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The effect of long-term migration dynamics on population structure in England & Wales, and Scotland

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We investigated the effect of migration on population dynamics in England & Wales and Scotland from the mid-nineteenth century to the present by comparing actual population size and structure with estimates based on zero net migration from a range of starting dates. In this period, Scotland had the largest net outflow among countries in Europe for which detailed information is available, whereas overall net migration in England & Wales was close to zero. In the absence of migration, population would have been over twice as large in Scotland in 2013 as the actual value, but similar to its actual value in England & Wales. Levels and pace of population ageing have been broadly similar in both countries, so the major impact of differential migration has been on population size rather than structure. We discuss these findings in relation to the debate on migration policy between political parties supporting and opposing independence in the 2014 Scottish referendum.

Keywords: England & Wales; Scotland; migration; demographic modelling; historical trends.

Introduction

Migration has become an increasingly important factor in population change in European countries; net migration accounted for 85 per cent of population increase in the European Community in 2014 (Eurostat 2015). Immigration is frequently advocated for its assumed economic benefits, for example: ‘There is thus general consensus in the literature that migration is a valid policy approach in the context of a demographic deficit. Immigration to Europe will in the short term achieve immediate increases in total fertility rates, population growth and labour market contribution’. (Harper 2012, p. 2). Even the nationalistic Russian President Putin has recently advocated selective migration, in addition to increasing fertility, as a way of stimulating population growth in the Russian Federation (Putin 2012). However, public attitudes to migration are much less positive. The Pew Research Center Survey of 2014 found that 55 per cent of respondents in the UK stated that fewer migrants should be allowed in, compared with 6 per cent who wanted more migration (Pew Research Center 2014). Similar poll results have been found across Europe; the recent Gallup World Poll found only 7.5 per cent of Europeans in favour of increased migration and 52 per cent in favour of its reduction (IOM Migration Research Division 2015).

Political concern about the dangers of population decline or growth rates relatively lower than those of neighbouring countries has been a recurrent theme in European history (Teitelbaum and Winter 1985; Winter and Teitelbaum 2013) but contemporary governments have to balance competing pressures. A comparison of England & Wales and Scotland provides a particularly relevant case study. Among countries across Europe with detailed long-term information, Scotland has had the largest net outflow from about the middle of the nineteenth century to the present, whereas overall net migration in England & Wales has been close to zero over the period. There has been considerable political and media support for population growth in Scotland (Anderson 2012), but little in England and Wales.

The population of Scotland fell by 3 per cent p.a. over the period 1971-2001, whereas in England & Wales it grew by 7 per cent (Jefferies 2005, Table 1.8). The issue that we address here is the long-term demographic consequences of past migration in the two countries, which may help to explain why such different views about population growth co-exist in the same island.

England & Wales and Scotland are not nation states, but parts of the United Kingdom, which included Ireland until 1922 and Northern Ireland since then. Information on Ireland is not available over the period covered here. Migration therefore includes those moving within the United Kingdom as well as international movements outside the United Kingdom.

Much attention has been given to the analysis of short-term labour market implications of migration levels in a variety of countries but a number of studies have also looked at future scenarios that compare population size and structures based on projections that include assumptions about future migration and with no net migration (United Nations Population Division, 2000). Such no-migration scenarios are commonly produced as part of regular official projections (Office for National Statistics 2015a; United Nations Department of Economic and Social Affairs 2015). Some are stylized and present results to show that certain objectives cannot plausibly be met, such as that South Korea would need to import the population of the whole world to maintain the current ratio of older to younger people (United Nations Population Division 2000). Other studies compare a no-net-migration scenario with the best official assessment in medium variant population projections to show the impact on population size and structure of the migration assumptions adopted. However, even such ‘realistic’ projections must be treated with caution. Migration is volatile and the constant or gentle trends drifting towards zero in most scenarios are clearly unrealistic. We need to look at how migration has affected long-term population trends in practice as well as in theory. We require analyses of the experiences of real populations to assess the impact of migration on population size and structure. To our knowledge, few such analyses have been undertaken. Le Bras (1991) and Philipov and Schuster (2010) are exceptions for Europe, but their analyses were not over extended historical periods.

The paper is organized as follows. We discuss the data used and describe the development of the models we used to estimate the impact of net migration on population size and structure. We then present the results of an analysis that compares trends in England & Wales and Scotland. We discuss the implications of these findings for both demographic history and the role that migration policy played in the 2014 referendum on independence for Scotland.

Data and methods

Data for England & Wales and for Scotland were taken from the Human Mortality Database (HMD), which contains information on estimated mortality rates and population size by single year of age and sex for each calendar year from around the time of the start of national vital registration, 1841 and 1855 respectively. These estimates are based on information from official statistics such as censuses, vital registration, and population estimates over this period (Wilmoth et al. 2007; Human Mortality Database 2015). The database also includes information on total annual number of births and deaths. Mortality rates are available in both period and cohort form for most years. Since our principal interest is in comparing national values, we use a common start date of 1855. Data are available up to 2013.

We estimated the effect on population dynamics with no net migration by calculating survival of cohorts without migration from various time points starting with the earliest available date of 1855. For example, for those born after the start year of 1855, the population numbers in the absence of migration are given by

$P_{nomig}(a,t) = B_{nomig}(t\text{-}a)L_x(a,t\text{-}a)$

where $P_{nomig}(a,t)$ is population aged *a* in year *t*

$B_{nomig}(t\text{-}a)$ is births in year *t-a* (equivalently for birth cohort *t-a*)

$L_x(a,t\text{-}a)$ are the L_x values for age *a* based on a life table for the cohort *t-a* with radix set to 1.

For years after 1855, the numbers of those born before 1855 are given by:

$P_{nomig}(a,t) = P_{actual}(a\text{-}(t\text{-}1855),1855)\ L_x(a,t\text{-}a)/L_x(a\text{-}(t\text{-}1855),t\text{-}a)$

where *nomi*g refers to the no-migration population and *actual* to the original actual population.

