International Institute for
Applied Systems Analysis
Schlossplatz 1
A-2361 Laxenburg, Austria

Tel: +43 2236 807 342
Fax: +43 2236 71313
E-mail: publications@iiasa.ac.at
Web: www.iiasa.ac.at

Interim Report IR-07-024

The Contribution of Migration to Europe's Demographic Future: Projections for the EU-25 to 2050

Wolfgang Lutz (lutz@iiasa.ac.at)
Sergei Scherbov (scherbov@iiasa.ac.at)

Approved by

Leen Hordijk
Director

September 17, 2007

Contents

Abstract

This paper quantifies the extent to which different assumptions about net migration gains in the European Union contribute to future population growth and to diminishing the rate of population aging. This is done first in the context of probabilistic population projections, where the results of a model based on the full uncertainty distributions in fertility, mortality and migration are contrasted to an otherwise identical model in which a closed population is assumed, i.e., without migration gains or losses. The results show that without migration gains, Europe would be headed towards continuous population shrinkage. As a second approach, 25 scenarios are specified that combine five alternative future fertility levels (ranging from total fertility rates of 0.8 to 2.4) with five alternative migration levels (ranging from zero to 2.0 million annual net migration gains). The results show that fertility and migration have a compensatory relationship where, around the middle of the considered range, a fertility rate that is constantly 0.1 children higher has the same effect on the old-age dependency ratio as an additional constant annual migration gain of 375,000 at the level of the EU-25 by 2050.

About the Authors

Wolfgang Lutz is Leader of the World Population Program at IIASA, and Director of the Vienna Institute of Demography of the Austrian Academy of Sciences.

Sergei Scherbov is a Senior Research Scholar in the World Population Program at IIASA, and Leader of the Population Dynamics and Forecasting Research Group at the Vienna Institute of Demography of the Austrian Academy of Sciences.

The Contribution of Migration to Europe's Demographic Future: Projections for the EU-25 to 2050

Wolfgang Lutz and Sergei Scherbov

Europe is frequently called the "Old Continent" and it truly deserves this name in a demographic sense. With 38 years, Europe's population currently has the highest median age of any continent. By the middle of the century, the median age is likely to be as high as 52 years in Europe, while in the "New World," i.e., North America, the median age will only be around 42. All other continents will still be younger.

Europe has been spearheading global demographic trends in the 19th and 20th centuries, and it is likely to spearhead population aging in the 21st century. The population above age 60 has been increasing rapidly, and that below age 20 has been diminishing. Because of the very low levels of reproduction that prevailed in large parts of Europe over the past decades, the age structure of the population has already been altered to such a degree that there will be fewer and fewer women of reproductive age in the years to come; continued population aging and even shrinking is quasi pre-programmed (Lutz et al. 2003). The total population size of Europe is expected to decline in the long run, even when assuming sizeable immigration and continued increases in life expectancy. Without migration gains, Europe's population would age even more rapidly and population size would start to decline in the near future.

Although significant future population aging in Europe is a near certainty, the exact degree of aging will depend on future trends in fertility, mortality, and migration that cannot yet be fully anticipated. There is significant uncertainty around the three key questions: Will the birth rates in Europe recover, stay around the current level, or even continue to fall? Are we already close to a maximum life expectancy beyond which there will be no further decline in mortality rates? And how many migrants will enter Europe in the coming decades?

All three of these factors matter for the future population size and structure of Europe, but this paper will primarily focus on the role of migration in future population dynamics. This will be achieved by looking at different possible future migration regimes against the background of realistic ranges of future fertility and mortality changes. A short summary of the principles of population dynamics will be followed by a look at probabilistic population projections for the European Union and an attempt to quantify the importance of future migration for this outlook. The final part of the paper will explicitly and systematically address the frequently asked question: To what degree can immigration compensate for the low birth rate in Europe?

Population Dynamics

As compared to other social and economic factors, demographic trends are very stable and have a great momentum. For this reason, population dynamics can be projected with greater accuracy over a longer time span. Of course, such projections are not absolutely certain because human behavior is not purely deterministic and there can be unforeseen trends and disasters. But since most of the people who will live in 2020 are already alive today, we know with a high probability what the age structure of the labor force is likely to be in that year.

Future population size and age structures are determined by the present age structure and the future trends in three basic demographic components: fertility (birth rate), mortality (death rate) and migration. Any change in the population must operate through one of these three factors. But due to the great inertia of population dynamics, even rather rapid changes in one of the factors may take quite a long time to have an impact on the total population. If, for instance, smaller cohorts of women are entering the childbearing ages, even a possible increase in the mean number of children per woman may not lead to an increase in the total number of births. Similarly, the so-called "baby boom" of the 1960s (and not a discontinuity in life expectancy gains) is the main reason why we expect the proportion above age 60 to increase sharply after 2020.

