THE FUTURE IS DIVERSITY:

NEW FORECASTS FOR THE UK'S ETHNIC GROUPS

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Abstract
Developed countries with below replacement fertility face population ageing. This is slowed by a net inflow of international migrants. The influx leads to a population of increasing ethnic diversity. Most researchers focus on a historical understanding of the ethnic transition process. We use this understanding to forecast the population of the United Kingdom, projecting the ethnic transition forward for 50 years. This chapter describes the context, model, estimates and assumptions for projections of ethnic group populations in England at local authority scale, and in Wales, Scotland and Northern Ireland. Demographic component rates for ethnic populations are estimated using 2001 and 2011 Census data and vital statistics. A bi-regional cohort-component model is used with assumptions are aligned to recent official projections. We pay special attention to international migration assumptions because of the prospects of a new relationship between the UK and the rest of the European Union, consequent on UK electors voting in the referendum of 23 June 2016 to leave the European Union. Official assumptions and project assumptions about UK international migration are compared for their direct effect on the UK population between 2011 and 2061. There are also indirect effects through the higher natural increase for younger groups, which we illustrate for one set of assumptions.

In a LEEDS Interim projection, for international migration we assume higher immigration, emigration and net balances of 253 thousand in the long term compared with the most recent official assumption of 185 thousand. The projections show that the UK population grows significantly, from a population of 59.1 million in 2001 to 84.5 million in 2061. Black, Asian and other Minority ethnic groups expand their share of the UK population from 8% to 30% in that period. This increasing diversity is greatest in the UK's largest cities but ethnic minority groups grow fastest outside those cities. We show through a comparison of 2001 based and 2011 based projections that there is considerable uncertainty both nationally and locally in future diversity although the direction of travel to a more diverse future is certain. Our projections track the "Diversity Explosion" for the UK population and its spatial diffusion across the country. Preliminary results indicate a speedier ethnic transition than previously projected, from a Black and Minority Ethnic (BAME) share of 12.7% in 2011 to 30.3% in 2051. This increase in diversity is transmitted to all urban regions and their peripheries through internal migration.

Key words
Population projections, Ethnicity, Local projections, Component estimates

1 INTRODUCTION

Many developed countries are experiencing low or negative growth of their native born populations. They have completed the first demographic transition to low fertility and mortality and now experience the below-replacement fertility characteristic of the second demographic transition. The demand for labour is not met by the supply of native born young adults. In countries growing economically, high immigration of foreign origin populations occurs to meet labour demands. Family building in young immigrant groups occurs at first in the major centres of immigration and then more widely as socio-economic advancement and internal migration produce a diffusion of ethnic minorities. Bill Frey, in his book *The Diversity Explosion*, has documented these processes for the United States, using census data and projections (Frey

2015). Rees et al. (2011, 2012) have explored the population future of the UK through developing population projections by ethnicity at sub-national scale, which show the UK following the US in this transformation, 25 years in lag.

The extent to which such information is routinely produced varies widely between countries. At one extreme is France where enquiries into a person's race or ethnicity are forbidden under the constitution (Sabbagh 2008). At the other extreme the recording of race was embedded in the constitution of the United States in order to use counts of the "Negro" slave population in electoral apportionment. The US Bureau of the Census produces projections of the national and state populations by age, sex, four races, Hispanic origin and nativity (Colby and Ortman 2015). Statistics New Zealand (2015a) reports on the 2013 round national ethnic population projections for four ethnic groups. The New Zealand census allows multi-ticking of ethnic categories. As a result projected group populations overlap. Statistics New Zealand also produces sub-national projections by ethnicity for territorial areas (Statistics New Zealand 2015b).

The aim of this chapter is to explain the challenges posed by extending conventional projections to produce forecasts of ethnic populations. A model is described for UK local authorities which finds solutions to the challenges of adding the ethnicity dimension to conventional projection models.

Why project ethnic populations? The fundamental reason is that it is important to understand the future mix of populations with different national and cultural backgrounds. If we do that then it is easier to work towards a harmonious society. Ethnic populations are groups with a common national origin, distinguished by birthplace, citizenship, migration status, race or language. Many groups face difficulties in entering or progressing in labour and housing markets and in education. Statistics on ethnic populations are needed for monitoring disadvantage and establishing discrimination. Reliance has been placed on census statistics for this background information but this quickly becomes dated. Population projections provide population numbers for short and medium term planning. Ethnic population projections also play a part in health studies, proving context population variables for conditions where ethnicity may be a factor affecting risk.

In the UK ethnicity statistics depend on a self-identification question. Respondents to censuses or surveys are presented with lists of ethnic group titles and asked to tick one group. Prior to each of the UK censuses of 1991, 2001 and 2011, the UK National Statistical Agencies consulted with potential users about the ethnic question. As a result of consultation and because the UK population was becoming more ethnically diverse, the ethnic group classification changed over time and across the national territory. Nine groups were identified in the 1991 Censuses of England, Wales and Scotland; in 2011 18 groups were distinguished in England and Wales, 16 were used in Scotland and 11 were employed in Northern Ireland.

Table 1 presents the 12 groups used in the projections reported in this chapter, which have been harmonized across the last two censuses and the four home countries. For many uses, the 12 can be grouped into the five broader categories of White, Mixed, Asian or Asian British, Black or Black British

and Other. The census classifications are also employed in official household surveys, in health studies, in administrative records and the National Pupil Census. However, they have not been used in the recording of births, deaths, internal migration or international. The methods for estimating demographic rates by ethnicity are described in a later section.

[Table 1 about here]

The outline of the chapter is as follows. The next section, 2, presents a checklist of design decisions that must be made when building a projection model for sub-national populations classified by ethnicity, and identifies the options used in the 2011 based projection described in this chapter. Section 3 lays out the sequence of equations implemented in our ethnic population projection model. Section 4 summarises the methods used to estimate the ethnic components of change, presenting some new results on the ethnicity of international migration. Section 5 sets out the assumptions used in two rounds of projections, 2001 based and 2011 based. Section 6 compares the results. Significant changes in the ethnic composition of sub-national populations in Britain are forecast in both projections. Section 6 summarises the trend in future diversity and its spread. Section 7 looks at the impact of international migration on ethnic population change. Section 8 examines ways of changing the international migration assumptions in future projections, to take into account the effect of BREXIT, a vote by the British electorate that the UK should leave the European Union. In the chapter we report on one projection, TRENDEF, based on information from the 2001 Census and on one projection, LEEDS Interim, based on 2011 Census data. The final section places the work in the context of demographic transitions introduced in this introduction.

2 INGREDIENTS FOR PROJECTING ETHNIC GROUP POPULATIONS

2.1 General considerations

The model specifications for the 2011-based population projections by ethnicity are listed in Table 2. The design of the projections was informed not only by recent practice and literature but also through face to face consultations with the UK National Statistical Agencies, the Welsh Government, a set of local authority districts (LADs) and research centres. Prior to formulating the projection assumptions a 2001-2011 time series of LAD components of change by ethnicity was estimated and constrained to the equivalent ONS all-person LAD components. An account of this reconciliation procedure is provided in Rees et al. (2016). The population and component estimates are heavily dependent on ethnic information from the UK censuses of 2001 and 2011. In the ETHPOP set of projections, reliance was placed on population estimates and components based on just the 2001 Census (Rees et al. 2011, 2012).

[Table 2 about here]

2.2 The ethnic classification

In general, ethnic groups are closed populations which do not exchange populations. However, there are two exceptions: first, new-born infants may have a different ethnicity from their parents and second, all people have an opportunity to choose their group at the end of each time interval in the projection.

2.3 Geographical coverage and zones

The model covers the whole UK population, integrating data published by ONS, NRS (National Records of Scotland) and NISRA (Northern Ireland Statistics and Research Agency). In the 2011 based projections described in this chapter, the geographical scale is Local Authority Districts (LADs) in England together with Wales, Scotland and Northern Ireland.

2.4 The number of population groups

The number of groups for which projections are reported in this chapter is 3,924 (327 × 12). To project such a large number of population groups is challenging. However, there are good reasons for modelling populations in this detail. Projecting the populations of 327 LADs simultaneously ensures consistency and enables comparison of the results of one LAD with outcomes for the UK, home country, region or neighbouring LAD. When small numbers are converted into rates and applied to populations, the model provides an opportunity for small groups to become larger in future.

2.5 Genders, ages and time intervals

Ethnic group populations and components of change are disaggregated by gender, with the exception that only women are at risk of giving birth. Single years of age are used from 0 to 99, with a final age of 100 and over. This matches the one year time interval employed in the model. All component information is organised for projection in period-cohort format, starting with the new born to age 0, followed by age 0 to age 1, age 1 to age 2 and so on to age 99 to age 100, with a final period-cohort being age 100+ to age 101+. There are therefore 101 population ages and 102 period-cohorts. Although estimates of the very oldest populations and period-cohorts are subject to some uncertainty, this age range is needed in anticipation of further population ageing in future.

2.6 Projection horizons

The projections are designed to run for up to 100 years, because this is the full time span over which the current population could survive and the effects of current ethnic-age structures will be worked out. Local users are interested in the short term (the next 25 years) for planning purposes; national users are also interested in the medium term (up to 50 years ahead) for social security computations; infrastructure planners adopt a long term horizon out to 100 years. In section 18.5, we report on results in the medium term, 40 years on from the jump off year.

2.7 How migration is treated in the projection model

Sub-national projections must incorporate internal and international migration components but there many methods for handling these components. Table 2 lists five features associated with the way migration is handled.

S*ystem representation* refers to the way the regions in the projections are managed. The first option is to represent each region as a single isolated unit incorporating total migration as a net term (the uni-regional approach). The second option is to represent regions as full interacting sets within a country and to model internal migration as the product of an origin population multiplied by the rate of out-migration (the multi-regional approach). The third option is to represent regions as a set of pairs, the region itself and the rest of the country (the bi-regional approach). The fourth option is to represent regions in two layers in which the upper tier is modelled as a multi-regional system and the lower tier uses a simpler model with lower tier results constrained to upper level projections (the hierarchical approach). The NewETHPOP projection reported in this chapter use the bi-regional approach.

The *migration concept* refers to the way migration is measured in the data. Two concepts can be employed: either the transition concept, which records a person's shift in region of residence between two fixed time points, or the movement concept, which records all changes of residence between fixed time points.

Every projection model is based on a set of *demographic accounts*. These ensure that in each time interval population inputs equal population outputs and that the final population is consistent with the start population and the components of change. Projection models can be built using either migration concept given suitable data. However, in practice it is difficult to handle the projection of births and deaths as transitions unless the time interval between censuses and the time interval of migration are coincident. Most national statistical agencies, including ONS, therefore use the movement concept (Raymer et al. 2015).

The final feature of a projection model is the *Population at risk,* which must match the demographic account type. For projections using the movement concept, a population-time exposure measure is needed. This is approximated as the average of start and final populations in a time interval. This poses the problem that the final population is unknown at the start of any time interval. The usual approach is to re-work the model equations to re-define the rates to eliminate the need for a final population (Rogers and Ledent 1976). The problem with his approach is that every time the model is changed, new equations for the rates are needed. In the NewETHPOP model we instead compute the population at risk iteratively. This method has the advantage of the population at risk equations remain the same even irrespective of projection model.

