

The Impact of Migration on Long-Term European Population Trends, 1850 to Present

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RELATIVELY LITTLE attention has been paid to the long-term implications of international migration for national population size. The most common approach is to produce future scenarios that compare population sizes and structures from projections that include assumptions with and without net migration (United Nations Population Division 2000; Holzmann 2005; Lutz and Scherbov 2007). Such scenarios are often included in official projections (Office for National Statistics 2015; United Nations Department of Economic and Social Affairs 2015). Some scenarios are stylized and designed to show that certain objectives cannot plausibly be met, such as that South Korea would need to import the whole world's population by 2050 to maintain the current ratio of its working-age population (aged 15–64) to people aged 65 and older (United Nations Population Division 2000; Coleman 2002). Other studies compare a no-net-migration scenario with the best current forecast as found in official population projections to show the impact on population size and structure of the migration assumptions adopted. Even such realistic projections, however, must be treated with caution since long-term trends are often formulated by assuming continuation of current patterns, whereas experience suggests that migration is volatile and the constant or modest trends drifting toward zero in most scenarios are clearly unrealistic. It is therefore instructive to look at how migration has affected long-term population trends in practice as well as in theory.

In the following I develop models to estimate the total impact on population size of net migration, including not only emigrants and immigrants but also their descendants. I compare trends in 11 European countries from the mid-nineteenth century to the present to show the heterogeneity of trends and consider the relative contribution of net migration and natural population change to long-term population growth. Finally, I examine whether recent trends are a continuation of long-term patterns or suggest the emergence of a qualitatively different European migration regime.

Data and methods

Data are taken from the Human Mortality Database (HMD), which includes estimates of mortality rates and population size by single year of age and sex for each calendar year, together with information on total annual numbers of births and deaths. These estimates are constructed using a uniform method applied to information from validated official statistics such as censuses, vital registration, and population estimates (Wilmoth et al. 2007; Human Mortality Database 2015). Since I am interested in long-term trends, I confine attention to 11 countries with at least 100 years of continuous data: five Nordic countries (Denmark, Finland, Iceland, Norway, and Sweden), five from Western Europe (England and Wales, Scotland (both treated for present purposes as separate countries), France, Netherlands, and Switzerland), and Italy in Southern Europe. These countries account for just over half of the total population size of Northern, Western, and Southern Europe as defined by the United Nations.

Estimates such as the 55 million Europeans who left for the Americas and Australasia between 1850 and 1914 (Hatton and Williamson 1998)—a number that Okólski (2012, p. 8) contextualizes as one fifth of Europe's 1850 population—suggest that migration had a major impact on European population growth. However, I am concerned with population change and therefore concentrate on net rather than gross flows. Historically, net migration numbers are considerably smaller than both gross numbers and natural increase. For example, in four large Western European countries, France, Great Britain, Italy, and Sweden, in the peak period of inter-continental European migration, 1880 to 1913, there were 106.0 million births and 76.5 million deaths, resulting in a natural increase of 29.4 million, compared with 6.6 million net out-migrants based on HMD data. Net migration flows were considerably smaller than gross flows based on sources such as ship passenger arrival records, with return rates being two or three times higher than had often been assumed (Bandiera et al. 2013).

My primary goal is to compare national patterns from 1850, or the first available year if this is later, to the last available year around 2011 (see Appendix Table A.1).^{*} Only limited data are available for the first half of the nineteenth century when transatlantic migration was described as just a trickle compared with later flows (Ferrie and Hatton 2015, p. 56) and intra-European migration in North-Western Europe was at historically low levels (van Lottum 2007, Table 5.1). I estimate the effect of migration in a given period by comparing a later actual population with the same population that experienced no net migration over that period.¹ I calculate the survivors of cohorts without migration from various time points starting from either the first available year or 1850. For example, with a start year of 1850, all values

^{*}Appendix is available at the supporting information tab at wileyonlinelibrary.com/journal/pdr.

before that date are unaltered. In years after 1850, the numbers in the no-net-migration population aged a in year t of those born before 1850 are given by:

$$P_{nomig}(a, t) = P_{actual}(a - (t - 1850), 1850) L_x(a, t) / L_x(a - (t - 1850), 1850)$$

where *nomig* refers to the no-migration population and *actual* to the original actual population. $L_x(a, t - a)$ are the L_x values for age a based on a life table for the cohort $t - a$ with radix set to 1. For those born after 1850, the population numbers in the absence of migration are given by

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

where $B_{nomig}(t - a)$ is births in year $t - a$ (equivalently for birth cohort $t - a$). If the first available year is later than 1850, I start calculations in that year.

