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A local analysis of ethnic group population trends and projections for the UK

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Abstract Projections of the UK's ethnic populations from 2001 to 2051 show significant future change. Groups outside the White British majority will increase in size and share, not only in core areas but throughout the country. Ethnic minorities will shift out of deprived local authorities and into less deprived ones, while the White distribution remains stable. The share of the Mixed group population in the most deprived quintile (Q5) of local authorities reduces from 26 to 19%, while its share in the least deprived quintile (Q1) increases from 22 to 29%. The corresponding shifts for Asian groups are from 25 to 18% for Q5 and from 9 to 20% for the Q1. For Black groups the Q5 quintile sees a decrease from 54 to 39% while the Q1 sees an increase from 7 to 19%. There are shifts to local authorities with lower ethnic minority concentrations by Mixed, Asian and Black populations from local authorities with high ethnic concentrations, while the White, Chinese and Other group distributions remain in 2051 as they were in 2001. So, ethnic minority groups will be less segregated from the rest of the population in 2051 than in 2001. Indices of Dissimilarity between each group and the rest of the population fall by a third over the projection period. The UK in 2051 will be a more ethnically diverse society than in 2001.

Keywords Ethnic group · Population projection · Local areas · United Kingdom · Ethnic re-distribution

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Introduction

The last two decades in the UK since 1990 have been characterized by a considerable net immigration flow. From the 1950s to the 1980s there were also important immigration streams though often emigration was higher. Many immigrants have settled in the UK, found work, raised families, become citizens and participated in British business, politics and culture. However, their identity as immigrants changed, as new generations were born. Immigrants and their descendants became members of ethnic communities, still associated with their origin countries but increasingly linked with the UK. The recognition that immigrants and their descendants become distinctive ethnic communities has been built into official statistics since the 1980s when an ethnic question was introduced into official surveys. Since 1991 an ethnic question has been asked in the population census; ethnicity is one of the population differences monitored by the Equality and Human Rights Commission, and a large body of work has studied the nature of ethnic communities over this period. In a research project funded by ESRC (see Acknowledgments) we were interested in looking at the UK's ethnic future. We posed the following research question: what effect will ethnic differences in fertility, mortality, internal and international migration have on the size and ethnic composition of UK local populations?

Why are these changes important? They are altering the ethnic composition of the population, with many implications for the cohesion of UK society, for the nature of British culture and for coping with the challenges of ageing to mid-century. Demographic intensities vary across ethnic groups: that heterogeneity needs to be incorporated into projections. Ethnic projections are needed in planning for social goals (greater equality of opportunity), economic goals (the future labour supply) and community goals (the right schooling, goods and services). You might object that the future is likely to be uncertain and that projections will turn out to be wrong. The range of uncertainty can be estimated by running projections under different scenarios or by sampling from error distributions of the inputs. We run several scenarios to assess uncertainty.

To answer the research question, we built and used a new population projection model to explore alternative futures. To drive this model we built estimates of ethnic group fertility using census data, birth statistics and survey tables. We estimated ethnic group mortality (hitherto unmeasured) through modelling mortality from morbidity proxies. We built a databank of administrative variables related to international migration for local areas in order to develop estimates for long-term immigration and emigration. We constructed estimates of internal migration by ethnic groups from census and register migration data.

The plan for the paper is as follows. The second section reviews approaches to ethnic population projection and selects a model for use in the UK. The third section summarizes the features of the model. The fourth section summarizes the methods used to estimate ethnic specific component inputs and presents the assumptions used. The fifth section describes the scheme adopted for our four projections and the main results at national scale. The sixth section carries out a spatial analysis of the local authority projection results. The final section summarizes our main findings.

A review of projection practice for ethnic groups

Coleman (2006) has reviewed methods in different European countries where foreign status (defined by citizenship or country of birth) is the ethnic definition used; these projections lead to the absorption of the foreign into the national population after one or two generations. However, ethnic differences may persist into later generations. As we have adopted self-identification to define ethnicity, we focus the review on British work.

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

'Ethnic' derives from the Greek word *ethnos*, meaning belonging to a nation. Ethnicity may be defined using a variety of measures from surveys, censuses or registers. Persons are born into an ethnic group and usually remain there for the rest of their lives. The stability of ethnic status contrasts with age and family status which change through the life course, and with social class, which changes through occupational mobility. Variables used to define ethnicity include country of birth, country of citizenship, country of family origin, race, language, religion or self-identification. Many of these statuses do change over time and lead to problems in identifying groups; for example, people may change their self-identified ethnicity. Rees (2002) made suggestions about how changes might be incorporated at the onset of adulthood, but robust empirical evidence about changes in ethnic self-identification is lacking (Simpson and Akinwale 2007; Simpson et al. 2005).

Ethnic classifications in the United Kingdom are based on self-reporting through census or social survey questionnaires (ONS 2003). Considerable consultation goes into the formulation of the question. The resulting categories are a compromise between the demands of pressure groups interested in identifying their own group and the need to keep the question simple. Ethnic classifications change as new groups immigrate and couples from different groups have children of mixed ethnicity.

Table 1 shows the ethnic group classifications adopted in the 2001 Census in England, Wales, Scotland and Northern Ireland. The classifications are based on two concepts: race and country of origin (either directly through migration or through ancestry). Many studies (e.g. Rees 2008; Rees and Parsons 2006) used a collapsed version of the classification (e.g. White, Mixed, Asian, Black, Chinese & Other) but these merged classes hide huge differences in sub-group attributes and dynamics. Most studies (e.g. Coleman 2006; Coleman and Scherbov 2005; Rees and Butt 2004) drop the Mixed groups. Since the 2001 Census revealed these groups to have the youngest age structures and therefore growth potential, such an omission is regrettable. In 2011 a new census will be taken, which proposes an ethnic question with few changes from that used in the 2011 Census (Cabinet Office 2008; White and McLaren 2009). The projection results described in this report can be easily aggregated to the new 2011 classification.

In our work we have adopted the 16 ethnic groups used in the 2001 Census for England and Wales and made estimates of the Scotland and Northern Ireland

Table 1 Ethnic groups in the 2001 UK Census

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

population of these groups using ancillary information (custom tables supplied by GROS and NISRA).

We add the demographic attributes of age and sex to that of ethnicity in the projection model. It would be very interesting to identify further attributes of local ethnic group populations such as generation, country of birth, language ability or socio-economic status. These attributes are all studied using historical survey or census evidence. However, such a more general model is beyond the scope of the research reported here and probably best first attempted for the national population rather than local populations.

The structure of ethnic population projection models

Ethnic projection models may differ from standard projection models in three ways. The first is whether or not a mixing process is introduced into the fertility submodel (e.g. Coleman 2010; Wilson 2009). The second is whether transitions between ethnic groups are allowed during the life course. The third difference is whether people are allowed to belong to more than one ethnic group, which may arise when multi-ticking of response categories is allowed. In the New Zealand census this is allowed: the group populations used in the projections are all the people who ticked an ethnic category. Thus, the sum of projected populations for the New Zealand ethnic groups exceeds the projected populations for all groups. In other respects ethnic projection models are replications of the standard model, for which ethnic specific inputs are needed.

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. Where subnational units are used, then consideration must be given to how migration between them is handled. There are three approaches: (1) the single region model, which treats each subnational unit as a single entity with streams of net-migration or in-migration and out-migration (Rees and Parsons 2006); (2) the multi-region model, which handles all subnational units together and models the flows between them (Rogers 1995); and (3) the bi-region model, which projects each subnational unit along with its rest-of-the-country unit. The single region approach is easy to compute but theoretically flawed (Rogers 1990). The multi-region approach is more elegant theoretically but difficult to compute if there are a large number of regions. The bi-region approach is a reasonable compromise which Wilson and Bell (2004) argue gives results close to the multi-regional model.

Population projection models adapted for ethnic groups

In Wohland et al. (2010) we reviewed the history of ethnic population projections and their associated models. Here we summarize the main insights of that review.