2.8 The modelling of internal migration

Internal migration model options are as follows. Migrations between regions can be projected either as (1) rates multiplied by populations at risk in the origin region or as (2) exogenous flows, which need to be projected using an independent model (e.g. a gravity model). The first option is used in the NewETHPOP model described here, using constant rates. There is a concern that this model, when applied using time-constant rates, leads to excessive drift towards a stable equilibrium. In reality migration trends lead to feedback effects which change the rates. ONS (2015) has introduced destination population controls to alleviate this drift in the 2014 based National Population Projections.

2.9 The importance of international migration

International migration is projected to make a much bigger contribution to future UK population change than natural increase. Rees et al. (2013) computed, for the ETHPOP 2001-based projections, the effects of assumptions about the demographic components using a scheme of scenario projections designed by Bongaarts and Bulateo (1999). This analysis found that international migration (direct and indirect effects) accounted for 87% of total UK population change over the 50 years from 2001. ONS (2015) computed a reference projection assuming no international migration for comparison with the Principal projection and estimated the direct and indirect contribution of international to population growth to be 67% between 2014 and 2039. These impacts on the UK's future population mean that there are tensions in setting international migration assumptions between what the time series of flows tells us – international migration is substantially higher than recent official assumptions – and what government would like the figures to show – net international migration below 100,000 per annum.

2.10 The modelling of international migration

Little attention has been paid to the design of the *International migration model* used in population projections. Should future international migration be simply a function set of judgements about net international migration flows? Or should they be framed separately as immigration and emigration assumptions? Or should immigration assumptions be set in absolute flow numbers and emigration as rates multiplied by a UK population at risk? Bijak (2012) recommended that ONS formulate assumptions using gross immigration and emigration flows which can be linked directly to determinants rather than using net international migration. Bijak proposed a model which adopted assumptions based on immigration flows and emigration rates, as used in Rees et al. (2011, 2012). ONS (2014) experimented with the Bijak proposal but found the results implausible. The UK Home Office's Migration Advisory Committee, which advises on official immigration policy, commissioned a report on how to best forecast international migration (Disney et al. 2015). The authors conclude that no single model could be recommended for forecasting immigration flows but that decomposition into streams to and from different parts of the world was useful.

2.11 Formulation of assumptions, uncertainty and outputs

We took a pragmatic approach to the formulation of *assumptions* (see section 5 for details). There is always huge *uncertainty* in any projection of the future population. This can be ascertained through variant projections (implemented by ONS) or through probabilistic projections (Statistics New Zealand 2015a, 2015b). We focussed on the preparation of a deterministic projection coupled with variants (Rees et al. 2015). Each projection delivers a huge quantity of projected outputs, which are delivered via www.ethpop.org.

3 THE NEWETHPOP MODEL EQUATIONS

REDUCE THIS SECTION

Table 3 sets out the notation used in the projection model. The variables and the equations are listed in Table 4. Cross-referencing these tables establishes the meaning of the variables. We use single letters for the demographic variables, lower case letters for rates or probabilities and upper case letters for counts of stocks and flows.

[Table 3 about here]
[Table 4 about here]

A key feature of the notation for the NewETHPOP model is that people stay in the same period-cohort during a time interval and change period-cohorts by ageing on at the end of the interval. Final populations in a period-cohort at end of one interval become start populations in the next period-cohort and time interval. This way of handling ageing was used by Stone (1971).

Projection computations begin with input of the jump-off populations (step 1) as start populations for the first time interval, mid-year 2001 LAD ethnic populations in the ETHPOP projections and mid-year 2011 populations in the NewETHPOP projections. After the first time interval, start populations are the transferred from final populations of the previous interval (step 24). Initial values are adopted for the populations at risk for birth, death and internal migration in step 2. The iterative loop for computing populations at risk starts here. Once all of the components have been projected a population at risk can be computed as the average of start and final populations in a time interval (step 22) and checked for convergence. Computations then return to step (3) if convergence has not been achieved.

At step (3) births by gender, ethnicity and nativity are computed by summing the products of fertility rates and female populations at risk, followed by application of probabilities of different ethnicity to the mother and sex proportions. Births are computed as "start populations" for the new-born period-cohort, so all period-cohorts can be computed together.

Step (5) computes the projected number of deaths by multiplying the population at risk by the period-cohort mortality rate. Period-cohort mortality rates are computed from life tables for each LAD-

ethnic group population. A slightly different equation may be needed (step 6) at the oldest ages when conventional mortality rates may exceed unity because observed deaths and estimated populations come from different data sets in the UK rather than being part of one integrated population register. If this is the case then one minus the survivorship probability, a term which is always positive, can be substituted.

At step (7) prisoners (convicted persons) and armed forces populations for the projection year are subtracted from the start populations. New values of these special populations are added back in at step (19). The numbers are small, spread over about one third of LADs. In the NewETHPOP projection reported here, we do not include these numbers.

The next three steps in Table 6 concern options for projecting emigration. These can be introduced as exogenous flow assumptions (option 1, step 8), as exogenous (transmission) rate assumptions multiplied by LAD populations at risk (option 2, step 9) or as (admission) rate assumptions multiplied by the population at risk in the Rest of the World (option 3, step 10). Option 1 was used for both the 2001-based TRENDEF and 2011-based LEEDS projections. Option 2, the model recommended by Bijak (2012), was used for the 2001 based UPTAPER projections. As the populations of UK LADs grow, so does emigration. When a constant immigration flow long-term assumption is adopted, this leads to shrinking net international migration and slowing population growth. ONS regarded this scenario as implausible; we take the same view for our 2011-based projections. Projected emigration flows are subtracted from the start population.

Three options for internal migration are then set out. Option 1 (11) involves multiplication of out-migration rate assumptions by LAD populations at risk. This is used in our LEEDS interim projections in bi-regional form. Option 2 (12) is an adjustment to constant out-migration rates reflecting the influence of changing destination populations, introduced by Statistics Canada (Dion 2014) and adopted by ONS (2014) for modelling internal migration between home countries in NPP2014. Option 3 (13) introduces exogenous results from a gravity model, specified here in general form. There is a very large body of work exploring the factors driving inter-regional migration but very little of this has been used in population projections. Projected out-migration flows (summed over all destinations) are subtracted from the start population.

Step (15) adds together the variables projected up to this point and computes the accounting residual balance. The remaining terms are then added to the residual balance to produce the end of interval final population. The first input term is sum of internal in-migrations to each LAD; the options for modelling have already been described earlier.

Immigration options are then set out in steps (17) to (18), which parallel those for emigration. In option (1) assumed immigration flows are input (used in the LEEDS projection); in option (2) assumed immigration rates are multiplied by populations at risk for the Rest of the World; for option (3) assumed immigration admission rates are used multiplied by LAD populations at risk. The second option leads to rapid increases in immigration as the Rest of the World population grows and so is suitable only as a

reference projection against which restrictive policies can be assessed for impact. Option (3) was considered in preparations for NPP2014 but thought implausible (ONS 2014).

Step (21) sums the population inputs including the residual balance to provide the final population at the end of the interval. Two final processes follow. In step (22) we allow ethnic groups to switch identities by multiplying the final populations by switching probabilities. These are based on an analysis of the Longitudinal Study which links the 2001 and 2011 Census for a sample of individuals (Simpson 2014). In effect, switching is envisaged as a repeated census question asked at the end of each projection time interval. The final step in the model, (18.24), is to age on the final population in a period-cohort to become the start population one year older in the next period-cohort in the next time interval.

4 ESTIMATING THE ETHNIC INPUTS

In theory, it should be easy to consult official demographic statistics to access ethnically classified components of change rates, as can researchers in the US and New Zealand. However, in the UK indirect methods must be used to estimate fertility, mortality, internal and international migration by ethnicity.

We have revised all of the demographic inputs by ethnicity in two ways: developing estimates based on the 2011 Census and by connecting those estimates to the 2001 Census estimates. The objective was to reconcile the 2001 to 2011 local ethnic group population estimates and components of change with the ethnic group populations from the 2001 and 2011 Censuses. This task turned out to require innovations such as the concept of the Census Based Book End (CBBE) and the development of algorithms to interpolate by age, period and cohort. Rees et al. (2016) provide an account of the reconciliation exercise.

4.1 A triangular approach to ethnic fertility using census data, vital statistics and survey information

Norman et al. (2014) describe the methods and data sets used to develop fertility rates by ethnicity for 2001, employing Census data, births statistics and survey information. These ethnic fertility estimates have been updated to 2011 and extended to include a nativity classification, distinguishing native and foreign born potential mothers (Norman 2015). A time series of fertility by ethnicity has been developed for 2001-2011. Table 7 presents UK total fertility rates in 2011 for 12 harmonized ethnic groups. Overall TFR rose over the previous decade from 1.63 to 1.93 as a result of catch up (women having children in their 30s who previously postponed children in their 20s). The range of TFRs is wide, with 6 below the average and 6 above the average, ranging from a low of 1.26 for the Black Other (OBL) group to a high of 3.47 for the Bangladeshi (BAN) group. An equivalent set of fertility rates have been estimated for LADs in England. For the projections reported in section 18.6, we use the England estimates for ethnic groups in Wales, Scotland and Northern Ireland.

[Table 7 about here]

4.2 A geographic distribution approach to ethnic mortality

Revised ethnic mortality estimates have been made for 2011, using data on ethnic populations from the Census and LAD statistics on deaths. In Rees et al. (2009), two ways of estimating ethnic mortality were developed: (1) a method based on the relationship between limiting long-term illness (LLTI) and mortality and (2) a method that used LAD mortality rates weighted by the different geographical profiles of ethnic groups. Subsequent research has shown that LLTI and mortality are only partially correlated. The healthy immigrant effect was also important. So, we used a *Geographically Distributed Method* (Wohland and Rees 2015, Wohland 2015a). Figure 1 presents results for 16 ethnic groups in 2001 and 2011. The difference between the 2011 (red plots) and 2001 (blue plots) shows the continuing improvement in life expectancy over the decade (between 1.5 and 2 years depending on group). The variation between ethnic groups is much smaller than between LADs. Deprivation, which varies radically between LADs, is more important in determining life expectancy than ethnicity. Two ethnic groups have markedly lower life expectancy than the White British majority: the Bangladeshi and Pakistani group, reflecting their lower economic status. However, over the decade Bangladeshi women improve their relative position compared with Pakistani women, because their concentration in London affords better chances of educational and occupational improvement than does the concentration of the Pakistani population in northern de-industrialized cities.

4.3 Using the census to estimate ethnically specific internal migration

New estimates of internal migration by ethnicity have been made using commissioned migration tables from the 2011 Census (Lomax 2015, Lomax & Rees 2015). These flow data show that ethnic minority groups are moving away from areas of highest concentration of the group and following the White British and Irish group in outward migration from metropolitan areas. Figure 18.2 reports on the variation across ethnic groups in the share of inter-LAD migration flows using a simple classification of LADs into metropolitan and non-metropolitan. For all minority groups the share of flows within metropolitan regions is much larger (37% to 54%) than for the White British and Irish (WBI) (23%). The shares of flows that are between metropolitan and non-metropolitan regions for minority groups (40% to 49%) are closer to the WBI share (50%). Where the balance is negative (e.g. the Chinese group), flows are concentrated in the 16-24 age group at which non-metropolitan teenagers leave for higher education in metropolitan areas. Flows within non-metropolitan areas are most important for the WBI group. Further analysis of the flows suggests that ethnic minority groups are spreading out spatially within the UK, though not yet as widely as the WBI majority.

