

Quarterly Population Estimates

Methodology

September 2007

Contents

- 1. Introduction.....3
- 2. Data Sources and Availability4
 - 2.1 Births and deaths..... 4
 - 2.2 International Migration:..... 4
 - International Passenger Survey and Migrant Switchers.....4
 - Visitor Switchers.....4
 - Irish Migrants.....5
 - Asylum Seekers5
 - 2.3 Internal Migration..... 5
 - 2.4 Other Changes 5
- 3. Forecasting Components of Change6
 - 3.1 Births and Deaths..... 6
 - 3.2 International Migration 6
 - International Passenger Survey and Migrant Switchers.....6
 - Visitor Switchers and Irish Migrants7
 - SAS Best-fit Time Series Models7
 - Asylum Seekers7
 - 3.3 Internal Migration..... 7
- 4. Combining Components – total population in current quarter8
- 5. Population by age and sex.....9
- 6. Seasonality in the QPEs10
- 7. Data published each quarter10
- 8. Revisions10
- 9. Future changes to methodology10
- 10. Contacts10

Methodology for producing Quarterly Population Estimates for England, Wales and English Government Office Regions

1. Introduction

The Office for National Statistics (ONS) produces estimates of the resident population of England and Wales. The most authoritative population estimates are produced every ten years and come from the Census of Population and Housing. These are updated to produce mid-year population estimates in the intercensal period. The population estimates give a stock count of people living in each local authority and health authority area, and the composition of the population in these areas by age and sex. Further population statistics, including migration estimates, vital events (covering births, deaths, marriages and divorces) and population projections are also available.

At present, population estimates for England and Wales are produced 14 months after the end of the reference period. This timing ensures that when they are released, the population estimates are of sufficient quality that they will not need to be revised during the intercensal period. More timely population weighting totals for use by surveys have historically been derived from population projections.

Population projections are based on assumptions that past trends in fertility, mortality and migration will continue into the future. The one certainty in making population projections is that the projections will, to a greater or lesser extent, turn out to be incorrect as a forecast of future demographic behaviour.

The National Statistics Centre for Demography (NSCD) of ONS is responsible for the production of population estimates for England and Wales, for subnational population projections for England and for national population projections. Responsibility also lies with GROS for Scottish population estimates and subnational population projections; NISRA for Northern Ireland population estimates and subnational projections and WAG for subnational population projections for Wales. Historically NSCD have co-ordinated the supply of population data to the LFS.

Population statistics are used to weight the Labour Force Survey (LFS) estimates, as well as other ONS surveys. These surveys require population weighting totals to be available on a more timely basis than the mid-year estimates, which reflect information available on changes in the population since the latest official estimate. Thus Quarterly Population Estimates (QPEs) are proposed that would be available shortly after the reference period. These will have to include an element of projection, as required data are not available so soon after the period. QPEs are released initially on an experimental basis, and further development is needed before they will be classed as National Statistics. They will not be used as population weights for surveys until after they achieve National Statistics status.

QPEs effectively aim to predict the end June population that will be created the following year for the mid-year estimate. They will be produced using the demographic cohort component method and as far as possible will use the same data sources as are used in the mid-year estimates. Some components will have to be forecast, and some minor components used in the mid-year estimates will have to be ignored as there are no quarterly data available for these. QPEs are initially available for England and Wales, by broad age groups and sex.

Data Sources and Availability

2.1 Births and Deaths

The compulsory registration of births and deaths ensures that very high quality data are available from the Registrar General's office.

Births data are provided by numbers of live births, by sex, occurring and registered in any given quarter, extracted 28 days after the end of the quarter, for each quarter of each year. Extracts are also provided for the number of births occurring in the relevant quarter of the previous year, in order to estimate the number of late registrations for the current quarter.

Births are allocated to the area of usual residence of the mother. Included in the births data is a group called "elsewhere births". Account is taken of mothers whose usual residence is outside England and Wales, but who give birth to children in England and Wales (these are elsewhere births), and of mothers whose usual residence is in England and Wales who give birth to children outside England and Wales. In practice, it is assumed that the numbers of births to mothers in the former group (approximately 400 per year) compensates for the number of births to mothers in the latter group.

