



# National Population Projections Accuracy Report

July 2015

## 1. Introduction

National population projections by age and sex are produced for the UK and its constituent countries every two years. The projections are based on the most recently available mid-year population estimates and a set of underlying demographic assumptions regarding future fertility, mortality and migration. The latest set is 2012-based.

The primary purpose of the projections is to provide an estimate of future population, which is used as a common framework for national planning in a number of key policy areas. It is important to note that these projections are not forecasts and do not attempt to predict the impact that future government or local policies, changing economic circumstances or other factors might have on demographic behaviour. The trends for these projections take into account information from the 2011 Census.

It is acknowledged that projections become increasingly uncertain the further they are carried forward and it is noted that long-term projections should be used with caution. To help understand the uncertainty, a number of variant projections are produced alongside the principle projections and these are based on alternative demographic scenarios to show users the range of possible outcomes. This report will only assess how well the principal national population projections have performed as predictions of future UK population.

The [last accuracy review of the national population projections](#) was carried out in 2007 following the 2001 Census and subsequent revisions. In line with this, the current review is timed to include the 2011 Census results and the results of rebasing the population estimates.

The Government Actuary's Department (GAD) was responsible for producing the projections from the 1954-based set through to the 2004-based projections. Responsibility then passed to ONS. Only limited information is available for projections published before the 1970s, so the report will generally focus on projections from the last 40 years, although for variables where the information is available (e.g. for total population), the full set of projections will be analysed.

The projections have been compared with population and migration estimates, and births and deaths data up to 2013, where available. These comparisons allow for the review of the accuracy of past projections which are useful for projection makers, to identify areas where improvements may be made, and for projection users, to provide an indication of the uncertainty associated with the projection of demographic variables.

In this analysis, total fertility rate (TFR) and life expectancy figures for up to 2012 were used as, at the time of writing, they were the most recent figures available. The most recent set (2012-based) of population projections, published in 2014, have been included in the analyses where data for 2013 have been available for comparison. Otherwise, projections up to the 2010-based have been analysed.

Please note that 'projected' figures for fertility, mortality and migration refer to the average of successive mid-year to mid-year (e.g. 1 July 2011 to 30 June 2012); whilst 'actual' figures refer to calendar year (1 January 2012 to 31 December 2012).

## 2. Total population

Figure 1. Actual and projected UK population, 1951 to 2065, selected projections by base year

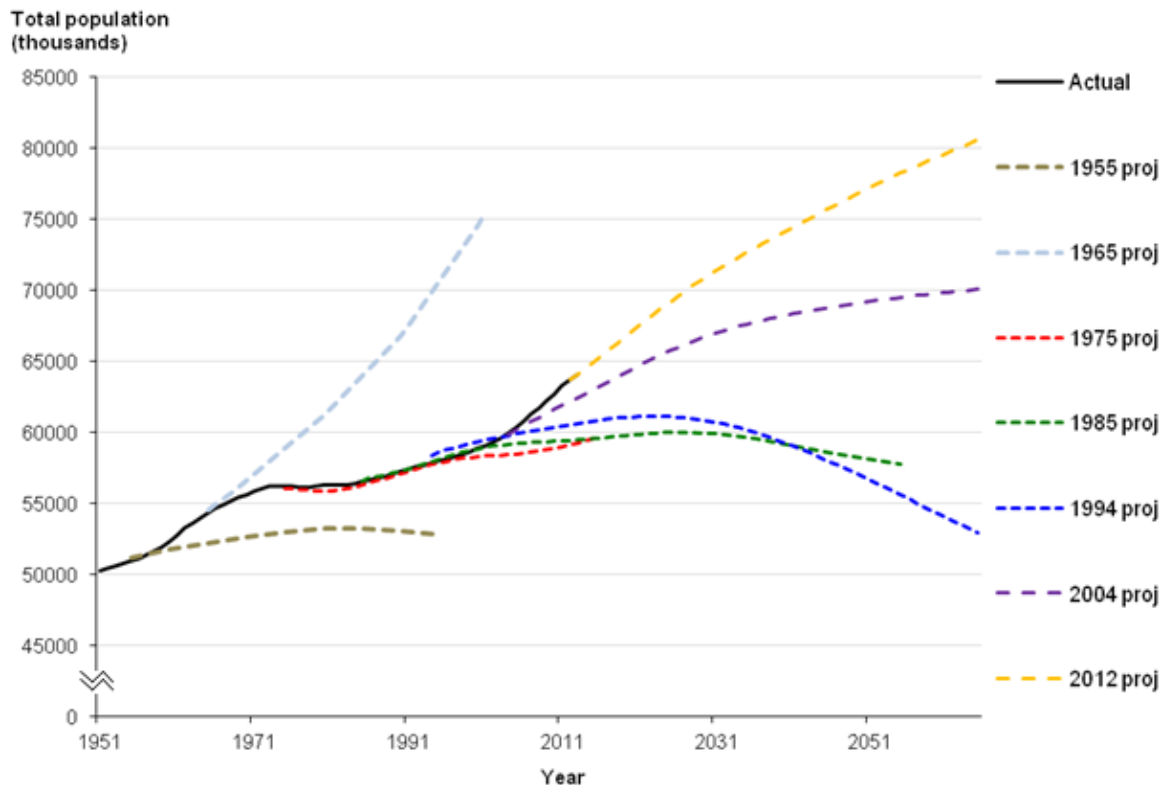


Figure 1 shows the future population of the UK from projections made at roughly ten year intervals over the last 60 years and demonstrates just how widely the various projections can differ. The 1955-based projections were the first produced by GAD for which we have information up to 40 years ahead. As discussed in the [previous accuracy review](#), the fact that the 1960s baby boom was not foreseen contributed to this projection producing a figure for 1995 that was over 5 million below the actual figure. On the other hand, as fertility rates rose from the mid-1950s to mid-1960s, much higher fertility assumptions were made, leading to the high population figures seen in the 1965-based projections. The 1965-based projection for 2001 ended up being over 16 million higher than the actual estimate for that year.

Projections made during the 1970s, 1980s and early 1990s reflected the decrease of fertility rates to below replacement level and assumed only modest net inward migration to the UK. This resulted in projections which showed relatively slow growth and often showed declines in the population by the end of the projection period.

Long-term fertility assumptions fell below the replacement level of 2.1 in the 1985-based projections and the lowest ever assumptions were long-term TFRs of only 1.74 for the 2002- and the 2004-based projections. Despite this, recent projections have all envisaged a continually increasing population. This is because the below replacement fertility has been offset by higher life expectancy and migration assumptions. Migration assumptions in particular have changed greatly, from assuming long-term net outward migration in the 1970s, to assuming net inward migration of 200,000 for the 2010-based projections, which is the highest long term net migration assumption made thus far.

The estimated population of the UK at mid-2013 was 64.1 million. The projections for this date made from 1973 onwards were all underprojections, with the 1977-based projection producing the lowest figure of 57.9 million (6.2 million, or 9.7%, lower than the actual estimate of 64.1 million). This is in

contrast with the previous accuracy review, where projections for 2005 from 1973 onwards showed errors in both directions.

### 3. Sources of error

Errors in the projections of the total population are mainly due to errors in the projections of the three components of population change (births, deaths and migration). The population estimates used for the base year of the projections may also be a source of error because, while the projections are based on the best estimates of population size and age structure at the time they were made, these estimates tend to accumulate errors the further they are made from the previous Census. The estimates are subject to later revisions, based on the subsequent Census, which therefore reveal the extent of these errors. Population estimates are generally most accurate immediately after a Census as this provides a new benchmark and removes errors that have accumulated as a result of the annual updating process.

Generally, the accuracy of each projection is estimated at set durations from the base year, e.g. at five, 10, 20 etc. years ahead, so that comparisons can be made between different projections. For example, the 1975-based projection for 1980 can be compared with the 2008-based projection for 2013 to assess the relative accuracy of the projections for five years ahead.

Appendix 1 gives more detail on the terminology and how accuracy has been measured in this report but, in short, projection error is defined as the projected value for a certain variable (e.g. total population) minus the actual value. Caution should be applied when utilising the findings from this report as the analysis only explores numerical differences. Therefore, larger numerical differences found in later projections are also likely due to the increases in the population size rather than an over- or underprojection and it should be reiterated that projections are not forecasts.

Mean error is defined as the average projection error for a specified forecast duration e.g. five years ahead, for which you would have a set of different projections, 2008-based, 2006-based, 2004-based and so on back to 1971-based (mean error is calculated only where there is a minimum of five observations). Mean absolute error is defined in the same way but irrespective of sign. A similar approach was utilised by an [earlier report](#) which compared UK projections with projections from other European countries (including Belgium, France, Germany, Norway and the Netherlands).

Overprojections of deaths are presented as negative errors since these lead to the future population size being underprojected.

**Figure 2. Total cumulative error in projected UK population at 2013 by component, selected projections**

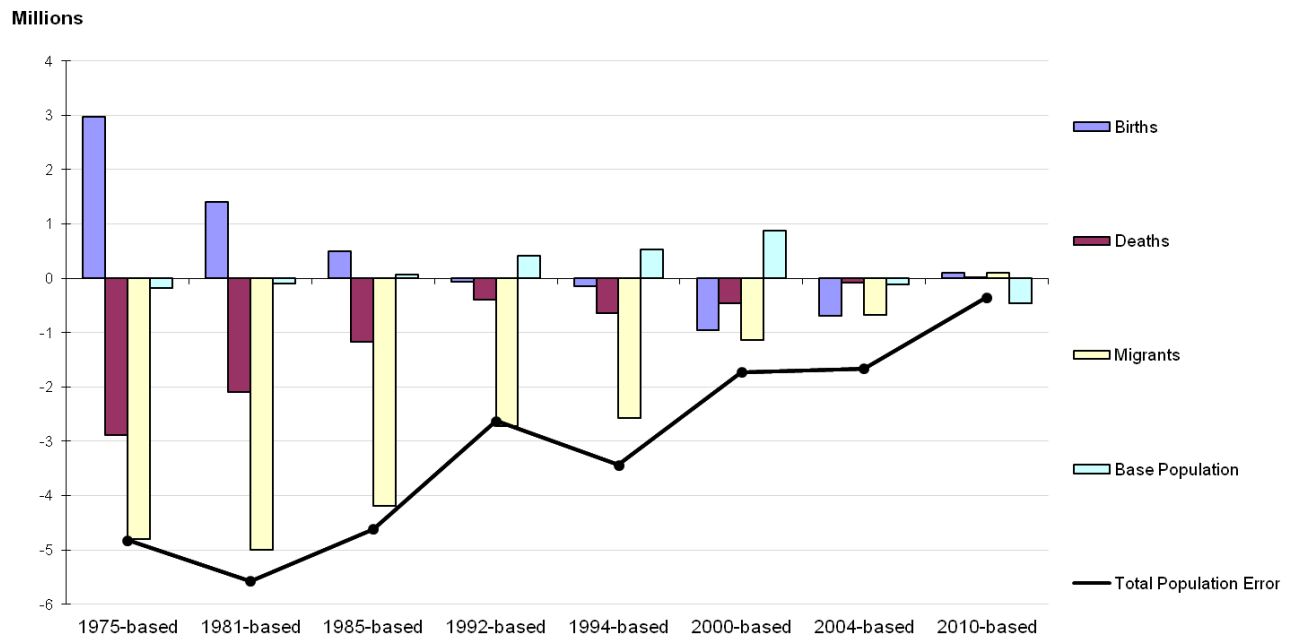


Figure 2 shows the total cumulative error in selected projections to 2013. For the 1975-based projections, for example, this refers to the total births projected over the 28 years to 2013 minus the actual births recorded in that same period, and so on.

The chart shows that errors in the projections to 2013 from the 1970s and 1980s were due to an overprojection of deaths and an underprojection of migration which is partially offset by an overprojection of births. For later projections, births and migration have been both underprojected whilst deaths continue to be overprojected all contributing to an underprojection of the population.

Generally, the total errors diminish with successive projections because they cover shorter periods of time, although there are some notable exceptions. For example, the projections made in the early 2000s assumed low TFRs, but actual TFRs started to rise in this period, which led to relatively large underprojections in the number of births over a short period of time. Thus, the 2000-based projections underprojected the total births to 2013 by just over 950,000, whereas the 1992-based projections underprojected the total births to 2013 by only about 61,000 despite covering an extra eight years.

