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EXPLORING POPULATION PROJECTIONS: SOURCES OF UNCERTAINTY AND THE USER PERSPECTIVE

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***Abstract*:** Government population projections are typically underpinned by a set of assumptions based on what has happened in the past, informed by expert opinion on what the future holds. The assumptions made are inevitably subject to uncertainty e.g. trends may change unexpectedly. This seminar considers sources of uncertainty in recent population projections for Northern Ireland and the Republic of Ireland, both national and sub-national. Past experience with population projections is examined to illustrate the effects of changing trends and economic circumstances. The seminar then looks at sources of uncertainty in the most recent 2006-based projections. The concluding remarks discuss the management of uncertainty.

Keywords: population growth, population projection, data collection
JEL Classifications: C80, Q56, R11

1. INTRODUCTION

The future is inherently uncertain. That is why users of statistics look to official population projections to help in planning for the future across a range of government functions. In framing policies and making decisions on the future allocation of resources, projections help to answer questions such as:

- **Education** – what is the number of school places likely to be needed over the next 5, 10 or more years?
- **Infrastructure** – what level of provision will be required for roads, water, sewage and other services?
- **Health and social care** – how are the needs of the population likely to evolve in coming years? Are we adequately prepared for an ageing population?
- **Housing** – how many additional dwellings will be required in future years?

Dealing with uncertainty is also the major challenge in producing population projections. Government population projections are typically underpinned by a set of assumptions based on what has happened in the (recent) past, informed by expert opinion on what the future holds. The assumptions made are inevitably subject to uncertainty: trends can change direction; cyclical events and longer-term trends can be more or less difficult to disentangle; external and/or unanticipated 'shocks' may occur; and, the economic climate may change.

This paper considers the sources of uncertainty in recent population projections for Northern Ireland and the Republic of Ireland, both national and sub-national. Past experience with population projections is examined to illustrate the effects of changing trends and economic circumstances. The paper then looks at sources of uncertainty in the most recent 2006-based projections. The concluding remarks discuss the management of uncertainty, primarily from the user perspective.

2. PROCESS

In a number of important respects, Northern Ireland and the Republic of Ireland adopt a very similar process for producing population projections. Both countries employ a standard methodology i.e. the cohort or demographic component method, which is described in the next part of this paper. Briefly, the method projects forward a base or start year population under chosen assumptions for the future direction of trends in mortality (which determines deaths), fertility (for calculating births) and net migration.

While the methodology for making population projections is the same in both countries, there are some differences which are worth noting at this juncture. Mainly, the differences relate to the frequency with which projections are produced and the presentation of the results.

Within the United Kingdom (UK), responsibility for producing national population projections, both for the UK as a whole and the four home countries, lies with the Office for National Statistics (ONS).[1] The projections are undertaken at the request of the National Statistician and the Registrars General of Scotland and Northern Ireland and they are produced by ONS to ensure UK consistency. The Northern Ireland projections are jointly published by both ONS and the Northern Ireland Statistics and Research Agency (NISRA).

Presently, projections are made every second year, following a review of trends affecting fertility, mortality and migration. The assumptions on which projections are based are agreed in liaison with the devolved administrations. Consultations are also undertaken with key users of the projections in each country and with advice from an expert panel.

Any set of assumptions adopted will clearly be subject to uncertainty. For that reason, ONS produces what is called *the principal projection* and an accompanying set of *variant projections*, both for Northern Ireland and the other constituent countries of the UK. The use of variant projections is one means of handling uncertainty. The ONS variants for Northern Ireland are discussed later in this paper when considering the most recent 2006-based projections.

The principal and variant projections for Northern Ireland are available from the Government Actuary Department's (GAD) projections database.[2] The most recent principal projections for Northern Ireland, from 2006 onwards, were published by NISRA in October 2007.[3]

NISRA also produces sub-national population projections, for each of 26 Local Government Districts (LGDs). Only one set of LGD projections is produced, from the principal projection. The most recent LGD projections, from a 2006 population base, were released in February 2008.[4] The LGD projections are prepared on a 'top-down' basis to ensure consistency with the Northern Ireland projections. Thus, in each year for which projections are made, the sum across the 26 LGDs of, say, the projected number of males aged 0-4 years will be the same as the overall Northern Ireland projections prepared by the ONS. Similarly, the components of change at LGD level will each sum to the respective Northern Ireland figures for births, deaths and net migration.

Though they are not discussed in this paper, NISRA also uses the population projections as a basis for projecting household numbers, by type and location. The 2006-based household projections were released in March 2008.[5]

In the Republic of Ireland, population projections are produced by the Central Statistics Office (CSO). The CSO also produces labour force projections which are derived from the age and sex population projections. The projections for Ireland are prepared on a five-year cycle, following each Census of Population. Thus, for the most recent projections, covering the period 2011 to 2041,[6] the base population by age and sex is derived from the 2006 Census.

Ireland therefore differs from the UK in the frequency with which projections are prepared, as the latter follows a two-year cycle. This also highlights a second difference in the approach. In Ireland, the projections are based on Census of Population results. In the UK mid-year population estimates are used for the base population, as the UK only conducts a Census on a decennial basis. This means, however, that the estimated base population figures in UK projections are subject to revision following the completion of a Census.

Similar to the UK, the projections for Ireland are based on assumptions regarding future trends in fertility, mortality and migration, with input from an Expert Group. In contrast to the UK, Ireland does not produce a principal or central projection. Rather, a set of projections is prepared based on alternative combinations of

[1] Previously, the projections had been prepared by the Government's Actuary Department (GAD), going back to 1954. Responsibility was transferred to ONS in 2006.
[2] At http://www.gad.gov.uk/Demography_Data/Population/Index.asp.
[3] See NISRA, 2007. For a review and commentary, see Dignan, 2008.
[4] See NISRA, 2008a.
[5] See NISRA, 2008b.
[6] See CSO, 2008a. Available at http://www.cso.ie/releasespublications/po_lab_project_2011-2041.htm.

assumptions. Typically, the variant projections include high, low and/or medium assumptions for fertility and migration and a single mortality assumption. For example, in the most recent projections produced by the CSO, four variant projections were prepared, based on two migration assumptions combined with two fertility rate assumptions. In addition, two special case variants were produced, based on a zero net migration assumption for each fertility rate assumption.

The CSO also produces sub-national projections, for each of eight Regional Authority areas. In contrast to Northern Ireland, where only the principal projection is disaggregated, regional projections are made for the main national variants produced by the CSO.

As in Northern Ireland, the CSO's regional projections are prepared on a 'top-down' basis to ensure consistency with the national projections. Reflecting the greater uncertainty that attaches to sub-national projections, the time period over which regional projections are made is shorter than for the national projections. Whereas the national projections extend for 35 years from the base year, a 20-year horizon is adopted for the regional projections. The most recent projections are for the period 2011-2026 and were published in December 2008.[7]

3. THE COHORT COMPONENT METHOD

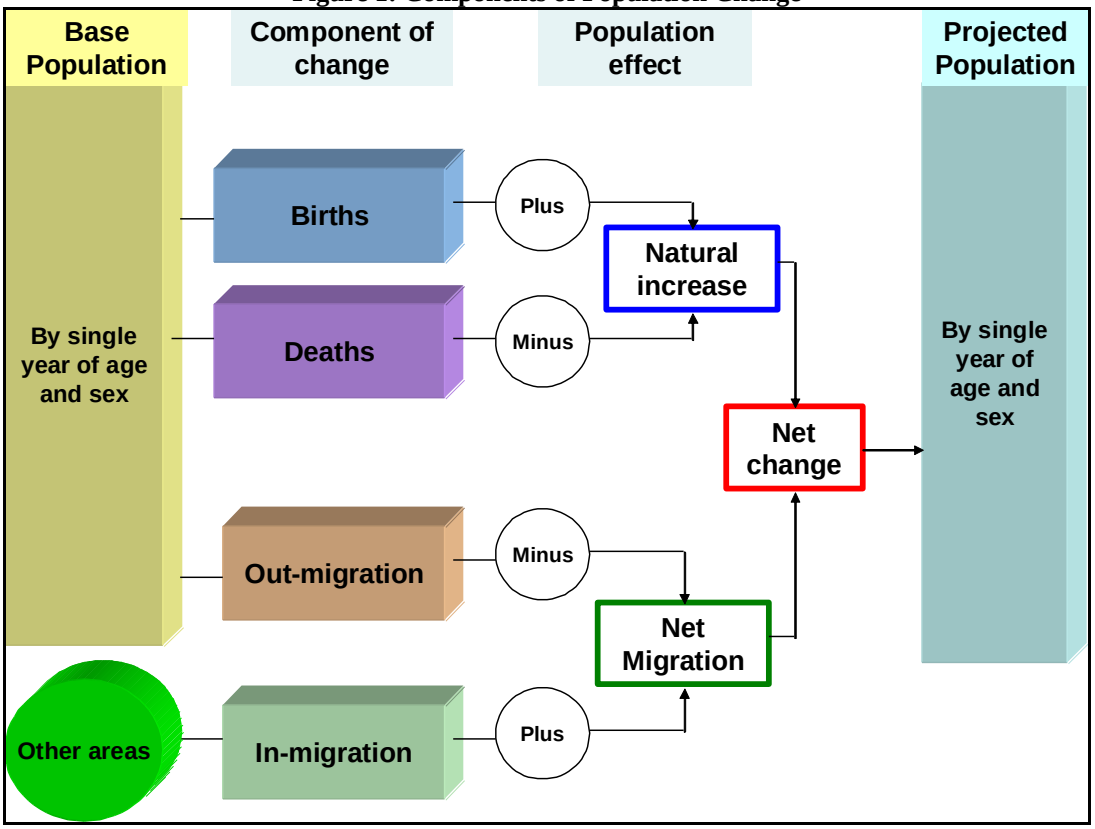
The standard approach to making population projections, employed both in the UK and Ireland, is the cohort component method. The method is best understood as an accounting framework based around the following formula (see also Figure 1):

Projected population
equals
Base population *plus* **births** *minus* **deaths** *plus* **net migration**

The difference between births and deaths is referred to as the *natural increase* in the population. *Net migration* is the difference between population gains due to in-migration from other areas compared with losses due to out-migration to other areas. As shown in Figure 1, the *net change* in the population from one period of time to another is determined by adding together natural increase and net migration. The net change can be positive or negative, depending on the balance between those components that result in additions to the base population (births, in-migration) and the components that bring reductions in the base population (deaths, out-migration).

[7] See CSO, 2008b. Available at http://www.cso.ie/releasespublications/documents/population/2008/popmig_2008.pdf.

Figure 1: Components of Population Change



In practice, population projections using the cohort component method are prepared by single year of age and sex, i.e. age-sex cohorts.[8] Starting from the base population, each age-sex cohort is successively aged through each of the years for which projections are to be made. For each cohort in each year for which projections are to be made, the projected number of deaths occurring in that year is calculated, based on an extrapolation of mortality trends, and then subtracted to give the surviving population in that cohort, which is aged on one year to the next period. Similarly, the assumed level of net migration is added (or subtracted if there are more out-migrants than in-migrants) to each age-sex cohort in each time period. Births are calculated in each projection period by applying assumed age-specific fertility rates to the female population of child-bearing age (generally 15-44).

The components of change framework depicted in Figure 1 highlights the main challenges involved in preparing a population projection. Thus, the accuracy or otherwise of the projected population will depend on:

- The base population estimate.
- The assumptions adopted for calculating the net change components.

As the base population estimate provides the starting point for the projections, any errors in the base population figures will be transmitted to all later years for which projections are made.

The key requirement in projecting deaths is to make assumptions regarding the mortality of the population. This is done by single year of age and sex, albeit deaths are strongly concentrated in the older age groups. The projected number of births in each period is obtained by applying age-specific fertility rates (the number of births per 1,000 women) to the number of women within each child-bearing age cohort.

At the national level, migration can be projected on a net basis, as in the UK, or by making separate assumptions for immigration and emigration and then deriving the net migration figure, as in the CSO model for Ireland. In either event, it is necessary to make assumptions about the age distribution of migration.

[8] See ONS, 2008, for a detailed explanation of the methodology

As noted by Shaw (2007), "due to the inherent uncertainty of demographic behaviour, any set of projections will inevitably be proved wrong, to a greater or lesser extent, as a projection of future demographic events or population structure". This is a fundamental point to be appreciated in the use and interpretation of population projections. As noted above, the cohort component method is an accounting framework: if the assumptions for fertility, mortality and migration proved to be exactly 'correct', the resulting population projections would provide perfectly accurate predictions of the future course of population growth.

Of course, the future can never be predicted with certainty. The actual out-turn for fertility, mortality, and net migration will inevitably diverge from the assumptions. Hence, the projected population will differ from what actually transpires in future years.

In general terms, the greatest uncertainty surrounds the assumptions for net migration. Partly, this is because, due to official registration systems, historical data on births and deaths are more reliable as a basis for extrapolating trends into the future. Historical migration data, on the other hand, will generally entail a degree of estimation and hence will be subject to a higher degree of error.

There are, however, other reasons why the components of change vary in terms of the uncertainty that attaches to the assumptions made for the cohort component method. In particular, the components vary in respect of the extent to which they are influenced by the choices that people make at different stages in their lives and the social and economic circumstances that shape those choices.

In that regard, there is perhaps less uncertainty around the projected number of deaths, because the population for whom assumptions need to be made have (mostly) already been born. Greater uncertainty surrounds fertility rate assumptions for projecting the number of births in future years. This is because people make choices about the number of children that they might wish to have and the stage in their lives at which to have children. Such choices are clearly subject to social and economic influences, which can be difficult to predict. Indeed, for longer-term projections (over 20-25 years), some of those who will be making those choices in future years have not yet been born themselves.

Net migration presents the greatest difficulty in making population projections. Partly, this reflects the fact that, unlike births and deaths, net migration is a derived figure, resulting from the balance between inflows and outflows. Mainly, however, the uncertainty stems from the array of influences, many of them external, to which migration flows are subject. In particular, migration flows are sensitive both to economic conditions and prospects in the host or receiving nation and to the relative attractiveness of the host nation to countries from which in-migrants originate. Consequently, net migration can fluctuate in tandem with the economic cycle, making it more difficult to discern trends likely to be sustained over any period of time. In general, migration is the most volatile component of population change and hence presents the greatest difficulty when seeking to make plausible assumptions regarding the future.

Depending on the forecast horizon, the foregoing uncertainties will vary in terms of their impact on different age cohorts and hence on the projected population age structure. For example, over a 15-20 year time period:

- Mortality assumptions will have their largest effect on the projected number of older persons (i.e. those aged 65+).
- The fertility assumptions will affect the projected number of young persons (less than 15-20).
- The migration assumptions will mainly affect the projections for the working age population, especially those in the 15-44 age bands, albeit there will also be an effect as in-migrants in one period will subsequently have children.

4. PAST EXPERIENCE

This section seeks to demonstrate the effects of two important sources of uncertainty in the use (and production) of population projections:

- Changing trends, especially the turning point problem.
- Changing economic circumstances.

The approach taken is to compare previous projections for Northern Ireland and Ireland with the actual out-turn in the respective jurisdictions. It should be emphasised that the purpose of the comparisons is to demonstrate

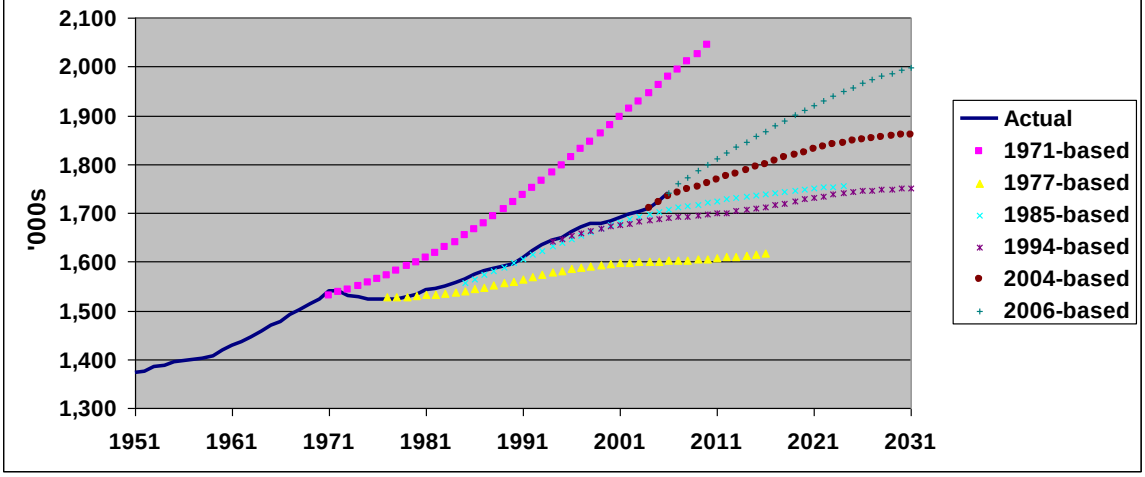
the uncertainties associated with each component of change, not to provide an evaluation of the 'accuracy' or otherwise of the projections.[9]

The influence of changing trends is demonstrated by focusing on the projections made for Northern Ireland in selected years from 1971 onwards, drawing on the GAD projections database. The impact of changing economic circumstances is illustrated with reference to the more recent experience in the Republic of Ireland.