The fact that there are only three factors to be considered in population projection does not necessarily make the task easier, because the projection of each of the factors is difficult and associated with significant uncertainties. Even the future of *mortality,* which traditionally has been considered the most stable demographic trend with steady improvements over the years, has recently become more uncertain. Over the last 50 years, life expectancy in Western Europe has increased by about 10 years, implying an average gain of two years per decade. Despite this significant gain that has surpassed all expectations expressed in earlier years, most statistical offices producing projections assume a slowing of improvements over the coming years, in some cases even constant life expectancy. Eurostat, the statistical office of the European Commission, assumes, in the medium projection, a gain in life expectancy at birth of about three years over a period of 20 years. But there is increasing scientific uncertainty about limits to human longevity and consequently about the future gains still to be expected. In contrast to the traditionally dominant view that we are already very close to such a limit (actually, the assumed limits are being constantly moved upwards by projectors as real gains surpass their expectations), alternative views suggest that such limits (if they even exist) might be well above 100 years. This scientific uncertainty about the future trends in old-age mortality also needs to be reflected in the population projections.

Fertility is the most influential of the three demographic components under a longer time horizon. Changes in fertility not only impact the number of children, but also the number of grandchildren, etc. For this reason, relatively small changes in fertility may have very significant consequences for population size and age structure in the longer run. Despite its significance, we know fairly little about the future trends of fertility in Europe. The history since World War II does not help us anticipate the future trend. During the baby boom, most Western European countries had period fertility rates of above 2.5 children per woman. This was followed by a rapid fertility decline during the 1970s, bringing the European average down to about 1.5. Since then we have seen diverging trends, typically at levels well below replacement fertility. The most significant fertility declines have appeared in the Mediterranean countries, with Italy and Spain having around 1.3 children per woman. Some of the Central and Eastern European countries have reached even lower levels, while France and the Northern European countries have showed somewhat higher levels. There have also been significant regional differentials within countries, e.g., between northern and southern Italy.

A further uncertainty is due to the fact that part of these trends is caused by the depressing effect of “tempo” changes, i.e., a postponement of births, and it is unclear for how long this will continue. There is no clear scientific paradigm to adequately anticipate future reproductive behavior. The notion of a “second demographic transition” has been suggested to capture these trends, but it does not say where and when the endpoint of this transition might be reached. For this reason, again, population projections need to reflect uncertainty through a range of fertility assumptions.

Migration is the most volatile of the three demographic components. The number of people entering or leaving a country can change from one year to the next due to political events or the enforcement of new legislation. The past 10 years have witnessed great ups and downs in European migration levels. The problem with projecting migration trends is not only the intrinsic difficulty of foreseeing such political events, but also the fact that net migration is the result of two partly independent streams (in-migration and out-migration) that depend on conditions in both sending and receiving countries. In this respect, projections can do little more than demonstrate the impacts of alternative net migration assumptions.

Policies to manage the future and meet the demographic challenges require the best available information about future demographic trends. The standard way to project the future population path, which is considered most likely by experts, is a well-established methodology, the so-called “cohort component” method. The more difficult issue is how to deal with uncertainty in future demographic trends. As indicated above, there are significant uncertainties associated with all three components: fertility, mortality, and migration.

The conventional way of handling these uncertainties is to produce different scenarios or variants that combine alternative fertility assumptions with single mortality and migration paths. The current practice of providing “high” and “low” variants to communicate uncertainty around the medium projection suffers from several drawbacks. The most important are: (a) In many cases, variants only address fertility uncertainty, ignoring mortality and migration uncertainty. (b) The variants approach is unspecific about the probability range covered by the high and low variants. (c) The variants are probabilistically inconsistent when aggregating over countries or regions because the chances of extreme outcomes in many countries or regions at once are portrayed as being the same as an extreme outcome in a single country or region. (d) The variants typically do not allow for fluctuations such as baby booms and busts that can produce bulges in the age structure. These problems can only be solved by turning to fully probabilistic projections to cover the uncertainty.

Probabilistic population projections are a rather recent methodological development about which a large body of literature has been written. The specific methodology applied in this paper has been extensively described elsewhere and cannot be described in detail here. The model specifications follow those of the 13 world regions (Lutz et al. 2001, 2004).

Comparing Population Outlooks

This section presents two different sets of probabilistic population projections for the EU-25 (the 25 member states of the European Union as of 2006). Both are based on identical assumptions about the future range of fertility and mortality, but have different migration assumptions. The case labeled "regular" considers the full range of uncertainty in future migration as it looks plausible from today's perspective. In the second case, which is labeled "no migration," the purely hypothetical, unrealistic case of Europe being entirely closed to migration is examined. The comparison between the two projections will allow us to evaluate the contribution of migration to Europe's demographic future.

The assumptions made closely resemble those of the Eurostat projections. A detailed documentation and description of methods is given in Scherbov and Mamolo (2006). In numerical terms, fertility for the EU-25 is assumed to show on average a minor recovery, with the total fertility rate (TFR) increasing from 1.52 children per woman in 2004 to a median of 1.60 in 2030. The 90 percent uncertainty range is assumed to cover the Eurostat high and low bounds of 1.9 and 1.3 children per woman, respectively. This range is kept constant after 2030. For female life expectancy, which for the EU-25 in 2004 stood at 81.3, we assumed that the median would see an increase of two years in life expectancy per decade with the 90 percent uncertainty interval covering a decadal gain between zero and four years. For male life expectancy, which in 2004 was 75.1, the same trend and uncertainty was assumed. Each uncertainty distribution is modeled in terms of a normal distribution with tails of 5 percent of the cases above and below the stated values.

