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Population Projections Revisited:

Moving beyond convenient assumptions on fertility, mortality and migration

Part 1:
Revisiting the Projection Assumptions on Demographic Drivers by International Organization, National Institutes, and Academic Literature

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Population Projections Revisited: Moving beyond convenient assumptions on fertility, mortality and migration – 1st quarter 2015

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The views and conclusions cannot be attributed to any institution with which we are associated, and all remaining errors are our responsibility.

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Abstract

Pension systems and reforms are critically influenced by demographic developments that are increasingly compared across countries to identify common issues and trends. For demographic projections researchers across the world rely on those produced by the United Nations (UN); for Europe the demographic projections by Eurostat form the basis of the periodic aging report by the EU Commission. While these projections are technically well done the underlying assumptions for the demographic drivers – fertility, mortality and migration – in the central variants are limited and are largely flawed. Worse, they risk offering a wrong picture about the likely future developments and the relevant alternatives. This paper investigates the assumptions of the demographic drivers by UN and Eurostat, compares it with those by national projections in Portugal and Spain, and offers a review of alternative, recent and cutting edge approaches to project demographic drivers that go beyond the use of past demographic developments. They suggest that economic and other socio-economic developments have a main bearing on future trends in fertility, mortality and migration. And they support the assessment that the UN/Eurostat projected re-increase in fertility rates may not take place, that the increase in life expectancy may be much larger, that the future flows of net migrants to EU countries may be much higher and rising. The resulting overall underestimation of population aging has a bearing on the financial sustainability of the pension systems and reform choices, a topic to be explored in the next papers.

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1. Introduction: Background, Objectives and Structure

Demographic structures have a major bearing on the financial sustainability of pension schemes whether unfunded or funded, and demographic projections provide an important signaling tool for policy makers and the population at large on the need to adjust pension programs accordingly. A critical benchmark for policy reform pressure are demographic and financial sustainability projections in other countries as moving in a herd makes policy makers and countries more comfortable.

To this end policy researchers and policy makers rely worldwide and in Europe typically on the demographic projections by the UN. These projections are technically well done and accessible via the internet but have a main problem – the underlying assumptions for the 8 published variants are limited and are largely flawed. Worse, they risk offering a wrong picture about the likely future development and the relevant alternatives. Very briefly: The main fertility variant assumes a long-term convergence of countries toward replacement level (for those currently below and above). This may be politically expedient but is in contrasts to scientific results on the determinants of fertility over the last 100+ years. The alternative variants tend to be too optimistic: Too high increases in fertility for the rich countries, too high reduction for the poorest ones. The main mortality assumption is too pessimistic about future progress (the only alternative variant is constant mortality). And the main migration assumption is a migration balance between countries broadly reflecting recent levels that converge as of 2050 toward zero (!) at the end of the projection period in 2100 (the only alternative variant is no migration at all).

Against this background this publication project has three objectives and proceeds in three parts, i.e. papers. Part 1 and this paper present the demographic assumptions by international organizations, in particular the UN, Eurostat for European Countries, and Portuguese and Spanish National Statistical offices for their country' population projections. These assumptions and underlying concepts are compared and evaluated against the broader economic/empirical literature that explains the demographic drivers - fertility, mortality and migration - not only through self-contained demographic models but economic drivers such as income level, income dynamics and income gaps. Part 2 and the next paper will explore the effects of differences in driver assumptions on demographic outcomes, in particular median age, old-age share and demographic old-age dependency ratio with retrospective and prospective old-age definition. In a first stage the paper will have to rely on and exploit existing demographic projections to offer results. In a second stage it may be possible and useful, at least for Portugal and Spain, to engage with forecast institution to derive new population projections and results. Part 3 and the final paper will assess the implications of more realistic demographic assumptions and outcomes on the key policy areas, i.e. family policy, labor market policy and pension system reform. To this end we may present (a) the policy approaches for and trade-off between family policy and migration policy, and the experience of countries; (b) the labor market implications of different scenarios and policies for different scenarios to address them; and (c) the implication of the demographic scenarios for pension policy and the demands/ requirements on pension systems and their reforms. Conclusions and proposals for next step are provided at the end.

This paper reviews the assumptions by the UN and other international organizations on fertility, mortality and migration in comparison to the recent academic literature on past drivers and future trends as well as national (and European) developments and forecasts. This should allow an assessment to what extent the assumptions and in consequence the existing cross-country demographic projections need to be taken with a grain of salt and reconsidered, and in which direction such assumptions may be directed.

To this end, the structure of this paper is as follows: Section 2 presents the assumptions on the key demographic drivers – fertility, life expectancy and net migration - underlying the existing country projections by international organizations (UN, World Bank), by Eurostat for the EU countries, and by the key Spanish and Portuguese demographic research institutions, explores the communalities and differences, and briefly surveys the quoted literature that has been used to this end, if available. Section 3 reviews and presents alternative recent academic literature that uses long-term data sets to determine empirically trends and drivers of past developments as well as their economic determinants. The latter aspect is typically missing in population projections undertaken by demographers. The information of both sub-sections set should form the background for an assessment and suggestions in what direction assumptions for revised demographic projections should be developed (presented in Section 4). The final Section 5 offers brief summary and first directions for the other two parts/papers.

2. The assumptions on demographic drivers in institutional forecasts

To assess the challenges that future demographic changes represent to age-related expenditure programs so as to shed light on the economic challenges that policy-makers will have to face, it is essential to consider the age-structure of the population today and how it will evolve in coming decades. The dynamics of a given population depend on its initial age-age structure and on key demographic determinants, namely: (i) total and age-specific fertility rates; (ii) age-specific mortality rates and (iii) the level and age composition of net migration. Official population projections are normally prepared by national statistical offices for their own countries (such as for Portugal and Spain) that in some cases may cover all countries (such as by the US Census Bureau), supranational institutions (such as Eurostat for the EU), international organizations (in particular UN, to some extent World Bank) and sporadically some international research institutes (such as IIASA – International Institute for Applied System Analyses). The long-term population projections provide an indication of the timing and scale of demographic changes that would result from a combination of expert-based assumptions and statistical modelling of demographic determinants in a "no-policy change" scenario. To a certain extent, they are helpful in highlighting the immediate and future policy challenges posed for governments by long term trends of the demographic drivers.

Population projections are computational procedures to calculate population size and structure at some future moment based on its initial figures, together with a specification of how change takes place during the interim period. These projections are produced using a cohort-component method and are based on assumptions about demographic drivers of change (future births, deaths, and net international migration).

The computational procedure begins with an estimated base population, consistent with the most recent census data. First, components of population change (mortality, fertility, and net international migration) are projected based on time series analysis of historical trends and the adoption of stochastic methods. Next, for each passing year, the population is aged one year and the new age categories are updated using the projected survival rates and age and sex specific levels of net international migration for that year. A new birth cohort is then added to form the population under one year of age by applying projected age-specific fertility rates to the average female (of childbearing age) population and assumptions on the dynamics of the sex ratio at birth. The new birth cohort is updated for the effects of mortality and net international migration.

Formally, the cohort-component method is based on the demographic balancing equation for each sex and cohort:

$$P_{t+n} = P_t + N_{t,t+n} - D_{t,t,+n} + I_{t,t+n} - E_{t,t+n}$$

where P_t and P_{t+n} denote, respectively, the population at time t and t+n, $N_{t,t+n}$ is the number of birth between t and t+n, $D_{t,t+n}$ represents the number of deaths between t and t+n; $I_{t,t+n}$ and $E_{t,t+n}$ denote, respectively the number of international immigrants and emigrants between t and t+n.

The period n considered is typically one year for national population projections but for data and other reasons it is typically 5 years in large-scale international projections.

The drivers of the population dynamics – births, death, and migration – are calculated on assumptions related to the existing population structure through the application of fertility rates per female age group (say 15 to 45), mortality rates and migration rates to all age groups and by gender. And it is these future projected rates by age group and gender – for fertility, mortality and migration – and their surrounding assumptions and models the population projections are built. And it is the assumptions and models about these rates this paper is about[1].

The way in which these deterministic projection variants are being constructed has been questioned due to its insufficient theoretical foundations and to the lack of information on the assumptions used to establish the different paths for the future levels of the demographic components.

Because of this, in the 1990s a number of papers argued for the need to move away from variant-style projections to probabilistic ones (see, e.g., Lee and Tuljapurkar, 1994; Lutz, 1996; Bongaarts and Bulatao, 2000). From the methodological point of view, the advantages seem to be clear: probabilistic projections specify the likelihood that a particular future population value will occur given a set of assumptions about the underlying probability distributions.

On the other hand, with variant projections the user has no idea how likely they are. This means that users have to trust that the experts have provided them with plausible scenarios representing the "most likely" (the central projection) and the variants (the high and low population projections). In both cases, the quality of the forecasts depends on the quality of the input data, on the projection models and on the assumptions made.

Despite the advantages of a probabilistic approach, nearly all national statistical offices in the world (including the Portuguese and the Spanish) still rely on deterministic

[1] Applying the same projected rates to different starting population structures leads to a different dynamics for many decades. For this reason the initial population structure is often considered as a 4th demographic driver in demographic discussions.

variant projections to accomodate uncertainty. Uncertainty in population projections come from four main sources: the projection model(s), parameter estimates, expert judgments and historical data. Uncertainty can also be based on the results of past projections.

Uncertainty in projections can be ignored, described using various plausible scenarios or quantified using probabilities. The deterministic scenarios can be data-driven, i.e., based on simple mathematical extrapolations of past trends, or expert-driven, that is, relying mainly on expert judgment. Similarly, stochastic (probabilistic) projections can be based on time series analysis or extrapolation of past projection errors, or based on expert opinion used to assess the future uncertainty.

In what follows we provide details about the methods used to project fertility rates, mortality rates, and future levels of net international migration in international and national population projections and the way they address the uncertainty in these projections.

a. UN Population Projections

The key institution for comparable demographic projections across countries is the UN, with the Population Division of the Department of Economics and Social affairs in charge of the demographic scenarios developed. All other international organizations use this data or make institution-specific minor adjustments around their medium (normal) projection, such as the World Bank. For this reason the UN demographic projections have such an importance in the pension world and such a wide use in policy and research. The assumptions and projections are subject to an elaborate participatory process and well documented[2]. This comprehensive process may explain why assumption and projections are little questioned and subject to external critique.

The projections prepared by the UN Population Division are based on a theoretical framework known as demographic transition (see, for example, Chesnais, 1992). Over the course of the demographic transition, populations move from a regime of high mortality and high fertility to a regime of low mortality and low fertility. Over time rapid population growth takes place because mortality decline typically begins before fertility decline: as death rates fall but birth rates remain high, the number of births exceeds the number of deaths and population therefore grows. The countries that are still in the beginning or in the middle of the demographic transition are expected to complete their transitions over the next several decades. Both fertility and mortality levels in these countries are assumed to decline. For the countries that have already completed their demographic transitions, mortality is still assumed to be declining but fertility is expected to fluctuate around or below a level of about two children per woman. For the countries with natural growth close to zero (i.e., when the number of deaths is close to equal to the number of births), future population trajectories are to a greater extent influenced by assumptions about future migration in or out of the countries. Future population trajectories therefore depend on assumptions about future trends in fertility, mortality and migration. In addition, the current population age structure influences future growth by actually affecting the overall number of births, deaths and migrations that are implied by fertility, mortality and migration rates. All four demographic components can have a significant impact, positive or negative, on future population growth (UN, 2014a).

Fertility Projections:

Against the background of the demographic transition model, the UN defines three groups of countries in transition for which special modeling techniques are applied and assumptions made:

- Group 1: High-fertility countries: Countries that until 2010 had no fertility reduction or only an incipient decline;
- Group 2: Medium-fertility countries: Countries where fertility has been declining but whose estimated level is above the replacement level of 2.1 children per woman in 2005-2010;
- Group 3: Low-fertility countries: Countries with total fertility at or below the replacement level of 2.1 children per woman in 2005-2010.

This differentiation by groups has been a main characteristic of UN projections over recent decades. While the key assumptions for all countries within a group were originally identical they become somewhat more differentiated over time. E.g. since the last (2010) projection, the 2012 takes somewhat account that in Group 1 that in some countries the fertility decline has not happened as envisaged or even increased. For Group 3 (which includes Portugal and Spain), the original assumption was a re-increase in the total fertility rate to replacement rate of 2.1 children per woman. In the 2010 projection this common convergence rate within the projection period was somewhat reduced. The 2012 projection allows for some differentiation across countries according differences in trends with an average for Western Europe by 2100 of 1.90 (UN, 2012, Vol. II, p. 27).

