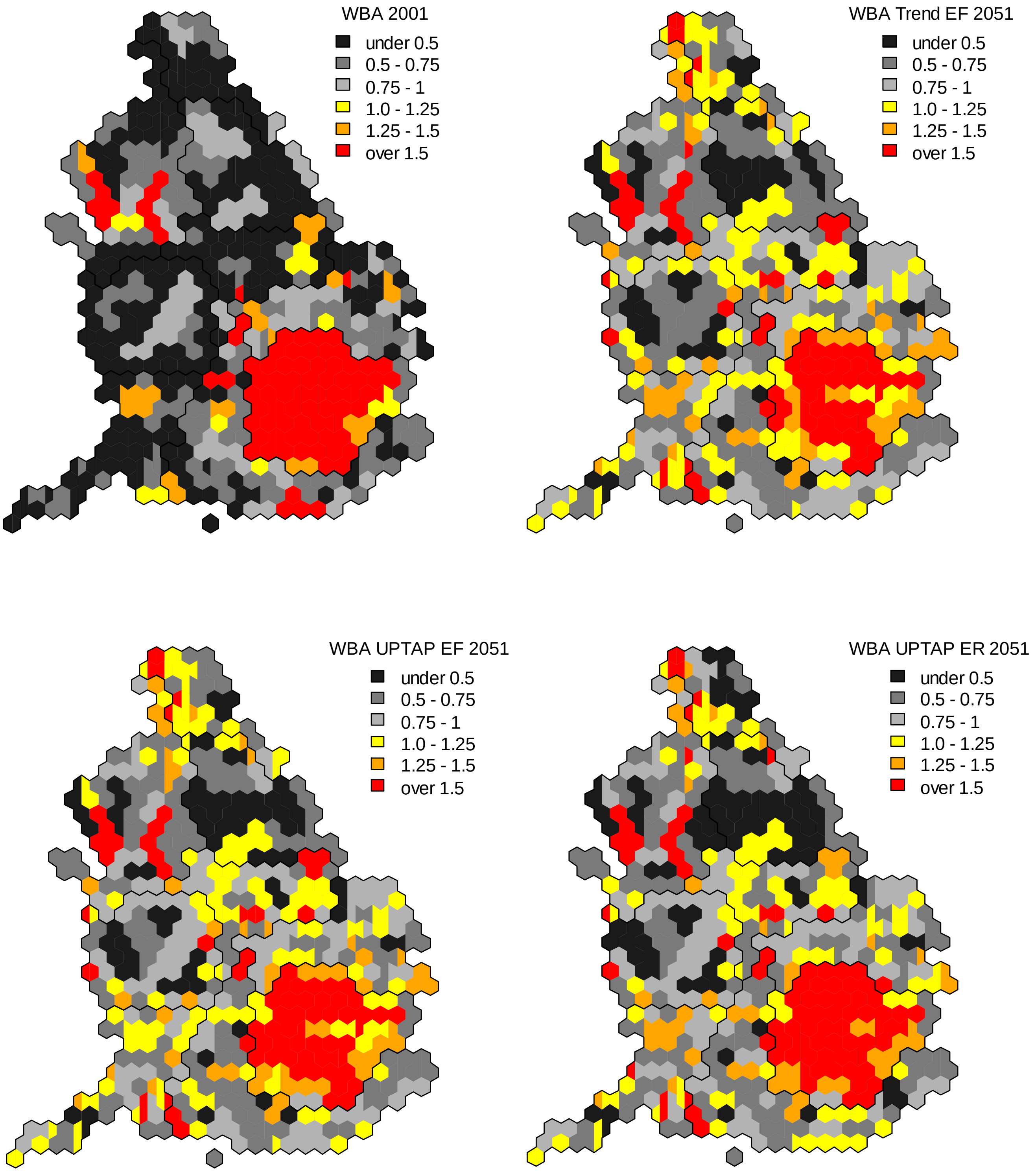


Figure 11.10: Location quotients in 2001 and 2051 for selected projections, White and Black African

11.2.7 Mixed groups: White and Asian

Table 11.9 presents the changes in shares and relative numbers between 2001 and 2051 for the White and Asian group. The 2051 population of the group increases to between 3.1 and 5.2 times its 2001 population, depending on projection chosen. Its share of the population increases to 0.9% to 1.3% of the population, about 2.8 times its 2001 share.

Table 11.9: Percentage shares and time series indices for the White and Asian groups

WAS	Mid-Year estimate 2001	TREND-EF projection 2051	UPTAP-EF projection 2051	UPTAP-ER projection 2051
% Share	0.33	1.30	1.28	0.87
Time series	100	515	511	307

The location quotients for 2001 and the selected projections in 2051 are mapped in Figure 11.11 for the White and Asian group. There is spatial de-concentration from 2001 foci of Greater London, Manchester, Leeds, Leicester and some smaller southern towns. By 2051 the intensity of concentration in London and Birmingham has decreased and LQs have increased outside the capital in the ring of surrounding LAs. The index of dissimilarity between the White and Asian group and the rest of the population shrinks from 30 in 2001 to 27 in 2051 (UPTAP-ER projection).

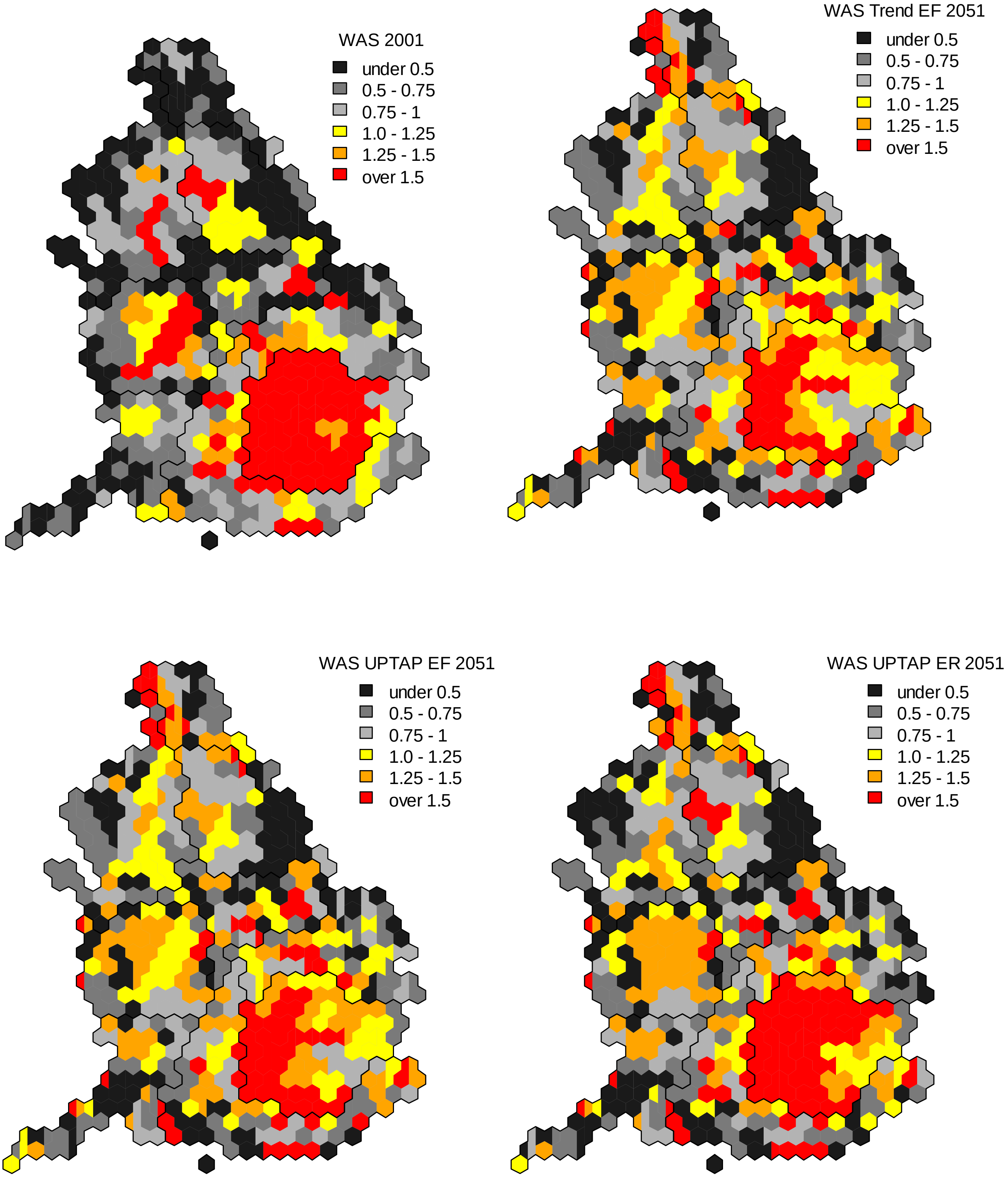


Figure 11.11: Location quotients in 2001 and 2051 for selected projections, White and Asian

11.2.8 Mixed groups: Other mixed

Table 11.10 presents the changes in shares and relative numbers between 2001 and 2051 for the Other Mixed group. The 2051 population of the group increases to between 3.1 and 5.6 times its 2001 population, depending on projection chosen. The Other Mixed share of the population increases to 0.7 to 1.2% of the population, about 2.9 times its 2001 share.

Table 11.10: Percentage shares and time series indices for Other Mixed

OMI	Mid-Year estimate 2001	TREND-EF projection 2051	UPTAP-EF projection 2051	UPTAP-ER projection 2051
% Share	0.27	1.18	1.14	0.72
Time series	100	564	555	309

The location quotients for 2001 and the selected projections in 2051 are mapped in Figure 11.12 for the White and Asian group. There is spatial de-concentration from 2001 foci of Greater London. By 2051 the intensity of concentration in London has not decreased but LQs have increased outside the capital in the ring of surrounding LAs. The index of dissimilarity between the Other Mixed group and the rest of the population shrinks from 35 in 2001 to 30 in 2051 (UPTAP-ER projection).

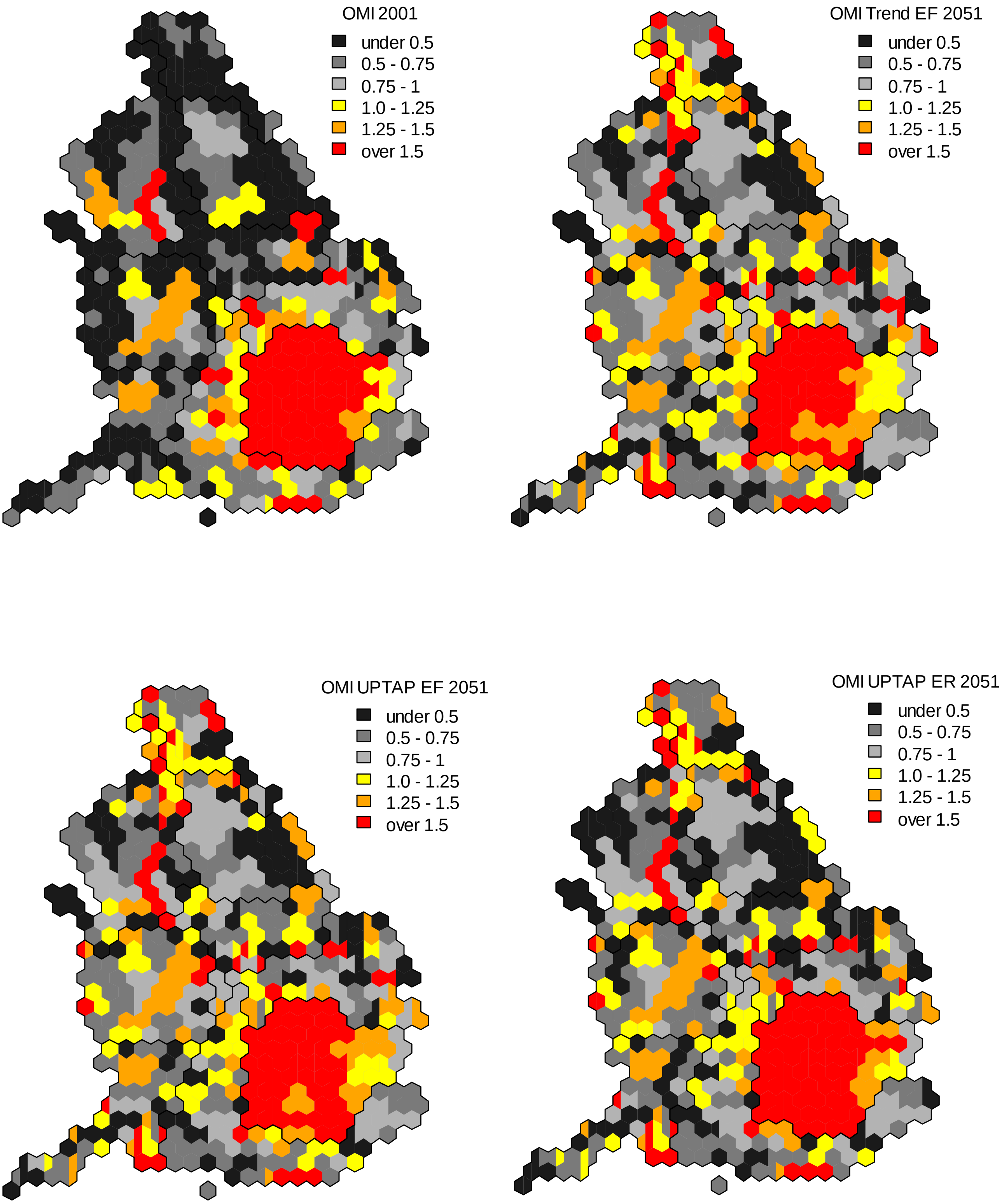


Figure 11.12: Location quotients in 2001 and 2051 for selected projections, Other Mixed

11.2.9 Traditional groups: the Indian group

We now review the projection outcomes for four traditional immigrant groups from Asia, which are projected to grow substantially under our preferred UPTAP-ER projection. The Asian groups all have a young age structure in 2001 reflecting their immigration in the 1960s to 1990s and so have the potential to grow given the concentration of the population in the family building ages (Figure 11.13, bottom panel). The Pakistani group grows fastest, followed by the Bangladeshi and Other Asian groups and the slower growing Indian group. The age profiles of all the groups show progress towards an older structure by 2051 and the differences between these profiles and the whole population have reduced though all groups have higher percentages of people aged less than 40 and lower percentages aged 80 and over.

Table 11.11 presents the changes in shares and relative numbers between 2001 and 2051 for the Indian group. The Indian population increases 2.0 to 2.7 times between 2001 and 2051, depending on projection chosen. Its share of the population increases from 1.8% to 3.1-3.7%, about 1.9 times its 2001 share. In 2001 the Indian group was the third largest ethnic minority group after the Other White and White Irish groups. In 2051 it is projected to the second largest.

Table 11.11: Percentage shares and time series indices for the Indian group

IND	Mid-Year estimate 2001	TREND-EF projection 2051	UPTAP-EF projection 2051	UPTAP-ER projection 2051
% Share	1.81	3.68	3.39	3.12
Time series	100	268	250	203

The location quotients for 2001 and the selected projections in 2051 are mapped in Figure 11.14 for the Indian group. There is very little spatial de-concentration from its 2001 foci of West, North West and North East London, the West Midlands, Manchester, Sheffield and Leicester. The 2051 map shows relatively little change. The index of dissimilarity between the Indian group and the rest of the population falls from 58 in 2001 to 55 in 2051 (UPTAP-ER projection).

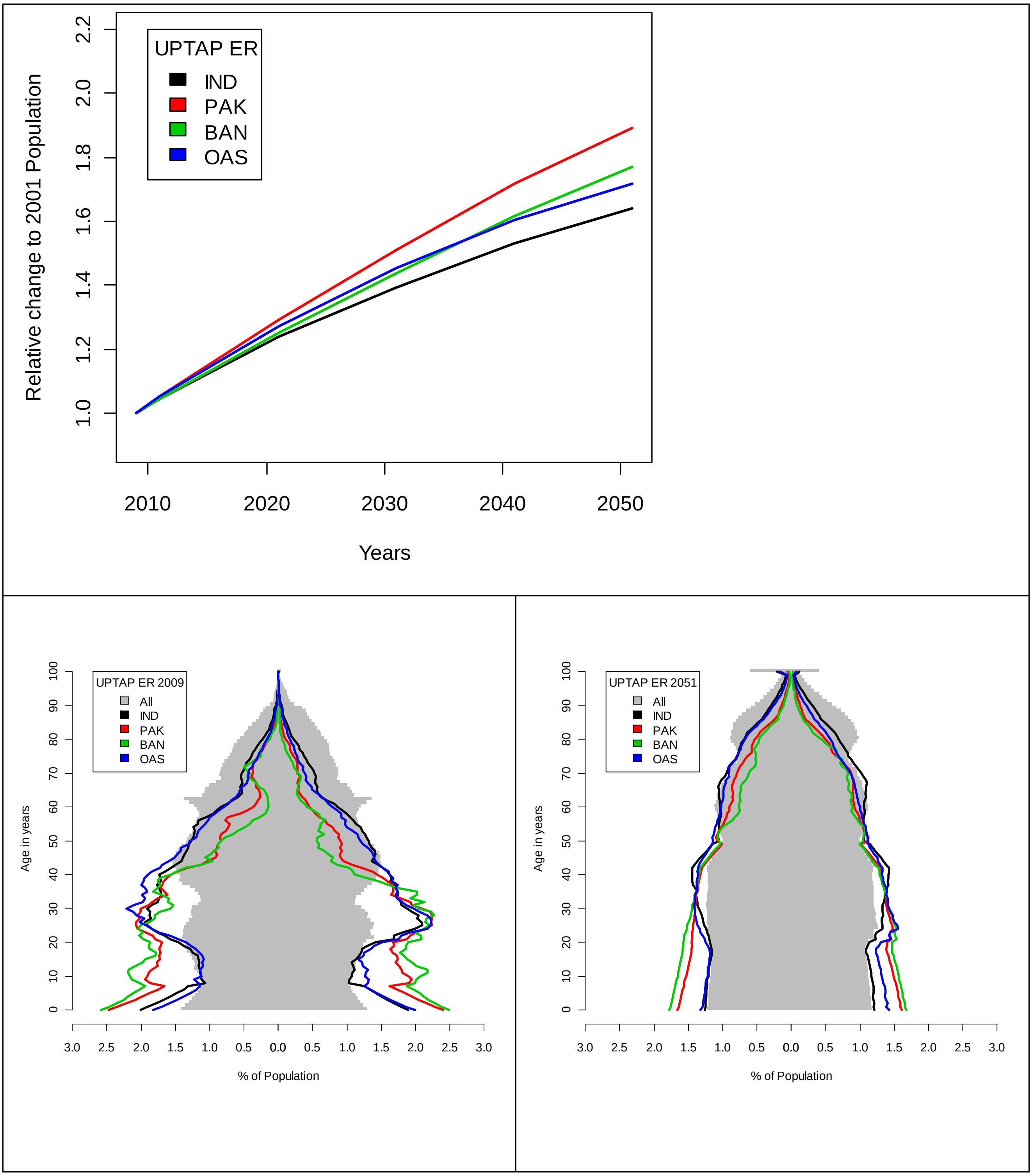


Figure 11.13: Time series indexes and population age profiles for four traditional groups, UPTAP ER projection, 2009-2051

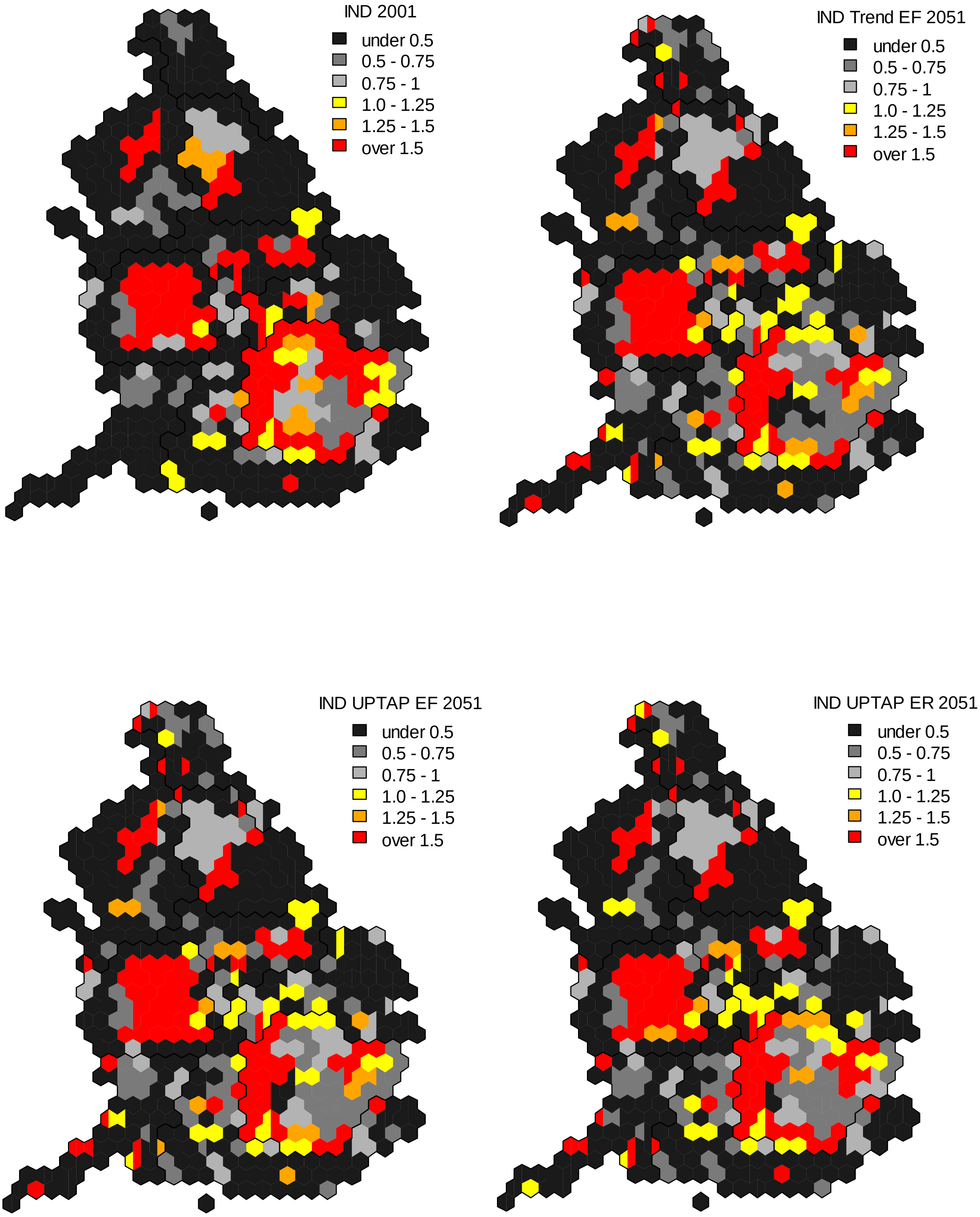


Figure 11.14: Location quotients in 2001 and 2051 for selected projections, Indian

11.2.10 Traditional groups: the Pakistani group

Table 11.12 presents the changes in shares and relative numbers between 2001 and 2051 for the Pakistani group. The Pakistani population increases 2.4 to 3.1 times between 2001 and 2051, depending on projection chosen. Its share of the population increases from 1.3% to 2.6-3.0%, about 2 times its 2001 share. In 2001 the Pakistani group was the fourth largest ethnic minority group after the Other White and White Irish groups. In 2051 it is projected to be the third largest.

Table 11.12: Percentage shares and time series indices for the Pakistani group

PAK	Mid-Year estimate 2001	TREND-EF projection 2051	UPTAP-EF projection 2051	UPTAP-ER projection 2051
% Share	1.29	2.99	2.85	2.62
Time series	100	305	295	241

The location quotients for 2001 and the selected projections in 2051 are mapped in Figure 11.15 for the Pakistani group. The Pakistani group is the only one in which London is not the principal metropolis of concentration. There is spatial de-concentration from its 2001 foci of North East Lancashire (Blackburn with Darwin, Hydburn, Burnley, Pendle), Greater Manchester (Manchester, Rochdale, Oldham), West Yorkshire (Bradford, Calderdale, Kirklees, Sheffield) and North East London (Redbridge, Waltham Forest) and Parts of West London, the West Midlands (Birmingham, Walsall, Sandwell). The 2051 maps show evidence of dispersion. The index of dissimilarity between the Pakistani group and the rest of the population falls from 61 in 2001 to 50 in 2051 (UPTAP-ER projection).