For future migration into the EU-25 we also oriented our assumptions on the Eurostat projections. In the "regular" case (to distinguish it from the "no migration" case discussed below), the annual net migration gain for the EU in this decade was considered to span the three Eurostat scenarios which range from 928,000 to 1.6 million and assumed it covers 90 percent. From 2010 onwards we then take the best guess Eurostat assumption which fluctuates around a level of 800,000 net migration gains per year until 2050 and assume that the 90 percent range goes from zero net migration to double the Eurostat medium assumption. The assumed uncertainty distribution also implies that in 5 percent of the cases, Europe actually loses more people than it gains and in another 5 percent it will gain more than 1.6 million per year. In the alternative "no migration" case a closed population was assumed, i.e., the EU is neither winning nor losing people by migration. For each of the cases 1,000 independent population projections by single year of age and sex were performed drawing each year from the above-defined fertility, mortality, and migration distributions with stochastic annual fluctuations (which avoid traditional but unrealistic assumptions of linear trends, instead providing for more realistic annual ups and downs in rates).

Figures 1a and 1b show the resulting uncertainty distribution for the future total population size of the EU-25. They show that, as can be expected, the uncertainty range expands over time. For the coming decade, the range is very narrow, while in 2050 the 95 percent range goes from less than 400 million to well above 500 million inhabitants.

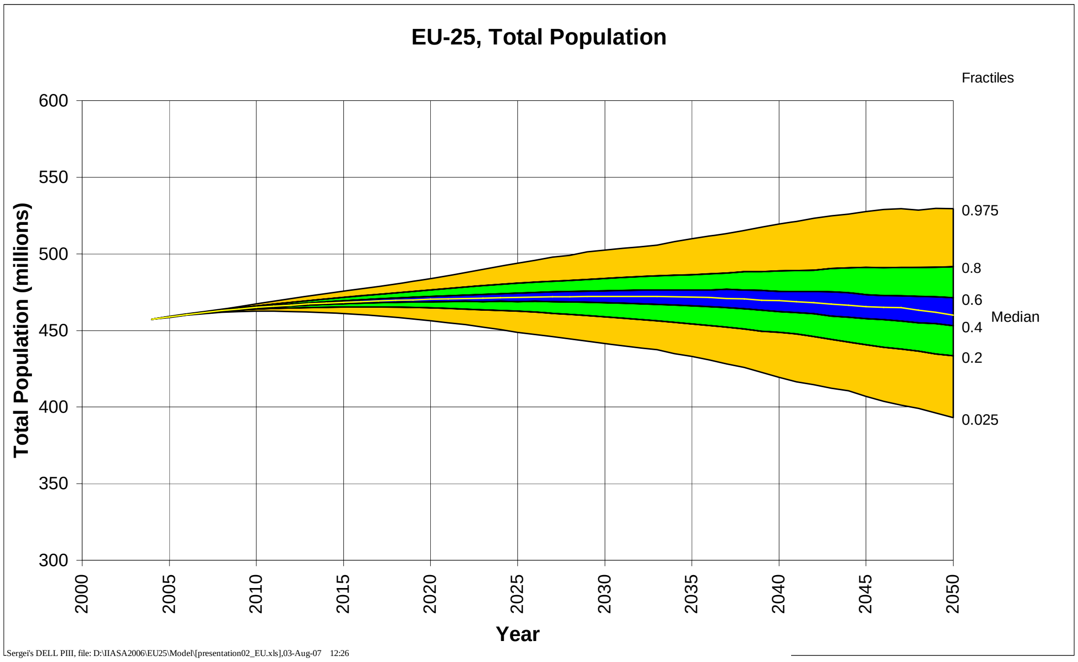

Figure 1a. Probabilistic projections for the total population size of the European Union (EU-25) including migration. Fractiles of the resulting uncertainty distributions.