The base population error indicates where the base population estimate used in the projections was later revised as a result of the next Census. There was an increasing error in the base population for projections made between the 1991 and 2001 Censuses because population estimates rolled forward from the 1991 Census had increasingly overprojected the UK population and this was later corrected in the rebased estimates using the 2001 Census results.

For the 2010-based projections, error in the base population accounts for the majority of the total error, which would be expected given the short time period covered and the fact that these projections were made at the maximum possible distance from the previous Census.

Future net migration has been consistently underprojected since the 1970s and migration errors are the single biggest component of total error up until the 2004-based projections. This is logical since net migration tends to be more volatile than fertility and mortality. It is also important to emphasise that the migration assumptions are set based on past demographic trends.

## 4. Headline assumptions

Table 1 shows the headline assumptions made for selected projections. The total fertility rate (TFR) gives the average number of children that would be born to women if they were to experience the age-specific fertility rates assumed for the year in question throughout their childbearing years. Period expectation of life at birth gives the average number of years that new born boys or girls would live if they were to experience the assumed age-specific mortality rates of the year in question throughout their lives.

These period measures have been used rather than cohort ones because the actual final values of cohort statistics cannot be known until the cohort has fully completed the life events being measured (e.g. for life expectancy, the final value cannot be known until everyone in the cohort has died). Period measures on the other hand allow immediate comparison.

**Table 1. Headline assumptions for selected projections**

	Base year for projections								
	1971	1975	1981	1985	1992	1994	2000	2004	2012
<b>Total fertility rate (TFR)</b>									
Projection for 1991 (actual=1.82)	2.34	2.12	2.01	1.89	-	-	-	-	-
Projection for 2001 (actual=1.63)	2.33	2.12	2.09	2.00	1.90	1.77	1.65	-	-
Projection for 2011 (actual=1.93)	2.32	2.12	2.11	2.01	1.90	1.80	1.73	1.73	-
Projection for 2021	-	-	2.11	2.01	1.90	1.80	1.74	1.74	1.89
Projection for 2031	-	-	-	-	1.90	1.80	1.74	1.74	1.89
<b>Period expectation of life at birth (males)</b>									
Projection for 1991 (actual=73.10)	71.04	69.82	71.44	72.95	-	-	-	-	-
Projection for 2001 (actual=75.68)	71.91	70.41	72.16	74.13	75.40	75.20	75.72	-	-
Projection for 2011 (actual=78.79)	72.59*	70.99	72.89	74.73	76.75	76.75	77.43	78.47	-
Projection for 2021	-	-	73.61	75.03	77.60	77.65	78.60	80.21	81.40
Projection for 2031	-	-	-	-	78.20	78.30	79.34	81.39	83.26
<b>Period expectation of life at birth (females)</b>									
Projection for 1991 (actual=78.63)	77.60	76.11	77.48	78.54	-	-	-	-	-
Projection for 2001 (actual=80.41)	78.59	76.75	78.19	79.48	80.60	80.20	80.40	-	-
Projection for 2011 (actual=82.72)	79.37*	77.37	78.91	79.95	81.85	81.55	81.58	82.25	-
Projection for 2021	-	-	79.55	80.18	82.65	82.60	82.85	83.91	84.87
Projection for 2031	-	-	-	-	83.20	83.25	83.56	85.05	86.56
<b>Net migrants (thousands)</b>									
Projection for 1991 (actual=44)	-50	-32	-35	-17	-	-	-	-	-
Projection for 2001 (actual=179)	-50	-32	-35	-17	50	50	155	-	-
Projection for 2011 (actual=205)	-50	-32	-35	-17	25	38	135	145	-
Projection for 2021	-	-	-35	-17	0	0	135	145	165
Projection for 2031	-	-	-	-	0	0	135	145	165

\*Projection for 2010-11

The table shows that fertility assumptions have been reduced gradually from above replacement levels in the 1971-based projections to a low of 1.74 children per woman for the 2002- and 2004-based projections. The most recent projections have seen a slight increase in the long term TFR assumptions and they were set at 1.89 children per woman for the 2012-based projections, although this is still below replacement level.

Mortality assumptions in the early/mid-1970s assumed very little mortality improvement; from the 1977-based projections a greater level of improvement has been assumed.

Net migration assumptions have also increased over time. Projections from the 1970s and 1980s assumed that the trend of long term net outward migration would continue into the future. More recent projections have however taken into account the rise in immigration to the UK which started in the 1990s and assume that this will be largely sustained in the long term.

## 5. Total population errors

Figures 3 and 4 show the bias and precision estimates for the projections of total UK population for different lengths of forecast duration (years ahead of the base year). Figure 3 shows that the mean error (bias) is positive for short forecast durations (up to seven years into the future), indicating that the projections are higher than the estimates, meaning that there is a tendency to overproject the UK population a few years into the future. For most forecast durations, however, the mean error is negative, meaning that the UK population has generally been underprojected. Overall, it appears that the overprojection of births seen in many projections has been more than offset by overprojection of deaths and underprojection of migration.

For forecast durations of 33 to 35 years ahead, the error is again positive. This is because this duration covers projections mainly from the 1960s and these tended to grossly overproject births due to the effect of the baby boom on trends at that time.

**Figure 3. Mean error (bias), UK total population, by forecast duration, 1955-based to 2012-based projections**

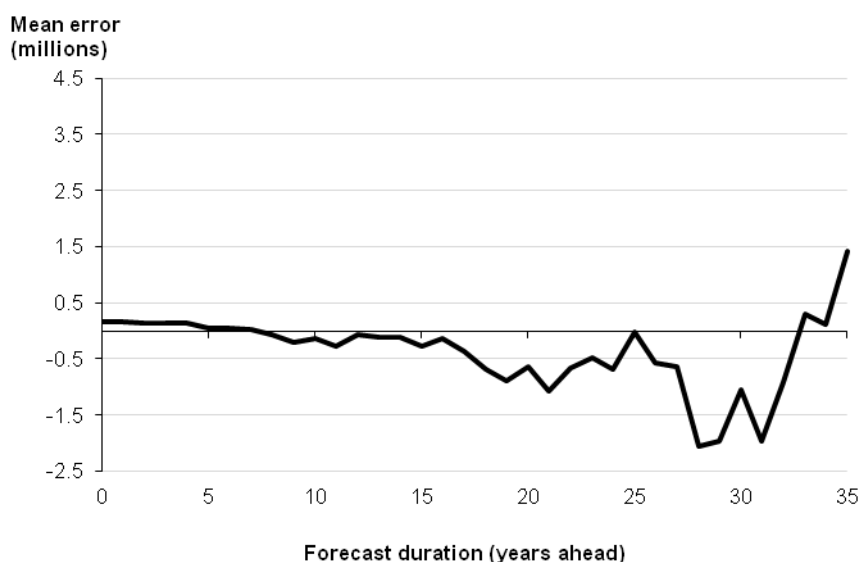


Figure 4 illustrates the absolute error (precision) of the projections and shows that, as would be expected, error tends to increase with time. On average, mean absolute error has been about half a million after five years and just over one million after 15 years. The peaks in the chart at five, 10 and 15 years reflect the fact that there are extra observations for these years from projections made in the

1950s and 1960s when errors were relatively high<sup>1</sup>. The gradient of the line gets steeper for the projections beyond 30 years ahead since only the older projections are available for this duration.

The longer forecast durations are influenced in particular by the 1965- and 1967-based projections, which were made at the height of the baby boom and massively overprojected the population at the turn of the millennium. It should be noted in general that results for longer forecast durations are based on smaller numbers of observations so can be influenced greatly by one or two atypical projections.

**Figure 4. Mean absolute error (precision), UK total population, by forecast duration, 1955-based to 2012-based projections**

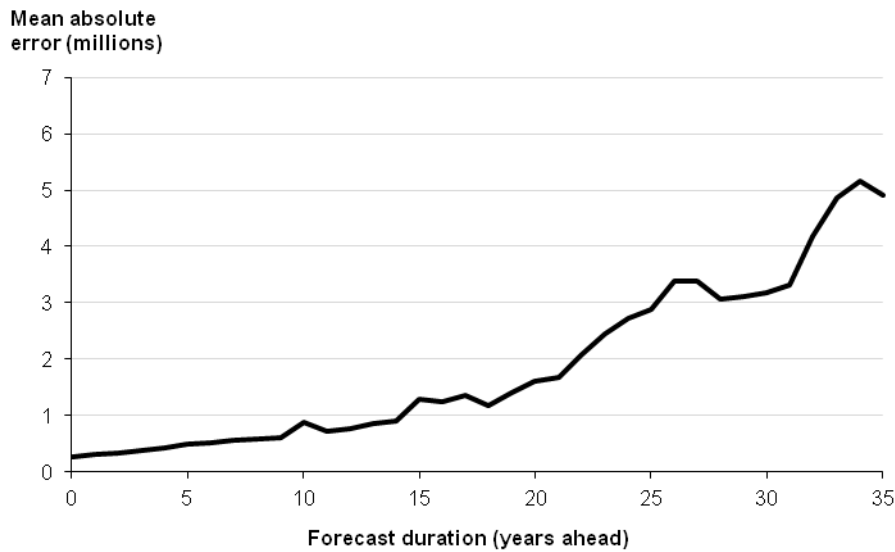
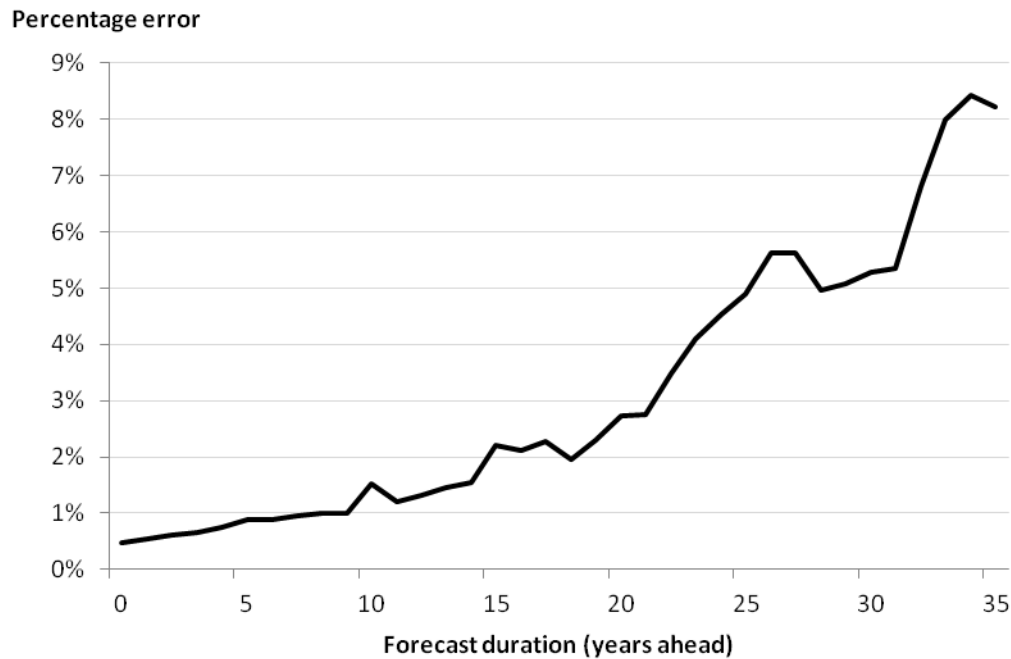


Figure 5 shows that mean absolute percentage error at 20 years ahead is around 2.7%, rising to over 8% at 35 years ahead.

<sup>1</sup> Year five included 28 observations, year 10 included 23 observations, and year 15 included 20 observations.