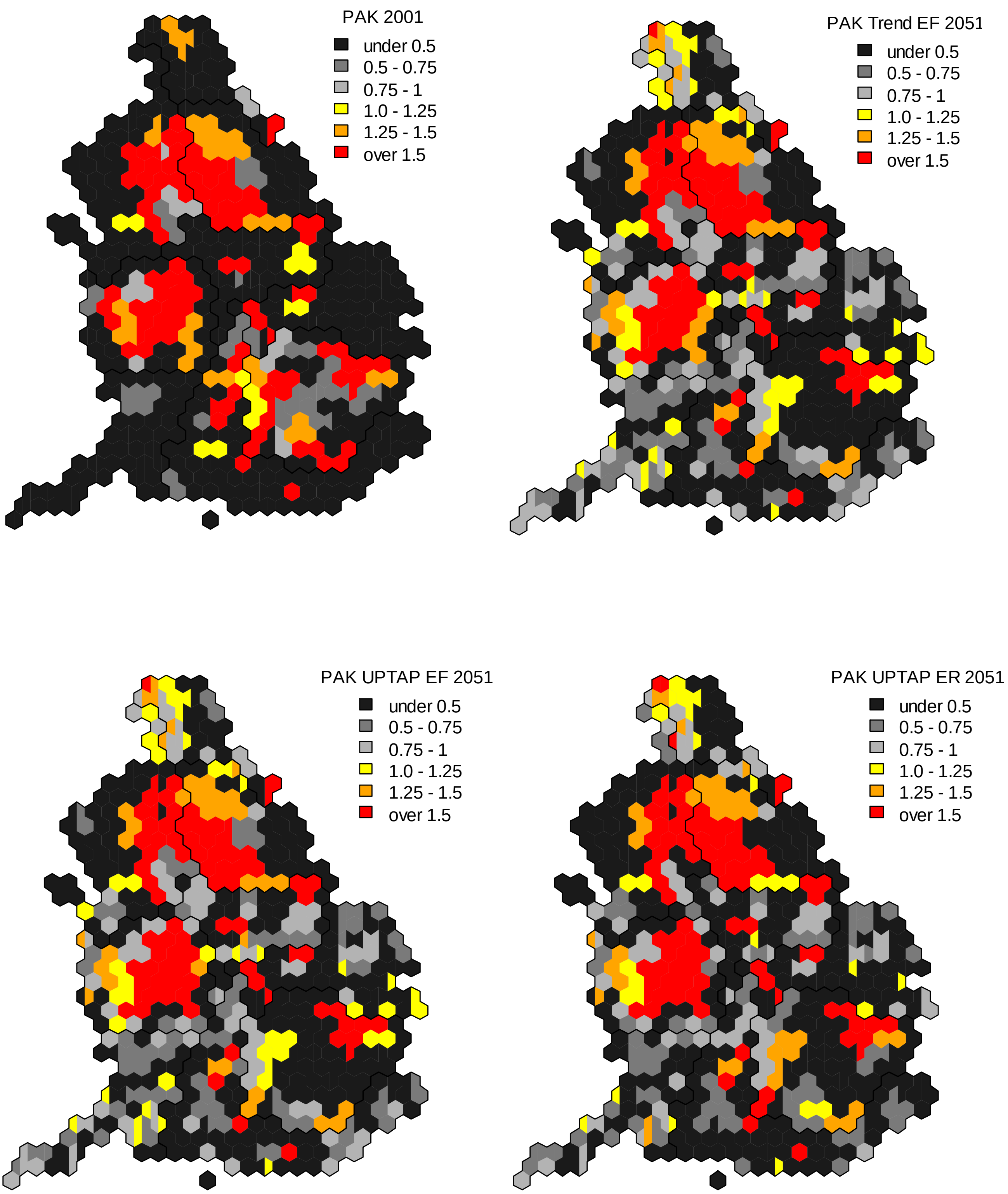


Figure 11.15: Location quotients in 2001 and 2051 for selected projections, Pakistani

11.2.11 Traditional groups: the Bangladeshi group

Table 11.13 presents the changes in shares and relative numbers between 2001 and 2051 for the Bangladeshi group. The Bangladeshi population increases 2.2 to 2.6 times between 2001 and 2051, depending on projection chosen. Its share of the population increases from 0.5% to close to1%, about twice its 2001 share.

Table 11.13: Percentage shares and time series indices for Bangladeshi

BAN	Mid-Year estimate 2001	TREND-EF projection 2051	UPTAP-EF projection 2051	UPTAP-ER projection 2051
% Share	0.49	0.98	0.96	0.90
Time series	100	263	262	218

The location quotients for 2001 and the selected projections in 2051 are mapped in Figure 11.16 for the Bangladeshi group. The Bangladeshi group is concentrated in inner east and central London (Tower Hamlets, Newham, Camden, Islington), the West Midlands (Birmingham, Walsall, Sandwell), Greater Manchester (Manchester, Tameside, Oldham, Rochdale, Rossendale, Burnley) and West Yorkshire (Bradford). There is spatial de-concentration from these 2001 foci by 2051 to surrounding local authorities. The index of dissimilarity between the Bangladeshi group and the rest of the population falls from 60 in 2001 to 44 in 2051 (UPTAP-ER projection), so it is less spatially separated from the rest of the population in 2051 than the other South Asian groups.

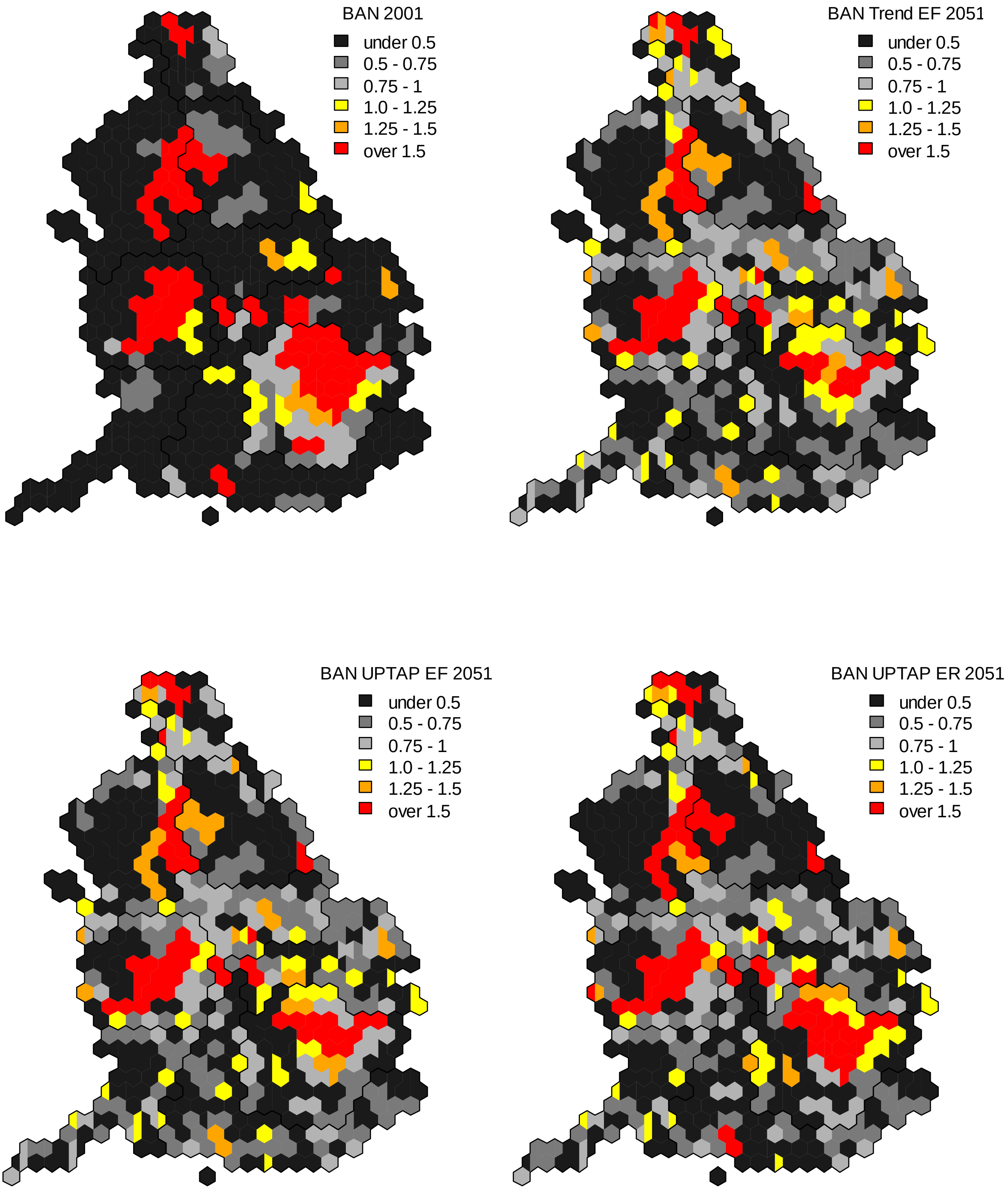


Figure 11.16: Location quotients in 2001 and 2051 for selected projections, Bangladeshi

11.2.12 Traditional groups: the Other Asian group

Table 11.14 presents the changes in shares and relative numbers between 2001 and 2051 for the Other Asian group. The Other Asian population increases 2.2 to 3.6 times between 2001 and 2051, depending on projection chosen. Its share of the population increases from 0.4% to 0.8- 1.2%, depending on projection, about 2 times its 2001 share.

Table 11.14: Percentage shares and time series indices for the Other Asian group

OAS	Mid-Year estimate 2001	TREND-EF projection 2051	UPTAP-EF projection 2051	UPTAP-ER projection 2051
% Share	0.43	1.18	1.10	0.81
Time series	100	361	343	224

The location quotients for 2001 and the selected projections in 2051 are mapped in Figure 11.17 for the Other Asian group. The Other Asian group concentrated in most London boroughs, Birmingham, Leicester, and Manchester. There is spatial de-concentration from these 2001 foci by 2051 to surrounding local authorities. The index of dissimilarity between the Other Asian group and the rest of the population falls from 52 in 2001 to 40 in 2051 (UPTAP-ER projection), so it is less spatially separated from the rest of the population in 2051 than the other traditional Asian groups.

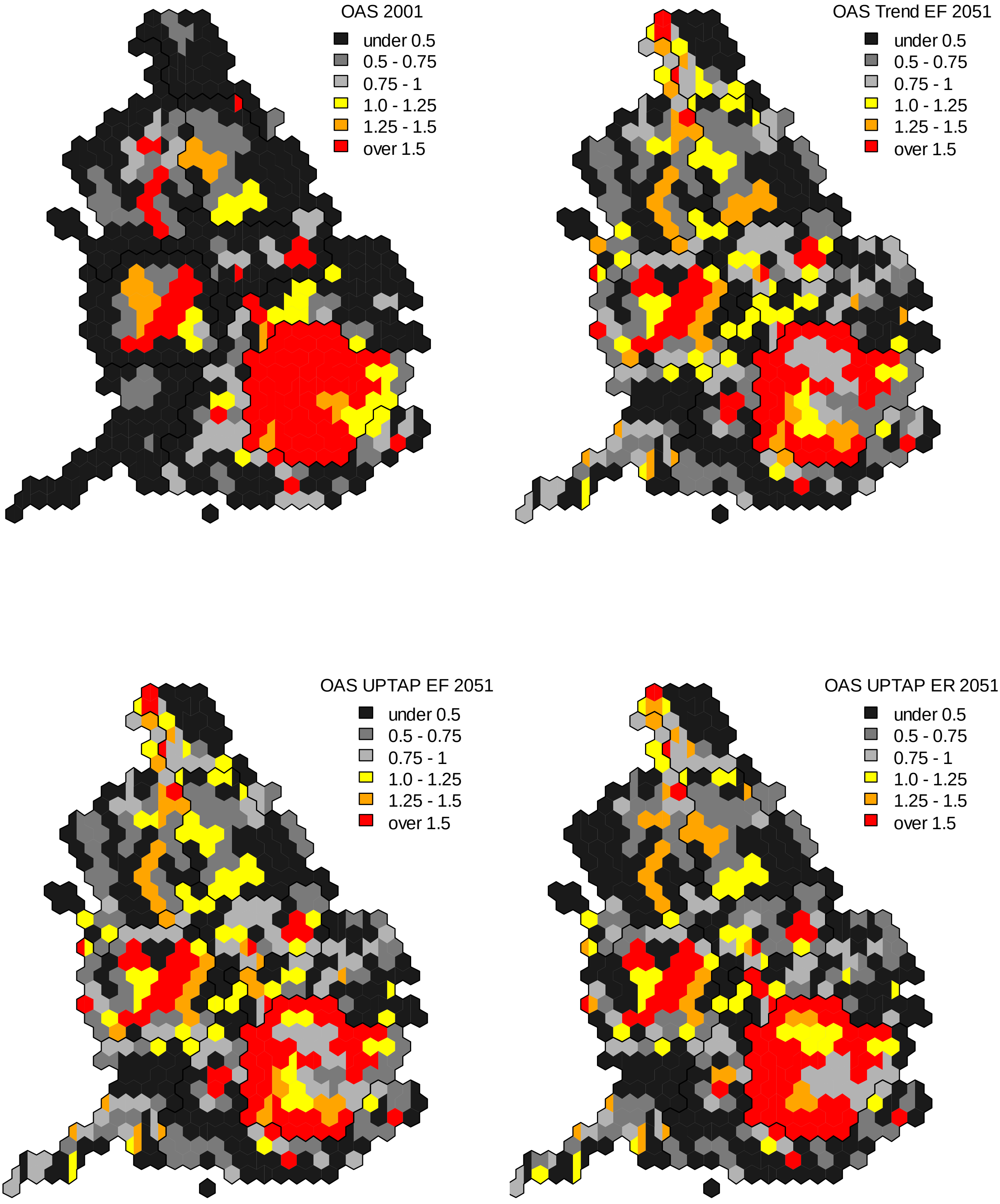


Figure 11.17: Location quotients in 2001 and 2051 for selected projections, Other Asian

11.2.13 Newer groups: the Black African group

We now review the projection outcomes for four immigrant groups whose entry into the UK has occurred in more recent decades than the previous traditional groups. These newer groups are projected to grow substantially under our preferred UPTAP-ER projection. The newer groups all have an age structure in 2001 dominated by the age groups of high immigration so have the potential to grow given the concentration of the population in the family building ages (Figure 11.18, bottom panel). The Other Black group grows fastest, followed by the Black African, Chinese and Other Ethnic groups. The age profiles of all the groups show progress towards an older structure by 2051 and the differences between these profiles and the whole population have reduced though all groups have higher percentages of people aged less than 50 and lower percentages aged 75 and over than the population as a whole. Note that the "Other Black" and "Other Ethnic" groups are collective labels for a large number of separate ethnicities.

Table 11.15 presents the changes in shares and relative numbers between 2001 and 2051 for the Black African group. The Black African population increases 2.1 to 4.0times between 2001 and 2051, depending on projection chosen. The Black African share of the population increases from 0.9% to 1.5-2.6%, about 2 times its 2001 share.

Table 11.15: Percentage shares and time series indices for Black African

BLA	Mid-Year estimate 2001	TREND-EF projection 2051	UPTAP-EF projection 2051	UPTAP-ER projection 2051
% Share	0.85	2.57	2.38	1.50
Time series	100	400	374	209

The location quotients for 2001 and the selected projections in 2051 are mapped in Figure 11.19 for the Black African group. The group is overwhelmingly concentrated in London, present in almost all Boroughs. Other places with high LQs include Reading, Slough, Luton and Manchester. But in most local authorities the Black African LQ is in the lowest category. There is some spatial de-concentration from its 2001 foci of London. The 2051 map shows relatively moderate change. The index of dissimilarity between the Black African group and the rest of the population falls from 69 in 2001 to 54 in 2051 (UPTAP-ER projection).

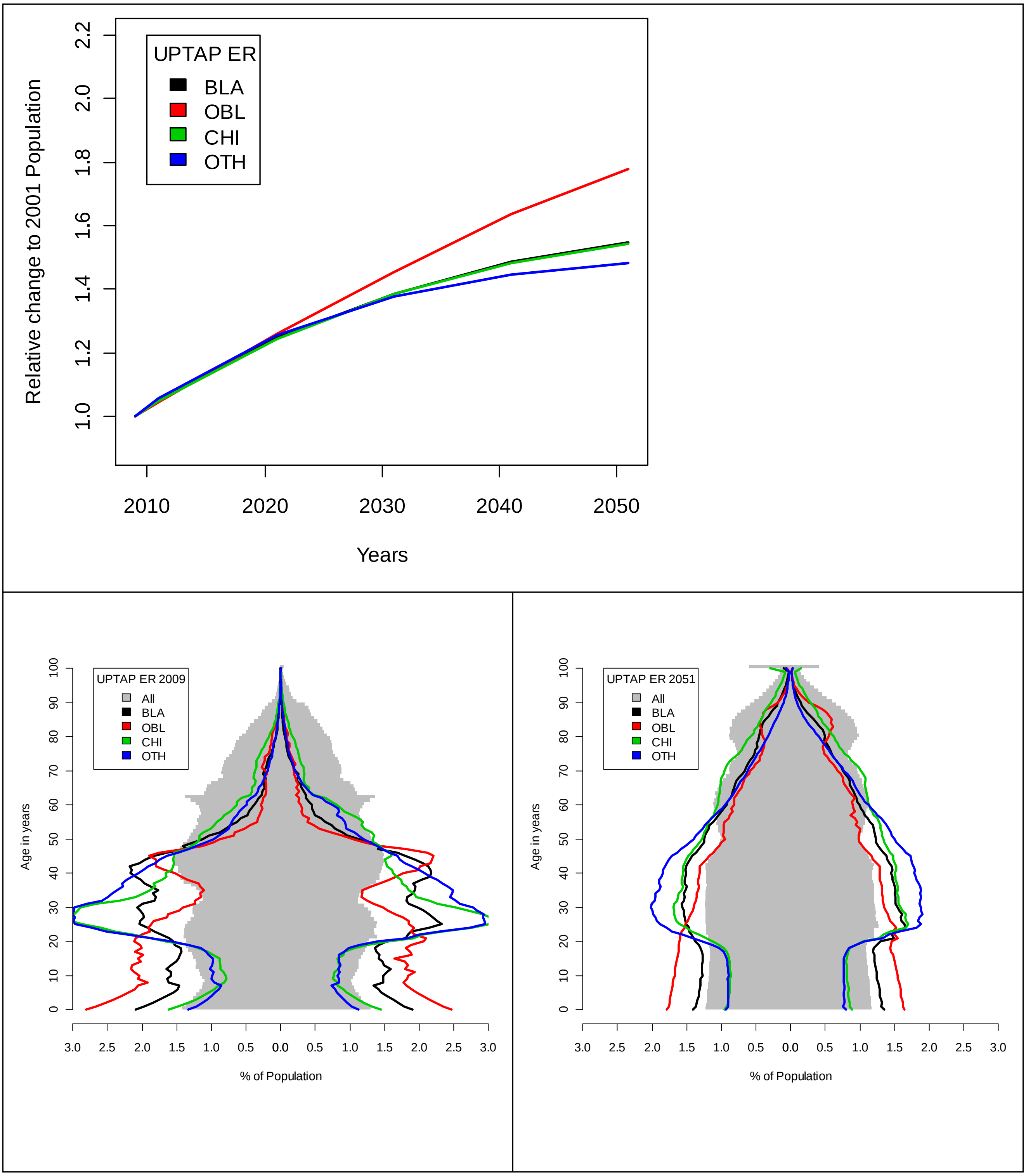


Figure 11.18: Time series indexes and population age-sex profiles for four newer groups, UPTAP-ER projection, 2009-2051

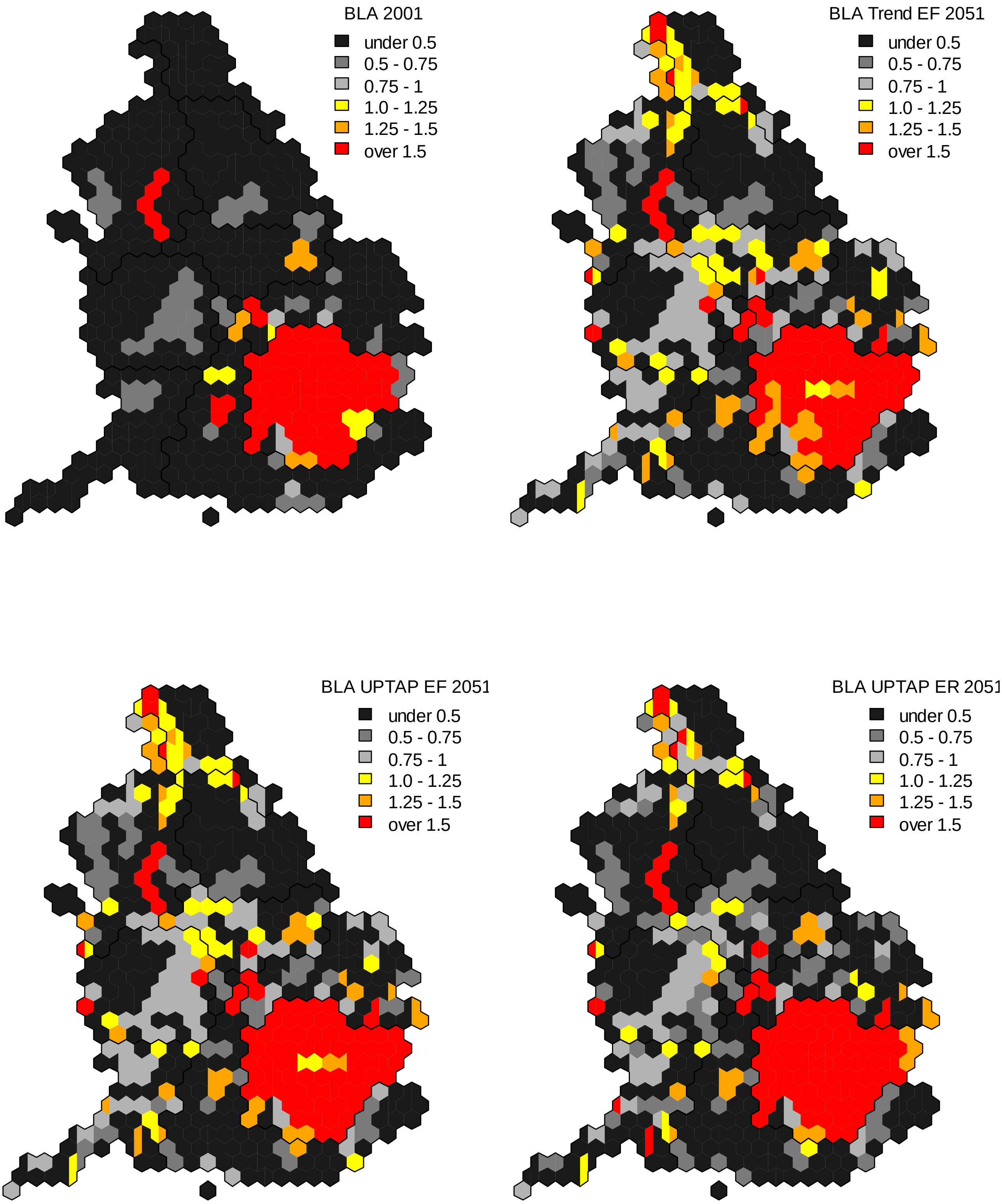


Figure 11.19: Location quotients in 2001 and 2051 for selected projections, Black African

11.2.13 Newer groups: the Other Black group

Table 11.16 presents the changes in shares and relative numbers between 2001 and 2051 for the Other Black group. The Other Black population increases 2.2 to 2.8 times between 2001 and 2051, depending on projection chosen. The Other Black share of the population increases from 0.2% to 0.4%, about 1.8 times its 2001 share.

Table 11.16: Percentage shares and time series indices for Other Black

OBL	Mid-Year estimate 2001	TREND-EF projection 2051	UPTAP-EF projection 2051	UPTAP-ER projection 2051
% Share	0.17	0.36	0.35	0.31
Time series	100	282	282	218

The location quotients for 2001 and the selected projections in 2051 are mapped in Figure 11.20 for the Black African group. In 2001 the Other Black group is concentrated in London, Birmingham and Manchester. Other places with high LQs include Reading, Slough and Luton. But in most local authorities the Other Black LQ is in the lowest category. There is substantial spatial de-concentration from its 2001 foci. The 2051 map shows considerable expansion of LAs in the fourth and fifth LQ classes, still under-represented but much less than in 2001. The index of dissimilarity between the Other Black group and the rest of the population falls from 61 in 2001 to 35 in 2051 (UPTAP-ER projection), the greatest reduction of any ethnic group.

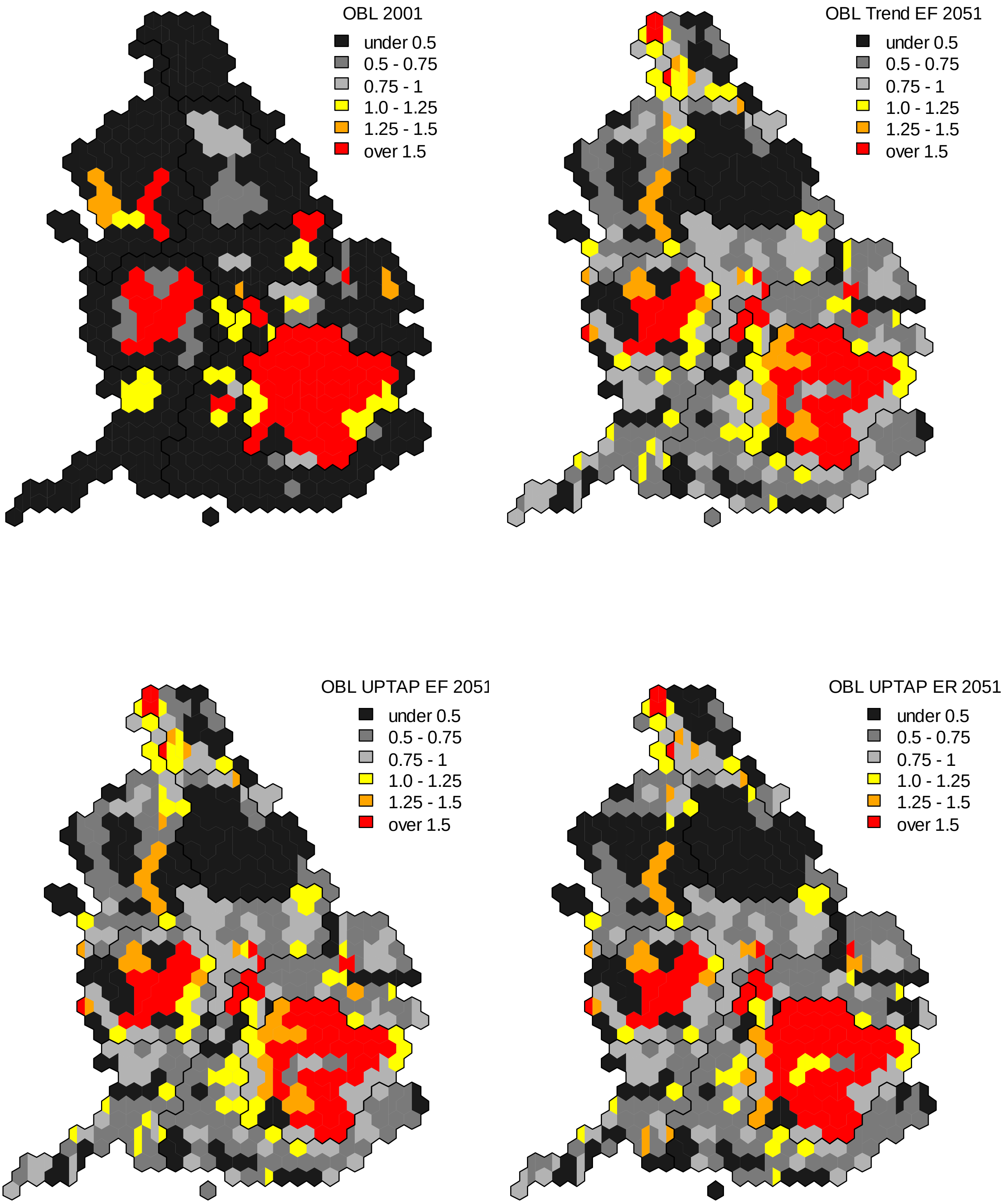


Figure 11.20: Location quotients in 2001 and 2051 for selected projections, Other Black

11.2.13 Newer groups: the Chinese group

Table 11.17 presents the changes in shares and relative numbers between 2001 and 2051 for the Chinese group. The Chinese population increases 2.0 to 4.3 times between 2001 and 2051, depending on projection chosen. The Chinese share of the population increases from 0.4% to 0.8 to 1.4%, about 2 to 3 times its 2001 share. Note that choice of projection makes a substantial difference for this group. As a substantial proportion of this group enters as students taking HE courses, it is reasonable to expect high emigration once those courses are completed.