Cohort life tables from age zero to the age reached in 2013 (or age 110 if reached earlier) are available for cohorts born between 1841 and 1922 for England & Wales and 1855 to 1922 for Scotland in the HMD. Cohort mortality rates are not available for those born before the initial year, and we therefore constructed partial life tables for cohorts from the age that the cohort reached in 1855 up to age 110 years. Cohort mortality rates are available for cohorts born between 1923 and 1982 so we constructed cohort life tables to age reached by 2013 for those born in this period. For cohorts born after 1982, only period mortality rates are available, so we constructed approximate cohort life tables for those born in year *t* by using mortality rates for age 0 in year *t*, age 1 in year *t+1* etc. up to the latest available year.

The no-net-migration population is assumed to have the same fertility and mortality patterns as the actual population. Annual information on age-specific fertility is only available from 1923 for England & Wales and after 1945 for Scotland. Therefore we estimated the expected number of births as follows:

The distribution of age-specific fertility rates $f(a)$, with $\Sigma f(a)=1$, is given by a beta distribution, $\beta(2.7,2.7)$, scaled to be between ages 15 and 45 with mean of 30 and standard deviation of 6 years. This is a typical fertility pattern for populations over this period, and in practice results are insensitive to the chosen pattern.

The actual number of births in year t, $B_{orig}(t)$, is given by:

$$B_{actual}(t) = k(t)\Sigma P_{actual}(a,t)f(a) \qquad (1)$$

where $P_{actual}(a,t)$ is the actual population aged a in year t.

This provides an estimate of $k(t)$, the level of fertility in year t, as the expected number of children per adult with the above fertility distribution.

The number of births in the no-migration population is calculated as

$$B_{nomig}(t) = k(t)\Sigma P_{nomig}(a,t)f(a) \qquad (2)$$

(1) provides an estimate of the level of fertility $k(t)$ and (2) provides an estimate of $B_{nomig}(t)$.

Thus we assumed that the ratio of births $B_{nomig}(t)$ to $B_{actual}(t)$ was equal to the ratio of the corresponding populations at risk of reproducing, weighted by the values of a representative fertility schedule. This is an indirect standardization method with the standard population rates being those of a typical fertile population. Note that we use the schedule for populations with both sexes combined rather than just for women as in most applications, but this makes no difference to our substantive conclusions (for further details see Appendix A). This procedure differs from Philipov and Schuster's (2010) Method 1, where they assumed no migration from birth for cohorts from 1947, but did not allow for the fact that if there was no migration, the number of births would be different. Over time, the values with and without migration will diverge and the annual number of births will become increasingly inconsistent with the population at risk of giving birth, leading to problems in the interpretation of findings.

We repeated this exercise with net migration being set to zero from time points 10 years apart between 1860 (Scottish values just after the 1855 start date that may understate number of vital events) and 2000, to assess the long-term effects on population up to the latest available year of 2013. Values before the no-migration start date were unaltered.

Fertility assumptions for no-migration scenarios

We assumed that the fertility rates of the no-migration population were the same as those of the actual population since differences in number of births depends only on populations at risk. This assumption needs to be justified. Immigrants sometimes have elevated fertility after arrival since they may be rejoining families or 'catching up' following the disruption of family life by migration (Hervitz 1985; Andersson 2004). On the other hand some migrants may be selected for lower fertility, possibly being more highly educated and career-oriented and in these cases migration may delay or inhibit family formation. The available evidence shows a variety of differences between the fertility level of emigrants and that of the static population. For example, French migrants to Québec in the eighteenth century had very high fertility while mainland France was already starting to show signs of fertility limitation (Henripin and Péron 1972). On the other hand, Irish migrants to USA had lower fertility than those who remained (Guinnane et al. 2006). We cannot conclude that either group would have had the same levels if they had not migrated since the Canadian frontier environment was conducive to high fertility whereas urban life in the nineteenth-century US may have been the reverse. US data suggest that migrants from Latin and South America have higher fertility than both those who remain and US natives (Lichter et al. 2012), although these conclusions are sensitive to the choice of indicator (Parrado 2011). Abbasi-Shavazi and McDonald (2002) found that emigrants to Australia had higher fertility than their peers who remained in the Netherlands, Italy, or Greece, whereas those from the United Kingdom had lower fertility. The differences were small but groups tended to move towards Australian levels. Fertility of intra-European immigrants is similar to levels in the host country across European countries (Office for National Statistics 2014, Table 4; OECD/European Union 2015).

There has been considerable discussion of the interpretation of migrant and non-migrant fertility data, and how pre- and post-arrival patterns can be combined (Toulemon 2004). However, for our analysis this was not an issue on substantive or technical grounds. There is little evidence of such disruption effects for the European populations we were mainly concerned with (Andersson 2004; Devolder and Bueno 2011). There is a clear distinction between births prior to migration since the child will be classified as a migrant on arrival, and after migration, when the child will be classified as native.

While the proportion of births to overseas-born mothers was just over one quarter in England & Wales and 14 per cent in Scotland in 2011 (Office for National Statistics 2012, Figure 10), these figures were much smaller in the past. In the 1851

Census, only 0.5 per cent of the population in England & Wales and 0.4 per cent in Scotland were recorded as being born outside the United Kingdom and these were overwhelmingly from other European societies with levels of fertility similar to Britain's, so the effect on the overall average level would have been very small. Although care is needed in interpreting fertility data on migrants owing to the disruption effect, there is evidence that recent migrants to Europe who come from other continents often have higher fertility than the native population and that this is sufficient to increase total fertility rate levels by 0.1 children per woman in England & Wales in 2011, but only 0.02 in Scotland where the proportion of such women is smaller (Office for National Statistics 2012).

A number of studies suggest that the fertility of second-generation and later-generation immigrants tends to move towards the level of fertility prevailing in the host country (Glusker 2003; Parrado and Morgan 2008; Waters and Pineau 2015), and since we were concerned with fertility over multiple generations, this reinforces our case that there appeared to be no strong reason in our initial counterfactual scenario to assume that the fertility of migrants differed from that of the populations we were concerned with.

