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New forecast: Population decline postponed in Europe

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Abstract. We present results of a probabilistic forecast for the population in 18 European countries, to 2050. Other forecasts have recently predicted a falling population size for those countries. However, there are reasons to expect higher immigration and lower mortality than the earlier forecasts did. Hence, we find that population decline is postponed in our forecast. The forecast also alerts us to the fact that many demographic developments cannot be forecasted accurately. Although ageing is certain, the extent to which this will occur is difficult to predict accurately. The number of elderly persons is very uncertain in the long run. This has major implications for all European countries in which reforms for pension systems and the provision of health care for the elderly are considered. The reforms must be robust against unexpected demographic developments.

Keywords: Population forecast, Europe, uncertainty, ageing

1. A probabilistic forecast for 18 European countries

The United Nations and Eurostat recently predicted that the population in 18 European countries will fall in the future. However, the results of a new forecast show that there is reason to expect higher immigration and lower mortality than that predicted by the UN and Eurostat. Hence, the population decline will happen later, and perhaps as late as 2050.

Demographers and statisticians from three European countries have analysed the demographic development of 18 European countries, which we shall denote as EEA+ countries. The group consists of the 15 members of the European Union pre-2004, plus Norway, Iceland, and Switzerland. Except for Switzerland, these countries made up the so-called European Economic Area, hence EEA+. (Liechtenstein has not been included.) We analysed historical developments in fertility, mortality, and migration, and we separated the time trend in these variables from random deviations from the trend. By giving estimates both for the time trends and the random deviations in the future, we were able to calculate forecast results

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in terms of probability distributions, thus quantifying forecast uncertainty. The forecast horizon was 2050. Many methodological details can be found at the web site http://www.stat.fi/tup/euupe/. The web site also contains forecast results for each of the 18 countries, including details of age and sex for ten-year intervals to 2050.

The UPE project. The new forecast was prepared by an international team of demographers and statisticians from Finland, the Netherlands, and Norway, in the framework of the project "Uncertain Population of Europe" (UPE). An important aim of the project was to compute the probability distributions of future demographic variables, such as population size, age groups etc. for each country and for the EEA+ as a whole. While such probabilistic demographic forecasts have been produced in the past for a few countries [1,2,11,14,17,19], one innovative aspect of the UPE-project is that it provides the first comprehensive look at empirical correlatedness of forecast errors in fertility, mortality, and international migration across countries. Probabilistic forecasts for major world regions have also been computed earlier, but estimates of the statistical dependency across regions were not empirically based [18] or had to rely on a limited data base [20].

The project was partly funded by the EU Commission (Contract HPSE-CT-2001-00095). The views expressed are those of the Project Team and they do not necessarily reflect the views of the Commission, or the views of the national statistical agencies in the three countries.

Based on our forecast, we expect a modest annual growth rate of 0.2 per cent for the population in the EEA+ countries in the years 2003–2050. This contrasts with recent predictions by the United Nations and Eurostat. In its 2004 Revision of World Population Prospects, the UN predicts that the population in the EEA+ countries will decrease in the years 2030–2050 from 407 million to 400 million, after an initial increase from the current level of 392 million [22]. In contrast, the new forecast anticipates 427 million inhabitants by 2050. Eurostat predicts that the 15 member countries of the former EU will have a population of 384 million in 2050, 7 per cent less than the new forecast [10]. The new forecast assumes higher life expectancy and higher immigration levels than both the UN and Eurostat predicted. However, population growth is modest because assumed future fertility levels are low, ranging from an expected 1.4 to 1.8 children per woman in the 18 countries. This will lead to an eventual decline, but later than has been thought until now.

2. Strongest growth in the UK, but German population remains largest

Although the population in the EEA+ countries as a whole is expected to grow, some countries may show a decline. Germany, whose 82 million inhabitants account for 21 per cent of the population in the area, is expected to remain the largest in 2050 but its population is expected to fall to 79 million (19 per cent) in 2050. However, France will increase from 60 to 67 million in 2050, which means that France will probably maintain its current share of 16 per cent. Population growth in France is only slightly lower than in the United Kingdom. The UK population is expected to increase from the current 59 million (15 per cent) to 68 million (16 per cent) in 2050. Italy is expected to loose more than one million inhabitants, from just over 57 million (15 per cent) today to 56 million (13 per cent) in 2050.