Table 11.17: Percentage shares and time series indices for the Chinese group

CHI	Mid-Year estimate 2001	TREND-EF projection 2051	UPTAP-EF projection 2051	UPTAP-ER projection 2051
% Share	0.43	1.39	1.25	0.76
Time series	100	427	388	208

The location quotients for 2001 and the selected projections in 2051 are mapped in Figure 11.21 for the Chinese group. In 2001 the Chinese group is concentrated in London, Manchester and Liverpool. However, there are lots of other LAs where the group has LQs between 1 and 1.5. In other words the group was already widely dispersed in 2001. There is no further spatial de-concentration from the 2001 distribution. The index of dissimilarity between the Chinese group and the rest of the population is 30 in 2001 and 29 in 2051 (UPTAP-ER projection), the smallest reduction of any ethnic minority group.

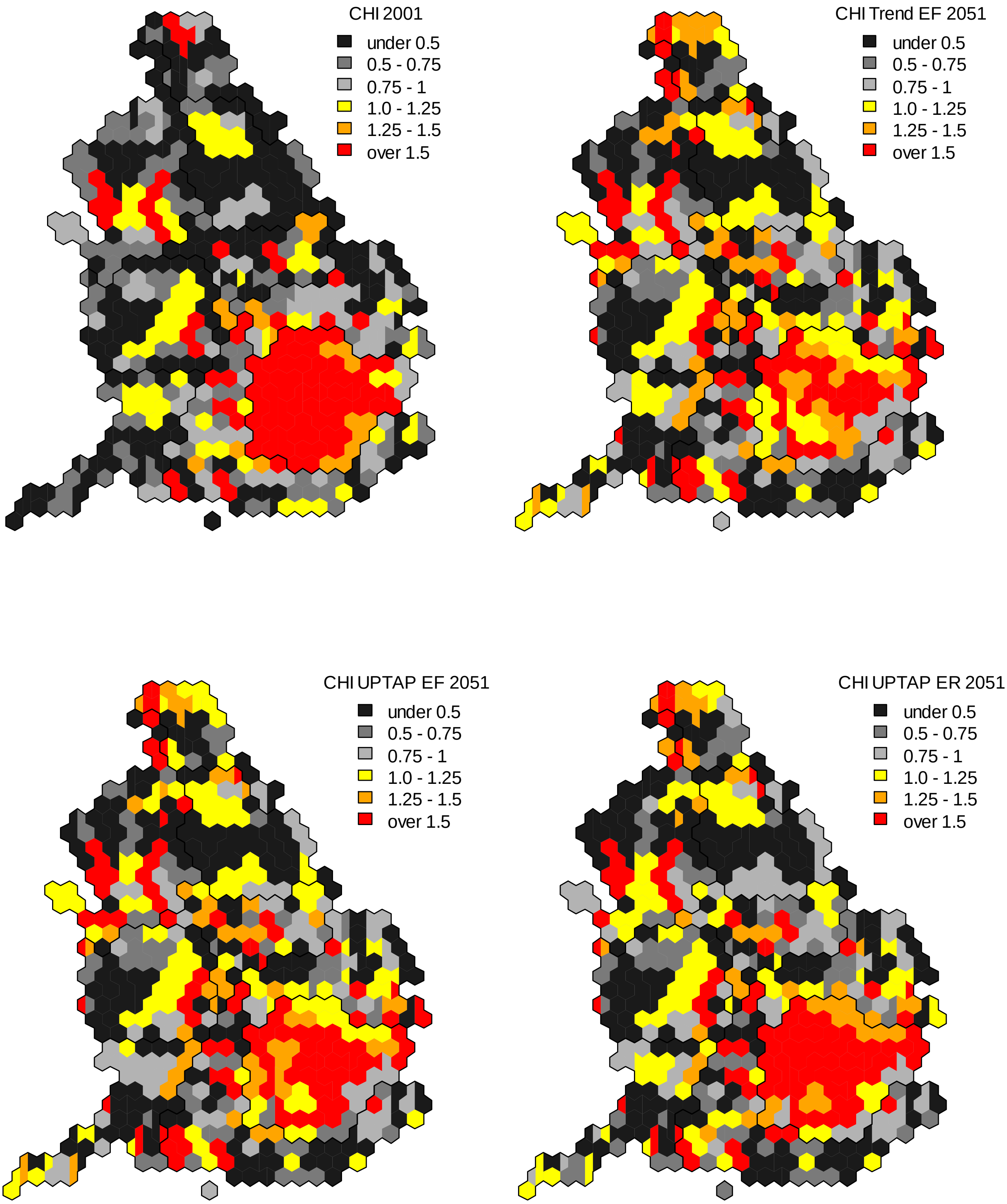


Figure 11.21: Location quotients in 2001 and 2051 for selected projections, Chinese

11.2.13 Newer groups: the Other Ethnic group

Table 11.18 presents the changes in shares and relative numbers between 2001 and 2051 for the Other Ethnic group. This group is really an amalgam of many groups not covered elsewhere in the classification. The Other Ethnic population increases 2.4 to 6.7 times between 2001 and 2051, depending on projection chosen. The Other Ethnic share of the population increases from 0.4% to 0.8 to 2.0%, about 2 to 5 times its 2001 share. Note that choice of projection makes a substantial difference for this group.

Table 11.18: Percentage shares and time series indices for the Other Ethnic group

OTH	Mid-Year estimate 2001	TREND-EF projection 2051	UPTAP-EF projection 2051	UPTAP-ER projection 2051
% Share	0.40	2.05	1.82	0.81
Time series	100	668	604	236

The location quotients for 2001 and the selected projections in 2051 are mapped in Figure 11.22 for the Other Ethnic group. In 2001 the Other Ethnic group is very concentrated in London with overrepresentation in a few other LAs. There is some moderate spatial de-concentration from the 2001 distribution. The index of dissimilarity between the Other Ethnic group and the rest of the population is 45 in 2001 and 37 in 2051 (UPTAP-ER projection), one of the smaller reductions.

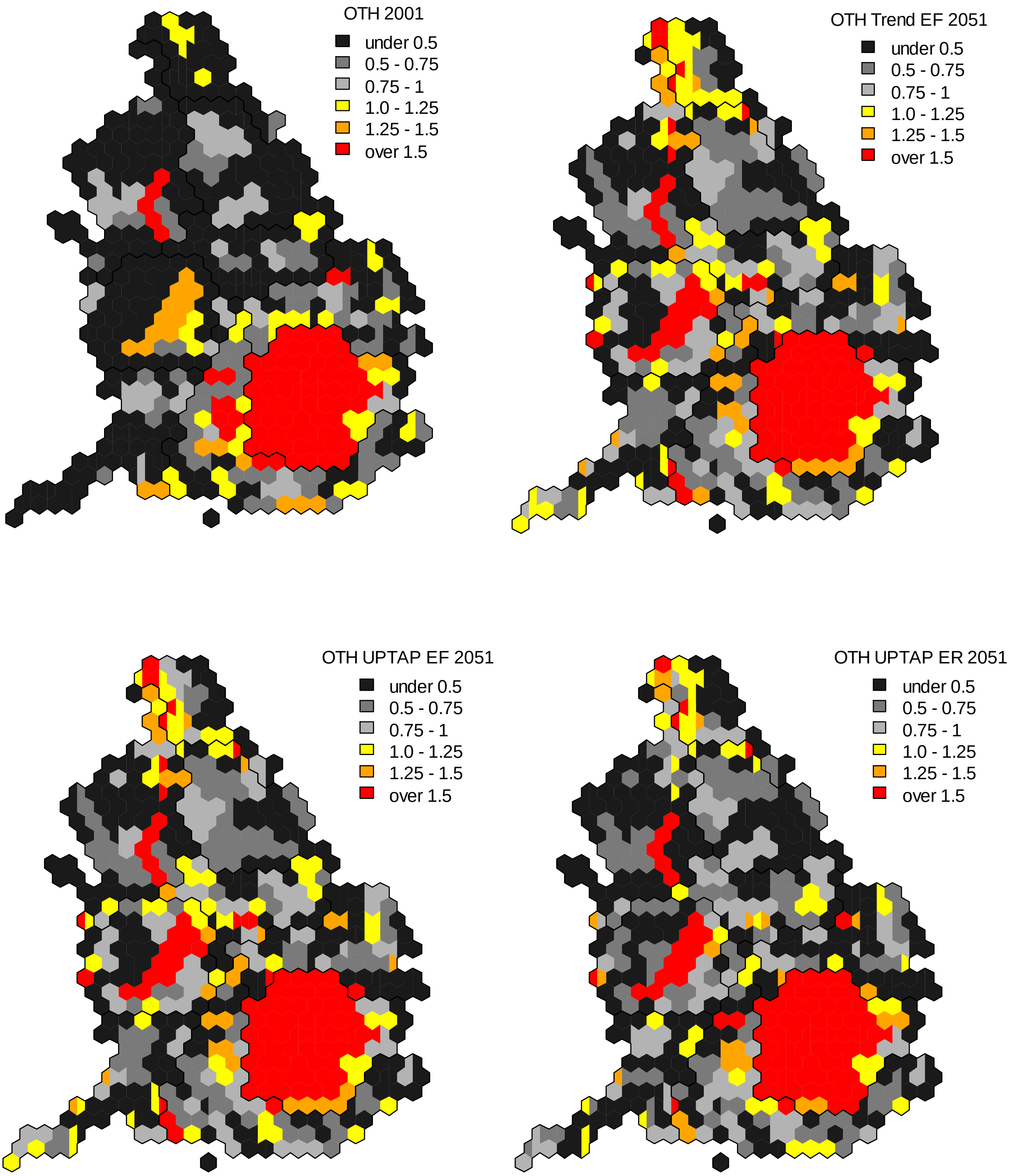


Figure 11.22: Location quotients in 2001 and 2051 for selected projections, Other Ethnic

11.3 Population ageing of the ethnic groups

All European populations are experiencing ageing and most developing countries are also now well down this path, as a result of the first demographic transition. European populations are experiencing additional ageing because of several decades of fertility rates well below replacement level, the second demographic transition. In the next forty years they will also go through "super-ageing" as the high fertility cohorts born in the 1950s and 1960s move into the older ages. The third demographic transition sees opportunities for migration from outside Europe to fill labour force vacancies produced by shrinking birth cohorts over the past three decades. These immigrant populations have a young age structure on entry and so help slow down the population ageing process. However, because the fertility of immigrant groups also falls and survival chances improve, the populations of immigrant groups also themselves age. All of these processes apply to the ethnic groups identified in the UK (all with an immigrant origin). Our projections enable us to track the population ageing process across all sixteen ethnic groups. The different age structures for the ethnic groups have profound implications in terms of their child and old age dependency ratios and degrees of concentration in the labour force.

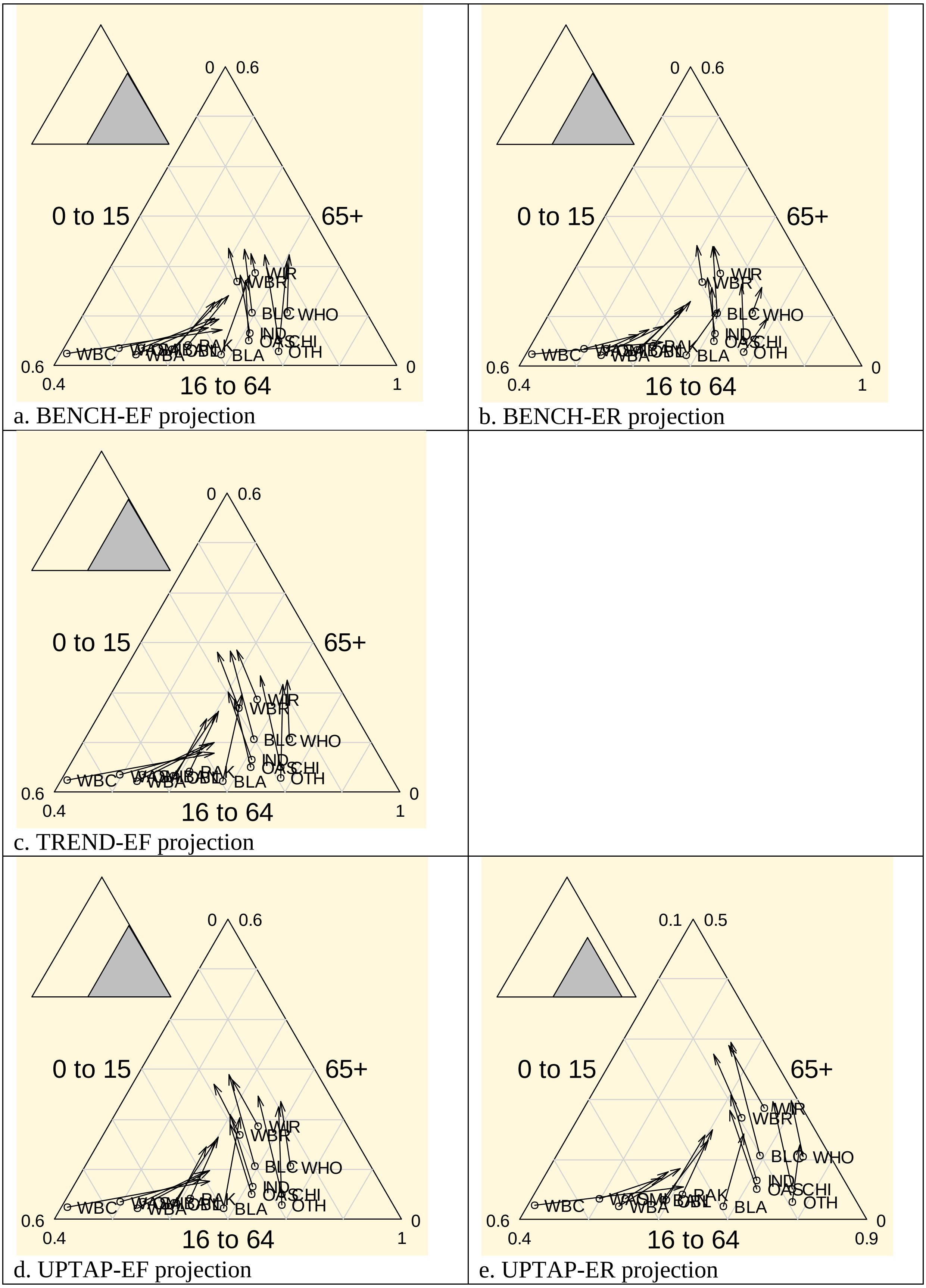
The ways in which ethnic group age structures change are presented in Table 11.19 and Figure 11.23. In the table and graph we group the individual ages of the projections into three: ages 0-15 representing childhood, 16-64 representing the potential working ages and 65+ representing the retired ages. These are the conventional definitions used internationally. We should recognise that for the UK these age groupings are very crude: a large proportion of the ages 16-24 are in further or higher education; many people retire from the work force before age 65 and conversely increasing numbers work beyond age 65. The ages of retirement and pension eligibility are under-going changes over the next four decades (e.g. a rise of one year every decade in the age of basic state pension entitlement from 60 (women)/65 (men) to at least 68 by 2044-46). So the current analysis is merely the start of analyses that establish the activity status and health status of populations at all ages, which will provide a better basis for social planning.

Table 11.19 sets out for the sixteen ethnic groups the percentage of the population in age groups 0-15, 16-64 and 65+ at mid-years 2001, 2026 and 2051 for the five projections reported here. Then in Figure 11.23 we plot the 2001 and 2051 percentages for the five projections on triangular graphs. Triangular graphs are difficult to read compared with conventional rectangular graphs so the percentages have been provided in Table 11.19.

We first examine the direction and degree of ageing using the percentage of the group population aged 65+, drawing on the UPTAP ER projection. All groups experience increases in this indicator. The increases are greatest for the Asian and Black groups with Asian groups experiencing 10-14% increase in 65+ population share between 2001 and 2051 and Black groups experiencing between 11 and 19% increase (the latter for the Black Caribbean population). The Chinese group experiences an increase of 15% in the 65+ population with the Other Ethnic group having a projected increase of only 9% in the older population share.

Table 11.19: Ethnic group projected age structures for 16 ethnic groups, 2001-2051

Group	Ages	2001	BENCH ER 2026	BENCH EF 2026	UPTAP ER 2026	TREND EF 2026	UPTAP EF 2026	BENCH ER 2051	BENCH EF 2051	UPTAP ER 2051	TREND EF 2051	UPTAP EF 2051
WBR	0-15	19	17	17	18	18	19	17	18	18	18	19
	16-64	64	60	60	56	56	56	59	59	54	54	54
	65+	17	23	23	26	26	26	24	24	27	28	27
WIR	0-15	15	15	15	16	15	16	14	14	15	14	15
	16-64	66	63	63	58	60	59	62	63	56	58	57
	65+	19	23	22	26	25	25	24	22	29	28	28
WHO	0-15	14	11	10	13	11	12	10	8	11	8	9
	16-64	76	80	82	77	81	80	75	70	69	69	67
	65+	11	9	7	11	8	8	16	22	20	22	24
WBC	0-15	57	40	37	42	39	40	32	27	34	28	29
	16-64	41	58	61	56	59	58	63	66	61	64	63
	65+	2	2	2	2	2	2	5	7	5	8	8
WBA	0-15	45	36	34	39	36	37	31	26	33	27	28
	16-64	53	60	62	57	60	59	61	64	59	63	62
	65+	2	4	4	4	4	4	8	9	9	10	10
WAS	0-15	47	41	39	43	41	41	36	29	36	30	31
	16-64	50	55	58	53	56	55	58	63	57	62	61
	65+	3	4	3	4	3	3	6	8	7	8	8
OMI	0-15	43	38	35	40	37	38	34	27	35	28	29
	16-64	53	58	61	56	59	58	59	63	57	62	61
	65+	3	4	4	4	4	4	7	9	8	10	10
IND	0-15	23	20	20	21	22	22	18	18	19	20	19
	16-64	71	68	68	65	65	65	64	64	60	60	60
	65+	7	12	12	14	13	13	18	18	21	20	21
PAK	0-15	34	26	25	28	27	27	23	22	25	23	24
	16-64	61	68	68	65	66	65	64	63	60	60	60
	65+	4	6	6	7	7	7	13	14	15	16	16
BAN	0-15	38	29	28	30	28	29	26	24	26	24	24
	16-64	59	66	67	64	66	65	63	63	61	60	60
	65+	3	5	5	6	6	6	11	13	13	16	16
OAS	0-15	23	20	20	22	22	23	18	18	21	19	20
	16-64	72	70	71	66	68	67	66	65	61	62	61
	65+	5	10	9	11	10	11	16	17	18	19	19
BLC	0-15	20	15	15	16	16	16	14	15	15	15	15
	16-64	69	68	68	65	65	65	62	62	56	56	56
	65+	11	17	16	19	19	19	24	23	30	28	29
BLA	0-15	30	20	19	23	21	22	19	17	21	18	18
	16-64	68	74	74	71	72	71	69	65	65	63	62
	65+	2	6	7	7	7	7	12	18	14	20	20
OBL	0-15	37	28	29	31	30	31	25	25	26	26	26
	16-64	60	66	66	63	64	63	63	62	60	59	59
	65+	3	6	5	6	6	6	12	13	14	15	15
CHI	0-15	18	14	15	16	16	17	13	12	14	13	12
	16-64	77	75	76	73	74	74	71	66	67	64	63
	65+	5	10	9	11	9	10	16	22	20	23	25
OTH	0-15	19	13	12	15	13	14	12	9	13	10	10
	16-64	78	82	82	79	81	80	79	70	74	69	67
	65+	3	6	6	7	6	7	10	21	12	22	23



a. BENCH-EF projection

b. BENCH-ER projection

c. TREND-EF projection

d. UPTAP-EF projection

e. UPTAP-ER projection

Figure 11.23: Changes in the age structure of ethnic group populations, 2001-2051

The White groups experience less ageing with increases of 9-10%, lower than the traditional and newer immigrant groups. However, they already have in 2001 an older population so that they still have higher than average older population shares. In 2051 under the UPTAP ER projection, the oldest groups are the White Irish with 29% and Black Caribbean group with 30% of the population aged 65+, followed by the White British with 27%, followed by the Indian (21%) group and the Chinese group with 20%. The other traditional and newer groups have older population shares in 2051 between 12 and 18%, roughly comparable with the White British group in 2001. The Mixed groups show the least degree of ageing with increases in the 65+ population of 5% to 9%.

The degree to which a group's population is concentrated in the working ages gives an indication of its economic potential. One of the factors driving East and South East Asian economic growth in the past three decades has been the concentration of the population in the working ages consequent on their demographic transitions. For the White British group the percentage of the population aged 15-64 decreases from 64% in 2001 to 54% in 2051, with similar transitions for the White Irish and Black Caribbean groups. The ethnic groups that in 2001 had greater concentrations in the working ages than the White British were the Other Ethnic group (78%), the Chinese group (77%), the Other Asian group (72%) and the Indian group (71%). These are the ethnic groups which Simpson *et al.* (2006) reports have the most favourable socio-economic profiles. All of these groups experience a downward shift in working age share by 2051 of between -4% to -11%. The Other Black, Pakistani and Bangladeshi groups have working age shares in 2001 lower than the White British but experience minor changes by 2051 (-1% to +2%). The Mixed groups all have working age shares well below those of the White British but experience increases in these shares to 2051. The Other White group has a concentration of 76% in the working ages in 2001 but this concentration declines to 69% by 2051.

We can track these shifts in age structure in the graphs of Figure 11.23 across the five projections. The graphs show that the changes in the age structures were broadly similar in all projections. What differs between projections is the overall size of the populations. The arrows connect the 2001 position of a group in the graph with its position in 2051. Groups move around the triangular space in a particular path. The youngest groups are situated close to bottom LH corner and move rightward, increasing their working age share but not yet their older population share (e.g. Mixed groups). Then there are a set of groups that start about half way across the graph close to the bottom that move in a north-east direction keeping their share of the working age population stable but reducing the child share of the population and increasing the elder share. Then there are a set of groups positioned towards the RH corner of the graph with high percentages in the working ages, low percentages in the older ages which move in a north-north-west direction increasing their elder shares while seeing their working age shares decrease. Finally, there is a set of groups which already have a high percentage in the older group which see this percentage increase as the labour force and child ages decrease.

11.4 A spatial analysis of the ethnic group projections

Our projections yield a picture of the future ethnic group populations in very fine spatial detail, which we have presented in the maps for individual groups in the previous section. In this section, we try to make better sense of the spatial diversity by presenting our results as geographical and generic classifications. Successively, we examine trends in ethnic composition by Home Country, by Government Office Region (GOR) within England, by selected LAs with high shares of ethnic minorities within GORs, by local authority types from a general purpose classification, by LAs in England organized by deprivation quintile, by density quintile and by ethnic concentration quintile. We explain the significance of the various classifications in each sub-section.

11.4.1 The Home country trends

Figure 11.24 shows the ethnic composition trends for the four Home country populations. The White British majority is shaded in cream colour and forms the majority of the population in each home country. In Northern Ireland the White Irish population forms a large proportion of the population. Here we made estimates of this population, combining information from the Northern Ireland ethnic group table, which does not use that group definition, with information from the Community Background table. For both Northern Ireland and Scotland we made estimates of the full sixteen ethnic group populations in order to produce projections that cover the whole of the United Kingdom.

Figure 11.24: Home country ethnic group trends, UPTAP-ER projections, 2009-2051
Notes: WA = Wales, SC = Scotland, NI = Northern Ireland

England has the most diverse population of the four home countries. Northern Ireland's ethnic group composition is dominated by just two groups, White British and White Irish. In both Wales and Scotland, the White British group dominates, with small communities of other ethnic groups in the largest cities (Cardiff, Newport and Swansea in Wales and Glasgow and Edinburgh in Scotland).

11.4.2 The Government Office region trends

Figure 11.25's graphs summarise the changes in ethnic composition of each government office region. The London region has the largest ethnic minority population and the most diverse. Note the importance of the Other White group, which reflects London's status as a world city attracting to its finance businesses and universities the most qualified Europeans, North Americans, Antipodeans and Latin Americans. Also more important than in other regions are the Black populations and the Indian group.