There is some inconsistency in that the fertility of emigrants is assumed to be that of their original population, whereas that of immigrants is assumed to be that of the host population. This is the standard assumption of no-migration scenarios produced by official agencies. The actual impact of migration on fertility is the difference between the loss of people and their subsequent births owing to emigration and the corresponding gain from immigrants. There is no strong evidence to identify what would have been the probable fertility of both sets of migrants if in fact they had not migrated, or even the magnitude of such gross flows for these countries. Our estimates are therefore simply of what would be the outcome if we assumed, in the absence of evidence to the contrary, that fertility and mortality of both immigrants and emigrants and their descendants had been the same as that of the observed national population. This assumption could be amended, especially for recent periods when more information on the fertility of migrant groups is becoming available (Jeffries 2005), although it less so for information on the fertility of emigrants.

Although there is evidence that the convergence of fertility to national levels for descendants of those migrant groups originally from some non-European countries is proceeding more slowly than for others (Kulu et al. 2015), the numbers of these migrant groups were small in former times, and, as we show later, the main trend was that of migrants leaving Great Britain rather than the reverse. Over the extended period of this study, there is no evidence that emigrants from Britain were likely to achieve either higher or lower fertility abroad than if they had remained in their original country. Although we have argued that differentials between native and migrant demography were likely to be relatively small and unimportant for this analysis, there are advantages in looking at an example with negative net migration since the impact of non-native migrants would then be even less than in the case of positive inflows.

If overall observed fertility was higher than native fertility but lower than immigrant fertility, this would give a slightly higher number of births in the no-migration case than if native-only values had been used. The method would under-estimate the impact of migration on population change and therefore our results would—if anything—be conservative. Since we are concerned not only—or even principally—with the fertility of migrants but also with that of their descendants, who tend to adapt to prevailing levels, this further supports the case for assuming the same fertility for all population groups in this study.

Long-term fertility implications

The estimation procedures we have used are based on net rather than gross migration; gross migration flows are not available. Even though Scotland experienced substantial net outflows, there were also major inflows—initially overwhelmingly from Ireland. Since Ireland was part of the United Kingdom at that time along with Great Britain (England, Wales and Scotland), this was internal rather than international migration, and our analysis does not distinguish between them. At the start of the period, 7 per cent of the population enumerated in Scotland in 1851 were born in Ireland, in part following mass emigration driven by the Irish Potato Famine of the late 1840s. In 1901 the Irish-born accounted for 4.6 per cent of Scotland's population, though in the twentieth century the largest immigrant groups were from England & Wales (Brabar 2012).

The overall long-term impact of migration on population includes the contribution not only of migrants themselves, but of their offspring. Indeed, over time the majority of long-term population gain (or loss) through migration is not from the original migrants but from the numbers of their descendants. With assimilation, these descendants are increasingly born to parents with both migrant and non-migrant forebears and any distinction between 'migrant' and 'non-migrant' becomes meaningless at the individual level. There is no such person as a 'net migrant', but net migration is meaningful as a macro-level variable. We have simply assumed that an individual of a given age at a particular time point will generate the same average flow of population numbers in years to come irrespective of migration status (in the case of an emigrant, this flow will be negative). While our results are based on the assumption that fertility was the same in the actual and no-migration populations, this assumption can be relaxed if required either to produce alternative scenarios or to incorporate more detailed data if information on long-term gross flows were to become available. However, this would require much more detailed data and strong assumptions (Murphy 2016, forthcoming).

Results

We present results with net migration being set to zero from 1855 and every 10 years starting from 1860. We show the long-term effects of migration patterns in various time periods on population in the latest year, 2013 (although for clarity, we show graphical results only every 20 years; full results are available on request). We start with some descriptive results. There are 11 European countries in the HMD with continuous information from the nineteenth century or earlier (Human Mortality Database 2015; Murphy 2016, forthcoming). Although there are European countries such as Ireland with less complete information that had higher levels, Scottish overall out-migration is twice as high as in any other country included in this set. It therefore provides a particularly clear case study for investigating the impact of migration. Scottish migration patterns are also noteworthy in that the flows have been consistently negative. In the period from 1855, when records first became available from vital registration, in 132 out of the 145 years up to 2000 net migration was negative for Scotland (although positive in all years of the twenty-first century so far). In England & Wales, the overall net migration rate is close to zero and more years had positive net outflows than net inflows, although migration tended to be negative in the earlier part of the period and positive later.

Net migration was more negative in Scotland than in England & Wales for virtually every decade from the mid-nineteenth century (Table 1). Over the whole period 1855 to 2013, the annual average net migration rate showed a loss of about 3.1 persons out of every 1,000 in Scotland but the value was close to zero in England & Wales where the mean gain was 0.2 per 1,000. These values do not, of course, relate only to natives. Emigrants will include immigrants who subsequently move to another country, such as Irish migrants from Scotland, and immigrants will include native-born Scots who return after a period living abroad.

[Table 1 about here]

We estimated the total impact of migrants and their offspring by comparing the actual values with the no-migration scenarios that allowed for the fact that subsequent birth cohort numbers would differ from those observed since the population of childbearing age would be different. Figure 1 shows the estimated national population sizes up to 2013 if net migration had been zero from a number of time points over the past 160 years. For England & Wales, the impact of net migration is small; around year 2000 the actual population size was in the middle of a narrow range of zero migration estimates, although moving above these in the very latest period. In contrast, Scotland shows a much larger impact of migration with actual numbers in 2013 substantially lower than in the no-migration cases. The effect is largely monotonic and cumulative; the longer the period when migration is excluded, the larger the subsequent impact of net migration. In 2013 the population in Scotland was 1.9 times its value in 1855, but the corresponding figure for England

& Wales was three times larger over the same period (Table 2). If there had been no net migration from 1855, the ranking of these ratios would be reversed—the 2013 population in Scotland would have been over four times that of the 1855 population compared with just below a three-fold increase for England & Wales. While migration had little impact on population growth in England & Wales over this extended period, it led to the size of the Scottish population being 5.3 million in 2013, under half of the 11.4 million people that would have been expected if net migration had been close to zero (Table 2).