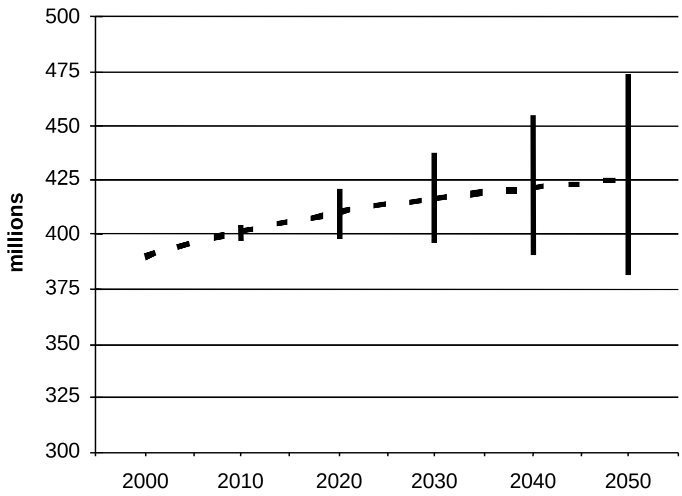

Fig. 1. Population size in EEA+-countries. The dashed line is the 50% line (or median): chances are 50% that population size in 2050 will be less than 425 million; but a population larger than 425 million is equally likely. The median is slightly lower than the expected value (427 million). The black vertical lines represent 80% intervals. There is an 80% probability (odds four to one) that population size in 2050 will be between 381 and 474 million. Thus chances are 10% that it will be less than 381 million, but also 10 % that it will be more than 474 million. Note that uncertainty regarding predicted population size increases over time, as the 80% intervals widen up rapidly. EEA+-countries include the 15 member countries of the old European Union plus Iceland, Norway, and Switzerland.

3. Population figures in 2050 very uncertain

In addition to predicting stronger population growth, the new forecast is also innovative because it quantifies demographic uncertainty. We have not only predicted the population as a number but as a complete probability distribution. The predicted number of 427 million inhabitants in 2050 is just one number in the distribution – the average value. We can interpret this as our best guess. However, since the future is uncertain, we cannot exclude the possibility that the population in EEA+ countries in 2050 will differ from 427 million. The forecast gives us probability estimates for such higher or lower numbers. For instance, the UN expects 400 million in 2050. The new forecast predicts with 77 per cent probability that there will be *more than 400 million* in 2050. In other words, the UN forecast is probably too low, but it is not impossible. In addition, there is an 83 per cent chance that the EEA+ population in 2050 will be larger than the current 392 million. Thus, although we expect an increase in the EEA+ population as a whole, a decline cannot be excluded, but it has a low probability.

We have summarised the probability distributions in the form of 80 per cent prediction intervals. Figure 1 shows that there is an 80 per cent probability for a population in EEA+ countries in 2050 of between 381 and 474 million. The margin is so wide because we cannot be very certain about demographic trends so far into the future. Prediction intervals for ten years ahead, for example, are much narrower. Among the three components that determine future population, international migration and the uncertainty attached to it strongly determines long-term uncertainty in population size. Uncertainty in the other two components, i.e. fertility and mortality, is somewhat less important. However these two components have an impact on the age structure of the population, both in the long and short term.

4. Ageing is certain

The new forecast confirms the message from earlier forecasts that there is hardly any doubt about ageing in the countries involved. At present, 17 per cent of the EEA+ population is aged 65 or older and this share is expected to increase to 29 per cent in 2050 (Fig. 2; the age pyramid for EEA+ countries). For every 100 persons aged 20–64 in 2050, we can expect 57 persons aged 65 and over. This so-called Old Age Dependency Ratio (OADR) will be twice as high in 2050 as its current value of 28 per 100.

The increase in the OADR is the main factor behind concerns about the sustainability of state pensions in many countries. In the future, the 65 and 65+ share will increase, and that of the 20 to 64 will fall. As early as 2010, it is almost one hundred per cent likely that the OADR value that year will be higher than the current 0.28, and this is no less likely for subsequent years. Although 0.57 is our best guess for the OADR in 2050, we cannot rule out a higher value: a value of at least 0.60 still has a probability of 23 per cent! At present, Ireland has the youngest age structure (11 per cent of the population is aged 65 or older) and Italy the oldest one (19 per cent). By the middle of the century, we can expect the lowest share of 65+ in the Netherlands (23 per cent), and the highest one in Spain (35 per cent). For the EEA+ as a whole, the share will be 29 per cent.