Simpson and colleagues have used a projection software system, POPGROUP (CCSR 2010), that used spreadsheets and spreadsheet macros to implement a single region cohort-component projection model with total net migration flows in order to project local authority ethnic group populations; see Wohland et al. (2010) for a review of the local authority studies. Rees and Parsons (2006) expanded the single region model by handling migration in four streams: internal outmigration and emigration as rates or probabilities multiplied by origin region populations at risk, and immigration and internal in-migration handled as flows. These single region models are easy to implement for a large number of regions and groups, but they neglect the vital links between regions captured in multi-region models: the out-migrants from one region become the in-migrants to other regions.

The multi-region cohort-component projection model has been implemented by the Office of National Statistics (ONS). ONS use a subnational model for Local Authorities (LAs) in England with multi-region features (ONS 2010). However, these projections only handle the whole population, not ethnic group populations. Greater London has taken this additional step and implemented its multi-borough model for ethnic groups. As the UK city with the largest ethnic minority population, Greater London has a longstanding interest in understanding ethnic group population trends. Ethnic projections were prepared by London Research Centre (1999) and Storkey (2002), which incorporated ethnic fertility estimates and linked them 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 (see Wohland et al. 2010). Ethnic specific fertility rates were estimated using Hospital Episode Statistics accessed by the London Health Observatory.

The bi-region model was developed and tested against multi-region models by Wilson and Bell (2004) for Australian states, building on experiments by Rogers (1976). They establish that a set of bi-region models gives results close to a full

multi-region model. Wilson (2009) has also developed a bi-region model for the indigenous and non-indigenous population of the Northern Territory, Australia. The estimation and computational requirements of a bi-region model are much smaller than for a multi-region model.

This review of projection models (Wohland et al. 2010) 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. After experimentation, we adopted a bi-regional cohort-component model because the very large number of spatial units (355) and large number of ages (single ages to 100+) coupled with the very concentrated distributions of our 16 ethnic groups meant that we faced difficulties in estimating the inter-area migration probabilities.

A projection model for local ethnic group populations

We discuss first the accounting framework of our projection model, second the state-space of the model and third the computational steps in the model. A full account is given in Wohland et al. (2010).

The bi-region accounting framework

Table 2 shows the population accounting framework used in the model for a typical local authority, ethnic group and gender combination together with its twin population region in the rest of the UK. The table holds transition data, which derive from the 2001 Census in which a question is asked about usual residence 1 year before. We use 2001 Census data because this is the best source for ethnic group migration data at the local level. Tables of ethnic specific migration can be generated from the Labour Force Survey but reliably only at regional level. The migration data for years after 2001, which come from the NHS Patient Registers, report total migration not ethnic group migration. From the start population are subtracted the region non-survivors, the region emigrant survivors and the sum of out-migrant survivors to the rest of the country. Then we add the sum of in-migrant survivors from other regions within the country and surviving immigrants from the rest of the world to yield the end of interval population. We estimate surviving-stayers by subtracting in-migrant survivors and immigrant survivors from the 2001 Census population aged 1+. We add surviving internal out-migrants to surviving stayers to estimate the region population surviving within the country. This population is used to compute the probabilities of migration conditional on survival which can be multiplied by the within-country survivors to project the flow of surviving out-migrants. These conditional probabilities enable us to decouple the survival process from the migration process. We can estimate the survivorship probabilities from life tables. This procedure avoids problems of computing mortality probabilities directly from observed deaths and estimated populations for small ethnic groups and older ages, where the numbers may be inconsistent.

Table 2 Bi-region accounts for subnational populations using census migration data

Origins (existence at start of time interval)	Zone	Destinations at end of time interval				Deaths	Totals
		Same zone		Rest of the UK	Rest of World		
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**

The accounting framework applies to each period-cohort/sex combination from age 0/age 1 to age 100+/age 101+. 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

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

The state space for projecting ethnic group populations

To carry out the 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. We adopt the ethnic classification used in the 2001 Census (Table 1) rather than the broader groups adopted by other authors. Most variables in the projection model are classified by sex. The sexes only interact in the fertility process, where a female-dominant fertility model is adopted. The one special ingredient is a fertility module for generating mixed births. Women may have husbands or partners of a different ethnic group and their children will be of mixed ethnicity. Children are assigned an ethnicity by the household representative completing the census form. It is therefore possible to tabulate the ethnicity of children against their mothers' ethnicity. We use a commissioned table from the 2001 Census to estimate these mixing probabilities.

We use period-cohorts for most of the input variables for our cohort-component projection model. It is an advantage to use single years of age in a projection model, so that projections for each year of time can be produced and so that aggregate age groups can be flexibly constructed. We also extend the age range to 100 and over, recognizing that the population has aged in recent decades. We compute probabilities for the last period-cohort by assuming that probabilities in the last two period-cohorts are equal. We convert period-age fertility rates to period-cohort rates by averaging successive rates and use start-of-time ages for the population at risk.

The zones of the model are the lowest tier authorities in England together with Wales, Scotland and Northern Ireland as single zones. We merged the City of London with Westminster and the Isles of Scilly with Penwith because these LAs had small resident populations. The projection model regions were therefore 350 LAs and 2 merged LAs in England, with Wales, Scotland and Northern Ireland

treated as single regions. Local authorities were reorganized in 2009 but our results can easily be aggregated where mergers have occurred.

The time framework involves projecting from midyear (30 June–1 July) in one year to midyear in the next year. Where data refer to calendar year, we averaged successive calendar rates or flows to estimate midyear to midyear interval variables. We define the starting point of our projection (the jump off point) to be mid-2001. We use the projection model for all subsequent midyear to midyear intervals. For the first few years, from 2001–2002 to 2006–2007, the outputs are estimates rather than projections because we use published data to estimate the inputs to the projection. In 2007–2008 we have used as inputs updated estimates for the fertility and internal migration components and assumptions for the mortality and international migration components. From 2008 to 2009 onwards the inputs are set by assumption.

The projection model

A full account of the projection model equations is given in Wohland et al. (2010). Here we provide an outline of the model.

The projection of the new born

We use a standard female dominant fertility model. We compute the number of births by first averaging successive period-age fertility rates to obtain period-cohort rates. These are then multiplied by the start populations of women by age (10–49). We then sum over all ages to produce a total number of infants born to mothers of each ethnic group. This total is assigned to each sex using fixed sex proportions of 0.513 for boys and 0.487 for girls (UK values in 2001). We then add a routine to generate mixed ethnicity births. Detailed tables from the 2001 Census classify infants aged 0 in the census by their mother's ethnicity and their own. From these tables we compute the probabilities that infants have ethnicities conditional on their mother's ethnicity and apply these to the projected births. The conditional probabilities are computed for regions and assumed to apply to their constituent LAs. A similar technique has been used by Greater London with an extension to allow for the potential influence of the male population by age and ethnicity (Bains et al. 2005).

Projection of survivors and non-survivors using survivorship and non-survivorship probabilities

We derive survivorship probabilities from life tables produced using occurrence-exposure mortality rates based on zone of death. To estimate non-survivorship probabilities, we subtract survivorship probabilities from one. We developed full life tables for each ethnic group for all UK local authorities (Rees and Wohland 2008; Rees et al. 2009a, b). Survivorship and non-survivorship probabilities are used to generate the total number of survivors, from the start populations of origin zones, and the total number of deaths experienced by members of those populations.

We project the total number of survivors of the starting population for each ethnic group and sex by multiplying the start populations in an interval by the survivorship probabilities. Deaths are projected by multiplying the non-survivorship probabilities by the start populations.