Cohort life tables from age zero to the age reached by the last available year (or age 110 if reached earlier) are available for some cohorts in the HMD (Appendix Table A.1). For other cohorts, I derived my own life tables using mortality rates from HMD. Cohort mortality rates are available for earlier cohorts, so I constructed partial life tables for these cohorts from the age at which the cohort reached the start year up to age 110. Cohort mortality rates are also available for later cohorts up to around 1980, so I constructed cohort life tables to the age reached at the last available year for these cohorts. For those born after about 1980, only period mortality rates are available, so approximate cohort life tables for those born in year t were calculated using mortality rates for age 0 in year t , age 1 in year $t + 1$, and so on 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 for reasons set out below. Because annual information on age-specific fertility is not available over the extended period for which mortality data are available, I estimate the expected number of births as follows. The distribution of age-specific fertility rates $f(a)$, with $\sum_a f(a) = 1$, is given by a beta distribution, $\beta(2.7, 2.7)$, scaled between ages 15 and 45, with a mean of 30 years and a standard deviation of 6 years. This is a typical fertility pattern for populations over this period. The actual number of births in year t , $B_{actual}(t)$, is therefore given by:

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

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, and $k(t)f(a)$ as the age-specific fertility rates (note that $f(a)$ may also be time-dependent as discussed in the Appendix).

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

$$B_{nomig}(t) = k(t) \Sigma_a P_{nomig}(a, t) f(a). \quad (2)$$

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

Thus I assume that the ratio of births $B_{nomig}(t)$ to $B_{actual}(t)$ is 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, similar to that used by Calot and Sardón (2001), with the standard population being that of a typical fertile population. I use the schedule for populations with both sexes combined rather than just for women as in most applications, but this makes no difference to the substantive conclusions (for further details see the Appendix).

I constructed a period measure analogous to the conventional net reproduction rate by summing the product of age-specific fertility rates and the L_x values in the period life table of a given year to obtain the expected number of children a newborn would expect to have if s/he experienced these period fertility and mortality rates throughout life. I estimated an intrinsic rate of growth, r , as $r = \ln(NRR)/30$, where NRR is the net reproduction rate, which is approximately the annual intrinsic rate of growth continued for the mean length of a generation, here assumed to be 30 years (Wachter 2014, p. 233). I use this intrinsic rate of growth to index the natural demographic regime (i.e. fertility and mortality only) in these countries over time.

Fertility assumptions for no-net-migration scenarios

I assumed that the fertility rates of the no-net-migration population are the same as those of the actual population. This assumption needs to be justified. Immigrants sometimes have elevated fertility after arrival since they may be reunifying families or “catching up” following disrupted family lives (Hervitz 1985; Andersson 2004). On the other hand, some migrants may be self-selected for lower fertility, possibly being more highly educated and career oriented, and migration may delay or inhibit family formation. There has been considerable discussion of the interpretation of migrant and non-migrant fertility data and of how pre- and post-arrival patterns can be combined to control for the effect of migration disruption (Toulemon 2004).² However, for my analysis this is not an issue on substantive or technical grounds. Such disruption effects are mainly associated with non-European migrants, and there is little evidence of this effect for the European populations we are concerned with (Andersson 2004; Devolder and Bueno 2011).

While the proportion of births to overseas-born mothers around 2013 exceeded 25 percent in a number of European countries including Bel-

gium, Ireland, Austria, Sweden, Norway, and the United Kingdom, and 20 percent in France, Spain, and Italy (Eurostat 2013), these proportions were much smaller in the past. Around 1900, some 3 percent of the population in France and Denmark, 2 percent in Norway, and 1 percent in Sweden and the United Kingdom were foreign-born (Williamson and Hatton 2005, Table 2.2), and these migrants were overwhelmingly from other European societies with similar levels of fertility so the effect on the overall average fertility level was very small.

Studies suggest that the fertility of second- and later-generation immigrants tends to move toward the prevailing level of fertility (Glusker 2003; Parrado and Morgan 2008; Waters and Pineau 2015). Convergence of fertility to national levels among descendants of some recent migrant groups to Europe from countries that have higher fertility than the native population appears to be proceeding more slowly than for descendants of other migrant groups (Kulu et al. 2015). However, non-European migrants were rare in the past and the main trend was of migrants leaving European countries rather than entering, with the largest inflows being of return migrants (King 1996). Fertility of intra-European immigrants is similar to levels in the host country across European countries (OECD/European Union 2015). Over the extended period of this study, there is no evidence that emigrants were likely to achieve either higher or lower fertility abroad than if they had remained in their original country.

In terms of the model used, if observed fertility was higher than native fertility but lower than immigrant fertility, this would result in a slightly higher number of births in the no-net-migration case than if native-only values had been used. The method would therefore under-estimate the impact of migration on population change and my results would, if anything, be conservative.

The overall long-term impact of migration on population includes the contribution of both migrants and their offspring. Population gain (or loss) through migration increasingly depends on the descendants of migrants rather than on first-generation migrants. Since I am concerned not only 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. One cannot conclude that emigrants would have had the same fertility that they achieved abroad had they remained in their original country, but there appears to be no strong reason for my initial counterfactual scenarios to assume that the fertility of migrants differed from that of the populations I am concerned with.³ It is reasonable to assume that an individual of a given age at a particular time will have the same average flow of population numbers in years to come (in the case of an emigrant, this flow will be negative) irrespective of migration status, but this assumption could be amended if appropriate.