5. Lower mortality

There are three major reasons for more optimistic mortality assumptions. First, there is considerable room for improvement. Current life expectancies in the 18 countries range from a low 77.2 years in Belgium and Portugal, to high values of 79.9 years in Italy and Sweden, and 80.4 years in Iceland and Switzerland [8,10]. Japanese men and women have even higher life expectancies – the highest in the world at 81.8 years in 2002 (Japan Statistics Bureau 2005). Thus, the Japanese experience proves that higher life expectancies are a realistic possibility. Second, no matter how mortality is analysed (directly via mortality rates, via life expectancy, or via record life expectancy), all trends lead to higher life expectancies than assumed in past forecasts. For example, the record life expectancy has increased linearly by an average of 2.3 years per decade since 1840, when it was 44 years [21]. By record life expectancy, we mean the highest life expectancy observed internationally in a given year. There is no indication that the record life expectancy will be less, or stagnate, in the near future. Third, population forecasters have continuously underestimated the increases in future life expectancy. Ten-year life expectancy forecasts made by European statistical agencies after the Second World War were an average of 1.3 years too low. The difference was a total of 3.5 years for a forecast horizon of 20 years [15]. For these reasons, we assumed relatively high life expectancy values in 2050: they range from 84.5 years in the Netherlands to 88 years in Spain. The UN assumes lower values: between 82 (Greece) and 86.1 years (Iceland) [22]. Eurostat assumes life expectancies in 15 EU countries in 2050 that on average are 1.9 years (women) and 2.4 years (men) lower than ours.

6. Higher immigration

Future immigration to the EEA+ countries is likely to be higher than in the past. The gap in economic well-being between Europe and developing countries will continue to attract immigrants. Economic and political crises in the South and East will continue to put pressure on the wealthy EEA+ region. However, the ageing of European populations will make it necessary for the national governments not

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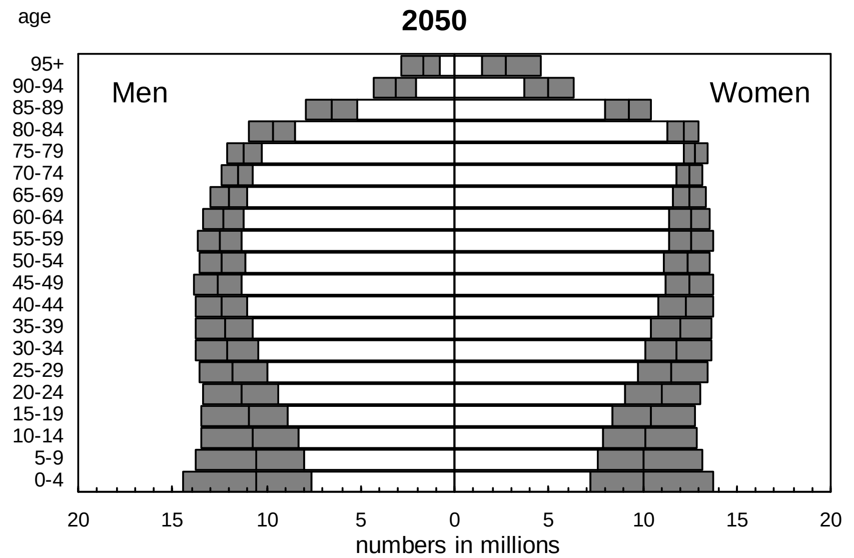

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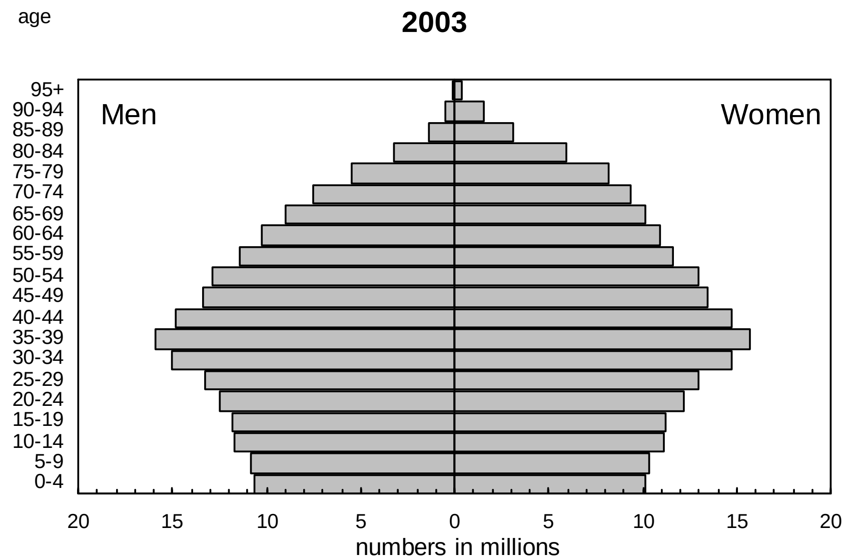