Northern Ireland

Figure 2 compares the mid-year population estimates for Northern Ireland with various projections made since 1971. Most strikingly, perhaps, the 1971-based projection[10] was in excess of the actual out-turn in each year of the projection period. If the Northern Ireland population had followed the trajectory indicated by the 1971-based projection, the population would have risen from 1.5m to almost 2m by 2006, compared to the estimated out-turn of 1.74m. By contrast, the 1977-based projection under-predicted the actual population change in each projection year. The more recent projections shown in Figure 2, made in 1985, 1994 and 2004, have also under-predicted the actual population, albeit by much reduced margins compared to 1977.

Figure 2 Actual and projected population, Northern Ireland,1971-2031

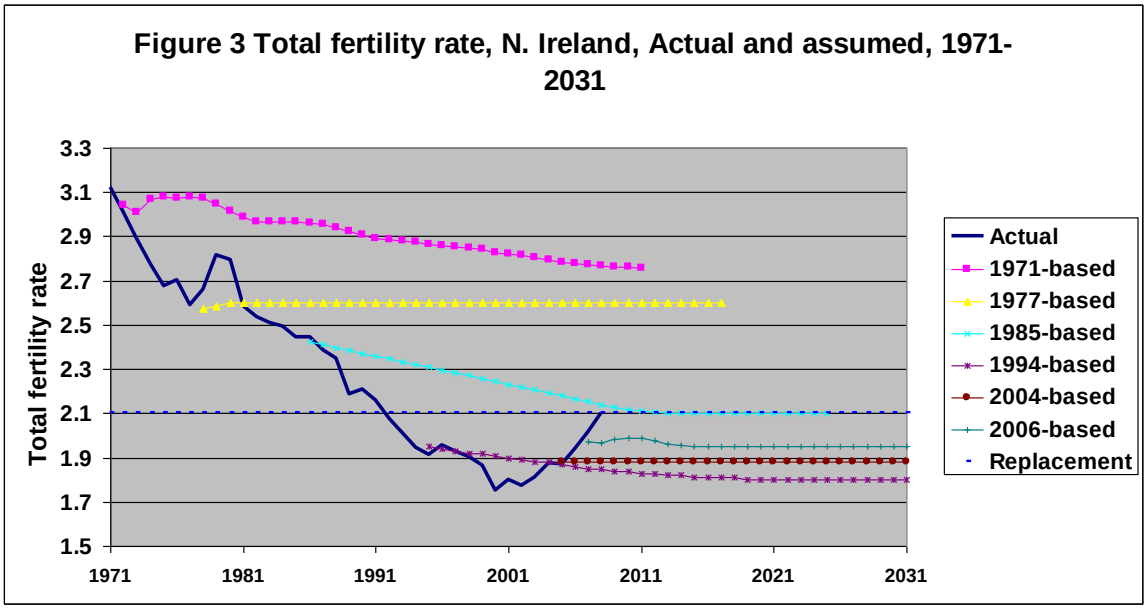


The main reason that the 1971 projection over-predicted the growth in population is that it did not anticipate the sharp fall in fertility rates that brought an end to the 1960s baby-boom.[11] Throughout the 1960s, the number of births in Northern Ireland was in excess of 30,000 per annum. The 1971-based projection assumed that fertility rates would remain high in subsequent years, with the number of births continuing to exceed 30,000 per annum. This assumption did not materialise.

A useful summary measure for illustrating the fertility assumption is the Total Period Fertility Rate (TPFR). The TPFR gives the average number of children that a woman would be expected to have over the course of her child-bearing years, given the age-specific fertility rates prevailing in a particular period of time. For example, the TPFR for Northern Ireland in 2006 was 1.94; based on the 2006 age-specific fertility rates, 1.94 is the number of children that a woman would be *expected* to have during her lifetime.

As can be seen from Figure 3, Northern Ireland entered the 1970s with a TPFR in excess of three. The 1971 projection assumed that the rate would taper off only slightly. As events transpired, the TPFR declined much more quickly than anticipated, tumbling from 3.12 in 1971 to 1.75 in 2000. Consequently, the number of births per annum dropped from over 30,000 in 1971 to 22,000 in 2000.

[9] See, for example, Shaw (2007) and Keilman (2007) for evaluations of the accuracy of past projections.
[10] Throughout this paper, projections are referred to according to the base or start year for the projection.
[11] The UK population projections were not alone in that regard. See Shaw (2007) and Keilman (2007).

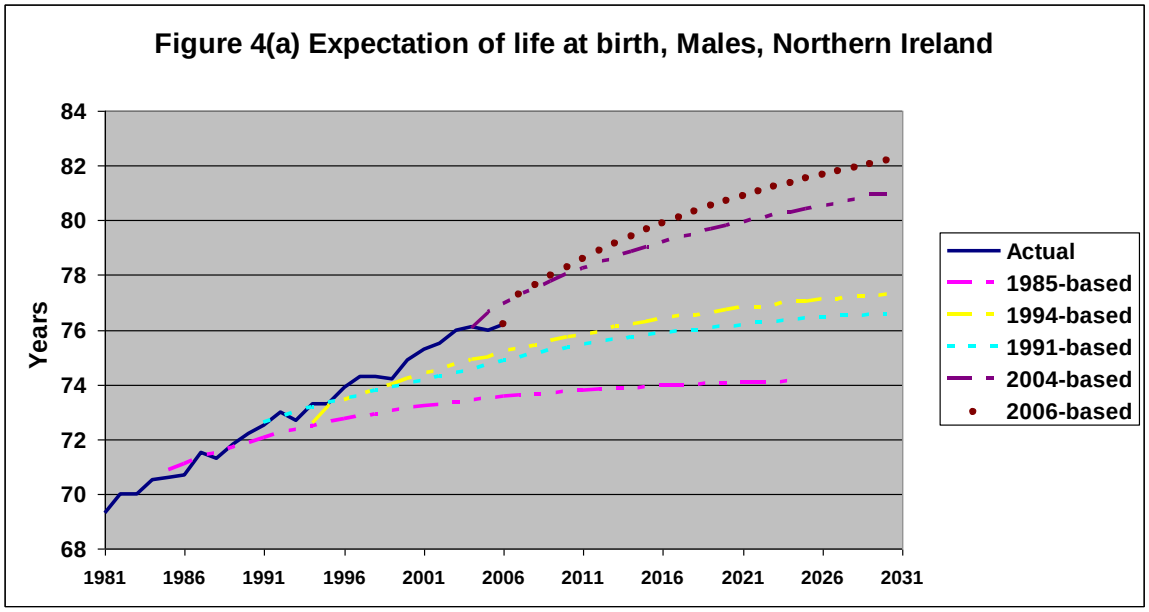


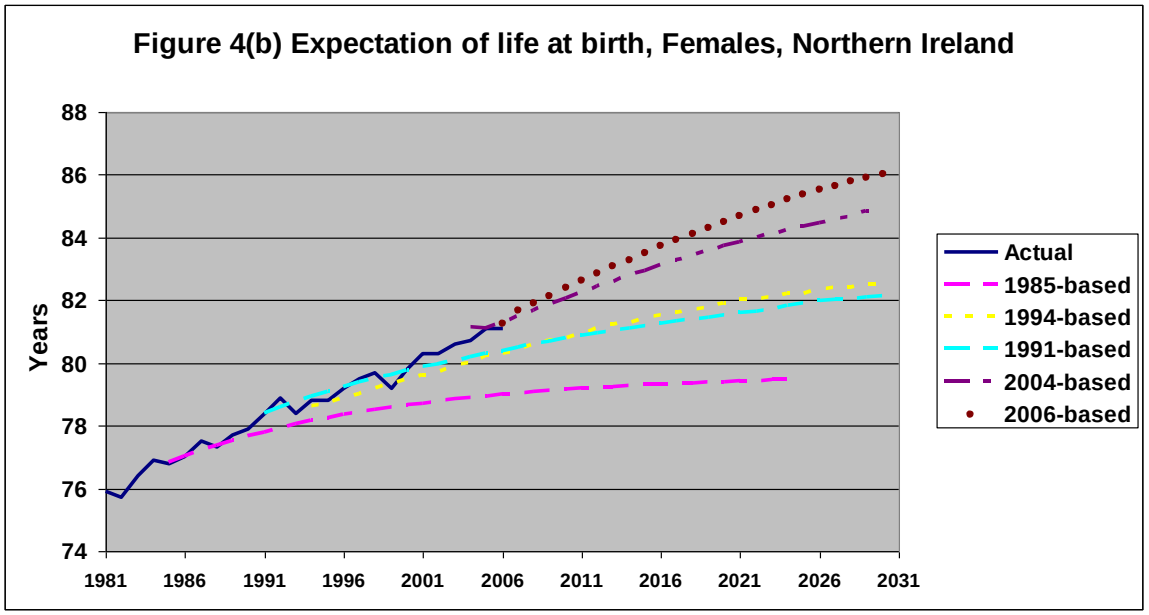
In each of the years 1977, 1986 and 1994, the assumed long-term fertility rates continued to be lowered in tandem with the falling trend in actual rates. However, as can be seen from Figure 3, fertility rates in subsequent years continued to decline more quickly than had been assumed. That is, over the period from 1971 to around the mid-1990s, fertility rate assumptions have been behind the actual trend. It is only since the actual fertility rate bottomed out and started to increase again in the early-2000s that the projection assumptions appear to have become more aligned with the actual out-turn. Whether the up-turn in fertility rates from 2003 onwards continues is an important issue for the 2006 projections, which are discussed later in this paper.

A broadly similar pattern can be seen from the comparison between mortality rate assumptions and the actual out-turn. Again, a summary indicator is useful for illustrating the relevant historical trends and the assumptions used for extrapolating into the future. The *expectation of life at birth* (EOLB) gives the number of years that a person would be expected to live, if that person experienced the age-specific mortality rates pertaining in the year of their birth.[12] A rising EOLB signifies falling mortality rates, that is, people living longer.

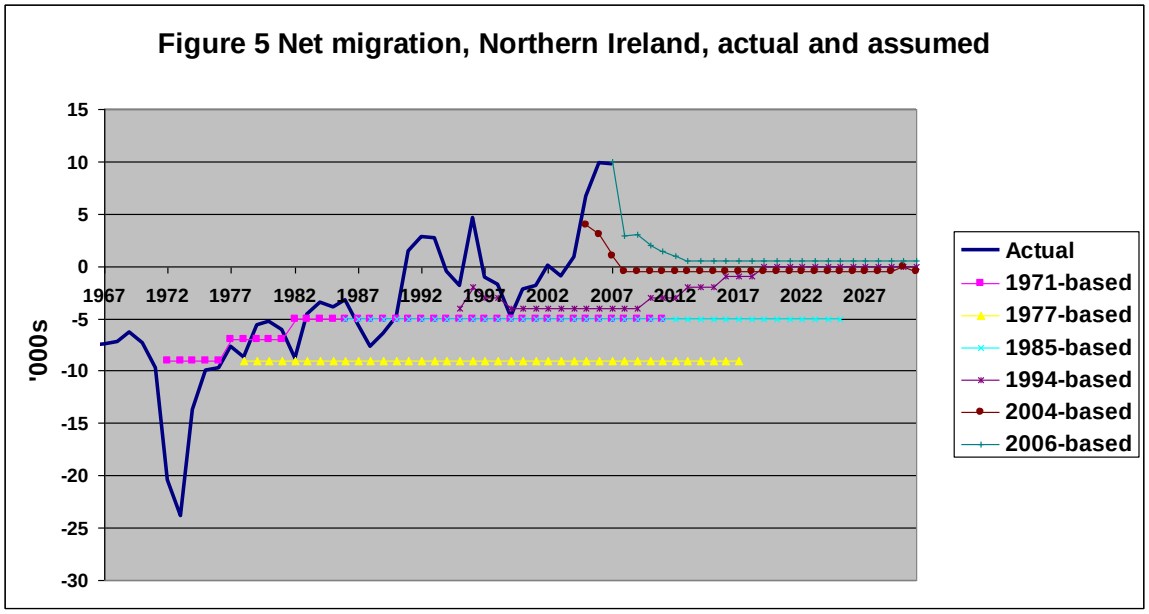
As can be seen from Figures 4(a) and (4(b), there has been a persistent under-prediction of the EOLB for both males and females in the Northern Ireland projections. This reflects uncertainty regarding the extent to which past improvements in mortality can be expected to persist into the future.

[12] That is, the period expectation of life at birth (see Bray, 2008).





The net migration assumptions for various projections made for Northern Ireland are shown in Figure 5. Overall, the assumptions have erred on the pessimistic side, i.e. the assumed population losses due to net out-migration have been in excess of the actual out-turn. This was most apparent in the 1977-based projection. Reflecting the surge in out-migration resulting from the deepening troubles of the early-1970s, it was assumed that net out-migration would continue at a rate of 9,000 per annum. This did not prove to be the case. More recently, the net migration assumptions in the 2004-based projections did not anticipate the large inflows from Eastern Europe following the A8 accession.



The effects of the disparities between the assumptions made for each component and the actual out-turn from the population base year through to 2006 are summarised in Table 1. Thus, comparing the 1971-based projection for the 35-year period period from 1971 to 2006 with the actual out-turn over the same period, total population was over-predicted by an annual average of 7,000. Mainly, this was because the projected numbers of births exceeded the actual out-turn, on average, by 10,000 per annum. The excess in the number of projected births was partly offset by an over-prediction of the number of deaths, by 1,000 per annum, and a net out-migration assumption that was in excess of the out-turn by 2,000 per annum.

Table 1 Northern Ireland population projections: Difference between 2006 projected and actual, annual averages, '000s

Projection base year:	**Total population**	**Births**	**Deaths**	**Net migration**	***Base year to 2006***
	'000s	*'000s*	*'000s*	*'000s*	*Yrs*
1971	7	10	1	-2	*35*
1977	-5	4	2	-7	*29*
1985	-1	3	0	-4	*21*
1994	-4	0	1	-4	*12*
2004	-4	0	0	-5	*2*

Note: Sum of components may not add to total change due to rounding error

In both the 1977 and 1985-based projections, births were also over-predicted when compared with the out-turn through to 2006, albeit by much diminished margins compared to 1971, as the fertility rate assumptions were successively adjusted downward in line with more recent data. As the fertility trend flattened out in the 1990s, the projections for births were more closely aligned with the out-turn.

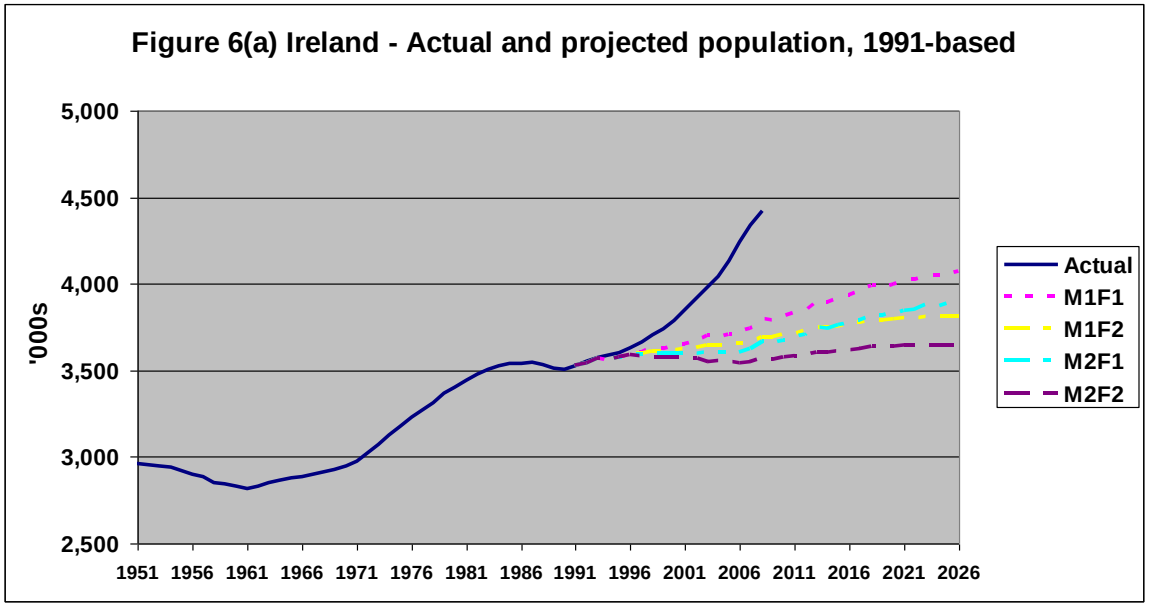
The successive narrowing of the disparity between projected and actual births is partly a function of the shorter time periods over which comparisons can be made with the 2006 out-turn. But the Northern Ireland experience, which was not unique, also serves to illustrate the difficulties that were encountered in 'catching up' with the declining trend in fertility following the unexpected turning point that occurred in the early-1970s. Such turning points give rise to uncertainties for those producing projections when it is unclear whether, at the time it occurs, the change marks the beginning of a new trend or the flattening out of a pre-existing trend.