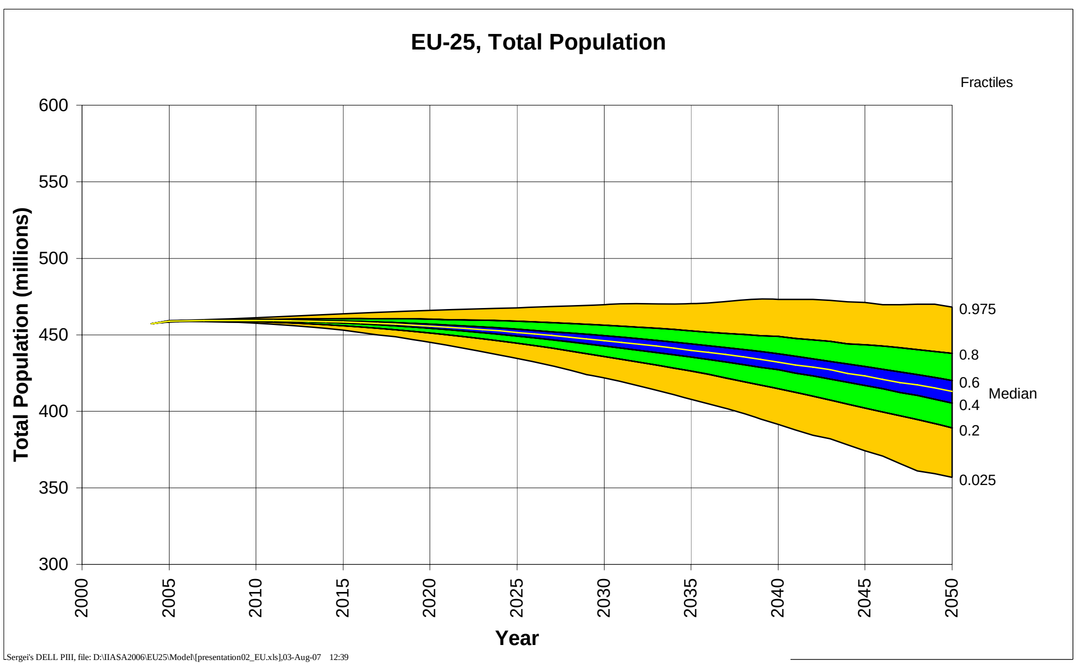

Figure 1b. Probabilistic projections for the total population size of the European Union (EU-25) assuming a closed population. Fractiles of the resulting uncertainty distributions.

In the "regular" case (Figure 1a), the total population of the EU 15 is still likely (in more than half of the simulations) to increase somewhat until around 2020 and then start to decline. The median of the projection shows a small increase from the current 457 million to 472 million in 2025, followed by a decline to 460 million in 2050 (see Table 1). In other words, even in the case of significant immigration (on average 800,000 per year) the population size in the EU-25 is likely to be about the same level in 2050 as it is today.

In the case of a hypothetically closed population (the "no migration" case shown in Figure 1b), the median starts to fall immediately. An initially moderate decline will then gain momentum over time and result in a rather steep decline after 2030. In this case, the median would decline by around 6 million by 2025, but by 45 million over the coming half century. A comparison of the two "trumpets" of uncertainty in Figures 1a and 1b shows that the uncertainty range for the "regular" case is broader than for the "no migration" case because of the added migration uncertainty, which makes a difference in the total uncertainty. The comparison of the two graphs shows that in the case of "no migration" the uncertainty is essentially downwards, i.e., the open question would not be whether the population declines, but by how much the population declines, depending on future fertility and mortality trends.

In 2050, the median of the "no migration" projection is 47 million lower than that of the "regular" projection. This is more than 10 percent of the total population of the EU-25. In other words, this shows that until mid-century, migration gains in the EU-25 are likely to make a difference of more than 10 percent in total population size.

But migration matters not only for population size; the speed and the degree of population aging are also sensitive to migration. Table 1 shows that the proportion of the population age 65 or above is almost certain to increase from its current level of 16.4 percent under practically all conditions, with or without migration. Any meaningfully assumed level of immigration, even when combined with high fertility and low gains in life expectancy, cannot stop a very significant increase in the proportion of the elderly. In terms of the medians, it would increase to 32.0 percent in the "regular" case and to 34.1 percent in the "no migration" case by 2050 (see Table 1). This difference looks relatively minor when compared to the huge change from the current 16.3 percent. This difference is 12 percent of the total expected increase; 88 percent of the increase is already embedded in the current age structure and is due to continued low fertility and increasing life expectancy.

Table 1. Total population (in millions) and proportion above age 65 in the EU-25 (medians with 80 percent uncertainty ranges), "regular" and "no migration" cases.

Year	Total Population (in millions)	Proportion 65+
2004	457	0.165
2025 "regular"	471 (457-485)	0.227 (0.214-0.239)
"no migration"	451 (441-462)	0.234 (0.222-0.247)
2050 "regular"	460 (417-506)	0.320 (0.272-0.365)
"no migration"	413 (376-450)	0.341 (0.291-0.384)

A look at the full age pyramids is very illuminating. Figure 2 shows the current age pyramid of the EU-25. The picture is clearly dominated by the so-called baby boom generation, those large cohorts born during the 1960s. Never before and never since have birth cohorts in Europe been that large. The pyramid is narrow at the bottom as a consequence of the decline in birth rates since the 1970s. This age structure has future population aging and even shrinking pre-programmed. At the moment, the sizes of younger cohorts are still a bit inflated by the fact that the large baby boom cohorts have just moved through their prime reproductive ages, increasing the number of potential mothers. Over the coming years, the number of potential mothers in Europe will significantly decline and therefore the number of births will go down, even in the unlikely case that fertility would fully recover to the replacement level of two surviving children.