TABLE 1 Average net migration rate (per 1,000 population) for selected periods to the latest available year

Country	Initial year	Final year	Average net migration rate (per 1,000)				
			Initial year–final year	Initial year–1900	1900–1950	1950–2000	2000–final year
Denmark	1850	2011	0.1	−1.2	0.4	0.6	2.3
England and Wales	1850	2013	0.2	−0.7	−0.3	0.6	4.1
Finland	1878	2012	−0.5	−0.4	−1.0	−0.7	1.9
France	1850	2013	1.5	−0.4	3.0	1.8	2.0
Iceland	1850	2013	−1.3	−3.3	−0.9	−0.7	2.6
Italy	1874	2012	−0.9	−2.9	−1.7	−0.4	6.0
Netherlands	1850	2012	0.0	−1.2	−0.2	1.2	1.1
Norway	1850	2014	−1.2	−4.6	−2.0	0.8	4.4
Scotland	1855	2013	−3.1	−2.8	−5.0	−3.2	3.2
Sweden	1850	2014	−0.3	−3.7	−0.7	1.9	4.4
Switzerland	1876	2011	1.8	−0.6	0.2	3.4	6.8
Total ^a	Initial	Final	0.0	−1.2	−0.2	0.7	3.2

NOTE: Rates are averages of annual net migration rates over the period.

^aBased on first and last years for which country values are available.

SOURCE: Author's estimates based on Human Mortality Database

The models are concerned with net migration rather than gross flows. With assimilation, these descendants will increasingly be born to parents with different migrant backgrounds, and any distinction between migrant and non-migrant becomes meaningless at the individual level.⁴ Net migration is a meaningful macro-level determinant of population size, and the contribution of net migration occurring in a particular period to population numbers at any given time can be identified uniquely with the assumptions discussed above. I now consider these results in detail.

Results

For each country I set net migration to zero from a series of start years 5 years apart between 1850 (or the first available year) and 2000. Rates before the date from which migration is set to zero remain unaltered. This makes it possible to assess the long-term effects of migration on population at various time periods up to the latest available year. Six countries had negative net migration rates averaged over the whole period: the Nordic countries apart from Denmark, as well as Italy and Scotland; three had rates close to zero: Denmark, England and Wales, and the Netherlands; and France and Switzerland had positive rates (Table 1). Scotland had a negative rate twice as large as the next country, Norway. Switzerland had the largest positive rate, followed by France. While the average net migration rate over all observations for these populations was zero, there was a shift

TABLE 2 Relationship between population size in initial and final year, with and without migration

Country	Population (thousands)			Ratio			Net reproduction rate
	Initial	Final	Final no migration	Final to Initial	Final no migration to Initial	Final no migration	
Denmark	1,407	5,561	5,812	3.95	4.13	0.96	1.22
England and Wales	17,579	56,761	53,853	3.23	3.06	1.05	1.14
Finland	1,971	5,401	5,858	2.74	2.97	0.92	1.17
France	35,673	63,651	49,087	1.78	1.38	1.30	1.00
Iceland	60	322	404	5.40	6.77	0.80	1.37
Italy	27,121	59,400	75,735	2.19	2.79	0.78	1.13
Netherlands	3,056	16,730	17,042	5.48	5.58	0.98	1.28
Norway	1,386	5,109	7,043	3.69	5.08	0.73	1.27
Scotland	2,812	5,321	11,406	1.89	4.06	0.47	1.21
Sweden	3,441	9,645	10,778	2.80	3.13	0.89	1.14
Switzerland	2,748	7,870	5,443	2.86	1.98	1.45	1.04
Total ^a	97,254	235,771	242,460	2.42	2.49	0.97	-
Standard deviation (unweighted)	-	-	-	1.20	1.52	0.26	0.10

NOTE: Years covered are shown in Table 1.
^aBased on aggregate of initial and final country values, therefore reference start and finish years vary.
SOURCE: Author’s estimate based on Human Mortality Database.

over time. In the nineteenth century, all 11 countries had a net outflow, but over the twentieth century the trend was toward positive inflows, so that by the twenty-first century all rates were positive. The patterns were heterogeneous across both time and space, so I now consider how these affect population sizes over this extended period.⁵

Population change is the sum of natural increase and net migration according to the balancing equation, which provides an estimate of how much each contributes to population change in a short time interval. However, if the impact of migration is measured by the difference in population sizes with and without migration, the balancing equation does not provide an estimate of the relative contributions of natural change and net migration, since the offspring of immigrants will contribute to natural increase and—more importantly for long-term European experience—the “missing” offspring of emigrants will have the reverse effect.

I now show how these migration differences translate into differences in population sizes with and without migration since 1850 (or the first available year) (Table 2). Because fertility and mortality rates are the same in both cases over the period, the only difference is the effect of migration. Therefore I use the ratio of the actual population to the no-net-migration population in the final year as the estimate of the total impact of migration—not just migrants—on population size from a specific date. The ranking of countries on this ratio is similar to that of the overall net migration rate in Table 1, and the correlation coefficient between these two variables is 0.98.

As expected, countries with smaller population sizes than would be the case without migration mainly have negative net migration rates, and those with larger sizes have positive rates.