4.4 Using census data and survey data to estimate international migration

For international migration new estimates of immigration and emigration by ethnicity have been created using International Passenger Survey/Long Term International Migration (IPS/LTIM) tables published by ONS in combination with 2001 and 2011 Census tables of ethnicity by country of birth (Clark and

Rees 2016). From published tables we reconstructed a six dimensional array of estimated flows. The dimensions included country of birth, region of last or previous residence within the UK, broad age and gender. From the 2001 and 2011 Censuses we used tables that cross-classified ethnicity by country of birth to compute the probability that an immigrant or emigrant belonged to a particular ethnic group. The regional compositions by ethnicity were used to adjust LAD estimates of ethnicity produced through interpolation between CBBE estimates based on the 2001 and 2011 Censuses (Rees et al. 2016). The ethnic compositions of emigration and immigration streams are different. Over the period 2000-2014 the WBI group contributed 55% of emigrants but only 33% of immigrants. The ethnic minority which contributes most immigrants (24%) and emigrants (20%) is the White Other group. Individual Black and Asian Minority Ethnic (BAME) groups contribute smaller numbers but figure much more prominently in immigration than emigration. For example, the Indian group makes up 8% of immigrants and 4% of emigrants. The differences in ethnic composition between immigration and emigration streams contribute to the large differences in growth between the WBI group and ethnic minorities.

We illustrate our estimates of the ethnic composition of UK immigration and emigration by examining the inflows and outflows to London (Figure 3), the most ethnically diverse UK region. The WBI and WHO groups make the largest contributions to immigration to London but the time trends are different. WBI immigration declines from a peak in the late 1990s to much lower levels after 2010. The WHO group sees higher levels from 1998 onwards, reflecting the addition of 10 countries to the EU in the 2000s and the impact of poor employment conditions in southern EU states since 2010. The BAME groups make smaller individual contributions to immigration than the two main groups but, because emigration is much lower, these immigration streams are more effective in adding to the population.

[Figure 3 about here]

5 ASSUMPTIONS FOR PROJECTIONS

Table 6 lists the assumptions for the 2001-based and 2011-based projections described in section 6. The method for assumption setting varies with the component. For fertility we assume a long term total fertility for the UK. The ratios of local, ethnic group TFRs based on the 2011 Census and associated data to the national TFR are applied to the national TFR to generate assumptions. The long term TFR was assumed to be 1.84 in the 2001 based projection and 1.89 in the 2011 based projection. No convergence of ethnic group fertility on the national average is assumed. There is minor short term downward adjustment of TFRs from the levels reported in Table 18.5.

[Table 6 about here]

Mortality assumptions draw on ONS practice in NPP2008 and NPP2014. An annual rate of decline constant across most ages is used: this was a 1% decline in the TRENDEF projection and 1.2% decline in the LEEDS projection. These decline rates are applied to all LAD-ethnic group mortality rates.

For internal migration we assumed constant application of the 2000-2001 based probabilities (ETHPOP) and the 2010-2011 rates (NewETHPOP). For international migration assumptions we specify long term levels of immigration and emigration as set out in Table 18.6. These totals are shared out across LADs, ethnic groups, genders and ages using 2001 and 2011 based shares. Note that the long term immigration assumptions rose more than the emigration assumptions, leading to a higher net inward balance in 2010-11. The LEEDS 2011 based assumption was set by fitting a logistic function to the IPS/LTIM time series discussed in section 18.4. In the short term, 2014-2015 higher immigration and emigration levels are assumed to trend down to the long term assumptions.

6 FUTURE DIVERSITY AND SPREAD

Populations projected using the LEEDS assumptions are listed in Table 7. The all-person population of the UK grows substantially from 2011 to 2061 by 34%. Almost all this growth (80%) occurs in the BAME groups while the most of the 20% growth in the White grouping is due to the increase in the White Other population with the WBI population growing to 2021 and then decreasing. At the bottom of the table we make comparisons with other projections. In the 2001 based TRENDEF projection we over-projected the 2011 White population by 1.3 million. The difference in the White population decreases to 2051 as the WHO group grows. Our 2001 based projection of the BAME population under-shot by 1.2 million people. The difference between the 2001 and 2011 based projected BAME population increases to reach 4.5 million by 2051. Our 2001 based projections radically under-estimated the speed of the ethnic transition from a largely White population in 2001 to a White population making up only 7 in 10 of the population in 2061.

[Table 7 about here]

The final comparison in Table 7 is between the LEEDS 2011 based projection and the NPP2014 results. Our 2011 based projected population of the UK in 2061 is 4.3 million people higher than NPP2014. The main reason for this is our higher assumption for immigration. In net terms NPP2014 assumes a net 185, 000 international migrants per year, while the LEEDS projection adds a net 254,000. Over 50 years to 2061 the difference cumulates to 3.5 million extra people, out of a total difference of 4.3 million.

Figure 4 graphs the trends, expressed as a percentage of the 2011 population, for the 12 harmonized groups used in the 2011 based projections. The most rapidly growing groups are the Pakistani and White Other group in the 2011 based projection. The differences between these projection

and the 2001 based are greatest for these groups. For the Pakistani group we revised the long term fertility assumption upwards using 2011 information while the White Other group maintains its share of a higher immigration assumption. Most BAME groups are expected to grow more in the 2011 based projections because the starting population is based on the 2011 Census. The only group which experiences a lowering of its growth path between the two projections rounds is the Black Caribbean group. This diminishes at younger ages because an increasing share of offspring of Black Caribbean parents are Mixed in ethnicity. At older ages the BLC group loses emigrants who return to the Caribbean at retirement ages.

[Figure 4 about here]

So far, we have commented on national results. Our projections provide a wealth of projection detail for 324 LADs in England. Figure 5 presents one map set from a potential atlas of results. The variable plotted on each map is the Index of Diversity (see the note to Figure 5). Diversity ranges from very low (0.05 to 0.15) in deep blue to very high (0.61-0.92) in deep red. The same classification scheme is used in each map so comparison can be made between two censuses, two projections and two times. Small extensions of high diversity occur between the two censuses (5A vs 5C). Over five decades (5A vs 5B) or four decades (5C vs 5D) high diversity spreads out from metropolitan cores to nearby non-metropolitan areas. This spread is slightly more extensive in the 2001 based projections (5B).

[Figure 5 about here]

The degree of spread depends mainly on the structure of the internal migration matrix of out-migration rates. During favourable parts of the economic cycle, people are confident to move home outside of their origin location. During unfavourable economic phases the volume of internal migration declines and people are more conservative in their location choices. The spread in the 2001 based projections is driven by conditions in 2000-2001 (the interval measured by the census question) which was in the middle of a long boom; the spread in the 2011 based projections is affected by the financial crash of 2008-2009, which depressed economic activity in 2010-2011, particularly the housing market. This difference explains the diminished spread of diversity in the 2011 based projections.

7 THE IMPACT OF INTERNATIONAL MIGRATION ON ETHNIC POPULATION CHANGE

The future assumptions for the demographic components determine population change. The assumptions vary by level according to ethnic groups but the same trends into the future are assumed. So although we forecast a small decline of TFR from 1.93 (2011) to 1.89 (long term assumption), the higher fertility of Bangladeshi, Pakistani and Black African populations will persist and mean, because of their

young age structures, substantial natural increase. Our mortality forecasts are quite optimistic and will lead to substantial additional ageing. However, ethnic differences are small, apart from lower Pakistani and Bangladeshi life expectancies, so all groups will experience the boost to ageing but at different times. Internal migration is important in redistributing ethnic group populations but has only a little effect on overall UK group population change. The most important component in determining future population change will be international migration. International migration has both a direct effect (adding new immigrants to each group) but also an indirect effect as immigrants settle and produce children. To assess the total impact of immigration on ethnic group populations, we ran two reference projections. The first was a **no international migration** scenario in which no immigrants joined the population and no emigrants left the population. The second was a **no migration** scenario in which we additionally assumed there would be no internal migration. The differences between the main projection and these reference scenarios capture the direct and indirect effects of migration.

The results are presented in a set of graphs in Figures 6 through 9. Figure 6 shows what might happen to the total population (all ethnic groups combined). Under the LEEDS Interim scenario, the UK's population grows from 63 to 85 million in the 50 year projection period. If international migration is turned off, then the population peaks in the 2030s at 67 million and declines thereafter (Figure 6). The more dynamic demographic regimes of ethnic minority groups are not sufficient to counteract the ageing and declining White British and Irish majority. International migration would add about 32 million to the UK. When we turn off internal migration, the decline after 2040 slows. Why should this happen? Most probably because ethnic group populations with higher rates of natural increase do not migrate out of their 2011 residential concentrations. They do not experience the fertility decline associated over the generations with migration to lower density local areas.

[Figure 6 about here]

We organise the equivalent graphs for the 12 ethnic groups in three sets. Figure 7 shows what happens to groups that in recent past have participated in immigration to the UK but with average or low fertility rates. Almost all additional population growth in the main projection disappears in the White Other, Chinese and Other Ethnic groups. Population potential keeps the Indian and Other Asian groups growing.

[Figure 7 about here]

Figure 8 shows the impact of no international migration on five groups where the impact is much lower. Most growth in the Mixed population comes from natural increase. High fertility and young populations

maintain the strong growth of Pakistani and Bangladeshi populations. Immigration is more important for the Black African and Other Black populations, so that their growth is halved.

[Figure 8 about here]

The final set of graphs (Figure 9) picks out the two groups forecast to lose population over the next half century. Restricting international migration to zero allows the Black Caribbean, which currently experience substantial emigration, to grow modestly before experiencing decline in the 2050s when the second generation (children of the settlers of the 1950s) reach old age and die. The effect of international migration on White British and Irish is small – slightly less decline in the 2050s. Without internal migration, the decline is moderated somewhat, as the group stays in local areas with higher natural increase.

8 WHAT HAPPENS AS A RESULT OF BREXIT?

On the 23rd June 2016 the British Electorate was asked whether the UK should remain a member of the European Union or whether it should leave. A small majority of 52% voted to leave. The Conservative Government has chosen to regard this as a firm mandate to start negotiations about exiting the EU (now called BREXIT or British Exit). The projections reported in this paper are therefore in need of serious revision. The media have reported different views about the likely short run future. An impending recession resulting from lowered business and consumer confidence and loss of access to the UK's biggest market, the EU, may discourage EU citizens from migrating to Britain. Other, however, have argued that there will be a surge in EU immigrants, wishing to settle before the immigration gates are largely closed. These commentator views are not particularly helpful in in setting future international migration assumptions.