**Figure 5. Mean absolute error (percentage), UK total population, by forecast duration, 1955-based to 2012-based projections**

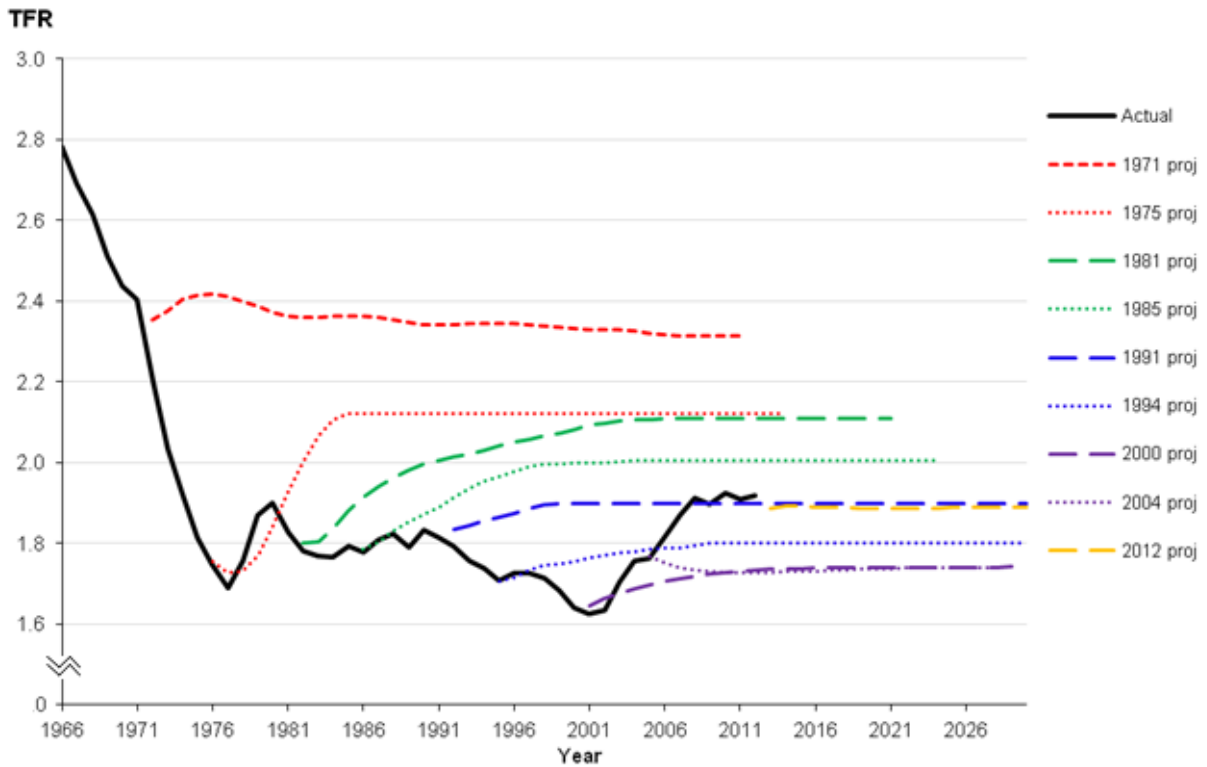


## 6. Fertility

### 6.1 Total fertility rates

Figure 6 shows how TFR assumptions have changed since the 1971-based projections, which are the first for which detailed information on fertility rates is available. Up until the 2004-based projections, the assumed TFR had been gradually reduced in successive projections. The 1985-based projections were the first to assume below replacement level long-term fertility. Recently, the assumptions have been increased slightly to reflect the continued high levels of period fertility currently observed and the impact of this on the achieved fertility of women born in the 1970s and 1980s, which suggests that falls in completed family size are slowing.

**Figure 6. Actual and projected total fertility rates, United Kingdom, 1966 to 2030, selected projections**

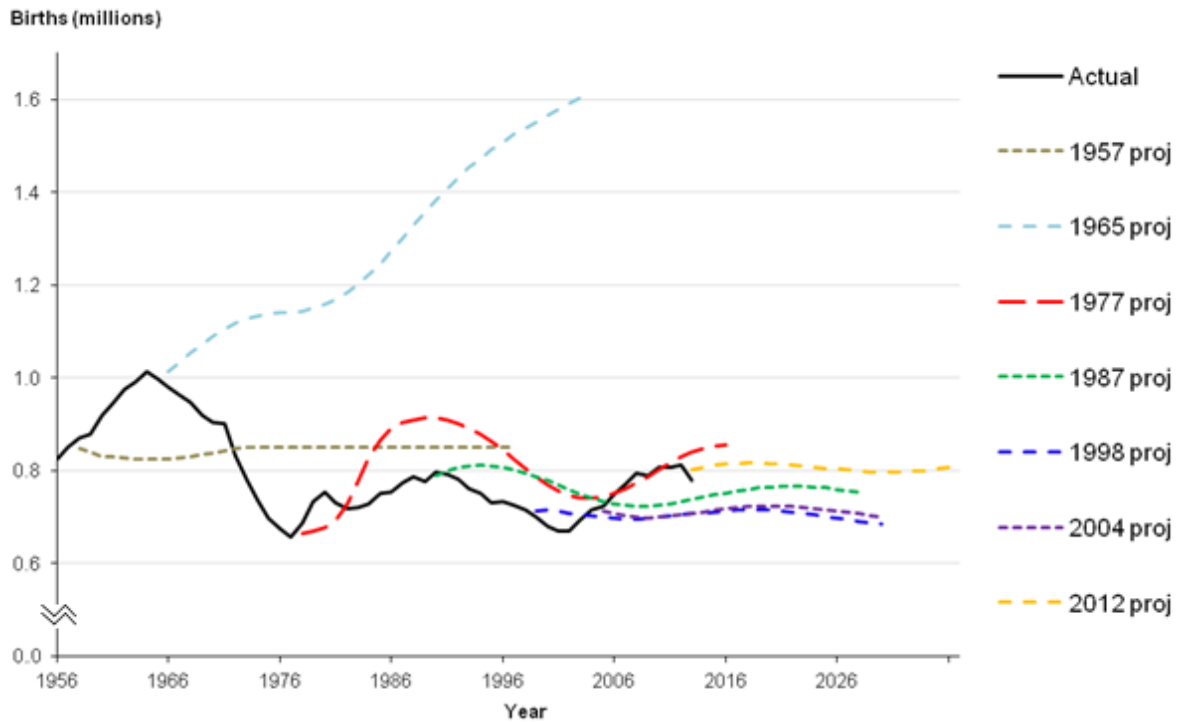


## 6.2 Births

Figure 7 shows the actual and projected numbers of births from 1956 until 2030. These are affected by fertility rates but also the number of women of childbearing age in the population. This is why projected births in the 2004-based projections are slightly higher in 2030 than in the 1998-based even though the 1998-based projections have a higher TFR (1.8 compared with 1.74). The 2004-based projections project a higher population of childbearing women because higher net migration assumptions were made for these ages.

Although information on assumed fertility rates was not available for projections from the 1950s and 1960s, the projected births figures are, and figure 7 shows the extent of the errors that can be made in projecting births. In particular, the 1965-based projections were unable to predict the drop in fertility after the baby boom so they ended up with a large overprojection of births all the way into the new millennium. Projections in the early 2000s, on the other hand, assumed that there would only be a slight and slow recovery from record low TFRs; whereas, the recovery in fertility was relatively strong and quick, meaning that births were underprojected.

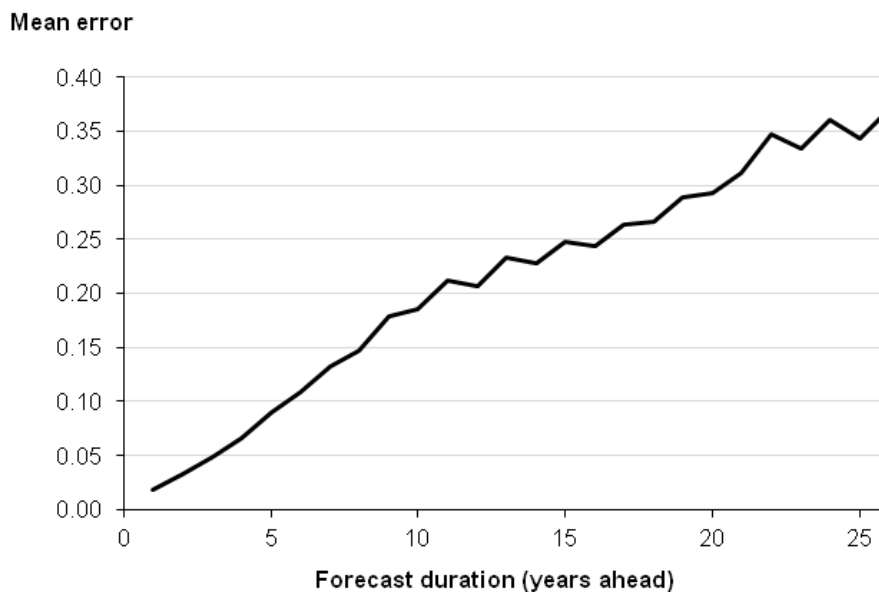
**Figure 7. Actual and projected number of births, United Kingdom, 1956 to 2030, selected projections**



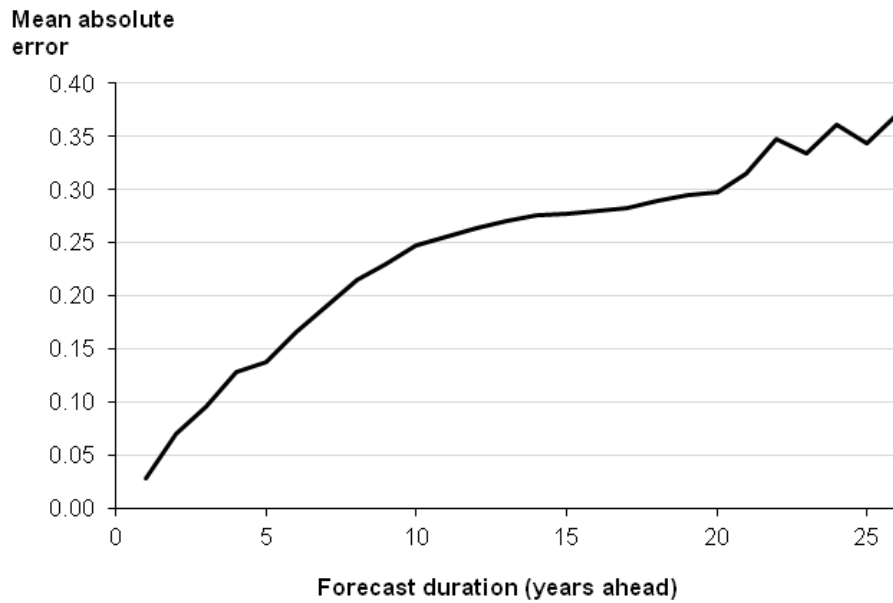
### 6.3 Bias and precision

Figures 8 and 9 show that errors in the TFR from the 1970s until the 2010-based projections have been consistently positive, indicating that fertility tends to be overprojected overall. It should be noted however that, if the current slightly higher fertility rates continue, the projections from the 1990s and early 2000s may turn out to be underprojections in the long term, so the picture may change in the future. The start of a shift to underprojection of births can already be seen in figure 2.