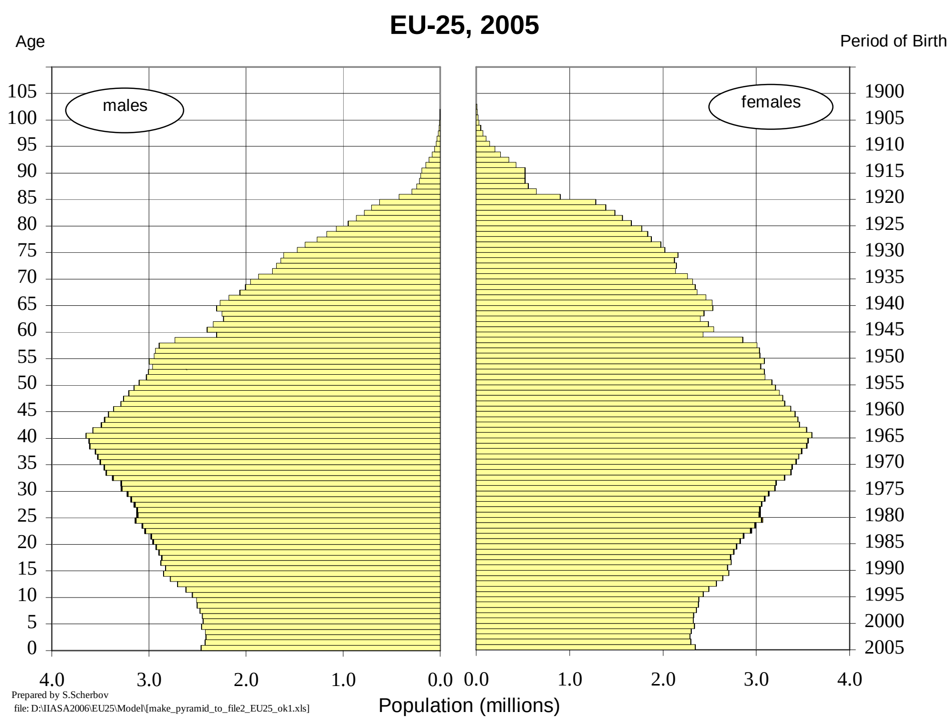

Figure 2. Age pyramid of the population of the European Union (EU-25) in 2005.

Figures 3a and 3b give probabilistic age pyramids for the population of the current EU-25 for the year 2050. These pictures are still dominated by the baby boom generation, which in 2050 will be above age 80. The female side of the pyramids shows that the cohort of women aged 80-85 is still likely to be the biggest cohort alive. This is difficult to imagine today, but especially in the “no migration” case, Figure 1b clearly shows that in 2050 no other age group of women will be as numerous as those aged 80-85. This incredible pattern is somewhat less pronounced for men because of their lower life expectancy. By 2050 a higher proportion of the male members of the baby boom generation will have died.

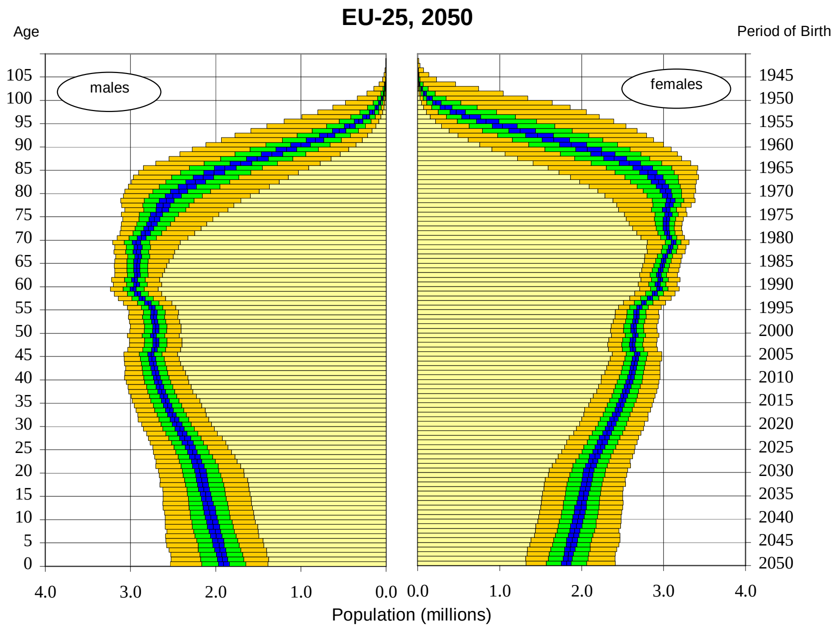

Figure 3a. Probabilistic population pyramids for the European Union (EU-25) for 2050, the "regular" projection. The different shadings refer to the fractiles of the uncertainty distributions (see Figure 1a).

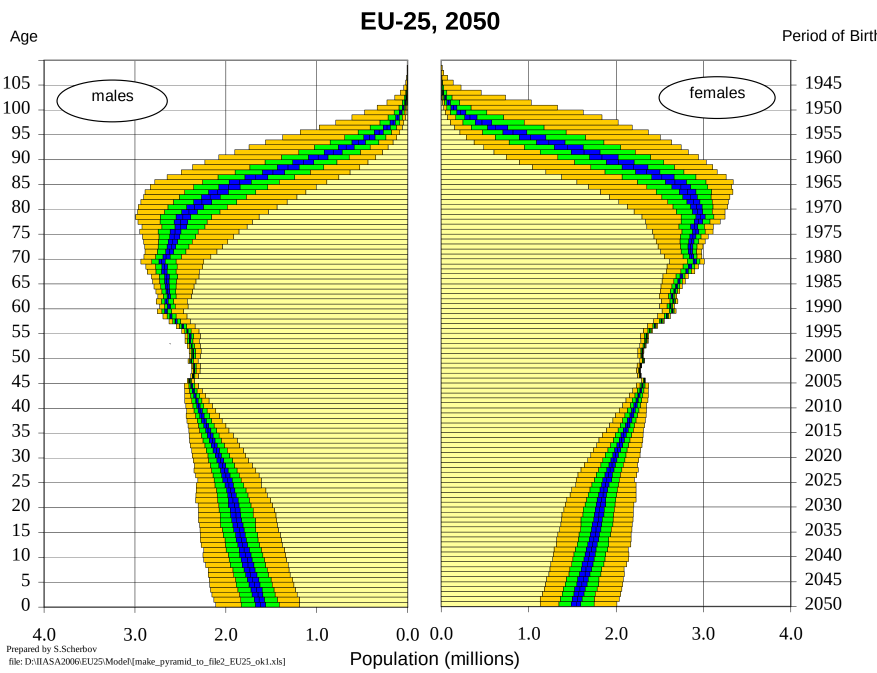

Figure 3b. Probabilistic population pyramids for the European Union (EU-25) for 2050, the "no migration" case. The different shadings refer to the fractiles of the uncertainty distributions (see Figure 1b).