We have instead looked at the data on recent immigration under Conservative Party policy regimes. Full details are reported elsewhere but the main ideas are as follows. The immigration and emigration statistics of the 2010 to 2015 period of the Coalition Government provide a guide. Policy during this period was directed by a Conservative Home Secretary, Teresa May with strong views on restricting immigration. who subsequently became Prime Minister in July 2016. If we classify immigration by citizenship, the statistics for 2010 to 2015 show quite different trends. That for non-EU citizens is consistently downward over the six year as visa regulations were tightened. By contrast, from 2012 onwards the volume of EU immigration grew fast. This gives the basis for a policy driven forecast. We measure the downward trend for non-EU immigrants and apply the trend after 2019 to EU immigration, after BREXIT subject to the tight control exercised on non-EU immigration. Between 2016 and 2019, we assume two competing effects: a slump in immigration because of a BREXIT induced recession and a small surge of arrivals of EU citizens attempting to enter before BREXIT is finalised. The results of this BREXIT model are

summarised in the last panel of Table 8. Immigration and emigration are reduced compared with both the LEEDS Interim projection reported in this paper and the ONS Principal projection. The table also reports on the Low and High Variants of ONS. The BREXIT scenario is closest to the Low Variant.

The final column of Table 8 reports on the direct effect of international migration on the UK population over the period 2011 to 2061. Under the ONS High scenario a net balance of just over 13 million people would have been added to the UK population; under the LEEDS Interim projection, the balance of international migration just under would have accrued. This positive balance shrinks by a half under the BREXIT scenario. In future work, the projections described in this paper will be re-run with these new international migration assumptions.

9 DISCUSSION

This paper constitutes a case study of the demographic dynamics of a country in the midst of what has been termed the *third demographic transition* (Coleman 2006): when smaller birth cohorts reach the labour market, the demand for labour rises, and is filled by international migration. New ethnic communities are created with large demographic potentials because young age structures favour for family formation (North, West Europe, North America, Australasia). The *fourth demographic transition* (Frey 2015) involves the spatial distribution of ethnic minorities (of immigrant origin), shifts from their initial places of settlement (mainly large cities) to other parts of the country. These two transitions can be termed collectively the *ethnic transition*.

Most researchers take a backwards look at such demographic processes. We have taken a forward look by building a population projection model which can detect the transitions. This is a challenging task in the UK because the ethnicity classification adopted in the population census and official surveys has not been ported over to registers and administrative databases that record demographic events. We have filled the void by using indirect, innovative methods to provide ethnic and local estimates of the necessary component rates. It has also been necessary to think hard about the additional processes that need to be added to a conventional population projection model, including the process when parents of different ethnicities have a child of mixed ethnicity and the process of changing identity.

Using the new estimations and projection model, we have carried out a second set of projections based on the 2011 Census and learnt valuable lessons from comparisons with previous projections and official projections.

Acknowledgements

The research reported in this paper was supported by ESRC award ES/L013878/1 for the project *Evaluation, Revision and Extension of Ethnic Population Projections – NewETHPOP* and by the University of Leeds Higher Education Innovation Fund. The datasets used in the analysis were sourced from the Office for National Statistics, National Records Scotland and the Northern Ireland Statistics & Research Agency under the terms of the UK's Open Government Licence. The data are subject to Crown Copyright.

Table 1: Definitions of the harmonized ethnic groups used for projection

Abbreviation	Ethnic group description	Broad Grouping	Figure 18.1 groups
WBI	White: British, Irish, Gypsy, Irish Traveller	White	WBR+WIR
WHO	White: Other White	White	WHO
MIX	Mixed or Multiple Ethnic Groups	Mixed	WBA+WBC+WAS+OMI
IND	Asian or Asian British: Indian	Asian	IND
PAK	Asian or Asian British: Pakistani	Asian	PAK
BAN	Asian or Asian British: Bangladeshi	Asian	BAN
CHI	Asian or Asian British: Chinese	Asian	CHI
OAS	Asian or Asian British: Other Asian	Asian	OAS
BLA	Black or Black British: African	Black	BLA
BLC	Black or Black British: Black Caribbean	Black	BLC
OBL	Black or Black British: Other	Black	OBL
OTH	Other Ethnic Group	Other	OAT

Notes: Minority groups = WHO to OTH. BAME = Black and Asian Minority groups = MIX to OTH.

TABLE 2: The 2011 based LEEDS model specifications

Features	Description
GENERAL AND DATA CONSIDERATIONS	
Purpose	To revise projections of ethnic group populations for local areas.
Consultations	4 National Statistics Agencies, 8 LADs, 5 Other organizations.
External constraints	Not yet implemented
Special populations	Armed Forces, Prisoners, not yet implemented.
Evaluation/review/ reconciliation	Population and component estimates have been evaluated for 2001-2011 against ONS total populations and components and reconciled between "Census Based Book Ends".
Available data	2001 and 2011 Census population data, ONS mid-year population data, 2001 to 2011 component data, reconciled between mid-year 2001 and mid-year 2011.
Making estimates	Ethnic component flows and rates must be indirectly estimated
GROUPS, REGIONS, GENDERS, AGES, TIMES	
Population groups	Projections in this chapter: 12 harmonized ethnic groups
Group transitions	Groups are independent, with two exceptions. New-born infants may be assigned an ethnicity different from their mothers. At the end of each time interval group members may transfer to another group.
Geography: coverage	United Kingdom.
Geography: regions	Projections in this chapter: 324 LADs in England plus Wales, Scotland and Northern Ireland (327 zones)
Gender detail	Males, Females. Female dominant fertility model.
Age-detail	Single Years of Age: 0, … , 99, 100+.
Age-time plan	Period-Cohorts: Birth to age 0, age 0 to age 1, … , age 99 to age 100, ages 100+ to ages 101+.
Time interval	One year, mid-year to mid-year (30 June/1 July).
Time horizon	Medium term, mid-year 2011 to mid-year 2061. Long term mid-year 2011 to mid-year 2111.
HANDLING MIGRATION	
System representation	Bi-regional: 327 pairs of LADs & Rest of the UK, + Rest of World.
Migration concept	Movement migration, derived from 2001 to 2014 NHS registers with 2001 and 2011 Census data used in estimation.
Demographic accounts	Movement accounts and components of change.
Population at risk	Average of start and final populations; computed iteratively.
Internal migration model	Occurrence-exposure rates × Populations at risk (average in interval).
International migration model	Assumptions about emigration flows and immigration flows.
PROJECTION CONSIDERATIONS	
Formulation of assumptions	Trajectories (short-term & long-term) of leading indicators. Constant distribution across LADs, ethnic groups, sexes and ages.
Uncertainty	Deterministic projections plus scenarios.
Projection outputs in online database	Populations by LAD, ethnicity, gender and single year of age; component totals.

Notes: 1. LADs: Local Authority Districts (lowest tier). 2. ONS = Office for National Statistics (UK)

TABLE 3: A notation for an ethnic population projection model

Variable	Description
Stocks	*Counts of people*
P^S	Start Population in a time interval (count)
P^F	Final Population in a time interval (count)
A	Armed Forces population
C	Prisoners
Flows	*Movements from one state to another*
B	Births
D	Deaths
E	Emigrations (international migration from UK to Rest of the World)
M	Migrations (internal to the country)
M^{ij}	Migration from LAD i (origin) to LAD j (destination)
M^{i+}	Total out-migrations from LAD i = $\Sigma_{j\neq i}M^{ij}$
R	Residual (balances)
M^{+i}	Total in-migrations to LAD i = $\Sigma_{j\neq i}M^{ji}$
I	Immigrations (international migration to the UK from the Rest of the World)
Intensities	*Either probabilities or occurrence-exposure rates*
f	Fertility rates (occurrence exposure rates) for period-ages
d	Death rates (occurrence-exposure rates) for period-cohorts
m	Internal migration (transmission) rates
e^o	Emigration (transmission) rates
e^a	Emigration (admission) rates
i^o	Immigration (transmission) rates
i^a	Immigration (admission) rates
v	Sex proportion at birth
b	Mixing probabilities of the ethnicity of a new-born given the ethnicity of mother
s	Switching probabilities of a new ethnicity a new ethnicity given ethnicity at a prior census
Indexes	*Subscripts or superscripts*
x	Age index (used for period-ages and period-cohorts)
b	Age index referring
g	Gender (or sex) index
e	Ethnic group
n	Nativity group (birth place)
i	Zone index for zone of interest (origin)
j	Zone index for zone of interest (destination)
z	Zone index for the last zone in the system
$u(i)$	Zone index for rest of the UK
$w(u)$	Zone index for rest of world or rest of world region
o	Transmission rate = migration/origin population
a	Admission rate = migration/destination population
t	Stocks: a point in time; Flows: an interval in time from t to t+1
O	Stocks: indicates removal (out)
I	Stocks: indicates addition (in)

Table 4: Projection model equations

Description	Variable or equation	Step
Start populations	P_{xgen}^{S1}	(1)
Initial populations at risk	$P_{xgen}^{ARi} = P_{xgen}^{Si}$	(2)
The fertility and nativity model for births	$B_{bgen}^{Si} = v_g^i \times \sum_{x=10}^{x=49} f_{xen}^i \times P_{xfen}^{ARi}$	(3)
Mixing: assigning ethnicity to the new-born	$B_{bgfn}^{Si} = \sum_e x_{ef}^i \times B_{bgen}^{Si}$	(4)
Mortality model: when x <90	$D_{xgen}^i = d_{xgen}^i \times P_{xgen}^{ARi}$	(5)
Mortality model: when x >= 90	$D_{xgen}^i = (1 - s_{xgen}^i) \times P_{xgen}^{Si}$	(6)
Subtraction of special population stocks (prisoners and armed forces)	$-C_{xgen}^{i+} - A_{xgen}^{i+}$	(7)
Emigration option (1) Exogenous projected emigration flows	E_{xgen}^i	(8)
Emigration option (2) Emigration (transmission) rates × Populations at Risk	$E_{xgen}^i = e_{xgen}^{ti} \times P_{xgen}^{ARi}$	(9)
Emigration option (3) Emigration (admission) rates × Populations at Risk in the Rest of the World	$E_{xgen}^i = e_{xgen}^{ai} \times P_{xgen}^{ARw(u)}$	(10)
Internal out-migration option (1) Multi-regional equation with constant or trended transition rates	$M_{xgen}^{ij}(t) = m_{xgen}^{ij} \times P_{xgen}^{ARi}$ (t)	(11)
Internal out-migration option (2) Adjustment of migration flow to destination shares of populations	$\left(\frac{P_{xgen}^{Sj}(t)/\sum_j P_{xgen}^{Sj}(t)}{P_{xgen}^{Sj}(ref)/\sum_j P_{xgen}^{Sj}(ref)}\right) \times m_{xgen}^{ij}(ref) \times P_{xgen}^{ARi}$	(12)
Internal out-migration option (3) Gravity model based on origin, destination and impedance factors	$M_{xgen}^{ij}(t) = a_0 + \sum_k a_k X_k^i + \sum_l a_l Y_i^j + f(c^{ij})$	(13)
Total internal out-migrations are the sum of projected migration out-flows	$M_{xgen}^{i+} = \sum_{j \neq i} M_{xgen}^{ij}$	(14)
Residual balances	$R_{xgen}^i = P_{xgen}^{Si} - M_{xgen}^{i+} - E_{xgen}^i - C_{xgen}^{i+} - A_{xgen}^{i+} - D_{xgen}^i$	(15)
Total internal in-migrations are the sum of projected migration in-flows	$M_{xgen}^{+i} = \sum_{j \neq i} M_{xgen}^{ji}$	(16)
Immigration option (1)Externally generated projected immigration flows	I_{xgen}^i	(17)
Immigration option (2) Immigration (transmission) rates × Population at Risk in Rest of the World	$I_{xgen}^i = i_{xgen}^{ti} \times P_{xgen}^{ARw(u)}$	(18)
Immigration option (3) Immigration (admission) rates × Population at Risk	$I_{xgen}^i = i_{xgen}^{ai} \times P_{xgen}^{ARi}$	(19)
Addition of prisoners and armed forces	$+C_{xgen}^{+i} + A_{xgen}^{+i}$	(20)
Final populations	$P_{xgen}^{Fi} = R_{xgen}^i + M_{xgen}^{+i} + I_{xgen}^i + C_{xgen}^{+i} + A_{xgen}^{+i}$	(21)
Populations at risk, convergence test	$P_{xgen}^{ARi} = 0.5 \times [P_{xgen}^{Si} + P_{xgen}^{Fi}]$	(22)
Ethnic switching	$P_{xgfn}^{Fi} = \sum_e s_{ef}^i \times P_{xgen}^{Fi}$	(23)
Ageing on	$P_{x+1gen}^{Si} = P_{xgen}^{Fi}$	(24)