Deaths are also allocated to the area of usual residence of the deceased. As with births the situation is complicated by people whose usual residence is outside England and Wales who die in England and Wales; and people whose usual residence is in England and Wales who die outside England and Wales. It is again assumed that the former compensate for the latter.

Deaths data are provided by numbers of registered deaths, by single year of age and sex, extracted 28 days after the end of the quarter, for each quarter of each year. Extracts are also provided for the number of deaths occurring in the relevant quarter of the previous year, in order to estimate the number of late registrations for the current quarter. Age at death is converted to the age the person would have been had they survived to the end of the quarter.

2.3 International Migration

Estimates of international migration are put together from a number of sources: the International Passenger Survey (IPS), flows from the Republic of Ireland from the Irish Central Statistical Office and Home Office data on Asylum Seekers (AS). Estimates are compiled using an agreed methodology by ONS's Migration Statistics Unit (MSU), and are made available for QPEs using finalised data, or more timely provisional data if available.

The main data-source for international migration is the IPS, which gives total monthly inflows and outflows for the United Kingdom and subnational areas, based on people's *intentions* to stay for more than one year. The latest processed data usually relate to one year ago.

To account for people who do not realise their intended length of stay on arrival, two adjustments are made. First, visitor data from the IPS are used to estimate those people who initially come to or leave the UK for a short period but subsequently stay for a year or longer ('visitor switchers'). Second, people to intend to be migrants, but who in reality stay in the UK or abroad for less than a year ('migrant switchers'), are estimated from IPS migrant data. MSU provide detail of total quarterly inflows and outflows, for the UK countries and subnational areas. The latest processed data usually relate to one year ago.

Data on the numbers travelling between the UK and the Republic of Ireland are provided by the Irish Central Statistical Office, using data from the Irish Quarterly Household survey and the National Health Service Central Register. These data usually relate to one year ago.

For some quarters, provisional data will be available for more recent periods. In these cases, the most recent data will be used to forecast to the current quarter. Use of provisional rather than final data in the forecasting process will be noted in the productions notes on publication.

Asylum Seekers are people entering the UK seeking asylum. The Home Office provide data on asylum seekers and their dependants, which are used by ONS to calculate the asylum seeker adjustment to the migration estimates. Provisional timely data on applications and removals are provided by the Home Office shortly after the latest quarter. Revised data are provided by the Home Office to MSU a few months later, giving more detail that is used in the creation of more robust estimates.

2.2 Internal Migration

For migration within England and Wales, extracts of the National Health Service Central Register (NHSCR) are used. The NHSCR records the movement of patients between former Health Authority areas in England and Wales. Since most people do eventually re-register with a new doctor after moving, the NHSCR figures are generally regarded as providing the best available proxy data on internal migration. NHSCR data are lagged by one month, which is estimated to be the average time between a person moving and the NHSCR being notified of the move. These data are available as total inflows and outflows, cross-border flows between constituent countries of the UK, and cross-GOR for each quarter. The most recent data available in time to do the QPEs usually relate to nine months ago.

2.4 Other changes

Quarterly data are not available for home and foreign armed forces, foreign armed forces dependants, prisoners and school boarders, which are included in the mid-year estimates. However, it is assumed that the base population from the mid-year estimate will include these groups, and that quarterly changes in these sources are be minimal, and so need not be included.

3. Forecasting Components of Change

3.1 Births and Deaths

The data available from the live registrations system for the relevant quarter are scaled to take account of late registrations. This assumes a stable relationship exists between the available data and the actual occurrences as that observed for the previous year's relevant quarter. Data are also adjusted to take into account weekends and public holidays occurring at the end of a quarter.

Key

Oyy,q	= quarterly birth occurrences, current year yy, quarter q (q = 1 to 4)
Oyy-1,q	= quarterly birth occurrences, quarter q in previous year (i.e. 4 quarters ago)
ORyy,q	= number of births occurring and registered in current quarter t
ORyy-1,q	= number of births occurring and registered, quarter t in previous year (i.e. 4 quarters ago)
Ryy,q	= number of deaths registered in current year yy, quarter q
Ryy-1,q	= number of deaths registered, quarter q in previous year (i.e. 4 quarters ago)
E(Oyy,q)	= estimate of quarterly occurrences, current quarter t

Births – “Quarterly Scale-up Estimator”

$$E(Oyy,q) = Oyy-1,q * ORyy,q / ORyy-1,q$$

Data for quarter yy,q are adjusted according to how many days at the end of the quarter yy,q were weekends or public holidays, for both years yy and yy-1. This allows for the number of occurrences in the quarter that could not be registered by the end of that quarter because the registration office was closed, when in the previous year they could have been registered, and vice versa.