Overall, a mechanical statistical approach against the background of the transition model is applied to forecast the future fertility rates of countries. It has a (nowadays slightly) differentiated convergence path with somewhat different levels at the end of the projection period in 2100, with the convergence path driven and estimated by most recent data[3]. The ultimate maximum convergence level for low fertility countries is still left at 2.1. Stronger differentiation in the convergence path based on most recent data is also introduced for the convergence from

[2] See http://esa.un.org/wpp/

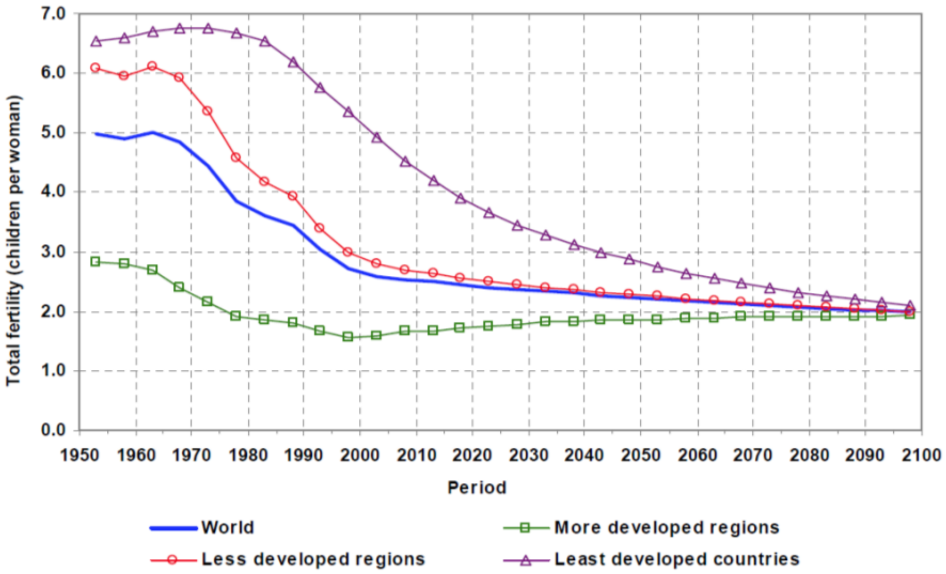
[3] Group 3 convergence is modelled with a first order auto-regressive time series model (AR(1)) in a Bayesian hierarchical framework. See UN (2014a) for more technical details.

above for group 1 and 2 but the assumption of a below reproduction level final convergence is retained.

Figure 1 exhibits the convergence paths for the World (i.e. average of all countries) and the main country groupings by the UN: More developed countries that have essentially all a convergence from a above; less developed countries where the fertility is mostly in full decline but that includes also countries with rates below replacement level (such as Sri Lanka); and the least developed countries where there are countries (in Africa) where fertility decline has not yet started or have known recently reverses.

The broad but not full alignment of transition stage with broad economic development level indicates that there are differences in speed and convergence levels that are not well captured in the current statistical approach of projection that uses only historical demographic information. Furthermore, there may be other considerations that speak for differences in the convergence levels in the short and long run, a point that will be taken-up later in the paper.

Figure 1. Total fertility trajectories for the world and development groups, 1950-2100 (medium variant)



Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2013). *World Population Prospects: The 2012 Revision*. New York: United Nations.

In addition to the medium variant 4 other fertility paths are projected in scenario calculations: a low fertility variant that subtracts 0.5 (children) in each year from the medium fertility level of a country; the high fertility variant adds 0.5; a constant fertility variant that keeps fertility at the level of the period 2005/10 throughput the whole projection period; and an instant replacement fertility variant that selects the fertility level in such a way that would keep the population constant assuming no change in mortality and net migration.

<u>Mortality/life-expectancy Projections:</u>

The 2012 projections use new approaches to project improvements in mortality and thus longevity in countries. In summary, the key elements of these projections are as follows:

- The projections differentiate between countries without and with HIV epidemics (the latter are not discussed here).
- The standard mortality projection assumption used for the 2012 Revision introduced two innovations: (1) future values of female life expectancy at birth are now based on a probabilistic projection model of life expectancy at birth (modelled as a random walk with drift where the drift is determined by a Bayesian Hierarchical Model), and (2) future male life expectancies at birth take into account the correlation between female and male life expectancies and the empirical regularity that life expectancy is typically higher for females than for males.
- The life expectancy estimation use the empirically documented improvements of female life expectancy at birth as the starting position, taking account of the almost linear gains over decades that can be differentiated by the reached levels of life-expectancy across countries.

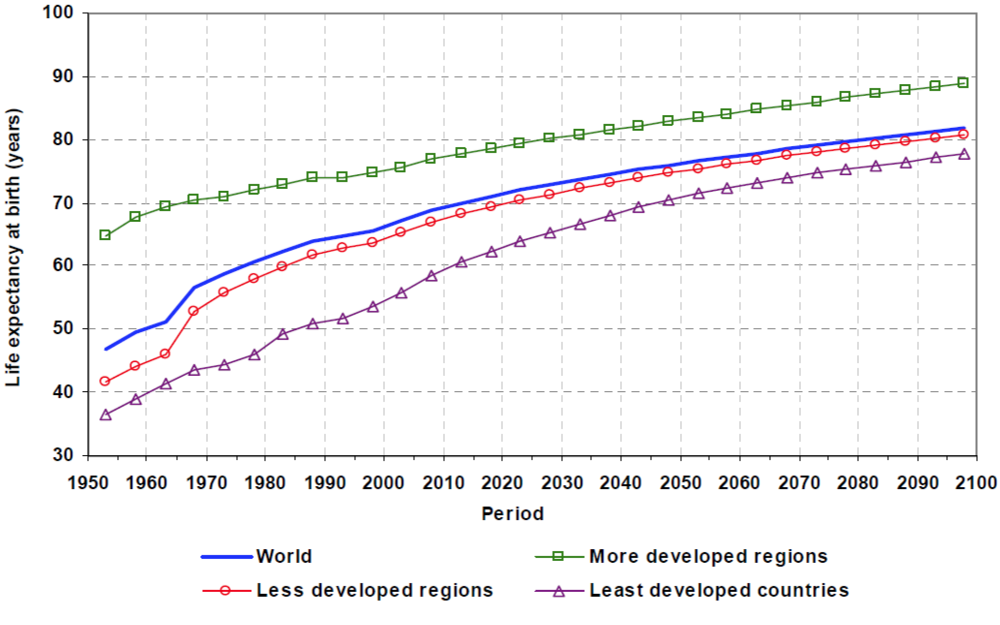
- For all countries undergoing mortality transition, the pace of improvement in life expectancy at birth is decomposed into a systematic decline and random distortion terms.
- To construct projections of female life expectancy at birth for a country, the Bayesian Hierarchical Model was used to generate 1,450,000 double-logistic curves for each country, representing the uncertainty in the double-logistic gain function. A 1/14 sample of double-logistic curves is then used to calculate over 100,000 life expectancy projections for each country. The median of these 100,000 trajectories is used as the standard mortality projection in the World Population Prospects.
- To construct projections of male life expectancy at birth, the gender gap autoregressive model was then used in conjunction with probabilistic projections of female life expectancy at birth to generate 100,000 trajectories for each country, representing the uncertainty in the future gap between female and male life expectancy projections.
- The sample of gender gap trajectories was then used to calculate over 100,000 male life expectancy projections for each country. The median of these projections was used as the standard mortality projection in the World Population Prospects.
- Once the path of future expectation of life was determined, mortality rates by five-year age group and sex that are consistent with the expectation of life at birth for each quinquennium were calculated.

This quite sophisticated statistical approach signals the difficulty of modeling and estimating future changes (i.e. improvements) in life expectancy. In the past such improvements have essentially always been underestimated, i.e. actual life expectancy increased faster than the projected one. This new modelling and estimation approach attempts to overcome this weakness while having a globally applicable framework. Whether this will do justice to high-income countries will need to be seen. Therefore, essentially most and soon all of the future gains in life expectancy at birth will happen after retirement as mortality till this age is already very low. However, the modelling of such gains is fraught with uncertainties as sparse data on mortality rates for the highest age groups indicate flattening or even decreases; it is unclear whether these are temporary and cohort specific phenomena or a general trend (taken up again later in the paper).

Figure 2 highlights the projected life expectancy for the world and the three UN development regions. As visible, for the world the projections assume a further increase but with slowing pace that is driven by low and least developed regions and their slowing progress in improvement (also due to HIV epidemics). In contrast, for more developed regions the projections foresee an almost linear improvement that is much more in line with past experience. Yet further under-estimations given past developments are still not excluded.

There are no other mortality/longevity variants to the presented medium (or most probable) variant.

Figure 2. Life expectancy at birth for the world and development groups, 1950-2100



Migration Projections:

The UN population team acknowledges very frankly that migration flows are difficult to predict as they depend on economic, political, demographic, and increasingly (again) environmental developments that are difficult to foresee and even more difficult to put into numbers, also because they have to be symmetrical between countries.

The UN projections allow for differentiation between migrants (voluntary) and refugees (involuntary), as well as by gender and by age groups. The latter differentiation is critical as it has main effects on population dynamics, if sustained, but it is also most difficult to get data for disaggregation.

The UN projects only the net migration flows between countries (i.e. immigration minus emigration) and these flows have to be symmetrical in size and structure (by age groups and gender) between countries.

Only two scenarios are considered: Normal migration assumption, and zero (net) migration assumption.

Under the **normal migration assumption**, the future path of international migration is set on the basis of past international migration estimates and consideration of the policy stance of each country with regard to future international migration flows. Projected levels of net migration are generally kept constant over the next decades. After 2050, it is assumed that net migration would gradually decline and reach zero by 2100. This assumption is very unlikely to be realized but it proved impossible to predict the levels of immigration or emigration within each country of the world for such a far horizon. Sending countries of today may become receiving countries and vice versa (UN, 2014a).

Under the zero **migration assumption**, for each country, international migration is set to zero starting in 2010-2015.

Table 1 present the average annual figures of migrants per decade by development group and major areas for the period 1950/60 to 2000/10 (actual) and 2010/20 to 2050/60 (projected); thereafter this figures are assumed to reach linearly zero by 2090/2100.

Table 1. Average annual number of migrants per decade by development group and major area, 1950-2050

	Net number of migrants (thousands)									
Major area	*1950-1960*	*1960-1970*	*1970-1980*	*1980-1990*	*1990-2000*	*2000-2010*	*2010-2020*	*2020-2030*	*2030-2040*	*2040-2050*
More developed regions	29	601	1 307	1 475	2 548	3 455	2 564	2 349	2 331	2 320
Less developed regions	- 29	- 601	- 1 307	- 1 475	- 2 548	- 3 455	- 2 564	- 2 349	- 2 331	- 2 320
Least developed countries	- 105	- 169	- 917	- 1 038	- 73	- 1 210	- 919	- 802	- 799	- 794
Other less developed countries	76	- 433	- 390	- 437	- 2 475	- 2 246	- 1 645	- 1 547	- 1 532	- 1 526
Africa	- 101	- 185	- 487	- 501	- 443	- 388	- 484	- 497	- 499	- 498
Asia	116	12	- 319	- 294	- 1 334	- 1 780	- 1 397	- 1 256	- 1 245	- 1 233
Europe	- 427	41	414	525	960	1 866	1 119	935	916	905
Latin America and the Caribbean	- 80	- 318	- 439	- 708	- 707	- 1 155	- 609	- 533	- 525	- 526
Northern America	403	324	792	880	1 438	1 282	1 220	1 200	1 200	1 200
Oceania	89	126	39	98	87	175	151	152	153	153

Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2013). *World Population Prospects: The 2012 Revision*. New York: United Nations.

b. World Bank Population Projections

The (annual) population data and projections by the World Bank from 1960 till 2050 for almost 200 countries are largely based on those of the UN medium (normal) variants, with own projections for some (small) countries for which UN data and projections are not available; see World Bank web site.

The main data sources of the World Bank's demographic estimates and projections include the UN Population Division's *World Population Prospects*; census reports and other statistical publications from national statistical offices; household surveys conducted by national agencies, ICF International, UNICEF, and the U.S. Centers for Disease Control and Prevention; Eurostat, Demographic Statistics; U.S. Bureau of the Census, International Database; UN Statistical Division's Population and Vital Statistics Report (various years); and Secretariat of the Pacific Community, Statistics and Demography Programme (see World Bank, w/o year).

Population projection is conducted up to 2050. The base year of the population projections is mid-2010. For those countries with the 2010 population estimates that are from UN Population Division's *World Population Prospects*, UN population projections of medium fertility are directly taken (rounded to nearest 1000). For other countries, projection software PROJPC is used to project the populations, with five-year period assumptions of mortality, fertility and migration data from the UN Population Division's World Population Prospects of medium fertility.