**Figure 8. Mean error (bias), total fertility rate, by forecast duration, 1971-based to 2010-based projections**

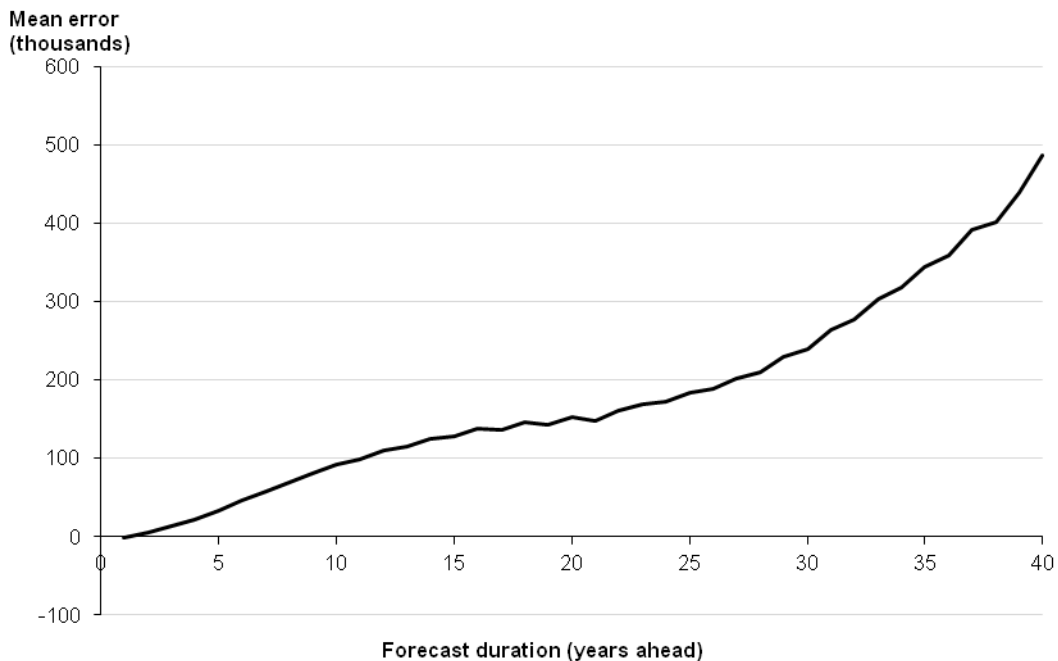


**Figure 9. Mean absolute error (precision), total fertility rate, by forecast duration, 1971-based to 2010-based projections**

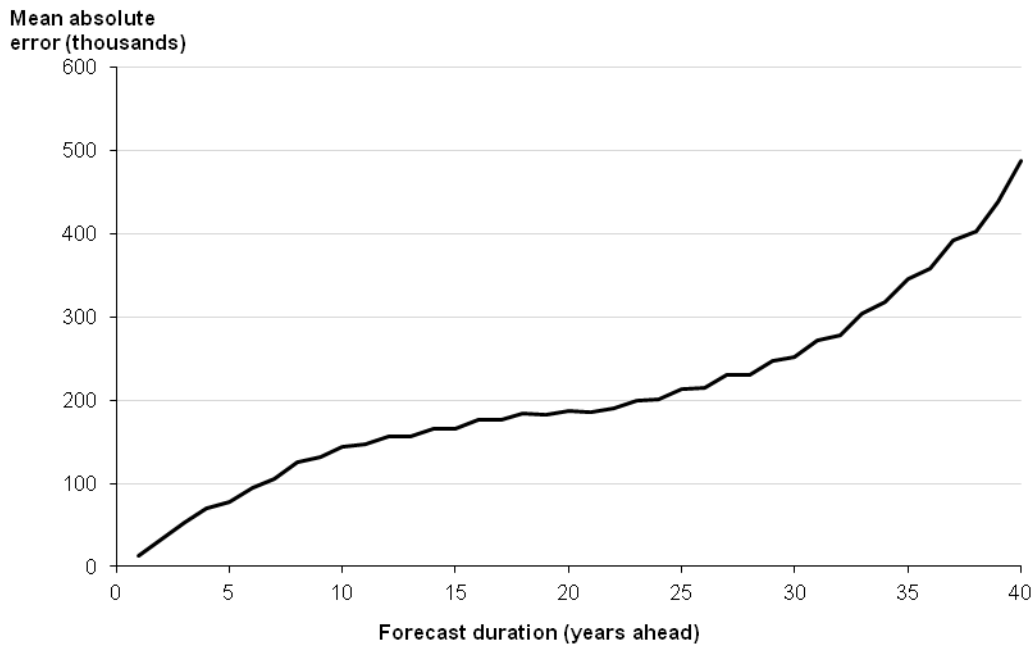


Figures 10 and 11 show the errors in births. The older baby boom era projections are included here and these contribute to the steepening of the curve for the longer forecast durations where only the older, less accurate projections are available.

**Figure 10. Mean error (bias), births, by forecast duration, 1957-based to 2012-based projections**



**Figure 11. Mean absolute error (precision), births, by forecast duration, 1957-based to 2012-based projections**

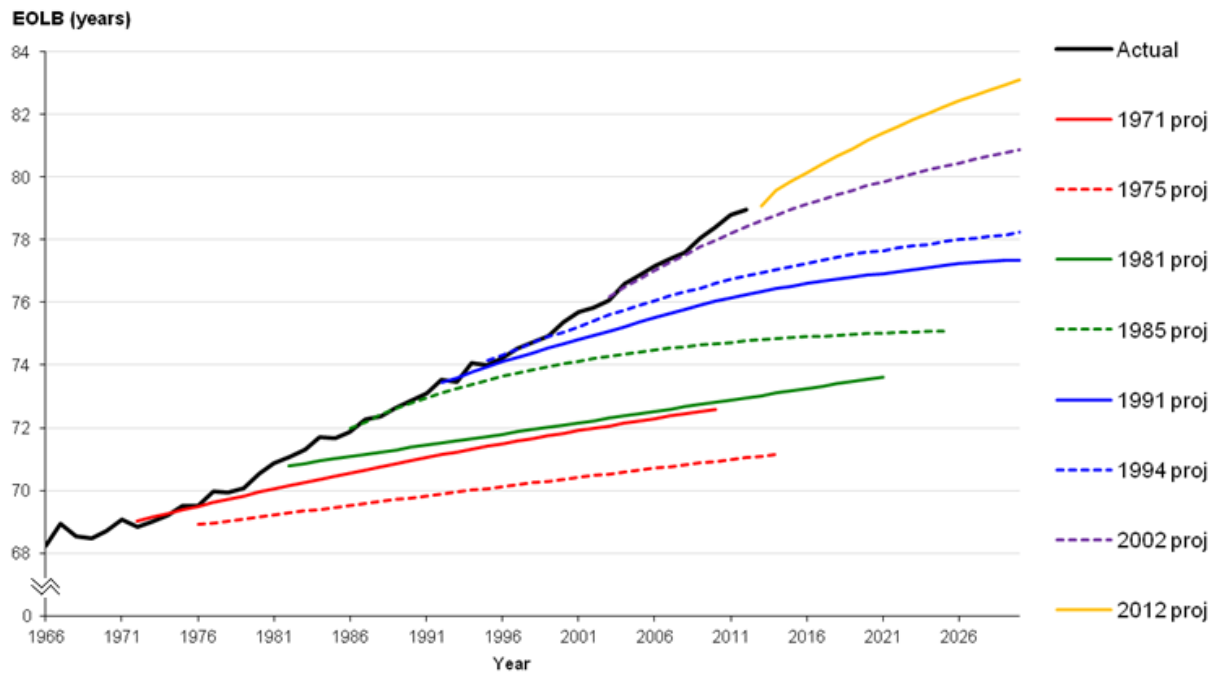


## 7. Mortality

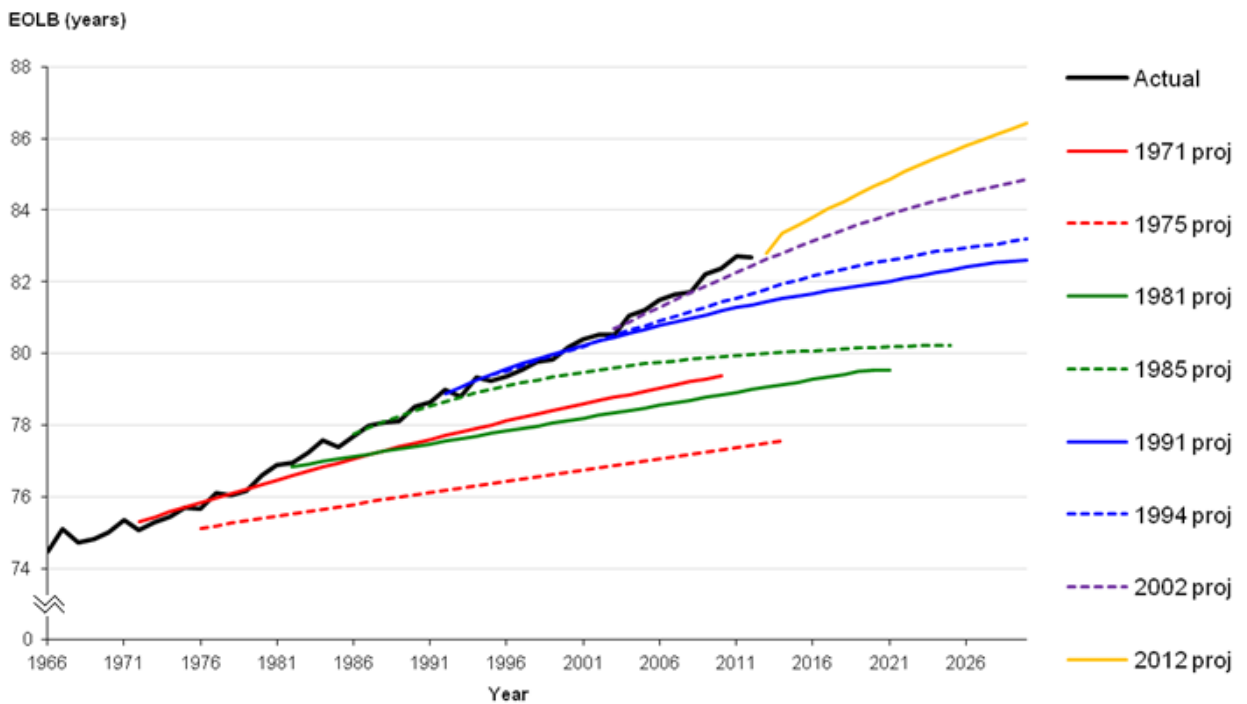
### 7.1 Life expectancy at birth

Figures 12 and 13 show that actual period life expectancy has increased at a fairly steady rate for both males and females over the last 50 years. The projections have however consistently assumed that the rate of improvement in life expectancy will slow, meaning that life expectancy has been consistently underprojected. Projections from the mid-1970s were particularly pessimistic. Later projections have adopted progressively more optimistic mortality assumptions but have still consistently underprojected life expectancy. The 2012-based projections have been the most optimistic so far.

**Figure 12. Actual and projected period expectation of life at birth, males, United Kingdom, 1966 to 2030, selected projections**



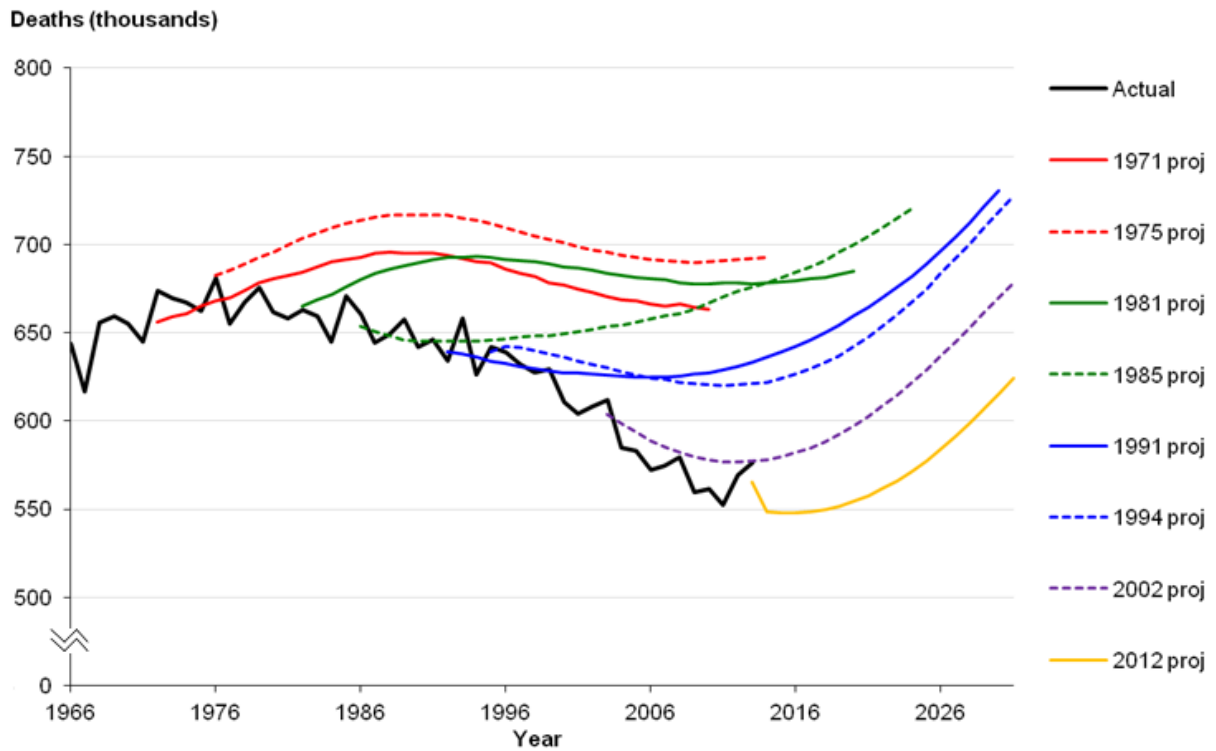
**Figure 13. Actual and projected period expectation of life at birth, females, United Kingdom, 1966 to 2030, selected projections**



## 7.2 Deaths

Information on deaths is only available for projections from the 1970s onwards. In line with the fact that life expectancy has been underprojected, deaths have been consistently overprojected. The shape of the curves (figure 14), with most projections eventually projecting eventual upturns in deaths, reflects the large cohorts born after the Second World War ageing on and dying.