Deaths – “Quarterly Ratio Estimator”

$$E(Oyy,q) = Oyy-1,q * Ryy,q / Ryy-1,q$$

Data for the quarter yy,q are adjusted according to how many days in the previous quarter (yy,q-1), and how many at the end of the current quarter were weekends or public holidays, for both years yy and yy-1. This allows for the number of deaths registrations that were “carried over” from the previous month because they could not be registered at the weekend or on a public holiday, and the number of registrations that could not take place in the current month for the same reason, in relation to the situation in the previous year. Deaths estimates are first calculated by broad age-group and sex. These are then disaggregated from broad age-groups to single year of age, using the same distribution in the age-groups in the previous year's occurrences.

In the absence of comparable data, alternative methods of forecasting such as growth rates, time series forecasting or applying fertility or mortality rates may be applied.

3.2 International Migration

International Passenger Survey and Migrant Switchers

These two components are calculated together. The England and Wales level quarterly inflows and outflows are modelled using SAS Time Series Forecasting System, with SAS diagnostics choosing

the best-fit model according to the lowest RMSE. The forecast is made for the latest quarter, usually 4 quarters ahead. Finally the net flow is calculated.

Visitor Switchers and Irish Migrants

England and Wales-level quarterly inflows and outflows are modelled using SAS Time Series Forecasting System, with SAS diagnostics choosing the best-fit model according to series diagnostics and lowest RMSE. The forecast for the latest quarter is usually made for four quarters ahead. Finally the net flows are calculated.

SAS Best-fit Time Series Models

Forecasting was done using SAS diagnostic checks on the data, fitting the model with the lowest RMSE. Because there is currently only a short historic series available, the evaluation period is the same as the modelling period for the “best-fit” model.

Limitations of time series forecasting

As described earlier in this document, time series models are used to forecast the most recent observations for some components of the QPEs. These models make the assumption that future behaviour of the series being forecast will follow the pattern of past behaviour. The reliability of the forecasts will therefore partly depend on the extent to which this holds in practice. Changes in policy and other external influences can make the migration numbers particularly difficult to forecast for this reason. Such changes will be accounted for where they can be estimated independently and isolated from the generic model. Other determinants of forecast reliability are the extent to which the model is correctly formulated, and the inherent volatility of the historical series. The replacement of forecasts with estimates based on survey or administrative data, when they become available, will inevitably be a regular source of revisions to the QPEs.

Asylum Seekers

Home Office supply timely provisional data on UK applications and removals shortly after the end of each relevant quarter. These are then converted onto a resident population basis (i.e. for those remaining in the country for longer than 12 months) by subtracting the numbers who have been removed within a year, and estimating the total outflows. The method used to estimate these flows follows as far as possible the method used by MSU for the official published international migration flow figures. However due to the time restraints for QPEs not all HO sources are available on time, so a simplified method has been formulated and agreed.

UK estimates are disaggregated to England and Wales level using the same method as used by MSU, using the most recently available necessary data.

3.3 Internal Migration

The latest quarter’s internal migration flows for each country are forecast using the SAS Time Series Analysis System, based on past quarterly flows from 1991 onwards. SAS diagnostics choose the best-fit model out of all possible default models tested, choosing the results with the lowest

Root Mean Square Error (RMSE). The flows by area are constrained with respect to their standard error, to meet the criterion that net flows for the UK sum to zero.

4. Combining Components

Calculating population totals for each quarter – “Demographic Cohort Component Equation”

$$\text{Pop (t+q)} = \text{Pop (t)} + \text{B(q)} - \text{D(q)} + \text{Int(q)} + \text{Ext(q)}$$

Key

pop(t+q) = population in latest quarter
pop(t) = population in previous quarter

Components of change:

B(q) = estimated number of births in current quarter
D(q) = estimated number of deaths in current quarter
Int(q) = forecast net internal migration in current quarter (for England and Wales this is net cross-border flows with Scotland and Northern Ireland)
Ext(q) = forecast net international migration in current quarter (from International Passenger Survey, Asylum Seeker, Visitor Switcher and Republic of Ireland source data)

The population for the previous quarter is rolled on to the latest quarter by allowing for quarterly change. QPEs are rebased annually when the latest mid-year estimate is available. Any available observed component data are used instead of forecasts, and the time series forecasts are re-run for migration sources in order to get the best available estimate of change.