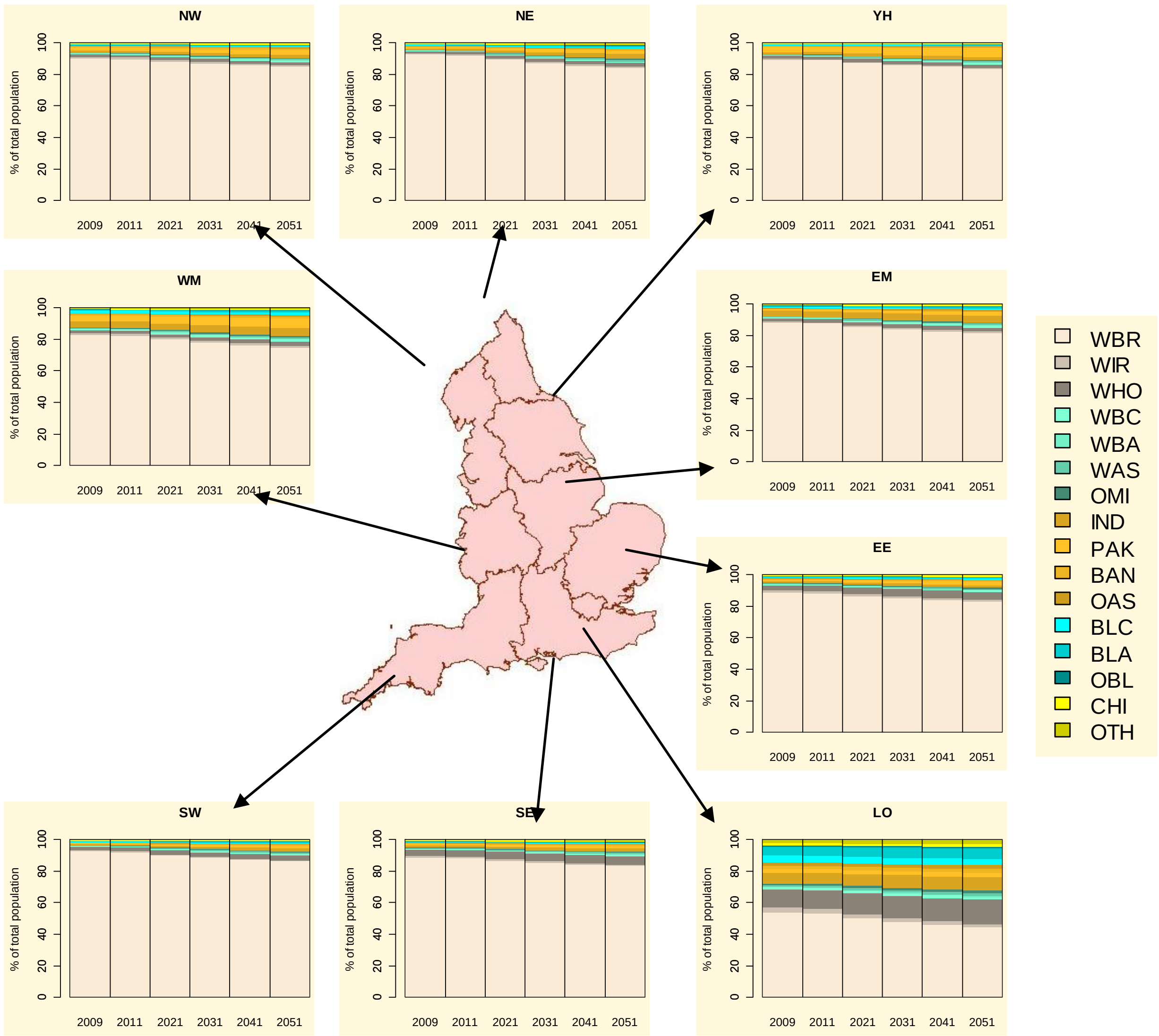


Figure 11.25: Government Office Region ethnic group trends, UPTAP-ER projections, 2009-2051

The other regions have smaller ethnic minority populations: Asian groups are more prominent than the Black groups in the regions outside London. However, which Asian group is most important varies between regions. The Pakistani is the largest Asian group in the West Midlands, Yorkshire and the Humber and the North West, whereas in the East Midlands the Indian group is the largest Asian group.

11.4.3 Trends for selected local authorities

Figure 11.26: Selected local authority ethnic group trends, UPTAP-ER projections, 2009-2051
Notes: For colour codes, see Figure 11.25.

The region graphs average a range of ethnic compositions and trends. Figure 11.26 above graphs the changing ethnic composition for selected local authorities, covering all of the GORs. In London we show six Boroughs: Newham vies with Brent as the most diverse local authority in the UK; Hackney houses important Black communities but also a large Other White group. Both Wandsworth and City of London and Westminster also have important Other White group communities. Hammersmith and Fulham is a west London borough which houses important Australian, Polish and French communities. Barking and Dagenham shows a trend of a decreasing White British population and an increasing ethnic minority population and is a London Borough with some political tensions, with the British National Party attempting but failing to exploit White British working class anxieties.

Although the South East is dominated by the White British population (Figure 11.25), some local authorities have become the foci of Asian immigration. We show the example of Slough, a manufacturing town, which has a large Asian origin population, almost equally split between Indians and Pakistanis. By 2051 the White British, though still the largest group, has become an ethnic minority. The city of Leicester in the East Midlands houses one of Britain's most important and successful Indian communities, a large section of which arrived after explusion from East Africa in the 1970s. The cities of Northern England have varying ethnic mixes: Newcastle and Sheffield have small ethnic minority populations, Manchester, Bradford and Bradford have important ethnic minorities. Manchester has a diverse population but both Blackburn and Bradford are dominated by South Asian groups: both Indian and Pakistani in Blackburn but predominantly Pakistani in Bradford. The largest ethnic minority group in Birmingham is also the Pakistani but it has a more diverse population than the northern textile towns. The South West and East of England GORs have relatively small ethnic minority populations but the largest cities in the regions, Bristol and Peterborough do have significant ethnic minorities. Bristol's is very diverse while Peterborough's largest ethnic minority is from Pakistan.

11.4.4 Projected populations for local authorities aggregated to local authority types

So far our discussion of the UK's ethnic group population geography has referred to specific places (countries, regions, local authorities). There are, of course, 355 ethnic population histories (1951-2001) and futures (2001-2051). We will release our full outputs in July 2010 so that readers can access the full details of our projections. However, it is useful to use some generic classifications which describe the socio-economic organization of the 355 zones used in the model to analyse the spatial population re-distribution implied in our projections.

One of issues in using classifications of objects over time is that the objects may need to be re-classified because of changes in the characteristics used in the classification. When we look at the distributions of populations across classes, change in those distributions may be due to real shifts between classes or because the objects themselves change their classification. The solution is to use classifications at the start and end of the time period studied and to analyse change using both classifications. Unfortunately, in a projection context we cannot easily re-classify our objects at the end of interval unless we have a prediction model for the characteristics used in the classification. We must therefore be cautious in interpreting change against a time stamped classification, as in the classification of local authorities using a Townsend index based on four poverty related variables from the 2001 Census (Townsend 1987). This point should be kept in mind when reading the rest of section 11.4.

The first classification is the geo-demographic classification of UK local authorities developed by Vickers *et al.* (2003), using variables derived from 2001 Census data. To keep the tables manageable we use five broad ethnicities rather than the full set of sixteen groups. Table 11.20 shows the distribution of ethnic group populations across four LA types plus a summation of Wales, Scotland and Northern Ireland we call the

"Celtic Fringe". For ALL groups, our results indicate little shift in the distribution across local authority classes: the Rural UK population share increases by 1% while that for Prosperous Britain and the Celtic Fringe decrease by 1%, with 0% shifts in the Urban UK and Urban London classes, when we compare the 2001 distribution with that in 2051 according to the UPTAP-ER projection. Shifts for the White group are small: a loss of 1% from the Urban UK category (cities outside London in the main) and a gain of 2% in the Rural UK categories with no change in Prosperous Britain and Urban London shares. The ethnic minority groups show a common pattern of strong gains in Rural UK and strong losses in Urban London, with small losses from Urban UK in the Mixed and Asian groups but small gains for the Black group.

11.4.5 Projected populations for local authorities aggregated to deprivation quintiles

Table 11.21 reports on the distribution of ethnic groups across LAs classified by quintile of degrees of deprivation. Note that the quintiles contain equal numbers of LAs rather than equal populations. When we look at the first panel of Table 11.21 we see that 33% of the population resides in LAs in the least deprived quintile. There is general stability in the distribution of the whole population by deprivation. The 2051 distributions are almost the same as the 2001. This is true also for the White groups, as shown in the second panel of the table. Whites are slightly more favourably distributed across the quintiles than the population as a whole. The Mixed population has lower percentages in the least deprived quintile than all groups in 2001 (22% compared with 33%) and higher percentages in the most deprived quintile (26% compared with 9%). By 2051 the distribution has shifted towards the less deprived quintiles: quintile 1 gains 7% (ER projection) and quintile 2 gains 2% whereas quintile 5 loses 7% and quintile 4 loses 3%. The Asian groups are concentrated in the bottom three quintiles but by 2051 they have lost 7% from the bottom quintile and 3% from quintile 4 and gained 11% in quintile 1 and 2% in quintile 2. The Black groups are even more concentrated in 2001 in the more deprived quintiles with 54% of the population in the bottom quintile. By 2051 this has dropped to 39% (ER projection) and the percentage in the top quintile has risen from 7 to 19%. The Chinese and Other Ethnic groups have a more favourable deprivation distribution than the Asian or Black groups in 2001 but the changes are relatively small to 2051: gains of 3% in the least deprived quintile and losses of 3% in the most deprived quintile.

Table 11.20: Time series for broad ethnic groups, local authority types, 2001-2051

Local authority types	Estimate 2001	BENCH-ER projection 2051	TREND-EF projection 2051	UPTAP-EF projection 2051	UPTAP-ER projection 2051
ALL	100	100	100	100	100
Urban UK	27	27	26	26	27
Rural UK	31	32	31	31	32
Prosperous Britain	16	15	16	16	15
Urban London	10	11	13	12	10
Celtic Fringe	16	14	14	15	15
WHITE	100	100	100	100	100
Urban UK	27	26	25	25	26
Rural UK	32	34	33	33	34
Prosperous Britain	16	16	16	16	16
Urban London	7	8	9	8	7
Celtic Fringe	17	17	17	17	17
MIXED	100	100	100	100	100
Urban UK	30	29	28	28	28
Rural UK	20	28	29	29	29
Prosperous Britain	17	15	16	16	16
Urban London	29	22	21	21	21
Celtic Fringe	5	6	5	5	6
ASIAN OR ASIAN BRITISH	100	100	100	100	100
Urban UK	41	40	37	37	38
Rural UK	12	20	23	24	22
Prosperous Britain	11	11	12	12	11
Urban London	33	27	26	25	26
Celtic Fringe	4	2	3	3	3
BLACK OR BLACK BRITISH	100	100	100	100	100
Urban UK	19	21	20	20	20
Rural UK	8	20	23	23	21
Prosperous Britain	9	10	11	11	10
Urban London	63	48	45	45	47
Celtic Fringe	1	1	1	1	1
CHINESE OR OTHER ETHNIC	100	100	100	100	100
Urban UK	23	25	24	24	23
Rural UK	17	21	24	24	22
Prosperous Britain	18	14	16	16	15
Urban London	34	33	29	29	30
Celtic Fringe	9	7	8	8	9

Table 11.21: Time series for broad ethnic groups, deprivation quintiles, 2001-2051

Deprivation quintile	Estimate 2001	BENCH-ER projection 2051	TREND-EF projection 2051	UPTAP-EF projection 2051	UPTAP-ER projection 2051
ALL	100	100	100	100	100
Quintile 1 Least deprivation	33	33	32	32	33
Quintile 2 Low middle deprivation	15	15	15	15	15
Quintile 3 Middle deprivation	15	15	15	15	15
Quintile 4 High middle deprivation	11	12	12	12	11
Quintile 5 Most deprived	9	11	11	11	10
Wales, Scotland, Northern Ireland	16	14	14	15	15
WHITE	100	100	100	100	100
Quintile 1 Least deprivation	35	35	34	35	35
Quintile 2 Low middle deprivation	16	16	16	16	16
Quintile 3 Middle deprivation	15	15	14	15	15
Quintile 4 High middle deprivation	10	10	10	10	9
Quintile 5 Most deprived	7	8	9	8	7
Wales, Scotland, Northern Ireland	17	17	17	17	17
MIXED	100	100	100	100	100
Quintile 1 Least deprivation	22	28	30	30	29
Quintile 2 Low middle deprivation	13	14	15	15	15
Quintile 3 Middle deprivation	17	17	17	17	17
Quintile 4 High middle deprivation	18	16	15	15	15
Quintile 5 Most deprived	26	20	18	18	19
Wales, Scotland, Northern Ireland	5	6	5	5	6
ASIAN OR ASIAN BRITISH	100	100	100	100	100
Quintile 1 Least deprivation	9	18	21	22	20
Quintile 2 Low middle deprivation	8	9	10	10	10
Quintile 3 Middle deprivation	23	21	21	21	21
Quintile 4 High middle deprivation	32	31	27	27	29
Quintile 5 Most deprived	25	19	17	17	18
Wales, Scotland, Northern Ireland	4	2	3	3	3
BLACK OR BLACK BRITISH	100	100	100	100	100
Quintile 1 Least deprivation	7	18	21	21	19
Quintile 2 Low middle deprivation	6	9	11	11	10
Quintile 3 Middle deprivation	14	15	16	16	16
Quintile 4 High middle deprivation	18	16	14	14	15
Quintile 5 Most deprived	54	41	37	37	39
Wales, Scotland, Northern Ireland	1	1	1	1	1
CHINESE OR OTHER ETHNIC	100	100	100	100	100
Quintile 1 Least deprivation	20	20	24	25	23
Quintile 2 Low middle deprivation	12	12	13	13	12
Quintile 3 Middle deprivation	16	17	17	17	17
Quintile 4 High middle deprivation	15	17	15	15	15
Quintile 5 Most deprived	28	27	23	23	25
Wales, Scotland, Northern Ireland	9	7	8	8	9

11.4.6 Projected populations for local authorities aggregated to density quintiles

We saw in the analysis of ethnic group population shifts across the local authority classification that a shift would occur in ethnic minority populations out of Urban London and Urban UK LAs and into Rural UK LAs. A classification of LAs into population density classes enables us to examine systematically the projected shifts of population down the settlement hierarchy. This analysis is presented in Table 11.22. For all groups and the White groups there is relatively little change in the population distribution. For the Mixed groups there is a loss of 11% in the population share in the highest density quintile in 2051 (ER projection) compared with 2001 and a 6% gain in the low density quintile. For the Asian groups the equivalent percentages shifts are an 11% loss in the high density quintiles and a 6% gain in the low density quintiles. For the Black groups the loss from the high density quintile is 18% and the gain to the low density quintile 6%. For the Chinese and Other Ethnic groups the loss is smaller from the high density quintile at 6% and the gain in the low density quintile is 4%. What we see in our projections is that ethnic minority groups are following the same path of de-concentration from high density to low density areas that the White group has experienced in past decades (Rees and Kupiszewski 1998).

11.4.7 Projected populations for local authorities aggregated to ethnic concentration classes

One important question is often asked about ethnic group populations: are they growing in the areas of highest concentration or are they dispersing to areas of lower concentration, thus making those areas more diverse. Table 11.23 shows the results of an analysis that attempts to answer that question. We classify LAs into four classes according to the degree of concentration of ethnic minority populations (not White) using location quotients. The classes are low concentration areas with LQs below 50, low middle concentration areas with LQs from 50 up to 100, high middle concentration areas with LQs from 100 up to 150 and high concentration areas with LQs from 150 up to 200. This classification is fixed at 2001. We could also classify areas according to their concentration in later years but we leave this to future analysis. ALL groups show little change in the distribution across concentration classes. The White groups show a small gain of 1% in the lowest concentration class and no loss in the highest concentration class. The Mixed groups exhibit a gain of 13% in the lowest concentration class and a loss of 10% in the highest concentration class. The Asian groups gain 14% in the lowest concentration class and lose 10% in the highest class. The Black groups lose 19% of their population in the highest concentration class and gain 18% in the lowest. The Chinese and Other Ethnic groups lose 3% from the highest class and gain 6% in the lowest concentration class. This analysis gives quantitative expression to the commentary about the different degrees of spatial de-concentration which we project will be experienced by ethnic minority groups up to mid-century.

Table 11.22: Time series for broad ethnic groups, density quintiles, 2001-2051

Density quintile	Estimate 2001	BENCH-ER projection 2051	TREND-EF projection 2051	UPTAP-EF projection 2051	UPTAP-ER projection 2051
ALL	100	100	100	100	100
Low density	22	21	21	21	22
Low middle density	14	14	14	14	15
Middle density	13	13	13	13	13
High middle density	22	21	20	20	21
High density	29	31	32	31	29
WHITE	100	100	100	100	100
Low density	24	23	23	24	24
Low middle density	15	16	15	15	16
Middle density	14	14	14	14	14
High middle density	22	21	21	21	21
High density	25	26	26	26	25
MIXED	100	100	100	100	100
Low density	7	13	13	13	13
Low middle density	8	10	11	11	11
Middle density	9	11	12	12	12
High middle density	19	19	20	20	19
High density	57	47	45	45	46
ASIAN OR ASIAN BRITISH	100	100	100	100	100
Low density	4	8	10	10	10
Low middle density	2	6	8	8	7
Middle density	6	7	8	8	7
High middle density	20	21	20	21	21
High density	67	58	54	54	56
BLACK OR BLACK BRITISH	100	100	100	100	100
Low density	2	7	8	8	8
Low middle density	2	6	8	8	7
Middle density	3	6	7	7	7
High middle density	8	11	13	13	12
High density	85	69	64	64	67
CHINESE OR OTHER ETHNIC	100	100	100	100	100
Low density	11	12	15	15	15
Low middle density	7	7	9	9	8
Middle density	8	8	9	9	8
High middle density	15	14	15	15	15
High density	60	59	52	52	54

Table 11.23 Time series for broad ethnic groups, ethnic concentration classes, 2001-2051

Ethnic Concentration Class	Estimate 2001	BENCH-ER projection 2051	TREND-EF projection 2051	UPTAP-EF projection 2051	UPTAP-ER projection 2051
ALL	100	100	100	100	100
Low NWH LQ<50	59	57	56	56	59
Low Middle NWH LQ >=50, <100	13	12	12	12	12
High Middle NWH LQ >=100, <200	12	12	12	12	12
High NWH LQ>=200	16	19	20	19	17
WHITE	100	100	100	100	100
Low NWH LQ<50	63	63	62	63	64
Low Middle NWH LQ >=50, <100	14	13	13	13	13
High Middle NWH LQ >=100, <200	12	12	12	12	12
High NWH LQ>=200	12	12	13	13	12
MIXED	100	100	100	100	100
Low NWH LQ<50	27	39	41	41	40
Low Middle NWH LQ >=50, <100	14	12	13	13	13
High Middle NWH LQ >=100, <200	17	15	15	15	15
High NWH LQ>=200	42	34	31	31	32
ASIAN OR ASIAN BRITISH	100	100	100	100	100
Low NWH LQ<50	10	22	26	26	24
Low Middle NWH LQ >=50, <100	10	8	8	8	8
High Middle NWH LQ >=100, <200	19	17	17	17	17
High NWH LQ>=200	61	53	49	49	51
BLACK OR BLACK BRITISH	100	100	100	100	100
Low NWH LQ<50	6	23	27	27	24
Low Middle NWH LQ >=50, <100	5	6	6	6	6
High Middle NWH LQ >=100, <200	12	12	13	13	12
High NWH LQ>=200	77	60	54	54	58
CHINESE OR OTHER ETHNIC	100	100	100	100	100
Low NWH LQ<50	29	31	37	37	35
Low Middle NWH LQ >=50, <100	13	11	11	11	11
High Middle NWH LQ >=100, <200	14	13	13	13	13
High NWH LQ>=200	44	45	39	39	41

11.5 Spatial de-concentration

We now summarise these observations by constructing one synthesis of spatial de-concentration. Careful inspection of the changes between the maps for 2001 and for 2051 has shown moderate degrees of spread for most ethnic groups. The group members have de-concentrated from their 2001 clusters by 2051. We can confirm this impression by bringing together the summary indexes that show the extent of redistribution. We computed the Index of Dissimilarity (IOD) across the 355 zones for each ethnic group compared with the rest of the population for 2001 and 2051. The index ranges between a minimum of zero (no difference in the spatial distributions of the two groups) and a maximum of 100 (complete difference between the two spatial distributions. We plot the 2051 values of the IOD against the 2001 IODs in Figure 11.27. For all but one group the index values have fallen, in some cases quite profoundly. This indicates that in 2051 all groups bar the Other White will be less segregated from the rest of the population than they were in 2001. In Figure 11.27 we plot the average relationship (regression line) between the 2001 IODs and the 2051 IODs. The slope of the line 0.70, below 1, indicating that the de-concentration effect will be greater for the groups that were most segregated in 2001. Note that the intercept of the regression equation, 7, can be interpreted as the average dissimilarity if ethnic group members were randomly distributed across the 355 zones. If we divide the slope value by the number of years (50), we obtain the average reduction per year in IOD, which is 0.01 or 1%. The converse of this de-concentration will be increasing diversity of local authorities that are currently quite mono-ethnic.

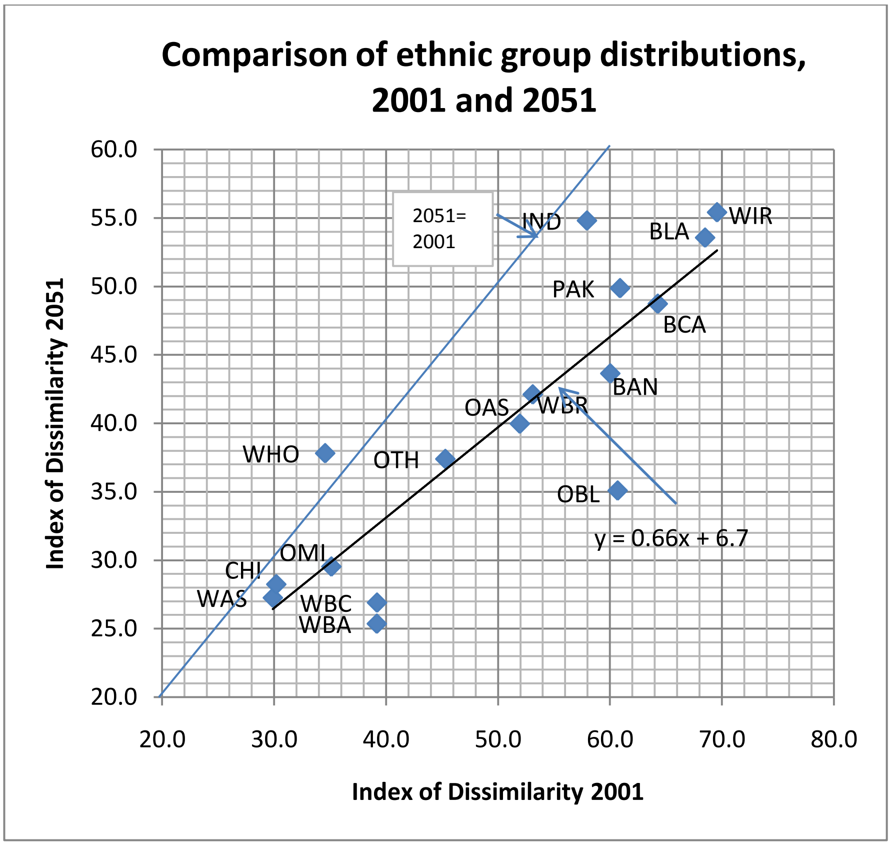


Figure 11.27: Indexes of dissimilarity in 2001 and 2051 for 16 ethnic groups for the UPTAP-ER projection

12. DISCUSSION AND CONCLUSIONS

In this final section of the report we discuss our projections in relation to other efforts and summarise our findings. We compare, in section 12.1, our projections with ethnic population estimates by ONS to mid-year 2007, with ethnic population projections by GLA to mid-year 2031 for Greater London (Klodawski 2009) and with ethnic population projections for the UK to 2056 by Coleman (2010). In section 12.2 we reflect on these comparisons, on what has been accomplished in our projections and what further improvements are needed. Finally in section 12.3 we summarise our most important findings.

12.1 Comparisons of our projections with other estimates and projections

12.1.1 Comparison with ONS ethnic group estimates in 2007

ONS have a rolling programme for producing mid-year ethnic population estimates for local authorities in England (ONS 2009b, Large and Ghosh 2006b). We compare the latest in this series, for mid-2007, with our projections for mid-2007. ONS estimates the components of population change for each year from mid-2001 using techniques described in Large and Ghosh (2006a). We develop independent estimates of each component and introduce these estimates as rates, probabilities and flows into our projection model. The projection results for mid-2007 are compared directly with the ONS estimates in Table 12.1. The differences over just six years are considerable. Our figure for the England population is 359 thousand greater than that of ONS or 0.70% greater. Our estimates for the White population are larger than those of ONS while our ethnic minority estimates are lower. Some of the lower figures for Asian or Asian British groups or Black or Black British groups may be a result of introducing ethnic specific mortality as these groups had lower life expectancies than the total population (Table 7.1).

That we should obtain such different estimates over a very short period is concerning and will need to be investigated in detail. The differences serve to highlight that there is a great deal of uncertainty in estimating the population broken down by ethnicity.

12.1.2 *Comparison with Greater London Authority ethnic group projections 2001-2031*

The Greater London's Data Management and Analysis group, led by John Hollis, has a long history of preparing London Borough projections since the 1970s and of ethnic group projections since 1999, reviewed in section 2. We have aggregated our 16 ethnic groups to match the 10 groups used by Greater London and summed our London Borough projections to yield totals for Greater London. The GLA assigns the White and Black Caribbean and White and Black Caribbean groups to the Black Other group (see Table 2.3). The White and Asian group is merged into the Other Asian group while the Other Mixed group is combined into the Other Ethnic group. The GLA projections have an estimate base at mid-year 2008 while the UPTAP-ER projection starts in 2001 and use the emigration rates model, which matches the technique used by the GLA. The results are set out in Table 12.2.

Table 12:1: Comparison for England of ONS ethnic group estimates and the TREND-EF projections, mid-year 2007

Ethnic group	ONS	TREND-EF	Difference	ONS%	TREND-EF%	Difference in Percent	% Difference
All Groups	51092	51,451	359	100.00	100.00	0.00	0.70
WHITE							
White British	42736	43,105	369	83.65	83.81	-0.16	0.86
White Irish	571	638	67	1.12	1.24	-0.12	11.80
Other White	1776	1,998	221	3.48	3.88	-0.40	12.46
MIXED							
White and Black Caribbean	283	287	4	0.55	0.56	-0.01	1.36
White and Black African	114	109	-5	0.22	0.21	0.01	-4.22
White and Asian	261	250	-11	0.51	0.49	0.02	-4.19
Other Mixed	212	214	2	0.41	0.42	-0.01	0.90
ASIAN OR ASIAN BRITISH							
Indian	1316	1,255	-61	2.58	2.44	0.14	-4.65
Pakistani	906	877	-29	1.77	1.71	0.06	-3.16
Bangladeshi	354	332	-22	0.69	0.65	0.04	-6.25
Other Asian	339	312	-27	0.66	0.61	0.05	-7.89
BLACK OR BLACK BRITISH							
Black Caribbean	600	612	13	1.17	1.19	-0.02	2.12
Black African	731	661	-69	1.43	1.29	0.14	-9.50
Other Black	118	114	-4	0.23	0.22	0.01	-3.09
CHINESE OR OTHER ETHNIC GROUP							
Chinese	400	316	-84	0.78	0.61	0.17	-21.06
Other	376	371	-5	0.74	0.72	0.02	-1.39

Sources: ONS (2009b) and authors' computations.
Notes: The populations are in 1000s.