The observed total population size was about 2.4 times larger at the end of the period than at the start, slightly below the ratio of 2.5 in the no-net-migration case. Ratios varied across countries, with observed growth ratios ranging between 1.8 in France and 5.5 in the Netherlands. The impact of migration also differed substantially. The shortfall in population size between the no-net-migration and the actual populations is particularly marked in the case of Italy, which has about 16 million fewer people, or about 20 percent smaller, in 2012 than if it had experienced no migration throughout the late nineteenth and all of the twentieth centuries. Norway is about 30 percent smaller and Scotland over 50 percent smaller than if there had been no migration. In contrast, France shows a population with 15 million more people (about 30 percent larger) in 2013, and Switzerland has 2.5 million more people (nearly 50 percent larger) than if net migration had been zero over the past century and a half. Broadly similar net migration rates are seen in Norway, Sweden, and Iceland, but Denmark, England and Wales, and the Netherlands have broadly similar population sizes with and without migration. In the first two of these countries, the actual population including migration overtook the no-net-migration population only recently, and the same is likely to happen to the Netherlands during this decade. It is not, of course, the case that there was no migration but rather that the impact of emigration on population change in these three countries was largely offset by the gains from immigration.

The levels of net migration experienced were sufficient to produce population sizes between about 50 percent lower and 50 percent higher than would have been the case without net migration. However, the levels were negatively correlated with population growth, therefore the effect of migration was to reduce differences in growth rates over the period. In the absence of net migration, at the tails of the distribution, I estimate that the population of France would have increased by only 40 percent rather than 80 percent over the period 1850–2013, whereas Iceland would have increased by 580 percent rather than by 440 percent. Switzerland and France, the two countries with growth ratios of the no-net-migration population below the average ratio of 2.49 over the period (based on the combined total population), experienced positive contributions to growth from migration, whereas eight out of the nine countries with above-average ratios experienced negative contributions (if England and Wales and Scotland were combined and shown as Great Britain, all values would be negative). The standard deviation of the ratio of final to initial actual population size, 1.20, is smaller than the standard deviation of 1.52 for the ratio of the final no-net-migration to initial population sizes (Table 2). This suggests that migration has tended to reduce long-term variability in growth rates compared

with what they might otherwise have been, reinforcing the suggestion of a positive impact of population growth on gross transatlantic flows over the period (Easterlin 1961; Hatton and Williamson 1994).

Migration patterns varied across time between countries. Figure 1(a) shows population sizes for four large exemplar countries that have different patterns. Population sizes for the other seven countries are shown in Figure 1(b). I present the expected population size if net migration was set to zero from selected start years. Since estimates for two different start years have the same fertility and mortality rates in all years and the same migration rates in years outside this range, the difference between the two final-year population estimates is due to different net migration in the intervening years between the start dates. The overall difference between the final observed population and the no-net-migration population from the first available year can therefore be attributed to migration in the intervening time periods.

While there have been some changes in migration over time (Table 1), the net effect of migration in England and Wales was small over this period, even though there were considerable outflows to countries such as the US and Australia. The actual population size is located within a narrow range of estimates based on no net migration starting at various time points, only exceeding these estimates in the most recent period. In contrast, Italy had substantial net outflows especially in the late nineteenth and early twentieth centuries as measured by changes in final-year population sizes from different start dates. Net migration over 1880–1910 accounted for well over half of the total impact of migration since 1873 on the contemporary Italian population. Net migration continued to be negative until the late twentieth century when the situation was reversed.

France exhibited a different time pattern. Although considerable attention has been given to Italian transatlantic migration, about half of Italian emigration was within Europe and especially to France in this period (Castles and Miller 2009, p. 87). France experienced high rates of immigration from the early twentieth century, but with a sharp temporary increase around 1960 related to major inflows of French citizens following independence of former French colonies in North Africa that contributed to the substantial impact of the 1940–1970 period in Figure 1 (the reintegration of Alsace-Lorraine following wartime annexation also had some influence). Switzerland was the other country with substantial inflows although with a later start to mass immigration. There was little impact until the mid-twentieth century but migration accelerated sharply in the immediate postwar period, which increased current population size by about one quarter, and high levels of migration have continued until the present.

Although this selection of 11 countries mainly from Northern and Western Europe is not random, they cover the majority of people in these regions and show that patterns over the late nineteenth and twentieth

FIGURE 1 (a) Population by year in which net migration is first assumed to be zero, exemplar countries (b) Population by year in which net migration is first assumed to be zero, additional countries.