5. Population by Age and Sex

The QPE totals are disaggregated to single years of age and sex using the latest mid-year estimate's age/sex distribution, assuming a uniform ageing on each quarter. The estimates of births and deaths are allowed for directly, and a correction is made for the net migration age/sex distribution. Estimates by single year of age and sex will not be published, but will be aggregated to larger age groups.

The calculation works as follows:

- Take the total population figure created as above, for the previous mid-year (we have the mid-year estimate for comparison) and the current year
- Calculate the previous year's age and sex distribution, and age-on one year (add aged-on proportion for age 79 into age group 80+)
- Take out estimated natural change element (subtract births since mid-year to date, add deaths since mid-year to date) to give A (total figure)

For first quarter after the mid-year:

- Apply 0.75 of previous year's age/sex distribution, and 0.25 of aged-on age/sex distribution to A to give B (single year of age and sex figures).
- Add back in the estimate of births for current quarter by sex, and subtract estimate of deaths for current quarter by single year of age and sex to give C (single year of age and sex)

For the second quarter after the mid-year:

- Apply 0.5 of previous year's age/sex distribution, and 0.5 of aged-on age/sex distribution to A to give B (single year of age and sex figures).
- Add back in the estimate of births for 2 quarters by sex, and subtract estimate of deaths for 2 quarters by single year of age and sex to give C (single year of age and sex)

For the third quarter after the mid-year:

- Apply 0.25 of previous year's age/sex distribution, and 0.75 of aged-on age/sex distribution to A to give B (single year of age and sex figures).
- Add back in the estimate of births for 3 quarters by sex, and subtract estimate of deaths for 3 quarters by single year of age and sex to give C (single year of age and sex)

For the fourth quarter after the mid-year:

- Apply aged-on age/sex distribution to A to give B (single year of age and sex figures).
- Add back in the estimate of births for 4 quarters by sex, and subtract estimate of deaths for 4 quarters by single year of age and sex to give C (single year of age and sex)

at this point we have an aged-on population, but migrants are assumed to have the same age and sex distribution as the rest of the population. To adjust for this:

- Calculate C as above for the previous year
- Divide the previous year's mid-year estimate by C for each single year of age and sex to give D, a migration age/sex "correction factor".
- Multiply the current year estimate C by the previous year's correction factor, D

Although this method allows population by single year of age and sex to be calculated, single year of age data are not considered accurate enough to be published, so they are combined to give age-groups.

6. Seasonality in the QPEs

The QPEs will not be published as a seasonally adjusted series. However, it should be noted that the differences in the quarterly changes are quite marked, with only around one eighth of annual growth occurring in each of the December and March quarters, around one quarter in the June quarter, and around a half in the September quarter. Thus, much of the quarter on quarter change can be accounted for by seasonality.

7. Data published each quarter

Six to eight weeks after the end of each quarter, the latest quarterly population estimate will be published. Any delays in the publication of the mid-year estimate in August each year will have a knock-on effect on the publication of the QPE.

8. Revisions

Quarterly population estimates will be revised once a year, when the latest mid-year estimate is available. Quarterly population estimates between two mid-year estimates will be finalised, and later QPEs will be rebased to the latest mid-year estimate.

9. Future changes to methodology

QPEs are initially released on an experimental basis. While estimates are being published on this basis, all aspects of the methodology will be subject to further investigation to see what improvements can be made.

Once these estimates have been created for a number of quarters, it will be possible to conduct a thorough analysis of the revisions that arise when new mid-year estimates are released. This analysis will be made available, in order to help inform users about the quality of these early estimates of the resident population.

10 Contacts

For further information or specific questions about Experimental Quarterly Population Estimates, please contact:

Email: QPE@ons.gov.uk

Telephone: 01329 81 3913

Post: Quarterly Population Estimates, Room 2300, Office for National Statistics, Segensworth Road, Titchfield, Hampshire, PO15 5RR