A second interesting aspect of the Northern Ireland experience has been the effect of the net migration assumptions. From 1977 onwards, the projections have assumed a higher level of out-migration – and hence population losses - than actually occurred. At least through to 2004, the effect on the disparity between the relevant population projections and the 2006 out-turn has not varied greatly, ranging from an under-estimate of 4-7,000 per annum. Indeed, apart from 1971, this has been the main source of 'error' when the population projections are compared to the 2006 out-turn. This might suggest that, based on past experience, migration assumptions for Northern Ireland should be less 'pessimistic' on future occasions. However, as noted earlier, net migration is subject to an array of influences and can vary sharply from one year to the next. In that context, the (recent) past may not necessarily be a reliable guide to the future. Thus, the lesson to be drawn is perhaps that greater attention needs to be paid to the migration component. This conclusion is reinforced by considering the recent experience with population projections in the Republic of Ireland.

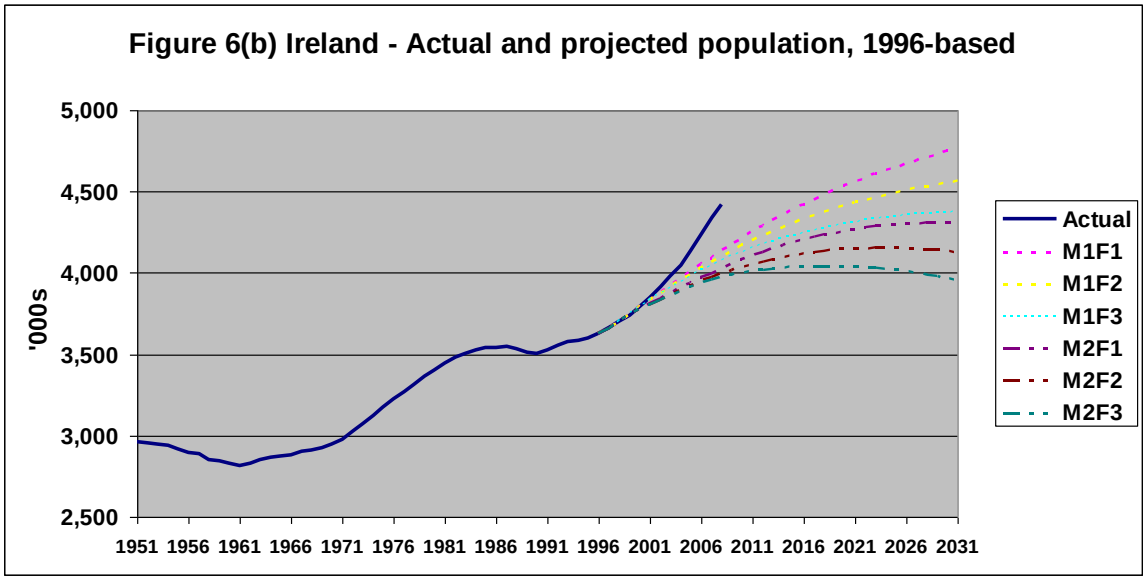
Ireland

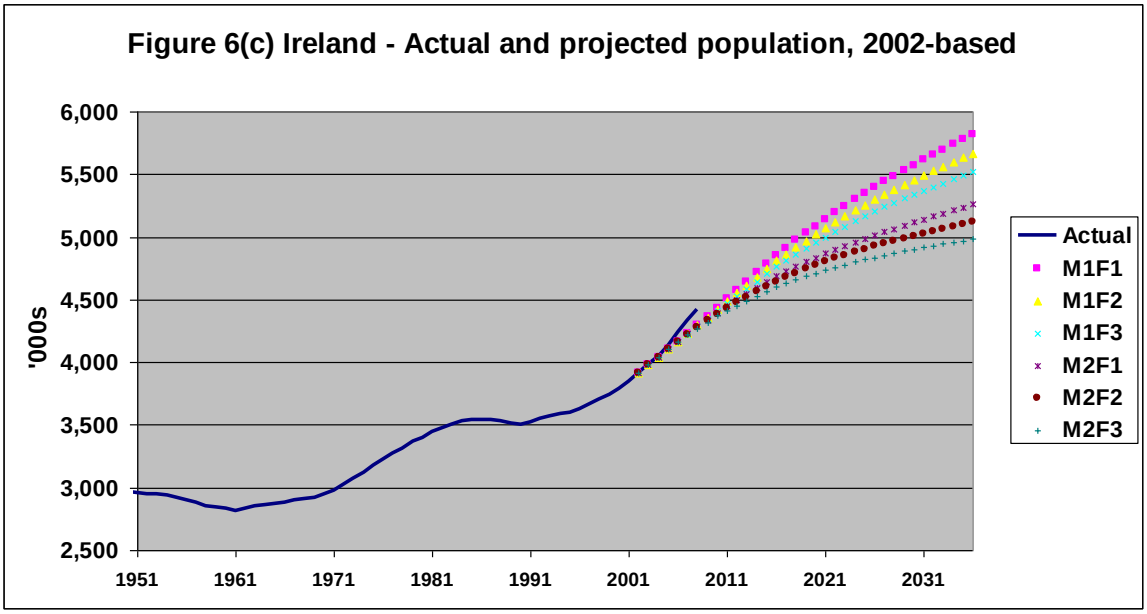
As noted above, the CSO does not produce a principal projection for Ireland. Instead, it presents a range of projections based on alternative combinations of fertility and migration assumptions. The projections made following the population censuses of 1991, 1996 and 2002 are shown in, respectively, Figures 6a, 6b and 6c below.

The 1991-based projection, made for the period 1996 to 2026, comprises four variants, based on two migration assumption (referred to as M1 and M2) and two fertility assumptions (termed F1 and F2) (CSO, 1995). Each variant is referred to according to the combination of assumptions on which the projection is based, hence M1F1, M1F2, etc. M1F1 gives the highest projected population while the lowest is associated with M2F2. As can be seen from Figure 6(a), each of the variant projections, including the high population growth projection (M1F1), under-predicted the actual population growth in the period from 1991 to 2008. For the 1996-based projections, six variants were prepared, based on three fertility and two migration assumptions (CSO, 1999). Again, the actual population growth was in excess of the projected growth for the period through to 2008. Notwithstanding the shorter time period, each of the variants in the 2002-based projection[13] also under-predicted the population growth to 2008.

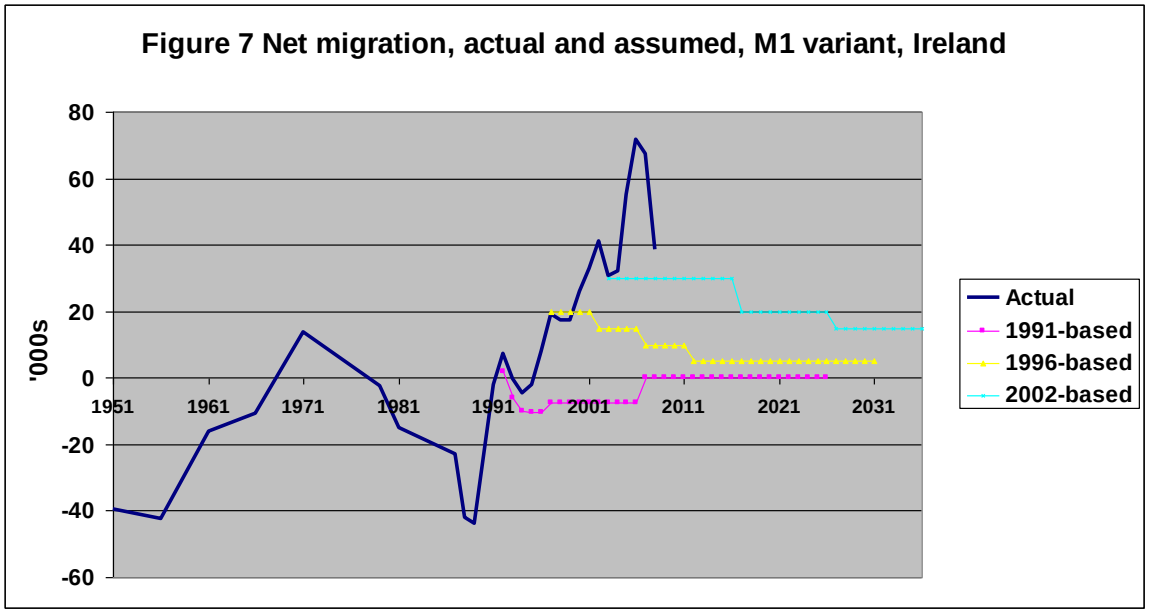


[13] CSO, 2004.



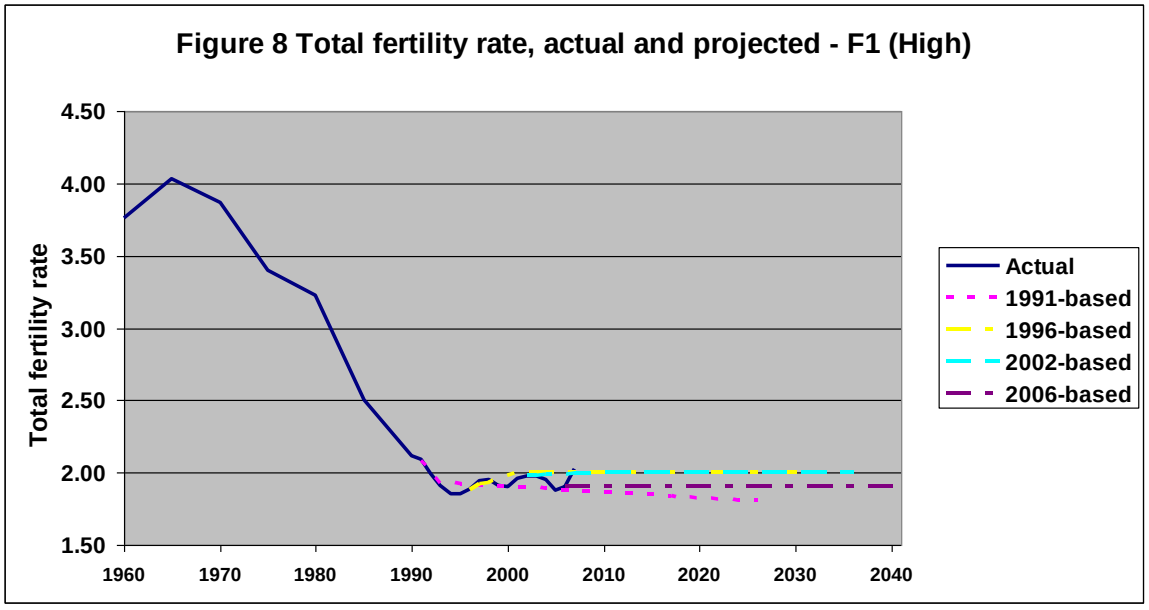


The main reason that the foregoing projections have under-predicted the actual population growth is that net migration has been persistently higher than anticipated in any of the assumptions made (Figure7).



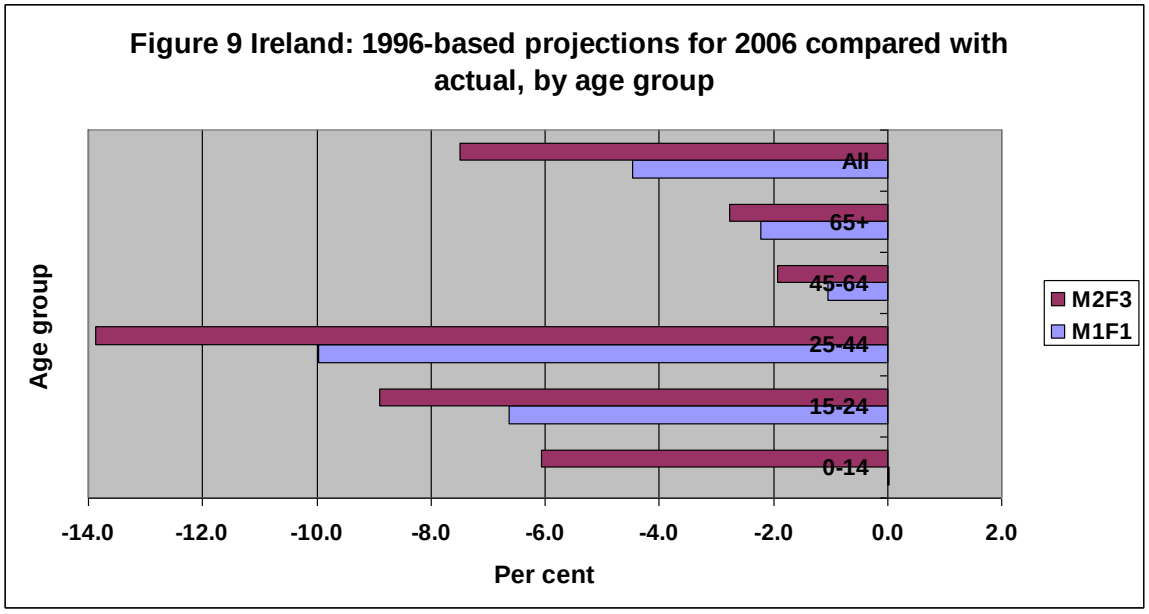
Historically, and apart from the 1970s, Ireland experienced net outflows of population due to the excess of emigration over immigration. The migration turnaround that commenced in the early-1990s was clearly due to the change in Ireland's economic circumstances and the relatively fast pace of growth that was maintained until recently. Since 2004, there have also been large inflows from Eastern Europe in the wake of the accession of the A8 countries. Thus, from the mid1990s through to 2008, Ireland has experienced sustained net inward migration at levels that were both unprecedented and unexpectedly large. Consequently, the migration assumptions have essentially been following in the wake of the upward movement in the net inflows.

In the period from 1991 to 2002, the fertility rate assumptions have exerted less influence than migration on the disparity between the population projections and the actual out-turn. As can be seen from Figure 8, Ireland also experienced a sharp decline in fertility rates throughout the 1970s and 1980s. However, the trend was broadly flat during the 1990s and the assumptions made in successive projections were largely in line with the actual out-turn.

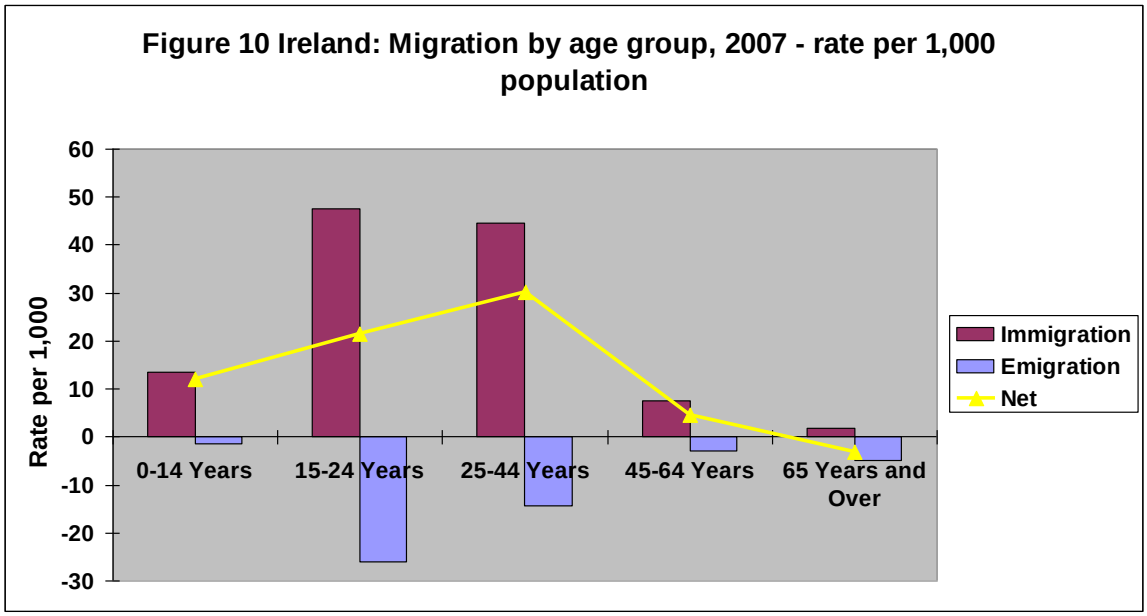


The dominant effect of the migration assumptions is also evident from the disparities by age group between the population projections and the actual out-turn. Focusing on the1996-based projections for 2006, the high population variant (M1F1) resulted in a total population projection that was four per cent below the 2006 out-

turn (Figure 9). There were, however, large differences by age group, ranging from an under-projection of 10 per cent for the 25-44 age group to zero per cent for the 0-14 age group. The disparities are even more pronounced for the low population growth scenario (M2F3).