Figures 3a and 3b also show how important fertility uncertainty is in the longer run. Under the “regular” projections, the 95 percent uncertainty range for children aged 0 to 1 is a full million children ranging from about 1.3 to 2.3 children. Uncertainty at the highest ages is even somewhat larger due to the uncertainty about the future increase in life expectancy. The range is smallest for ages 50-70, which are the cohorts born between 1980 and 2000. These cohorts are only affected by migration uncertainty because they are already alive today (we know the actual cohort size; there is no fertility uncertainty) and they have not yet entered the high mortality ages in which mortality uncertainty matters a lot. This is also evident in the “no migration” case (Figure 3b). For the cohorts born shortly before 2000, there is no uncertainty because in this projection there is zero migration and therefore no migration uncertainty.

In Figures 3a and 3b, a comparison between the two age pyramids illustrates visually what has been discussed about the contribution of migration to population size and aging above. In the “no migration” case the pyramid is narrower at the base because of fewer young people in Europe, and smaller in total area because of smaller total population size. The “regular” pyramid has a broader base because migrants tend to come at a younger age and because migrants also have children. These projections assume, for simplicity’s sake, that immigrants have the same average birth rates as the general population. If it is assumed that immigrants have on average more children, the difference between the two cases becomes even more pronounced.

Can Immigration Compensate for Low Fertility?

The second part of this paper chooses another demographic approach to studying the quantitative contribution of migration. Without considering the full uncertainty of future demographic trends, we focus on this specific question: What are the implications for Europe’s population size and structure of alternative future fertility levels combined with alternative levels of immigration? What follows presents the results of 25 scenarios that combine five different fertility levels with five different migration levels for the entire EU-25 taken together.

Figures 4 and 5 present selected findings from a large number of different simulations that were calculated at the level of the EU-25 with a population of 457 million in 2004. Since the discussion of this question mainly concerns the long-term impacts, the figures only show the results for 2050. They are based on alternative population projections in which fertility and net migration are kept constant over time at the level indicated (assuming an instant move to that level), while mortality – the third component of population change – is improving slowly, as assumed in the regular projections (the median of the above-discussed uncertainty distribution). The figures group the projection results by the assumed TFR ranging from 0.8 to 2.4. For 2004, Eurostat gives a TFR of 1.50 for the EU-25, which covers a range from the Czech Republic (1.22), Latvia (1.24), Slovakia (1.24) and Greece (1.29) at the lower end, to Finland (1.8), France (1.91), and Ireland (1.93) at the higher end. The different bars under each fertility assumption refer to different assumed levels of net migration gain, ranging from a zero annual net migration gain at the low end to a two million gain per year as the high extreme. For the coming years Eurostat assumes as the most likely trend a net migration gain of around 800,000 persons for the EU-25. Since trends are kept constant at the indicated levels the scenario assuming a net migration gain of two million per year adds up to 90 million over the projection horizon.

Figure 4 presents the results with respect to the total population size of the EU-25. Not surprisingly, the lowest population size in 2050 (315 million, or a 31 percent decline from today) results from the combination of a TFR of 0.8 with the assumption of zero net migration gains. At the high end, the combination of a TFR of 2.4 with a 2.0 million annual migration gain results in a population size of 703 million in 2050, which is an increase of 54 percent as compared to today. The figure shows the population size in 2004 as a horizontal line. Of all the alternative scenarios included in the figure, the ones with fertility below 1.6 point to population decline (except for 1.2 combined with a two million migration gain). Fertility of 1.6 and above, particularly when combined with high immigration, results in population growth. When comparing the figures, one has to keep in mind, however, that these are cumulative effects over four and a half decades, a rather long time span.