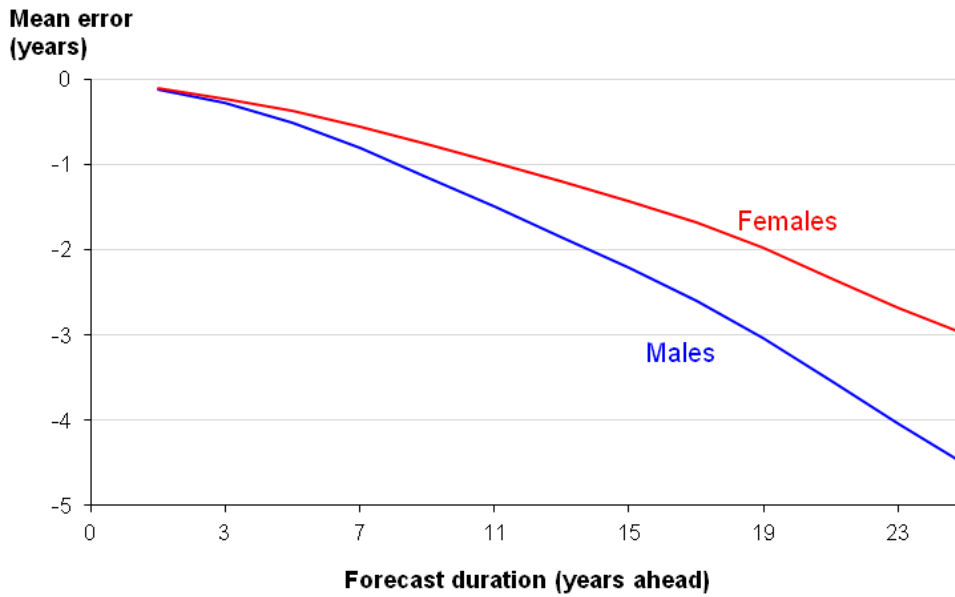
**Figure 14. Actual and projected total deaths, United Kingdom, 1966 to 2030, selected projections**



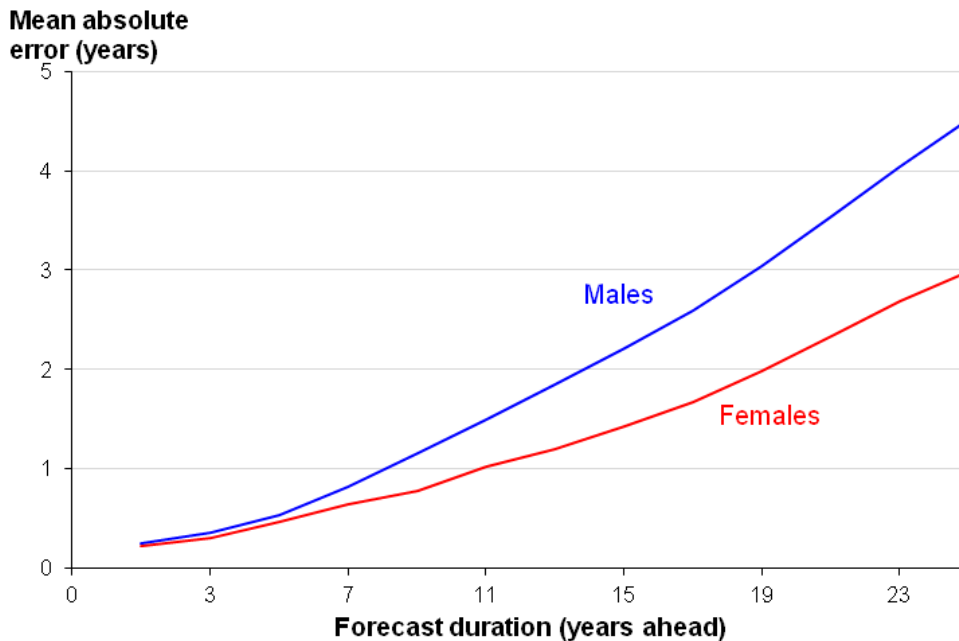
## 7.3 Bias and precision

Figures 15 and 16 show the bias and precision of the projected life expectancies. Errors are consistently negative, indicating that life expectancy is underprojected, particularly in the long-term. In fact, no projections have overprojected life expectancy more than 12 years ahead. Errors for females are lower than for males, reaching only 3 years after 25 years duration (figure 16), reflecting the fact that female life expectancy has risen less than male since 1971.

**Figure 15. Mean error (bias), life expectancy at birth, by forecast duration, 1971-based to 2010-based projections**



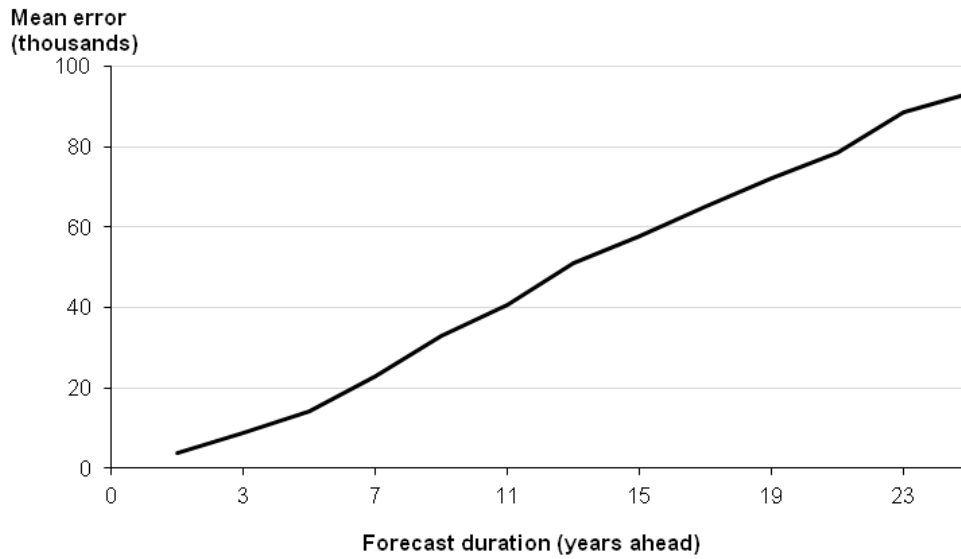
**Figure 16. Mean absolute error (precision), life expectancy at birth, by forecast duration, 1971-based to 2010-based projections**



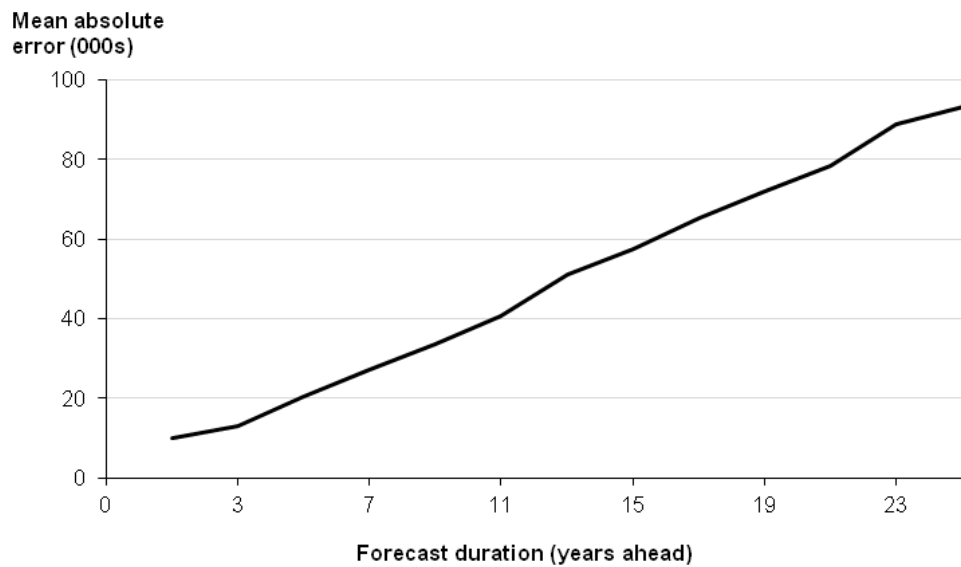
Figures 17 and 18 show the mean errors in deaths for the projections. Notably, the errors are much lower than those for births. Mean absolute error is only 93,000 after 25 years, compared with a mean absolute error in births of 213,000 over the same period. Generally, it may be expected that deaths would be easier to project than births since the only uncertainty in deaths is when they will occur. In contrast, there is an element of choice involved in births in both timing and number per woman, which is harder to predict.



**Figure 17. Mean error (bias), deaths, by forecast duration, 1971-based to 2012-based projections**



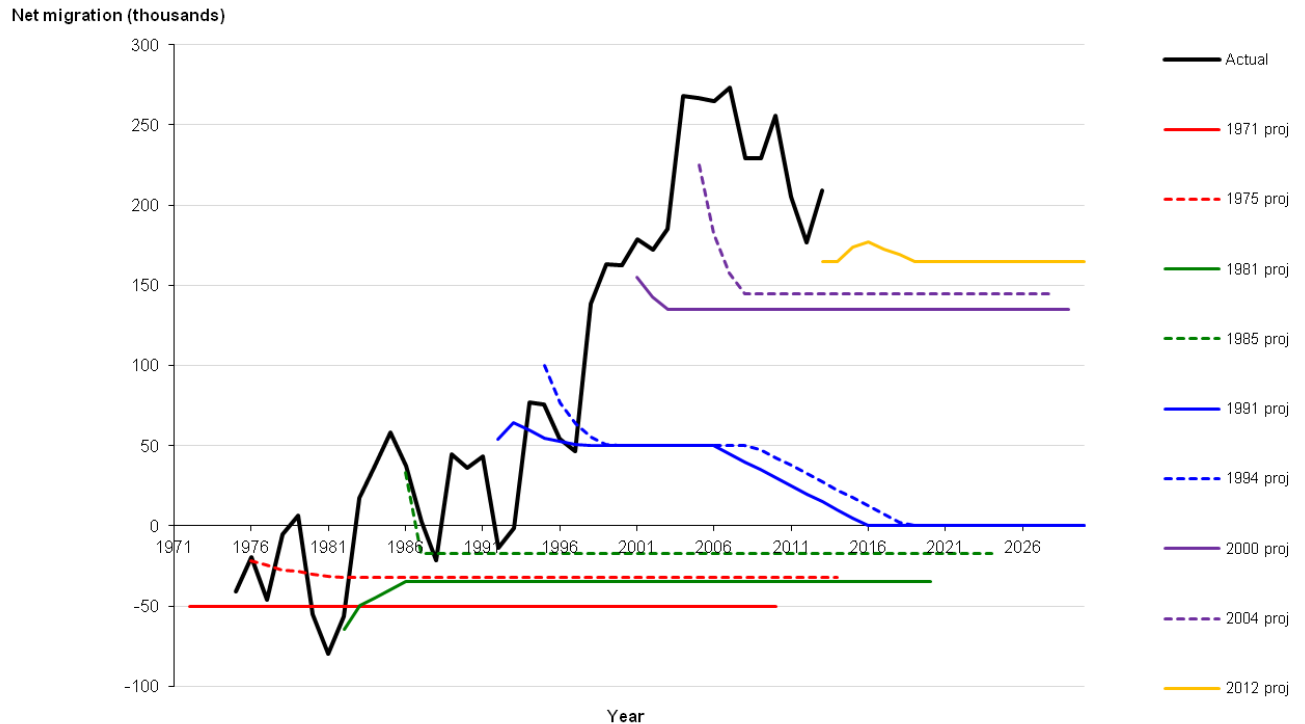
**Figure 18. Mean absolute error (precision), deaths, by forecast duration, 1971-based to 2012-based projections**



## 8. Net migration

Figure 19 shows the actual and projected net migration from selected projections.