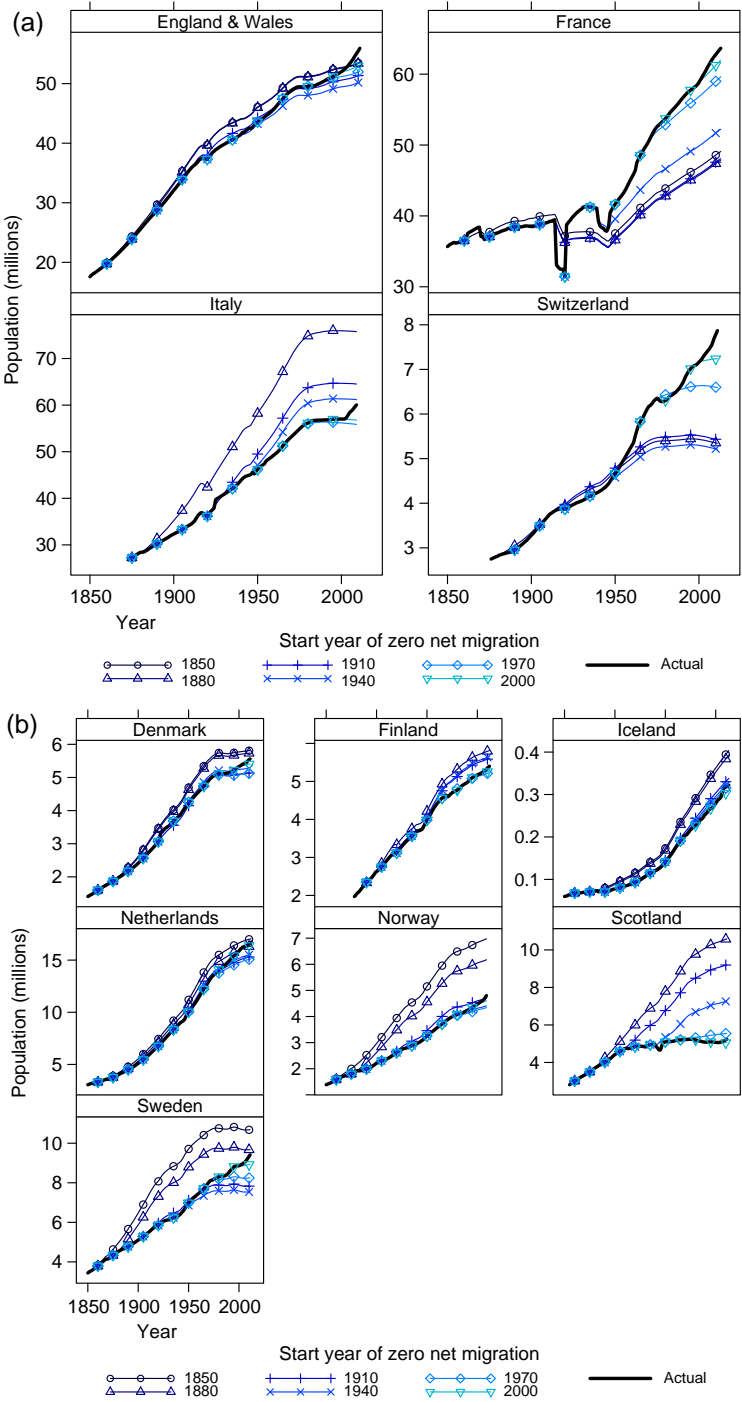


TABLE 3 Regression coefficients of population dynamics on migration and natural growth

Variable	MigEffect on NMR (3) ^a	NoMigTrend on intrinsic rate of growth (4) ^a	PopTrend on NMR and intrinsic rate of growth (5) ^a	Standardized coefficients from (5) ^a
Constant (ln(α))	-	0.40 (0.04)	0.34 (0.05)	-
NMR (β)	0.22 (0.01)	-	0.23 (0.02)	0.82 (0.08)
Intrinsic (γ)	-	0.15 (0.01)	0.16 (0.01)	1.28 (0.08)
R ²	0.97	0.98	0.97	0.97

NOTES: for definition of variables, see text.
Standard errors in parentheses
^arefers to equation number in text
SOURCE: Author's estimates based on Human Mortality Database.

centuries are heterogeneous. In general, there is a tendency for net migration to move from being largely negative to largely positive over the period. In some cases, however, the major net flows occurred in the nineteenth century while in others they occurred in the twentieth; some countries had relatively constant patterns over time, such as Finland; others, such as Sweden, switched from high outflow to high inflow (Table 1 and Figure 1(b)).