Projection of emigration and surviving emigrants using emigration rates and survivorship probabilities

As explained earlier, we need to estimate surviving emigration probabilities. The statistics available on emigration derive from the International Passenger Survey (IPS) which estimates the number of emigrations occurring over a 1-year interval, based on a question about intention to leave the country for 12 months or more. However, some of these emigrants may die before the year is out. The emigration counts must therefore be converted to surviving emigrants by applying survivorship probabilities to the emigration flow. We use the square root (geometric mean) of the survivorship probability to reflect the reduced risk of exposure to dying.

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

We compute the numbers in the starting population who survive within the country by subtracting surviving emigrants and non-survivors from the starting population. Then we can estimate surviving internal migrants within a country by multiplying within-country survivors by the probability of migration (from a local area to the rest of the country and from the rest of the country to a local area).

The final populations

We can now bring together the steps defined above and reduce the projection into one statement of how the end population in a time interval is computed for the zone of interest. The final population (by age, sex, ethnicity and local area) is start population minus the projected surviving internal out-migrants and surviving emigrants and plus the surviving in-migrants from the rest of country and surviving immigrants from the rest of the world. More details are given in Wohland et al. (2010).

Estimates of the component inputs and assumptions

One feature of our estimates in the period 2001–2002 to 2006–2007 is that they are independent and distinct from the ethnic population estimates for local authorities produced by ONS (Large and Ghosh 2006a, b). We chose to do this because ONS estimates make no attempt to estimate ethnic specific mortality, have low variation in ethnic fertility estimates and constrain to immigration estimates which may be flawed (Boden and Rees 2010a, b). We now describe the estimates and the assumptions adopted for the projections we label Understanding Population Trends and Processes (UPTAP).

Ethnic fertility estimates, trends and assumptions

We need to estimate age-sex specific fertility rates (ASFRs) and fertility trends by ethnic group. Various population and sample data sets are used to estimate rates since the precise ethnic group information is not necessarily available for our model populations. Four sources of data are combined to make the estimates. Aggregate census data from 1991 and 2001 are used to compute child-woman ratios for local authorities and all 16 ethnic groups. Samples of Anonymized Records from 1991 to 2001 are used to compute more precise child-woman ratios because mothers can be linked to their children. Labour Force Survey data are used annually from 1981 to 2006 to estimate national age-specific fertility rates by ethnic group. Finally, information on births by age of mother and midyear population estimates for local authorities and the resulting local ASFRs provide constraints for the estimation. Total fertility rates (TFRs) by ethnic group and LA are estimated from 1991 to 2001 Census data using child to woman ratios (CWRs) which are assumed to proxy 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. ASFRs are converted from 5-year to single-year using the Hadwiger function fitted to national rates. The estimates are adjusted to agree with local birth statistics.

Assumptions are needed on the direction of fertility in the future. Fertility rates have risen recently from an all-time low in 2001 (Tromans et al. 2008); demographic momentum and social change will affect 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 with 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 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 2009, the fertility of the White and Other groups stays pretty constant whilst the fertility levels of all other ethnicities tend to decline. In the projection model, the decline (growth) rates from 1 year to the next by 5-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 their subgroups. Table 3 sets out the assumed TFRs. Groups with above average fertility (1.93) are the Bangladeshi, Pakistani, Indian and White and Black African groups. Groups with low fertility (TFR of 1.7 or less) are Other White, White and Asian, Other Mixed, Other Asian, Black Caribbean, Other Black, Chinese and Other Ethnic groups. The White British, White Irish, White and Black Caribbean and Black African groups have intermediate fertility levels around the average.

Table 3 The total fertility rate assumptions of the UPTAP projections

Ethnic group	2006–11 average	2021 onwards
White British	1.90	1.88
White Irish	1.75	1.73
Other White	1.71	1.69
White and Black Caribbean	1.82	1.78
White and Black African	2.05	2.01
White and Asian	1.56	1.53
Other Mixed	1.62	1.58
Indian	2.10	1.98
Pakistani	2.32	2.12
Bangladeshi	2.47	2.29
Other Asian	1.74	1.70
Black Caribbean	1.78	1.62
Black African	1.82	1.71
Other Black	1.74	1.70
Chinese	1.47	1.33
Other Ethnic Group	1.74	1.70
All Groups	1.92	1.93

Source: authors' estimates

Mortality estimates, trends and assumptions

Mortality data by ethnic group are not available in the UK since ethnic group is not registered when a person dies. 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 represents only 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 cannot provide local mortality information.

Various studies using longitudinal data find that self-reported health is a strong predictor for subsequent mortality, for subgroups as well as total populations (e.g. Burström and Fredlund 2001; Heistaro et al. 2001; Helweg-Larson et al. 2003; McGee et al. 1999). Because no adequate ethnic mortality data are available, we use illness rates as a proxy measure. Data are given in the 2001 Census on limiting long-term illness by LA and ethnic group.

To estimate mortality by ethnic group, we use a suite of census, official midyear population estimates and vital statistics data to estimate ethnic group life expectancy. First we calculated standardized illness ratios (SIRs) for each LA by sex with data from the 2001 Census. Then we computed standardized mortality ratios (SMRs) for all local areas and both sexes from midyear 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. Full details are given in Rees and Wohland (2008).

We found pronounced differences between the ethnic groups. The 2001 column in Table 4 presents our life expectancy estimates. Most extreme differences are found between the Chinese women with most areas in the top 25% of the distribution of life expectancies across LAs and ethnic groups and the Pakistani women with the largest numbers of areas in the bottom 25%. Most groups experience a North–South gradient. 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.

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 update ethnic mortality in line with the mortalities for all groups.

For the TREND projection (see below), we implemented the mortality assumptions built into the National Population Projections (2008-based). We adopt 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

Table 4 Ethnic life expectancies: 2001 estimates and UPTAP projections to 2051

Ethnic group	Men		Women	
	2001	2046–51	2001	2046–51
White British	75.9	84.7	80.5	86.7
White-Irish	74.9	85.5	80.3	85.5
Other White	76.9	86.6	81.3	87.9
White-Black Caribbean	73.4	82.6	78.7	85.4
White-Black African	74.2	83.8	79.5	86.0
White-Asian	75.1	84.1	80.0	86.3
Other Mixed	74.6	83.8	79.9	86.2
Indian	75.5	84.3	79.3	86.0
Pakistani	73.1	83.1	77.3	84.4
Bangladeshi	72.7	82.5	77.7	84.4
Other Asian	75.2	84.6	79.5	86.0
Black Caribbean	74.4	84.6	79.1	86.2
Black African	76.1	86.8	80.4	87.2
Other Black	73.4	83.3	78.5	85.5
Chinese	78.1	87.8	82.1	88.0
Other Ethnic	76.2	86.3	81.5	88.0
All groups	76.0	84.7	80.5	86.6

Source: 2001 estimates from Rees et al. (2009a, b), projections from Wohland et al. (2010)

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 projection we adopted the long-term rate of decline of 1% used by ONS. For the UPTAP projections we adopted a higher (2%) rate of decline. Table 4 shows the period life expectancies associated with our 2% decline assumption. By 2050 we anticipate an increase of 8.7 years in male life expectancy between 2001 and 2050 and a 6.1 year increase in female life expectancy in the same period, continuing the convergence observed over the period 1991–2006.

International migration estimates, trends and assumptions

International migration is a significant driver of population change in the UK. There are various alternative sources which provide intelligence about the movement of population into and out of the UK (Rees et al. 2009a). 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 (see Rees and Boden 2006 and Green et al. 2008). A 'New Migrant Databank' (NMD) has been developed to produce a repository of UK-wide migration statistics from national to local authority level (Boden and Rees 2010a, b). An alternative method for distributing immigration flows has been derived combining Total International Migration (TIM) statistics at a national level with subnational 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 2010b). The method uses flow 'proportions' to distribute national TIM totals to subnational areas.

The alternative method results in a very different regional and local distribution of immigration flows from that recorded in official statistics. 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 difficult. The 2001 Census provides the only direct source of data on ethnic flows and then only for immigration. We used additional administrative data to create better immigration profiles. NINo registration data from the Department for Work and Pensions were used 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, we 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 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 relied upon census information in combination with aggregate age-sex profiles from the ONS published TIM statistics. 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.