[Figure 1 and Table 2 about here]

Note that the interpretation of the results that assume zero net migration is analogous to the interpretation of the 'no migration' variant in standard population projections that show the sensitivity of population size and structure to alternative futures. The results reveal the difference in population size and structure that would have been observed with and without net migration with the stated assumptions. The results also indicate the fraction of actual population change attributable to migration by apportioning overall change between the direct and indirect effects of migration and fertility and mortality. This latter interpretation of these results may also be used to show the impact of net migration in different time periods. For example, the difference in 2013 estimates between the actual population and one with net migration being set to zero between 1900 and 1925 gives the net impact of migration in the period 1900 to 1925 because the observed and no-migration populations have identical demographic regimes for all other time periods outside this window.

Table 3 decomposes the difference between the actual population size in 2013 and its size if there had been no migration to the intervening time intervals between 1855 and 2013. In the absence of migration, the population in England & Wales would be 2.8 million lower (4.0 per cent) than observed, whereas in Scotland it would have been 6.1 million (114 per cent) higher. In Scotland, every interval contributed positively to this difference, apart from the most recent one when the longstanding pattern of a positive net migration outflow was reversed. While there were outflows over most of the period, the largest impacts of Scottish migration on current population occurred in the late nineteenth and first half of the twentieth centuries.

[Table 3 about here]

For England & Wales, net migration in about half of the periods analysed contributed positively, and in about half contributed negatively to population size in 2013. However, migration in all decades from 1930 contributed to a larger actual population size than would have been the case in the absence of migration. The impact of migration in the most recent period has been very substantial, with population size in 2013 being 3.4 million higher owing to migration since 2000, whereas the impact of migration over the whole period 1855-2000 would have led to a population slightly lower than observed, by about 550 thousand people. For England & Wales, no periods are particularly influential in relation to total population size, for either positive outflows or inflows apart from the most recent period.

Although the overall impact of migration on population numbers in Great Britain during the late nineteenth century and twentieth century was to reduce growth, much debate has taken place about the possible negative consequences of immigration and a number of restrictions on settlement have been introduced from the 1960s, following the increase that occurred in the 1950s.

Natural and total growth

A migration event will change population numbers by one when it occurs. In the longer term, the values from later generations depend on the fertility and mortality of descendants and the extent to which they remain distinctive, though we assume convergence as discussed in the methods section. Population growth is determined not only by migration but also by fertility, mortality, and the sex and age structure of the initial population although the impact of initial conditions becomes attenuated over time. Ultimately different initial populations that are subject to the same—possibly time-varying—rates will have identical age distributions and growth rates in the absence of migration (Arthur 1982). Fertility and mortality rates have been *broadly* similar in England & Wales and Scotland over the past 150 years or so, with mortality somewhat higher in Scotland and life expectancy there being on average about two or three years less than that in England & Wales from about 1900, so Scottish levels were typically those of England & Wales about one decade earlier (Figure 2a). Therefore in this period, Scotland's mortality disadvantage was more than offset by its generally higher fertility, using the sex-neutral TFR measure defined in Appendix A (Figure 2b).

[Figure 2]

The joint effect of fertility and mortality on population change is shown using the NRR-type measure defined in Appendix A and the corresponding intrinsic rate of growth (Figure 2c). The NRR value was 20 per cent higher in Scotland than in England & Wales in the first part of the twentieth century, the same value as that determined by Glass and Blacker (1938). The Scottish higher intrinsic rate of growth reinforces the conclusion of the earlier analysis that Scotland would have grown faster than England & Wales in the absence of migration over this extended period, although fertility has been lower in Scotland than in England & Wales in recent decades. We therefore conclude that migration has been the dominant force in the major divergences in population growth between these two populations, even though the annual difference in proportions of net migrants was only three persons in every 1,000.

Population structure

We now consider the interplay of fertility and mortality trends in relation to the other main focus of the demographic impact of migration, which is its effect on population age structure. Migration is widely advocated as a response to population ageing so we estimated how migration has influenced population ageing over an extended period. We present two widely-used indicators of population ageing: (i) the proportion of people aged 65 and over, and (ii) the potential support ratio, the ratio of people of nominal working age, 20 to 64, to those aged 65 and over. This gives the number of potential workers per nominal retiree, the reciprocal of the so-called old-age dependency ratio (OADR).These measures are demographic ratios rather than indicators of social or economic dependency, and they ignore the fact that over time typical ages at starting and finishing working life have changed. Nevertheless, the measures are in widespread use in discussions of population ageing.

For both England & Wales and Scotland, the proportion aged 65 and over increased from about 5 per cent to 16 per cent over the twentieth century, although the values in Scotland were generally slightly lower than for England & Wales by about 0.5 of a percentage point on average in this period (Figure 3a). As might be expected, migration has little influence on population structure in England & Wales and values were similar irrespective of migration. For Scotland, the effect of migration is larger and its outcome has been to make the population structure older, with the proportion aged 65 and over typically being about 1.5 percentage points higher than it would have been with no migration. In consequence, the observed pattern in Scotland is closer to that observed in England & Wales than it is to the Scottish no-migration pattern.

Rather than the proportion aged over 65, we prefer to concentrate on the potential support ratio of nominal workers to retirees since this is more directly related to economic sustainability (Figure 3b). The potential support ratio was less favourable in Scotland than in England & Wales in the nineteenth century and early part of the twentieth, but more recently it has been broadly similar and even slightly larger than that of England & Wales. However, without migration, Scotland would have had a distinctly more favourable profile, typically by about an additional working-age person for each retiree over the twentieth century. High migration from Scotland in the early part of the twentieth century (Table 2) led to a deficit of older people many decades later that partially offset the impact on population ageing of larger fertility falls in Scotland than in England & Wales in recent decades. However, the main conclusion is that the impact of migration on population ageing was limited, typically shifting the curves in Figure 3 by about 15 to 20 years, with this lag tending to fall over time as the impact of migration early in the twentieth century faded. Even though Scotland had very high migration rates compared with other European countries over this extended time scale, the effect on population structure was limited and declining over this period. The larger potential support ratio for Scotland than for England & Wales in the no-migration case is a result of the fact that the population would have been growing more quickly owing to its higher fertility and therefore the ratio of young to old age groups would have been higher.