Table 5: Fertility estimates by ethnic group, England, 2011

Ethnic group	ASFRs						
	<20	20-24	25-29	30-34	35-39	40+	TFR
WBI	19	67	98	108	61	14	1.83
WHO	21	75	110	121	68	16	2.06
MIX	9	51	88	95	47	9	1.49
IND	20	84	129	130	64	12	2.20
PAK	65	150	171	160	83	11	3.20
BAN	71	162	185	174	90	12	3.47
CHI	8	43	74	80	40	7	1.26
OAS	13	71	123	133	66	12	2.09
BLA	45	115	140	138	73	17	2.64
BLC	30	76	93	91	49	11	1.75
OBL	8	42	73	78	39	7	1.23
OTH	11	60	104	113	56	11	1.77
Total	21	71	104	112	63	14	1.93

Notes: ASFR = age specific fertility rate, births per 1,000 women. TFR = Total Fertility Rate, births per woman = sum of ASFRs/1000.

Source: Author's computations from ONS Births, 2011 Census Data Tables & Samples of Anonymised Records and Annual Population Survey.

Table 6: LEEDS 2001-based and 2011 based projection assumptions

Component	**Assumptions**
TRENDEF projection	
Fertility	Long term TFR = 1.84
Mortality	Mortality decline rate = 1% pa
Internal migration	Constant 2000-01 conditional probabilities
International migration	Long term immigration = 435k, Long-term emigration = 293k (net 142k)
LEEDS (INTERIM) projection	
Fertility	Long term TFR = 1.89
Mortality	Mortality decline rate = 1.2% pa
Internal migration	Constant 2010-11 out-migration rates
International migration	Long term immigration = 617k, Long term emigration = 364k (net 253k)

Table 7: Projected ethnic group populations, UK, 2001-2061

Broad Grouping	MY2001	MY2011	MY2031	MY2051	MY2061
White	54,384	55,211	59,289	59,821	59,370
Mixed	687	1,260	2,297	3,543	4,183
Asian	2,627	4,333	8,209	12,697	15,080
Black	1,174	1,881	2,831	3,844	4,279
Other	238	592	1,038	1,480	1,670
All	59,111	63,278	73,664	81,386	84,582
BAME	4,726	8,066	14,375	21,564	25,212
White %	92.0%	87.3%	80.5%	73.5%	70.2%
BAME %	8.0%	12.7%	19.5%	26.5%	29.8%
LEEDS vs TRENDEF: White		-1,345	-502	-261	
LEEDS vs TRENDEF: BAME		+1,249	+3,178	+4,456	
LEEDS vs NPP2014: All			+1,957	+3,660	+4,333

Notes: 1. Broad groups are defined in Table 18.1. 2. TRENDEF = 2001 based, trended based projection using ETHPOP model. 3. NPP2014 = National Population Projections, 2014-based population (ONS 2015). 4. Populations are in 1,000s.

Table 8: Alternative scenarios for international migration for the UK, 2011-2061

Projection	Flow	Estimate 2011-2016	Short term 2016-2019	Medium Term 2019-2031	Long Term 2031-2061	Sums 2011-2061
ONS Low	Inflow	577	510	480	479	24,542
	Outflow	316	369	373	373	18,349
	Balance	261	142	107	106	6,193
ONS Principal	Inflow	577	550	519	518	26,301
	Outflow	316	329	333	333	16,549
	Balance	261	222	186	185	9,752
ONS High	Inflow	577	590	559	558	28,101
	Outflow	316	289	293	293	14,749
	Balance	261	302	266	265	13,352
LEEDS Interim	Inflow	577	610	615	617	30,601
	Outflow	316	354	360	364	17,878
	Balance	261	256	255	253	12,723
LEEDS Brexit	Inflow	577	546	415	349	19,973
	Outflow	316	315	281	249	13,363
	Balance	261	231	134	100	6,610

Notes:
Migration numbers are in 1000s. All estimates, except those in the "Sums" column report annual figures.
Time interval 2011-2016 reports ONS LTIM estimates
Time interval 2016-2019 reports adjustment period projections after the 23 June 2016 Referendum
Time interval 2019-2031 reports trended flows to a limit
Time interval 2031-2061 reports the constant long term flow assumptions.

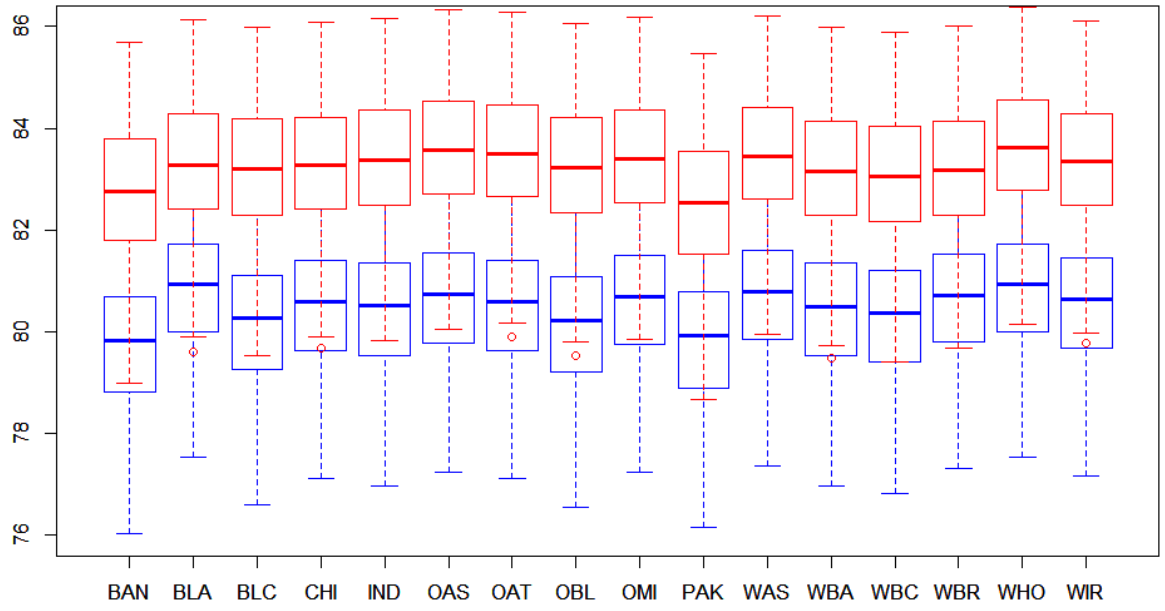


FIGURE 1: Life expectancy at birth for women, estimated using the geographical distribution method, English LADs 2001 and 2011

Notes: Boxes show the median LAD and the inter-quartile range (IQR). Whiskers show the minimum and maximum values with dots representing a few outliers. See Table 18.1 for ethnic group definitions.
Source: Wohland (2015b)

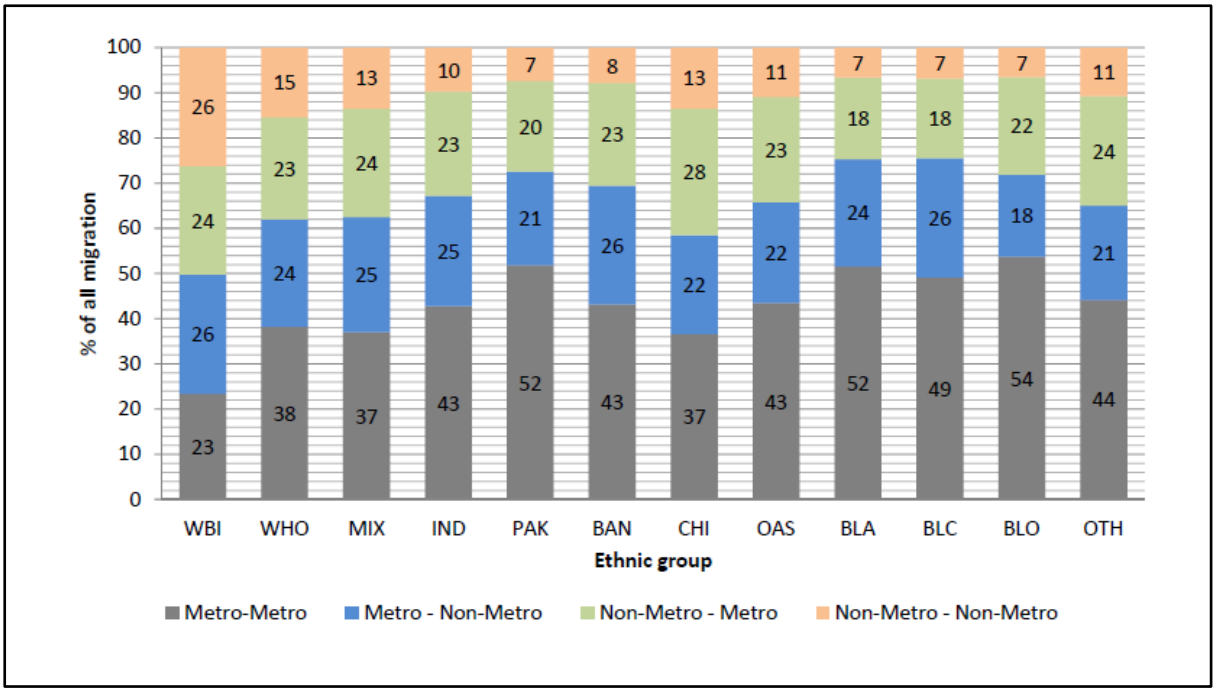
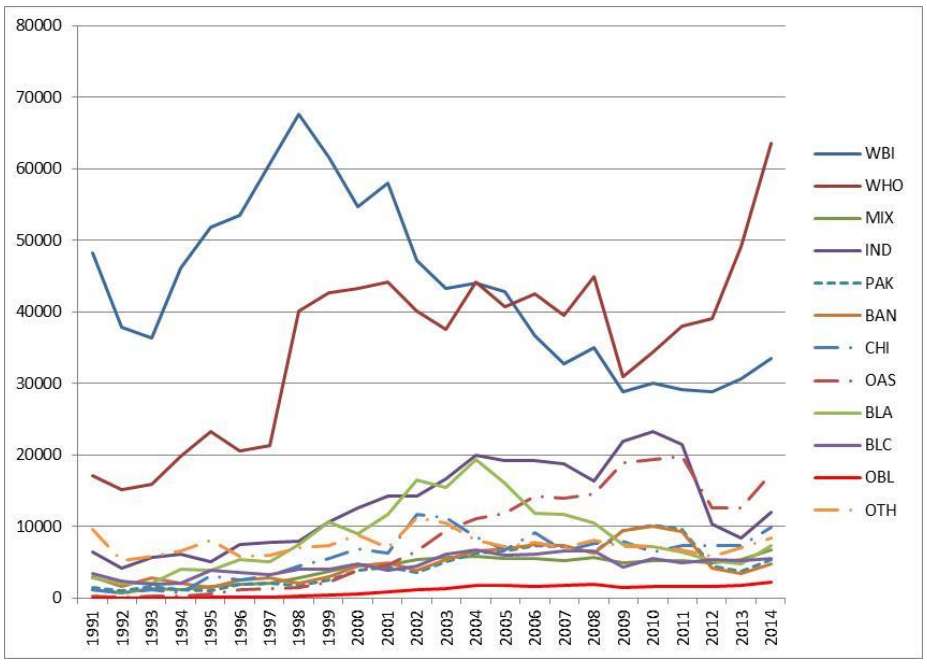