Using TIM statistics at a national level, an estimate of the British/non-British split of emigration was 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 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.

Table 5 sets out the net international migration results of our estimates and assumptions for the UPTAP projections for the 5-year period leading up to the 2011 census, a period 25 years hence and a period at the end of our projection horizon.

Table 5 Net international migration associated with the UPTAP assumptions

Ethnic group	UPTAP-EF assumptions		UPTAP-ER assumptions	
	2006–11	2031–36 onwards	2006–11	2031–36 onwards
White British	−31	−25	−24	−16
White Irish	7	5	6	3
Other White	108	94	57	13
White and Black Caribbean	0	0	−2	−5
White and Black African	2	2	1	−2
White and Asian	2	2	0	−5
Other Mixed	3	3	1	−4
Indian	17	14	12	4
Pakistani	9	8	6	0
Bangladeshi	1	1	0	−2
Other Asian	7	6	4	0
Black Caribbean	3	2	1	1
Black African	16	14	7	−4
Other Black	0	0	0	−1
Chinese	12	10	5	1
Other Ethnic Group	22	19	9	0
All Groups	178	155	83	−17

Annual net international migration in 1000

Source: authors' estimates

The table shows that net international migration is dependent on the projection model adopted (explained below). The UPTAP-EF projection uses emigration flows and assumes a level of net inward migration below that of National Statistics in the long run. In the UPTAP-ER projection, emigration rates are applied to a growing population and the net balance in the long term becomes negative.

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 needed robust estimates of internal migration. Data on migration by ethnic group are available in two sources: the decennial census and the annual Labour Force Survey (LFS). The LFS has been used to understand the structure of UK migration by ethnicity by Raymer and Giulietti (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—internal migration for 16 ethnic groups for LAs in England. Fortunately, commissioned table CO528 was available from the 2001 Census which reports the inter-district flows in England by 16 ethnic groups. To add age and sex as independent variables, a national age-sex profile of migration from the 2001 Census was used.

Because we use census migration data between LAs, there is an opportunity to separate the process of survival from that of migration. Migration data from the 2001 census are generated from a question on location 1 year ago, asked (by definition) of those who have survived the year. So from these data we can compute the probabilities of relocation 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 migration given survival. The ethnic internal migration probabilities thus computed are all non-negative and less than one.

We developed inter-zone migration tables for all 16 ethnic groups and all 355 zones in our analysis. From these tables we are able to compute both the conditional probabilities of out-migration given survival from a local area to the rest of the UK and the probabilities for the reverse flow. To add age-sex detail, 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 inter-regional analysis. This estimate assumes independence of the origin–destination pattern of migration from the age-sex pattern, which is satisfactory as a first approximation. The paper by Stillwell et al. (2008, Fig. 2) presents age profiles for 9 ethnic groups of age-specific migration for 9 ethnic groups and 7 age groups. While these profiles differ by migration level, the relative age profiles are similar. There are restrictions on the detail of origin–destination migration tables by ethnicity, age and sex which the Office for National Statistics is prepared to release. The data set used by Stillwell et al.

(2008) represented the maximum detail available. Further work would be needed to use this information and our national profiles to model local authority single-year-of-age out-migration rates. Microdata from the Labour Force Survey (as used by Raymer et al. 2007) and from the Census Sample of Anonymised Records for Local Authorities, the Small Area Microdata (SAM), could also be used.

These conditional probabilities of migration by ethnicity are updated from their 2000–2001 values derived from the 2001 Census using the time series of all group LA migration from 2001–2002 to 2007–2008 based on the PRDS and NHSCR migration data published by ONS. The LA to LA migration flows after 2000–2001 were estimated for the whole of the UK by Dennett (2010) 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 2007–2008 probabilities would remain constant to 2050–2051, the end of our projection period. Table 6 sets out the consequent total internal migration flows at the start and end of the projection period. The total volume of inter-zone migration projected over the period grows in line with respective projections. It is the directional specificity of migration into and out of local areas which has the most significant effects.

Table 6 Projected totals of inter-zone migration for 355 zones by ethnic group

Ethnic group	UPTAP-EF		UPTAP-ER	
	2006–11	2046–51	2006–11	2046–51
White British	2368	2,679	2,361	2,503
White Irish	33	37	32	30
Other White	283	485	270	304
White and Black Caribbean	26	56	25	47
White and Black African	14	39	14	29
White and Asian	30	80	30	59
Other Mixed	28	72	27	51
Indian	95	148	93	119
Pakistani	41	71	41	60
Bangladeshi	17	28	16	25
Other Asian	31	57	30	41
Black Caribbean	31	36	30	30
Black African	82	146	80	102
Other Black	8	15	8	13
Chinese	46	74	44	49
Other Ethnic Group	48	86	45	51
All Groups	3,180	4,109	3,149	3,515

Source: Authors' estimates.
Notes: Migration numbers are in thousands

Projection results: national overview

The framework for the projections

In this section of the paper we explain how we construct four different projection scenarios. The first (BENCH) explores the effect of ethnic population dynamics prevalent at the start of the century; the second (TREND) explores trends since 2001 and uses assumptions aligned to those in the ONS National Population Projections; the third (UPTAP-EF) and fourth (UPTAP-ER) adopt different trends from 2006 to 2007 that reflect the best judgment of the authors and vary the way in which emigration is handled in the model. In the EF model emigration is introduced as a flow. In the ER model emigration is modelled as an emigration rate multiplied by a population at risk. Table 7 summarizes the characteristics of the four projections.

The UPTAP-EF and UPTAP-ER projections 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 from particular origins. 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 partly 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 as other European member states, other destinations have their own immigration controls which will affect emigration from the UK. We are able to measure the effect of these alternative conceptualizations of international migration on the projected population.

Projections for the United Kingdom

This section picks out the highlights from our projections, concentrating on comparison between 2001 and 2051 populations. We focus on national results in this section and consider the spatial variation in projected ethnic populations in the next section.

Table 7 The framework for the ethnic population projections

Projection	Bi-regional model with	Benchmark inputs	Estimates 2002–07	Assumptions 2007–51
BENCH	Emigration Flows	2001–2002	Constant	Constant
TREND	Emigration Flows	2001–2002	Estimated	Aligned with 2008 NPP
UPTAP-EF	Emigration Flows	2001–2002	Estimated	UPTAP Project
UPTAP-ER	Emigration Rates	2001–2002	Estimated	UPTAP Project

EF emigration flow model, *ER* emigration rates model, *UPTAP* understanding population trends and processes, *BENCH* benchmark, based on 2001–2 (or 2000–1) inputs held constant over the projection horizon

Table 8 Ethnic group projected populations, UK, 2001–2051

Ethnic group	2001	BENCH 2051	TREND 2051	UPTAP-EF 2051	UPTAP-ER 2051
White British	51,469	45,937	58,570	60,274	56,638
White Irish	1,451	1,340	1,610	1,624	1,470
Other White	1,465	4,231	5,059	4,807	2,888
White and Black Caribbean	246	612	778	815	662
White and Black African	83	282	357	362	259
White and Asian	197	589	772	782	564
Other Mixed	162	515	666	671	461
Indian	1,070	2,210	2,669	2,573	2,091
Pakistani	761	1,773	2,120	2,027	1,711
Bangladeshi	289	642	717	730	620
Other Asian	253	620	745	721	518
Black Caribbean	574	669	815	805	693
Black African	500	1,223	1,456	1,421	966
Other Black	99	201	252	256	209
Chinese	254	620	765	734	472
Other Ethnic Group	238	766	898	858	484
All Groups	59,111	62,230	78,249	79,461	70,705

Source: Authors' computations. Notes: All populations are in thousands

Table 8 presents the total populations for the United Kingdom projected under our four scenarios. A comparison of the benchmark projection which uses 2001–2002 component rates, probabilities and flows with the other three projections shows how profoundly the UK's demographic regime has changed in the 2000–2009 decade. Net inflows from outside the UK have increased, fertility rates have risen leading to more births and continued improvement in survival changes have led to higher numbers of older people. The UK population was 59.1 million in 2001. Under the 2008-based National Population Projection (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. 2010). Our TREND projection, 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 again than the TREND projection. We can interpret the NPP-2008 and TREND 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 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 fourth projection in our set, the UPTAP-ER projection, shows projected populations that differ considerably from the NPP aligned projection (TREND). The model for handling emigration is different, as explained above. 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 mainly present results of the TREND and UPTAP-ER projections, so that the reader can agree either with our view of the relationship between the UK and the rest of the world or with the ONS view. Selected results from the other two projections are presented as appropriate.