[Figure 3 about here]

Discussion

Much of the current debate about immigration has centred not on its contribution to overall numbers but on its impact on population structure, especially in relation to the sustainability of pensions and health care systems (United Nations 2000). Against this background, the recent Scottish independence referendum of 2014, which ended in a majority decision (55 per cent to 45 per cent) not to opt for independence, provided the opportunity for a range of issues to be debated openly, including migration.

The pro-independence Scottish National Party's (SNP) manifesto for the 2015 General Election advocated an 'Immigration policy that works for Scotland', arguing that 'Diversity is one of Scotland's great strengths. Effective immigration controls are important, but we must also remember that those who have come to Scotland from other countries make a significant contribution to our economy and our society. We will support sensible immigration policies that meet our economic needs' (Scottish National Party 2015, p.9). The former Labour administration in the Scottish Assembly had also advocated increased migration in response to Scotland's relatively low rates of population growth. A decade earlier in February 2004, Jack McConnell, the Labour Scottish Executive First Minister had directly linked migration to demographic trends stating that: 'The single biggest challenge facing Scotland as we move further in the 21st century is our falling population' (Scottish Executive 2004, p. 1).

In the discussion of migration policy during the 2014 independence referendum, Scottish politicians argued that their pro-immigration policy would mitigate the perceived problems of population size and population ageing and provide social, economic, and demographic benefits. It is relatively unusual for politicians to argue that immigration has major intrinsic benefits. Immigration is more often treated as a necessary evil, attributable to such national failures as having too few children or not producing workers with the right type of employment skills. The generally negative attitude of the UK to immigration was seen in Scotland as largely reflecting the interests of the more populous England & Wales. The two main political parties in the UK, both of which opposed independence, were advocating further restrictions on immigration. The difference between the attitudes of Westminster and Scottish governments to immigration was exemplified by the fact that in the 2013 UN report on monitoring population policies, only two European countries, the UK and Serbia, stated that they wished to reduce the immigration of skilled migrants (United Nations Department of Economic and Social Affairs 2013).

In 2014 the figure for net migration to the UK was 320 thousand (Office for National Statistics 2015b). During the 2015 General Election campaign, the Conservative Party stated that it remained their objective to keep net migration down to the tens of thousands and to make it more difficult for EU migrants to claim welfare and housing benefits (Conservative Party 2015). The Labour Party pledged to employ more border staff, to reduce benefits, and to cap the number of non-EU migrant workers (Labour Party 2015).

Migration has a clear impact on population size, but many also see immigration as a permanent solution to the economic challenges associated with population ageing. This is an error, as the analysis above shows, unless levels of immigration consistently increase. As Preston and Stokes point out (2012, p. 222), it is only *change* in migration rates that can alter population structures. The impact of emigration over the past 150 years on population size has been substantial in

Scotland. The population is less than half the size it would have been in the absence of that emigration, but the effect on population structure has been very modest. The emigration has led to only a relatively small change in the proportion of older people in the population as compared to England & Wales, where emigration has had little effect on either size or structure.

We have compared two constituent parts of the United Kingdom, one part with negligible levels of net migration and one where it has been substantial. They have been subject to similar, although not identical, social and governance systems, but the substantial differences in economic opportunities between the two have led to very different migration pressures and trends (Devine 2012). Concerns about the level of immigration have increased substantially in recent years, and it is a major issue in the debates preceding another referendum, in June 2016, that in which the subject is the United Kingdom's membership of the European Union.

Our findings reinforce the conclusion from earlier theoretical studies that migration is likely to have little effect on long-term population structure in decades to come. Results that depend on assumptions about migration patterns well in excess of 50 years ahead may have difficulty in convincing sceptics, but we have shown that shown that migration has had a substantial effect only on population size.

Appendix A

The fertility measure *k(t)* is the average number of children per person required to produce the observed number of births in that year. This is based on an assumed pattern of fertility between ages 15 to 45 given by a beta distribution as discussed in the Methods section. It is similar in interpretation to a gross reproduction rate (GRR) except that it relates all births to all adults, rather than confining daughters to women, i.e. it is also an age-standardized fertility measure for a population that contains equal numbers of people in each single-year-of-age group but in which fertility rates vary from year-to-year. Since we did not have annual age-specific fertility rates for even half the period analysed, we could not compute indicators such as TFR, GRR, or NRR in the traditional way. Therefore our approach is analogous to indirect standardization with a fixed rate distribution used to compare the observed number of events and expected number of events with the no-migration population.

We used both sexes combined for consistency with the rest of the analysis, although we have replicated these calculations for daughters per woman and sons per man separately to assess the sensitivity of results to these alternatives (all the analyses presented here can be undertaken separately for males and females). In order to compare the value of children per adult, we multiplied the value by 2 to approximate to the average number of children per woman so this indicator (Total, shown in Appendix Figure A) is on the same scale as the traditional TFR. We also constructed the value based on number of children per woman (TFR_alt), which is the basis of the conventional official TFR. For the period for which we do have annual estimates, from 1923 in the case of England & Wales, values are very similar (Appendix Figure A) in levels, and the correlation between the official and model values is over 0.99.

[Insert Appendix Figure A about here]

Trends in values for men, women, and both sexes combined are very similar, but the levels are slightly different. This is largely because the number of men aged 15 to 45 was smaller than the number of women in the same age group in earlier periods, so that each man in this age range would need to have more children on average to obtain the same number of births.