FIGURE 2: Internal migration between LADs by ethnicity classified by type of flow, 2011 Census, UK

A: Immigration to London 1991-2014



B: Emigration from London 1991-2014

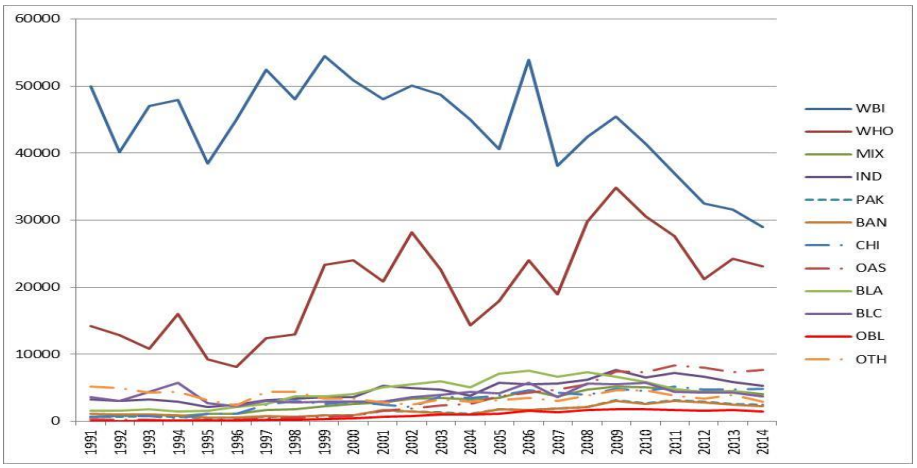


FIGURE 3: Estimates of immigration and emigration by ethnicity, London, 1991-2014
Notes: See Table 1 for the definitions of ethnic groups.
The London region comprises the 33 London Boroughs (LADs).

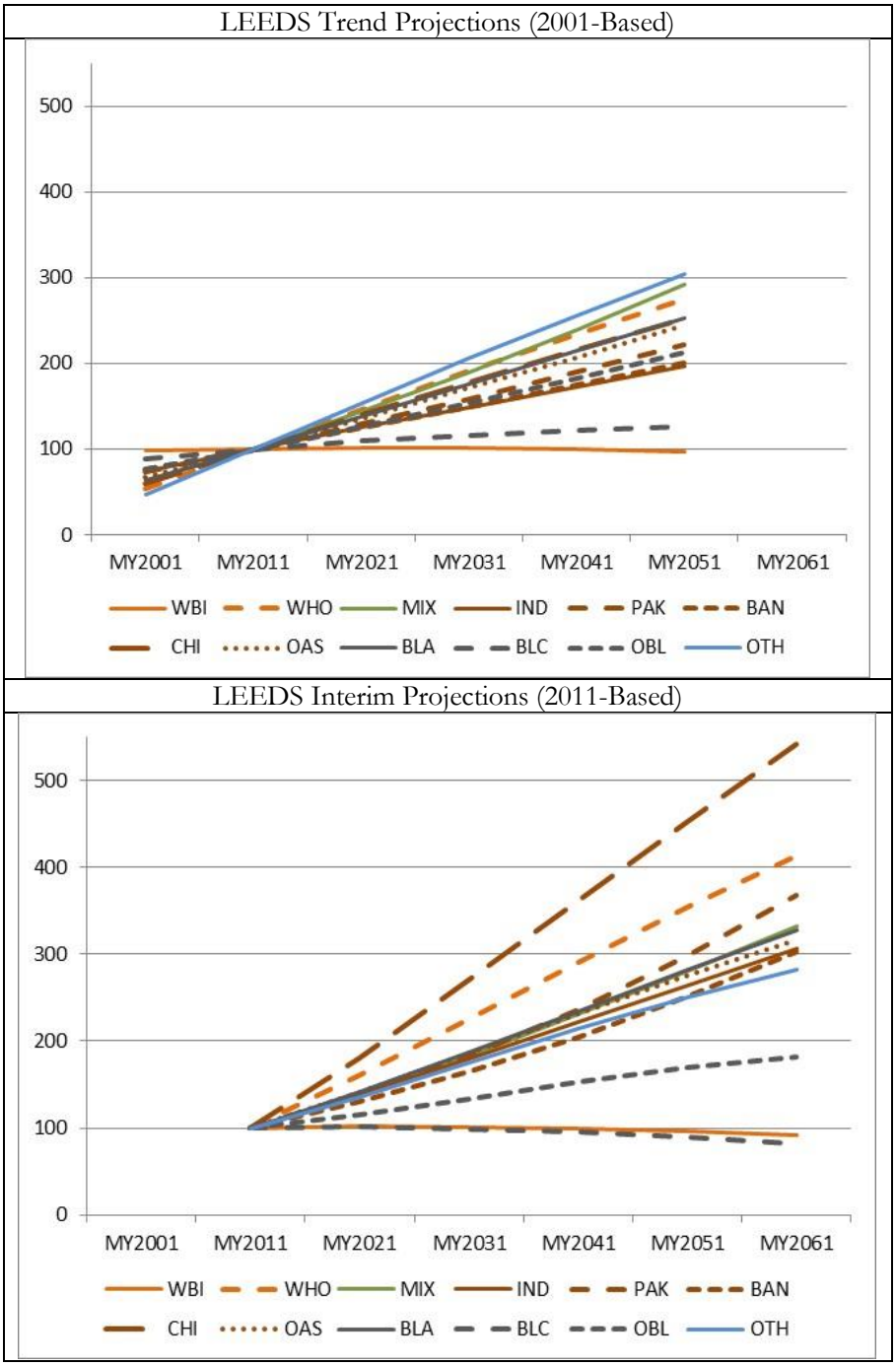


FIGURE 4: Projected ethnic group trends: 2001-based and 2011-based
Notes: See Table .2 for the definitions of the ethnic group abbreviations.
The vertical axis is a time series index set to 100 for MY2011. 3. MY = mid-year = 30 June/1 July.
Sources: TRENDEF: Rees et al. 2011, 2012a. LEEDS: NewETHPOP project.

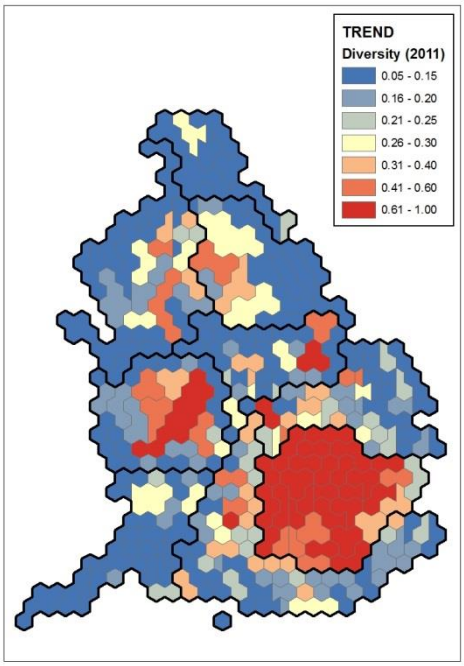
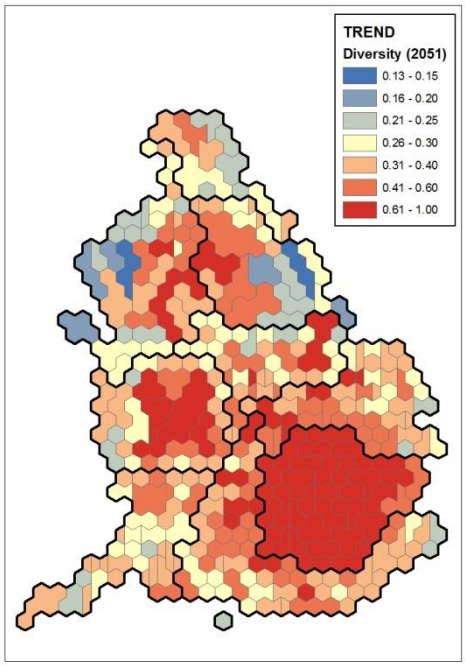
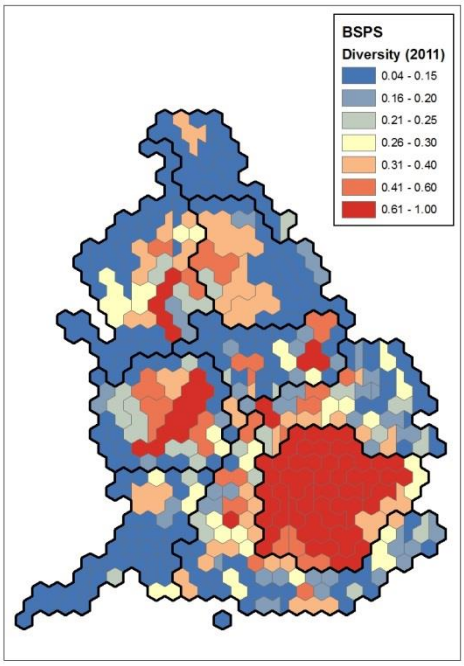
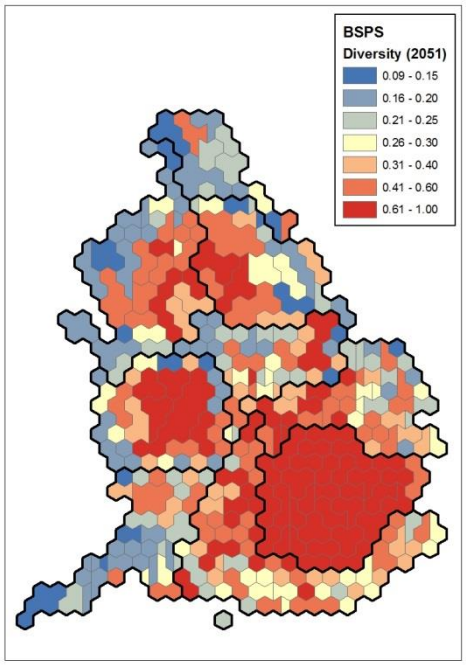
A TRENDEF Projection (2001-Based): Mid-Year 2011	B TRENDEF Projection (2001-Based): Mid-Year 2051
	
C LEEDS Interim Projection (2011 Census based) Mid-Year 2011	D LEEDS Interim Projection (2011-Based): Mid-Year 2051
	

FIGURE 5: The changing diversity of England's local populations

Notes: 1. Diversity = 1 minus the sum over all ethnic groups of the squares of the proportions of LAD populations in an ethnic group. Minimum diversity = 0, where the whole LAD population belongs to one ethnic groups. Maximum diversity is 0.917, where each of 12 groups has the same share (8.3%).