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 four projections in Table 8 together with populations for 2001. In Table 9 these numbers are converted to percentages to show how the ethnic composition of the population changes to 2051. Table 10 shows the percentage increases in ethnic group populations from 2001 to 2051.

In the BENCH 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

Table 9 Ethnic group projected percentage compositions, UK, 2001–2051

Ethnic group	2001	BENCH 2051	TREND 2051	UPTAP-EF 2051	UPTAP-ER 2051
White British	87.07	73.82	74.85	75.85	80.10
White Irish	2.46	2.15	2.06	2.04	2.08
Other White	2.48	6.80	6.46	6.05	4.09
White and Black Caribbean	0.42	0.98	0.99	1.03	0.94
White and Black African	0.14	0.45	0.46	0.46	0.37
White and Asian	0.33	0.95	0.99	0.98	0.80
Other Mixed	0.27	0.83	0.85	0.84	0.65
Indian	1.81	3.55	3.41	3.24	2.96
Pakistani	1.29	2.85	2.71	2.55	2.42
Bangladeshi	0.49	1.03	0.92	0.92	0.88
Other Asian	0.43	1.00	0.95	0.91	0.73
Black Caribbean	0.97	1.08	1.04	1.01	0.98
Black African	0.85	1.97	1.86	1.79	1.37
Other Black	0.17	0.32	0.32	0.32	0.30
Chinese	0.43	1.00	0.98	0.92	0.67
Other Ethnic Group	0.40	1.23	1.15	1.08	0.68
All Groups	100.00	100.00	100.00	100.00	100.00

Source: Authors' computations

Table 10 Ethnic group projected percentage changes, UK, 2001–2051

Ethnic group	2001	BENCH 2051	TREND 2051	UPTAP-EF 2051	UPTAP-ER 2051
White British	0	−11	14	17	10
White Irish	0	−8	11	12	1
Other White	0	189	245	228	97
White and Black Caribbean	0	149	217	232	170
White and Black African	0	241	331	337	212
White and Asian	0	199	292	298	187
Other Mixed	0	217	310	313	184
Indian	0	106	149	140	95
Pakistani	0	133	179	167	125
Bangladeshi	0	122	148	153	114
Other Asian	0	145	194	185	105
Black Caribbean	0	17	42	40	21
Black African	0	145	191	184	93
Other Black	0	102	154	158	110
Chinese	0	144	202	189	86
Other Ethnic Group	0	221	277	260	103
All Groups	0	5	32	34	20

Percentage change = 100 × [(Population 2051 − Population 2001)/Population 2001]

Source: Authors' computations

some cases substantially. The differences between groups are due mainly to the following factors: the favourable age structure for growth in most 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, counterbalanced for some groups by higher mortality.

How does the ethnic composition of the UK population change under the four 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 73 and 80% while the White share falls to between 82 and 86%. 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 2000–2009 decade that is reflected in the TREND and UPTAP-EF projections. The UPTAP-ER projection assumes that growing numbers of migrants from eastern Europe will return home. The latest international migration estimates suggest that this has begun; in the year to September 2008 the net inward migration from the A8 countries was 43,000 while in the year to September 2009, there was a net loss of 12,000 migrants.

To understand what is happening in our projections it is helpful to examine the growth percentages. We focus attention on the second to fourth projections, remarking that the BENCH projection is already unrealistic and is useful only for

reference. The growth of the White British and White Irish groups is very modest over the 50 years. The White British group grows between 10 and 17% depending on projection and the White Irish between 1 and 12%. The White group as a whole is maintained by the high growth projected for the Other White population, which under the TREND and UPTAP-EF projections increases by 245% and 228% respectively. Under the UPTAP-ER scenario, increased emigration (return migration), the increase is a more modest 97% though this means a near-doubling of the population in 50 years. Three of the Mixed groups exhibit the highest growth over the 50 years, quadrupling in size under the TREND and UPTAP-EF scenarios (+300% growth) because of their very young age structure. Under the UPTAP-ER scenario the Mixed groups only triple in population. The longer established ethnic groups from South Asia and Africa triple their populations under the TREND and UPTAP-EF projections and double them under the UPTAP-ER projection. The Other Asian population grows most among these groups followed by the Pakistani group. Comparable growth is experienced by younger and more recently migrated Black African and Other Black groups. The growth anticipated for the Black Caribbean group is, however, much lower because of a combination of older age structure, lower fertility, higher mortality and a higher level of emigration back to the Caribbean. The Other Ethnic Group experiences substantial growth under the TREND and UPTAP-EF scenarios and reduced growth under the UPTAP-ER projection. The Chinese group grows substantially as well through immigration and because of low mortality though its fertility is low.

A spatial analysis of the ethnic group projections

We now investigate the local variation in the projection outcomes for ethnic groups. We first present maps of projected population change for five out of the sixteen ethnic groups, selecting one from each of the broader racial groupings. Then we try to understand the spatial re-distribution that is projected using a series of classifications of local areas in terms of their position in the UK socio-economic and settlement systems. Fuller details of the spatial analysis are available in Wohland et al. (2010).

The projections generate 355 local ethnic group populations, which we need to examine using maps. 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. 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

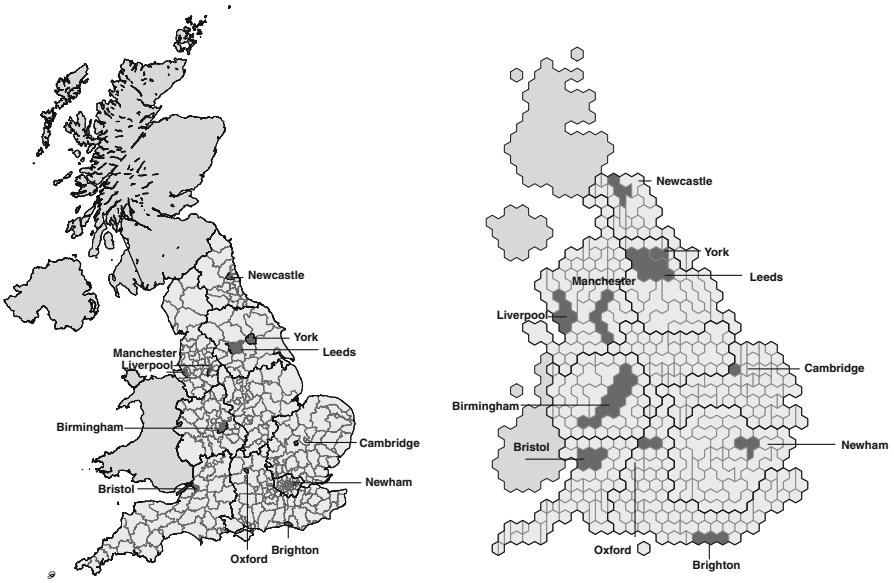

Fig. 1 Geographic map and population cartogram of the UK, with principal cities identified

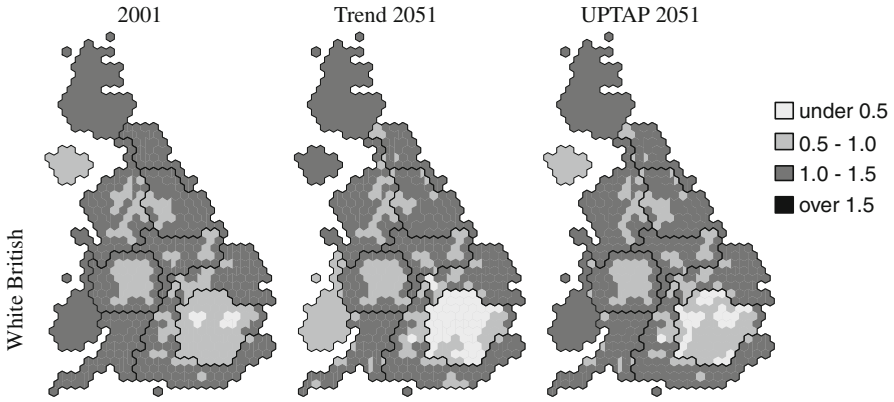

Fig. 2 Location Quotients, 2001 and 2051 for selected projections, White British

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 (Fig. 1).