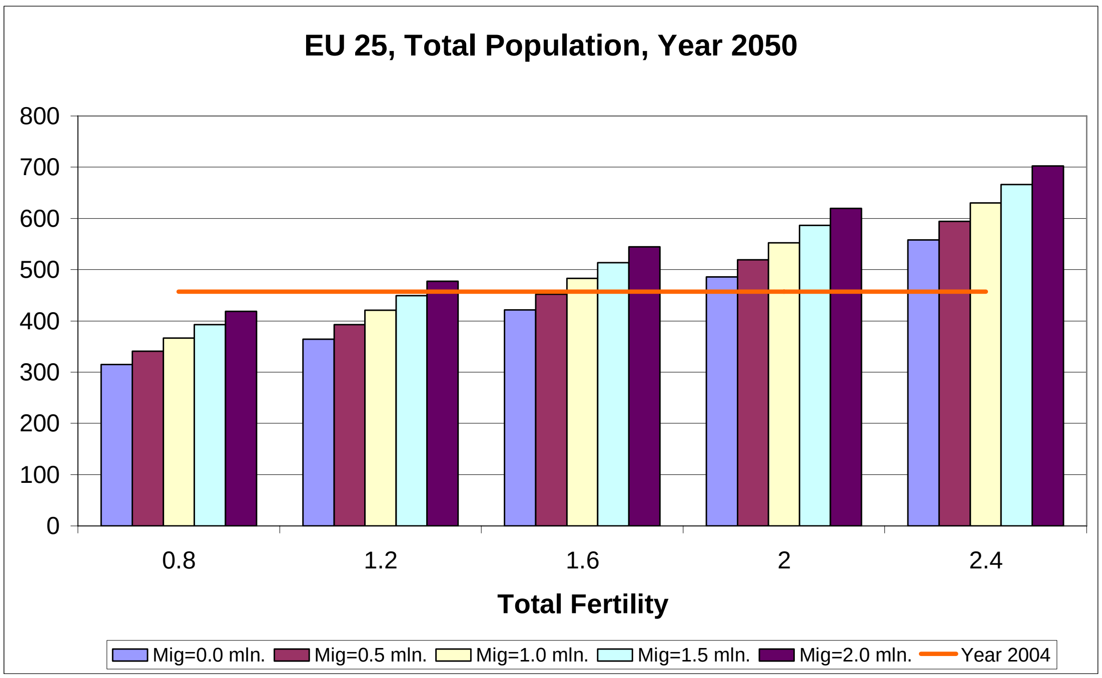

Figure 4. Total population (in millions) of the European Union (EU-25) in 2050, according to alternative projections assuming a wide range of fertility and annual net migration levels. The population size of 2004 is shown by a horizontal line.

Figure 5 shows that the population age structure is expected to change more rapidly and more profoundly than population size. There is no doubt about the direction of change, because all scenarios show an increase. The graph plots the so-called old-age dependency ratio, which is defined here as the proportion of the population above age 65 divided by the population aged 15-64. At the level of the EU-25 this ratio is presently 0.25, implying that there are currently four people in the hypothetical working age (in fact not all work) to every one person above age 65. Due to the inevitable changes that are mostly pre-programmed in the current age structure of the population, this ratio is bound to increase significantly under all scenarios, in most cases by a factor of two or more until 2050. It is interesting to see that even continued massive immigration to Europe makes little difference for the old-age dependency ratio. The positive impact of migration on the old-age dependency ratio is more pronounced in the case of very low assumed fertility and less pronounced for the higher fertility scenarios.

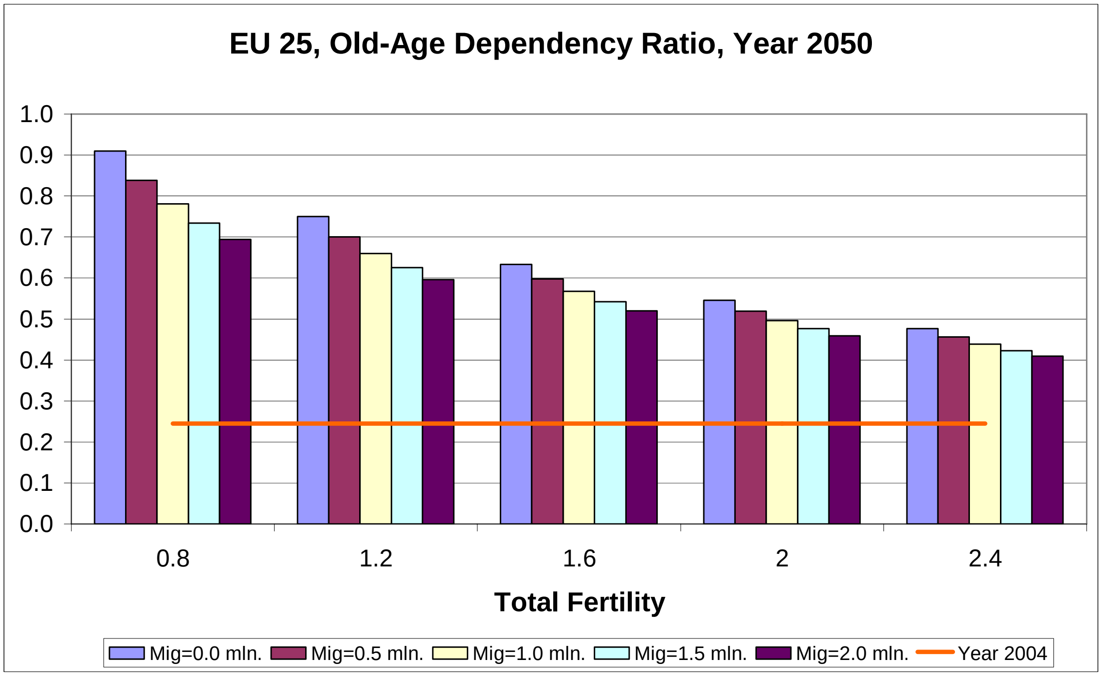

Figure 5. Old-age dependency ratio for the European Union (EU-25) in 2050, according to alternative projections assuming a wide range of fertility and annual net migration levels. The level in 2004 is shown by a horizontal line.