**Figure 19. Actual and projected net migration, United Kingdom, 1971 to 2030, selected projections**

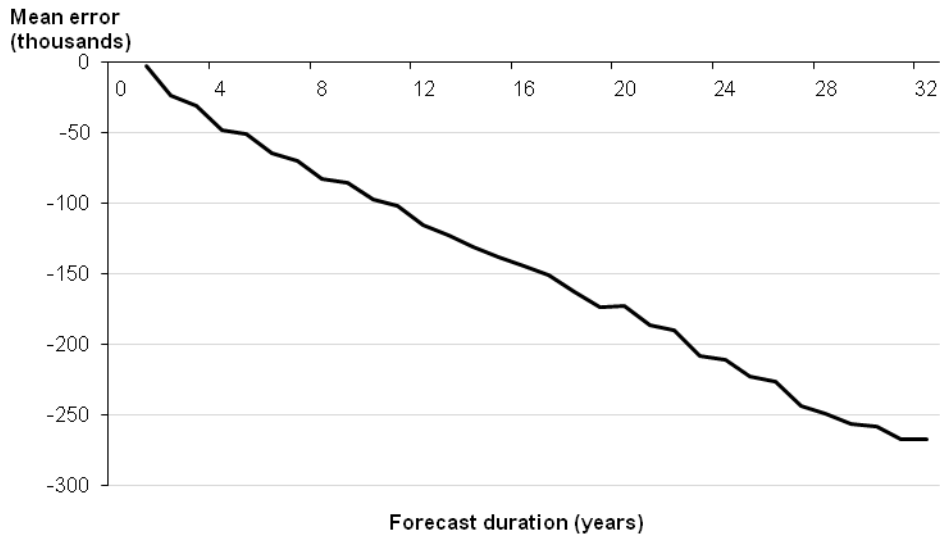


Note: The actual data up until 2000 are the net migration and other changes component from the population estimates while the data from 2001 onwards are Long-term International Migration (LTIM) figures.

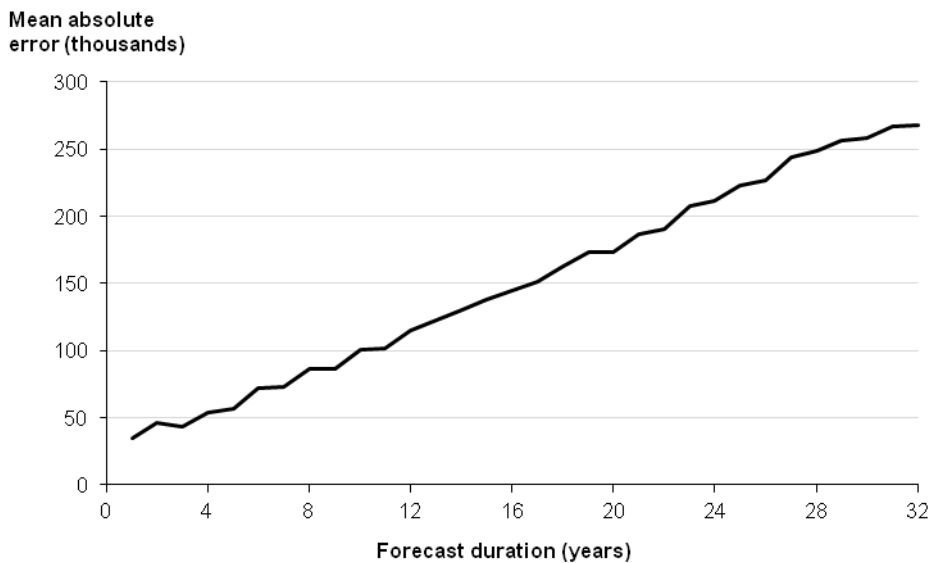
The chart shows that net migration has fluctuated considerably between 1975 and 2013 but that it has been consistently positive since the early 1990s, which represents a shift from the previous pattern of net outflow. None of the pre-1990s projections were able to anticipate this fundamental change in migration patterns so they all projected modest net outflows. In fact, long term net inflows were not assumed until the 1996-based projections, after which point there was a generally steady increase in the assumptions until the 2010-based projections where a long-term inflow of 200,000 migrants per year was assumed. The 2012-based projections assumed slightly lower net inflow of 165,000 per year, based on a decrease in migration in the two years since 2010.

Figures 20 and 21 show the mean errors in total net migration for the projections. Notably, the errors are much larger than those for births and deaths. Overall, the mean error trends suggest a consistent underprojection of net migration from the 1971-based to the 2012-based projections. However, it is noted that net migration is a more unpredictable component in comparison to fertility and mortality.

**Figure 20. Measure of bias, total net migration, by forecast duration, 1971-based to 2012-based projections**



**Figure 21. Mean absolute error (precision), total net migration, by forecast duration, 1971-based to 2012-based projections**



## 9. Accuracy of projections by age and sex

The population by five year age group and sex is available for projections back to the 1955-based set so the percentage error at five, 10 and 25 years ahead was examined for all available projections (figures 22 and 23). Figure 22 shows that there tends to be overprojection of children, which increases with time and this is generally consistent with the tendency of earlier projections to overproject births. On the other hand, there seems to be a tendency to underproject adults, which is consistent with underprojections of net migrants (particularly in the younger working ages) and the mortality projections generally being too pessimistic.

Figure 22. Mean error (bias) by age group, persons, 1955-based to 2006-based projections

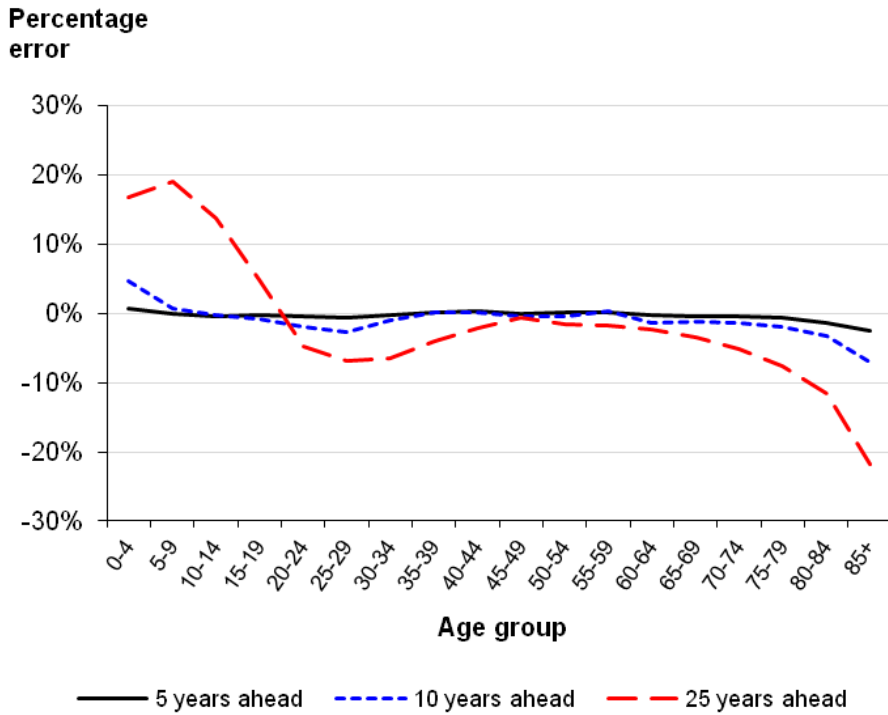
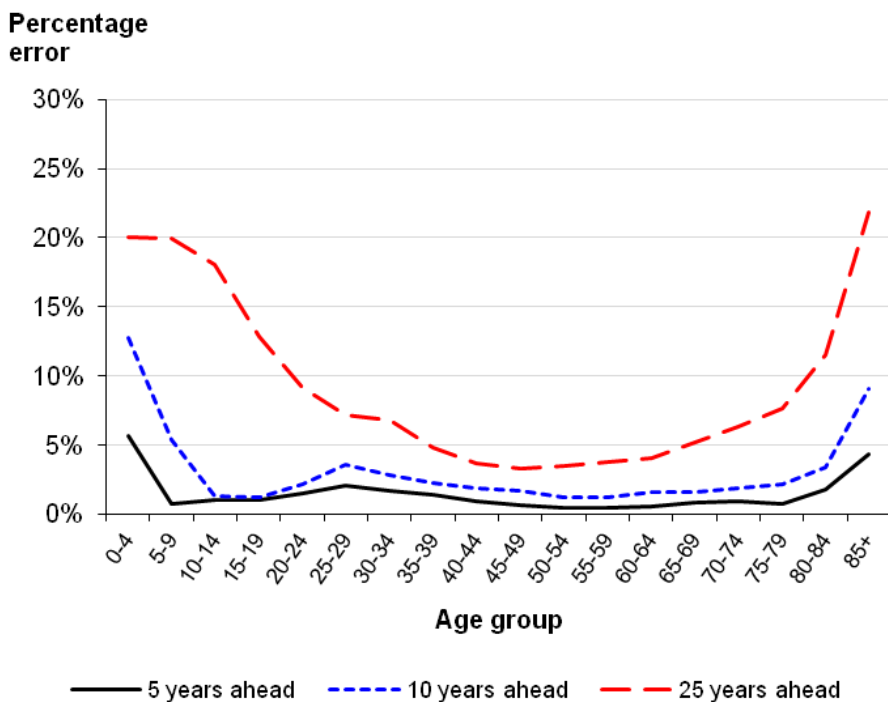


Figure 23 shows that the absolute error for most age groups is less than 5% at both five and 10 years ahead, with only the very youngest (0-9 years old) and oldest (85+) age groups exceeding 5% error after 10 years. For 25 years ahead, the errors increase, as would be expected, with the percentage error exceeding 5% for most ages and exceeding 10% for 0-19 year olds and the over 80s.

Figure 23. Mean absolute error (precision) by age group, persons, 1955-based to 2006-based projections



In total, 13 projections could be analysed at 25 years ahead (with the last one being the 1987-based) and the errors by age group varied considerably between different projections. For example, the 1965-based projections overprojected the 0-4 year olds 25 years ahead by almost 70%, which is mainly due to the impact of the baby boom, while the 1983-based projections were very close to the actual number, underprojecting 0-4 year olds by only about 2%. For these age groups, fertility assumptions are likely to be the biggest source of error, although migration and mortality do also play a part.

It is acknowledged that the projected numbers of future births and deaths are themselves partly dependent on the assumed level of net migration. Because migration is concentrated at young adult ages, the assumed level of net migration affects the projected number of women of childbearing age and hence the projected number of births. Therefore, if we underproject migration, we are also likely to underproject births, not via the fertility assumption but via the population at risk.

Errors for the older age groups also varied between projections, but since the impact of fertility assumptions 25 years ahead is limited only to those under 25 years old, errors in the ages above 25 must therefore be due to a combination of only mortality and migration errors.

At ages 25-64, mortality rates are low, so migration is likely to be the main source of error at these ages. Errors at these ages were fairly low and consistent for the 1955-based to 1975-based projections, but errors in the younger working ages started to increase for the later projections. This reflects the fact that net migration had been relatively steady at a low level until the mid-1980s but then started to increase quite sharply, which the projections could not take into account. All of this rise in net migration would be encompassed at 25 years ahead of the 1985-based projections, whereas this would not affect the 1955-based projections at 25 years ahead at all.

At the older ages, mortality is likely to be the main source of error. At the very oldest ages (85+), errors 25 years ahead were much higher in the projections made up to the 1979-based than they were in the more recent projections. In contrast, errors for the 65-84 year olds were remarkably low for older projections, particularly the 1955-based projections, compared with projections from the 1970s and later. This may be partly due to the fact that improvements in life expectancy started to accelerate in the 1970s and some of the projections from the 1970s, made especially pessimistic mortality assumptions. The effect of migration on people ageing through to the 65+ age group could also have an effect since later projections cover a period of more volatile migration than the older projections.

Figures 24 and 25 show the mean errors at 25 years ahead by age and sex for all projections for which relevant data were available. At younger ages, there is little difference between males and females, which indicates that the sex ratio assumed at birth in the projections has been borne out in reality. The greater absolute errors for males in the ages above 60 reflects the fact that improvements in life expectancy for males have generally been underprojected more than for females.