White groups: the White British group

Figure 2 presents the location quotient maps for the White British, the largest ethnic group. There are three maps in the diagram. The LH map shows the LQ distribution at mid-year 2001. The middle map shows the LQ distribution in 2051 according to the TREND projection, the projection most closely aligned to the 2008 based NPP.

The RH map depicts the UPTAP-ER projection LQs. This arrangement of three maps is repeated for each of the selected ethnic groups. The distinctive feature of the White British group is that the majority of LAs fall into the first class with LQs above one 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 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 underconcentration 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 projection differs from the UPTAP-ER pattern for 2051 in two ways. There is greater underrepresentation in many parts of London and greater overrepresentation 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.

Mixed groups: the White and Asian group

Table 9 indicates 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 0.80 and 0.99% of the UK population, depending on projection chosen. The location quotients for 2001 and the selected projections in 2051 are mapped in Fig. 3 for the White and Asian group. There is spatial deconcentration 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.

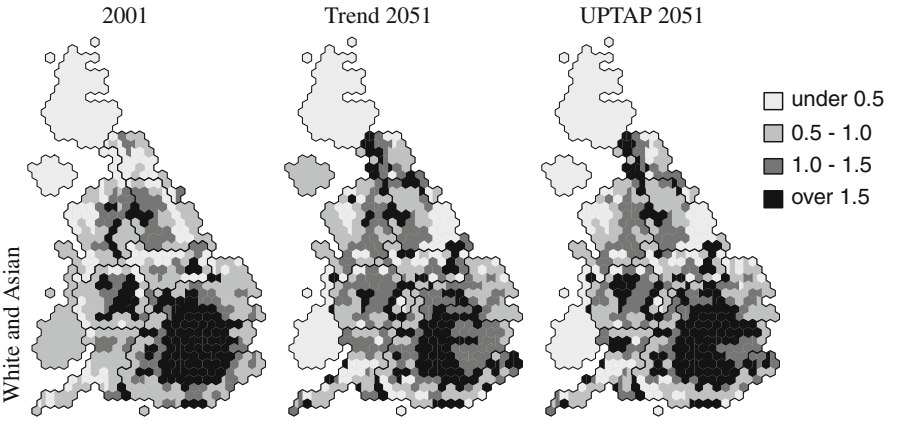

Fig. 3 Location Quotients, 2001 and 2051 for selected projections, White and Asian

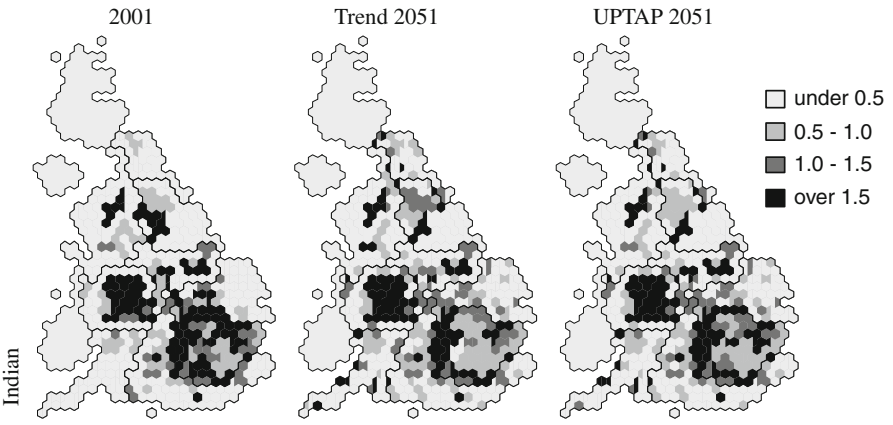

Fig. 4 Location Quotients, 2001 and 2051 for selected projections, Indian

Asian groups: the Indian group

The Indian population increases its share from 1.8% to between 3.0 and 3.6% between 2001 and 2051, depending on projection chosen (Table 9). 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 be the second largest. The location quotients for 2001 and the selected projections in 2051 are mapped in Fig. 4 for the Indian group. There is very little spatial deconcentration 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.

Black groups: the Black Caribbean group

The Black Caribbean group is the oldest postwar immigrant group. In the 2001 Census we find evidence of four immigrant generations represented as bulges in its 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 15–25. 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. The Black Caribbean population also experiences a high level of emigration back to their West Indies origins. Table 10 indicates that the growth in the Black Caribbean group between 2001 and 2051 varies between 21 (UPTAP-ER projection) and 42% (TREND 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

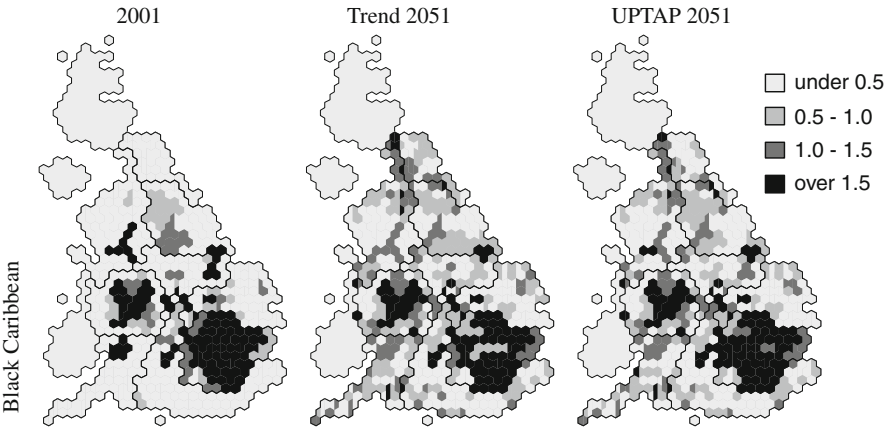

Fig. 5 Location Quotients, 2001 and 2051 for selected projections, Black Caribbean

marriages or unions mean the demographic momentum effect is subdued and return migration reduces ageing.

The spatial distributions of the Black Caribbean groups in 2001 and in 2051 under three projections are plotted in Fig. 5. 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 deconcentration: fewer LAs fall in the bottom band (LQs less than or equal to 0.5) and more occupy the band of LQs from 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 deconcentration occurs in the TREND projections than in the UPTAP-ER projection.

Other groups: the Chinese group

Tables 9 and 10 present the changes in shares and relative numbers between 2001 and 2051 for the Chinese group. The Chinese population increases between 86 and 202% between 2001 and 2051, depending on projection chosen. The Chinese share of the population increases from 0.7 to 1.0%, just over 2 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. The location quotients for 2001 and the selected projections in 2051 are mapped in Fig. 6 for the Chinese group. In 2001 the Chinese group is concentrated in London, Manchester and Liverpool. However, there are many 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.