Table 12.2: Comparison of GLA and UPTAP-ER projections for Greater London, 2031, ten groups

Ethnic group	GLA-2008 2031	UPTAP-ER 2031	% GLA 2008 2031	% UPTAP-ER 2031	% Difference GLA-UPTAP-ER
Total	8789	8561	100	100	2.6
White	5305	5526	60.4	64.5	-4.2
Black Caribbean	430	340	4.9	4.0	20.9
Black African	644	556	7.3	6.5	13.7
Black Other	284	74	3.2	0.9	73.9
Indian	664	681	7.6	8.0	-2.6
Pakistani	258	206	2.9	2.4	20.2
Bangladeshi	270	191	3.1	2.2	29.3
Other Asian	330	193	3.8	2.3	41.5
Chinese	151	136	1.7	1.6	9.9
Other	455	657	5.2	7.7	-44.4
BAME	3484	3034	39.6	35.4	12.9

Source: Klodawski (2009) and author's computations
Notes: BAME = Black and Minority Ethnic Population. The 16 ethnic groups from the 2001 Census have been aggregated to 10 GLA ethnic groups. The populations are rounded to the nearest thousand.

The UPTAP-ER projections are 2.6% lower than the GLA projections. The UPTAP-ER White population is larger while the BAME population is smaller. The differences vary between groups: the Indian and Other Asian group populations are very close, while projected numbers in the Black and Other South Asian groups are lower in the UPTAP-ER projections than in the GLA projections. These differences may well be a consequence of the adoption of ethnic specific mortality rates and survivorship probabilities in our projections. These groups have worse than average mortality experience. Differences may also occur because of detailed differences in the way international migration is handled and because the GLA model is constrained to the all group projections. The projected percentage of the population of Greater London that belongs to the Black and Minority Ethnic (BAME) population is similar though lower in our projections (35%) compared with 40% in the GLA projections. Some 35% of the UK BAME population in 2031 reside in Greater London under our UPTAP-ER projection, so we can be pleased with the degree of similarity of our projections with those of the organization with most experience in this field.

12.1.3 *Comparison with the UK ethnic group projections of David Coleman, 2031-2056*

Table 12.3 assembles results for the UK from Coleman's paper for 2031 and 2056 and compares them with our UPTAP-ER projections in 2031 and 2051. Again we need to aggregate from our projections to match the ethnic groups used by Coleman: the White Irish group was merged with the Other White group; the Mixed groups were summed. The Coleman projection produces higher populations for the UK than either of our UPTAP projections. The projections for the White British group and BAME population are very different.

Table 12.3: Comparison with the UK ethnic group projections of Coleman (2010) for twelve groups

Ethnic groups	2001	Coleman 2031	Coleman 2056	UPTAP-ER 2031	UPTAP-ER 2051
White British	51.47	51.69	44.99	54.7	54.52
Other White	2.92	4.78	8.34	4.55	4.87
Mixed	0.69	2.23	4.21	1.61	2.06
Asian Bangladeshi	0.29	0.84	1.36	0.51	0.63
Asian Indian	1.07	2.82	4.60	1.84	2.18
Asian Pakistani	0.76	2.13	3.59	1.45	1.83
Asian Other	0.25	0.84	1.38	0.48	0.57
Black African	0.50	2.08	3.76	0.93	1.04
Black Caribbean	0.57	0.73	0.79	0.69	0.71
Black Other	0.10	0.18	0.24	0.18	0.22
Chinese	0.25	1.33	2.37	0.47	0.53
Other	0.24	1.41	2.56	0.52	0.56
All groups	59.11	71.06	78.17	67.92	69.71
BAME	4.73	14.59	24.86	8.68	10.32
%BAME	8.00	20.53	31.80	12.77	14.81

Source: Coleman (2010) and authors' computations
Notes: Populations in millions. BAME = Black and Minority Ethnic population.
See Table 12.5 for correspondence between Coleman groups and UPTAP groups.

In order to understand why this might be we need to compare assumptions. We can ignore our internal migration assumptions because Coleman's projection is for one spatial unit only. We also cannot compare the mortality assumptions because Coleman uses the all group mortality rates for all ethnicities whereas we use ethnic specific mortality rates. This difference will probably result in lower projected numbers for Other Black, Bangladeshi and Pakistani groups given their low life expectancies while Chinese, Other White and Other Ethnic groups will have higher numbers. We can, however, compare fertility assumptions (Table 12.4) and international migration assumptions (Table 12.5). Coleman presents assumptions for the 2006-11, 2031-36 and 2056-61 periods. We include our 2006-11 projected total fertility rates and those for 2031-36. From 2020-21 onwards we hold fertility rates constant.

Overall the UK TFR is slightly higher in our projections than in Coleman's. However, the profiles of fertility across groups are different. We assume higher fertilities for the White British group for the later periods of the projections and the Indian group throughout, while Coleman assumes higher fertility for the other BAME groups. Differences are substantial (over 0.4 of a child) for the Black Caribbean, Black African, Other Black and Other Ethnic groups and higher the Pakistani and Bangladeshi groups at the start of the projections. These differences will contribute to the differences in projected ethnic mix: in particular, to the lower UPTAP projected populations for the Asian and Black groups.

Table 12.4: Comparison of the fertility assumptions of the Coleman and UPTAP projections

Coleman assumptions				UPTAP assumptions			Differences (Coleman minus UPTAP)	
Ethnic group	2006-11	2031-36	2056 onwards	Ethnic group	2006-11 average	2031-36	2006-11	2031-36
WBR	1.90	1.83	1.83	WBR	1.90	1.88	0.00	-0.05
				WIR	1.75	1.73	0.15	0.10
WHO	1.68	1.68	1.75	WHO	1.71	1.69	-0.03	-0.01
MIX	1.70	1.72	1.80	WBC	1.82	1.78	-0.12	-0.06
				WBA	2.05	2.01	-0.35	-0.29
				WAS	1.56	1.53	0.14	0.19
				OMI	1.62	1.58	0.08	0.14
IND	1.84	1.74	1.70	IND	2.10	1.98	-0.26	-0.24
PAK	2.82	2.30	1.99	PAK	2.32	2.12	0.50	0.18
BAN	2.98	2.29	2.00	BAN	2.47	2.29	0.51	0.00
OAS	2.02	1.93	1.90	OAS	1.98	1.94	0.04	-0.01
BLC	2.16	2.04	2.00	BLC	1.78	1.62	0.38	0.42
BLA	2.34	2.13	1.99	BLA	1.82	1.71	0.52	0.42
OBL	2.42	2.16	2.00	OBL	1.54	1.50	0.88	0.66
CHI	1.42	1.55	1.70	CHI	1.47	1.33	-0.05	0.22
OTH	2.37	2.14	2.00	OTH	1.61	1.58	0.76	0.56
Total	1.91	1.86	1.84	Total	1.92	1.93	-0.01	-0.07

Notes:
Positive differences mean Coleman assumptions are greater than UPTAP assumptions.
Negative differences mean Coleman assumptions are less than UPTAP assumptions.
See Table 12.5 for correspondence between Coleman groups and UPTAP groups.

Table 12.5 sets out the net international migration assumptions in the Coleman principal projection and the net international migration outcomes of the two UPTAP projections. The table is organized with the Coleman assumptions in the top panel; the UPTAP outcomes are in the bottom panel. On the RH side of the top panel we have placed the differences and on RH side of the bottom panel we have reported the ethnic

Table 12.5: Net international migration assumptions in the Coleman projections and the net international migration outcomes in the UPTAP projections

Coleman	Coleman assumptions			Coleman minus UPTAP-EF			Coleman minus UPTAP-ER		
Ethnic group	2006-11	2031-36	2056 onwards	2006-11	2031-36	2046-51	2006-11	2031-36	2046-51
WBR	-74	-74	-74	-43	-49	-49	-50	-58	-58
WHO	95	78	78	-20	-21	-21	32	62	67
MIX	8	8	8	1	1	1	8	24	30
IND	42	42	42	25	28	28	30	38	39
PAK	21	21	21	12	13	13	15	21	24
BAN	9	9	9	8	8	8	9	11	11
OAS	11	11	11	4	5	5	7	11	12
BLC	2	2	2	-1	0	0	1	1	1
BLA	30	30	30	14	16	16	23	34	36
OBL	1	1	1	1	1	1	1	2	2
CHI	26	26	26	14	16	16	21	25	26
OTH	26	26	25	4	7	6	17	26	27
Total	197	180	180	19	25	24	114	197	218
UPTAP	UPTAP assumptions-EF			UPTAP assumptions-ER			Ethnic group correspondence		
Ethnic group	2006-11	2031-36	2046-51	2006-11	2031-36	2046-51	UPTAP ethnic group	Coleman ethnic group	
WBR	-31	-25	-25	-24	-16	-16	WBR	WBR	
WIR	7	5	5	6	3	3	WIR	WHO	
WHO	108	94	94	57	13	8	WHO	WHO	
WBC	0	0	0	-2	-5	-7	WBC	MIX	
WBA	2	2	2	1	-2	-2	WBA	MIX	
WAS	2	2	2	0	-5	-7	WAS	MIX	
OMI	3	3	3	1	-4	-6	OMI	MIX	
IND	17	14	14	12	4	3	IND	IND	
PAK	9	8	8	6	0	-3	PAK	PAK	
BAN	1	1	1	0	-2	-2	BAN	BAN	
OAS	7	6	6	4	0	-1	OAS	OAS	
BLC	3	2	2	1	1	1	BLC	BLC	
BLA	16	14	14	7	-4	-6	BLA	BLA	
OBL	0	0	0	0	-1	-1	OBL	OBL	
CHI	12	10	10	5	1	0	CHI	CHI	
OTH	22	19	19	9	0	-2	OTH	OTH	
Total	178	155	155	83	-17	-38	Total	Total	

Note: All figures are in 1000s and are average annual net migration for the 5 year intervals indicated.

group correspondences. The Coleman assumptions for the UK stick with the ONS long term assumptions, while we envisage smaller net inflows in both UPTAP projections, arguing that declared restriction policies will have an effect. If the population is free to emigrate, as under the UPTAP-ER projection, then the outcome will be a small net international migration loss by 2031-36. There is some disagreement between the allocations. The Coleman projections assume larger net outflows of the White British group compared to the UPTAP projections. The net inflows of the BAME groups are larger in the Coleman projection compared to the UPTAP projections. Overall Coleman assumes a larger net inflow of migrants into the UK compared to both of our UPTAP projections, particularly to the UPTAP-ER project, where substantial return migration is assumed and some groups show a negative net migration in later years of the projection.

12.2 Reflections

These comparisons have shown that our projections differ considerably from the estimates of ONS and from the projections of David Coleman, but are quite close to the projections of the Greater London Authority. There are many sources of difference. First, there are the methods used to estimate the components of change for each ethnic group. Our projections are the only ones to estimate ethnic specific mortality. Each of the projection endeavours makes estimates of ethnic group fertility, drawing on vital statistics, survey and census data in different mixes. Our projections assume much lower fertility rates for the main BAME groups than the Coleman projections. A paper comparing the two methodologies in detail is needed. The projections differ substantially in the way international migration is allocated across the ethnic groups. Again a paper is needed comparing the methodologies in detail. We may need to revise our assumptions in the light of the Coleman analysis, making greater use of the International Passenger Survey information at UK level. Our projections make use of internal migration estimates by ethnicity drawing on both the 2001 census and the post-census all groups migration data. At the moment we do not check our projections by ethnicity and age against the all group estimates for 2001-2 to 2007-8 in the same way we did for mortality and fertility. There is also an opportunity to improve the internal migration estimates by using the LFS data employed by Raymer *et al.* (2008) and Raymer and Giulietti (2009).

So there is considerable uncertainty about the degree of change in the UK's ethnic populations. There is, however, agreement about the direction of change – towards increasing population diversity. Our projections have shown how that diversity will develop at local scale in England.

12.3 Summary of findings

This document has reported on the findings of an ESRC funded research project that has investigated ethnic population trends at local area scale in the United Kingdom and built a model to project those trends under a variety of assumptions into the future. At the start of our project many said that the job we proposed could not be done. The Office for National Statistics had decided that it would not, yet, extend its national or sub-national population projections to include an ethnic dimensions, though they had launched a really useful exercise to estimate local populations in England for the 16 ethnic groups used in the 2001 census and in single year of age detail. To carry out the projections, we have had to work hard to make the best possible estimates of components rates, probabilities and flows for sixteen ethnic groups for 355 local areas. We have already published several papers drawing on this estimation work (on ethnic mortality and on international migration) and we will publish further analyses (on ethnic fertility and ethnic internal migration).

The **key findings** of the research are as follows.

Model innovations

(1) We have designed an **innovative model** to project forward ethnic group populations for local areas in the UK simultaneously.

(2) The key innovative feature of the model is its **bi-regional structure** that captures the migration connections between areas and enables simultaneous projection of 355 zone populations.

(3) The model handles internal migration through **probabilities of out-migration conditional on survival within the country**. Such probabilities enable the proper separation of mortality and migration processes.

(4) The model design makes possible **different configurations of the international migration process** as gross or net flows or rates. We have explored two configurations: treating immigration and emigration as gross flows (the EF model) and treating immigration as gross flows and emigration as a product of emigration rates and populations at risk (the ER model).

(5) The model handles all **sixteen ethnic groups** recognised in the 2001 census.

(6) The model connects together ethnic groups by generating **births of mixed ethnic parentage**, using information from the 2001 census.

(7) The model handles explicitly **all population components** of change: fertility, mortality, immigration, emigration, internal in-migration and internal out-migration for each local area and for each ethnic group population.

(8) The model uses **single years of age** from 0 to 100+, which recognizes the need to know more about the distribution of the population of the very old, as the population ages.

(9) The model has been written as **a set of R scripts**. R is a general purpose statistical computer language/package, which has handles large arrays well and enables the projections to be run in a few hours.

Component estimates

(10) New **estimates of ethnic group mortality** have been prepared, which show moderate variation. The range in life expectancies between best and worst experience is 5 years, lower than in other countries where equivalent information is available such as the USA or New Zealand.

(11) Assumptions about mortality are driven by adopting annual percentage decline rates for age-sex-ethnic specific mortality which are converted into improvement rate for the survivorship probabilities used in the model. For the UPTAP projections we adopt a **decline rate of 2% per annum**, which is much lower than the decline in the last decade, about equivalent to the declines of the past 25 years and much higher than the 1% per annum assumed by National Statistics.

(12) Our fertility rate estimates are based on three sources: annual vital statistics, census populations (mothers and children) and LFS data for post-census information on ethnic fertility. The method is calibrated for 1991 and 2001. For 2006-11 the **total fertility rate estimates** range from 1.47 for the Chinese women to 2.47 for Bangladeshi women, with TFRs for White women estimated to be 1.88 and for Mixed women 1.74. Asian group fertility is estimated to be higher than Black group fertility. These estimates are higher than those of National Statistics but lower than those of Coleman.

(13) Our work on international migration has focussed on improving **local area estimates of immigration** using administrative sources. We combined this with the ethnic profile based on the 2001 Census immigrations. These estimates are different from the ONS and Coleman alternatives.

(14) Our internal migration estimates were based on a commissioned table from the 2001 Census which provided counts of total migrants (persons) moving between local authorities in the UK by ethnic group. From this information we computed the **total probabilities of out-migration (given survival within the UK)** and **the total probabilities of out-migration from the Rest of the UK to the local authority**. Uniform age profiles by age and sex were applied to these probabilities. After 2000-1 the migration probabilities were factored up or down depending of changes in the rate of out-migration from local authorities as monitored by the Patient Registration Data System.

(15) There is clear evidence in our projections that the internal migration probabilities are driving a **significant redistribution of the BAME populations**. They are spreading out from their clusters of concentration in 2001 to a wider set of residential locations by mid-century.

Projection results

(16) When we aligned our projection assumptions as closely as possible to the 2008-based National Population Projections (NPP), we obtain a comparable trajectory for the UK population as a whole. In 2051 in these TREND-EF projections, the UK population grows to 77.7 million compared with 77.1 million in the NPP. The gap of 0.6 million is **an estimate of the aggregation effect** in projection, being due to the difference between projecting four home country populations and projecting a large number (355 ×16 = 5680) of local authority-ethnic groups.

(17) Our BENCHMARK projections produced much lower projected populations than the NPP at 55.1 million (the ER model) and 63.0 million (the EF model) in 2051. The gaps of 20.0 and 14.1 million people demonstrate **the dramatic demographic shift** in the 2000s, that is, the combined impact in the 2001-2009 period of lower mortality (gains of 2.1 years in male life expectancy and 1.5 years in female for the UK 2000-7), higher fertility (gains of 0.33 of a child in TFR for the UK 2001-8) and higher net immigration (+154 thousand in 2000 and +217 thousand in 2007).

(18) The differences between our UPTAP-EF and UPTAP-ER projections demonstrate **the impact of a change in the model for emigration** can have. Modelling emigration as a fixed flow count rather than a flow produced by applying a fixed rate to a changing population at risk produces total populations in 2051 that differ by 9.1 millions.

(19) Our projections show **huge differences in the potential growth of the different ethnic groups**. Under the TREND-EF projection between 2001 and 2031 the White British group grows by 4%, the White Irish group by 10% and the Black Caribbean group by 31%. These are the low growth groups. The Mixed groups grow between 148 and 249%. The Asian groups increase between 95 and 153%. The Black African group grows by 179%, the Other Black group by 104%, the Chinese group by 202% and the Other Ethnic Group by 350%.

(20) As a result of these differences, **the ethnic composition of the UK will change** substantially over the period to 2051. Under the TREND-EF projection, the White share of the population shrinks from 92 to 79% and the BAME share increases from 8 to 21%. Two groups face loss in share: the White British population share shrinks from 87.1 to 67.1% and the White Irish share shrinks from 2.5% to 2.1%. The Black Caribbean share stays stable at 1.0%. The other BAME groups expand their population shares along with the Other White group share, which grows from 2.5% to 9.9% (the greatest gain). Mixed groups increase their share by 3%, Asian groups by 4.8%, Black groups by 2% and Chinese and Other ethnic groups by 2.6%.

(21) **All ethnic groups undergo population ageing**. The BAME groups in general increase the share of their population that is elderly so that the 2051 share (except the Mixed groups) is comparable with the White British share in 2001. The share of the White British population in 2001 that was 65 or over in age was 17%. The BAME (except Mixed) shares in 2051 range from 15 to 28% (TREND-EF projection). The Mixed groups still have smaller elderly shares at 8-10% in 2051. The White British share has risen from 17 to 27%. This ageing has important implications for social policy.

(22) **Changes in working age shares vary depending on ethnic group**. Only the Mixed groups and the Bangladeshi group increase their working age share. The other groups see falls in the working age share ranging from -1% for the Other Black and Pakistani groups to -13% for Black Caribbean group.

(23) There is **important regional and within region variation** in the changes in ethnic group population sizes, shares and concentration. Detailed accounts of regional and local variations in ethnic population change are provided in the paper.

(24) **Ethnic minorities will shift out of the most deprived local authorities and will move into the least deprived local authorities**. The distribution of ethnic minority populations shifts favourably over the projection horizon, while that of Whites remains stable. The percentage of the Mixed group population in the most deprived quintile of LAs reduces from 26% to 19%, while the percentage in the least deprived quintile increases from 22% to 29%. The corresponding shifts for Asian groups are from 25 to 18% for the most deprived quintile and from 9% to 20% for the least deprived quintile. For Black groups the most deprived quintile sees a decrease from 54% to 39% while the least deprived quintile sees an increase from 7% to 19%.

(25) There are **significant shifts to LAs with lower ethnic minority concentrations** by Mixed, Asian and Black populations from LAs with high ethnic concentrations, while the White and Chinese and Other group distributions remain in 2051 as they were in 2001.

(26) **Ethnic groups will be significantly less segregated** from the rest of the population, measured across local authorities, in 2051 than in 2001. The Indexes of Dissimilarity between each group and the rest of the population fall by a third over the projection period.

(27) **The UK in 2051 will be a more diverse society than in 2001** and this diversity will have spread to many more part of the country beyond the big cities where ethnic minorities are concentrated.

REFERENCES

Bains, B. (2008) GLA 2007 Round Ethnic Group Projections. DMAG Briefing 2008-03, February 2008, Data Management and Analysis Group, Greater London Authority, London. Available at: http://www.london.gov.uk/who-runs-london/mayor/publications/society/facts-and-figures

Bains, B. and Klodawski, E. (2006) *GLA 2005 Round: Interim Ethnic Group Population Projections*. DMAG Briefing 2006/22, November 2006. Data Management and Analysis Group, Greater London Authority, London. Available at: http://www.london.gov.uk/gla/publications/factsandfigures/dmag-briefing-2006-22.pdf.

Bains, B. and Klodawski, E. (2007) *GLA 2006 Round: Ethnic Group Population Projections*. DMAG Briefing 2007/14, July 2007. Data Management and Analysis Group, Greater London Authority, London. Available at: http://www.london.gov.uk/gla/publications/factsandfigures/DMAG-Briefing-2007-14-2006.pdf.

Bains, B., Hollis, J. and Clarke, V. (2005) Transgenerational Ethnicity. DMAG Briefing 2005/21, August 2005, Data Management and Analysis Group, Greater London Authority, London. Available at: http://www.london.gov.uk/who-runs-london/mayor/publications/society/facts-and-figures

Bauere, V., Densham, P.J.M. and Salt, J. (2007). Migration from Central and Eastern Europe: local geographies. *Population Trends* 129 (Autumn 2007): 7-20.

Bijak, J. (2010) Independent Review of Methods for Distributing International Immigration Estimates to Regions. Report for the Office for National Statistics. Online at: http://www.ons.gov.uk/about-statistics/methodology-and-quality/imps/updates-reports/current-updates-reports/index.html

Bijak J., Kupiszewska D., Kupiszewski M., Saczuk K. (2005) Impact of international migration on population dynamics and labour force resources in Europe. *CEFMR Working Paper 1/2005*. Central European Forum for Migration Research, Warsaw. Online at: http://www.cefmr.pan.pl/docs/cefmr_wp_2005-01.pdf.

Bijak J., Kupiszewska D., Kupiszewski M., Saczuk K. and Kicinger A. (2007) Population and labour force projections for 27 European countries, 2002–2052: impact of international migration on population ageing. *European Journal of Population* 23 (1), 1-31.

Boden P. and Rees P. (2008a) New Migrant Databank: concept and development. Chapter 5 in Stillwell J., Duke-Williams O. and DennettA. (eds.) *Technologies for Migration and Commuting Analysis*. IGI Global, Hersey, PA.

Boden P. and Rees P. (2008) New Migrant Databank: Concept, development and preliminary analysis. Paper presented at the QMSS2seminar on Estimation and Projection of International Migration, University of Southampton, 17-19 September 2008. Online at: http://www.ccsr.ac.uk/qmss/seminars/2008-09-17/documents/QMSSPaper-PBPHR-Sept2008.pdf

Boden, P. and Rees, P. (2009) International migration: the estimation of immigration to local areas in England using administrative data sources, *Journal of the Royal Statistical Society, Series A*, Accepted. Online: http://arxiv.org/ftp/arxiv/papers/0903/0903.0507.pdf.

Boden, P. and Rees, P. (2010) New Migrant Databank – concept and development, in Stillwell, J., Duke-Williams, O. and Dennett, A. (eds.) *Technologies for Migration and Commuting Analysis: Spatial Interaction Data Applications*, IGI Global, Hershey, In press.

Booth, H. (2006) Demographic forecasting: 1980 to 2005 in review. *International Journal of Forecasting* 22(3): 547-581.

Bradford Council (1999) *Population forecasts for Rochdale 1999-2021: age, sex and ethnic group*, City of Bradford Metropolitan District Council, Policy and Research Unit: Bradford.

Bradford Council (2000) *Population forecasts for Bradford 1999-2021: age, sex and ethnic group*, City of Bradford Metropolitan District Council, Policy and Research Unit: Bradford.

Burström, B. and Fredlund, P. (2001) Self-rated health: Is it as good a predictor of subsequent mortality among adults in lower as well as in higher social classes. *Journal of Epidemiology and Community Health*, 55, 836-840.

Cabinet Office (2008) *Helping to Shape Tomorrow: The 2011 Census of Population and Housing in England and Wales*. Presented to Parliament by the Minister to the Cabinet Office, by Command of Her Majesty. Laid before the National Assembly for Wales by the Minister for Finance and Public Service Delivery.