2. The map base is a population cartogram from Dorling and Thomas (2004), adapted by Wohland and Clark.

3. Population cartograms assign areas to zones in proportion to population. LADs are composed of one or more hexagons which represent equal populations. The darker boundaries are for the 9 English regions.

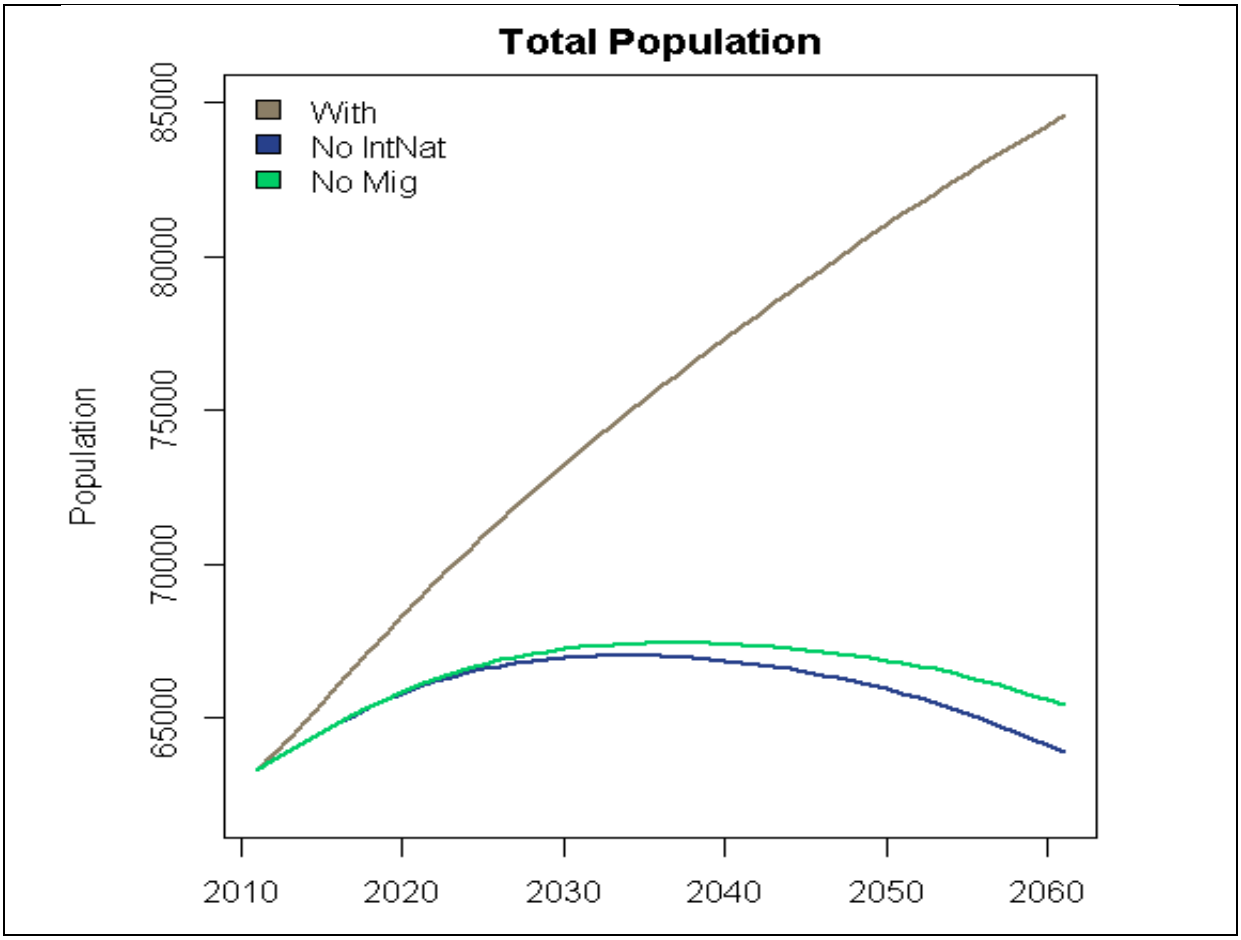


FIGURE 6: The impact of international and internal migration on UK population change

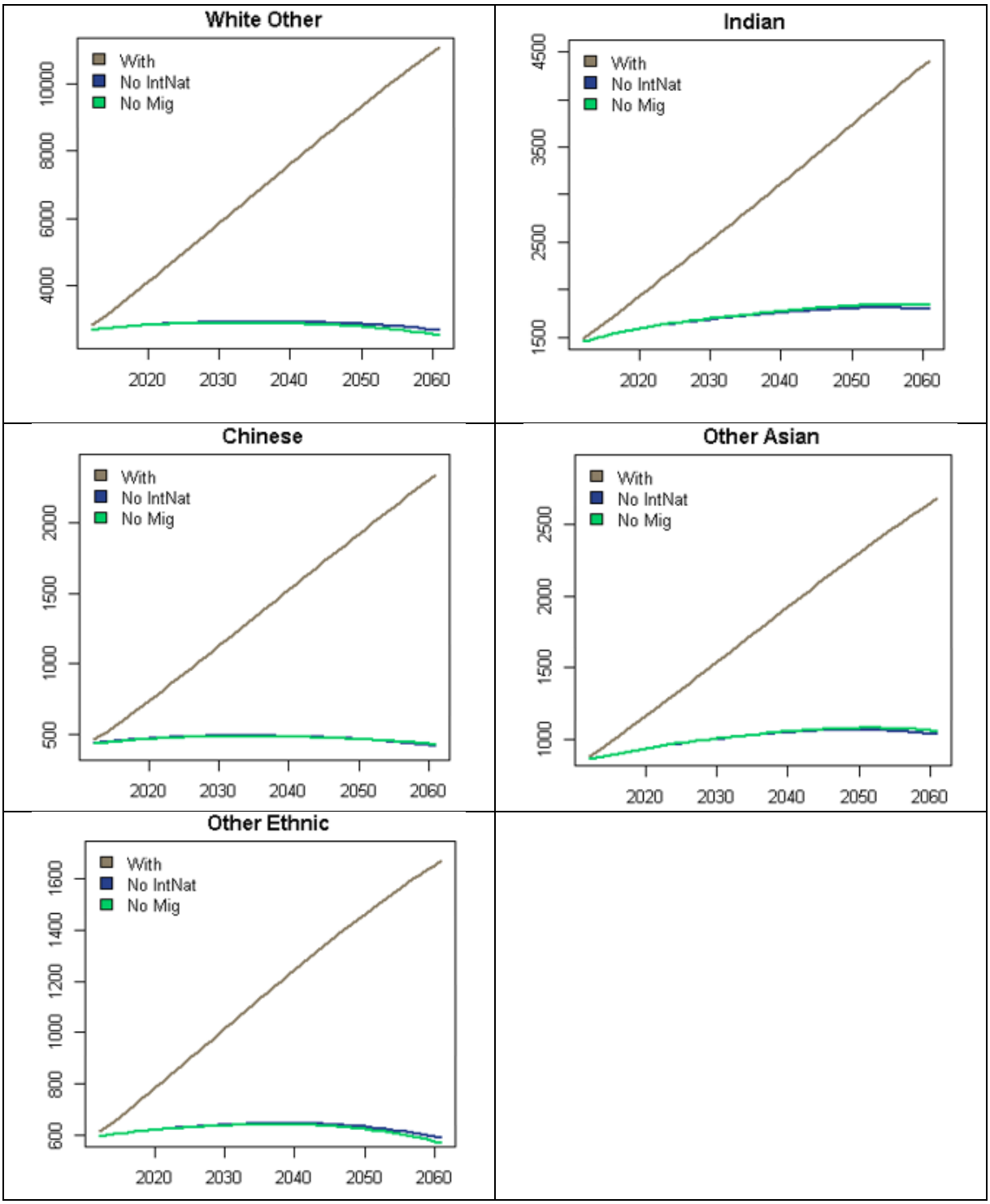


FIGURE 7: The Impact of international migration on ethnic groups reliant on immigration for population growth