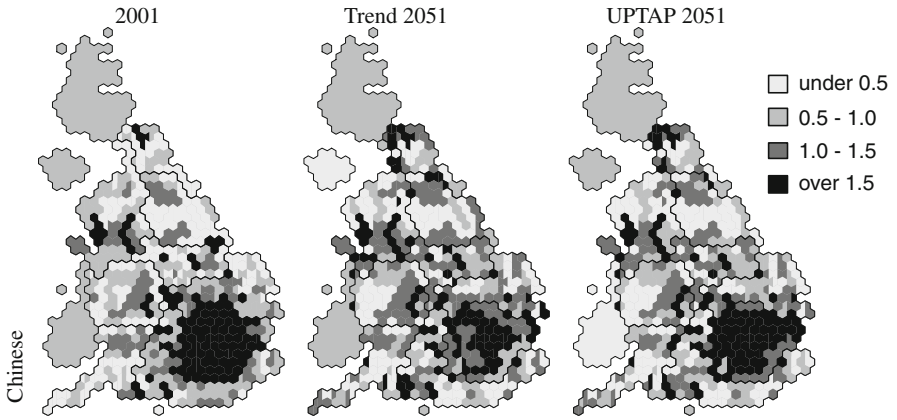

Fig. 6 Location Quotients, 2001 and 2051 for selected projections, Chinese

An analysis of ethnic group redistribution

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 generic classifications. Successively, we examine trends in ethnic composition 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 subsection.

Projected populations for local authorities aggregated to deprivation quintiles

Figure 7 reports on the distribution of ethnic groups across LAs classified by deprivation quintile for 2001 and for the BENCH, TREND and UPTAP-ER projections in 2051. The quintiles contain equal numbers of LAs rather than equal populations. Some 33% of the total population (ALL) 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 in 2001. This is true also for the White group, which is 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% (UPTAP-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% (UPTAP-ER projection) and the percentage in the top quintile has risen from 7 to

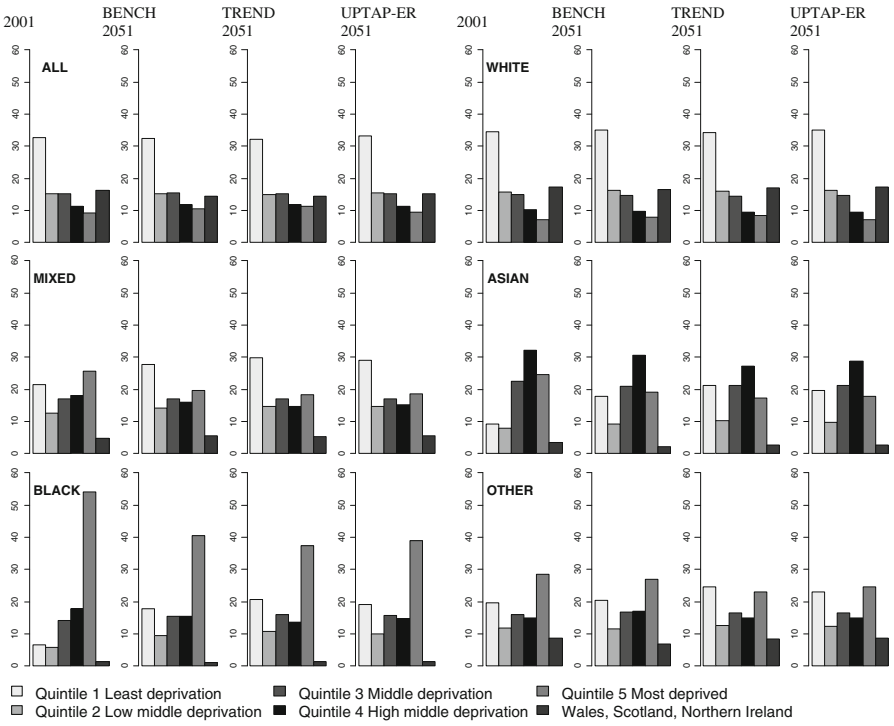

Fig. 7 Distribution of broad ethnic groups across deprivation quintiles, 2001–2051. *WHITE* White groups, *MIXED* mixed groups, *ASIAN* Asian or Asian British groups, *BLACK* Black or Black British groups, *OTHER* Chinese or Other Ethnic groups

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.

Projected populations for local authorities aggregated to density quintiles

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 Fig. 8. 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 (UPTAP-ER projection) compared with 2001, and a 6% gain in the low density quintile. For the Asian groups the equivalent percentage 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

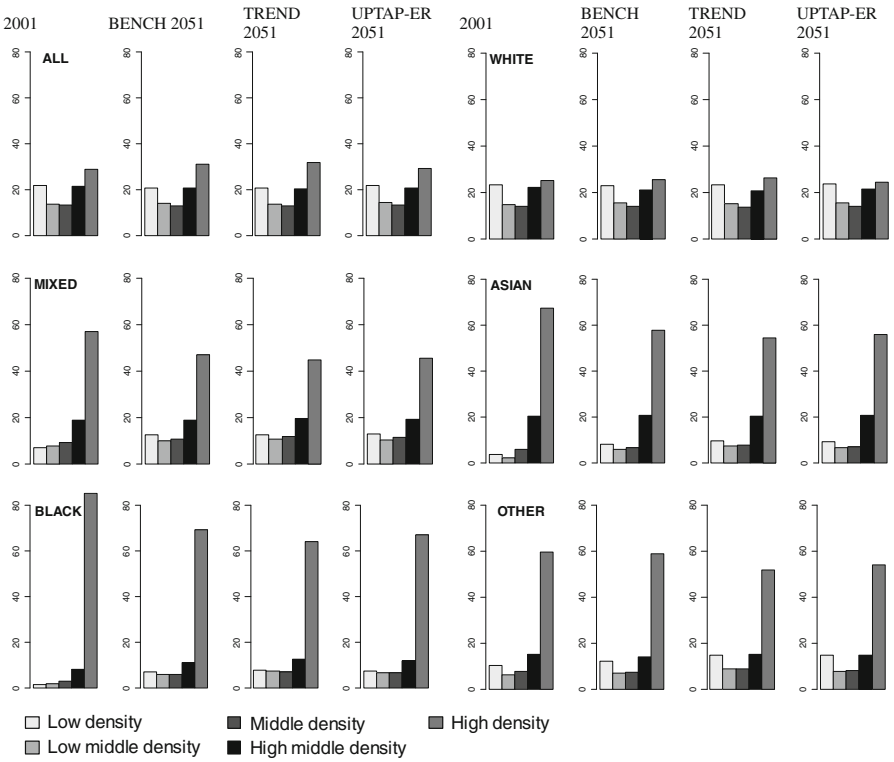

Fig. 8 Distribution of broad ethnic groups across density quintiles, 2001–2051. *WHITE* White groups, *MIXED* Mixed groups, *ASIAN* Asian or Asian British groups, *BLACK* Black or Black British groups, *OTHER* Chinese or Other Ethnic groups

projections is that ethnic minority groups are following the same path of deconcentration from high density to low density areas that the White group has experienced in past decades (Rees and Kupiszewski 1999).