The results with these alternative fertility indices are very similar and do not lead to any substantive differences in the interpretation of our findings related to the impact of migration on population size and structure that is the subject of this paper. Since the method is based on the ratio of populations at risk of actual and no-migration populations, any biases would be expected to affect estimates in the same way.

We have also constructed a period measure analogous to the conventional net reproduction rate by multiplying the beta distribution values by the L_x values in the period life table of a given year to obtain the expected number of children a new-born would expect to have if he or she experienced the period fertility and mortality rates of a given year throughout life. We used these period fertility measures together with mortality estimates to compare the demographic regimes in England & Wales and Scotland in Figure 2. From this NRR-type measure, we also estimated the intrinsic rate of growth on the basis that the NRR is approximately the result of the annual intrinsic crate of growth continued for the mean length of generation, here assumed to be 30 years. This gives the mean age of the fertility schedule in our application as $r=ln(NRR)/30$. These values are shown in Figure 3c.

We also assessed the sensitivity of the procedure to the assumed age-specific fertility schedule by altering the parameters of the beta distribution to change from an initial mean of 30 years to 26 years in 1970 before moving it back to 30 years by 2010, to reflect some of the main changes in the timing of fertility over the period. We find that this makes no meaningful difference to our conclusions.

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Table 1. Average annual net migration rate (per 1,000) by decade, England & Wales and Scotland, 1855-2013

Start year	England & Wales	Scotland
1855[1]	-0.69	0.26
1860	-0.30	-2.81
1870	-0.62	-2.90
1880	-2.01	-5.26
1890	-0.49	-1.87
1900	-1.08	-4.90
1910[2]	-1.69	-6.31
1920	-0.61	-8.75
1930	1.04	-2.88
1940[2]	0.64	-2.46
1950	0.89	-4.94
1960	0.52	-6.24
1970	-0.03	-1.83
1980	0.25	-2.88
1990	0.99	-0.44
2000[1]	3.95	3.77
Overall value	0.17	-3.09

Notes:

[1] 1855 values over years 1855-59 and 2000 values over years 2000-13

[2] Values for the 1910s and 1940s decades are less reliable due to problems with population estimated in period 1914-18 and 1939-45 in Scotland which relate only to the civilian population. Further details are available at Background and Documentation file. http://www.mortality.org/cgi-bin/hmd/country.php?cntr=GBR_SCO&level=1 .

Source: Human Mortality Database.

Table 2. Actual population and population without net migration from 1855; numbers and ratios, England & Wales and Scotland, 1855 and 2013,

Country	Population (000s)			Ratios		
	1855 Actual	2013 Actual	2013 No-Migration	2013 Actual to 1855 Actual	2013 No-Migration to 1855 Actual	2013 No-Migration to 2013 Actual
England & Wales	18,634	56,761	53,948	3.05	2.90	0.95
Scotland	2,812	5,321	11,406	1.89	4.06	2.14

Source: As for Table 1.

Table 3. Difference in population size (000s) in 2013 owing to migration, in decades, England & Wales and Scotland, 1855-2013

Start year of decade	England & Wales	Scotland
1855[1]	4	-68
1860	1	-376
1870	-218	-344
1880	-1,134	-621
1890	-257	-194
1900	-653	-569
1910	-1,177	-727
1920	-518	-863
1930	516	-358
1940	186	-652
1950	1,145	-497
1960	497	-579
1970	69	-195
1980	239	-250
1990	752	-60
2000[1]	3,360	267
Total[2]	2,813	-6,085

Notes:

[1]1855 values over years 1855-59 and 2000 values over years 2000-13

[2]Values over period 1855-2013.

Figure 1 Population to 2013 by year net migration becomes zero, England & Wales and Scotland, 1855-2013