The reason for the large differences by age group is that migration is highly age-selective (Figure 10). Thus, if the net in-migration assumptions are too low, the resultant under-projection will be greatest for those aged 15-44, and vice versa.[14] This serves to illustrate how uncertainties in one component (migration in this instance) have implications also for the projected age structure of the population.



[14] At least in the short- to medium-term, as net migration inflows in one period will result in additional births in later periods.

5. NATIONAL PROJECTIONS, 2006-BASED

Northern Ireland

The 2006-based principal projection for Northern Ireland is shown in Figure 2 above. Overall, the population is projected to increase from 1.7m in 2006 to almost 2m by 2031. The main assumptions underlying this projection are as follows (NISRA, 2007):

- The TPFR will stabilise at around 1.95, representing a slight increase on the 2006 rate of 1.94.

- Mortality rates by age group will converge to a common rate of improvement of one per cent per annum by 2031. The one per cent per annum decline in mortality rates is then held constant from 2031 onwards. For males, the EOLB will rise from 76 years in 2006 to 82 years by 2031. Females will see a rise from 81 years to 86 years.

- Net migration is slated to remain high in 2006-07, falling to +1,500 by 2010-11 and remaining constant thereafter at +500.

Each of the foregoing assumptions is subject to a degree of uncertainty. Regarding the fertility assumptions, fertility rates have been steadily increasing since the early-2000s. The upturn in fertility rates can partially be explained by delayed fertility, with older women having more babies than previously. However given that all the reasons for the increase are not fully understood makes for a degree of uncertainty in framing assumptions for the projection period. Indeed, the most recent data for Northern Ireland show an increase in the TPFR to 2.016, which is equivalent to replacement level fertility i.e. the level of fertility required for the population to replace itself in the long term (see Figure 3 above). This raises the possibility that the recent upturn in fertility rates may continue, leading to an under-projection of births in the projection period. Alternatively, the fertility rate may revert back to below-replacement level, as has been the case since 1992. As can be seen in Figure 3 above, fertility rates also increased for a period in the mid-1970s before resuming a downward path.

The migration assumptions underlying the principal NI projection would appear to be based on the premise that inflows, mainly from Eastern Europe, will continue to boost net migration for the first five years of the projection period. Beyond 2011, the assumption essentially is based on a return to the situation prior to the EU Accession, with inflows more or less aligned with outflows.

One way of addressing the uncertainties surrounding the principal population projection is to make use of the accompanying variant projections. Two types of variants are produced, standard and special case projections. The standard variant projections are designed to represent plausible alternatives to the principal assumptions. For example, what would happen to population growth if net migration was assumed to be higher (or lower) compared to the assumption used in the principal projection? The special case variants are intended to "illustrate the consequences of a particular, but not necessarily realistic, set of assumptions". For example, how would the population evolve if net migration was zero in all time periods i.e. where change was due entirely to the balance between births and deaths (natural increase)?

The special case variants are particularly useful in providing an understanding of the sources of population change in the principal projection so as to distinguish the separate effects of the fertility, mortality and migration assumption. Following the methodology outlined in Bray, 2008, it is possible to use the special case variants to identify the sources of change for the 25-year period 2006-2031, as follows:

- Population momentum from the current age structure, assuming replacement level fertility, no mortality improvement and zero net migration.
- The effect of below replacement level fertility.
- The effect of the assumed mortality improvement.
- The net migration effect.

The results are shown in Table 2. Thus, about two-thirds of the projected growth is due to the population momentum from the current age structure of the Northern Ireland population. The below replacement level fertility assumption reduces the projected growth, by 35,000. The assumed mortality improvement accounts for 30 per cent of the growth with the remaining 17 per cent due to the net migration assumption. Thus, in the principal 2006-based projection for Northern Ireland, migration is expected to play a relatively small role. This is in sharp contrast to the rest of the UK, where migration accounts for 70 per cent of the projected change.

The analysis of previous Northern Ireland projections presented above, which found a persistent under-estimation for net migration when assumptions were compared to actual out-turns, would seem to signal a concern that the central migration assumption in the 2006-based projections is on the low side. However, in the current economic circumstances, it is not unreasonable to assume a diminution in the net migration inflow, especially as the 2004-2007 period has seen unusually high volumes of net inflows (see Figure 4 above).

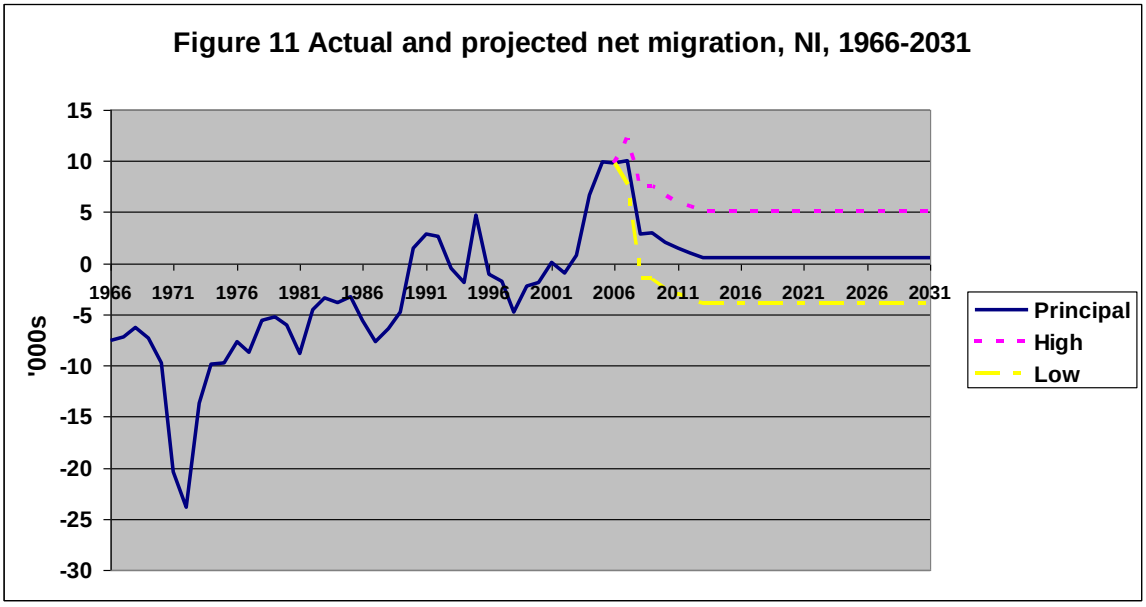
Table 2 Projected population change by source, 2006-2031, Northern Ireland

Source:	**Northern Ireland**		**United Kingdom**
	'000s	*%*	%
Population momentum from current age structure*	173	67.1	25.7
Assumed below replacement fertility	-35	-13.7	-20.0
Assumed mortality improvement	77	30.0	24.8
Assumed inward net migration	43	16.6	69.5
All	**257**	**100.0**	**100.0**

*Replacement level fertility, constant mortality, zero net migration

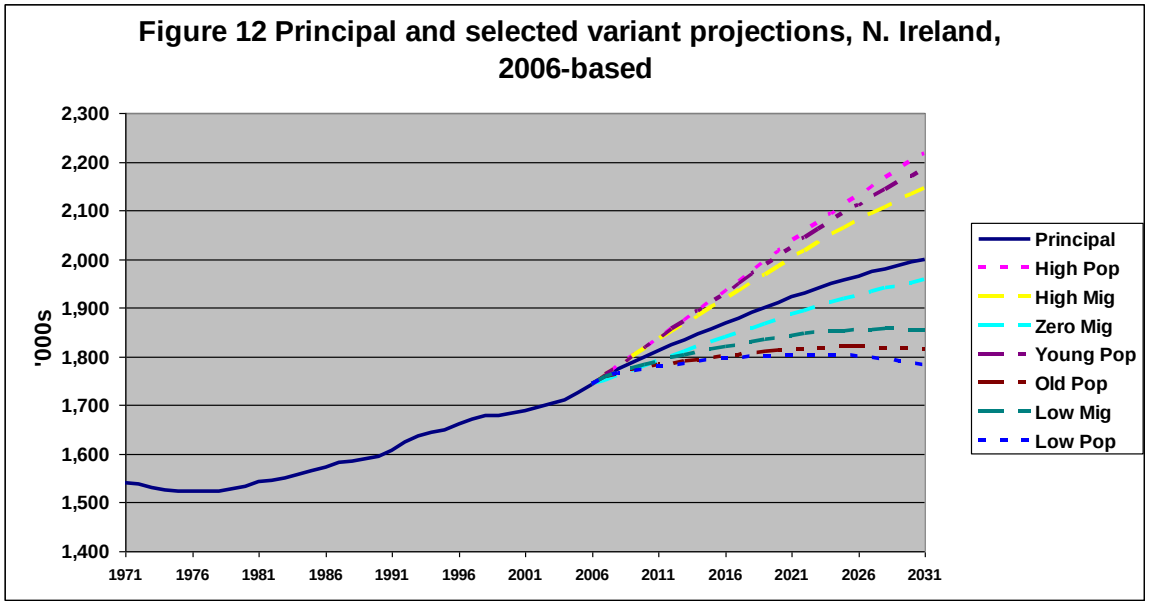
Furthermore, while net migration has been an important source of growth in more recent years, it has relied heavily on the large inflows in the wake of the accession of the EU8. The EU accession impact can be expected to diminish over time, for a variety of reasons. Other EU member states will open their labour markets to the accession countries, thereby presenting intervening opportunities for potential migrants. Further, the relative attractiveness of NI as a destination may well diminish, particularly if there is a protracted recession in the wake of the 'credit crunch'. Albeit the timescale is uncertain, the accession countries can also be expected to exhibit a degree of catch-up or convergence in economic terms on the rest of the EU, over the medium to long-term. Nonetheless, it is still useful to consider high and low migration variants on the principal projection, as set out in Figure 11.

Figure 11 Actual and projected net migration, NI, 1966-2031



As can be seen from Figure 12, the net migration variants account for most of the gap between the high and low population variants. Thus, if Northern Ireland was to experience an annual net inflow of +5,000, the population would rise to 2.14m by 2031 (Figure 12), or seven per cent above the principal projection. Conversely, a

persistent net outflow of -4,000 per annum would see the population rising to 1.854m by 2031, seven per cent below the principal projection.



In addition to the high and low migration scenarios, Figure 12 also shows some of the other population variants produced by ONS to illustrate the effect of varying assumptions regarding the components of population change.[15] These illustrative variants are of two main types:

- Single component variants, in which only one set of assumptions are varied e.g. the migration scenarios discussed above.[16]
- Combination variants, in which the assumptions for two or more of the components of change are varied. In Figure 12, the high population and low population projections are both combination variants.

The variants serve to reflect the uncertainty that necessarily attaches to any population projection. However, to quote GAD, they "are intended as plausible alternatives to the principal assumptions and *not* to represent upper or lower limits for future demographic behaviour".[17]
In that context, the ONS variants provide a means by which the user can test the sensitivity of their findings to variations in the principal population assumptions. For example, in assessing future needs for education facilities, the ONS scenarios could be used to examine the effects of faster or lower population growth on the needs assessment, compared to the principal projection. Nonetheless, care is required in selecting out the most appropriate variants for constructing alternative scenarios. In the education sphere, scenarios which illustrate uncertainties around the growth in the child population are likely to be of most relevance i.e. alternative fertility and migration assumptions.[18] Alternatively, if the planner or policy-maker is concerned with the needs of older people, variants that highlight uncertainties around the ageing of the population will be of most interest.

Ireland

[15] For an explanation of the variants, see http://www.gad.gov.uk/Demography_Data/Population/Index.asp?v=Variant&y=2006&subYear=Continue.
[16] In Figure 12, the single component variants are HF, HM, HL, LL, LM and LF.
[17] The methodology currently used by ONS does not permit the specification of upper and lower limits. See Shaw, 2007, and Keilman, 2007.
[18] Migration is highly age-selective and tends to be disproportionately concentrated in the age range 18-34. Migration inflows in one year will therefore boost the number of births in later years.

The 2006-based population projections for Ireland are based on two sets of fertility assumptions, as follows (CSO, 2008):

- F1: The TPFR to remain at its 2006 level of 1.9 for the lifetime of the projections.
- F2: The TPFR to decrease to 1.65 by 2016 and to remain constant thereafter.

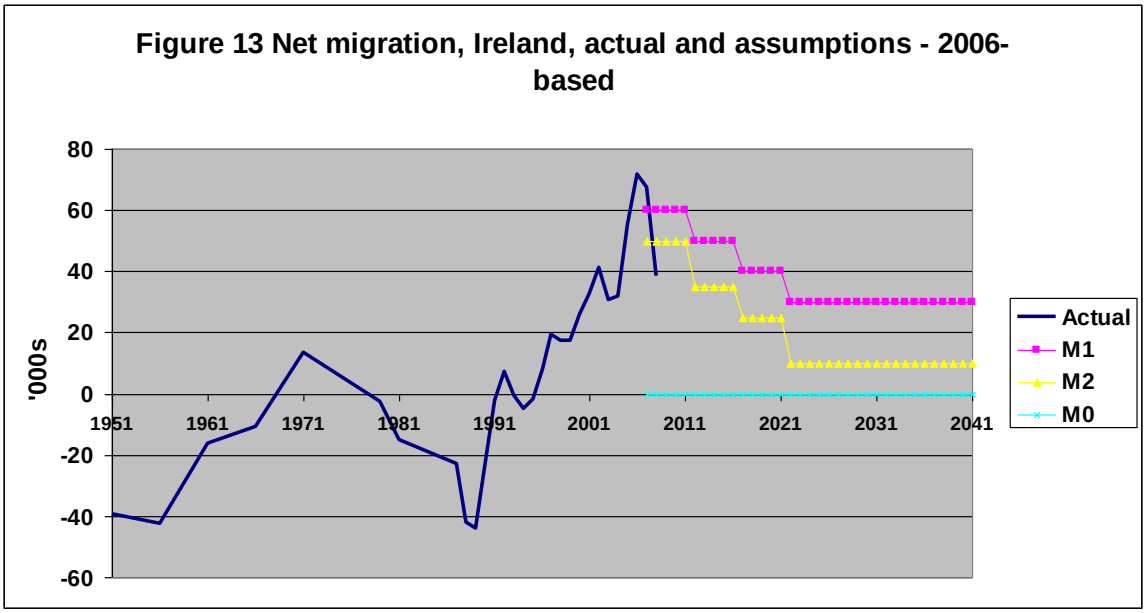
Similar to Northern Ireland, the projections for Ireland do not anticipate an increase in fertility over the projection period.

Mortality rates are assumed to decline to a long-term rate of 1.5 per cent per annum from 2031 onwards. For each year between 2005 and 2031, the mortality rates were calculated by linear interpolation.[19] For males, the expected decline in mortality will see an increase in life expectancy at birth from 76.7 years in 2005 to 86.5 years in 2041. Females will see a rise from 81.5 years in 2005 to 88.2 years by 2041.

Compared to Northern Ireland, the mortality assumptions envisage a larger increase in male life expectancy in the period from 2005 to 2041 (+9.8 years compared to +7.4 years). Similarly, for females, albeit the projected improvement is not as pronounced (+6.7 years compared to +6.0 years for Northern Ireland).

As stated by the CSO, and perhaps also reflecting the experience with previous projections as outlined above, the migration assumptions are based on the premise that "the high economic and labour force growth experienced by Ireland in the past decade has radically changed the outlook in regard to migration. In short, the country has moved from a long-standing pattern of emigration to a new pattern of relatively strong immigration and it is unlikely that that this will be reversed to any sustained degree over the projection period". It was decided therefore to adopt assumptions based on "immigration continuing at close to the current high rate and at more moderate levels". The resulting assumptions are shown in Figure 13.