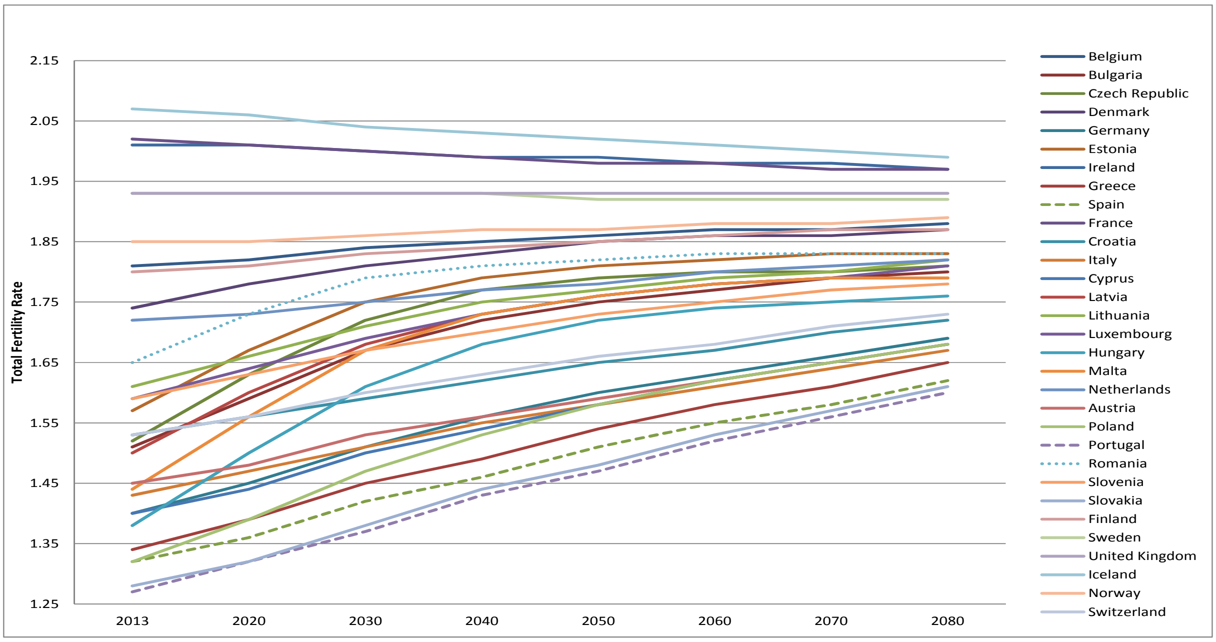
c. Eurostat population projections

Eurostat undertakes and publishes historical demographic data and undertakes demographic projections for all of its 28 member countries as well as the other 4 members of the EEA (see EU Commission website). The most recent population projection EUROPOP2013 is also the basis for the 2015 Ageing Report that undertakes the most recent assessment of demographic, economic and reform developments and the implications for public expenditure programs, in particular pensions, health and education. The 2015 Ageing Report itself is still pending but the Report on the underlying assumptions and projections has recently been released (EU Commission, 2014). While the way actual demographic data, including information on the collection of data and from which sources is well documented, there is little easily accessible information on the web about the methodology and assumptions of its most recent demographic projections. The Ageing Report (page 26) refers in a footnote 1 to a forthcoming description of EUROPOP2013 that seem to be still in preparation. Yet the assumed paths for the demographic drivers can be downloaded, turned into charts and interpreted:

Figure 3 presents the projected **total fertility rates (TFR)** for the 31 countries of the EEA for the period 2013 till 2080[4]. As visible, the projections for each country follow a moderately differentiated convergence approach. In general, the lower the initial TFR, the stronger the increase is assumed (i.e. β convergence is assumed, discussed in Section 3); for the few countries above some unknown convergence level such as France, Iceland, and Ireland a convergence from above takes place. However, for some Central and East European countries that had economic transition determined lower TFR levels it is assumed that their convergence speed will be faster. For some countries, such as Romania, it is assumed that the convergence ends already in 2060 with a TFR of 1.83. This is not the case for most other countries and the average of all 31 countries of the EEA. For the average of EEA countries the TTF rate increases broadly by 0.02 children as of the middle of the projection period and is 1.79 in 2080. Portugal and Spain share with Slovakia the privilege of having the lowest TFR in the EEA as starting position. The projections assume that their rates rise fast but remain for the total projection period at the bottom and in the same order; the TFR in 2080 for Portugal and Spain amount to 1.60 and 162, respectively, compared to the initial level in 2013 of 1.27 and 1.32, respectively.

[4] The European Economic Area (EEA) consists of the 28 EU countries plus Iceland, Norway, Switzerland (incl. Lichtenstein).

Figure 3. Eurostat Demographic Projections 2013: Projected Total Fertility Rates in EEA countries



Source: Eurostat (2014)

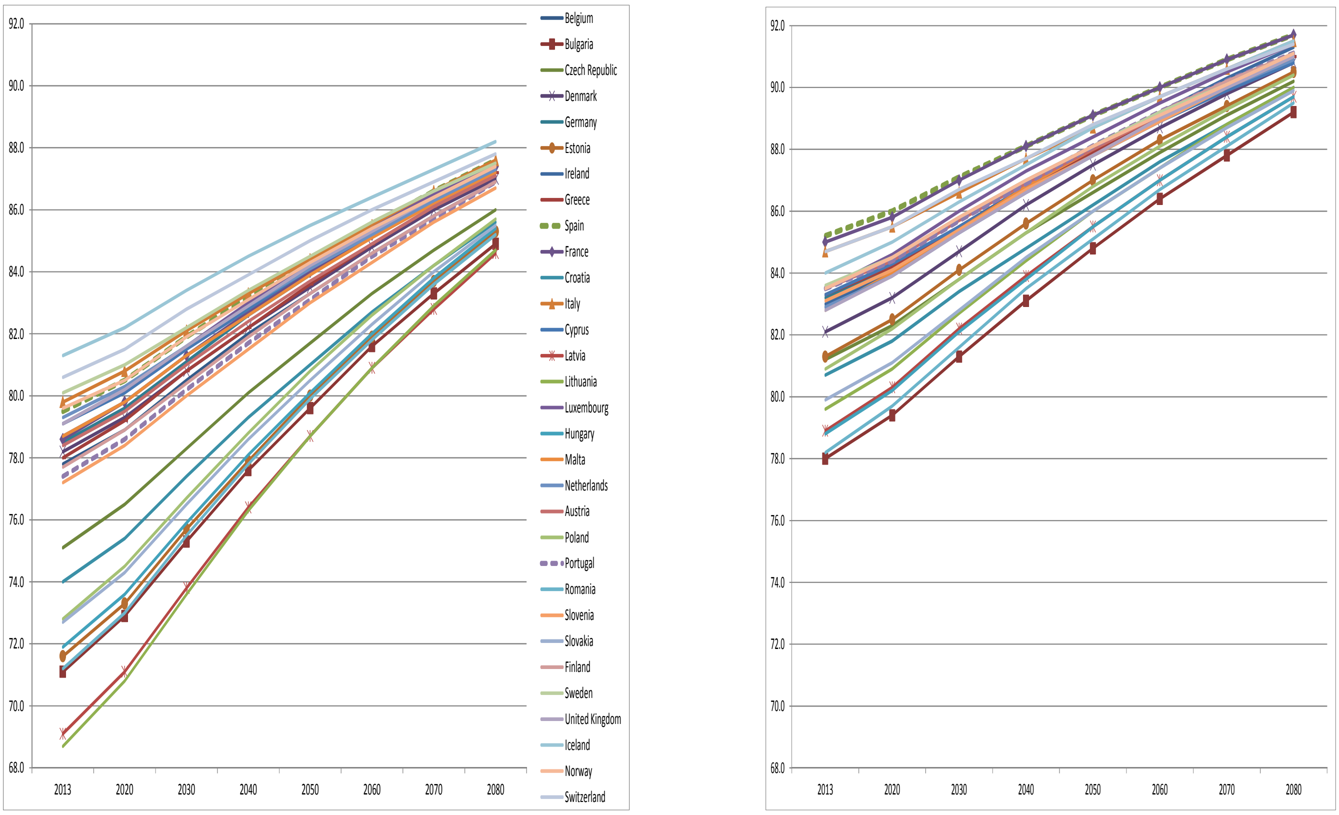
In addition to a medium TFR variant, Eurostat calculates a low and a high variant. The low variant differs from the medium variant in 2080 by 0.11 (Romania) to 0.5 (Iceland) children. In similar magnitudes but in the reverse order and sign are the differences between medium and high variant: The higher the level, the smaller the differences.

Figure 4 present the **male and female life expectancy** in the medium variant. A number of conclusions stand out:

- For both male and female the projections assume a strong further increase in life expectancy with, however, decreasing pace.
- The projections assume β convergence leading to a stronger increase for the laggards both for male and for female population.
- The marked gap between male and female life expectancy remains, albeit with some reductions.
- The difference between male and female is particularly stark in the economic transition economies of Central and Eastern Europe, and in consequence the projected stark improvements there for the male population.
- The male life expectancy in Portugal is at the lower end of the old EU countries, and remains there; that of Spain is among the top and also remains there.
- The female life expectancy of Spain starts and ends as the highest of all 31 EEA countries, only rivaled by Iceland and France; that of Portugal is in the good old EU average.

Figure 4. Eurostat Demographic Projections 2013: Projected Life Expectancy in EEA countries

Male | **Female**



Source: Eurostat (2014)

Eurostat calculates also a high fertility variant. The difference to the medium variant in 2060 amounts to 2.4 years (male) and 2.3 years (female), respectively. The difference for the countries ranges for males from 1.1 years (Italy and Spain) to 5.7 years (Latvia and Lithuania), and for females from 0.9 years (Italy and Spain) to 4.8 years (Romania) and 5.0 years (Bulgaria). In line with a β convergence hypothesis, the differences across countries are typically the stronger the lower the initial life expediency is.

Eurostat is not explicit about the assumptions and methodology on net migration that comprises both EEA internal migration as well as EEA external migration. The data available for the medium migration variant present the net migration balance for all 31 EEA countries. Table 2 presents the data and invites to the following observations:

- The base year 2013 is characterized by a number of particularities: fallout of crisis, in particular for Greece, Ireland, Portugal and Spain; economic transition travails plus fall-out, in particular the Baltic and Balkan countries; and refugee inflow, in particular Italy[5].
- The projection assume that these particularities are worked out within the next 2-3 decades so that by 2040 all EEA countries have again a positive migration balance.
- After 2040, however, and till the end of the projection period it assumed that net migration balances will broadly be reduced to lower levels.
- For the EEA as a whole the assumed reduction in the migration balances between 2040 and 2080 amount to 40 percent.
- For Portugal and Spain the migration balances after the recovery remain very small (Portugal) or modest (Spain), amount to much less than 1 percent of population.

[5] The negative sign for Germany must be an error as Germany is now among the most migrant receiving countries in the world.