Impact of net migration on population size

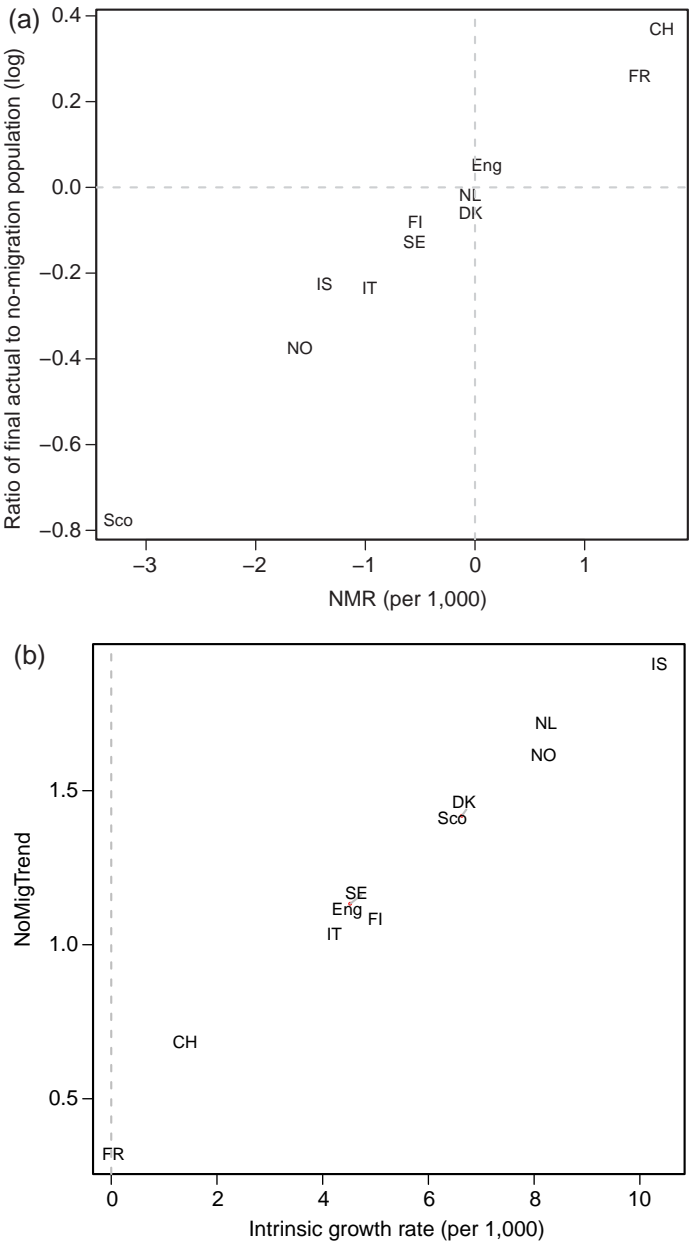
The 11 countries exhibit a range of net migration and natural growth regimes (Table 2). I now consider the consequences of these two variables for overall population growth. I suggested that the ratio at the final year of the actual population to the population with no net migration from the start year is an indicator of the effect of net migration over the intervening period since the two populations have the same fertility and mortality regimes and therefore observed differences can be attributed to migration differences. Since net migration is a continuous variable, similar demographic responses might be expected, for example, if net migration were to change by similar amounts in situations of positive and negative net out-migration. One would expect the ratio of actual and no-migration population sizes at the last available year (*LAY*) to be directly related to the exponential of the net migration rate, *NMR*, i.e. the model is:

$$P_{actual}(LAY)/P_{nomig}(LAY) = \exp(\beta NMR),$$

where *P(LAY)* denotes total population size in *LAY* for the actual and no-net-migration estimates as before, and *NMR* is the mean net migration rate per 1,000 population over the whole period, taken from Tables 1 and 2. I present regression results in Table 3 and Figure 2(a) for this model fitted as

$$MigEffect = \beta NMR, \tag{3}$$

FIGURE 2 (a) Relationship between ratio of final actual to no-migration population and net migration rate (NMR)
(b) Relationship between change over time in the no-migration population and the intrinsic growth rate



NOTE: NoMigTrend is logarithm of ratio of final to initial no-migration population

where $MigEffect = \ln(P_{actual}(LAY)/P_{nomig}(LAY))$, the log of the cross-sectional ratios at the final year. I do not weight these for relative population sizes since they are regarded as 11 separate demographic entities.

The relationship in Figure 2(a) is strongly linear. I expect the constant term to be statistically insignificant on theoretical grounds, since the actual and no-migration populations should be similar in magnitude when NMR is close to zero. This is the case and therefore I show results for the model fitted without a constant term.

The fitted model is $P_{actual}(LAY)/P_{nomig}(LAY) = \exp(.22NMR)$. The response is the same across the whole range, so that, for example, an increase of 1 per 1,000 in the average net migration rate for a century and a half would result in population size larger by about 25 percent (since $\exp(.22) = 1.25$), or an annual average increase of 1.4 per 1,000, than would otherwise have been the case irrespective of whether the initial value was positive or negative. The response also suggests that the result is relatively insensitive to the distribution of migration rates across the period and that the overall mean net migration rate captures almost all cross-national variation since it accounts for 98 percent of variance. These values were fitted to demographic regimes with total fertility rates ranging from over 5 births per woman to less than 1.3 and with life expectancy at birth (both sexes) ranging from under 20 years to over 80, therefore including virtually all contemporary global demographic regimes.

I now combine migration and natural change to assess their relative contribution to population growth across Europe.

Contribution of intrinsic and net migration rates to overall population growth

The mean levels of net migration are directly related to the ratio of actual to no-net-migration populations at the end of the period, so I use an analogous indicator to show the impact of natural changes arising from the fertility and mortality regimes experienced over this extended period. I use the intrinsic rate of growth, the principal indicator of underlying natural population change, which I expect to be related to the ratio of the final no-migration population to the initial population (a year when the actual and no-migration populations are identical). I specify the model as:

$$P_{nomig}(LAY)/P_{actual}(FAY) = \alpha \exp(\gamma r),$$

where FAY refers to the first available year and r is the mean intrinsic rate of growth over the whole period, Figure 2(b).

The pattern again is strongly linear and I present regression coefficients in Table 3 for the model

$$NoMigTrend = \ln(\alpha) + \gamma r, \quad (4)$$

where $NoMigTrend = \ln(P_{nomig}(LAY)/P_{actual}(FAY))$ is the change over the whole period in the no-migration population.