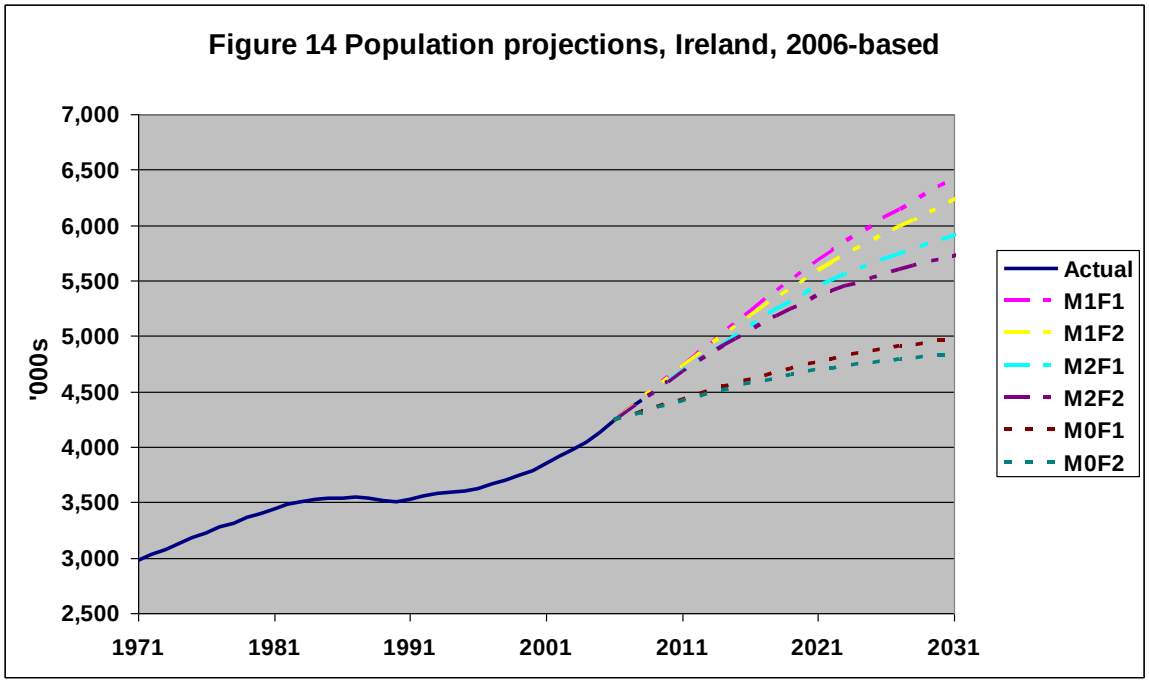
Figure 13 Net migration, Ireland, actual and assumptions - 2006-based



In addition, the CSO prepared zero net migration variants for the two fertility assumptions. This was to permit a fuller assessment of the impact of migration.

The variant population projections are shown in Figure 14. The high population growth rate (M1F1) gives a population projection of almost 6.6m by 2031, rising to over 7m by 2041. The low population variant (M2F2) would see the population expanding to 5.7m by 2031 and close to 6m by 2041.

[19] A revised methodology was used for the 2006-based projections, as described in Whelan (2008).



In both the high and low population variants, the migration assumptions exert the dominant influence. This is evident in Figure 14 from the size of the gap between the M1 and M2 variants and the zero net migration variant (M0), for a given fertility assumption, compared with the distance between alternative fertility rate variants for a given migration assumption. For example, in the M1F1 variant, the migration assumption accounts for two-thirds of the population growth projected for 2006 to 2031.[20]

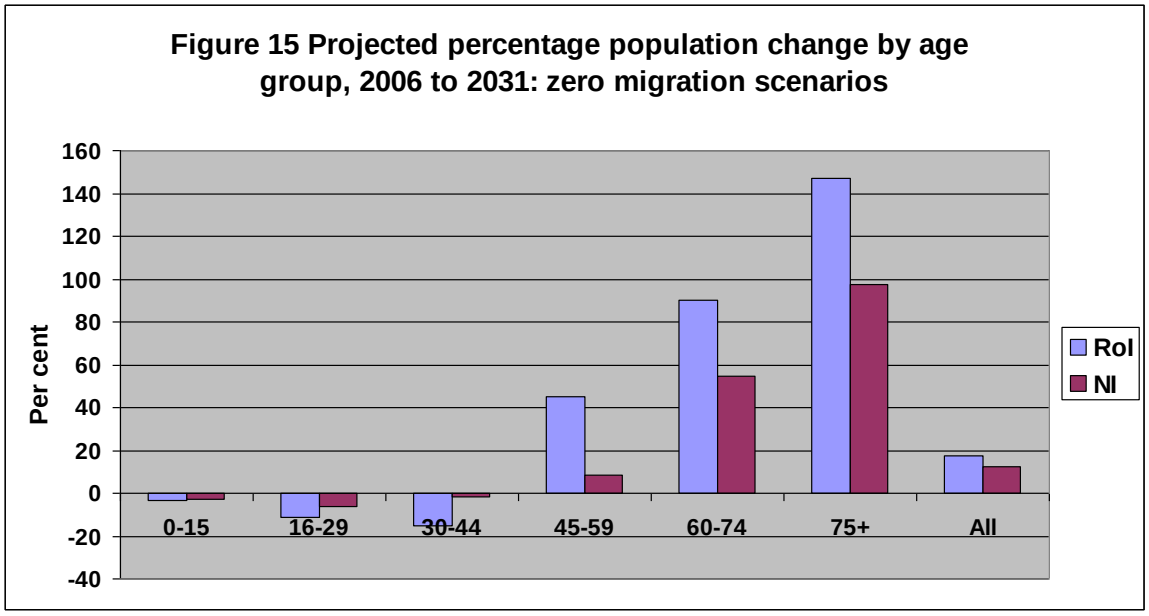
Considerable uncertainty must, however, be attached to the migration assumptions in the 2006-based projections. The key issue is whether Ireland has in fact moved to a period of sustained high immigration, especially along the lines suggested by the M1 variant? Alternatively, will more modest levels of net migration be observed in future years, compared to the variants in the 2006-based projections? That is, should the recent surge in net migration, especially in the period from 2004 to 2007, be viewed more as an artifact of a cyclical boom in the economy, allied to the unusually large increase in potential labour supply following the A8 accession, as compared to a permanent upward movement in net migration inflows to Ireland?

Recent developments would suggest the latter. For example, the latest population and migration estimates, for 2008, show a sharp fall-off in net migration, from 67,000 in 2007 to 38,500 in 2008 (CSO, 2008c). The comments made earlier regarding future immigration inflows to Northern Ireland from the A8 countries can equally be applied to Ireland. At the very least, the high population growth variant (M1) would seem to be untenable at this juncture.

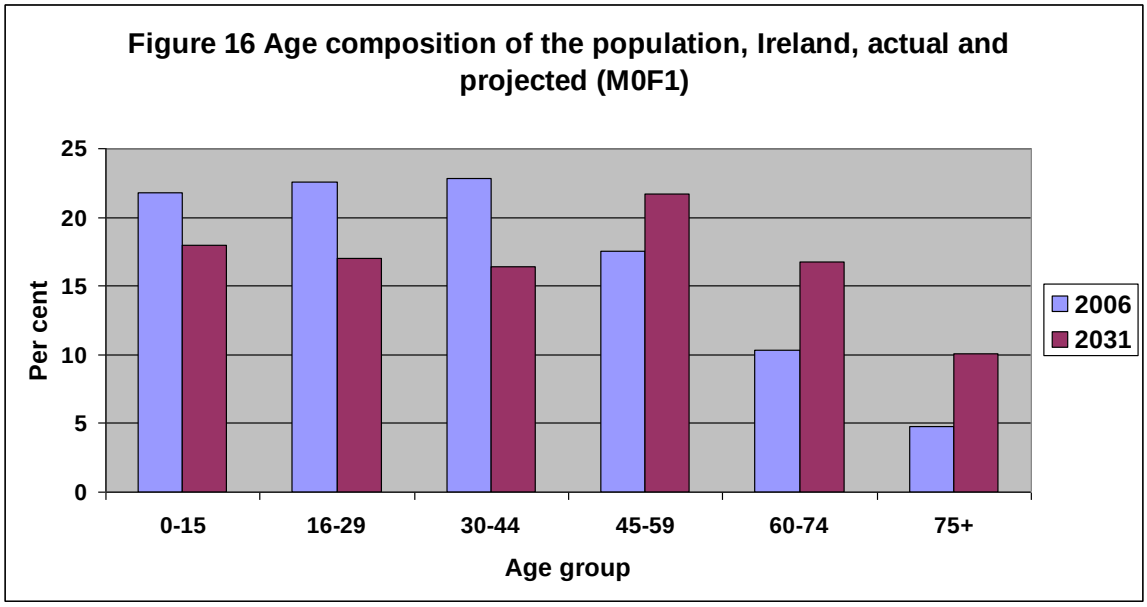
6. AGE COMPOSITION

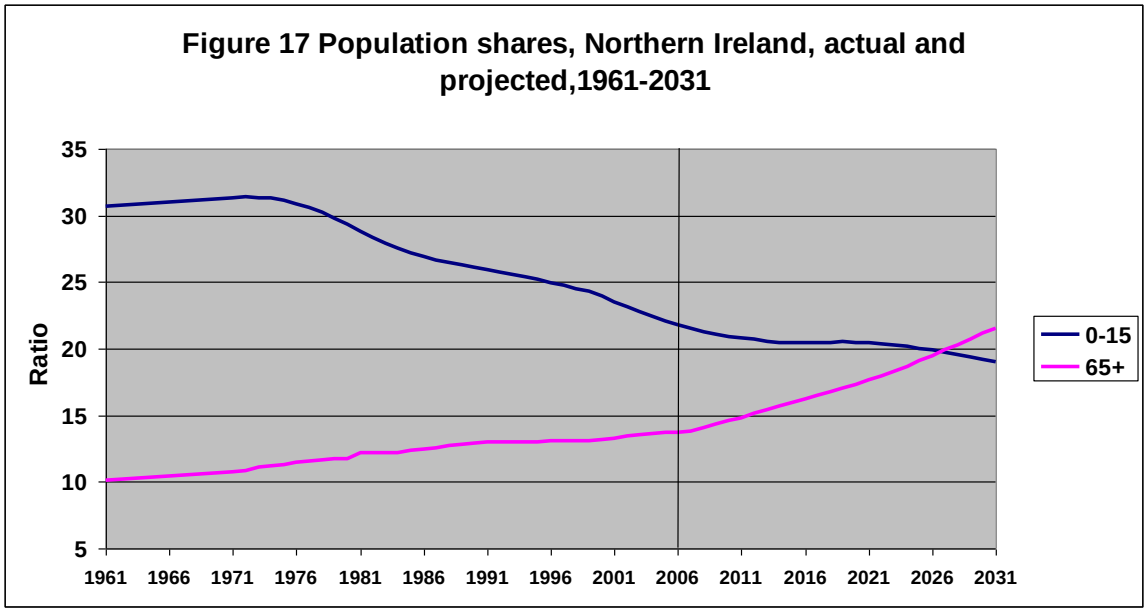
While there are acknowledged uncertainties in both sets of projections discussed above, there is little doubt but that both countries will witness an ageing of their respective populations in the coming years. The population in the older age groups (60+) will expand much more rapidly than other age groups. The underlying effect can be illustrated using the zero migration variants. For the Republic of Ireland, the population aged 75+ is projected to increase by over 140 per cent between 2006 and 2031, compared to overall growth of 20 per cent (Figure 15). In Northern Ireland, the same age group is projected to almost double.

[20] Including children born to immigrants over the projection period.



Consequently, in Ireland, the population aged 75+ is projected to increase its share of the total population from five per cent to 10 per cent (Figure 16). The number of people aged 60-74 is also expected to rise sharply, by 90 per cent in Ireland and 58 per cent in Northern Ireland, assuming zero net migration. By 2031, it is projected that people aged 60-74 will account for 17 per cent of the total population in Ireland, compared to 10 per cent in 2006 (Figure 15). In Northern Ireland, those aged 65 and over are expected to exceed the number aged 0-15 sometime before 2031 (Figure 17).





The ageing of the population in the 2006-based projections is not a new phenomenon and has been signalled in previous population projections for both countries. The consistency in the patterns shown for the growth of the older age groups also helps to reduce uncertainty regarding the projections for population age structures. Interestingly, when the two countries are compared, even under the zero net migration variants, the projected growth in the older population is more rapid in Ireland than in Northern Ireland. As only one mortality assumption is used in Ireland, it is not possible to assess from the published data the extent to which the contrast reflects differences in the assumptions adopted for improvements in mortality.

7. SUB-NATIONAL PROJECTIONS

As noted previously, both Northern Ireland and Ireland produce sub-national projections on a top-down basis i.e. all components by area must sum to their respective national totals. This is a major strength of the sub-national projections, as it results in a consistent framework within which projections are prepared.

Nonetheless, uncertainty will be greater for the sub-national projections by comparison with the national figures from which they are derived. Partly, this is because the assumptions adopted for the national projections must be stepped down to the sub-national level. For example, birth and death rates may vary from one area to another for reasons other than differences in population age structure.
At the sub-national level, however, migration presents the greatest difficulties. Migration flows at national level, both immigration and emigration, must be allocated on a geographic basis. At the sub-national level it is also necessary to take account of flows from one area to another i.e. internal migration. By definition, internal flows sum to zero at the national level. But they are there also an additional component of change that must be managed. This adds a layer of uncertainty to sub-national projections that does not exist at the national level. Partly, this is because the two migration streams are often subject to different influences. For example, the movement of population from the cities is a well-established trend across the UK[21] and the experience of Belfast shows Northern Ireland does not differ in that regard. External migration is subject to an array of influences, some of which can give rise to cyclical or short-term variations in flows to or from an area.

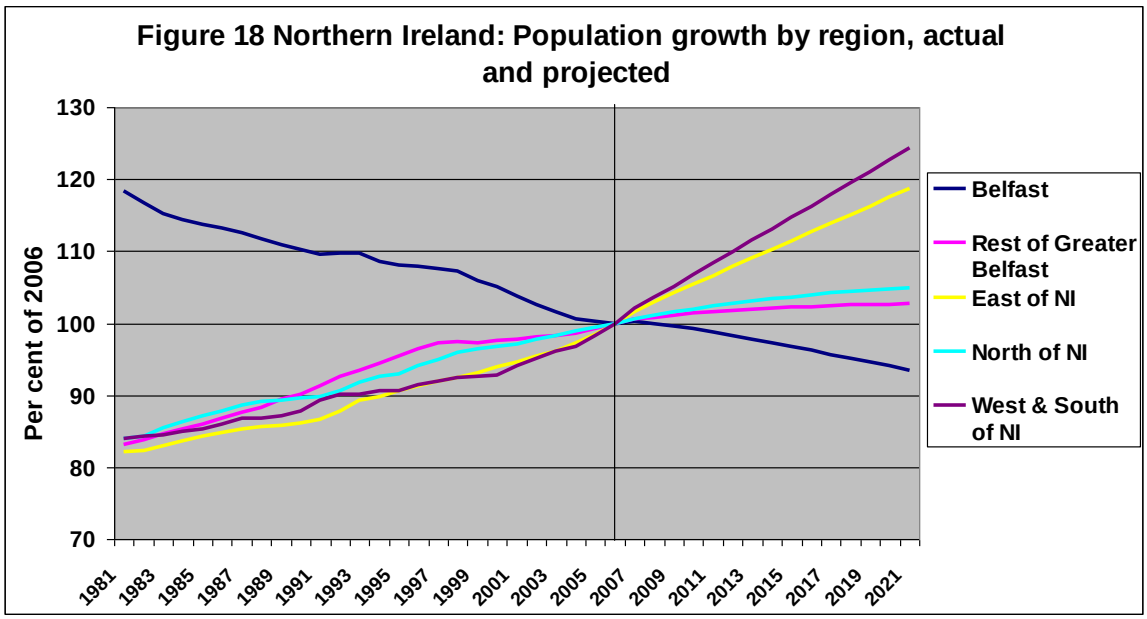
In addition, the smaller the area the more onerous will be the task of making population projections. Principally, this is because, the smaller the area, the more important is migration as a component of change.

As at national level, the cohort component method applied to sub-national areas relies in the first instance on the extrapolation of past trends, subject to modifications from other sources such as expert opinion. In that situation, it is useful for the user of such forecasts to first review the projected trends in light of the historical patterns. In a top-down framework it is particularly useful to look at area differences in population growth rates and/or shares. If the trends show an obvious break with the past the next step is to establish why that is the case and whether the 'story' behind the break in trend is credible.

[21] See Champion, 2000.