Table 2. Eurostat Demographic Projections 2013: Projected Migration Balance in EEA countries

	2013	2020	2030	2040	2050	2060	2070	2080
Belgium	61 192	80 214	80 903	69 764	46 801	42 120	37 432	32 760
Bulgaria	-2 901	-5 827	-5 841	5 323	3 660	623	1 249	1 594
Czech Repu	-1 297	28 042	35 777	40 736	25 480	21 240	19 088	17 597
Denmark	21 196	18 929	19 936	16 263	10 492	10 035	8 394	7 347
Germany (u	-1 126 999	228 679	220 234	142 591	119 267	97 891	83 133	78 895
Estonia	-2 699	-3 700	-2 189	640	567	8	199	255
Ireland	-32 413	-30 303	-12 140	4 819	16 731	15 063	13 394	11 719
Greece	-15 889	-22 262	-10 003	1 258	7 340	4 695	5 390	4 264
Spain	**-310 916**	**-79 009**	**87 513**	**225 207**	**305 561**	**275 002**	**244 449**	**213 888**
France	52 775	90 186	91 239	83 988	74 229	66 807	59 383	51 953
Croatia	2 281	2 415	3 528	4 580	5 709	4 750	4 048	3 784
Italy	1 135 522	348 082	382 425	335 911	214 822	196 417	181 859	157 990
Cyprus	-575	-627	2 794	6 016	8 834	7 945	7 061	6 181
Latvia	-10 085	-14 308	-9 895	933	737	-1	4	235
Lithuania	-16 802	-37 393	-21 066	964	396	5	5	156
Luxembourg	10 523	11 720	11 175	9 072	5 394	4 858	4 326	3 782
Hungary	8 089	24 302	20 936	24 176	15 315	14 014	11 615	10 151
Malta	1 617	1 565	1 468	1 422	1 336	1 146	1 002	893
Netherlands	22 064	24 163	23 537	12 995	8 949	9 257	8 019	6 668
Austria	55 540	51 343	51 904	41 918	27 179	24 758	21 568	19 546
Poland	-15 583	2 947	-903	25 433	29 474	11 566	9 344	12 158
Portugal	**-40 275**	**285**	**9 218**	**11 944**	**8 284**	**7 932**	**8 018**	**5 733**
Romania	-9 245	405	-24 656	11 626	7 092	2 397	3 153	3 663
Slovenia	782	4 076	4 639	5 460	5 417	4 462	3 968	3 753
Slovakia	2 037	2 982	2 464	4 668	4 718	2 403	2 282	2 176
Finland	17 158	22 047	21 743	17 682	9 603	8 864	7 702	7 011
Sweden	65 779	55 256	55 993	49 117	34 666	31 195	27 735	24 267
United King	165 003	172 091	203 324	209 284	190 246	171 229	152 197	133 177
Iceland	1 635	5	224	403	566	513	439	379
Norway	39 205	53 390	51 824	42 335	24 905	22 413	19 926	17 438
Switzerland	85 233	73 177	72 073	62 396	44 115	39 709	35 289	30 875
	161 952	**1 102 872**	**1 368 178**	**1 468 924**	**1 257 885**	**1 099 316**	**981 671**	**870 288**

Source: Eurostat (2014)

d. Spanish Population Projections: National Institute of Statistics/ Instituto Nacional de Estadística

Calculating predictions on the behavior of demographic variables is one of the fundamental tasks performed by public institutions of statistics. This is also the case for Spain's national statistics office, the Instituto Nacional de Estadística (INE), which is responsible for carrying out Spain's population projections, including projections of fertility, mortality and international migration.

How does the INE predict the different components that allow the behavior of the population as a whole to be projected? Below we will see a summary of the *Methodological Notes* elaborated by the aforementioned institution and which accompany the projections most recently performed for the Spanish population.

Determining the initial population in Spain at time t (stock magnitude)

First of all, when making predictions, the population at the current time should be determined as precisely as possible, or P_t. It is the *stock* magnitude of equation (1), as it quantifies the phenomenon at a specific moment in time, and in Spain it is usually obtained from statistical population records. The differences noted between different records, such as censuses and residency registers (known as "padrones"), can affect the projections carried out, one of the main objectives of public institutions being to make progress in obtaining figures that are as homogenous as possible[6] It is the stock magnitude of equation (1), as it quantifies the phenomenon at a specific moment in time, and in Spain it is usually obtained from statistical population records. The differences noted between different records, such as censuses and residency registers (known as "padrones"), can affect the projections carried out, one of the main objectives of public institutions being to make progress in obtaining figures that are as homogenous as possible[7]. with regard to the various demographic phenomena (see in Chart, 2014, an analysis of the recent evolution and projections of the population in Spain). For the latest projections published in October 2014, *Projections for the population of Spain 2014-2064,* the starting population as at January 1, 2014 used by the INE is made up of the *Provisional Population Figures* on this date. In the *Long-Term Population Projections of Spain* (2012-2052), the starting population was obtained from the Current Population Estimates as at January 1, 2012 (INE, 2012).

Once the starting stock population is established, and based on the retrospective study of the demographic flow phenomena (see births, deaths, emigration and immigration), hypotheses are drawn up on their occurrence in every year of the period for which the projections are being made, taking into account the fertility and mortality rates and migratory movements for each generation (and gender, since it is usually carried out independently for men and women). It should be noted that since 2014 differentiated hypotheses have been established for people of Spanish and foreign nationality for those demographic phenomena in which it is appropriate to do so, such as the analysis of fertility rates. This has made it necessary to establish hypotheses on the expected behavior of the number of individuals that acquire Spanish nationality. The same was not the case in the 2012 projections, in which the overall estimated rates of fertility were used.

Fertility projections

The INE estimates the evolution of the fertility[8] of women living in Spain for every year of the projection period, taking into account the modelling of the specific fertility rates by age observed during the last ten years, extrapolating it on the basis of this model. Since 2014, as we discussed previously, fertility modelling according to the nationality of the mother has been introduced, given the different behavior of Spanish and foreign women that we already analyzed in Ayuso and Holzmann (2014a).

Firstly, the retrospective series of fertility rates by age and nationality are modeled using the annual series of results of the *Basic Demographic Indicators*[9] (for the latest projections, the 2004-2013 series)[10] . The fertility rates observed for every age x are adjusted according to a linear-log function in time (2), the parameters being estimated using the Ordinary Least Squares (OLS) method.

$$f_{x,n}^{t} = a_{x,n} + b_{x,n} \ln(z)$$

with t=2014,..., 2063; x=15,..., 49 and z=3,4... (2)

Secondly, once the specified linear-log model has been estimated, the projection of the specific fertility rates is carried out based on this model, by year of birth of the mother in each year of the period 2014-2063 (or 2012-2051, in the case of the 2012 projections). Figures 5a and 5b show the observed and projected values for fertility rates

6 Censuses are exhaustive population counts that include the whole population that has its habitual residence in Spain (including the foreign population). Residency registers are administrative records that include all the residents that have their habitual residence in a given municipality.

7 See INE, (2014b), *Statistical Yearbook of Spain*, for a full description of the different statistical analyses carried out by the General State Administration. In June 2013, the INE begins to publish *Population Figures*, with the aim of providing, biannually, a quantitative measurement of the population living in Spain at a provincial level. In its calculation, it uses the Population Census of 2011 as its starting point and it factors in the mortality, fertility and migration rates that occur over time.

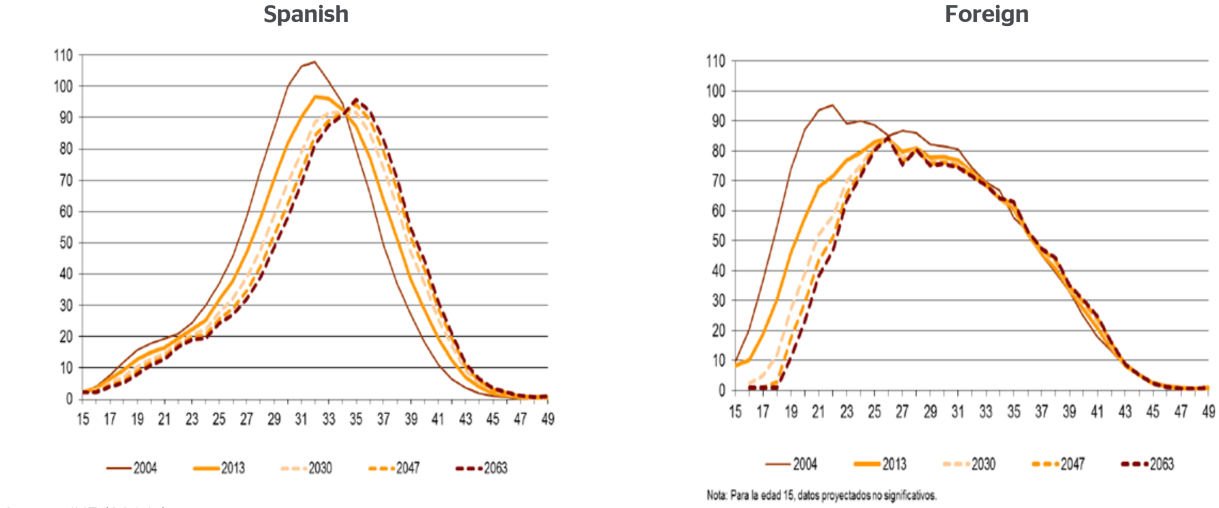
8 Remember that the fertility rate gives the number of live births for every 1,000 women between 15 and 49 years of age in a particular year (Ayuso and Holzmann, 2014a, section 2).

9 http://www.ine.es/jaxi/menu.do?type=pcaxis&path=/t20/p318/&file=inebase

10 For projections of 2012, the series of fertility rates corresponding to the period 2002-2011.

by age and nationality of the mother based on the 2014 projections, recently published by the INE.

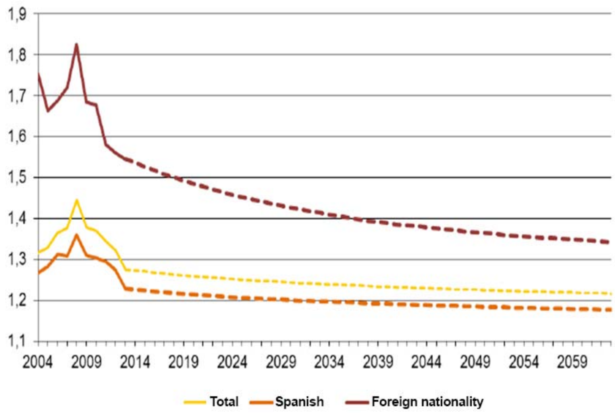
Figure 5a and 5b. Fertility rates for national and foreign population by age groups



Source: INE (2014a)

The evolution of the short-term fertility indicator according to observed and projected data, and taking into account the nationality of the mother, is shown in Figure 6. As can be seen, and unlike the projections carried out for 2012-2052 (see INE, 2012, where an increasing trend was noted in the expected number of children per woman, up to 1.55 in 2050) now a decrease in the fertility rate is projected, very accentuated for women of foreign nationality. The average number of children per woman is expected to be slightly above 1.20 in 2050, according to the new projections.

Figure 6. Short-term fertility indicator, observed (2004-2013) and projected (2014-2063)



Source: INE (2014a)

Mortality/life-expectancy projections

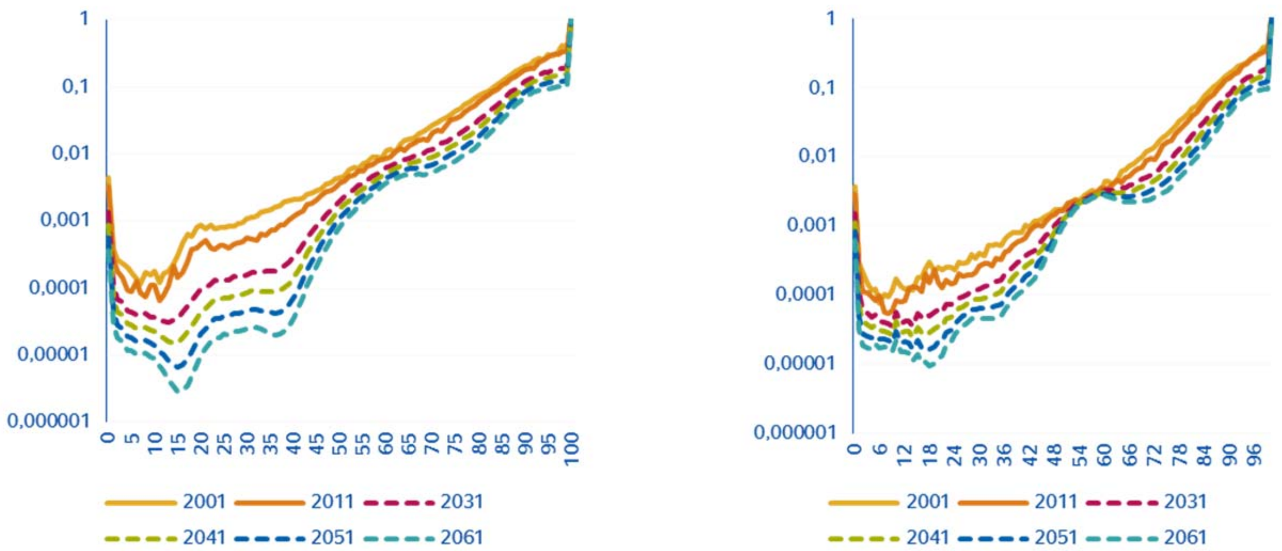
The projection of the mortality rate in Spain is carried out on the basis of extrapolating the probabilities of death at every age, adjusted through an exponential model of their smoothed trajectories over time, and differentiating by sex *s*:

$$\hat{q}_{s,x} = e^{\alpha_{s,x} + \beta_{s,x} t} \quad \text{with } x=0,\ldots,99. \qquad (3)$$

The corresponding parameters can be estimated by OLS on the linear models obtained from the logarithmic transformation of (3). The observed and projected mortality projections according to the 2014 projection figures are shown in Figures 7a and 7b, differentiated by gender. The charts highlight a decrease in the projected mortality rates, basically in the youngest and intermediate ages, but also, although less accentuated, in advanced ages.