I include a constant term since the intrinsic rate of growth shows the underlying growth rate for a population with fixed fertility and mortality rates, which is not the case here. A population such as that of France with an average intrinsic growth rate of zero and no migration over 160 years would still have grown considerably. The main reason is that the annual number of births would be expected to be relatively constant, but, with improving mortality, the population size corresponding to a constant number of births will be much larger. It appears that improvements in mortality are so similar across these 11 countries that a single constant is sufficient to account for this development. The single index of the mean value of r clearly accounts for a very substantial fraction of cross-national variation, again explaining 98 percent of variability in equation (4).

To assess the joint impact of net migration and natural change on population growth, I regress overall change as measured by the ratio of final to initial actual populations on these two independent variables:

$$P_{actual}(LAY)/P_{actual}(FAY) = \alpha \exp(\gamma r + \beta NMR),$$

which I fit as

$$PopTrend = \ln(\alpha) + \gamma r + \beta NMR, \quad (5)$$

where $PopTrend = \ln(P_{actual}(LAY)/P_{actual}(FAY))$ is the overall growth in population size over the whole period.

Note that adding equations (3) and (4) gives an equation of the same form as equation (5), although the fitting procedures differ and the estimated coefficients are not identical. However, Table 3 shows that the coefficients of equation (5) are very similar to the individual coefficients from equations (3) and (4), suggesting that the overall growth can usefully be decomposed into these two components in a robust way.

To show the relative importance of net migration and natural change for population growth over the period, I present the coefficients of equation (5) as standardized coefficients, i.e. the response to a change of one standard deviation in the independent variables in Table 3. The two coefficients are broadly similar in magnitude, with the intrinsic rate of growth being about 50 percent larger than the net migration rate. However, the correlation of the net migration rate with overall population growth is zero (Table 4), although net migration is a component of overall growth, whereas it is relatively strongly negatively related to the intrinsic rate of growth, which is structurally independent of migration. Net migration and natural change are both important, and migration offsets natural increase. It is not possible to establish whether high growth stimulated out-migration or the option of out-migration influenced fertility levels, but Hatton and

TABLE 4 Correlation coefficients of population parameters

	MigEffect	NoMigTrend	PopTrend	NMR	Intrinsic rate of growth
MigEffect	1	−0.58	0.09	0.99	−0.58
NoMigTrend	−0.58	1	0.76	−0.64	0.99
PopTrend	0.09	0.76	1	0.00	0.76
NMR	0.99	−0.64	0.00	1	−0.64
Intrinsic rate of growth	−0.58	0.99	0.76	−0.64	1

NOTE: for definition of variables, see text.
SOURCE: Author’s estimates based on Human Mortality Database.

Williamson (1994) argue that migration is influenced by population growth about 25 years earlier.

Conclusions

While European societies such as those analyzed here may appear to have had broadly similar demographic patterns over the late nineteenth and twentieth centuries, with relatively similar levels of fertility and mortality at each end of the period, population growth has been heterogeneous. France’s population increased by 80 percent over the period around 1850 to around 2010, whereas the Netherlands increased by 450 percent over the same period. Even two constituent parts of Great Britain showed very different growth: 89 percent in Scotland compared with 223 percent in England and Wales principally due to differences in net migration over the period, a fact that was used to underpin arguments for Scottish independence in the 2014 referendum (Murphy 2016). Large-scale inter-continental migration started in the early decades of the nineteenth century, but the volume became much greater from about 1850 and especially after 1880 when many of these countries started irreversible fertility decline.

Difficulties in obtaining detailed migration data persist. The data used here are not measured directly, but are estimates based on models that have been extensively used as the definitive dataset on long-term cross-national mortality trends. I used a number of simple demographic methods to incorporate migration more centrally into population dynamics. Although there is no relationship between overall population growth and levels of net migration, the relatively strong negative relationship between net migration and natural increase in these countries demonstrates that migration has been influential in shifting population growth toward the overall mean through its interaction with natural growth. While net migrant numbers may appear small, they have had a substantial impact on long-term population developments, leading to populations 50 percent lower or higher across Europe with the models presented here.

While my emphasis is on long-term trends, the data also highlight the major change in international migration beginning around the end of the twentieth century. For the first time, net migration has been positive in virtually all cases, partly as a result of large-scale movements from Eastern to Western Europe following the expansion of the EU. Migration levels are also much higher than previously. In some cases, such as England and Wales, net migration since the beginning of the twenty-first century is considerably greater than the cumulative level over the previous 150 years. Italy, which historically had been the country with the largest population deficit due to migration, had the largest positive net inflow of 2.4 million people in the first decade of the century, over 2 million more than in the previous decade. Most other countries experienced a more gradual increase, but also exhibited increasing population sizes as the descendants of earlier migrants also contribute to population growth. The number of migrants has continued to rise largely as a response to continuing conflict in the Middle East. In the most recent period, the International Organisation for Migration (2016) estimated that just over one million migrants from outside Europe arrived in 2015 alone, although the preferred destination for many of these is Germany, which is not included in this analysis.