Northern Ireland

For presentational purposes, this paper groups the 26 LGDs for which NISRA makes projections into the five main regional areas for which the principal population growth projections are shown in Figure 18.[22]

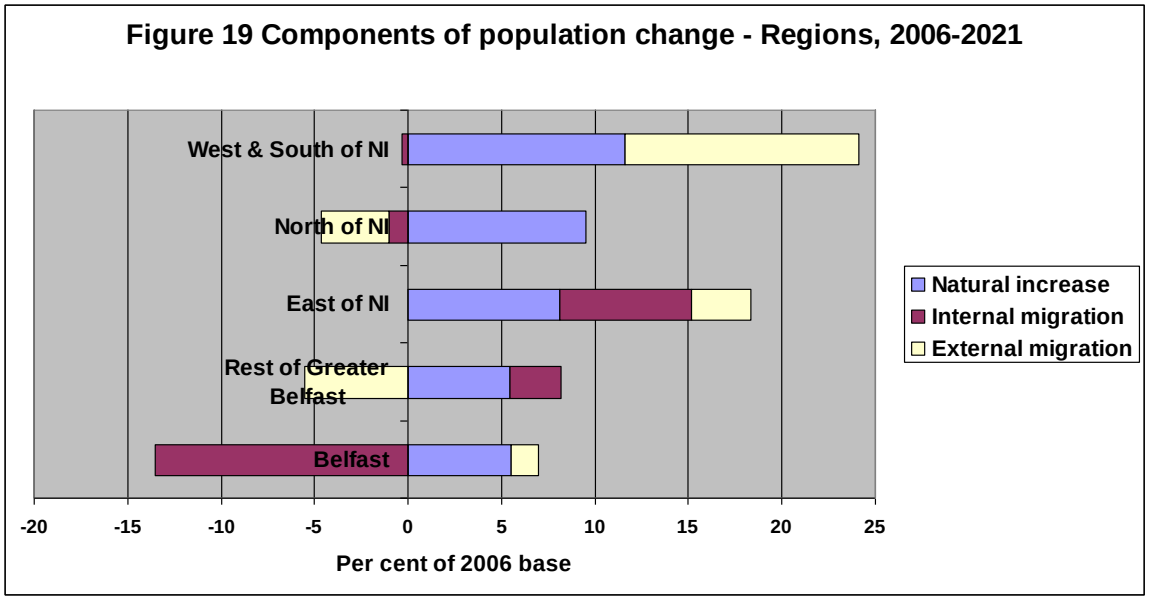


The historical pattern indicates a steady decline in Belfast's share of the total population of Northern Ireland. From 1981 to 2006, the regions outside Belfast have tended to grow at broadly comparable rates. However, the regional projections suggest that future years will see a degree of divergence in population growth rates that has not been apparent in previous years. In particular, both the West and South and North regions are projected to grow much more rapidly than their counterparts in the North and LGDs surrounding Belfast.

The shifts in projected regional growth rate differences shown in Figure 18 reflect the geographical patterns in the assumptions made for the components of population change i.e. natural increase and, at sub-national level, both internal migration and external migration.

Each of the five regions is set to gain from the natural increase effect (Figure 19). The West and South gains the most (+12 per cent), due to a younger population age profile and higher fertility rates. However, variations in rates of natural increase are not the major contributor to the divergent regional growth rates shown in Figure 18.

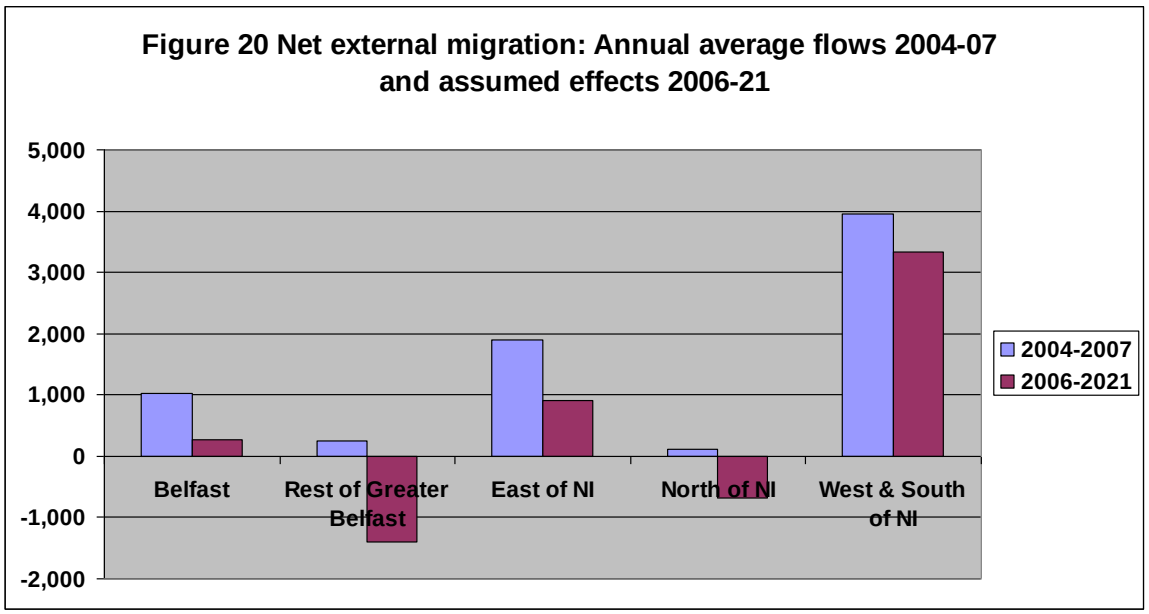
[22] That is, the five NUTS III areas, as described in the February 2008 NISRA press release.



Nor is the divergence due to the projected pattern of internal migration, as the effect of this component is entirely consistent with the historical pattern i.e. a movement out of Belfast (-14 per cent) and into the LGDs immediately adjacent to Belfast as well as those in the East of Northern Ireland.

The main contrast between the regions lies in the assumptions for the effect of external migration. Thus, the external migration effect assumed for the West and South adds +13 per cent to the region's 2006 base population by 2021. More modest effects are projected for the East of Northern Ireland (three per cent) and Belfast (one per cent). The North of Northern Ireland and the Rest of Greater Belfast are both projected to lose population as a consequence of external migration, by four and six per cent respectively.

As discussed above (see Figure 11), the external migration assumption for Northern Ireland as a whole anticipates a reduction from the historically high levels that prevailed from 2003-04 to 2005-06 to a figure on net migration of 500 in the long-term. At the regional level, this has essentially taken the form of a scaling back, in absolute terms, of the most recent net inflows within their constituent LGDs (Figure 20).



This does mean, however, that those areas with the highest net external migration inflows in the more recent past are also assumed to experience continued relatively high net inflows from 2006-2021. Effectively, the recent and very distinct geographical patterns in net external migration flows to Northern Ireland have been extrapolated into the future. In the case of the West and South region, the implied net inflows remain substantial by comparison with other areas. This is the reason for the large external migration effect in the West and South

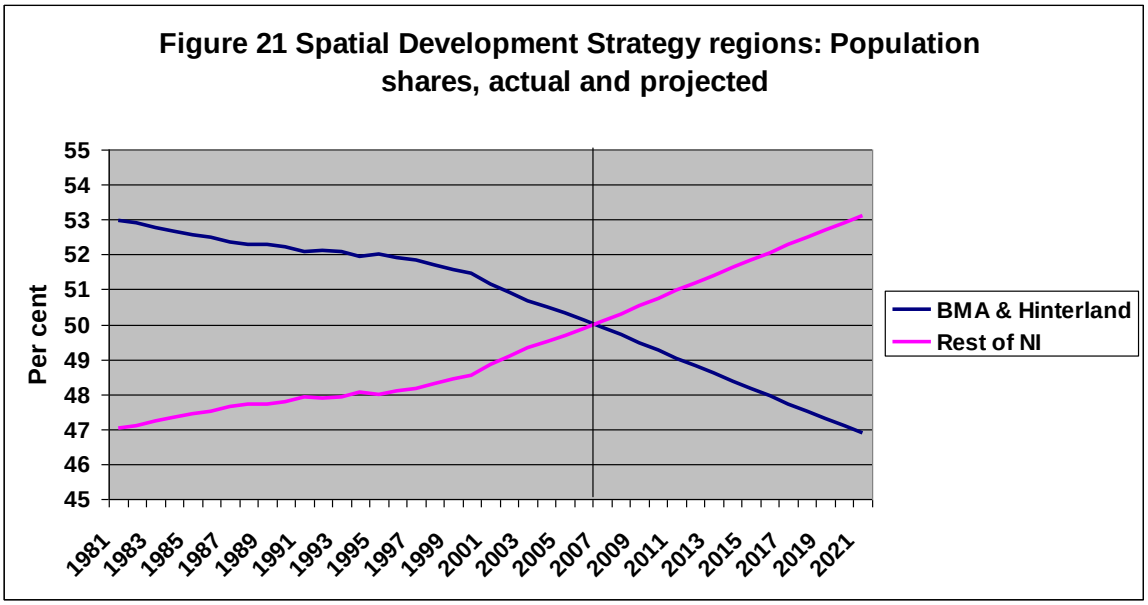
region and the resulting more rapid pace of growth in that region, when compared with the rest of Northern Ireland.

Within that context, the main source of uncertainty in the sub-national projections for Northern Ireland lies in the external migration assumptions. The risk identified from the simple trend analysis is that the assumptions provide too strong a boost to the projected population growth in the West and South of Northern Ireland. That risk is further illustrated when the population projections are shown for Northern Ireland's spatial development strategy regions, i.e.

- Belfast Metropolitan Area (BMA) and its hinterland, comprising Greater Belfast and parts of the East of Northern Ireland region.
- The rest of Northern Ireland, comprising all of the North, the West and South and part of the East region.

As can be seen from Figure 21, the regional projections suggest a sharp increase in the population share accounted for by the rest of Northern Ireland as compared with the BMA and its hinterland. From the preceding analysis of the external migration effect and its geographical distribution, it would appear that the sub-national projections may be overly reliant on the most recent trends. In that context, it would be useful to have an alternative projection variant to help in managing the uncertainty. This is not presently available in Northern Ireland.

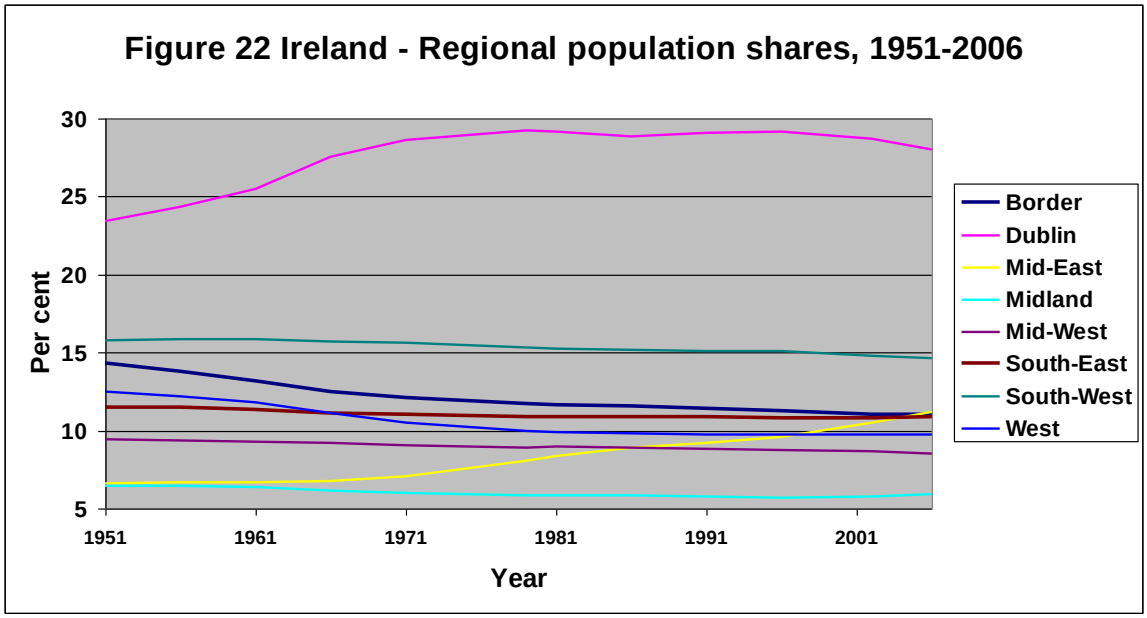
Figure 21 Spatial Development Strategy regions: Population shares, actual and projected



Ireland

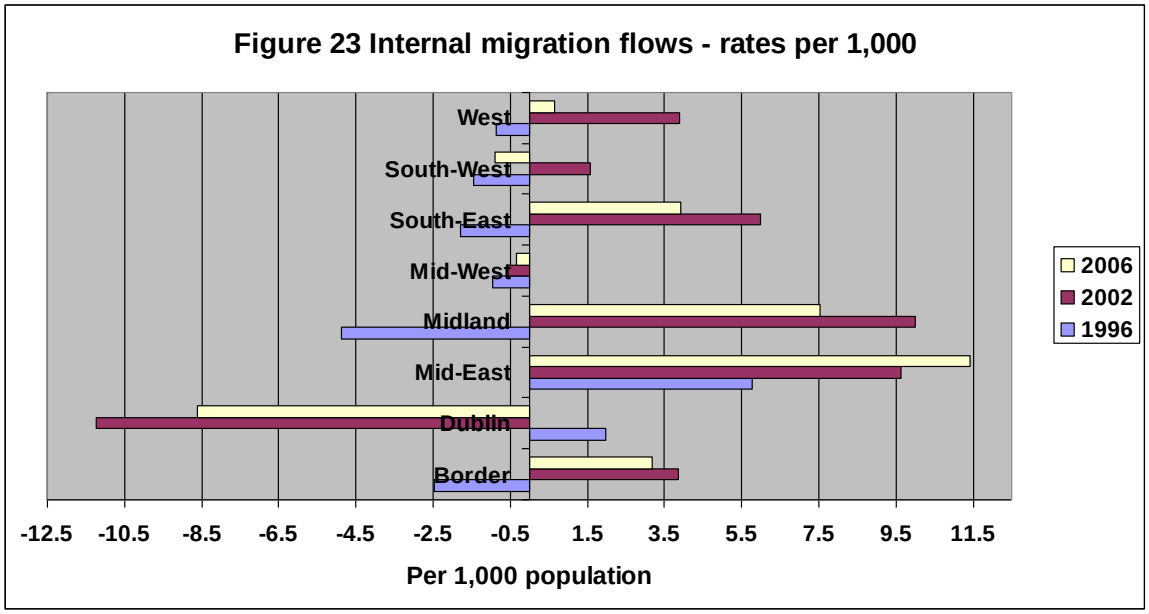
The most recent projections produced by the CSO for the eight Regional Authority areas in Ireland provide a contrast to Northern Ireland in two respects. First, they provide an instance of uncertainty around the future pattern of internal migration. Second, variant projections are provided for the regions and this helps to manage the uncertainty from the user's perspective.

As with the Northern Ireland case, it is useful to begin by briefly reviewing the broad pattern of historical trends in regional population growth. These are shown in Figure 22. Ostensibly, it would appear that the regional pattern in population shares in Ireland is highly stable. The only obvious trend is the steady increase in the population share of the mid-east region, which has benefitted from population overspill from Dublin.



From 1971 through to the mid-1990s, Dublin's population share was roughly constant. However, since then, the share has dipped, albeit only by a percentage point, from 29 per cent to 28 per cent. This has, however, been a source of considerable uncertainty in framing the regional population projections for Ireland. The source of that uncertainty lies in the shift in the regional pattern of internal migration that occurred in the mid-1990s.

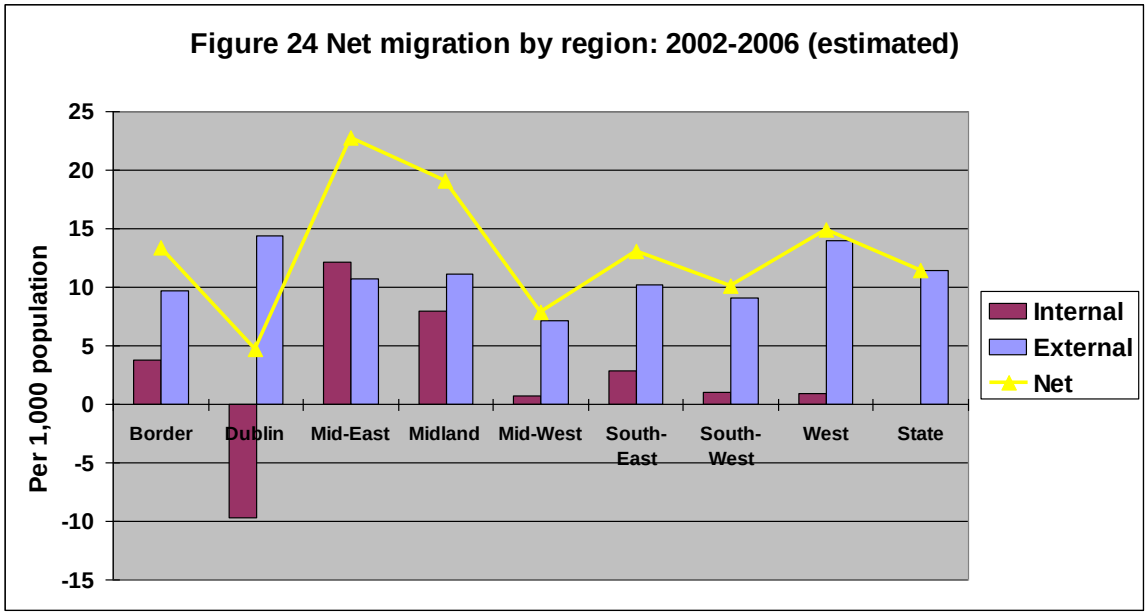
The traditional pattern of internal migration was one in which Dublin and the mid-east gained population from other regions with the remaining regions losing more people than they gained due to flows between the regions. This traditional pattern is shown by the internal migration flows from the 1996 Census of Population. By the time of the 2002 Census, the traditional pattern had reversed, with Dublin losing more people than it gained from internal migration. Apart from the mid-west, each of the other regions made net gains from internal migration. A similar pattern occurred in 2006.