Cm 7513. ISBN: 9780101751322. Retrieved 9 March 2010 from: http://www.ons.gov.uk/census/2011-census/2011-census-questionnaire-content
Campbell, P. R. (1996) *Population Projections for States by Age, Sex, Race, and Hispanic Origin: 1995 to 2025*, U.S. Bureau of the Census, Population Division, PPL-47. Retrieved 31 May 2009 from: http://www.census.gov/population/www/projections/ppl47.html
CCSR (2009) Welcome to the POPGROUP Website. Demographic forecasting with Popgroup. Online at: http://www.ccsr.ac.uk/popgroup/
Coleman D. (2006a) The European demographic future: Determinants, dimensions and challenges. In *The political economy of global population change, 1950–2050*, Demeny P and McNicoll G, eds. New York: Population Council; *Population and Development Review* 32(PDR Supplement):52-95.
Coleman, D. (2006b) Immigration and ethnic change in low-fertility countries: A third demographic transition. *Population and Development Review* 32(3):401–446.
Coleman, D. (2010) Projections of the Ethnic Minority populations of the United Kingdom 2006-2056. Paper submitted to *Population and Development Review*.
Coleman, D and Scherbov, S. (2005) Immigration and ethnic change in low-fertility countries – towards a new demographic transition? Presented at the Population Association of America Annual Meeting, Philadelphia. Available at http://www.apsoc.ox.ac.uk/Oxpop/publications%20files/WP29.pdf
Danielis, J. (2007) Ethnic Population Forecasts for Leicester using POPGROUP. CCSR Research Report, Cathie Marsh Centre for Census and Survey Research, The University of Manchester, Manchester. Online at: http://www.ccsr.ac.uk/research/documents/EthnicPopulationForecastsforLeicester.pdf.
Dennett, A. and Rees, P. (2010) Estimates of internal migration flows for the UK, 2000-2007. *Population Trends*, Forthcoming.
Dunnell, K. (2007) The changing demographic picture of the UK: National Statistician's annual article on the population. *Population Trends* 130, 9-21. Available online at: http://www.statistics.gov.uk/downloads/theme_population/Population_Trends_130_web.pdf.
ESPON (2009) *DEMIFER: Demographic and migratory flows affecting European regions and cities*. Applied Research Project 2013/1/3. Interim Report. The ESPON 2013 Programme. http://www.espon.eu/mmp/online/website/content/programme/1455/2235/1749_EN.html
Europa (2008) Population projections 2008-2060. Europa Press releases RAPID. http://europa.eu/rapid/pressReleasesAction.do?reference=STAT/08/119.
Fennelly, K. (2005) The healthy migrant effect, *Healthy Generations*, 5(3): 1-3.
Green, A.E., Owen, D. and Adam, D. (2008b) *A Resource Guide on Local Migration Statistics*, Report prepared for the Local Government Association. Online: http://www.lga.gov.uk/lga/publications/publication-display.do?id=1308025.
Harding, S., Balarajan, R. (2002) Mortality data on migrant groups living in England and Wales: issues of adequacy and of interpretation of death rates. Pp.115-127 in: Haskey, J., ed. *Population Projections by Ethnic Group: A Feasibility Study*. London: The Stationery Office
Heistaro, S., Jousilahti, P., Lahelma, E., Vartiainen, E. & Puska, P. (2001). Self-rated health and mortality: a long term prospective study in eastern Finland. *Journal of Epidemiology and Community Health*, 55(4) 227-232.
Helweg-Larson, M., Kjøller, M. and Thoning, H. (2003) Do age and social relations moderate the relationship between self-rated health and mortality among adult Danes? *Social Science and Medicine*, 57(7): 1237-1247.
Hollis, J. and Bains, B. (2002) *GLA 2001 Round Ethnic Group Population Projections*. DMAG Briefing 2002/4. Data Management and Analysis Group, Greater London Authority, London.
Hollis, J. and Chamberlain, J. (2009) *GLA 2008 Round Demographic Projections.* DMAG Briefing 2009-02, March 2009. Data Management and Analysis Group, Greater London Authority, London.
Hussain, S. and Stillwell, J. (2008) Internal migration of ethnic groups in England and Wales by age and district type. Working Paper 08/3, School of Geography, University of Leeds, Leeds, UK. Online at: http://www.geog.leeds.ac.uk/wpapers/08-03.pdf.
Klodawski, E. (2009) GLA 2008 Round Ethnic Group Population Projections. DMAG Briefing 2009-08, August 2009, Data Management and Analysis Group, Greater London Authority, London. Available at: http://www.london.gov.uk/who-runs-london/mayor/publications/society/facts-and-figures
Kupiszewska, D. and Kupiszewski, M. (2005), A revision of the traditional multiregional model to better capture international migration: The MULTIPOLES model and its applications, *CEFMR Working Paper* 10/2005.

Large, P. and Ghosh, K. (2006a) A methodology for estimating the population by ethnic group for areas within England. *Population Trends* 123:21-31.
Large, P. and Ghosh, K. (2006b) Estimates of the population by ethnic group for areas within England. *Population Trends* 124:8-17.
London Research Centre (1999) *1999 Round of ethnic group projections*. LRC, London.
McGee, D.L., Liao, Y., Cao, G. and Copper, R.S. (1999) Self-reported health status and mortality in a multiethnic US cohort. *American Journal of Epidemiology*, 149(1), 41-46.
NIDI (2008) LIPRO 4 for Windows. Online at: http://www.nidi.knaw.nl/en/projects/270101/.
Norman, P., Rees, P. and Boyle, P. (2003) Achieving data compatibility over space and time: creating consistent geographical zones, *International Journal of Population Geography*, 9(5): 365-386.
ONS (2008a) *National Population Projections: 2006-based.* Series PP2, No.26. Office for National Statistics, London. Published for ONS by Palgrave-Macmillan, Basingstoke. Online at: http://www.statistics.gov.uk/downloads/theme_population/pp2no26.pdf
ONS (2008b) Population change: UK population creases by 388,000. Online at: http://www.statistics.gov.uk/cci/nugget.asp?ID=950
ONS (2009a) Improvements to Migration and Population Statistics. February 2009. Office for National Statistics. Online: http://www.statistics.gov.uk/about/data/methodology/specific/population/future/imps/updates/downloads/msiwpfeb.pdf.
ONS (2009b) *Population Estimates by Ethnic Group: 2001 to* 2007. Commentary. September 2009. Online at: http://www.statistics.gov.uk/statbase/product.asp?vlnk=14238
ONS (2009c) 2008-based National Population Projections. Office for National Statistics. Online at: http://www.statistics.gov.uk/statbase/Product.asp?vlnk=8519
ONS (2010a) *Population Trends*, *139, Spring 2010*. Office for National Statistics, London. Online at www.statistics.gov.uk/poptrends.
ONS (2010b) Long-term international migration (LTIM) tables, 1991-latest. Office for National Statistics. Online at: http://www.statistics.gov.uk/statbase/Product.asp?vlnk=15053
ONS (2010c) Population Estimates by Ethnic Group (experimental), Current Estimates and Past Estimates. Office for National Statistics. Online at: http://www.statistics.gov.uk/statbase/product.asp?vlnk=14238
ONS (2010d) United Kingdom: Local Authority Districts, Counties and Unitary Authorities, March 2009. Online at http://www.statistics.gov.uk/geography/maps.asp as file CTY_LAD_MAR_2009_UK_MP[1].pdf. Accessed 29 May 2010.
ONS (2010e) Latest Migration Statistics. 27 May 2010. Online at: http://www.statistics.gov.uk/StatBase/Product.asp?vlnk=507
ONS and GAD (2006) *National Population Projections: 2004-based.* Series PP2, No25. Office for National Statistics, London. Published for ONS by Palgrave-Macmillan, Basingstoke. Online at: http://www.statistics.gov.uk/downloads/theme_population/PP2_No25.pdf
OPCS (1975) Country of birth and colour 1971-4. *Population Trends* 2, 2-8.
OPCS (1977a) *Social Trends 8*, Central Statistical Office, HMSO, London, pp.68-69.
OPCS (1977b) New Commonwealth and Pakistani population estimates. *Population Trends* 9, 4-7.
OPCS (1979) Population of New Commonwealth and Pakistani ethnic origin: new projections. *Population Trends* 16, 22-27.
OPCS (1986a) Estimating the size of the ethnic minority populations in the 1980s. *Population Trends* 44, 23-27.
OPCS (1986b) Ethnic minority populations in Great Britain. *Population Trends* 46, 18-21.
Parsons, J. and Rees, P. (2009) *Child poverty in the UK: Socio-demographic scenarios to 2020 for children (2008 update)*. Report on datasets, models and results to the Joseph Rowntree Foundation as part of their project on *Child Poverty in the UK: 2008 Update.* School of Geography, University of Leeds, Leeds, UK
Raymer, J. and Giulietti, C. (2008) Analysing structures of interregional migration in England, Paper presented at the ESRC Research Methods Festival Session 40: Handling Migration and Commuting Flow Data, Oxford, 2 July.
Raymer, J. and Giulietti, C. (2009) Ethnic migration between area groups in England and Wales, *Area*, [Early view, April 2009] doi: 10.1111/j.1475-4762.2009.00884.x
Raymer J., Smith, P. and Giulietti, C. (2008) Combining census and registration data to analyse ethnic migration patterns in England from 1991 to 2007, *Methodology Working Papers M08/09*, Southampton Statistical Sciences Research Institute, Southampton, UK. Online at: http://eprints.soton.ac.uk/63739/.

Rees, P. (1981) Accounts based models for multiregional population analysis: methods, program and users' manual. *Working Paper 295*, School of Geography, University of Leeds, Leeds, UK.
Rees P., Stillwell J. and Convey A. (1992) Intra-Community migration and its impact on the development of the demographic structure at regional level. *Working Paper 92/1*, School of Geography, University of Leeds, Leeds, UK.
Rees, P. (2002) New models for projecting UK populations by ethnic group at national and subnational scales, in Haskey, J. (ed.) *Population Projections by Ethnic Group: A Feasibility Study*, Studies on Medical and Population Subjects No. 67, The Stationery Office, London, pp. 27-52. Online: http://www.statistics.gov.uk/downloads/theme_population/SMPS_67_v2.pdf.
Rees, P. (2006) What is happening to the UK population in a global mobility system? Paper presented at the ESRC/ONS Public Policy seminar series on demographic change and Government Policy, Third Seminar on: Globalisation, population mobility and the impact of migration on population, Royal Statistical Society, London.
Rees, P. (2008) What happens when international migrants settle? Projections of ethnic groups in United Kingdom regions, in Raymer, J. and Willekens, F. (eds.) *International Migration in Europe: Data, Models and Estimates*, John Wiley and Sons, Chichester, pp. 329-358.
Rees, P. and Boden, P. (2006) *Estimating London's New Migrant Population. Stage 1 - Review of Methodology*, Mayor of London, Greater London Authority, London. Online: http://www.london.gov.uk/mayor/refugees/docs/nm-pop.pdf.
Rees P. and Butt F. (2004) Ethnic change and diversity in England, 1981-2001. *Area*, 36(2): 174-186.
Rees, P.H.; Kupiszewski, M. (1999) *Internal Migration and Regional Population Dynamics in Europe: a Synthesis*. Population Studies No.32, Council of Europe Publishing, Strasbourg. ISBN: 92-871-3923-7. French edition. *Migrations Internes et Dynamique Démographique Régionale en Europe*. Editions du Conseil de l'Europe, Strasbourg. ISBN: 92-871-3955-5.
Rees, P. and Parsons, J. (2006) *Socio-demographic scenarios for children to 2020.* York: Joseph Rowntree Foundation. Available at http://www.jrf.org.uk/bookshop/details.asp?pubID=809.
Rees, P. and Parsons, J. (2009) Child poverty in the UK: socio-demographic scenarios to 2002 for children (2008 Update). Report on Datasets, Models and Results, Report to the Joseph Rowntree Foundation, January, School of Geography, University of Leeds, Leeds.
Rees, P., Stillwell, J., Boden, P. and Dennett, A. (2009) Part 2: A review of migration statistics literature, in UK Statistics Authority (2009) *Migration Statistics: The Way Ahead?* Report 4, UKSA, London, pp. 53-140.
Rees, P. and Wilson, A. (1977) *Spatial Population Analysis*. Edward Arnold, London.
Rees, P. and Wohland, P. (2008) Estimates of ethnic mortality in the UK, *Working Paper 08/04*, School of Geography, University of Leeds, Leeds.
Online at: http://www.geog.leeds.ac.uk/wpapers/08-04.pdf
Rees, P., Wohland, P. and Norman, P. (2009) The estimation of mortality for ethnic groups at local scale within the United Kingdom, *Social Science & Medicine*, doi:10.1016/j.socscimed.2009.08.015. [web link]
Rees, P., Boden, P., Dennett, A., Stillwell, J., de Jong, A., ter Veer, M. (2010) Report on scenarios and a database of scenario drivers. DEMIFER Demographic and migratory flows affecting European regions and cities. Applied Research Project 2013/1/3. Deliverable 6. April 2010.
Rees, P., Boden, P., Dennett, A., Stillwell, J., Jasinska, M., de Jong, A., ter Veer, M., Kupiszewski, M. and Kupiszewska, D. (2010) *Regional population dynamics: a report assessing the effects of demographic developments on regional competitiveness and cohesion*. The ESPON 2013 Programme, DEMIFER Demographic and migratory flows, affecting European regions and cities, Applied Research Project 2013/1/3, Deliverable 7, April 2010.
Rogers, A. (1976) Shrinking large-scale population projection models by aggregation and decomposition. *Environment and Planning A* 8: 515–541.
Rogers**,** A. (1990) Requiem *for the* net migrant**.** *Geographical Analysis* 22, 283–300.
Schuman, J. (1999) The ethnic minority populations of Great Britain – latest estimates. *Population Trends* 96, 33-43.
Simpson, L. (2002) The starting population for population projections by ethnic group, in Haskey, J. (ed.) *Population Projections by Ethnic Group a Feasibility Study*, Studies on Medical and Population Subjects No. 67, The Stationery Office, London, pp. 73-80. Online: http://www.statistics.gov.uk/downloads/theme_population/SMPS_67_v2.pdf.
Simpson, S. (1997) Demography and ethnicity: case studies from Bradford, *New Community*, 23(1): 89-107.

Simpson, L. (2007a) Population forecasts for Birmingham. *CCSR Working Paper 2007-12*, Cathie Marsh Centre for Census and Survey Research, The University of Manchester, Manchester. Online at: http://www.ccsr.ac.uk/publications/working/2007-12.pdf.

Simpson, L. (2007b) Population forecasts for Birmingham, with an ethnic group dimension. CCSR Research Report, Cathie Marsh Centre for Census and Survey Research, The University of Manchester, Manchester. Online at: http://www.ccsr.ac.uk/research/documents/PopulationForecastsforBirminghamCCSRReport.pdf.

Simpson, L. (2007c) Population forecasts for Birmingham, with an ethnic group dimension. CCSR Technical Report, Cathie Marsh Centre for Census and Survey Research, University of Manchester, Manchester. Online at: http://www.ccsr.ac.uk/research/documents/PopulationforecastsforBirminghamCCSRTech.pdf.

Simpson, L., Akinwale, B. (2007) Quantifying stability and change in ethnic group. *Journal of Official Statistics* 23(2), (2007): 185–208.

Simpson, L. and Gavalas, V. (2005a) Population forecasts for Oldham Borough, with an ethnic group dimension. CCSR Research Report, Cathie Marsh Centre for Census and Survey Research, The University of Manchester, Manchester. Retrieved 8 January 2008 from: http://www.ccsr.ac.uk/research/documents/PopulationForecastsforOldhamCCSRReportMay05.pdf

Simpson, L. and Gavalas, V. (2005b) Population forecasts for Rochdale Borough, with an ethnic group dimension. CCSR Research Report, Cathie Marsh Centre for Census and Survey Research, The University of Manchester, Manchester. Online at: http://www.ccsr.ac.uk/research/documents/PopulationForecastsforRochdaleCCSRReportMay05.pdf.

Simpson, L. and Gavalas, V. (2005c) Population forecasts for Oldham and Rochdale Boroughs, with an ethnic group dimension. CCSR Technical Report, Cathie Marsh Centre for Census and Survey Research, The University of Manchester, Manchester. Online at: http://www.ccsr.ac.uk/research/documents/PopulationforecastsforOldhamandRochdaleCCSRTechMay05.pdf.

Simpson, L., Platt, L, Akinwale, B. (2005) Stability and change in ethnic group in England and Wales. *Population Trends* 121, (2005): 35-45.

Simpson, L., Purdam, K., Toya, A., Fieldhouse, E., Gavalas, V., Tranmer, M., Pritchard, J. and Dorling, D. (2006) Ethnic minority populations and the labour market: an analysis of the 1991 and 2001 Census, *Research Report No.333*, Department of Work and Pensions. Online at: http://asp.ccsr.ac.uk/dwp/info/report333.pdf

Sporton D and White P (2002) Fertility, in Haskey J (ed.) *Population Projections by Ethnic Group A Feasibility Study*, Studies on Medical and Population Subjects No. 67, The Stationery Office, London, pp. 81-92.
Online: http://www.statistics.gov.uk/downloads/theme_population/SMPS_67_v2.pdf.

Stillwell, J. and Hussain, S. (2008) Ethnic group migration within Britain during 2000-01: a district level analysis. Working Paper 08/2, School of Geography, University of Leeds, Leeds UK. Online at: http://www.geog.leeds.ac.uk/wpapers/08-02.pdf

Stillwell, J. and Hussain, S. (2008) Ethnic group migration within Britain during 2000-01: a district level analysis, *Working Paper 08/2*, School of Geography, University of Leeds, Leeds. Online at: http://www.geog.leeds.ac.uk/wpapers/08-02.pdf.

Stillwell, J., Hussain, S. and Norman, P. (2008) The internal migration propensities and net migration patterns of ethnic groups in Britain, *Migration Letters*, 5(2): 135-150.

Stillwell J., Rees P. and Boden P. (2006) Yorkshire & The Humber Population Projections: Age and Ethnicity. Report prepared for Yorkshire Futures (part of Yorkshire Forward, the Regional Development Agency). Online at: http://www.yorkshirefutures.com/siteassets/documents/YorkshireFutures/3/9/390F5D3F-E067-4872-8C5C-AB95E8F47FB7/Yorkshire%20&%20The%20Humber%20Population%20Projections.pdf

Storkey, M. (2002) *Population Projections of Different Ethnic Groups in London, 1991 to 2011*. PhD Thesis, University of Southampton. 261p.

Thomas, B. and Dorling, D. (2007) *Identity in Britain: A cradle-to-grave atlas.* Bristol: Policy Press.

Townsend, P. (1987) Deprivation, *Journal of Social Policy*, 16: 125-46.

Tromans, N., Natamba, E., Jefferies, J. and Norman, P. (2008) Have national trends in fertility between 1986 and 2006 occurred evenly across England and Wales? *Population Trends*, 133: 7-19.

Van Imhoff, E. & N. Keilman (1991) *LIPRO 2.0: an application of a dynamic demographic projection model to household structure in the Netherlands*. NIDI/CBGS Publications nr. 23, Amsterdam/Lisse:

Swets & Zeitlinger. 245 p. Online at: http://www.nidi.knaw.nl/en/output/nidicbgs/nidicbgs-publ-23.pdf/nidicbgs-publ-23.pdf
Vickers, D., Rees, P. and Birkin, M. (2003) A new classification of UK local authorities using 2001 census key statistics. *Working Paper 03/03*, School of Geography, University of Leeds, Leeds, UK. Online at: http://www.geog.leeds.ac.uk/wpapers/03-3.pdf
White, I. and McLaren, E. (2009) The 2011 Census taking shape: the selection of topics and questions. *Population Trends* 135, 8-19. Retrieved 31 May 2009 from: http://www.statistics.gov.uk/downloads/theme_population/Population_trends_135.pdf
Wilson, T. (2001) *A new subnational population projection model for the United Kingdom*. PhD Thesis, University of Leeds.
Wilson T (2008) A multistate model for projecting regional populations by Indigenous status: an application to the Northern Territory, Australia. Forthcoming in *Environment and Planning A.*
Wilson, T. and Bell, M. (2004a) Australia's Uncertain Demographic Future. *Demographic Research*, *11* 8: 195-234.
Wilson, T. and Bell, M. (2004b) Comparative empirical evaluations of internal migration models in subnational population projections. *Journal of Population Research*, *21* 2: 127-160.
Wilson, T., Bell, M., Heyen, G. and Taylor, A. (2004) New Population Projections for Queensland and Statistical Divisions. *People and Place*, *12* 1: 1-14.
Wilson, T. and Rees, P. (2003) Why Scotland needs more than just a new migration policy. *Scottish Geographical Journal* 119.3: 191-208.
Wilson, T. and Rees, P. (2005) Recent developments in population projection methodology: a review. Population, Space and Place, 11, 337-360.
Wohland P with Rees P & Norman P (2009) Trends in Life Expectancy in the UK: How have inequalities changed for local areas in the UK and what can we expect for the future? Presentation at the Fifth Biennial Population Geographies Conference, Dartmouth College, 6th August 2009 [PDF]

APPENDIX A.1 ETHNIC GROUP CODES AND NAMES

The 16 group classification

#	Code	Short name	Long name
1	WBR	White British	White: British
2	WIR	White Irish	White: Irish
3	WHO	Other White	White: Other White
4	WBC	White and Black Caribbean	Mixed: White and Black Caribbean
5	WBA	White and Black African	Mixed: White and Black African
6	WAS	White and Asian	Mixed: White and Asian
7	OMI	Other Mixed	Mixed: Other Mixed
8	IND	Indian	Asian or Asian British: Indian
9	PAK	Pakistani	Asian or Asian British: Pakistani
10	BAN	Bangladeshi	Asian or Asian British: Bangladeshi
11	OAS	Other Asian	Asian or Asian British: Other Asian
12	BLC	Black Caribbean	Black or Black British: Black Caribbean
13	BLA	Black African	Black or Black British: Black African
14	OBL	Other Black	Black or Black British: Other Black
15	CHI	Chinese	Chinese or other ethnic group: Chinese
16	OTH	Other Ethnic	Chinese or other ethnic group: Other Ethnic Group

The 5 group classification

#	Name	Membership
1	White	White British, White Irish, Other White
2	Mixed	White and Black Caribbean, White and Black African, White and Asian, Other Mixed
3	Asian	Indian, Pakistani, Bangladeshi, Other Asian
4	Black	Black Caribbean, Black African, Other Black
5	Chinese and Other Ethnic	Chinese, Other Ethnic

APPENDIX A.2: ZONE CODES AND NAMES

#	2001 code	Zone name	Metro and Non-metro Zones	GORs	Vickers Groups	Vickers Families	Deprivation Quintile	Density Quintiles	Ethnic concentration
1	00AA+00BK	City of London and Westminster	LON	LO	D2	D	T5	HID	HIC
2	00AB	Barking and Dagenham	LON	LO	A2	A	T5	HID	HMC
3	00AC	Barnet	LON	LO	D1	D	T3	HID	HIC
4	00AD	Bexley	LON	LO	B3	B	T2	HID	HMC
5	00AE	Brent	LON	LO	D3	D	T5	HID	HIC
6	00AF	Bromley	LON	LO	C2	C	T1	HMD	HMC
7	00AG	Camden	LON	LO	D2	D	T5	HID	HIC
8	00AH	Croydon	LON	LO	D1	D	T3	HID	HIC
9	00AJ	Ealing	LON	LO	D1	D	T4	HID	HIC
10	00AK	Enfield	LON	LO	D1	D	T4	HID	HIC
11	00AL	Greenwich	LON	LO	D1	D	T5	HID	HIC
12	00AM	Hackney	LON	LO	D3	D	T5	HID	HIC
13	00AN	Hammersmith and Fulham	LON	LO	D2	D	T5	HID	HIC
14	00AP	Haringey	LON	LO	D3	D	T5	HID	HIC
15	00AQ	Harrow	LON	LO	D1	D	T3	HID	HIC
16	00AR	Havering	LON	LO	B3	B	T1	HMD	LMC
17	00AS	Hillingdon	LON	LO	C1	C	T3	HID	HIC
18	00AT	Hounslow	LON	LO	D1	D	T4	HID	HIC
19	00AU	Islington	LON	LO	D2	D	T5	HID	HIC
20	00AW	Kensington and Chelsea	LON	LO	D2	D	T5	HID	HIC
21	00AX	Kingston upon Thames	LON	LO	C1	C	T2	HID	HMC
22	00AY	Lambeth	LON	LO	D3	D	T5	HID	HIC
23	00AZ	Lewisham	LON	LO	D3	D	T5	HID	HIC
24	00BA	Merton	LON	LO	C1	C	T4	HID	HIC
25	00BB	Newham	LON	LO	D3	D	T5	HID	HIC
26	00BC	Redbridge	LON	LO	D1	D	T3	HID	HIC
27	00BD	Richmond upon Thames	LON	LO	C1	C	T2	HID	HMC
28	00BE	Southwark	LON	LO	D3	D	T5	HID	HIC
29	00BF	Sutton	LON	LO	C1	C	T2	HID	HMC
30	00BG	Tower Hamlets	LON	LO	B3	B	T5	HID	HIC
31	00BH	Waltham Forest	LON	LO	D1	D	T5	HID	HIC
32	00BJ	Wandsworth	LON	LO	D2	D	T5	HID	HIC
33	00BL	Bolton	UNW	NW	A2	A	T3	HMD	HMC
34	00BM	Bury	UNW	NW	B3	B	T2	HMD	LMC
35	00BN	Manchester	UNW	NW	A2	A	T5	HID	HIC
36	00BP	Oldham	UNW	NW	A2	A	T4	HMD	HMC
37	00BQ	Rochdale	UNW	NW	A2	A	T4	HMD	HMC
38	00BR	Salford	UNW	NW	A2	A	T4	HID	LOC
39	00BS	Stockport	UNW	NW	B3	B	T1	HID	LMC
40	00BT	Tameside	UNW	NW	A2	A	T3	HID	LMC
41	00BU	Trafford	UNW	NW	B1	B	T2	HID	HMC
42	00BW	Wigan	UNW	NW	A1	A	T2	HMD	LOC
43	00BX	Knowsley	UNW	NW	A2	A	T4	HMD	LOC

#	2001 code	Zone name	Metro and Non-metro Zones	GORs	Vickers Groups	Vickers Families	Deprivation Quintile	Density Quintiles	Ethnic concentration
44	00BY	Liverpool	UNW	NW	A2	A	T5	HID	LMC
45	00BZ	St. Helens	UNW	NW	A1	A	T3	HMD	LOC
46	00CA	Sefton	UNW	NW	A1	A	T2	HMD	LOC
47	00CB	Wirral	UNW	NW	A1	A	T2	HMD	LOC
48	00CC	Barnsley	UYH	YH	A1	A	T3	HMD	LOC
49	00CE	Doncaster	UYH	YH	A1	A	T3	MID	LOC
50	00CF	Rotherham	UYH	YH	A1	A	T3	HMD	LOC
51	00CG	Sheffield	UYH	YH	A3	A	T4	HMD	HMC
52	00CH	Gateshead	UNE	NE	A2	A	T4	HMD	LOC
53	00CJ	Newcastle upon Tyne	UNE	NE	A2	A	T4	HID	LMC
54	00CK	North Tyneside	UNE	NE	A1	A	T3	HID	LOC
55	00CL	South Tyneside	UNE	NE	A2	A	T4	HID	LOC
56	00CM	Sunderland	UNE	NE	A2	A	T4	HID	LOC
57	00CN	Birmingham	WMC	WM	A2	A	T4	HID	HIC
58	00CQ	Coventry	WMC	WM	A3	A	T3	HID	HIC
59	00CR	Dudley	WMC	WM	B3	B	T2	HID	LMC
60	00CS	Sandwell	WMC	WM	A2	A	T4	HID	HIC
61	00CT	Solihull	WMC	WM	B3	B	T1	HMD	LMC
62	00CU	Walsall	WMC	WM	A2	A	T4	HID	HMC
63	00CW	Wolverhampton	WMC	WM	A2	A	T4	HID	HIC
64	00CX	Bradford	UYH	YH	A2	A	T4	HMD	HIC
65	00CY	Calderdale	UYH	YH	A2	A	T3	MID	LMC
66	00CZ	Kirklees	UYH	YH	A2	A	T3	HMD	HMC
67	00DA	Leeds	UYH	YH	A3	A	T3	HMD	HMC
68	00DB	Wakefield	UYH	YH	A1	A	T3	HMD	LOC
69	09UC	Mid Bedfordshire	REE	EE	C2	C	T1	LMD	LOC
70	09UD	Bedford	REE	EE	C1	C	T2	MID	HMC
71	09UE	South Bedfordshire	REE	EE	C2	C	T1	MID	LOC
72	11UB	Aylesbury Vale	RSE	SE	C2	C	T1	LMD	LMC
73	11UC	Chiltern	RSE	SE	C2	C	T1	MID	LMC
74	11UE	South Bucks	RSE	SE	C2	C	T1	MID	LMC
75	11UF	Wycombe	RSE	SE	C2	C	T1	MID	HMC
76	12UB	Cambridge	UEE	EE	A3	A	T3	HID	HMC
77	12UC	East Cambridgeshire	REE	EE	B1	B	T1	LOD	LOC
78	12UD	Fenland	REE	EE	B1	B	T1	LMD	LOC
79	12UE	Huntingdonshire	REE	EE	C2	C	T1	LMD	LOC
80	12UG	South Cambridgeshire	REE	EE	C2	C	T1	LMD	LOC
81	13UB	Chester	RNW	NW	C1	C	T1	LMD	LOC
82	13UC	Congleton	RNW	NW	B1	B	T1	MID	LOC
83	13UD	Crewe and Nantwich	RNW	NW	B3	B	T1	LMD	LOC
84	13UE	Ellesmere Port & Neston	RNW	NW	B3	B	T2	HMD	LOC
85	13UG	Macclesfield	RNW	NW	C2	C	T1	MID	LOC
86	13UH	Vale Royal	RNW	NW	B3	B	T1	MID	LOC