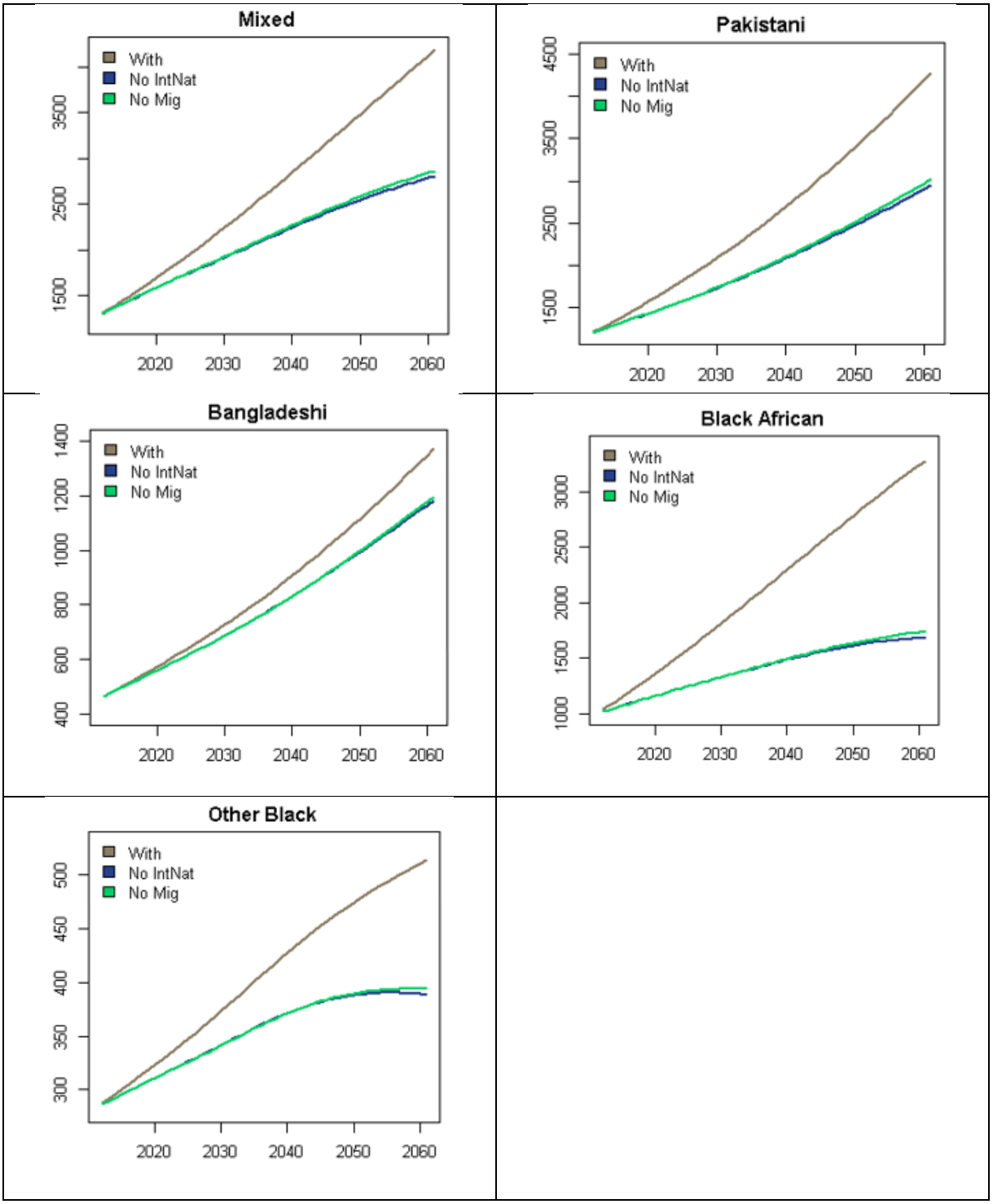


FIGURE 8: The impact of international migration on ethnic groups somewhat reliant on immigration for population growth

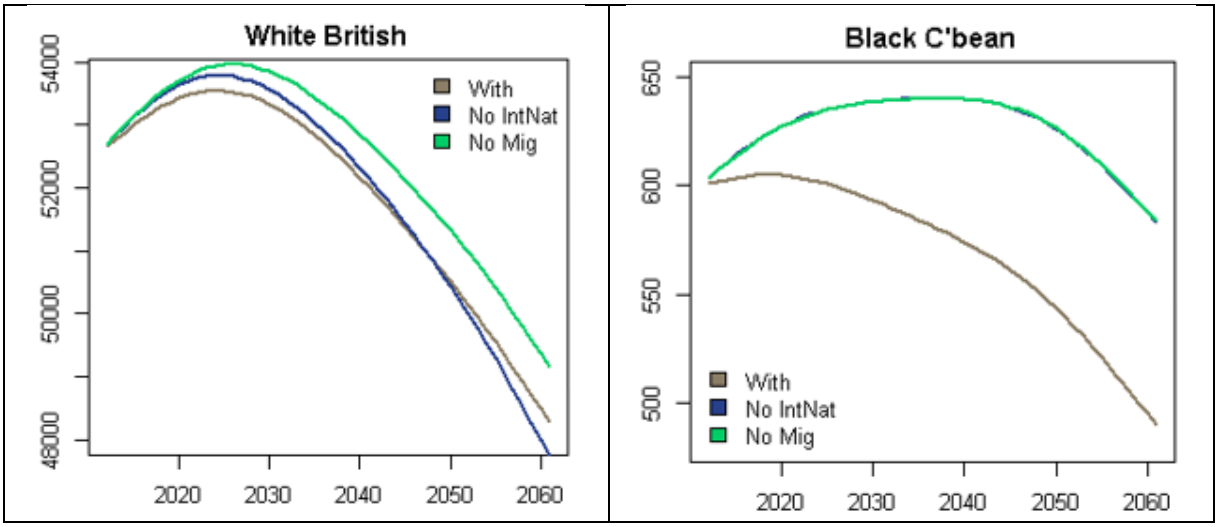


FIGURE 9: The impact of international migration on ethnic groups experiencing net emigration

REFERENCES

Bijak J (2012) Migration Assumptions in the UK National Population Projections: Methodology Review. http://www.ons.gov.uk/ons/guide-method/method-quality/specific/population-and-migration/population-projections/npp-migration-assumptions-methodology-review/index.html

Boden P & Rees P (2010). Using administrative data to improve the estimation of immigration to local areas in England, *Journal of the Royal Society Series A – Statistics in Society*, 173(4), 707-731.

Bongaarts J & Bulatao R (1999) Completing the demographic transition. *Population and Development Review* 25, 515–29.

Clark S & Rees P (2016) International Migration by Ethnicity to UK Regions: Results for 1991-2014 and Implications for the Future. Paper presented at the First International Conference on Migration and Mobility, Loughborough University, 18-20 July.

Coleman D (2006) Immigration and ethnic change in low-fertility countries: A third demographic transition. *Population and Development Review* 32(3), 401–446.

Colby S & Ortman J (2015) Projections of the Size and Composition of the U.S. Population: 2014 to 2060. *Current Population Reports*, P25-1143. https://www.census.gov/content/dam/Census/library/publications/2015/demo/p25-1143.pdf

Dion P (2014) Projection of interprovincial migration, Chapter 8 in *Population Projections for Canada (2013 to 2063), Provinces and Territories (2013 to 2038): Technical Report on Methodology and Assumptions,* Statistics Canada Catalogue, 91-620-X. http://www.statcan.gc.ca/pub/91-620-x/2014001/chap08-eng.htm

Dorling D & Thomas B (2004) *People and Places: A 2001 Census Atlas of the UK*. The Policy Press, Bristol.

Disney G, Wiśniowski A, Forster J, Smith P & Bijak J (2015) Evaluation of existing migration forecasting methods and models. Report for the Migration Advisory Committee. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/467405/Migration_Forecasting_report.pdf

Frey W (2015) *Diversity Explosion: How New Racial Demographics Are Remaking America*. Washington DC, Brookings Institution Press.

Lomax N (2015) Ethnic group migration patterns: a UK time series analysis, British Society for Population Studies, Annual Conference, Leeds, 7-9 September 2015. https://www.ethpop.org/Presentations/NewETHPOP/BSPS2015/NL%20BSPS2015%20Presentation.pdf

Lomax N & Rees P (2015) UK Internal Migration by Ethnicity, Presentation at the GISRUK2015 Conference, University of Leeds, 16 April. http://www.ethpop.org/Presentations/NewETHPOP/NLGISRUK%20UK%20Internal%20Migration%20by%20Ethnicity%20NL.pdf

Norman P, Rees P & Wohland P (2014) The use of a new indirect method to estimate ethnic-group fertility rates for subnational projections for England. *Population Studies*, 68(1): 43-64.

Norman P (2015) We can't just 'Call the Midwife'! Are variations in fertility rates more about ethnicity, country of birth or local geography of residence?, British Society for Population Studies, Annual Conference, Leeds, 7-9 September. http://www.ethpop.org/Presentations/NewETHPOP/BSPS2015/PN-ethnic-fertility-BSPS-2015.pdf

ONS (2014) Assessment of three potential methods for setting NPP migration assumptions as rates. Internal Paper, Office for National Statistics.

ONS (2015) National population projections, 2014-based Statistical Bulletin. Office for National Statistics. http://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/bulletins/nationalpopulationprojections/2015-10-29

Raymer J, Rees P & Blake A (2015) Frameworks for guiding the development and improvement of population statistics in the United Kingdom. *Journal of Official Statistics,* 31: 699-722.

Rees P, Wohland P & Norman P (2009) The estimation of mortality for ethnic groups at local scale within the United Kingdom. *Social Science and Medicine* 69, 1592–1607.

Rees P, Wohland P, Norman P & Boden P (2011) A local analysis of ethnic group population trends and projections for the UK. *Journal of Population Research*, 28(2-3): 149-184.

Rees, P., Wohland, P., Norman, P. & Boden, P. (2012) Ethnic population projections for the UK, 2001-2051. *Journal of Population Research*, 29(1): 45-89.

Rees P, Wohland P & Norman P (2013) The demographic drivers of future ethnic group populations for UK local areas 2001–2051. *Geographical Journal*, 179(1): 44-60.

Rees P, Clark S, Wohland P, Lomax N & Norman P (2015) Ethnic Population Projections for the UK and Local Areas, 2011-2061: New Results for the Fourth Demographic Transition. British Society for Population Studies, Annual Conference, Leeds, 7-9 September, Session, Demographic projections: ethnicity & projections. https://www.ethpop.org/Presentations/NewETHPOP/BSPS2015/BSPS%20Ethnic%20Population%20Projections%20Phil%20Rees.pdf

Rees P, Clark S, Wohland P, Lomax N & Norman P (2016) Using the 2001 and 2011 censuses to reconcile ethnic group estimates and components for the intervening decade for English local authority districts. Chapter 21 in Stillwell J & Duke-Williams O (ed.) *Unlocking the UK 2011 Census: Handbook of Census Resources, Methods and Applications*. Routledge, Oxford.

Rogers A & Ledent J (1976) Increment-decrement life tables: a comment. *Demography*, 13: 287-290.

Sabbagh D (2008) The Collection of Ethnoracial Statistics: Developments in the French Controversy. https://frenchamerican.org/sites/default/files/documents/media_policy_briefs/sabbagh_ethnicstatistics_brief_en.pdf

Simpson L (2014) How have people's ethnic identities changed in England and Wales? Briefing on the Dynamics of Diversity: Evidence from the 2011 Census. ESRC Centre on Dynamics of Ethnicity (CoDE). http://www.ethnicity.ac.uk/medialibrary/briefingsupdated/how-have-people's-ethnic-identities-changed-in-england-and-wales.pdf

Statistics New Zealand (2015a) National Ethnic Population Projections: 2013(base)–2038. http://www.stats.govt.nz/browse_for_stats/population/estimates_and_projections/NationalEthnicPopulationProjections_HOTP2013-38.aspx

Statistics New Zealand (2015b) Subnational Ethnic Population Projections: 2013(base)–2038. http://www.stats.govt.nz/browse_for_stats/population/estimates_and_projections/SubnationalEthnicPopulationProjections_HOTP2013base.aspx

Stone R (1971) *Demographic Accounting and Model Building*. OECD, Paris.

Wohland P (2015) Alternative methods to estimates mortality for UK ethnic groups, British Society for Population Studies. Annual Conference, Leeds, 7-9 September 2015. http://www.ethpop.org/Presentations/NewETHPOP/BSPS2015/Alternative%20methods%20to%20estimates%20mortality%20for%20UK%20ethnic.pdf

Wohland P & Rees P (2015) New estimates of ethnic mortality in the UK – resolving the debate. International Conference on Population Geographies, University of Queensland, Brisbane, Australia, 30 June to 3 July. http://www.ethpop.org/Presentations/NewETHPOP/PWEthnicMortality1.pdf