The uncertainty arising from the shift in regional internal migration patterns has been addressed by the CSO through the production of two variant projections for internal migration (CSO, 2008), i.e.:

- **Recent:** The pattern of inter-regional flows observed in the year to April 2006 (see Figure 23) is applied up to 2026.
- **Traditional**: The 1996 pattern of inter-regional flows is applied in 2016 and kept constant thereafter, with the difference between the 2006 and 1996 patterns apportioned over the years between 2006 and 2016.

As in Northern Ireland, the regional projections for Ireland also require a geographical allocation of external migration flows (immigration and emigration). The assumptions adopted for external migration are shown in Figure 24.[23] Thus, Dublin is projected to gain from external migration at a higher level than any other region.

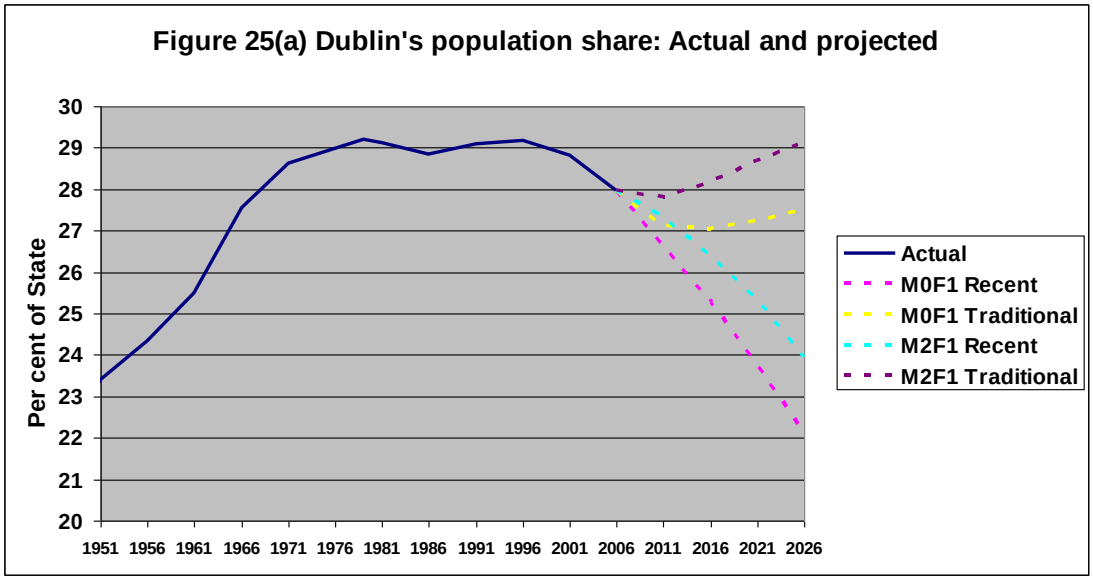


Finally, only the moderate (M2) and zero net migration (M0) assumptions for national migration were used in the regional projections produced by the CSO. The high migration variant (M1) was not used.
The uncertainty surrounding the regional population projections is primarily centred on the Dublin region. This is clearly evident from Figure 25(a), showing Dublin's projected population share under each alternative assumption (the projections for the remaining regions are also shown for completeness).

Clearly, the user faces a choice between two very different scenarios for the future evolution of Dublin's population share. In the cohort component method, both scenarios are driven by trends, albeit the 'traditional' scenario dates from the period prior to 1996. To that extent, the method itself provides no additional information on which to base a decision.

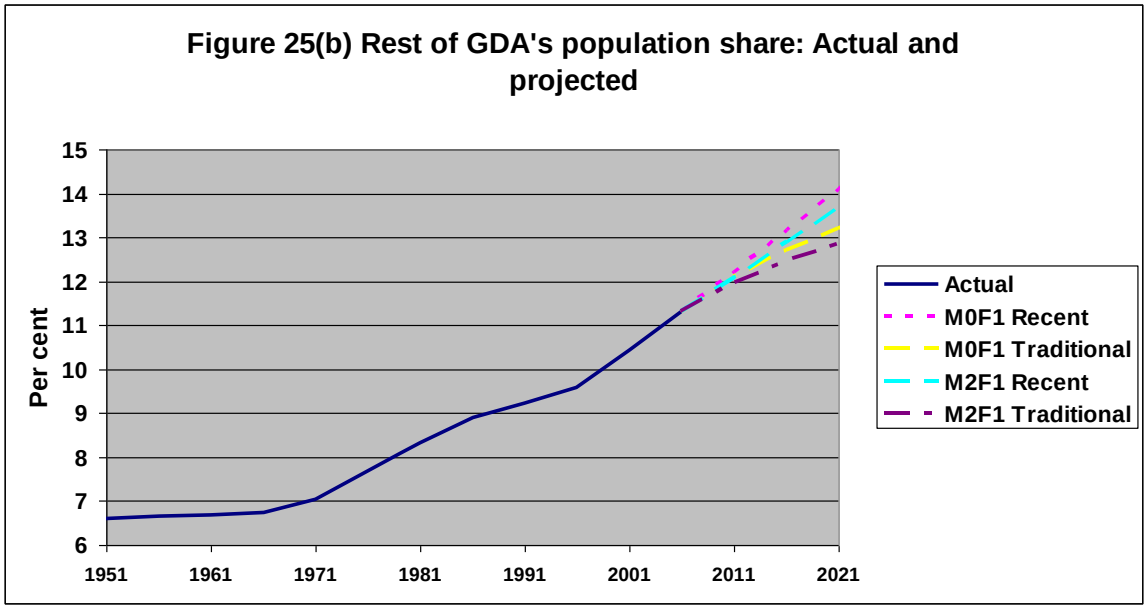
The choice between the two scenarios will essentially hinge on which of the two scenarios seems most plausible, given the user's understanding of, or access to, additional evidence on the reasons for Dublin's recent decline in population share and whether or not these reasons will extend into the future. For example, the fall in share may have reflected cyclical factors, such rapidly appreciating house prices during the economic boom period. Insofar as the user believes that Dublin's decline was largely a cyclical phenomenon, this would favour reliance on the traditional scenario, which projects a recovery in share under the M2 migration assumption and a stable share under M0.

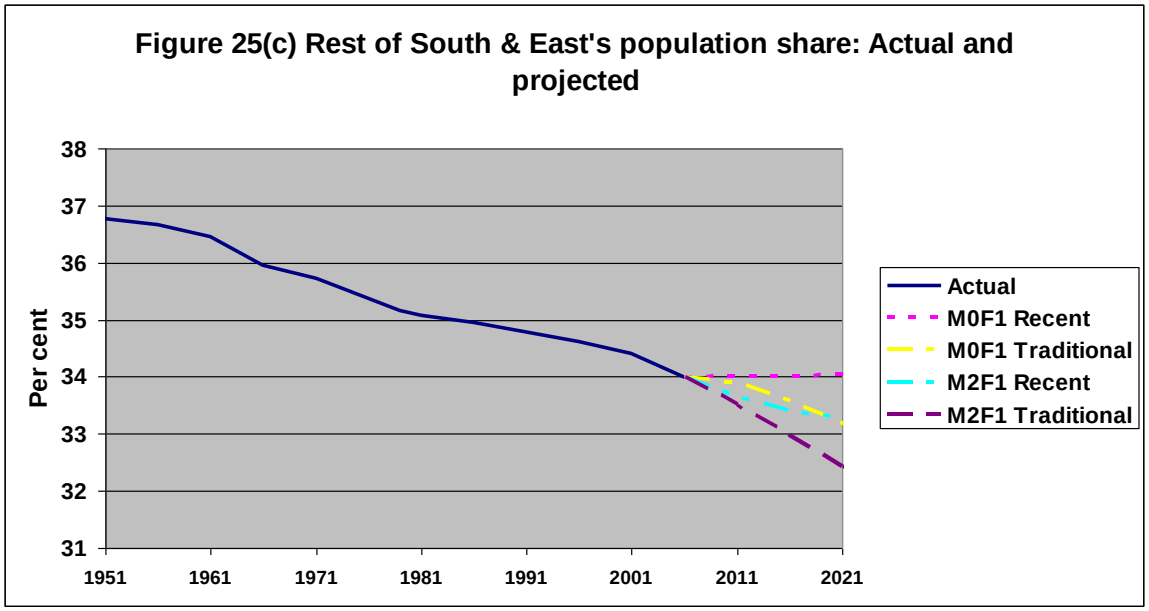
[23] The estimates shown in Figure 24 are derived from the regional shares of immigration and emigration published in the CSO's *Regional Population Projections 2011-2026* Release.

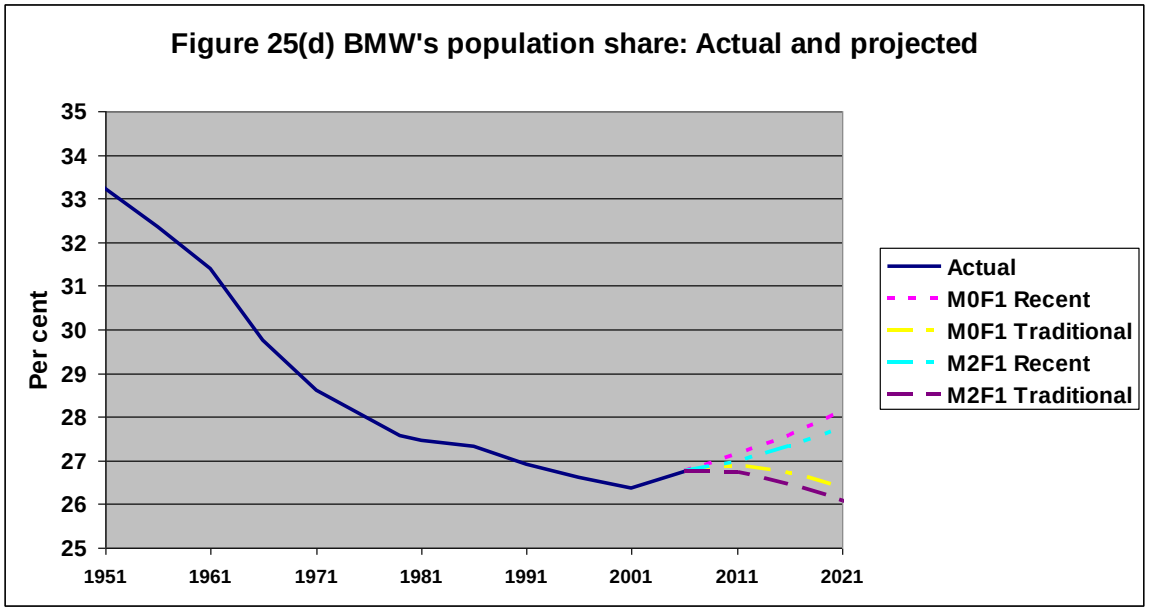


Conversely, the user may believe that the recent pattern of internal migration will in fact be sustained indefinitely. This would, however, see Dublin's share plummet to 22-24 percentage points. One would have to go back to 1951 to see Dublin with a lower population share. It is difficult to envisage such a dramatic weakening of Dublin's position.

Notwithstanding the choice facing the user, the Dublin case serves to illustrate the use of the cohort component method to produce alternative scenarios for the future evolution of the population by manipulating the assumptions required for the outputs. This is an important strength. However, the method does not provide any basis for choosing between alternative scenarios, other than the strength of the rationale on which those scenarios are based.







8. CONCLUDING REMARKS

From a user perspective, the main differences between the approaches adopted in Ireland and Northern Ireland are as follows:

- The frequency with which projections are prepared. There is a good reason for the five-year cycle in Ireland, as the Census of population provides a benchmark population base. In the UK approach, mid-year estimates are inevitably subject to a degree of measurement error. However, much can change in a five year period. There is therefore, a trade-off between the accuracy of the base year and the 'currency' of the most recent projection.
- The CSO eschews the nomination of a 'principal' or central projection. While this serves to illustrate the uncertainty that surrounds population projections, the user may ultimately need to select one or other of the variants. But what criteria should the user employ in making such a selection?
- In Northern Ireland, only the principal projection is disaggregated to sub-national level. But the uncertainty attaching to population projections is undoubtedly greater at sub-national level than at national level. For example, national projections do not need to concern themselves with population movements that occur from one area to another within a country i.e. internal migration.

For both Northern Ireland and the Republic of Ireland, population projections are produced within an accounting framework that is consistent in relation to the age and sex composition of the population and the geographical distribution of the population. This is a major strength, providing a detailed framework to aid decision-making by policy-makers and planners in assessing and anticipating the needs of the population.

In the cohort component method, if the assumptions for fertility, mortality and migration proved to be exactly 'correct', the resulting population projections would provide perfectly accurate predictions of the future course of population growth. The projections present a picture of what will happen *in the event that the assumptions prove to be correct*. However, as noted previously, the future can never be predicted with certainty. The actual out-turns for fertility, mortality, and net migration will inevitably diverge from the assumptions.

While they are underpinned by a substantial and growing volume of demographic data, and take into account expert views and consultations, the user does need to bear in mind that the assumptions which drive the projections in the cohort component method are primarily trend-based i.e. the past serves as a guide to what the future may hold.

The comparison of previous projections with actual out-turns in this paper indicates two important risks that users need to bear in mind when using projections. First, turning points are very difficult to judge, as illustrated by the unexpected and rapid decline in fertility rates that occurred during the 1970s and 1980s. Second, there is a tendency towards over-reliance on the most recent past. This has been most apparent in recent years in formulating appropriate assumptions for migration. Changes occurring in the near term may be cyclical rather than permanent. Thus, for example, the user should therefore ensure that population projections that seem to break with longer-term trends are underpinned by a coherent rationale.

These risks also prose problems for producers of population projections. One of the lessons to be drawn from the comparisons made between previous projections and actual out-turns is that more attention needs to be paid to the more volatile component of migration, both at national and regional level.

The cohort component method currently employed by the ONS and the CSO does not quantify the uncertainty associated with the principal or any variant projection e.g. some measure of expected upper and lower limits, though ONS is considering the use of such methods.[24] Within the current methodology, one approach to managing uncertainty is to make use of the variant projections, whereby different population growth trajectories result from plausible alternative assumptions about the components of change.

The assumptions in the population projections are derived from analysis of historical trends, input from expert advisors and user consultations. Considered as such, it is possible for the user to also manage uncertainty by interpreting the projections in the light of past trends. This is the strategy that was adopted in commenting on the geographical projections in both countries. In particular, attention was paid to the projected regional pattern in shifts in population shares compared to the historical pattern. Some patterns were clearly consistent with the longer term trends e.g. the falling Belfast population share. But in other areas a clear break with past behaviour could be identified e.g. recent versus traditional scenarios for the Dublin region. Where a clear break in past trends is identified in the projections, it is useful for users to satisfy themselves that the explanation behind the break is credible and plausible.

[24] See Box One in Shaw, 2007. See also Keilman's (2007) discussion of probabilistic methods.

Data Sources

Data for Northern Ireland projections were extracted from the Government Actuary Department (GAD) Population Projections Database (http://www.gad.gov.uk/Demography_Data/Population/).

Historical data for Northern Ireland were extracted from the NISRA Demography website (http://www.nisra.gov.uk/demography/default.asp18.htm).

The published CSO reports (CSO, 1995 and 1999) provide the source for the 1991-based and 1996-based national population projections for Ireland. The data for the 2002-based projections were obtained from the CSO Release Archive at
http://www.cso.ie/releasespublications/po_lab_project_2006-2036.htm.

The 2006-based projections were taken from the CSO's Current Releases and Publications at http://www.cso.ie/releasespublications/po_lab_project.htm. The same source was also used for the historical population data. Historical fertility rates are published in CSO, 2008a.

Historical migration data from 1987 to 2008 were obtained from CSO, 2008c. For years prior to 1987, annual averages were taken from the various Census of Population publications for 1951, 1956, 1961, 1966, 1971, 1979 and 1981.

The regional population projections 2011-2026 were sourced from the CSO Release Archive at http://www.cso.ie/releasespublications/pr_poparchive2008.htm. The same source was used for historical regional population data from 1961 to 2006. The 1951 and 1956 data were extracted from the Census of Population reports for those years.

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FIRST VOTE OF THANKS PROPOSED BY JOHN POWER, HEAD OF RESEARCH AND LIBRARY SERVICES, NORTHERN IRELAND ASSEMBLY

I'd like to start by thanking Dr. Dignan for a comprehensive and balanced overview of Ireland's population projections – past and present. Too often population analyses focus on one jurisdiction or the other and I know that my own analyses are deserving of that criticism. I make this observation not as some political point to embrace cross-border co-operation or all-Ireland working but to highlight that a better understanding of each jurisdiction's population dynamics can be gained from observing what is happening with our neighbour.