#	2001 code	Zone name	Metro and Non-metro Zones	GORs	Vickers Groups	Vickers Families	Deprivation Quintile	Density Quintiles	Ethnic concentration
87	15UB	Caradon	RSW	SW	B2	B	T1	LMD	LOC
88	15UC	Carrick	RSW	SW	B2	B	T2	LMD	LOC
89	15UD	Kerrier	RSW	SW	B2	B	T2	LMD	LOC
90	15UE	North Cornwall	RSW	SW	B2	B	T1	LOD	LOC
91	15UF+ 15UF	Penwith and Isles of Scilly	RSW	SW	B2	B	T2	LMD	LOC
92	15UG	Restormel	RSW	SW	B2	B	T2	LMD	LOC
93	16UB	Allerdale	RNW	NW	B2	B	T2	LOD	LOC
94	16UC	Barrow-in-Furness	RNW	NW	A1	A	T2	MID	LOC
95	16UD	Carlisle	RNW	NW	B2	B	T2	LOD	LOC
96	16UE	Copeland	RNW	NW	A1	A	T2	LOD	LOC
97	16UF	Eden	RNW	NW	B1	B	T1	LOD	LOC
98	16UG	South Lakeland	RNW	NW	B1	B	T1	LOD	LOC
99	17UB	Amber Valley	REM	EM	B3	B	T1	MID	LOC
100	17UC	Bolsover	REM	EM	A1	A	T2	MID	LOC
101	17UD	Chesterfield	REM	EM	A1	A	T3	HMD	LOC
102	17UF	Derbyshire Dales	REM	EM	B1	B	T1	LOD	LOC
103	17UG	Erewash	REM	EM	B3	B	T1	HMD	LOC
104	17UH	High Peak	REM	EM	B3	B	T1	LMD	LOC
105	17UJ	North East Derbyshire	REM	EM	B3	B	T1	MID	LOC
106	17UK	South Derbyshire	REM	EM	B1	B	T1	LMD	LOC
107	18UB	East Devon	RSW	SW	B2	B	T1	LMD	LOC
108	18UC	Exeter	USW	SW	A3	A	T2	HID	LOC
109	18UD	Mid Devon	RSW	SW	B1	B	T1	LOD	LOC
110	18UE	North Devon	RSW	SW	B2	B	T1	LOD	LOC
111	18UG	South Hams	RSW	SW	B1	B	T1	LOD	LOC
112	18UH	Teignbridge	RSW	SW	B1	B	T1	LMD	LOC
113	18UK	Torridge	RSW	SW	D3	D	T1	LOD	LOC
114	18UL	West Devon	RSW	SW	B1	B	T1	LOD	LOC
115	19UC	Christchurch	RSW	SW	B2	B	T1	HMD	LOC
116	19UD	East Dorset	RSW	SW	B1	B	T1	LMD	LOC
117	19UE	North Dorset	RSW	SW	B1	B	T1	LOD	LOC
118	19UG	Purbeck	RSW	SW	B1	B	T1	LOD	LOC
119	19UH	West Dorset	RSW	SW	B2	B	T1	LOD	LOC
120	19UJ	Weymouth and Portland	RSW	SW	B2	B	T2	HMD	LOC
121	20UB	Chester-le-Street	RNE	NE	A1	A	T2	HMD	LOC
122	20UD	Derwentside	RNE	NE	A1	A	T2	MID	LOC
123	20UE	Durham	RNE	NE	A3	A	T2	MID	LOC
124	20UF	Easington	RNE	NE	A1	A	T4	MID	LOC
125	20UG	Sedgefield	RNE	NE	A1	A	T3	MID	LOC
126	20UH	Teesdale	RNE	NE	B1	B	T1	LOD	LOC
127	20UJ	Wear Valley	RNE	NE	A1	A	T3	LMD	LOC
128	21UC	Eastbourne	RSE	SE	B2	B	T2	HMD	LOC
129	21UD	Hastings	RSE	SE	B2	B	T3	HID	LOC

#	2001 code	Zone name	Metro and Non-metro Zones	GORs	Vickers Groups	Vickers Families	Deprivation Quintile	Density Quintiles	Ethnic concentration
130	21UF	Lewes	RSE	SE	B1	B	T1	MID	LOC
131	21UG	Rother	RSE	SE	B2	B	T1	LMD	LOC
132	21UH	Wealden	RSE	SE	B1	B	T1	LMD	LOC
133	22UB	Basildon	REE	EE	B3	B	T2	HMD	LOC
134	22UC	Braintree	REE	EE	B1	B	T1	LMD	LOC
135	22UD	Brentwood	REE	EE	C2	C	T1	MID	LOC
136	22UE	Castle Point	REE	EE	B1	B	T1	HMD	LOC
137	22UF	Chelmsford	REE	EE	C2	C	T1	MID	LOC
138	22UG	Colchester	REE	EE	C1	C	T1	MID	LOC
139	22UH	Epping Forest	REE	EE	C2	C	T1	MID	LMC
140	22UJ	Harlow	REE	EE	B3	B	T3	HID	LMC
141	22UK	Maldon	REE	EE	B1	B	T1	LMD	LOC
142	22UL	Rochford	REE	EE	B1	B	T1	MID	LOC
143	22UN	Tendring	REE	EE	B2	B	T1	MID	LOC
144	22UQ	Uttlesford	REE	EE	B3	B	T1	LOD	LOC
145	23UB	Cheltenham	RSW	SW	C1	C	T2	HID	LOC
146	23UC	Cotswold	RSW	SW	B1	B	T1	LOD	LOC
147	23UD	Forest of Dean	RSW	SW	B1	B	T1	LMD	LOC
148	23UE	Gloucester	RSW	SW	B3	B	T2	HID	LMC
149	23UF	Stroud	RSW	SW	B1	B	T1	LMD	LOC
150	23UG	Tewkesbury	RSW	SW	B1	B	T1	LMD	LOC
151	24UB	Basingstoke and Deane	RSE	SE	C2	C	T1	LMD	LOC
152	24UC	East Hampshire	RSE	SE	C2	C	T1	LMD	LOC
153	24UD	Eastleigh	RSE	SE	C2	C	T1	HMD	LOC
154	24UE	Fareham	RSE	SE	B1	B	T1	HMD	LOC
155	24UF	Gosport	RSE	SE	B3	B	T2	HID	LOC
156	24UG	Hart	RSE	SE	C2	C	T1	MID	LOC
157	24UH	Havant	RSE	SE	B3	B	T2	HMD	LOC
158	24UJ	New Forest	RSE	SE	B1	B	T1	LMD	LOC
159	24UL	Rushmoor	RSE	SE	C1	C	T1	HID	LMC
160	24UN	Test Valley	RSE	SE	C2	C	T1	LMD	LOC
161	24UP	Winchester	RSE	SE	C2	C	T1	LMD	LOC
162	26UB	Broxbourne	REE	EE	B3	B	T1	HMD	LOC
163	26UC	Dacorum	REE	EE	C2	C	T1	MID	LMC
164	26UD	East Hertfordshire	REE	EE	C2	C	T1	MID	LOC
165	26UE	Hertsmere	REE	EE	C2	C	T1	HMD	LMC
166	26UF	North Hertfordshire	REE	EE	C2	C	T1	MID	LMC
167	26UG	St Albans	REE	EE	C2	C	T1	HMD	LMC
168	26UH	Stevenage	REE	EE	B3	B	T2	HID	LMC
169	26UJ	Three Rivers	REE	EE	B3	B	T1	HMD	LMC
170	26UK	Watford	REE	EE	C1	C	T2	HID	HMC
171	26UL	Welwyn Hatfield	REE	EE	C1	C	T2	HMD	LMC
172	29UB	Ashford	RSE	SE	B1	B	T1	LMD	LOC
173	29UC	Canterbury	RSE	SE	A3	A	T2	MID	LOC

#	2001 code	Zone name	Metro and Non-metro Zones	GORs	Vickers Groups	Vickers Families	Deprivation Quintile	Density Quintiles	Ethnic concentration
174	29UD	Dartford	RSE	SE	B3	B	T2	HMD	LMC
175	29UE	Dover	RSE	SE	B2	B	T2	MID	LOC
176	29UG	Gravesham	RSE	SE	B3	B	T2	HMD	HMC
177	29UH	Maidstone	RSE	SE	C2	C	T1	MID	LOC
178	29UK	Sevenoaks	RSE	SE	C2	C	T1	MID	LOC
179	29UL	Shepway	RSE	SE	B2	B	T2	LMD	LOC
180	29UM	Swale	RSE	SE	B3	B	T2	MID	LOC
181	29UN	Thanet	RSE	SE	B2	B	T3	HMD	LOC
182	29UP	Tonbridge and Malling	RSE	SE	B2	B	T1	MID	LOC
183	29UQ	Tunbridge Wells	RSE	SE	B1	B	T1	MID	LOC
184	30UD	Burnley	RNW	NW	A2	A	T3	HMD	HMC
185	30UE	Chorley	RNW	NW	B3	B	T1	MID	LOC
186	30UF	Fylde	RNW	NW	B1	B	T1	MID	LOC
187	30UG	Hyndburn	RNW	NW	A2	A	T3	HMD	HMC
188	30UH	Lancaster	RNW	NW	A3	A	T2	LMD	LOC
189	30UJ	Pendle	RNW	NW	A2	A	T3	MID	HMC
190	30UK	Preston	RNW	NW	A3	A	T3	HMD	HMC
191	30UL	Ribble Valley	RNW	NW	B1	B	T1	LOD	LOC
192	30UM	Rossendale	RNW	NW	B3	B	T2	MID	LOC
193	30UN	South Ribble	RNW	NW	B3	B	T1	HMD	LOC
194	30UP	West Lancashire	RNW	NW	B3	B	T1	MID	LOC
195	30UQ	Wyre	RNW	NW	B3	B	T1	MID	LOC
196	31UB	Blaby	REM	EM	B1	B	T1	HMD	LMC
197	31UC	Charnwood	REM	EM	C1	C	T1	MID	HMC
198	31UD	Harborough	REM	EM	C2	C	T1	LMD	LOC
199	31UE	Hinckley and Bosworth	REM	EM	B3	B	T1	MID	LOC
200	31UG	Melton	REM	EM	B1	B	T1	LOD	LOC
201	31UH	North West Leicestershire	REM	EM	B3	B	T1	MID	LOC
202	31UJ	Oadby and Wigston	REM	EM	C1	C	T1	HID	HIC
203	32UB	Boston	REM	EM	B1	B	T2	LMD	LOC
204	32UC	East Lindsey	REM	EM	B2	B	T1	LOD	LOC
205	32UD	Lincoln	REM	EM	A3	A	T3	HID	LOC
206	32UE	North Kesteven	REM	EM	B1	B	T1	LOD	LOC
207	32UF	South Holland	REM	EM	B1	B	T1	LOD	LOC
208	32UG	South Kesteven	REM	EM	B1	B	T1	LMD	LOC
209	32UH	West Lindsey	REM	EM	B1	B	T1	LOD	LOC
210	33UB	Breckland	REE	EE	B1	B	T1	LOD	LOC
211	33UC	Broadland	REE	EE	B1	B	T1	LMD	LOC
212	33UD	Great Yarmouth	REE	EE	B2	B	T3	MID	LOC
213	33UE	King's Lynn and West Norfolk	REE	EE	B1	B	T1	LOD	LOC
214	33UF	North Norfolk	REE	EE	B2	B	T1	LOD	LOC
215	33UG	Norwich	UEE	EE	A2	A	T4	HID	LOC
216	33UH	South Norfolk	REE	EE	B1	B	T1	LMD	LOC

#	2001 code	Zone name	Metro and Non-metro Zones	GORs	Vickers Groups	Vickers Families	Deprivation Quintile	Density Quintiles	Ethnic concentration
217	34UB	Corby	REM	EM	B3	B	T3	HMD	LOC
218	34UC	Daventry	REM	EM	C2	C	T1	LOD	LOC
219	34UD	East Northamptonshire	REM	EM	B1	B	T1	LMD	LOC
220	34UE	Kettering	REM	EM	B3	B	T1	MID	LOC
221	34UF	Northampton	REM	EM	B3	B	T2	HID	HMC
222	34UG	South Northamptonshire	REM	EM	C2	C	T1	LMD	LOC
223	34UH	Wellingborough	REM	EM	B3	B	T2	MID	HMC
224	35UB	Alnwick	RNE	NE	B1	B	T2	LOD	LOC
225	35UC	Berwick-upon-Tweed	RNE	NE	B1	B	T3	LOD	LOC
226	35UD	Blyth Valley	RNE	NE	A1	A	T3	HMD	LOC
227	35UE	Castle Morpeth	RNE	NE	B1	B	T1	LOD	LOC
228	35UF	Tynedale	RNE	NE	C2	C	T1	LOD	LOC
229	35UG	Wansbeck	RNE	NE	A1	A	T3	HMD	LOC
230	36UB	Craven	RYH	YH	B1	B	T1	LOD	LOC
231	36UC	Hambleton	RYH	YH	B1	B	T1	LOD	LOC
232	36UD	Harrogate	RYH	YH	B1	B	T1	LMD	LOC
233	36UE	Richmondshire	RYH	YH	B1	B	T1	LOD	LOC
234	36UF	Ryedale	RYH	YH	B1	B	T1	LOD	LOC
235	36UG	Scarborough	RYH	YH	B2	B	T2	LMD	LOC
236	36UH	Selby	RYH	YH	B1	B	T1	LMD	LOC
237	37UB	Ashfield	REM	EM	A1	A	T2	HMD	LOC
238	37UC	Bassetlaw	REM	EM	B3	B	T2	LMD	LOC
239	37UD	Broxtowe	REM	EM	B3	B	T1	HMD	LMC
240	37UE	Gedling	REM	EM	B3	B	T1	HMD	LOC
241	37UF	Mansfield	REM	EM	A1	A	T2	HMD	LOC
242	37UG	Newark and Sherwood	REM	EM	B3	B	T1	LMD	LOC
243	37UJ	Rushcliffe	REM	EM	C2	C	T1	LMD	LMC
244	38UB	Cherwell	RSE	SE	C2	C	T1	LMD	LOC
245	38UC	Oxford	RSE	SE	A3	A	T4	HID	HMC
246	38UD	South Oxfordshire	RSE	SE	C2	C	T1	LMD	LOC
247	38UE	Vale of White Horse	RSE	SE	C2	C	T1	LMD	LOC
248	38UF	West Oxfordshire	RSE	SE	C2	C	T1	LMD	LOC
249	39UB	Bridgnorth	RWM	WM	B1	B	T1	LOD	LOC
250	39UC	North Shropshire	RWM	WM	B1	B	T1	LOD	LOC
251	39UD	Oswestry	RWM	WM	B1	B	T1	LMD	LOC
252	39UE	Shrewsbury and Atcham	RWM	WM	B1	B	T1	LMD	LOC
253	39UF	South Shropshire	RWM	WM	B1	B	T1	LOD	LOC
254	40UB	Mendip	RSW	SW	B1	B	T1	LMD	LOC
255	40UC	Sedgemoor	RSW	SW	B1	B	T1	LMD	LOC
256	40UD	South Somerset	RSW	SW	B1	B	T1	LMD	LOC
257	40UE	Taunton Deane	RSW	SW	B1	B	T1	LMD	LOC
258	40UF	West Somerset	RSW	SW	B2	B	T1	LOD	LOC
259	41UB	Cannock Chase	RWM	WM	B3	B	T2	HMD	LOC
260	41UC	East Staffordshire	RWM	WM	B3	B	T2	LMD	LMC

#	2001 code	Zone name	Metro and Non-metro Zones	GORs	Vickers Groups	Vickers Families	Deprivation Quintile	Density Quintiles	Ethnic concentration
261	41UD	Lichfield	RWM	WM	B1	B	T1	MID	LOC
262	41UE	Newcastle-under-Lyme	RWM	WM	B3	B	T2	MID	LOC
263	41UF	South Staffordshire	RWM	WM	B1	B	T1	LMD	LOC
264	41UG	Stafford	RWM	WM	B3	B	T1	LMD	LOC
265	41UH	Staffordshire Moorlands	RWM	WM	B1	B	T1	LMD	LOC
266	41UK	Tamworth	RWM	WM	B3	B	T2	HID	LOC
267	42UB	Babergh	REE	EE	B1	B	T1	LMD	LOC
268	42UC	Forest Heath	REE	EE	B1	B	T2	LMD	LMC
269	42UD	Ipswich	UEE	EE	A3	A	T3	HID	LMC
270	42UE	Mid Suffolk	REE	EE	B1	B	T1	LOD	LOC
271	42UF	St Edmundsbury	REE	EE	B1	B	T1	LMD	LOC
272	42UG	Suffolk Coastal	REE	EE	B1	B	T1	LMD	LOC
273	42UH	Waveney	REE	EE	B2	B	T2	MID	LOC
274	43UB	Elmbridge	RSE	SE	C2	C	T1	HMD	LMC
275	43UC	Epsom and Ewell	RSE	SE	C2	C	T1	HMD	HMC
276	43UD	Guildford	RSE	SE	C1	C	T1	MID	LMC
277	43UE	Mole Valley	RSE	SE	C2	C	T1	MID	LOC
278	43UF	Reigate and Banstead	RSE	SE	C2	C	T1	HMD	LMC
279	43UG	Runnymede	RSE	SE	C1	C	T1	HMD	LMC
280	43UH	Spelthorne	RSE	SE	C2	C	T1	HMD	LMC
281	43UJ	Surrey Heath	RSE	SE	C2	C	T1	HMD	LMC
282	43UK	Tandridge	RSE	SE	C2	C	T1	MID	LOC
283	43UL	Waverley	RSE	SE	C2	C	T1	MID	LOC
284	43UM	Woking	RSE	SE	C2	C	T1	HMD	HMC
285	44UB	North Warwickshire	RWM	WM	B3	B	T1	LMD	LOC
286	44UC	Nuneaton and Bedworth	RWM	WM	B3	B	T2	HMD	LMC
287	44UD	Rugby	RWM	WM	B3	B	T1	LMD	LMC
288	44UE	Stratford-on-Avon	RWM	WM	C2	C	T1	LOD	LOC
289	44UF	Warwick	RWM	WM	C1	C	T1	MID	LMC
290	45UB	Adur	RSE	SE	B2	B	T1	HMD	LOC
291	45UC	Arun	RSE	SE	B2	B	T1	MID	LOC
292	45UD	Chichester	RSE	SE	B1	B	T1	LMD	LOC
293	45UE	Crawley	RSE	SE	B3	B	T2	HID	HMC
294	45UF	Horsham	RSE	SE	C2	C	T1	LMD	LOC
295	45UG	Mid Sussex	RSE	SE	C2	C	T1	MID	LOC
296	45UH	Worthing	RSE	SE	B2	B	T1	HID	LOC
297	46UB	Kennet	RSW	SW	B1	B	T1	LOD	LOC
298	46UC	North Wiltshire	RSW	SW	C2	C	T1	LMD	LOC
299	46UD	Salisbury	RSW	SW	B1	B	T1	LMD	LOC
300	46UF	West Wiltshire	RSW	SW	B1	B	T1	LMD	LOC
301	47UB	Bromsgrove	RWM	WM	B1	B	T1	MID	LOC
302	47UC	Malvern Hills	RWM	WM	B1	B	T1	LMD	LOC
303	47UD	Redditch	RWM	WM	B3	B	T2	HMD	LMC
304	47UE	Worcester	RWM	WM	B3	B	T2	HID	LOC

#	2001 code	Zone name	Metro and Non-metro Zones	GORs	Vickers Groups	Vickers Families	Deprivation Quintile	Density Quintiles	Ethnic concentration
305	47UF	Wychavon	RWM	WM	B1	B	T1	LMD	LOC
306	47UG	Wyre Forest	RWM	WM	B2	B	T1	MID	LOC
307	00EB	Hartlepool	UNE	NE	A1	A	T4	HMD	LOC
308	00EC	Middlesbrough	UNE	NE	A2	A	T4	HID	LMC
309	00EE	Redcar and Cleveland	UNE	NE	A1	A	T3	MID	LOC
310	00EF	Stockton-on-Tees	UNE	NE	A1	A	T3	HMD	LOC
311	00EH	Darlington	UNE	NE	A1	A	T2	MID	LOC
312	00ET	Halton	UNW	NW	A1	A	T3	HMD	LOC
313	00EU	Warrington	UNW	NW	B3	B	T1	HMD	LOC
314	00EX	Blackburn with Darwen	RNW	NW	A2	A	T4	HMD	HIC
315	00EY	Blackpool	RNW	NW	B2	B	T3	HID	LOC
316	00FA	Kingston upon Hull, City of	UYH	YH	A2	A	T5	HID	LOC
317	00FB	East Riding of Yorkshire	RYH	YH	B1	B	T1	LMD	LOC
318	00FC	North East Lincolnshire	RYH	YH	A1	A	T3	HMD	LOC
319	00FD	North Lincolnshire	RYH	YH	B3	B	T2	LMD	LOC
320	00FF	York	RYH	YH	C1	C	T2	HMD	LOC
321	00FK	Derby	UEM	EM	A3	A	T3	HID	HMC
322	00FN	Leicester	UEM	EM	A2	A	T5	HID	HIC
323	00FP	Rutland	REM	EM	B1	B	T1	LOD	LOC
324	00FY	Nottingham	UEM	EM	A2	A	T5	HID	HMC
325	00GA	Herefordshire, County of	RWM	WM	B1	B	T1	LOD	LOC
326	00GF	Telford and Wrekin	RWM	WM	B3	B	T2	MID	LMC
327	00GL	Stoke-on-Trent	RWM	WM	A2	A	T3	HID	LMC
328	00HA	Bath and North East Somerset	RSW	SW	C1	C	T1	MID	LOC
329	00HB	Bristol, City of	USW	SW	A3	A	T3	HMD	HMC
330	00HC	North Somerset	RSW	SW	B1	B	T1	MID	LOC
331	00HD	South Gloucestershire	RSW	SW	C2	C	T1	MID	LOC
332	00HG	Plymouth	USW	SW	A3	A	T3	HID	LOC
333	00HH	Torbay	RSW	SW	A1	A	T2	HMD	LOC
334	00HN	Bournemouth	RSW	SW	B2	B	T2	HID	LOC
335	00HP	Poole	RSW	SW	B1	B	T1	HMD	LOC
336	00HX	Swindon	RSW	SW	B3	B	T2	HMD	LMC
337	00JA	Peterborough	UEE	EE	B3	B	T3	MID	HMC
338	00KA	Luton	RSE	EE	D1	D	T4	HID	HIC
339	00KF	Southend-on-Sea	REE	EE	B2	B	T2	HID	LMC
340	00KG	Thurrock	REE	EE	C2	C	T2	HMD	LMC
341	00LC	Medway	RSE	SE	B3	B	T2	HMD	LMC
342	00MA	Bracknell Forest	RSE	SE	C1	C	T1	HMD	LMC
343	00MB	West Berkshire	RSE	SE	C2	C	T1	LMD	LOC
344	00MC	Reading	RSE	SE	C1	C	T3	HID	HMC
345	00MD	Slough	RSE	SE	D1	D	T4	HID	HIC
346	00ME	Windsor and Maidenhead	RSE	SE	C2	C	T1	HMD	LMC
347	00MF	Wokingham	RSE	SE	C2	C	T1	HMD	LMC

#	2001 code	Zone name	Metro and Non-metro Zones	GORs	Vickers Groups	Vickers Families	Deprivation Quintile	Density Quintiles	Ethnic concentration
348	00MG	Milton Keynes	RSE	SE	C1	C	T2	HMD	HMC
349	00ML	Brighton and Hove	RSE	SE	A3	A	T4	HID	LMC
350	00MR	Portsmouth	RSE	SE	A3	A	T3	HID	LMC
351	00MS	Southampton	RSE	SE	A3	A	T3	HID	LMC
352	00MW	Isle of Wight	RSE	SE	B2	B	T1	MID	LOC
353	WA	Wales	CEL	WA	E	E	T5	LOD	LOC
354	SC	Scotland	CEL	SC	E	E	T5	LOD	LOC
355	NI	Northern Ireland	CEL	0	E	E	T5	LOD	LOC