Figure 7a and 7b. Projected and observed mortality rates (2014-2063)

Men **Women**



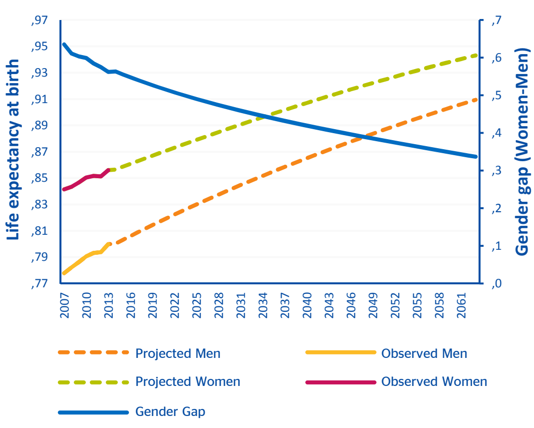
Source: own elaboration based on INE (2014)

From the projected annual mortality rates, the different biometric functions of the mortality table can be obtained, including the function of death, that gives us the number of deaths between two set periods (annual or with a duration of more than a year).

The data obtained also allows us to project the behavior of life expectancy at birth for men and women (left axis, Figure 8), as well as the gender gap between men and women (right axis, Figure 8).

Figure 8. Observed and projected life expectancy at birth (2014-2063)

Men and women, and gender gap



Source: own elaboration based on INE (2014)

As can be observed, an increase in life expectancy is expected both for men and for women over the projection period. In 2050, it is expected that women will live an average of 92.4 years in Spain, reaching 93.9 years in 2060. For men, the average life expectancy projected is 88.6 and 90.4 years, in 2050 and 2060, respectively. The gender gap between men and women is expected to reduce, going from 6.4 years difference in 2007 to 3.8 in 2050 and 3.5 in 2060.

International migration projections

The INE distinguishes, in the formulation and analysis of the hypothesis of international immigration, between the inflow of Spanish and foreign populations, taking into account their different nature and reasons that may justify it. The data on international immigration is entered into the projection, considering its overall intensity for Spaniards and foreigners in the current year, which remains constant for the whole projection period, distributed by sex and generation with average data from the last six years (in the case of the latest projections, those corresponding to the period 2008-2013, Migration Statistics[11]). The average distributions remain constant over the projection period.

As with immigration, in the analysis of international emigration the INE differentiates between that corresponding to Spanish people and foreign people, again, taking into account their different natures. In the calculation of projections, emigration rates by generation for each sex and nationality are taken into consideration. This way, for each nationality, the international emigration rates for each

11 http://www.ine.es/jaxi/menu.do?type=pcaxis&path=%2Ft20%2Fp277&file=inebase&L=0

generation, for each sex, of a certain year are calculated taking into account the so-called *Synthetic Index of International Emigration* (SIIE, which measures the intensity of emigration in the current year), a differential by gender, and a distribution of this intensity by generations (calendar by generation). In the case of latest projections, the observations obtained from the of the *Migration Statistics* in the period 2008-2013 are used. The SIIE used is assumed to be constant for the whole projection period (for example, the SIIE in September 2014 is 0.20 for the Spanish population, and 6.11 for the foreign population). Similarly, the differential by sex for the intensity of international emigration of each nationality, and the calendar of emigration by generation or year of birth, for each sex and nationality, are also set as constant for the whole projection period. All of them, as we have discussed, calculated in the latest projections based on the period 2008-2013.

Following a process similar to that presented for international emigration, the INE projects from 2014 onward the number of acquisitions of Spanish nationality.

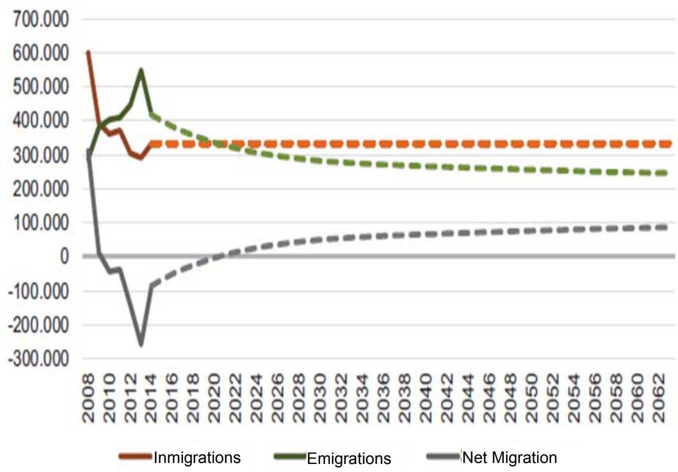
The international migration projections observed between 2009-2013 and projected 2014-2063 are shown in Table 3 and in Figure 9. In them a negative projected migratory balance can also be seen until 2018 (higher emigration than immigration), which changes sign starting from this date. Nevertheless, it should be emphasized that the projected number of immigrations is assumed to be constant for the whole projection period.

Table 3. Projected international migration of Spain

Year	Inmigrations	Emigrations	Net Migration
2009	392.963	380.118	12.845
2010	360.704	403.379	-42.675
2011	371.335	409.034	-37.698
2012	304.054	446.606	-142.552
2013	291.041	547.890	-256.849
2014	332.522	417.191	-84.669
2015	332.522	398.908	-66.386
2018	332.522	356.025	-23.503
2023	332.522	311.885	20.637
2028	332.522	288.152	44.370
2033	332.522	275.733	56.789
2043	332.522	262.809	69.713
2053	332.522	253.082	79.440
2063	332.522	245.903	86.619

Source: 2008-2013, Migration statistics (2013 provisional)

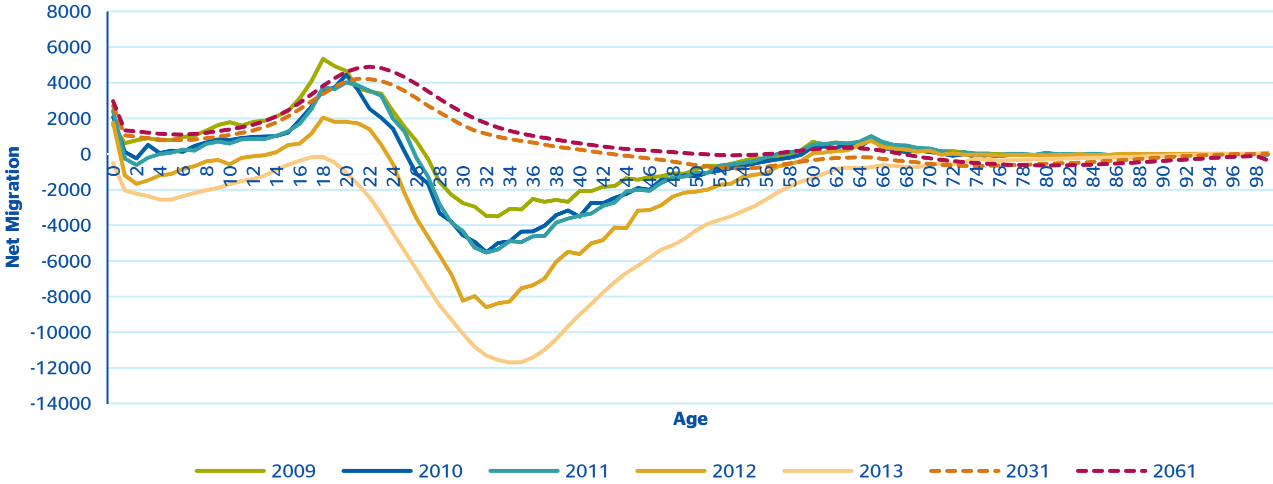
Figure 9. Projected international migration



Source: INE (2014c)

Finally the migratory balance by ages observed in the period 2009-2013 and projected for 2031 and 2061 is shown in Figure 10. As can be seen, the number of emigrations has increased compared with the number of immigrations in the period 2009-2013, causing increasingly accentuated negative migratory balances, predominantly in the age bracket associated with the labor market (20-60 years, approximately). The projections made show recoveries in this age bracket, although predominantly for the youngest ages, between 20 and 25 years.

Figure 10. Projected and observed migratory balance by age (2009-2061)



Source: own elaboration based on INE (2014)

To conclude this section, we point out that the INE has elaborated since 2008 the *Short-Term Population Projections* for Spain and its Autonomous Community regions and Provinces in the 10 next years, and every three years *Long-Term Population Projections* for Spain in the 40 next years. From 2014 onward, both analyses have been integrated into a single biannual projection: the *Population Projections*. A summary of the main figures derived from these projections is shown in Table 4.

Table 4. Population Projections 2014-2064

Population living in Spain	2014	2029	2064
Population on January 1	46.507.760	45.484.907	40.883.832
Demographic phenomena	**2014**	**2028**	**2063**
Births	408.901	299.279	229.434
Deaths	395.196	411.392	559.857
Immigration from abroad	332.522	332.522	332.522
Emigration abroad	417.191	288.152	245.903
Natural balance	13.705	-112.113	-330,423
Migratory balance	-84.669	44.370	86.619

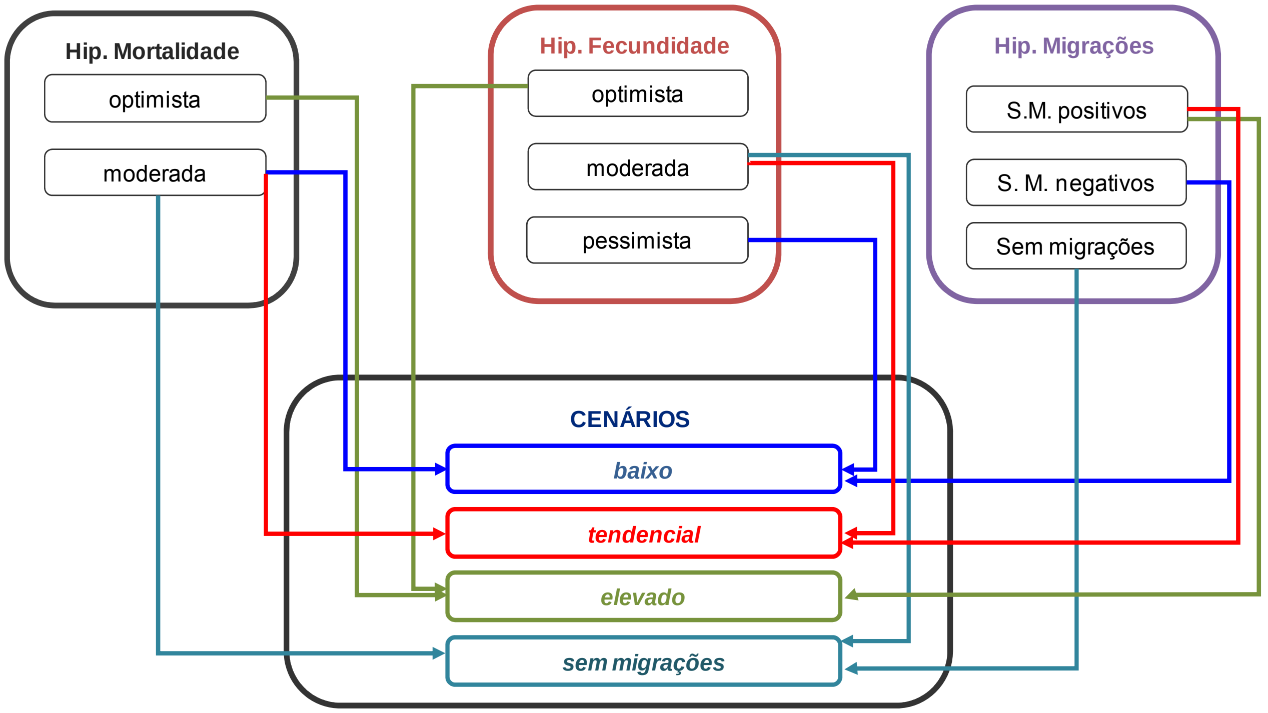
Source: 2014-2064 projection data (INE, 10/28/2014)

f. Portuguese Population Projections: Statistics Portugal/ Instituto Nacional de Estatística

The official population data and projections are periodically provided by Statistics Portugal/ Instituto Nacional de Estatística. The latest and recently 2012-2060 population projections (INE, 2014) take the annual provisional estimates of resident population on December 31, 2012 as the starting population. As other national statistical offices they continue preferring deterministic scenario projections over probabilistic ones.

The most recent projection exercise of 2014 comprises four alternative scenarios for the dynamics of the resident population (low - *baixo*, medium - *tendencial*, high - *elevado*, zero migration - *sem migrações*), resulting from the combination of different paths for the future levels of fertility, mortality and international migration. Figure 11 illustrates this approach.