In the field of population projections the approach that examines trends in each jurisdiction can be of particular value – most particularly it offers the potential for identifying a trend in one jurisdiction that may impact on the assumptions made in the other. In this regard – an all Ireland focus is also too narrow since population trends in GB can be useful in understanding Ireland's migration and fertility trends.

From Dr. Dignan's paper the three components of population change being births, deaths and migration are shown to have played a similar role in contributing to population projection error. Most recent projections – North and South – have failed to anticipate large immigration – principally from the A8 accession countries. Previous to the A8 accession, projections have under-estimated the rate of fertility decline - with more recent projections for Northern Ireland under-estimating the rising levels of fertility that have occurred since 2002. Even in mortality – the smallest of the three contributors to projection error – observed increases in life expectancy have been less than those demographers had assumed.

The general pattern of population projections is one that has underestimated actual population growth in Ireland. The sources of error have varied over time – in the more recent past migration has been underestimated and prior to this the rate of fertility decline exceeded expectations. The overall impact of such error is understated when simply evaluated in terms of actual population numbers compared to projected numbers. Specific cohorts and specific policy areas are impacted differently according to the source of the projection error:

- Errors in migration assumptions impact upon labour availability
- Errors in fertility assumptions impact upon education and school provision
- Errors in life expectancy impact upon age dependency and the provision of services for the elderly

A combination of errors in all three areas could theoretically provide an accurate projection of overall population numbers. For example, the 1985 projection for Northern Ireland would appear to be pretty close to what Northern Ireland's population numbers will be in 2015 – 30 years after the projection was made. However, the age structure for Northern Ireland in 2015 will be profoundly different to that projected in 1985.

It would be easy to conclude that demographers have been too conservative in their change assumptions when projecting into the future. To an extent this criticism is unfair – particularly when it is made with the advantage of hindsight. Rather than being critical, a more useful question is whether there are useful lessons to be learned from the errors made in the past and what can be done to improve the accuracy of future projections?

The analysis performed by Dr. Dignan demonstrates the utility of studying the population patterns occurring in neighbouring jurisdictions. For example, the fall in fertility rates to below replacement level that occurred in the Republic of Ireland consistently year on year for approximately 30 years (mid 1960s through to the mid 1990s) may have advised Northern Ireland's projections to have made less optimistic assumptions about future fertility trends.

Northern Ireland's 1971 projection (that assumed a future slight and slow decline in fertility) over projected population numbers principally due to a more rapid decline in fertility occurring than that assumed. Projections for later years (1977, 1985 and 1994) were all overly optimistic about Northern Ireland's future fertility trends. More recent projections (for 2004 and 2006) have had to factor in a turning point in fertility trends that occurred in the Republic of Ireland some 5 years earlier than in Northern Ireland.

In pointing to this fertility example where trends in the Republic of Ireland could have contributed to improving the accuracy of Northern Ireland's population projections, I must also emphasise that such cross-national/jurisdictional comparisons require considerable caution that require sensitivity to different economic environments, age structures and other matters that can bear upon the validity of assumptions made. For example, the fertility trends in the Republic of Ireland are more relevant to Northern Ireland's Roman Catholic community than they are to its population as a whole. However, the inclusion of British and Irish fertility trends

into the assumptions made for Northern Ireland may well have improved the accuracy of projections made for Northern Ireland in the 1970s and 1980s – but this too is open to question.

Year on year decline in fertility occurred in the Republic of Ireland some 20 years before Northern Ireland. The halt to this decline occurred in the Republic only 5 years before occurring in Northern Ireland. Since this halt the Republic has seen a stability in fertility at just below replacement levels but Northern Ireland's fertility rates have consistently increased to the level of replacement. Recent population projections for the Republic of Ireland have accurately assumed stability in fertility but this has not proven to be the case for Northern Ireland where fertility assumptions of stabilisation have been in error.

Cross-territorial comparisons are informative but past experience does not suggest any clear rule of thumb that can better inform territorial population projections. A lag time between the Republic of Ireland and Northern Ireland's Roman Catholic population appears evident but the period of this lag has closed and more recent trends suggest a departure. These changes challenge whether population projections today can be made more accurate through the study of extra-territorial patterns alone.

In part I have presented a "straw man" – cross territorial comparisons form only part of the knowledge used to inform population projections. More formal arrangements now exist that facilitate a broad range of expert opinion to inform population projection assumptions. As a member of this group (for Northern Ireland) I cannot be thought a truly independent critic of recent projections but I have some concerns relating to the information available and what population change may hold for Northern Ireland in the future.

I have already alluded to different demographic structures affecting the Roman Catholic and Protestant communities of Northern Ireland. Discussing these differences is 'the elephant in the room'. Dr. Dignan has wisely stayed away from this discussion since entering into it would soon have lost the important points he has made that need understood when assessing the accuracy of projections. Yet, sectarian head-counting is part of the body politic of Northern Ireland (though less so since devolution) and Dr. Dignan's analysis demonstrates how difficult this can be for the population overall. This error is magnified when dividing the population.

Whether population projections attend to sub-regional levels (the difficulties of which Dr. Dignan has already explained) or to sub-groups, the margin for error is amplified. In part, this is a natural outcome of our population counting mechanism. Some countries use population registration mechanisms that accumulate to national counts. These schemes build from the regional to the national level but in the UK and Ireland the opposite is the case. Here national estimates are distributed downwards so that regional estimates occur within these estimates. This mechanism renders regional projections subject to significant error – as Dr. Dignan's paper has already identified.

Variant projections using different assumptions are useful in identifying the magnitude of particular assumptions on projected population structures. This may be a useful tool to those involved in making (or advising on) population projections but it is more difficult to see how variant projections can assist those involved with policy making. In this regard, I prefer the single projection method used in Northern Ireland.

The problems associated with regional projections are similar to those of sub-populations – that error is amplified. In Northern Ireland the discourse has focussed on Protestant and Roman Catholic numbers. In part these analyses have focussed on differences in age structures and how these can impact upon community differences in overall outcomes in the labour market. For the larger part, sectarian demographic analyses have focussed on Northern Ireland's constitutional future.

Over recent years discussion of Northern Ireland's sectarian demography has been notable by its absence. In the context of employment growth, devolution and the political settlement that enabled devolution – this absence is not too surprising – but I believe this to be temporary and the debate will soon return. My reasons for this expectation include:

- The economic downturn that is being described in terms of recession which identify requirements for significant cut-backs in public expenditure. Northern Ireland is more dependent on public expenditure than the Republic of Ireland or any other region of the UK. Rising unemployment will lead to a sense of unfairness - as it did in the 1980s through to the 1990s and it "hasn't gone away". The unemployment differential still shows a higher proportion of Roman Catholics unemployed and if – as is expected – unemployment levels rise, media and political attention on sectarian differences is likely to increase.

- Little is known about the causes for the consistent year on year rises in fertility that have occurred since 2001. The rise in the number of live births is not yet showing any clear pattern in numbers of primary school entry (where numbers continue to decline). Interestingly however, for the last 2 years (2006/07 and 2007/08) Roman Catholic entrants have exceeded 50% for the first time since 2000.

- A noticeable increase in concern among unionist politicians about higher proportions of Protestants leaving Northern Ireland to take up university places in GB.

- The 2011 population census in now just 2 years away and.the legislation to enable this will need to pass through the Assembly where the content of the census form is likely to achieve close scrutiny. Notwithstanding the recent significant improvements made in the analysis and availability of population census data, the fullest enumeration of births and migration occurred in 1971 – almost 40 years ago. The population census may not be the most appropriate tool for measuring migration but it could provide a useful insight into fertility trends.

I would like to conclude my comments by returning to the most recent assumptions made for Northern Ireland's population projection – summarised in Table 2 of Dr. Dignan's paper. These assumptions point to below replacement fertility being roughly compensated by small inward net migration. In the short-run, the impact of the economic downturn on A8 in-migration appears reasonable but migration estimates are subject to poor measurement instruments that do not enumerate exits and under-record short-term migration and dependants who may accompany migrant workers. The more recent upturn in fertility is unlikely to persist and may well stabilise at near or below replacement level as it has done in the Republic of Ireland.

For Northern Ireland in 2031, setting migration assumptions aside, the current age structure and assumptions of a stabilisation in fertility with a slow increase in life expectancy describe a population with a smaller proportion of young, an older population of economically active age, a higher proportion of persons in retirement and a much larger proportion of persons aged 75 and over. For the UK as a whole, these impacts are expected to be mitigated by in-migration.

Can I finish by thanking Dr. Dignan for a professional and balanced overview of Ireland's population projects past and present. His analysis identifies the sources of projection error and point to interesting and challenging questions relating to current population trends and what these mean for Northern Ireland in the future.

SECOND VOTE OF THANKS PROPOSED BY AIDAN PUNCH, CENTRAL STATISTICS OFFICE

I am grateful to the Society for affording me the opportunity of seconding the vote of thanks to Dr Dignan's paper on "Population projections: Sources of Uncertainty and the User Perspective".

I suppose I should declare my interest from the start. I had an involvement in the 1991, 1996 and 2002 based exercises for the Republic of Ireland reported on in the paper, and chaired the Expert Group which agreed the set of assumptions for the 2006 based projections both at national and regional level. So in a sense Dr Dignan's paper represents a public examination of the accuracy of the work we carried out. This is one of the hazards of being involved in projections work – the passage of time provides the opportunity to compare the assumptions made against the actual outcomes achieved.

In addition to the three population projections for the South reported on by Dr Dignan there were also official projections based on the 1981 and 1986 censuses as well as a set of projections made by Jim Knaggs and Tom Keane (Knaggs and Keane, 1971) of the CSO and Bill Keating (Keating, 1977) also of the CSO.

The dominant influence which migration has exerted on the pattern of population change in the South since the foundation of the State is well known. The volatility of migration has constituted the single greatest source of uncertainty in projecting the population of the Republic. After decades of outward migration the 1970s represented a major turnaround with average net inward migration of 14,000 per annum. However, this was short lived with a resumption of net outward migration in the 1980s – particularly pronounced in the second half of the decade with average annual net outflows of 27,000. The so-called Celtic Tiger period saw inward migration at unprecedented levels with an average annual inflow of 48,000 in the 2002-2006 inter-censal period.

The Knaggs and Keane paper was written at a time when migration was just on the point of changing from outward to inward. Three migration assumptions (all outward) were combined with two fertility assumptions to yield six variants with projections up to 1996 (a twenty five year period). Two of the outcomes for 1996 were

2½ per cent either side of the actual population of 3.626 million – not a bad result on the face of it. However, on closer examination births were significantly over-estimated, deaths were over-estimated to a lesser extent and net emigration was also considerably over-estimated. In fact, all three migration assumptions were net outward – not surprising given the decades of net emigration which preceded the projections. So the components of population change were all wrong and yet the overall result was approximately right. The result of course is an incorrect age structure with the projected population aged 0-14 years being a third higher than the actual figure and the projected number of persons aged 65 and over being 17 per cent less. Thus one of the major advantages of the demographic component approach to making projections is that it allows us to compare not only the overall population but its composition in terms of age and sex and the contribution of each of the components to the overall change.

The Keating paper was written in 1977 when some evidence of net inward migration was emerging. The projections covered 1981 and 1986 only. Two migration assumptions were used: the first consisted of zero net migration over the period 1976-1986; the second consisted of zero net migration during 1976-1981 followed by average annual net outward migration of 25,000 during 1981-1986. As events transpired the migration out-turn for the 1976-1986 period was close to the second assumption. The projected population for 1981 was 3.2 per cent lower than the actual population while for 1986 the underestimation varied from 0.7 per cent to 1.5 per cent depending on the migration assumption used.

Turning to the 1991, 1996 and 2002 based projections for 2006 it is clear, as Dr Dignan has pointed out, that "net migration has been persistently higher than anticipated in any of the assumptions made". This is clear from figures 6a to 6c in Dr Dignan's paper. Perversely, the migration assumptions in the 2006 based exercise may turn out to be the opposite – particularly the M1 assumption which assumes immigration continuing at a high level and then moderating. The sharp downturn in the economy experienced in the recent past and likely to persist for some time to come will undoubtedly have a major impact on the magnitude and possibly the direction of net migration in the short to medium term.

However, if the economy were to return to a long term growth path of 4 per cent per annum, and assuming, say, 2 per cent productivity growth, a 2 per cent growth would be required in our labour force – about 40,000 a year. The zero migration scenario would only provide a modest 13,000 per annum. Given that every 10,000 shortfall in our labour force would require net immigration of 13,600 to achieve balance between supply and demand in the labour market we would be looking at net inflows of 35,000 per annum – not too far from M1 apart from the earlier part of the projection period.

The following table (Table 1) provides a comparison of assumed migration compared with actual outcomes for each of the official projections compiled to date.

Table 1: Comparison of Assumed Migration Compared with Actual Outcomes for each of the Official Projections Compiled To Date

Census base year	Comparison period	Variant	Assumed migration (000)	Published migration (000)	Comment
1981	1981-1991	M1	-62.5	-205	Net outward migration under estimated
1981	1981-1991	M2	-125	-205	
1986	1986-2001	M1	-225	-3	Net outward migration grossly over estimated.
1986	1986-2001	M2	-350	-3	
1986	1986-2001	M3	-450	-3	
1991	1991-2006	M1	-110	+380	Turning point missed resulting in sign and magnitude seriously out
1991	1991-2006	M2	-210	+380	
1996	1996-2006	M1	+175	+370	Seriously under estimated net inward migration
1996	1996-2006	M2	+100	+370	
2002	2002-2006	M1	+120	+240	Under estimated net inward migration
2002	2002-2006	M2	+120	+240	

While it is easy to be wise in hindsight it is not clear how the migration assumptions could have been improved given the volatility of the flows.

Regarding fertility, while uncertainty attached to this component in earlier projections this was at a stage when fertility was relatively high and the demographic transition to lower birth rates had yet to occur in Ireland, North and South. It is arguable that with fertility at or below replacement the degree of uncertainty regarding future trends is less than it was previously. We can look at the plausibility of our fertility assumptions, which are mainly elaborated in terms of age specific and total period fertility rates, by studying the implied completed (or cohort) rates.

From the results of the fertility question in the 2006 census in the South we know that the 1930 female birth cohort had the highest completed fertility (around 3.7) and that the 1960 female birth cohort (i.e. women aged 45 at the time of the 2006 census) was the first whose completed fertility dropped below replacement. It is unlikely in my view that we will see a reversal of this trend. The real issue is how low fertility will fall. Will it settle at Northern European levels of 1.85-1.90 or will it tend towards the low fertility levels of Southern Europe. I would tend towards the former.

It is worth stating that short term projections of births can be somewhat inaccurate because of issues such as postponement and recovery. Therefore their use for, say, projecting school going populations may be problematic.
Assumptions regarding mortality rates have tended to be on the conservative side. The paper draws attention to the projected population 75 years and over in 2031 in both the Northern Ireland and the Republic projections and notes that in NI this group is projected to double while in the Republic it is projected to increase by 140 per cent in the absence of migration. The difference would seem to me to be due to more aggressive assumptions in the RoI projections regarding increases in life expectancy. To the extent that there may be uncertainty around the specific numbers (and will this undoubtedly be important for pension provision) there is no doubting the general picture – it is one of significant increases in the older aged populations.

My final point about national level projections is whether to use a principal projection or to have a number of different variants. Both have their advantages and disadvantages and these are set out as follows:

Principal projection	**For**: User will be happy	**Against**: Other variants may not be used and users may give the forecast greater credibility that it deserves.
Different variants	**For**: These are simply options under different assumptions.	**Against**: Users will need guidance as to which variant is the most likely.

Turning finally to the regional projections it is clear that the level of uncertainty increases enormously as we move from national to regional projections. Even with top down projections there are added problems in applying regional variants of fertility, mortality and international migration coupled with the introduction of inter regional flows. In our recent projections, we considered the fertility differentials to be sufficiently important to warrant separate treatment whereas the differences observed for mortality did not call for regionalising that component. The additional accuracy would have been spurious. Reasonably good information exists from the census and the quarterly national household survey to enable a fairly robust disaggregation of assumed international migration. However, it was the inter-regional flows which presented most problems. The longstanding flows into Dublin were reversed in the last decade with an overspill into the Mid-East, Midlands and South East mainly because of a lack of affordable housing in Dublin. However, it is plain to see that the inter-regional flows observed from the most recent census are not sustainable. This is recognised in the most recent targets set out in the national spatial strategy where the target population for Dublin is just 5 per cent short of the projected population under M2F1 Traditional. So clearly, our projections are having some impact.

I would like to conclude by congratulating Dr Dignan on his important paper which highlights for users the pitfalls of using population projections.

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