Z_{17}	**Metro and Non-metro Zones**	
Number	*Code*	*Name*
1	UNE	Tyne and Wear, Teesside
2	RNE	Rest of North East GOR
3	UNW	Greater Manchester, Merseyside
4	RNW	Rest of NW GOR
5	UYH	South Yorkshire, West Yorkshire, Hull
6	RYH	Rest of Yorkshire & the Humber GOR
7	WMC	West Midlands County
8	RWM	Rest of West Midlands GOR
9	UEM	Derby, Leicester & Nottingham
10	REM	Rest of East Midlands GOR
11	UEE	Cambridge, Ipswich, Norwich, Peterborough
12	REE	Rest of East of England GOR
13	LON	London
14	RSE	South East GOR
15	USW	Bristol, Exeter, Plymouth
16	RSW	Rest of the South West GOR
17	CEL	Wales, Scotland, Northern Ireland

Z_{12}	**GORs (England) and Home Countries**	
Number	*Code*	*Name*
1	NE	North East
2	NW	North West
3	YH	Yorkshire and the Humber
4	WM	West Midlands
5	EM	East Midlands
6	EE	East England
7	LO	London
8	SE	South East
9	SW	South West
10	WA	Wales
11	SC	Scotland
12	NI	Northern Ireland

Z_{12}	**Modified Vickers *et al.* LA Groups**	
Number	*Code*	*Name*
1	A1	Industrial Legacy
2	A2	Established Urban Centres
3	A3	Young & Vibrant Cities
4	B1	Rural Britain
5	B2	Coastal Britain
6	B3	Averageville
7	C1	Prosperous Urbanites
8	C2	Commuter Belt
9	D1	Multicultural Outer London
10	D2	Mercantile Inner London
11	D3	Cosmopolitan Inner London
12	E	Wales, Scotland, Northern Ireland

Z_5	**Modified Vickers *et al.* LA Families**	
Number	*Code*	*Name*
1	A	Urban UK
2	B	Rural UK
3	C	Prosperous Britain
4	D	Urban London
5	E	Celtic Fringe

Z_5	**Townsend Deprivation Quintile (2001 Census)**	
Number	*Code*	*Name*
1	T1	Quintile 1 Least deprivation
2	T2	Quintile 2 Low middle deprivation
3	T3	Quintile 3 Middle deprivation
4	T4	Quintile 4 High middle deprivation
5	T5	Quintile 5 Most deprived

Z_5	**Density Quintiles**	
Number	*Code*	*Name*
1	LOD	Low density
2	LMD	Low middle density
3	MID	Middle density
4	HMD	High middle density
5	HID	High density

Z_4	**Ethnic concentration (2001)**	
Number	*Code*	*Name*
1	LOC	Low NWH LQ<50
2	LMC	Low Middle NWH LQ >=50, <100
3	HMC	High Middle NWH LQ >=100, <200
4	HIC	High NWH LQ>=200

APPENDIX A.3 AGE CODES AND NAMES

PERIOD-COHORTS USED IN THE PROJECTION MODEL

Code	Names: Period-cohorts	Code	Names: Period-cohorts	Code	Names: Period-cohorts	Code	Names: Period-cohorts
0	-1 to 0	25	24 to 25	50	49 to 50	75	74 to 75
1	0 to 1	26	25 to 26	51	50 to 51	76	75 to 76
2	1 to 2	27	26 to 27	52	51 to 52	77	76 to 77
3	2 to 3	28	27 to 28	53	52 to 53	78	77 to 78
4	3 to 4	29	28 to 29	54	53 to 54	79	78 to 79
5	4 to 5	30	29 to 30	55	54 to 55	80	79 to 80
6	5 to 6	31	30 to 31	56	55 to 56	81	80 to 81
7	6 to 7	32	31 to 32	57	56 to 57	82	81 to 82
8	7 to 8	33	32 to 33	58	57 to 58	83	82 to 83
9	8 to 9	34	33 to 34	59	58 to 59	84	83 to 84
10	9 to 10	35	34 to 35	60	59 to 60	85	84 to 85
11	10 to 11	36	35 to 36	61	60 to 61	86	85 to 86
12	11 to 12	37	36 to 37	62	61 to 62	87	86 to 87
13	12 to 13	38	37 to 38	63	62 to 63	88	87 to 88
14	13 to 14	39	38 to 39	64	63 to 64	89	88 to 89
15	14 to 15	40	39 to 40	65	64 to 65	90	89 to 90
16	15 to 16	41	40 to 41	66	65 to 66	91	90 to 91
17	16 to 17	42	41 to 42	67	66 to 67	92	91 to 92
18	17 to 18	43	42 to 43	68	67 to 68	93	92 to 93
19	18 to 19	44	43 to 44	69	68 to 69	94	93 to 94
20	19 to 20	45	44 to 45	70	69 to 70	95	94 to 95
21	20 to 21	46	45 to 46	71	70 to 71	96	95 to 99
22	21 to 22	47	46 to 47	72	71 to 72	97	96 to 97
23	22 to 23	48	47 to 48	73	72 to 73	98	97 to 98
24	23 to 24	49	48 to 49	74	73 to 74	99	98 to 99
						100	99 to 100
						101	100+ to 101+

PERIOD-AGES (FERTILITY MODEL)

Code	Period-ages	Code	Period-ages
0	15	18	33
1	16	19	34
2	17	20	35
3	18	21	36
4	19	22	37
5	20	23	38
6	21	24	39
7	22	25	40
8	23	26	41
9	24	27	42
10	25	28	43
11	26	29	44
12	27	30	45
13	28	31	46
14	29	32	47
15	30	33	48
16	31	34	49
17	32		

APPENDIX A.4: SEXES/GENDERS CODES AND NAMES

Code	Names
0	Males
1	Females
2	Persons

APPENDIX A.5: PROJECTION MODEL R SCRIPTS AND FILES NEEDED FOR DATA PREPARATION

N:\Earth&Environment\Geography\Research\Projects\EthnicProjections\Projections\Rprojection\FinalProjections\ProjectionScripts

Scripts described in Section 5	Location	File name	EF or ER	Description
Script 1	\BENCH	ReadIn_Bench.r		Script reads in all necessary data
	\ONSTrend	ReadIn_Trend.r		
	\UPTAP	ReadIn_UPTAP.r		
Script 2	\ALL_Scripts	Firstrunemrates_EF	EF	Projection from midyear 2001 to midyear 2002
		Firstrunemrates_ER	ER	
Script 3	\ALL_Scripts	Function_emrates_comp_newfert_EF.r	EF	Compiles function to project the remaining years
		Function_emrates_comp_newfert_ER.r	ER	
		Function_emrates_comp_oldfert_EF.r	EF	
		Function_emrates_comp_oldfert_ER.r	ER	
Script 4	\BENCH	Runmodel_emrates_Bench_comp_EF.r	EF	Specifications which inputs are used to run the model
		Runmodel_emrates_Bench_comp_ER.r	ER	
	\ONSTrend	Runmodel_emrates_trend_comp_EF.r	EF	
		Runmodel_emrates_trend_comp_ER.r	ER	
	\UPTAP	Runmodel_emrates_UPTAP_compEFER.r	EF & ER	
		Runmodel_emrates_UPTAP_comp_EF.r	EF	
		Runmodel_emrates_UPTAP_comp_ER.r	ER	

Additional	\ALL_Scripts	TablesByZones_function.r Tables_writeOut.r		Scripts for output files described in Appendix A6

Data preparation	Location	Files needed for data extensions described in Section 5.5
Survivorship probabilities	\AssumtptionAndTrendFiles\	030409_Read&Arrange.r Survivorextension.r
Fertility		FertilityChangeRates.csv FertilityChangeRates.xlsx Fertility-Trends_2001-2009 (for updating 2001 to 2001/2 to 2007/8) Rates-for-projection
International migration		IntMigAgeProfile.csv IntMigEthnicProfile.csv InternatMIGupdates.xlsx Scenarios - Int Mig Inputs - March 2010.xlxs Worksheet: Immig-Emig Assumptions v2TREND contains the multipliers for the TREND projection, worksheet Immig-Emig Assumptions UPTAP the multipliers for the UPTAP projections
Internal migration		UpdatingInternalMig.csv

APPENDIX A.6: DATABASE OF PROJECTION INPUT AND OUTFILES

All files are currently located on the University of Leeds shared N drive, used by research projects. The files for this project are located on:
N:\Earth&Environment\Geography\Research\Projects\EthnicProjections\Projections\Rprojection\FinalProjections
Access is restricted to the project team at present, but we will deposit a quality assured version with the UK Data Archive, make selected files accessible via our web site and, if successful with a January 2010 bid, make the full database available via a web interface for user access, subject to agreement with source data providers.

Input files and their location

Location	File name	Description
\Inputs\ BENCH	MYpop2001.csv	Midyear population 2001
	Survprob2001.csv	Survivorship probabilities 2001/2
	Allfertility2001.csv	Fertility rates ages 10 to 49 2001/2
	AllimmigrationFlow2001_2.csv ALL_EmigrationRates2001_Jan2010.csv	Immigration flows 2001/2 Emigration rates
	allinm2001.csv	In-migration probabilities into an area from the rest of the UK 2001/2
	alloutm2001.csv	Outmigration probabilities out of an area into the rest of the UK 2001/2
	Mixingmatrix_dec09.csv	Mixing matrix
	Zones.csv Zones_long.csv ethgroups5680.csv GORSlist.csv LA5680.csv	Look up tables
\Inputs\ TREND	MYpop2001.csv	Midyear population 2001
	Survprob2001.csv Survprob2002.csv Survprob2003.csv Survprob2004.csv Survprob2005.csv Survprob2006.csv	Survivorship probabilities 2001/2 to 2006/7
	Allfertility2001.csv Allfertility2002.csv Allfertility2003.csv Allfertility2004.csv Allfertility2005.csv Allfertility2006.csv Allfertility2007.csv	Fertility rates 2001/2 to 2007/8

	AllimmigrationFlow2001_2.csv Imm2002.csv Imm2003.csv Imm2004.csv Imm2005.csv Imm2006.csv allImm2007.csv allImm2008.csv allImm2009.csv allImm2010.csv allImm2011.csv allImm2012.csv allImm2013.csv allImm2014.csv	Immigration flows 2001/2 to 2014/15
	ALL_EmigrationRates2001_Jan2010.csv allemrates2002.csv allemrates2003.csv allemrates2004.csv allemrates2005.csv allemrates2006.csv allemrates2007.csv allemrates2008.csv allemrates2009.csv allemrates2010.csv allemrates2011.csv allemrates2012.csv allemrates2013.csv allemrates2014.csv	Emigration rates 2001/2 to 2014/15
	allinm2001.csv allinm2002.csv allinm2003.csv allinm2004.csv allinm2005.csv allinm2006.csv allinm2007.csv	In-migration probabilities into an area from the rest of the UK 2001/2 to 2007/8
	alloutm2001.csv alloutm2002.csv alloutm2003.csv alloutm2004.csv alloutm2005.csv alloutm2006.csv alloutm2007.csv	Outmigration probabilities out of an area into the rest of the UK 2001/2 to 2007/8
	MortalitydeclineONS2008Based.csv	Mortality decline assumptions TREND projection
	Mixingmatrix_dec09.csv	
	ethgroups5680.csv GORSlist.csv LA5680.csv Zones.csv Zones_long.csv	Look up tables
\Inputs\	MYpop2001.csv	Midyear population 2001

UPTAP	Survprob2001.csv Survprob2002.csv Survprob2003.csv Survprob2004.csv Survprob2005.csv Survprob2006.csv	Survivorship probabilities 2001/2 to 2006/7
	Allfertility2001.csv Allfertility2002.csv Allfertility2003.csv Allfertility2004.csv Allfertility2005.csv Allfertility2006.csv Allfertility2007.csv allfert2008.csv allfert2009.csv allfert2010.csv allfert2011.csv allfert2012.csv allfert2013.csv allfert2014.csv allfert2015.csv allfert2016.csv allfert2017.csv allfert2018.csv allfert2019.csv allfert2020.csv allfert2021.csv	Fertility rates 2001/2 to 2021/22
	AllimmigrationFlow2001_2.csv Imm2002.csv Imm2003.csv Imm2004.csv Imm2005.csv UPallImm2006.csv UPallImm2007.csv UPallImm2008.csv UPallImm2009.csv UPallImm2010.csv UPallImm2011.csv UPallImm2012.csv UPallImm2013.csv UPallImm2014.csv	Immigration flows 2001/2 to 20014/15
	ALL_EmigrationRates2001_Jan2010.csv allemrates2002.csv allemrates2003.csv allemrates2004.csv allemrates2005.csv UPallemrates2006.csv UPallemrates2007.csv UPallemrates2008.csv UPallemrates2009.csv UPallemrates2010.csv UPallemrates2011.csv UPallemrates2012.csv UPallemrates2013.csv UPallemrates2014.csv	Emigration rates 2001/2 to 20014/15

	allinm2001.csv allinm2002.csv allinm2003.csv allinm2004.csv allinm2005.csv allinm2006.csv allinm2007.csv	In-migration probabilities into an area from the rest of the UK 2001/2 to 2007/8
	alloutm2001.csv alloutm2002.csv alloutm2003.csv alloutm2004.csv alloutm2005.csv alloutm2006.csv alloutm2007.csv	Outmigration probabilities out of an area into the rest of the UK 2001/2 to 2007/8
	Mixingmatrix_dec09.csv	Mixing matrix
	MortalitydeclineONS2008Based.csv	Information on mortality decline trends for UPTAP projections
	GORSlist.csv LA355.csv LA5680.csv ethgroups5680.csv Zones.csv Zones_long.csv	Look up tables

Output files and their location

Standard set of output files from each projection and their location. Output files are for selected 11 years in five year intervals, starting with 2001, 2006, 2011 etc. all numbers are person counts. Each folder contains the same set of output files, with the generic file name specified with projection name and year.

Location for projections output files
\BENCHER
\BENCHEF
\TRENDEF
\UPTAPER
\UPTAPER

Generic name of output	Description	Number of ethnic groups	Age groups
pop11APROJECTIONYEAR	Population counts, all LA & eth g		11
pop16E PROJECTIONYEAR	SYA age	16	202
pop21APROJECTIONYEAR	Five year age groups		21
pop21A16EPROJECTIONYEAR	five year ages	16	21
pop3APROJECTIONYEAR	three ages		3
pop3A16EPROJECTIONYEAR	three ages	16	3
pop7APROJECTIONYEAR	seven ages of man		7
pop7A16EPROJECTIONYEAR	seven ages of man	16	7
DensE16PROJECTIONYEAR	Density quintiles	16	1
DensE5PROJECTIONYEAR	Density quintiles	5	1
EthConcE16PROJECTIONYEAR	Ethnic group concentration classes	16	1
EthConcE5PROJECTIONYEAR	Ethnic group concentration classes	5	1
GORE16PROJECTIONYEAR	All Government office regions	16	1
GORE5PROJECTIONYEAR	All Government office regions (GOR)	5	1
IllustrLAE16PROJECTIONYEAR	Most diverse districts in each GOR	16	1
IllustrLAE5PROJECTIONYEAR	Most diverse districts in each GOR	5	1
LAsE16PROJECTIONYEAR	Local areas	16	1
MetroE16PROJECTIONYEAR	Metro/non-metro zones	16	1
MetroE5PROJECTIONYEAR	Metro/non-metro zones	5	1
TownsE16PROJECTIONYEAR	Townsend quintiles	16	1
TownsE5PROJECTIONYEAR	Townsend quintiles	5	1
VickFamE16PROJECTIONYEAR	Vickers *et al.* families	16	1
VickFamE5PROJECTIONYEAR	Vickers *et al.* families	5	1
VickGroupE16PROJECTIONYEAR	Vickers *et al.* groups	16	1
VickGroupE5PROJECTIONYEAR	Vickers *et al.* groups	5	1

APPENDIX A.7: PROJECT PUBLICATIONS

#	Year	Title
1	2008	Boden P and Rees P (2008) New Migrant Databank: Concept, development and preliminary analysis. Paper presented at the QMSS2 seminar on Estimation and Projection of International Migration, University of Southampton, 17-19 September 2008 [PDF]
2	2008	Norman P, Gregory I, Dorling D and Baker A (2008) Geographical trends in infant mortality: England and Wales, 1970–2006, *Health Statistics Quarterly* 40: 18-29 [PDF]
3	2008	Rees P, Norman P and Boden P (2008) A population projection model for ethnic groups in the United Kingdom: a specification. Draft paper, School of Geography, University of Leeds
4	2008	Rees P and Wohland P (2008) Estimates of ethnic mortality in the UK. *Working Paper 08/04*, School of Geography, University of Leeds, Leeds [PDF]
5	2008	Rees P, Wohland P, Norman P and Boden P (2008) A Population Projection Model for Ethnic Groups: Specification for a Multi-Country, Multi-Zone and Multi-Group Model for the United Kingdom. Paper presented at the International Conference on Effects of Migration on Population Structures in Europe, Vienna, 1-2 December 2008 [PDF]
6	2008	Stillwell J, Hussain S and Norman P (2008) The internal migration propensities and net migration patterns of ethnic groups in Britain. *Migration Letters*, 5(2), 135-150 [PDF]
7	2008	Tromans N, Natamba E, Jefferies J and Norman P (2008) Have national trends in fertility between 1986 and 2006 occurred evenly across England and Wales? *Population Trends* 133: 7-19 [PDF]
8	2008	Wohland P and Rees P (2008) Is it who we are or where we live? Life expectancy in Yorkshire and the Humber by ethnicity, *The Yorkshire & Humber Regional Review*, 18(3): 20-22 [PDF]
9	2009	Rees, P., Stillwell, J., Boden, P. and Dennett, A. (2009) Part 2: A review of migration statistics literature. Pp.53-140 In UKSA, *Migration Statistics: the Way Ahead?* Report 4, July. London: UK Statistics Authority. ISBN: 978-1-85774-904-5. Online: http://www.statisticsauthority.gov.uk/assessment/monitoring-reports/index.html
10	2009	Rees P with Wohland P, Norman P and Boden P (2009) Ethnic Population Projections: A Review of Models and Findings, Paper presented at the Seminar on Multi-attribute analysis and projections of ethnic populations, Quantitative Methods in the Social Sciences, Seminar Series 2 (European Science Foundation), Thorbjørnrud Hotel, Jevnaker, Norway, 3-5 June 2009 [PDF]
11	2009	Rees P, Wohland P and Norman P (2009) The estimation of mortality for ethnic groups at local scale within the United Kingdom, *Social Science and Medicine*, 69, 1592-1607, doi:10.1016/j.socscimed.2009.08.015 [web link]
12	2010	Boden P and Rees P (2010) New Migrant Databank: concept and development, Chapter 5 in Stillwell J, Duke-Williams O and Dennett A (eds.) *Technologies for Migration and Commuting Analysis*. IGI Global, Hersey, PA
13	2010	Boden P and Rees P (2010) International migration: the estimation of immigration to local areas in England using administrative sources, *Journal of the Royal Statistical Society, Series A* (Statistics in Society), in press [link]
14	2010	Dennett, A. and Rees, P. (2010) Estimates of internal migration flows for the UK, 2000-2007. *Population Trends*, accepted subject to review and revision.
15	2010	Norman P (2010) Relationships between UK subnational trends in infant mortality and fertility. In *Population Dynamics and Projection Methods, UPTAP Volume 4*, Stillwell J and Clarke M (eds.). Springer: Dordrecht (forthcoming)
16	2010	Norman P, Rees P, Wohland P and Boden P (2010) Ethnic group populations: the components for projection, demographic rates and trends. Chapter 14 in Stillwell, J. and van Ham, M. (eds.) Ethnicity and Integration. Series: Understanding Population Trends and Processes. Berlin: Springer, in press. [PDF]
17	2010	Wohland P and Rees P (2009) Life Expectancy Variation across England's Local Areas by Ethnic Group in 2001, Journal of Maps, accepted subject to review and revision.

APPENDIX A.8: PROJECT PRESENTATIONS

#	Year	Title
1	2007	Norman P, Stillwell J and Hussain S (2007) Propensity to migrate by ethnic group: 1991 & 2001. Presentation at the Sample of Anonymised Records: User Meeting, Royal Statistical Society, London, 12 November 2007 [PPS]
2	2008	Rees P (2008a) Design of a subnational population projection model for ethnic groups and for dealing with uncertainty in internal migration. BSPS Day Meeting on Population Projections, 29 February 2008, .London School of Economics and Political Science, Houghton Street, London [PPS]
3	2008	Rees P, Norman P and Boden P (2008) What happens when international migrants settle? Ethnic group population trends and projections for UK local areas under alternative scenarios. Understanding Population Trends and Processes, Annual Conference, Leeds, 18-19 March 2008
4	2008	Rees P (2008b) Design of a subnational population projection model for ethnic groups and for dealing with uncertainty in internal migration. Seminar presented at the Office for National Statistics, Titchfield, 11 April 2008
5	2008	Rees P and Boden P (2008) Measuring long and short-term migration. Presentation at the Joint BURISA/Statistics User Forum Conference (with the Royal Statistical Society), All Change – How Can We Get Better Statistics to Plan Local Services, Royal Statistical Society, London, 16 May 2008. [PDF]
6	2008	Rees P (2008) Estimates of ethnic group mortality for local authorities in England. Presentation at the Greater London Authority, 13 June 2008
7	2008	Boden P and Rees P (2008) New migrant databank. Presentation at the Greater London Authority, City Hall, London, 13 June 2008
8	2008	Rees P and Wohland P (2008) Estimates of ethnic mortality in the UK. Presentation at the ESRC Research Methods Festival, Session: Research Methods for Understanding Population Trends and Processes using secondary data, St. Catherine's College, Oxford, 1st July 2008. [PDF]
9	2008	Tromans N, Natamba E, Jefferies J and Norman P (2008) Changing subnational fertility trends in England and Wales. Presentation at the British Society for Population Studies conference, Manchester, 10-12 September 2008. [PPS]
10	2008	Rees P and Wohland P (2008) Development of a projection model for ethnic groups in the UK incorporating internal and international migration and new estimates of ethnic mortality. Presentation at the QMSS2 Seminar on the Estimation and Projection of International Migration, University of Southampton, 17-19 September 2008. Also presented at the Office for National Statistics, Titchfield, 19 September 2008. [PDF]
11	2008	Rees P, Wohland P, Norman P and Boden P (2008) Design of a subnational population projection model for ethnic groups, group presentaiotn at the CSAP Meeting, School of Geography, University of Leeds, 14.October 2008 [PDF]
12	2008	Rees P and Wohland P (2008) Estimation of mortality for ethnic groups at local scale, Presentation at the Southampton Social Statistics Seminar, Thursday 20 November 2008 [PDF]
13	2008	Rees P, Wohland P, Norman P and Boden P (2008) A Population Projection Model For Ethnic Groups, Specification for a Multi-Country, Multi-Zone and Multi-Group Model for the United Kingdom, Presentation at the International Conference of Effects of Migrations on Population Structures in Europe, Vienna 1. and 2. December 2008 [PDF]
14	2008	Norman P, Boden P, Stillwell J and Rees P, Wohland P, Dennett A, Hussain S (2008) Ethnic populations: the components for projection, 2nd December 2008, Social Statistics Section, Royal Statistical Society, 12 Errol Street, London [PDF]

15	2008	Norman P and Rees P, Wohland P, Boden P, John Stillwell, Adam Dennett, Serena Hussain (2008) What happens when international migrants settle? Ethnic group population trends & projections for UK local areas -The components for projection, Regional Health Intelligence Forum, Yorkshire and Humber Public Health Observatory, University of York, 8th December [PDF]
16	2008	Rees P, Norman P, Wohland P and Boden P Ethnic (2008) Group Population Trends and Projections for UK Local Areas, Presentation to a Stakeholder Meeting, Thursday 18th December, 2008, GLA, City Hall, The Queen's Walk, More London, London SE1 2AA [PDF]
17	2009	Wohland P with Rees P & Norman P (2009) Trends in Life Expectancy in the UK: How have inequalities changed for local areas in the UK and what can we expect for the future?. Presentation at the Fifths Biennial Population Geographies Conference, Dartmouth College, 6th August 2009 [PDF]
18	2009	Boden P (2009) The New Migrant Databank, UPTAP-GROS Scottish Government workshop, Understanding Population Trends and Processes, Thursday 12th February 2009, Edinburgh [PDF]
19	2009	Boden P. (2009) International Migration-Using administrative datasets for migration analysis and estimation, ONS Centre for Demography, Titchfield, May 2009 [PDF]
20	2009	Rees P (2009) Ethnic Population Projections: Review of Models and Findings presented at the Seminar Multi- Paper QMSS2 on Multiattribute analysis and projections of ethnic populations, Thorbjørnrud Hotel, Jevnaker, Norway, June 2009 [PDF]
21	2009	Norman P (2009) UK subnational variations in fertility &infant mortality: 1981 to 2006. Presentation at the Fifths Biennial Population Geographies Conference, Dartmouth College, 6th August 2009 [PDF]
22	2009	Rees P and Wohland P (2009) What happens when international migrants settle? An analysis of the demographic future of ethnic mixing in the Presentation at the RGS-IBG Conference, 26th to 28th of August 2009, Manchester [PDF]
23	2009	Boden P and Rees P (2009) International migration: the local impact of uncertainty in national projections. Presentation at the British Society for Population Studies, Annual Conference, Brighton, 9-11 September 2009 [PDF]
24	2009	Norman P (2009) The estimation & application of ethnic group fertility rates in a projection of sub-national populations in the UK. Presentation at the British Society for Population Studies, Annual Conference, Brighton, 9-11 September 2009 [PDF]
25	2009	Rees P and Wohland P (2009) How will the ethnic composition of the UK population change in the next 50 years? A projection of the ethnic populations of local areas, regions and the country. Presentation to a Government Communications Network Event, Central Office of Information, London, 4th Dec 2009 [PDF]
26	2010	Rees P, Wohland P, Norman P, and Boden P (2010) How will the ethnic composition of the UK population change in the next 50 years? A projection of the ethnic populations of local areas, regions and the country , Presentation to a Stakeholder Meeting, Wednesday 6th January, 2010, GLA, City Hall, The Queen's Walk, London SE1 2AA [PDF]
27	2010	Boden P (2010) International migration - its impact upon local population estimates & projections. Presented at BSPS / ONS meeting on 'ONS changes to mid-year estimates: adding it all up', January 7th University of Leeds
28	2010	Dennett A & Rees P (2010) Estimates of internal migration flows for the UK, 2000-07. Presented at BSPS / ONS meeting on 'ONS changes to mid-year estimates: adding it all up', January 7th University of Leeds

29	2010	Norman P (2010) Effects on rates of revising mid-year estimates. Presented at BSPS / ONS meeting on ‘ONS changes to mid-year estimates: adding it all up’, January 7th University of Leeds