Fig. 2. (a). Age pyramid for EEA+-countries in 2050. The probability is 80 % (odds are four to one) that the number of boys aged 0–4 in the EEA+-countries in 2050 will be between 7.6 million and 14.4 million, see the grey bars (80% intervals). Chances are 50% that there will be at most 12.5 million women aged 65–69 in the EEA+-countries in 2050; see the black line (50% line) inside the grey bars. (b). Age pyramid for EEA+-countries in 2003. EEA+-countries include the 15 member countries of the old European Union plus Iceland, Norway, and Switzerland.

only to allow interested immigrants to come, but also that they actively seek new labour. For example, large numbers of elderly who need care will attract workers in the health sector from abroad. People would certainly be expected to come from the new EU member states, but also and primarily from

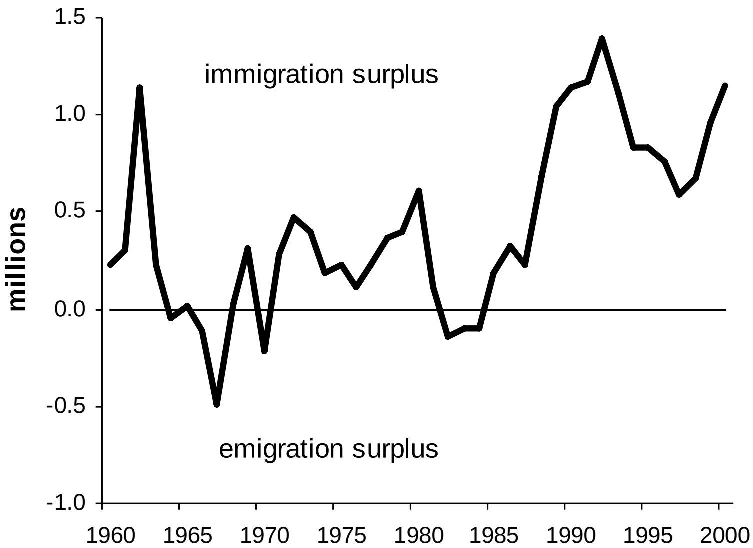

Fig. 3. Net migration into EEA+-countries. In 1962, independence of Algeria caused high migration to France. The peak in the early 1990s is caused by large migration flows from countries in Eastern Europe to the West, associated with the fall of the Iron Curtain, the reunification of the Germanys, and the war in the former Yugoslavia. EEA+-countries include the 15 member countries of the old European Union plus Iceland, Norway, and Switzerland.

outside Europe. As migrant populations are growing in EEA+ countries, family related migration is likely to increase in importance. However, business cycles and potential social tensions created by the transition of countries to a more multicultural society may lead to large fluctuations in migration flows, as has been the case in the past. However, the overall trend in net migration is upwards, as has been the case for the past 45 years (Fig. 3 – net immigration to the EEA+ region), and the assumption is that it will continue for the forthcoming decades. The new forecast assumes that by 2050 the annual level of net migration into the EEA+ countries is 1.3 million. The linear trend observed since 1960 (with considerable fluctuations) would have led to two million [15].

Germany, Italy, and Spain will receive most immigrants. By 2050, large annual immigration flows are expected for Germany (nearly 290 000 in terms of net immigration), Italy (260 000), and Spain (almost 180 000). Relative to current population size, affluent Luxembourg can expect to receive most immigrants in 2050: six per thousand, well above the EEA+ average of 3.4 per thousand.

7. Implications for welfare systems

This new forecast alerts us to the fact that we cannot foresee demographic developments accurately. This has major implications on how such issues as pension systems and the provision of health care for the elderly are studied. To recognize uncertainty this way leads to new criteria for evaluating policy reforms. In particular, a reform must be sufficiently robust so that unexpected demographic developments do not undermine its foundations or, say, put different cohorts in inequitable position relative to taxes and benefits.