The analysis described above shows that there is a clear compensatory relationship between fertility and migration. It is interesting to compare the height of the different bars around the center of the range. A TFR of 1.6 combined with a migration gain of two million per year yields the same old-age dependency ratio in 2050 as a TFR of 2.0 and a migration gain of only half a million. In other words, an increase in 0.4 children per woman has the same effect as a four times higher migration. The same relationship holds when comparing the scenario of a TFR of only 1.2 which yields about the same old-age dependency ratio in combination with two million migrants per year as a TFR of 1.6 with only half a million migrants. In this sense an increase in the fertility rate of 0.1 children has about the same effect as an additional 375,000 immigrants per year. Toward both ends of the range of scenarios considered, this general relationship changes with migration making a bigger difference in case of very low fertility and less of a difference if combined with high fertility.

Discussion and Recommendations

The question discussed in this paper gained wide public prominence following the 2000 publication of a UN study entitled "Replacement Migration: Is it a solution to declining and aging populations?". This study presents several scenarios for a set of eight countries as well as Europe and the EU as aggregates. One scenario computes and assumes the migration required to maintain the size of the total population; another keeps the working-age population constant; yet another maintains the current support ratio, i.e., the proportion of the population aged 15-64 over the population 65 or older. For the individual countries, the results show that significant immigration can result in constant population sizes and even constant sizes of the working-age population, whereas the support ratio can only be maintained with implausibly high immigration levels. The absurd number of 5.1 billion immigrants necessary to maintain a constant support ratio until 2050 in the Republic of Korea has received a lot of attention in this context. For the EU-15, these UN calculations showed that a total of 47.5 million (or 0.95 million per year) migrants would be required to keep the population size constant; 79.4 million (or 1.6 million per year) would be needed to maintain the working-age population; and an impossible 674 million (13.5 million per year) would be needed to keep the support ratio constant. It was interesting to see that in terms of public reactions to these calculations, one could find opposing conclusions ranging from "immigration can never solve the aging problem" to "immigration is urgently needed to solve the aging problem."

This UN study chose an approach that works top down – or more precisely, "back from the future." A certain demographic target (such as keeping the working-age population constant) is set and then one calculates what immigration would be needed to achieve this goal, assuming invariant paths of future fertility and mortality. This paper does not set a target, but rather calculates the outcomes of possible variations in the future paths of all three demographic components: fertility, mortality, and migration. Since policy considerations typically are not based on a certain target in terms of demographic outcomes in the distant future that is difficult to establish and defend substantively, but rather work in terms of processes evolving over time, the approach presented in this paper may be more relevant for policy discussions about migration in the context of an aging European population.

From the analysis above, two specific policy recommendations can be drawn:

1. It is not correct to speak of a "need of migrants for demographic reasons," a phrase often heard in policy circles. Demography and exercises in population dynamics of the kind presented in this paper are transparent and objective calculations that do not prove or disprove any "need." Demography can show that with near certainty in Europe, the ratio, e.g., of people aged 20-30 to people aged 60 and above will decline over the coming decades. Whether or not this is seen as a serious problem depends on judgments about the consequences of such trends that have little to do with demography. Even if it is considered a problem and fertility is not considered a policy variable, immigration is not the only remaining solution; there are other possible counter-strategies, such as increased female labor force participation, increases in the age of retirement, or faster gains in labor productivity through better, continued education. Having said this, it is difficult to imagine that a Europe entirely closed to migration would not suffer welfare losses.

2. Of the three determinants of population change, only fertility and migration can be subject to influence by policies in order to diminish the speed of aging (for mortality, only interventions that continue to bring down old-age mortality are acceptable, although they reinforce population aging). It is important to be clear that fertility and migration have a very different timing with respect to their impacts on population dynamics. Migrants can be let into the country at rather short notice (provided that the mechanisms are in place) at the time when a labor shortage is imminent. In contrast, policies aimed at increasing the birth rate need more than two decades in order to result in additional educated members in the labor force. This crucial difference in timing is often forgotten in the debates, but it makes a big difference when it comes to the planning of policies.

References

Lutz, W., W.C. Sanderson, and S. Scherbov. 2004. The end of world population growth. Pages 17-83 in W. Lutz, W.C. Sanderson, and S. Scherbov (eds.), *The End of World Population Growth in the 21st Century: New Challenges for Human Capital Formation and Sustainable Development.* London: Earthscan.

Lutz, W., B.C. O'Neill, and S. Scherbov. 2003. Europe's population at a turning point. *Science* 299: 1991-1992.

Lutz, W., W.C. Sanderson, and S. Scherbov. 2001. The end of world population growth. *Nature* 412: 543-545.

Scherbov, S. and M. Mamola. 2006. Probabilistic Population Projections for the EU-25. European Demographic Research Papers, 2006/2. Vienna: Vienna Institute of Demography of the Austrian Academy of Sciences. Can be downloaded at http://www.oeaw.ac.at/vid/publications/p_demographicresearchpapers.shtml

United Nations. 2000. *Replacement Migration: Is it a Solution to Declining and Aging Populations?* New York: United Nations Population Division, ESA/P/WP.160.