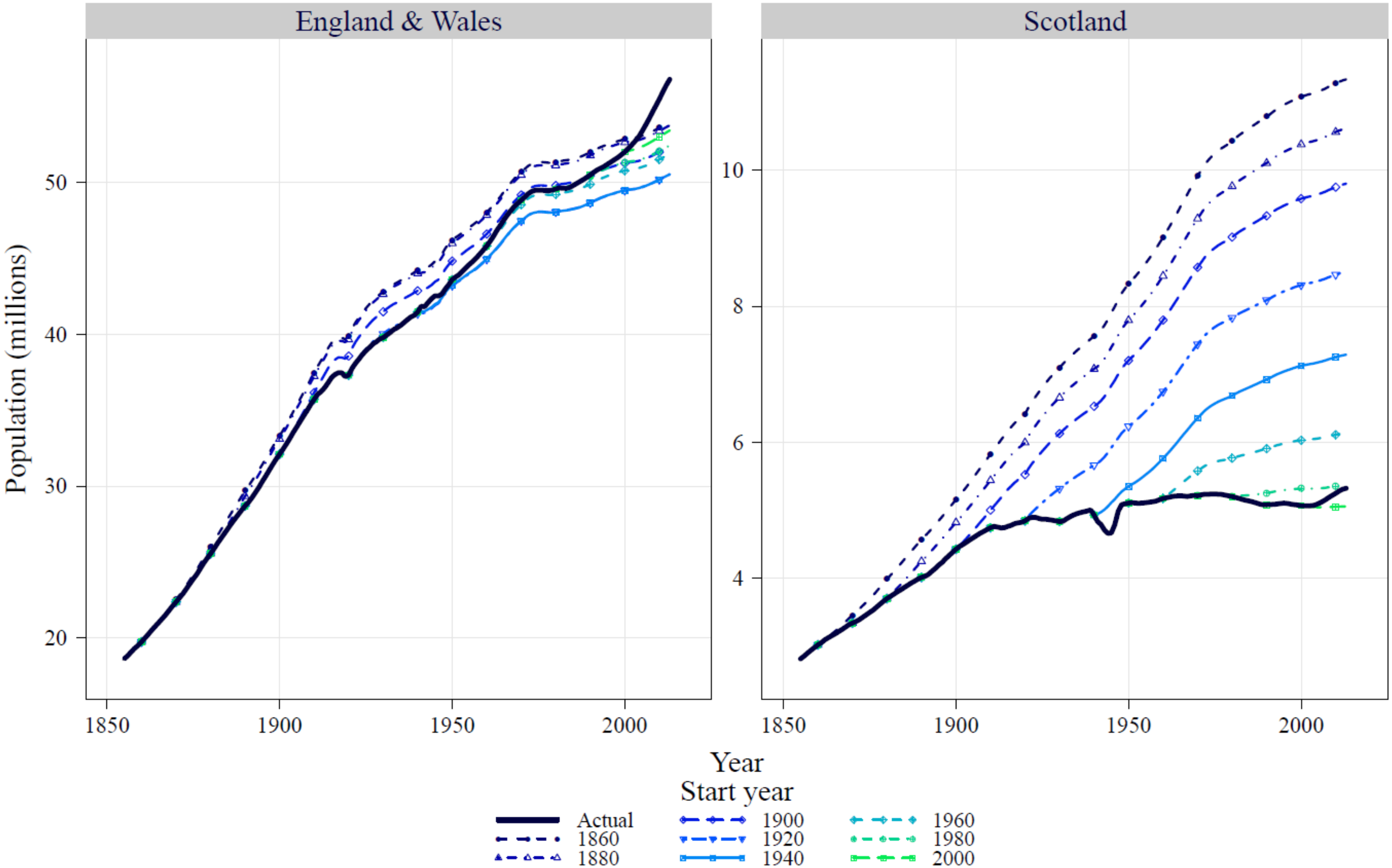


Figure 2 Demographic indicators of natural growth, England & Wales and Scotland, 1855-2013

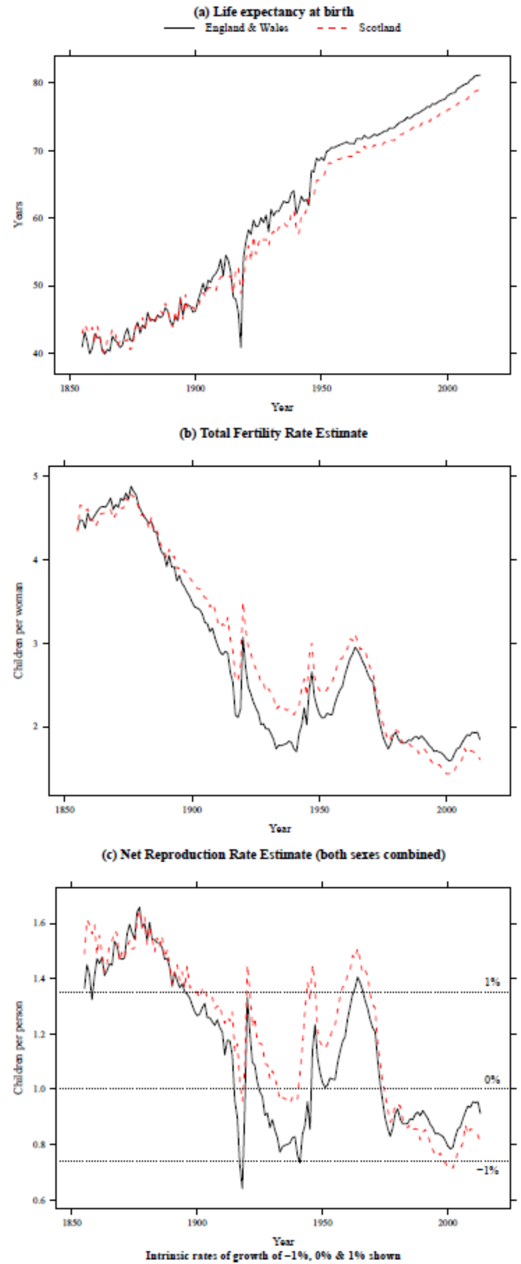


Figure 3 Demographic indicators of population ageing by year net migration becomes zero, England & Wales and Scotland, 1855-2013
(a) Proportion aged 65 and over (percent)