Figure 11. Alternative population projection scenarios for Portugal



Source: Authors' preparation based on Statistics Portugal.

Alternative assumptions regarding future levels of fertility and mortality are encompassed in pessimistic (pessimista), moderate (moderada) and optimistic (optimista) variants. Alternative assumption for future levels of international migration comprise a negative (S.M. negativos), a positive (S.M. positivos) and a zero (Sem migrações) net migration scenarios.

In what follows we provide details about the methods used to project fertility rates, mortality rates, and future levels of net international migration in Portugal and the way in uncertainty is addressed in population projections.

Projecting Fertility:

In Portugal, the methodology used by the official Statistics bureau to project the number of births is based on the analysis of time series fertility data, assumptions regarding the dynamics of the Total Fertility Rate (TFR), assumptions on the mean age at birth of a child, sex ration assumptions, fertility and family surveys and statistical modeling. Age-specific fertility rates (ASFRs) are modelled using the approach proposed by Schmertmann (2003, 2005).

The model describes the shape of the ASFR schedule in terms of the ages at which the graphical schedule reaches certain characteristic points, specifically α, the youngest age at which fertility rises above zero, P, the age at which fertility reaches its peak level, and H, the youngest age above P at which fertility falls to half of its peak level. Age-specific fertility rates $f(x)$ between age α and an upper age β (e.g., age 49) are modelled through a piecewise quadratic spline function.

$$f(x) = R\phi(x), \quad x = 14,\ldots,50 \qquad (2)$$

$$\phi(x) = \begin{cases} \sum_{k=0}^{4} \theta_k \left(x - t_k\right)_+^2, & \alpha \le x \le \beta \\ 0, & x \notin [\alpha, \beta] \end{cases},$$

where R is a scalar, "knots" $t_0 < t_1 < \ldots < t_4$ fall in the interval $[\alpha, \beta]$, $t_0 = \alpha$ (the lowest age of childbearing), and $(x-t_k)_+ = max(x-t_k;0)$ To reduce the number of parameters the knot positions are determined from the index ages, and certain mathematical restrictions are impose so that the spline function mimics common features of ASFR schedules. The $f(x)$ function is continuous, with quadratic subsections joined at knot values and yields a closed-form expression for TFR:

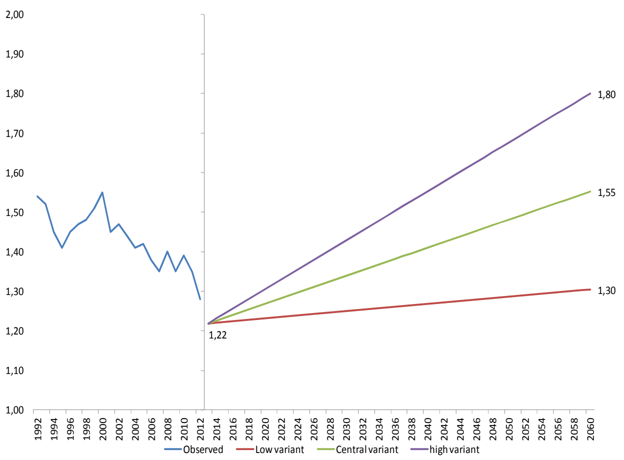
$$TFR = \int_{\alpha}^{\beta} f(x)\,dx = R\int_{\alpha}^{\beta} \phi(x)\,dx = \frac{R}{3}\sum_{k=0}^{4} \theta_k \left(\beta - t_k\right)^3 \qquad (3)$$

In preparing the fertility assumptions for Portugal, the results from the fertility and family survey conducted in 2013 (*Inquérito à Fecundidade* IFEC2013, INE 2013) were taken into consideration. Survey results provide an in-depth analysis of fertility decisions, particularly as the number of actual children (observed fertility), the number of children that families think they will have (expected final fertility), and the number of children that they would have given certain demographic and socioeconomic developments (desired fertility).

Three alternative assumptions regarding future levels of fertility have been defined. The *pessimistic* (low variant) hypothesis assumes TFR will roughly stabilize at around 1.30 children per woman (the observed TFR in 2012 was 1.28). The *optimistic* variant assumes a gradual recovery of TFR, reaching 1.80 children per woman in 2060. This assumption takes into account the results provided by IFEC2013, according to which the "expected final fertility" (actual and expected average number of children) of 18-49 years old women living in Portugal assumed this value. The *medium* variant assumes a moderate recovery of fertility levels, with and expected TFR of 1.55 children per woman in 2060.

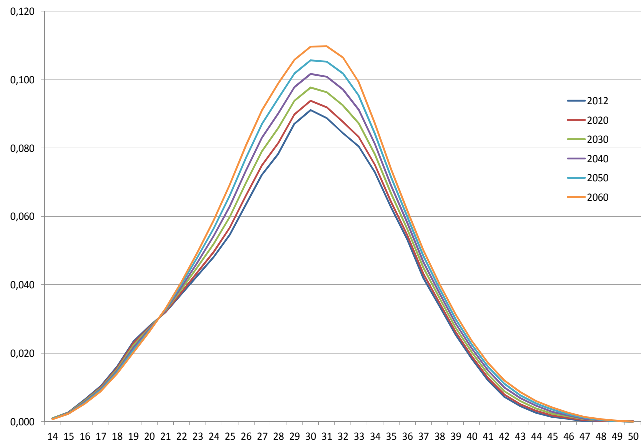
Figure 12 summarizes this information and exhibits the observed and forecasted values (in the three variants) for the total fertility rate in Portugal in the period 1992-2060. In Figure 13 we represent the forecasted age-specific fertility schedules for selected years considering the central scenario.

Figure 12. Total Fertility Rate, Portugal, 1992-2060 (observed and projected)



Source: Authors' preparation based on INE (2014)

Figure 13. Age-Specific fertility schedule, Portugal, selected years (central variant)



Source: Author's preparation based on INE (2014)

<u>Projecting Mortality and Longevity</u>

In addressing the mortality component of population projections, two alternative hypotheses have been considered: (i) a *medium* hypothesis, which assumes that recent observed trends in mortality will continue into the future, with nationwide life expectancy at birth increasing to 84.21 (89.88) years for the male (female) population by 2060; (ii) an *optimistic* hypothesis, which assumes a more marked increase in the longevity prospects for the Portuguese populating, with life expectancy at birth increasing to 86.44 (92.15) years for the male (female) population by 2060.

The projection of mortality is made using the Poisson-Lee-Carter (PLC) log-bilinear methodology (Brouhns et al., 2002) in conjunction with relational models (Brass, 1971) for subnational population levels. The classical age-period (AP) Lee-Carter (LC) model was first introduced by Lee and Carter (1992), combining a demographic model for the mortality rate, dependent only on factors related to age and period, describing the historical change in mortality, a method for fitting the model and a time series (Box-Jenkins) method for modelling and forecasting the time-varying parameter. From this forecast of the general level of mortality, the actual age-specific rates are derived using the estimated age effects[12].

The PLC log-bilinear methodology assumes that the number of deaths by age and calendar year, $D_{x,t}$, follows a Poisson distribution with parameter $\mu_{x,t}E_{x,t}$

$$D_{x,t} \sim Poisson\left(\mu_{x,t}E_{x,t}\right) \qquad (3)$$

[12] The main statistical tool of Lee and Carter (1992) is least-squares estimation via singular value decomposition of the matrix of the log age-specific observed forces of mortality. This implicitly means that the errors are assumed to be homoskedastic, which is quite unrealistic: the logarithm of the observed force of mortality is much more variable at older ages than at younger ages because of the much smaller absolute number of deaths at older ages. Another drawback of the Lee-Carter methodology is that the required data have to fill a rectangular matrix because of singular value decomposition. In addition, estimated prediction intervals are quite narrow.

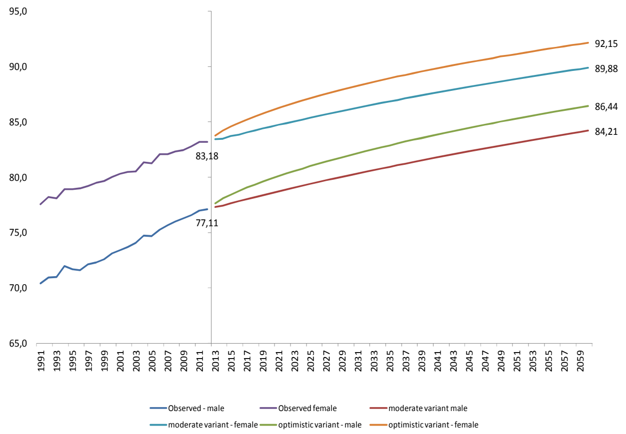
with

$$\mu_{x,t} = \exp\left(\alpha_x + \beta_x k_t\right) \qquad (4)$$

where $E_{x,t}$ denotes the exposure-to-risk at age x during year t, $\mu_{x,t}$, is the mortality force at age x during calendar year t. Parameter vector α_x represents the general shape of the mortality schedule in the sample period, vector β_x represents the age-specific patterns of mortality change and vector k_t denotes time-varying trend. Parameter estimates are obtained through maximum-likelihood methods using an unidimensional Newton-Raphson type iterative algorithm (Goodman, 1979). Initial parameter estimates are subjected to two constraints to ensure model identification. Box-Jenkins techniques are used to estimate and forecast k_t within an ARIMA (p, d, q) times series model. To project mortality rates for the oldest-old $(x \geq 85)$, INE uses a log-quadratic model proposed by Denuit and Goderniaux (2005). Forecasts of age-specific mortality rates are derived using the estimated age effects and the forecasted time-varying component. From this, life table biometric functions and other mortality and longevity markers can be calculated.

Figure 14 exhibits the observed and forecasted life expectancy at birth for both the male and female Portuguese populations in the period 2012-2060, in both the moderate (central) projection scenario and in a more optimistic scenario.

Figure 14. Observed and forecasted life expectancy at birth, Portugal, 1992-2060



Source: Author's preparation based on INE (2014)

Alternative scenarios have also been devised using an extension of the traditional PLC log-bilinear methodology but considering a limit life table (Bravo, 2007, 2010). To forecast regional level mortality rates, a Brass-type relational model has been adopted considering logit transformations of crude rates.

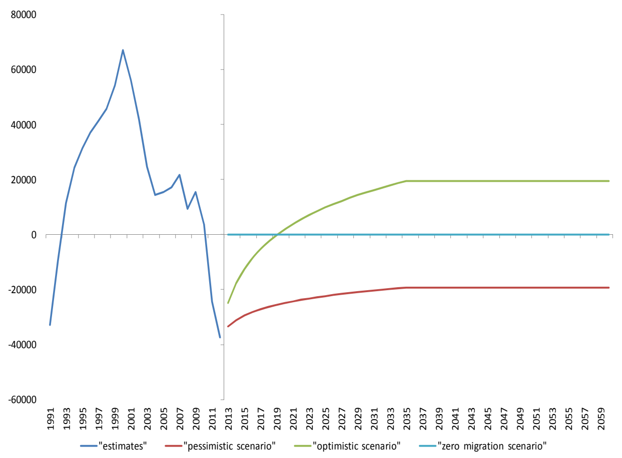
<u>Forecasting international net migration</u>

In addressing the international net migration component of population projections, three alternative hypotheses have been considered by Statistics Portugal for the period 2012-2060 (Figure 15):

I. A pessimistic hypothesis, which assumes negative annual international migration balances throughout the whole projection period, starting with the estimated values for the base year and converging in 2035 to the average 2010-2012 period observed figures;
II. An optimistic hypothesis, which assumes a gradual recovery of international annual migration balances shifting to positive values in 2020, starting with the estimated values for the base year and converging in 2035 to the average of net migration estimates observed in the period 1991-2012;
III. A zero net migration hypothesis, which admits the absence of international migration, which despite its improbability allows evaluating the influence of migration on population dynamics.

Annual international migration balances are distributed by age and sex using assumptions on the age structure of migration flows, considering the latest observed patterns.