As a first example, consider the analysis by Alho et al. into the sustainability of the pension system in Finland [5]. In the current system, pension benefits of persons born after 1947 are reduced when life expectancy increases. The actual reduction depends on the future longevity of an individual aged

62. However, this future longevity is estimated using *observed* mortality data during a five-year period *before* the individual becomes 62 years old. Thus there is no element of forecasting in the calculation, but individuals making career plans will be interested in possible pension reductions in the future and the uncertainty in those reductions. Alho et al. find that individuals born in 1968 should expect their pensions to be reduced by 8 per cent compared to the benefits that the 1947 cohort will receive, while the expected reduction is 13 per cent for individuals born in 1988. But future mortality is uncertain, and hence these reduction factors have a predictive distribution. Assuming that the volatility in Finnish mortality trends during the next 50 years does not exceed the volatility in mortality during 1900–1994, Alho et al. conclude that the 80 per cent prediction interval for the reduction factor of the 1968-cohort ranges from 0.86 to 0.99. For the 1988 cohort the interval is [0.78, 0.98]. Thus a person born in 1968 who is optimistic regarding mortality reduction might use the first decile (0.86) and decide to work longer or save more, than a pessimistic person born in the same year.

These findings are based on many assumptions, an important one being a fixed pension system. A second example illustrates possible changes in the pension system as a response to demographic uncertainty. Reforms of public old age pensions have been discussed in many countries in the past two decades, and in a number of cases, the reforms that were actually implemented included an increase in the retirement age. Such an increase reduces some of the problems in a public pension system based on the Pay As You Go principle, since workers extend the period over which they pay contributions to the pension system, and pensioners receive their benefits over a shorter period, other factors remaining the same. At a purely demographic level, the old-age dependency ratio (OADR) is the key variable that underlies pension costs. The OADR was defined above using a cut-off age equal to 65. But we can also use a more general definition. Suppose that the age at which people retire is R. Then define the OADR in general as the number of persons older than R years, as a ratio of the number of persons aged between 20 and R. By how much would the retirement age R have to rise in order to keep the OADR constant? For the case of Norway where the current retirement age is 67, Keilman [13] found that it has to be raised to 69.2 and to 71.9 years in 2030 and in 2050, respectively, if the aim is to keep the Norwegian OADR at 0.24, which is the level observed in the early 1990s. But demographic uncertainty suggests that predictive intervals for this retirement age are 67.9–70.6 years in 2030, and 68.7–75.1 years in 2050. The probability that the retirement age can remain unchanged while still having an OADR equal to 0.24, is only $2^1/_2$ per cent. Anderson et al. present similar results for the G7 countries [6].

These two examples illustrate how probabilistic forecasts can be used in analysing pension policy. The sustainability of other welfare provisions, such as public health care, have been analysed in a similar way. Lee and Miller give an example for the United States [16]. All these analyses are based on a probabilistic population forecast for just one country. But international bodies such as the OECD and the EU are concerned about the sustainability of welfare provisions in their member states. Thus one possible application of the multi-country forecast reported in this paper is the type of policy analyses prepared by the European Union (EU) for its member countries. EU's Economic Policy Committee monitors at regular intervals the financial impact of population ageing in member states, including tax revenues, unemployment benefits, and public expenditures on pensions, health care, and education [9]. These assessments do not include demographic uncertainty other than through sensitivity analyses implemented by means of high and low scenarios for key variables. In practice, we cannot know with certainty how future welfare systems will perform. Our proposal is to provide realistic descriptions of the future contingencies in a probabilistic fashion. The importance of conventional high and low scenarios without any probabilities attached to them is suspect, and their results are difficult to interpret. Analyses based on most likely assumptions have dominated, but they do not show us how robust welfare systems are against deviations of the most likely path.

In the past, the volatility of demographics has often been underestimated. Time and again demographic forecasters have been surprised about large errors in historical forecasts. The magnitude of demographic uncertainty should make us careful when recommending policies to avoid bad and unsustainable outcomes caused by ageing. For a risk-averse population the cost of future outcomes worse than expected outweigh the benefits of outcomes better than expected. Wise ageing policies should be especially robust against a worse demographic future than the expected one [5,7].