Errors in the working age population have been higher for females, suggesting that the population has generally been underprojected. As mentioned earlier, errors at these ages are probably mostly due to errors in net migration, which appear to have affected females more than males.

Figure 24. Mean error (bias) 25 years ahead by age/sex, 1955-based to 1979-based projections

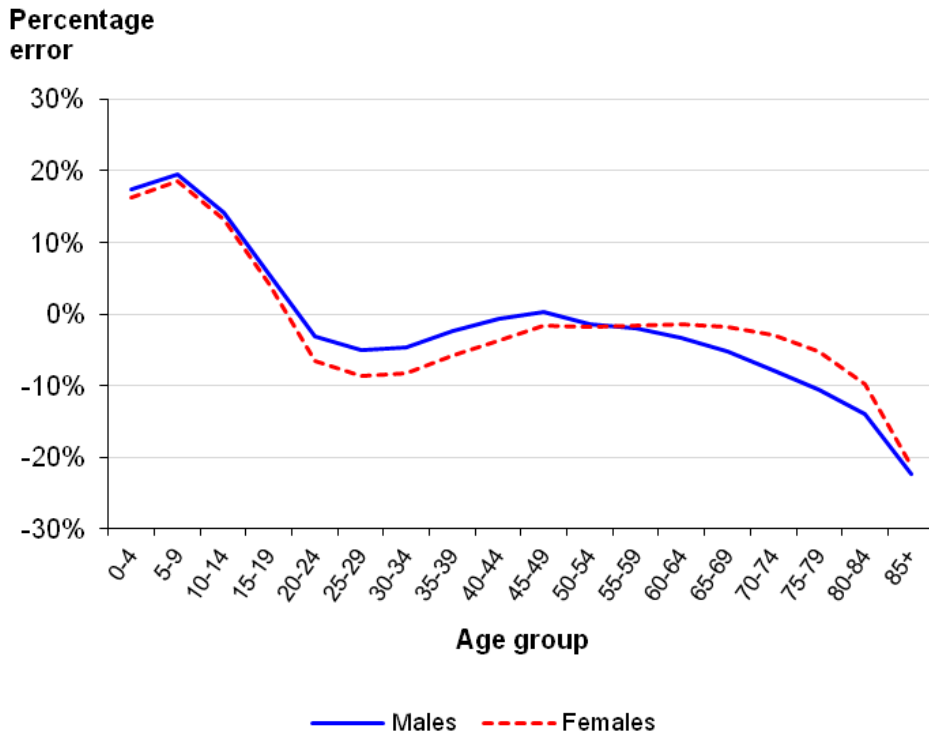
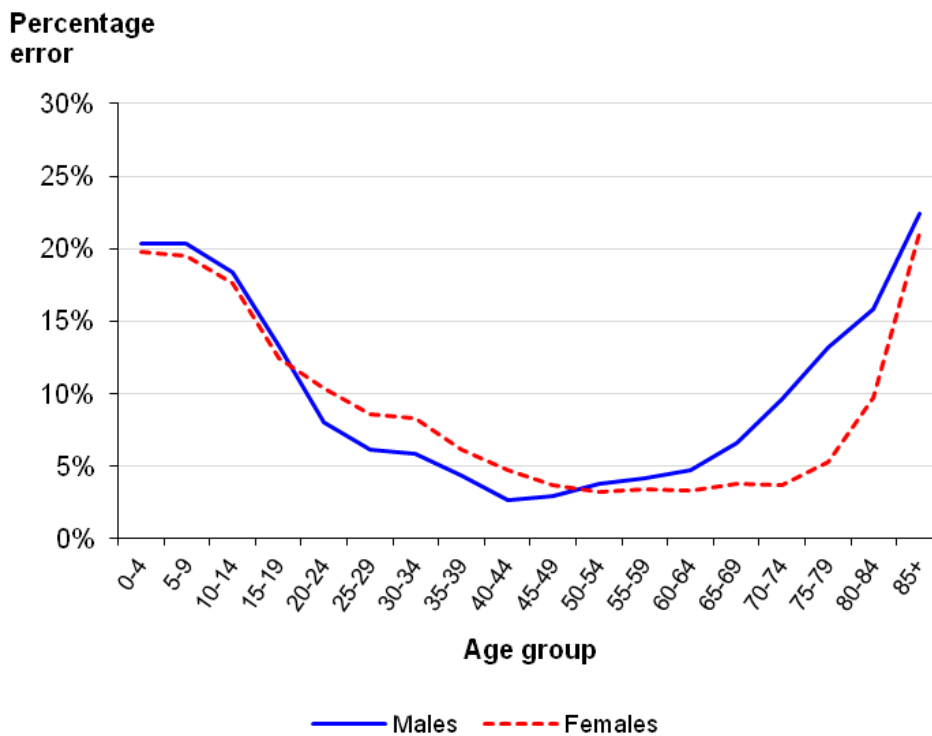
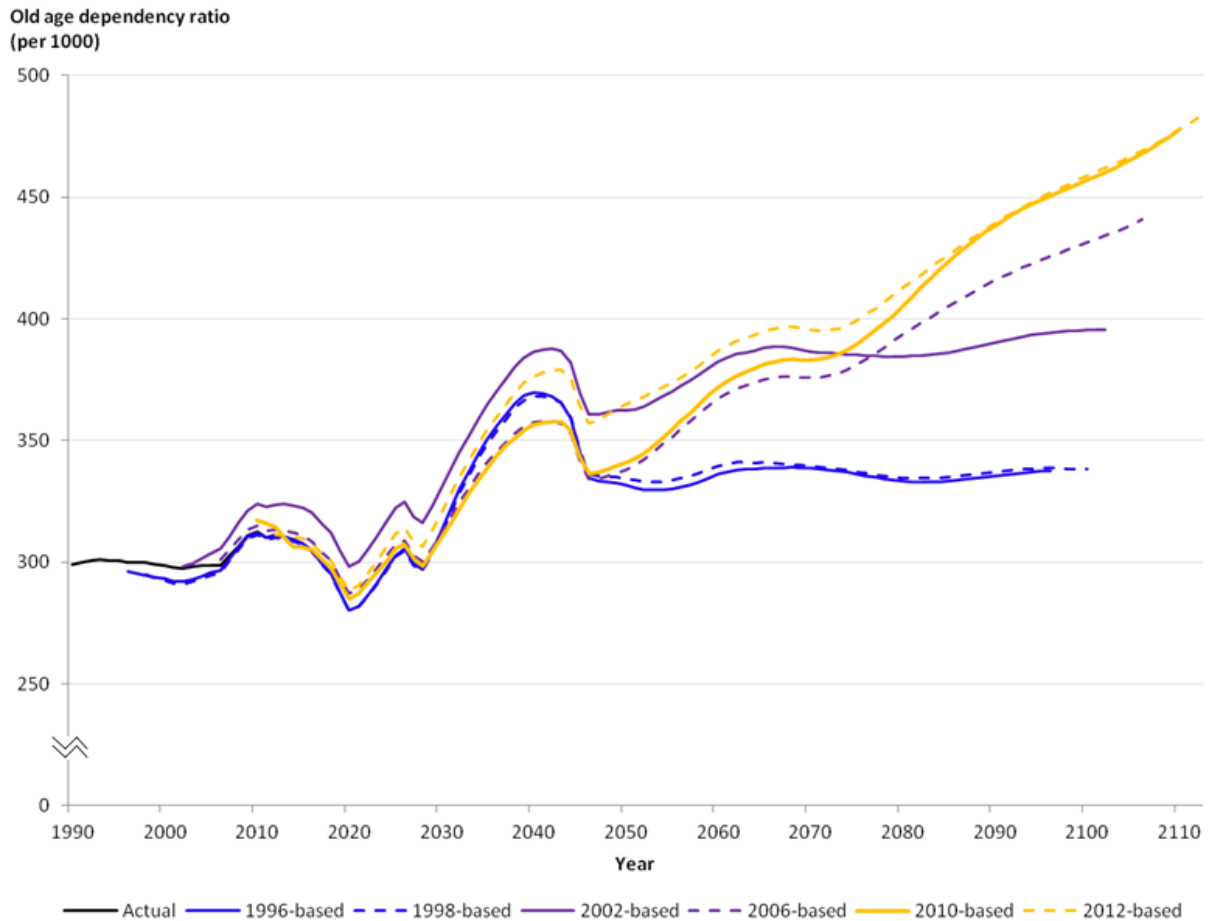


Figure 25. Mean absolute error (precision) 25 years ahead by age/sex, 1955-based to 1979-based projections



## 10. Dependency ratios

**Figure 26. Actual and projected old age dependency ratios under the 2014 Pensions Act, 1990 to 2112, selected projections**



A dependency ratio is an age-population ratio which relates the number of children (0 to 15 years old) and older persons (those of State Pension Age (SPA) and over) as those who are typically not part of the labour force, to the working-age population (from 16 years old to SPA). It indicates the potential effects of changes in population age structures for social and economic development, pointing out broad trends in social support needs.

In this analysis, an old age dependency ratio is presented, that is the ratio of older persons to the working age population. The dependency ratios shown are on the basis of the 2014 Pensions Act in which the SPA was increased from 66 years old to 67 years old which will come into effect between 2026 and 2028.

Figure 26 shows actual old age dependency ratios from 1996 to 2012 compared with projected dependency ratios to 2112 for selected projections for which single year of age population data are available. It should be noted that the SPA has changed over this time period and pension policies are informed using the dependency ratios calculated from the population projections.

All the projections initially follow a similar trajectory before diverging at around 2050 illustrating the knock-on effects that all the demographic components have on the dependency ratios. Early on, the number of working age and pensionable age people is only affected by migration and mortality

assumptions since fertility assumptions only affect people born since the beginning of the projection and they will not have reached working age yet. Later on, the fertility assumptions have an effect on working age people but it is only much later in the projections that the effects of fertility assumptions on the projections have also filtered through to people of pensionable age.

In the past, underprojections of older people due to pessimistic life expectancy assumptions have been partially offset by underprojections of net migration of working age people, so it could be expected that projected dependency ratios will be slightly more accurate than the projected numbers of people of pensionable age. This may not hold true in the future however if trends in mortality, migration or fertility change.

## 11. Are projections becoming more accurate?

As was done for the previous review, an assessment of how accuracy of the projections has changed over time will be made by splitting the projections into broadly even groups of 'older' projections and 'more recent' projections. It should be noted that, for periods five years ahead, projections up to 2006 can be analysed, but for longer periods progressively fewer projections are available, so some projections are included in the 'older' category for five years ahead but the 'more recent' category for 25 years ahead. A further caveat that needs to be considered is that there have been periods of relative stability in the different demographic components at different times in the last 50 years. Obviously, it is easier to produce more accurate projections at a time of stability so this factor has an effect on accuracy on top of any improvements or deteriorations in assumption-setting over time.

The previous review found that projections of total population were more accurate for more recent projections and figure 27 shows that this is still the case, although the difference between the projection groups has narrowed.

**Figure 27. Average absolute percentage errors in total population by early and late projection sets**

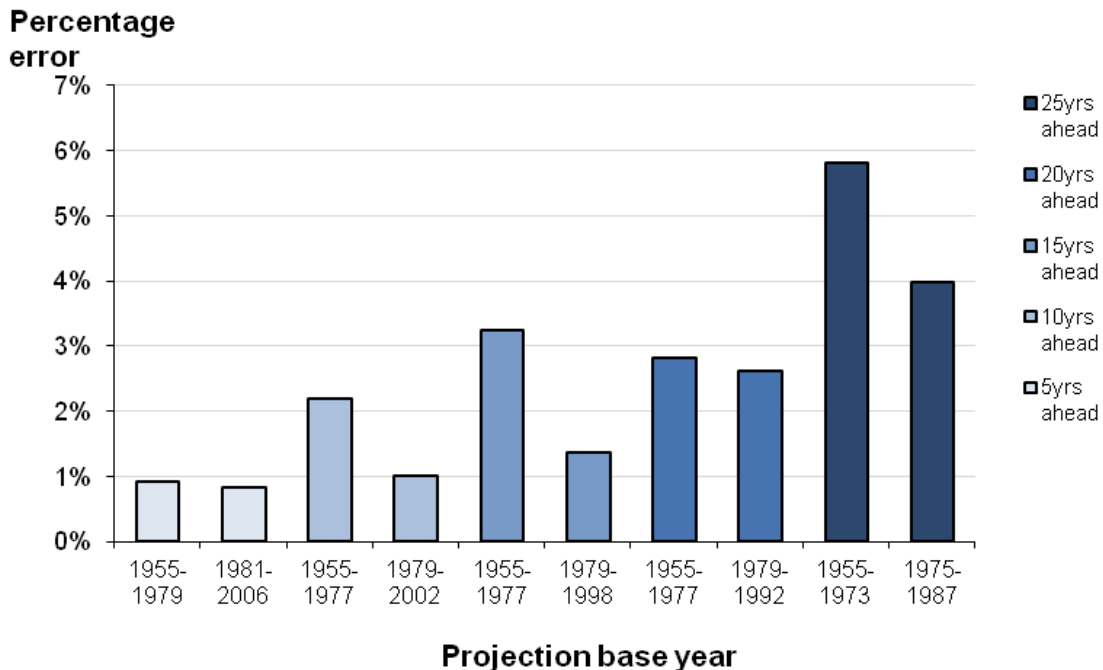


Figure 28 shows the average absolute TFR errors by projection group. More recent projections were more accurate for all projection lengths, although the difference is less pronounced for five years



ahead. Generally, fertility has gone through a period of relative stability since the late 1970s, meaning that it may be expected that projections made since this period would be more accurate regardless of improvements in methodology.