Figure 15. Observed and forecasted international net migration, Portugal, 1992-2060



Source: Author's preparation based on INE (2014)

Population projections for Portugal

Table 5. Population projections and markers, Portugal & NUTS II

Portugal & NUTS II	Scenarios/Components		Total Fertility Rate		Life Expectancy at birth				Net migration		Population		Old-age dependency ratio	
			2012	2060	2012		2060		2012	2060	2013	2060	2013	2060
					Male	Female	Male	Female						
Portugal	Scenario 1	Low	1,28	1,30	77,1	83,2	84,2	89,9	- 37 352	- 19 289	10 487 289	6 346 726	29,4	90,1
	Scenario 2	Central		1,55			84,2	89,9		19 493		8 575 339		67,0
	Scenario 3	High		1,80			86,4	92,2		19 493		9 223 617		70,9
	Scenario 4	Zero migration (central)		1,55			84,2	89,9				7 856 281		73,0
Norte	Scenario 1	Low	1,15	1,25	76,8	82,9	84,0	89,7	- 16 863	- 7 989	3 666 234	2 110 746	25,5	100,3
	Scenario 2	Central		1,51			84,0	89,7		3 852		2 788 256		74,5
	Scenario 3	High		1,76			86,3	92,1		3 852		3 014 128		78,7
	Scenario 4	Zero migration (central)		1,51			84,0	89,7				2 723 769		77,5
Centro	Scenario 1	Low	1,19	1,25	77,4	83,4	84,5	90,1	- 8 139	- 3 773	2 298 938	1 258 379	34,6	100,0
	Scenario 2	Central		1,51			84,5	90,1		3 941		1 709 950		72,7
	Scenario 3	High		1,76			86,7	92,4		3 941		1 844 314		76,7
	Scenario 4	Zero migration (central)		1,51			84,5	90,1				1 581 791		79,2
Lisboa	Scenario 1	Low	1,51	1,40	76,4	82,8	83,7	89,6	- 8 599	- 5 142	2 818 388	1 909 196	30,0	77,5
	Scenario 2	Central		1,66			83,7	89,6		7 670		2 642 332		58,1
	Scenario 3	High		1,86			86,0	91,9		7 670		2 818 302		61,7
	Scenario 4	Zero migration (central)		1,66			83,7	89,6				2 285 386		65,1
Alentejo	Scenario 1	Low	1,33	1,30	76,7	82,6	84,0	89,5	- 1 910	- 1 363	748 699	398 218	38,2	94,2
	Scenario 2	Central		1,56			84,0	89,5		976		536 737		69,6
	Scenario 3	High		1,81			86,2	91,9		976		579 674		73,7
	Scenario 4	Zero migration (central)		1,56			84,0	89,5				511 401		74,1
Algarve	Scenario 1	Low	1,43	1,35	76,5	83,4	83,8	90,1	- 942	- 290	444 390	319 930	30,7	75,8
	Scenario 2	Central		1,61			83,8	90,1		2 139		454 489		56,4
	Scenario 3	High		1,86			86,0	92,3		2 139		486 967		59,7
	Scenario 4	Zero migration (central)		1,61			83,8	90,1				345 651		68,7
R. A. Açores	Scenario 1	Low	1,34	1,32	72,7	80,0	80,7	87,5	- 133	- 324	247 549	189 159	18,7	70,8
	Scenario 2	Central		1,58			80,7	87,5		277		224 170		60,5
	Scenario 3	High		1,83			83,3	90,0		277		242 713		64,1
	Scenario 4	Zero migration (central)		1,58			80,7	87,5				213 909		63,0
R. A. Madeira	Scenario 1	Low	1,08	1,19	73,3	80,3	81,3	87,5	- 766	- 408	263 091	161 098	21,1	89,2
	Scenario 2	Central		1,45			81,3	87,5		638		219 405		65,7
	Scenario 3	High		1,70			83,8	89,9		638		237 519		69,4
	Scenario 4	Zero migration (central)		1,45			81,3	87,5				194 374		73,3

Source: Authors' preparation based on INE (2014)

3. The population drivers beyond demography: What data analyses and economics have to say!

Common characteristics in the assumptions for the three demographic drivers were the base for all projections presented in the prior Section: First, a convergence vision driven by the demographic transition model (fertility rates), a conjectured vision that age-specific mortality rates across will somehow become more similar but with decreasing speed, and convenience assumption that migration balances will be reduced or even disappear. Second, data used to estimate parameters for the projected developments of the three demographic drivers are exclusively of demographic nature – for individual countries but also for multi-country projections. While autoregressive approaches have their charm and convenience, in particular when high-frequency data is at hand (such as in financial markets), leaving out any economic explanation of the drivers for past and projected future developments is little understandable and conjectured to be wrong. Third and combining elements of the prior two components: Moving away from unconditional convergence (i.e. a common state) is suggested by the data; but as in economic (country) convergence without additional explanatory variables (and storyline), the projections are not credible. And there is economic and other research out there to offer both.

This Section reviews key economic variables that may be productively applied to assist demographic projections and presents some of the reviewed recent literature. As this is a first stab on the topic, the review will be selective, i.e. incomplete. Yet it will offer some gist in which direction future research and demographic projections should go.

a. The economic and other explanations of fertility development

This sub-section on fertility development focuses on three issues: (i) what is the role of income compared to mortality development in explaining the direction of fertility development?; (ii) is there a convergence of countries toward common fertility levels?, and (iii) what converging (total) fertility rate(s) do emerge from recent large-scale econometric analyses?

(i) Theories of demographic transition and the explanation on fertility development focus typically on either on the impact of the mortality or on the impact of income levels and economic growth. Demographers tend to emphasize, not surprisingly, the mortality channel while economists tend to emphasize the income channel broadly understood (i.e. rising income per capita serving as a proxy for technological change and productivity growth, see Herzer et al., 2012).

The most prominent explanations for the mortality channel offered by demographers are physiological mechanisms (such as the link between breast feeding and fecundity) and the concept of the ideal family size (implying a wish for the replacement of the deceased children). These channels establish a negative association between fertility and mortality which is, however, insufficient to explain demographic transition understood as a secular decline of net fertility, i.e. of the surviving children per family and thus the secular decline in population growth. In order to establish the mortality channel as a sufficient for demographic transitions several refinements of the demographic driven theory have been proposed, including the precautionary child-bearing of risk-adverse parents or more complex theories around the interaction between extrinsic survival conditions and child health, and the impact of adult longevity in fertility (Herzer et al., 2012).

For an economic theory of demographic transition the basic challenge is to explain the negative association between income and fertility without abandoning the assumption of children as “normal goods”. A common element of economic theories is that the positive income effect (more income increases the demand for children) is dominated by a negative substitution effect (more income increases the price/opportunity costs of children and reduces the demand). Examples for such explanation include two theories proposed by Gary Becker: One based on time allocation and the assumption that children are more time-intensive than other consumption goods (Becker, 1965); the other is based on a quantity/quality trade-off and the substitution of fertility with expenditure on children as income rises (Becker and Lewis, 1973).

With the rise of the unified growth theory (see Galor, 2005, 2011), the economic analysis of fertility has been framed in a dynamic context that rejects simple causality and allows for endogeneity from and to the main drivers of fertility. With this approach the focus has shifted away from the association between fertility and income levels (across countries) toward the association between fertility change and income growth (within countries and over time). Moreover, the time cost idea and the child quality trade-off have been refined. Yet a common element of these income based theories is that without further assumptions mortality plays no role in explaining fertility decisions. If added it is netted out in the standard model framework. A way to introduce a role for mortality is to abandon the assumption of homothetic utility in the model framework (Doepke, 2005).

Based on this modelling idea Hertzer, Strulik and Vollmer (2012) develop an econometric specification that allows the testing of the long run relationship between fertility, mortality and economic development

$$fert_{it} = a_t + \beta_1 mort_{it} + \beta_2 \log(gdp_{it}) + e_{it} \qquad [2]$$

Where i=1,2,...,N and t=1,2,...,T are country and time indices, $fert_{it}$ is fertility measured by the crude birth rate (births per thousand population), $mort_{it}$ stands for mortality, measured in crude death rate (death per thousand population), and $log(gdp_{it})$ is the GDP per capita measure in logs.

Using data over a 100 year period from 1900 to 1999 packed in 5 years averages for a mix of 20 developed and countries across the globe, panel co-integration techniques, dynamic OLS (DOLS), and a battery of cutting-edge statistical tests, they are able establish with high confidence the co-integrating relationship between fertility, mortality and income, test the robustness of the estimates and investigate the direction of the causality. Using a shorter data set (1950-1999) but for 119 countries they could also ascertain the coefficients are stable between the data sets and for a split between developed and developing countries (Table 6).

Table 6. DOLS Estimates of the Long-Run Effects on Fertility

	mortit	log(gdpit)	No of countries in sample
20 countries 1900-1999	0.378** (7.40)	-7.246** (-10.18)	20
Developed countries	0.623** (6.25)	-4.757** (-8.22)	12
Developing countries	0.470** (5.45)	-4.021** (-3.50)	8
119 countries 1950-1999	0.420** (13.74)	-5.829** (-11.46)	119
Developed countries	0.502** (5.96)	-5.567** (-4.03)	16
Developing countries	0.487** (10.45)	-4.987** (-9.83)	103

Source: Hertzer, Strulik and Vollmer (2012), based on tables 2, 3 and 4

Table 6 indicates highly and surprisingly stable coefficients across data sets and sub-samples. For the full 20 country data sample the coefficient of fertility with respect to morality is estimated to be positive and 0.378 (implying that in the long run a one standard deviation increase in the mortality variable is associated with an increase in the fertility variable equal to 25 percent of a standard deviation of this variable), while the coefficient of fertility with respect to log per capita income is negative and -5.246 (indicating a reduction by 42 percent of a standard deviation of the mortality variable by an increase of one standard deviation in the income variable). These results imply that an increase of GDP per capita by $1.000 and a decrease of the mortality rate by 0.5 percentage points both decrease the fertility rate by about 0.19 percentage points. These estimates further imply that a reduction of the mortality rate by 0.5 percentage points is associated with an increase of the population growth rate by 0.31 percentage points (0.5 minus 0.19) holding GDP constant. This allows the conclusion that declining mortality is insufficient to explain the declining population growth observed along the path of transition.

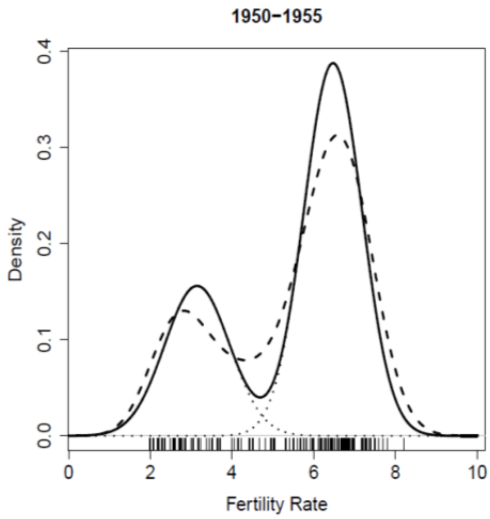
More generally, the results of this first macro-study with data for a full century and cutting-edge estimation techniques strongly suggest that (1) declining mortality leads to declining fertility; (2) growth in income per capita leads to declining fertility; (3) declining fertility is insufficient to explain the secular decline on population growth over the last century; and (4) fertility changes are both causes and consequences of economic development. But the observed linearity of the last century cannot continue as fertility and mortality are bounded to be non-negative and cannot continue to fall indefinitely with forever rising income. We return to this below.

(ii) A key assumption of the UN population projection is the convergence of all countries toward broadly the same (total) fertility rate. A main research topic over decades has been to establish whether and when such a convergence is taking place, what the key drivers are (morality reduction or also other and economic development's, discussed above), how the convergence differs between groups of countries, and what characteristics it has. The demographic convergence investigations in recent years have profited and borrowed from a similar economic literature on economic growth convergence. The access to better and more diversified data across the world has helped to this end.

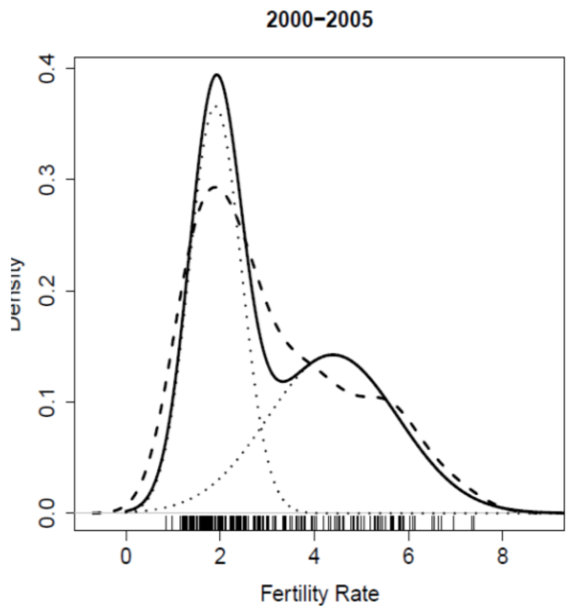
Cutting through a rich discussion of the topic, here are the critical issues and recent results:

First, the world was and is still separated into a low fertility regime and a high fertility regime. The twin peaks of fertility rates across countries have been shifting over time, the composition has changed, and the second peak of high fertility is reduced but not yet vanished. Figure 16 shows the changing shape between the period 1950-1955 and 2000-2005. In the first period the first peak comprised some 1/3 of the countries with low fertility and the second peak 2/3 of the countries with high fertility; in the second period size of the composition is broadly reversed[13].