Appendix: Method and assumptions

We quantified uncertainty of a demographic forecast by applying the cohort-component book-keeping model for each country 3 000 times, with a deterministic jump-off population, and stochastically varying values for age-specific mortality, age-specific fertility, and net migration. The forecast horizon was 2050. The method is based on the so-called scaled model for error [3]. The main characteristics of the model in the current application are qualitatively as follows:

- Uncertainty in age-specific mortality and age-specific fertility was treated in the relative (logarithmic) scale, for net-migration uncertainty was treated in the additive scale;
- Uncertainty was assumed to increase with forecast year based on empirical analyses. Error increments were scaled such that they represented increasing patterns of error variances;
- Error increments of each age and sex group have a constant non-negative autocorrelation estimated from the data. Similarly, cross-correlation of errors across age were represented by an AR(1) process with empirically estimated correlations between neighbouring ages;
- Correlation between error increments in male and female mortality, in each age, was specified;
- Correlation between errors in male and female net migration was specified;
- Uncertainty in fertility, mortality, and migration were assumed to be independent of each other;
- A normal distribution was used to represent error increments for each age- and sex-group.

The forecast assumptions were based on three separate sources.

1. Time series analyses of age-specific (and total) fertility; age- and sex-specific mortality and life expectancy at birth; net migration by age and sex, relative to total population size.
2. Analyses of historical forecast errors for total fertility, life expectancies, and net migration.
3. Interviews with subject experts for fertility, mortality, and migration.

In practice, we derived initial guesses for point predictions of model parameters and for uncertainty parameters from time series analyses. These were adjusted, where necessary, based on historical forecast errors. We made some further adjustments to reflect expert views.

For fertility, we grouped all countries except Portugal in two clusters. For the Northern EEA+-cluster (Belgium, Denmark, Finland, France, Iceland, Ireland, Luxembourg, Netherlands, Norway, Sweden, and the United Kingdom), we assumed a point forecast for the total fertility in 2049 of 1.8 children per woman. For the Mediterranean and the German-speaking cluster (Austria, Germany, Greece, Italy, Spain and Switzerland) we expected a long-term level of 1.4 children per woman. For Portugal an intermediate level of 1.6 children per woman was assumed. The 80% intervals in 2049 range from 1.1 to 2.8 children per woman for the Northern cluster and from 0.9 to 2.2 children per woman for the other cluster. For the timing of children, we assumed that the mean age at motherhood will continue to increase in all countries, and eventually will converge to a level of 31 years.

For mortality, we assumed that recently observed declines in age-specific mortality for each country will change linearly over time towards an average, European, rate of improvement by the year 2030. The resulting expected gains in life expectancy at birth for men during the period 2002–2049 vary between 6.5 (Netherlands) to well over 10 years (Luxembourg, Portugal and Spain). For women slightly lower improvements are expected, varying from 5.7 (Netherlands) to 9.6 years (Ireland). The 80% prediction intervals in 2049 range from 7.4 years for Austrian females to almost 12 years for males in Luxembourg.

Forecasting international migration was seriously hampered by the data situation. Available international time-series are rather short, and in some cases of poor quality. This implies that more than for fertility and mortality, expert knowledge had to be involved. We detected in many countries a significant upward linear trend in net migration since 1960. However, it is very uncertain whether these linear, rising trends will persist in the future. For this reason several arguments were used to adjust the linear trend estimates downwards. We assumed that for the total of the 18 countries net migration per thousand population in 2000 will rise to a level of 3.5 in 2049. This is considerably less than the 5 per thousand according to the linear trend. Next, we made long-term country-specific assumptions on relative net migration, that varied from 1.5 (Finland, France, Iceland) to 6 per thousand (Luxembourg). The 80% prediction intervals are smallest in the Nordic countries. This reflects the good quality of migration data in these countries, which all have a population register.

We estimated cross-national correlations from correlation patterns in historical forecast errors and from the residuals of the time series models. We used an eigenvalue analysis (factor analysis) for the correlation matrices relating to the errors in total fertility and the life expectancy at birth, and to observed net migration. The analysis suggested for fertility a contrast between the Mediterranean countries (Greece, Italy, Portugal and Spain) and the other countries. For mortality, we found two groups of countries: Portugal and Spain on the one hand, and all other countries on the other. The factor analysis for net migration resulted in three regions: one consisting of Austria, Germany and Switzerland; a second one consisting of Greece, Italy, Portugal and Spain; and a rest group consisting of the remaining countries. Finally, cross-national correlations of both fertility and mortality were preserved in the subsequent national simulations by post-processing the simulation counts using the "method of seeds" [4]. Net migration numbers were generated in such a way that they are correlated across the countries according to the assumed cross-country correlation structures.

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