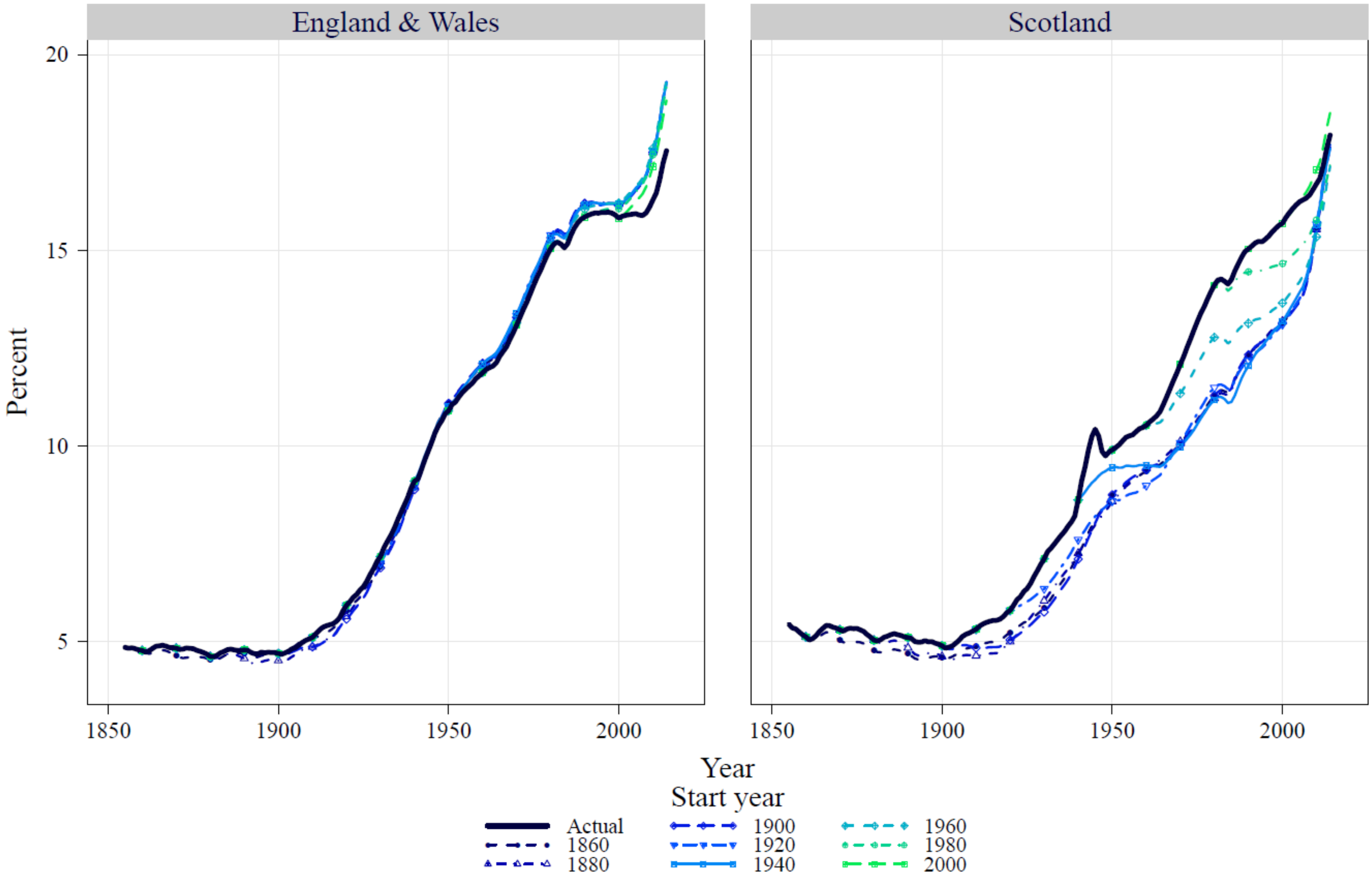
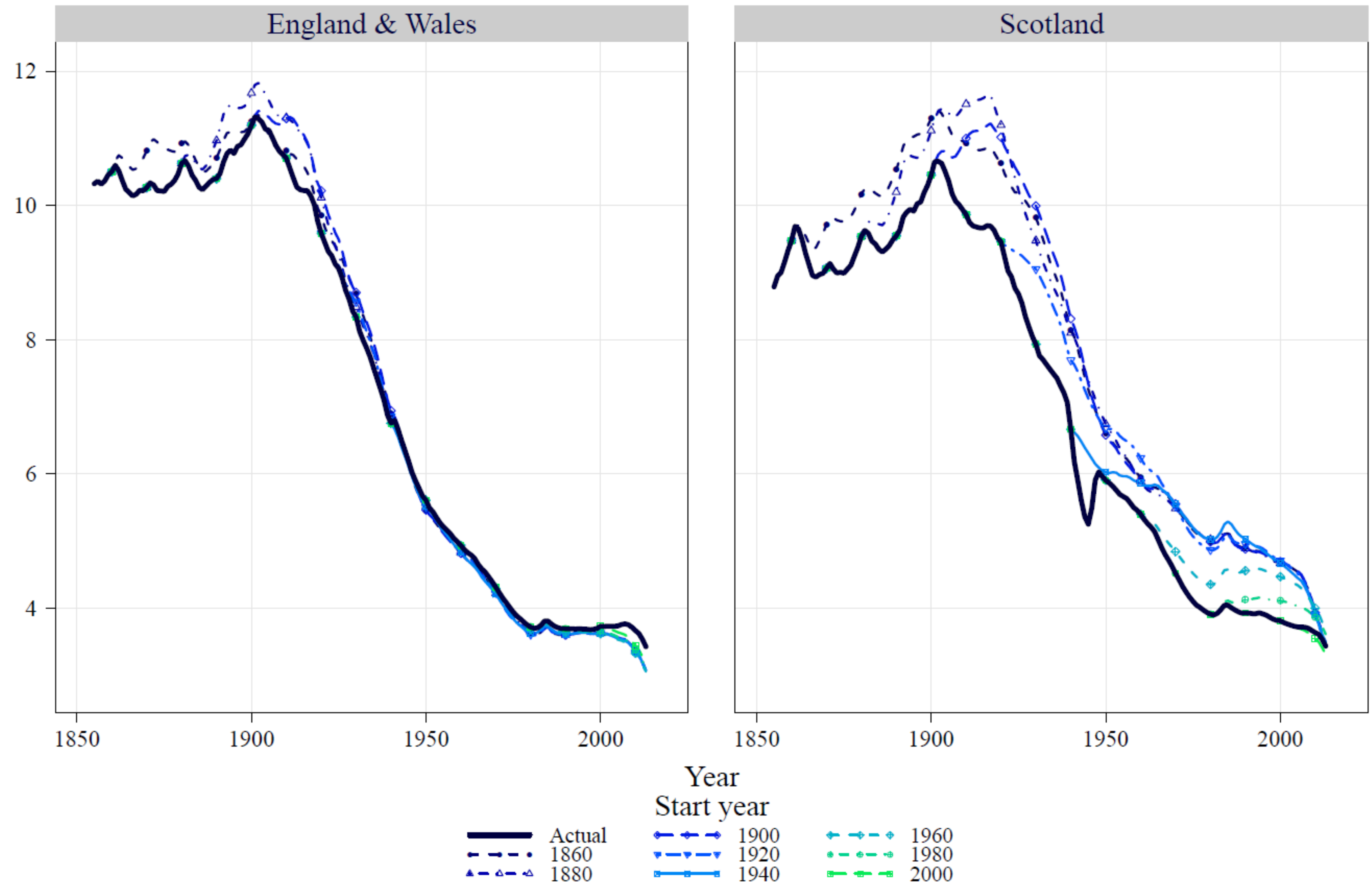


Figure 3 Demographic indicators of population ageing by year net migration becomes zero, England & Wales and Scotland, 1855-2013
(b) Potential support ratio (Persons aged 20-64 per person aged 65 and over)



Appendix Figure A. Alternative indicators of fertility