**Figure 28. Average absolute errors in total fertility rate for early and late projection sets**

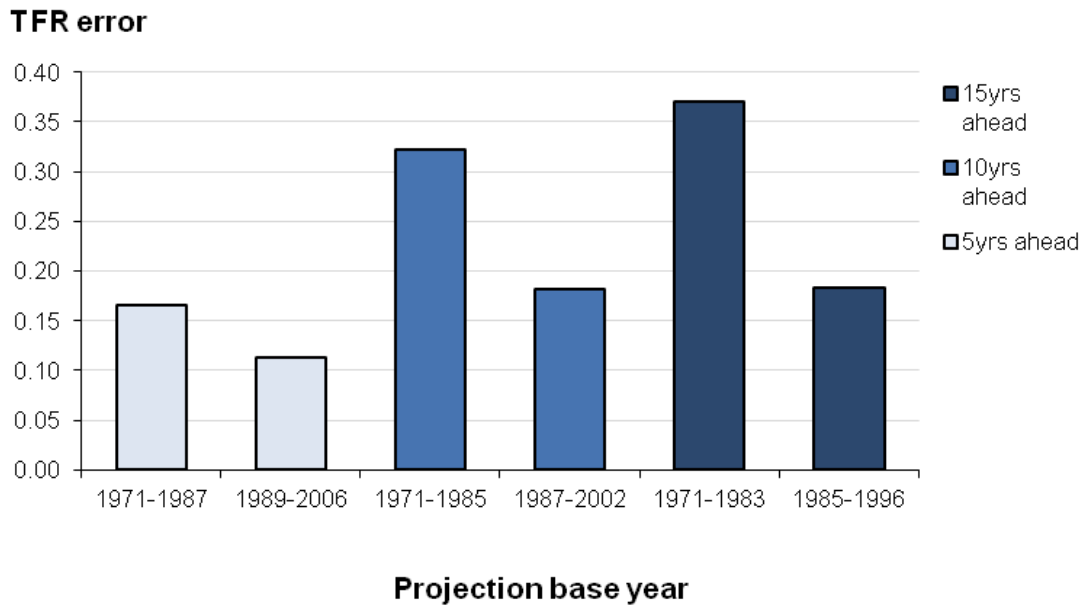


Figure 29 shows that accuracy in expectation of life at birth (EOLB) has improved in more recent projections compared with older ones, and that, generally, errors for males are greater than for females. Historical trends in life expectancy have been more stable and predictable than fertility and net migration over a longer period (see figures 12 and 13 which illustrate the consistent upward trend in EOLB over time). It could therefore be argued that the improvements in accuracy for mortality are more likely to actually reflect improvements in the projections rather than simply the changes in the volatility of the underlying trends.

**Figure 29. Average absolute errors in expectation of life at birth for early and late projection sets**

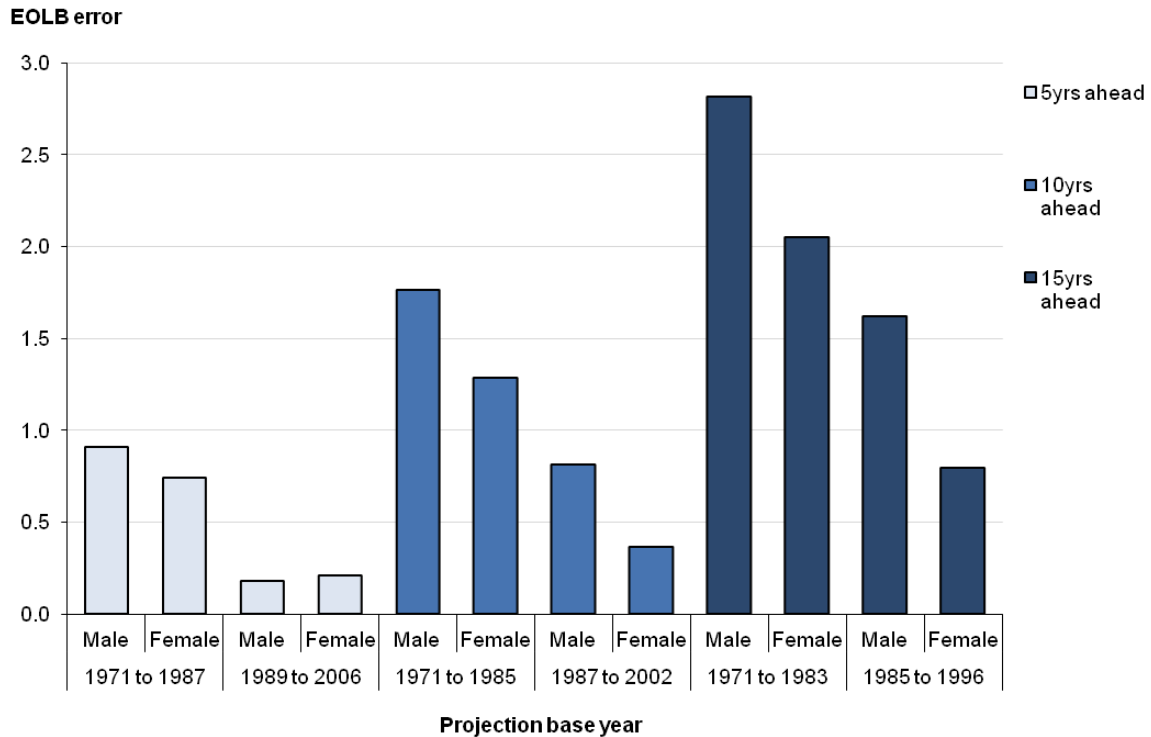
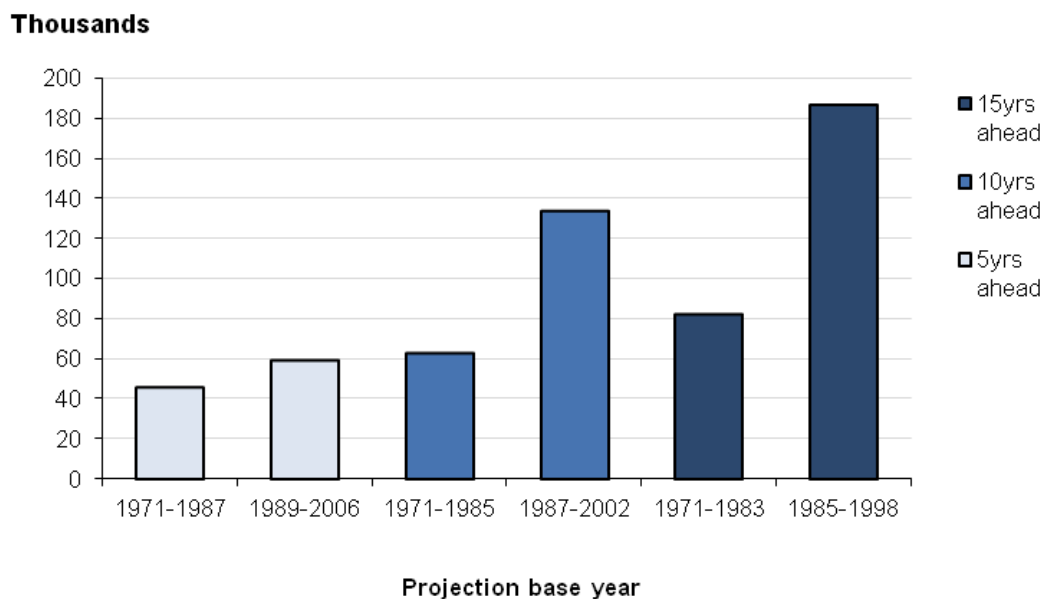


Figure 30 shows that net migration assumptions for more recent projections have been less accurate than older projections for all projection lengths. This is likely to be a consequence of trends in migration however, because net migration in the 1970s and 1980s was relatively stable (generally fluctuating around zero), whereas there has been a sustained rise since the 1990s. The older projections generally cover only the more stable period so could therefore be expected to be more accurate.

**Figure 30. Average absolute errors in net migration for early and late projection sets**



## 12. Conclusion

This review generally confirms the findings from the two previous reviews in 2007 and 1994 that fertility levels tend to be overprojected and net migration and improvements in life expectancy are underprojected. The 2007 review noted that there is no inevitability in the direction of errors (i.e. under- or overprojections); this was highlighted with the fertility trends. Historically fertility has been overprojected although an increase in fertility, which stabilised between 2008 and 2012, meant that a number of previous projections, particularly from the early 2000s have so far underprojected long-term fertility; this underprojection is still true despite the recent decreases in fertility since 2012 but in some projections, particularly the 2012-based, there was an overprojection of short-term fertility. It should also be noted that errors in the base population of the projections can also play a non-trivial role in projection error, particularly for projections made at a large distance from the previous Census.

All projections back to the 1973-based set underprojected the total population in 2013, reflecting the fact that life expectancy has improved faster than projected and that the projections were understandably unable to predict the unprecedented rapid rise in net migration that started in the 1990s.

Generally, the largest errors in the projections occur for the very young and the very old, reflecting the effects of errors in the fertility and mortality assumptions.

Nevertheless, there is some evidence of improvements in accuracy of the projections over time, particularly in mortality. Accuracy of the net migration assumptions appears to have decreased, but this can largely be attributed to recent increases in the volatility of the underlying trends.

In addition, the projected numbers of births and deaths are partly dependent on the assumed level of net migration. As migration is concentrated at young adult ages, the assumed level of net migration affects the projected number of women of childbearing age and, in turn, the projected number of births. Therefore if we were to underproject migration, we are also likely to underproject births via the population at risk and not via the fertility assumption.

It was interesting to note that the trends observed in this report were also similar to those found by [a previous report](#) which noted that during the past 30 years, the UK projections had larger errors for fertility and smaller errors for mortality; also it was found that migration forecast errors were similar to those of the European average of errors.

Overall, a balance must be sought between assumption drag, where the assumptions take a long time to catch up to actual trends, and being too reactive to new trends that are not sustained in the long term.

## Appendix 1: Measuring accuracy - Terminology

Projection error – the projected value of a variable (e.g. population size) minus its actual value as currently estimated (these 'actual' values may be subject to revisions based on future Census results etc.). A positive error therefore indicates overprojection and a negative error indicates underprojection.

Forecast duration – the difference between the base year of a projection and the calendar year for which a particular variable is projected e.g. for the 1973-based projection of the population in 1988, the forecast duration is 25 years.

Mean error – average of the projection errors for a particular set of observations e.g. the difference between projected and actual population for 20 years ahead for all projections for which these data are available. It gives an indication of bias of the projections (i.e. whether a variable was over or under projected on average).

Mean absolute error – average of the projection errors irrespective of sign. It gives an indication of precision.

## References

Keilman, N (2007). UK national population projections in perspective: How successful compared to those in other European countries? *Population Trends* **129**, 20-30.

Shaw, C (1994). Accuracy and uncertainty of the national population projections for the United Kingdom. *Population Trends* **77**, 24-32.

Shaw, C (2007). Fifty years of United Kingdom national population projections: how accurate have they been? *Population Trends* **128**, 8-23.