It may be too early to identify migration as the defining characteristic of this century, especially since international migrants still account for only 3 percent of the world's population (United Nations Department of Economic and Social Affairs 2013). Nevertheless, comparison of recent trends with the long-term trends presented here suggests that a major change in the nature of international migration in Europe is occurring and that the regularities identified above may not persist.

Notes

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1 Only net migration directly influences population dynamics through the balancing equation. The method compares the actual population with the no-net-migration case, which is the most obvious starting point for assessing the impact of migration. The assumption is that net migration is zero within each age and sex group, so that any emigrant is replaced by an immigrant with the same

profile. This assumption can be easily relaxed in order to compare the actual population with one having an arbitrary net migration pattern. The model can also be extended to include explicit consideration of both inflows and outflows of migrants, but this is not done for a number of formal and substantive reasons. Differences between demographic patterns of immigrants, emigrants, and static populations in Europe over most of the period studied here were relatively small, so there would be little difference in practice. Since I am concerned with the long-term consequences of migration when the patterns of descendants of migrants tend to become similar to the indigenous population, and indeed they become part of the indigenous population, even any initial differences

would become increasingly diluted. In order to extend the model, information would be required on the numbers of both immigrants and emigrants by age and sex, *and* on their fertility and mortality patterns. Such data are lacking for the 11 historical populations that I am concerned with. The inventory of data on migration flows from the early nineteenth century from the Oxford University International Migration Institute (IMI) DEMIG project <http://www.imi.ox.ac.uk/data/demig-data> shows the limited information available. Information on international migrants by age, sex, and origin since 1990 is available from the United Nations for all countries of the world (<http://www.un.org/en/development/desa/population/migration/data/estimates2/estimates15.shtml>). The OECD also has a number of international migration databases again relating to the recent past (<http://www.oecd.org/els/mig/oecdmigrationdatabases.htm>). The World Bank Global Bilateral Migration Database (<http://databank.worldbank.org/data/reports.aspx?source=global-bilateral-migration>) includes matrixes of bilateral migrant stocks over the period 1960–2000 (Özden et al., 2011). The quality and availability of the data are patchy and problematic.

2 The role of migration and fertility on reproduction has often been concerned implicitly with the implications for long-term population growth, although the main focus is often on topics such as the relative distribution of native to migrant births. Research on this topic falls into two main approaches. The first is the production of indicators concerned mainly with the ratio of the numbers of women in successive generations, allowing for the fact that migration as well as fertility will influence these numbers. This approach follows from initial work by Calot and Sardón (2001), which is closely related to the method used here, although age-specific fertility rates are required unlike in our case. A substantial number of alternative indicators of reproduction that include migration have been developed subsequently and are summarized and compared in Ediev et al. (2015, Table 1). The other main approach is concerned with incorporating differential fertility of first-generation migrant and indigenous groups and the construction of composite indicators

allowing for distortions in standard measures due to the migration event itself (Toulemon, 2004).

3 The total impact of migration is the difference between the loss of people and their subsequent progeny due to emigration and the corresponding gain due to immigrants. The standard assumption of no-migration scenarios produced by official agencies is that fertility and mortality rates are the same with and without migration, implicitly that rates of immigrants are the same as those of the destination population, whereas those of emigrants would have been the same as in their original population.

4 Studies that include both migrants and non-migrants are usually concerned with the relative numbers of the two groups. Even though it has been argued that "for demographic purposes, the continued separation of the components is essential for any meaningful analysis" (Ediev et al. 2014, p. 628), separation of the overall population into indigenous populations defined as those with long-term local ancestry and migrant populations is problematic. For separate analyses of sub-populations, information about the demographic characteristics of each group is also required, but these have been largely lacking until recent periods. While information about first-generation migrants is increasingly available, the long-term contribution of migration mainly arises from the fertility behavior of descendants of the original migrants. Information on second-generation migrants even now is not widely available, and it is almost non-existent for third and later generations. Over time, descendants of migrants tend to become more integrated through assimilation and intermarriage, hence separation into one of two groups becomes increasingly arbitrary (Edmonston 2010).

5 Le Bras (1991) estimated population sizes for seven countries around 1981–84 if there had been no migration from around 1946–51, three of which are also included here: France (1946–83), Italy (1951–81), and Sweden (1950–84). He was able to include differential fertility of immigrants in calculations, but I would contend that this is unnecessary over the extended period covered here. The 1946 baseline population used for

France in the immediate post–World War II period was substantially different from the one used here, so comparisons are not possible. French territorial boundaries were changed due to annexation in 1870, 1914–18, and 1939–45 (Glei et al. 2015). In the present analysis, the populations concerned would be treated as emigrants on annexation and as immigrants on re-unification, which should be borne in mind when interpreting French trends later. The baseline Italian population in 1951 was 0.6 million

larger than the one used here, but the difference between the no-migration and actual populations in 1981 estimated by Le Bras, 2.9 million, was very similar to the value of 3.0 million here. Swedish 1950 baseline and 1984 actual and no-migration values were identical in both analyses to those shown by Le Bras (1991, p. 19). I therefore conclude that results are reliable where it has been possible to cross-check them with an approach using more detailed data.

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