Projected populations for local authorities aggregated to ethnic concentration classes

One important question is often asked about ethnic group populations: whether they are growing in the areas of highest concentration or dispersing to areas of lower concentration, thus making those areas more diverse. Figure 9 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 0.5, low middle concentration areas with LQs from 0.5 up to 1.0, high middle concentration areas with LQs from 1.0 up to 1.5 and high concentration areas with LQs from 1.5 up to 2.0. This classification is fixed at 2001. The total population shows little change in the distribution across concentration classes. The White

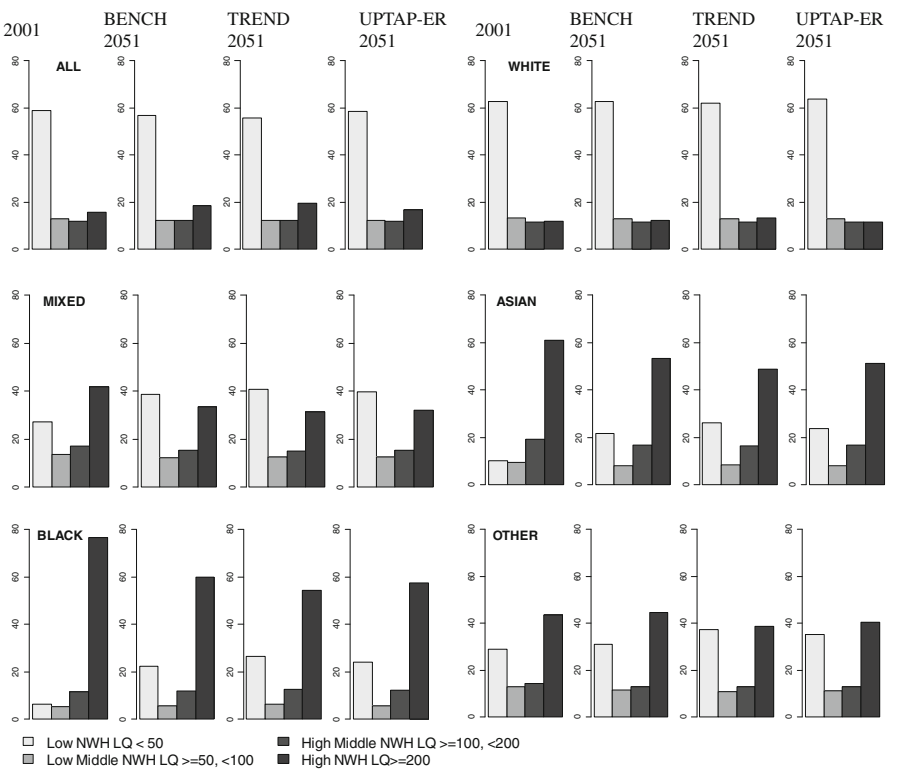

Fig. 9 Distribution of broad ethnic groups across ethnic concentration classes, 2001–2051. *NWH* Non White, *LQ* location quotient, *WHITE* White groups, *MIXED* Mixed groups, *ASIAN* Asian or Asian British groups, *BLACK* Black or Black British groups, *OTHER* Chinese or Other Ethnic groups

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. There is clear evidence that ethnic minority groups are shifting to areas of lower ethnic minority concentration.

Spatial deconcentration

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 deconcentrated from their 2001 clusters by 2051. We can confirm this interpretation by computing 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

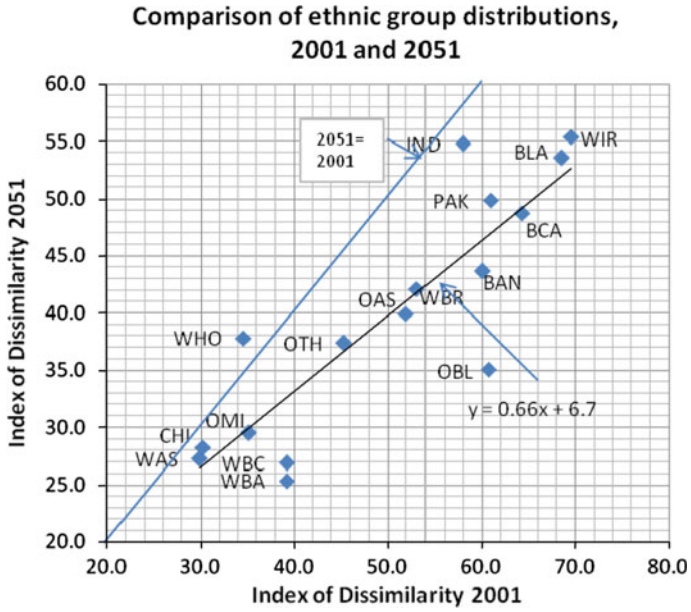

Fig. 10 Indices of dissimilarity in 2001 and 2051 for 16 ethnic groups for the UPTAP-ER projections

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 Fig. 10. For all but one group the index values have fallen, in some cases quite profoundly. This indicates that in 2051 all groups except the Other White will be less segregated from the rest of the population than they were in 2001. In Fig. 10 we plot the average relationship (regression line) between the 2001 IODs and the 2051 IODs. The slope of the line, 0.70, indicates that the de-concentration effect will be greater for the groups that were most segregated in 2001. 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 deconcentration will be increasing diversity of local authorities that are currently quite mono-ethnic.

Discussion and conclusions

In this final section of the report we discuss our projections in relation to other efforts and summarize our findings.

Comparison of the UPTAP with other projections

In Wohland et al. (2010), we compare our projections with ethnic population estimates by ONS to midyear 2007, with ethnic population projections by GLA to

midyear 2031 for Greater London (Klodawski 2009) and with ethnic population projections for the UK to 2056 by Coleman (2010). These comparisons showed that our projections differ considerably from the estimates of ONS and from the projections of Coleman, but are quite close to the projections of the Greater London Authority. There are several reasons why the projections may be different. First, the methods used to estimate the components of change for each ethnic group may be different. 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 lower fertility rates for the main BAME groups than the Coleman projections. The projections differ substantially in the way international migration is allocated across the ethnic groups. Our projections make use of internal migration estimates by ethnicity drawing on the 2001 census 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.

Findings

This paper has reported on some findings of an ESRC funded research project that 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 subnational population projections to include an ethnic dimension, 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 endeavoured to make the best possible estimates of components rates, probabilities and flows for sixteen ethnic groups for 355 local areas.

The key findings of the research at local scale are as follows (see Wohland et al. 2010 for an account of other project findings):

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.

When we aligned our projection assumptions as closely as possible to the 2008-based National Population Projections (NPP), we obtained a comparable trajectory for the UK population as a whole. In 2051 in these TREND 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 ($355 \times 16 = 5{,}680$) of local authority-ethnic groups.

Our BENCH projections produced much lower projected populations than the NPP at 63.0 million in 2051. The gap of 14.1 million people demonstrates the dramatic regime shift in the 2000s, that is, the combined effect in the 2001–2009

period of lower mortality (gains of 2.1 years in life expectancy for males and 1.5 years for females for the UK 2000–2007), higher fertility (gains of 0.33 of a child in TFR for the UK 2001–2008) and higher net immigration (+154,000 in 2000 and +217,000 in 2007).

The differences between our UPTAP-EF and UPTAP-ER projections demonstrate the effect that a change in the model for emigration can have. Modelling emigration as a flow produced by applying a fixed rate to a changing population at risk rather than a fixed flow count produces total population in 2051 that is lower by 9.1 million.

Our projections show huge differences in the potential growth of the different ethnic groups. Under the TREND projection between 2001 and 2051 the White British group grows by 14%, the White Irish group by 11% and the Black Caribbean group by 42%. These are the low-growth groups. The Mixed groups grow between 217 and 331%. The Asian groups increase between 149 and 194%. The Black African group grows by 191%, the Other Black group by 154%, the Chinese group by 202% and the Other Ethnic group by 277%.

As a result of these differences, the ethnic composition of the UK will change substantially over the period to 2051. Under the TREND projection, the White share of the population shrinks from 92 to 83% and the BAME share increases from 8 to 17%. Two groups face loss in share: the White British population share shrinks from 87 to 75% and the White Irish share shrinks from 2.% 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 6.5%. Mixed groups increase their share by 2.1%, Asian groups by 4.0%, Black groups by 1.2% and Chinese and Other ethnic groups by 1.2%.

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%.

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. Ethnic groups will be significantly less segregated from the rest of the population, measured across local authorities, in 2051 than in 2001. The Indices of Dissimilarity between each group and the rest of the population fall by a third over the projection period. The UK in 2051 will be a more diverse society than in 2001 and this diversity will have spread to many more parts of the country beyond the big cities where ethnic minorities are concentrated.

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