Figure 16. Cross-Country Distribution of Fertility Rates, 1950-1955 vs. 2000-2005



13 The data in the graph is based on a methodology which is invariant to strictly monotonic transformation thus robust against arbitrary presentation choices (See Holzmann et al., 2007)



Note: Fitted mixture model (solid line), weighted components (dotted lines), and kernel density estimator (dashed line). The rugs below the plots represent the observed fertility rates.

Second, when discussing convergence the literature on economic growth has developed two testing concepts called ***β***- and ***σ***-convergence (Barro and Sala-i-Martin, 1992). These concepts can easily be adapted to analyze fertility transition: ***β***-convergence applies if countries of initial high fertility experience a stronger decline than countries of initial low fertility; ***σ***-convergence if the cross-country dispersion (measured by the standard deviation of fertility), for a group of countries declines over time. ***β***-convergence implies a tendency for σ–convergence but is not sufficient. In turn, decreasing dispersion does not necessarily entail ***β***-convergence. Relatedly, the concept of club convergence with regard to economic growth can also be applied to fertility developments.

Using the idea of different regimes (clubs) and applying it to fertility transition Strulik and Vollmer (2015) were able to establish statistically that from 1950 to 2005 there exist two distinct fertility distributions: a high-fertility regime and a low-fertility regime. Here are their specific main results:

- Within both regimes fertility is falling over time starting from a much higher initial level in the high fertility regime
- They observe σ–convergence across the world and within the low fertility regime but not in the high fertility regime
- They observe β-convergence in the low fertility regime but not in the high fertility regime
- The high fertility regime is not a convergence club and, in consequence, countries in this regime cannot be conceptualized as belonging to a "high fertility" trap.
- The heterogeneity in the high fertility regime and the experience with fertility decline of other countries that moved to the low fertility regime suggests in the past suggest country specific transitions that cannot be forecasted.

(iii) A critical question for countries in the low fertility regime is about the final level of convergence and the likely reversal towards higher levels once lower levels are reached. Demographers have for a long time argued for an innate tendency for fertility to move toward replacement. While some temporary corrections have been observed in some countries, they are mostly due to differences in fertility rates of newly arrived migrants and an observed tendency to downward adjust fertility after some residency.

The papers presented in this section do not offer any hope for reversal and return toward replacement rate (or even its neighborhood). The estimates by Strulik and Vollmer (2015) allow an assessment via the β-convergence and predicted equilibrium. It suggests that for the low fertility regime that the transition is still ongoing at unchanged speed, with a predicted equilibrium level of 1.12. Such a fertility level is only slightly more than half of the replacement level and such rates and below already experience in some parts of the world such as Shanghai. The estimates by Herzer et al. (2012) using the same 119 countries shorter data base as well as a 20 country longer data base suggest that their linear model of fertility is during the observation periods not questioned. Hence further falling mortality (where progress is limited) and further increasing income (that is potentially unlimited) suggests a further and unlimited decrease in the fertility rate. As it is bounded from below at one moment the linear relationship will disappear but this does not seem to be tomorrow.

b. The economic and other explanations of mortality/life expectancy development

How mortality rates are changing over time, and in particular the increase observed in life expectancy, has been a topic of considerable academic and professional debate across the world over recent decades. The rise in the cost of providing for pensions, insurance and healthcare at older ages, determined by the rapid improvements in life expectancy, led life companies, pension schemes, individuals and governments to give more importance to how these costs will be met in the future.

In response to the increasing role of longevity risk and the demand for more accurate projections of future mortality rates, a vast literature on mortality forecasting has been produced during the last decade. Mortality forecasting methods can be divided into four major categories: expectation methods, extrapolative methods, explanatory methods and process-based methods[14].

The expectation method is based on expert opinions. For instance, expert judgement is used to specify a given forecast or scenario for a mortality/longevity measure (e.g. life expectancy, mortality rates, age-specific mortality reduction factors, target life table), often accompanied by alternative high and low scenarios and a specified path[15]. The main advantage of expert opinion methods is the possibility to incorporate (qualitative and quantitative) demographic,

[14] For an extensive literature review on the methods used for modelling and forecasting mortality see, for instance, Booth and Tickle (2008).

[15] Examples of the use of this methodology in the actuarial context and official statistical offices can be found, for instance, in Continuous Mortality Investigation Bureau (1990, 1999), Wong-Fupuy and Haberman (2004) and Bravo (2008).

epidemiological and other relevant knowledge about future longevity prospects. The main drawback refers to its subjectivity and potential for (upward/downward) bias.

Traditional extrapolative methods assume that future trends (e.g., in life expectancy) will essentially be a continuation of the past, i.e., they rely on the basic notion that the conditions which led to changing mortality rates in the past will continue to have a similar impact in the future. Advances in medicine or the emergence of new diseases that have a significantly different impact than those in the past could undermine the validity of the results of an extrapolative projection. In general, these models focus on the long term observed mortality patterns, and extract some latent factors from historical data, summarizing trends in mortality rates along a period or cohort dimension. Single and multifactor time series methods are commonly used in extrapolative forecasting, since they have the advantage of being stochastic and enable the calculation of the probabilistic prediction interval for the forecast value.

The Lee and Carter (1992) model provided the seminal approach to mortality modelling using a principal components analysis of mortality data with one common factor. Subsequently, a number of innovations have been developed, including modelling the cohort effect (Renshaw and Haberman, 2006), adding a second period effect (Cairns et al., 2006), using a state space framework (Pedroza, 2006), using functional principal components analysis (Hyndman and Ullah, 2007), using Bayesian methods to smooth over time, age and country (Girosi and King, 2008) and adding additional factors for varying mortality improvement rates across ages (Plat, 2009). Most of the models used in demographic and actuarial practice lie in this category.

Explanatory methods make use of expert medical knowledge and information on economic, behavioural and environmental changes (e.g., changes in lifetime smoking patterns) over time and try to explain and forecast mortality based on structural or causal epidemiological models of a set of causes of death involving disease processes and known risk factors. This type of model requires not only a determination of appropriate explanatory variables, but also their prediction, which might not be any simpler than predicting mortality directly.

Although the explanatory approach to forecasting mortality is still in its infancy, in that the relationships between risk factors and mortality are still imperfectly understood, making their use in forecasting difficulty, they are a valuable instrument in simulating the effect on morbidity and mortality of policy changes (e.g., health policies) affecting the risk factors. In some cases, an explanatory model is used in conjunction with expert opinion methods, for instance, in the specification of future scenarios for the medical breakthroughs in the treatment of a given disease.

Process-based methods focus on the factors that determine deaths and attempt to model mortality rates from a bio-medical perspective. This class includes the cause-of-death-type of models. The main difficulty with these models is that they generally assume independence among the causes of death, while in reality the different causes can be interrelated. In practice, the unreliability of cause-of-death reporting at older ages where most deaths occur, and the fact that cause-reduction may have minimal effect on overall mortality means that limited value can generally be gained from decomposition by cause of death.

There are many possible explanations for recent declines in mortality rates and life expectancy increases. Literature typically specifies future mortality improvement assumptions against a number of dimensions: gender, age, period, cohort. A large number of factors can in theory influence the rate of mortality improvement, many of those, however, are not independent of each other. Literature generally classifies changes into technological, medical, environmental and societal categories. Some of the crucial factors that have influenced mortality improvements over the past century are the access to primary medical care for the general population, the discovery and general availability of antibiotics and immunizations, the access to clean water supply and sanitation, and the rapid rate of growth in the general standard of living.

Using mortality as a proxy of health conditions is a common approach in trying to understanding the determinants of mortality. For instance, Auster et al. (1969) used the following health production model:

$$m_i = c_i + \alpha Z_i + \beta X_i + \gamma HC_i + \delta E_i + u_i \qquad (1)$$

where $\boldsymbol{m_i}$ are logged (standardised) mortality rates, $\boldsymbol{Z_i}$ socio-economic status (income, education), $\boldsymbol{X_i}$ lifestyle inputs (alcohol, tobacco), $\boldsymbol{HC_i}$ are healthcare inputs (drugs, doctors, hospital capital stock), $\boldsymbol{E_i}$ captures environmental variables (urbanization, industrialization) and $\boldsymbol{u_i}$ is a random term.

The increase in per-capita income allows people to spend more not only on health (doctors, medicine and hospital care) but also on non-health inputs that benefit health (e.g., better housing, more nutritious food, better clothing, gym membership[16]). Crucial to future life expectancy developments are the choices that individuals make in relation to their health. Lifestyle factors such as smoking (Leon, 2011), obesity and nutrition (Cutler et al., 2009), amount and type of physical activity and drugs (including alcohol) consumption (Miller and Frech, 2000) are all recognised as significant risk factors.

The role of advances in medical technology is critical in understanding the secular trends in mortality. Much of the decline in adult mortality in the second half of the twentieth century has been attributed to cardiovascular disease treatment (new drugs, new surgical procedures and specialised equipment). Factors that may influence future mortality improvements include the development and application of new diagnostic, surgical, and life-sustaining techniques, the rate of future increases in health spending and the efficiency of that spending relative to mortality improvement. Other factors considered are environmental air pollution, pharmaceutical expenditure (Miller and Frech, 2000) and crime (Thornton et al., 2002), the incidence of violence

[16] For a recent investigation on the relation between trends in mortality decrease and economic growth see Niu and Melenberg (2014).

and suicide, the isolation and treatment of causes of disease (e.g., genetic breakthroughs), the emergence of new forms of disease and the evolution of existing ones, the extent to which people assume responsibility for their own health, education regarding health, and changes in our perception of the value of life.

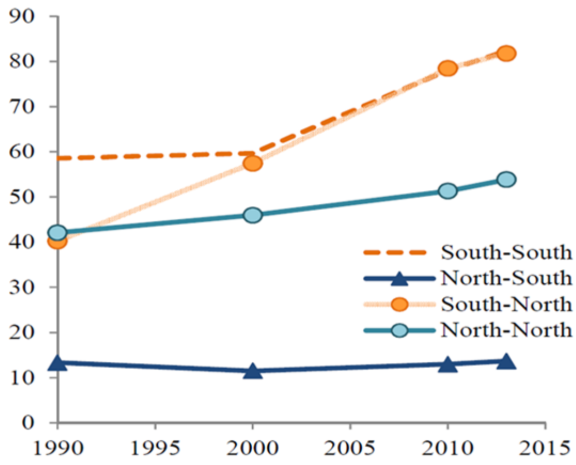
In recent years several OECD countries have taken steps to increase the retirement age in order to address the sustainability problems of pension systems. Usually, workers and their representatives strongly oppose such reforms, claiming that workers who spent their whole life working in physically demanding jobs should be allowed to retire early to avoid emerging health problems. If we all agree that leaving a pernicious work environment contributes to improve health, the overall consequences of early retirement on health could go in the opposite direction. In fact, retirement is associated with less cognitive and physical activity as well as with changes in daily routines and lifestyles that are potentially associated with unhealthy behaviour. For some countries, there is empirical evidence that shows that a reduction in the retirement age causes a significant increase in the risk of premature death (e.g, Kuhn et al., 2010). These results mean that early retirement does not only adversely affect government budgets but might also unintentionally increasing individuals' mortality risk. This conclusion has a major implication for pension reforms since labour-market policies aiming to keep older individuals at work not only contribute to the sustainability of pension systems but also raise individuals' welfare by prolonging their lives.

c. The economic and other explanations of migration development

The investigation of migration flows to and from a country is quite likely the area where most of the economic and non-economic research has taken place and this over many decades or even two centuries (see Chiswick and Miller, 2015). More recently and with the advent of re-increased migration flows and new and better data the migration literature has blossomed supporting some older conjectures and introducing a number of new spins. The traditional main questions on the determinants of migration between countries – who migrates and why, and the impact within receiving and sending countries are still in the forefront of analyses supplemented by more recently emerging issues such as size and role of remittances and portability of social benefits across international borders.

As of 2013, there are estimated some 232 million individuals living outside their home country, amounting to over 3.1 percent of world population with rising tendency[17]. From 1990 to 2013 the number of international migrants increased by 77 million or 50 percent (UN, 2013). Most of this international migration happens in the South-South and South-North Corridor leaving behind the North-North corridor movements in recent decades; the North-South corridor has been stagnant in absolute numbers (see Figure 17)[18].

Figure 17. Numbers of international migrants by origin and destination, 1990-2013 (millions)



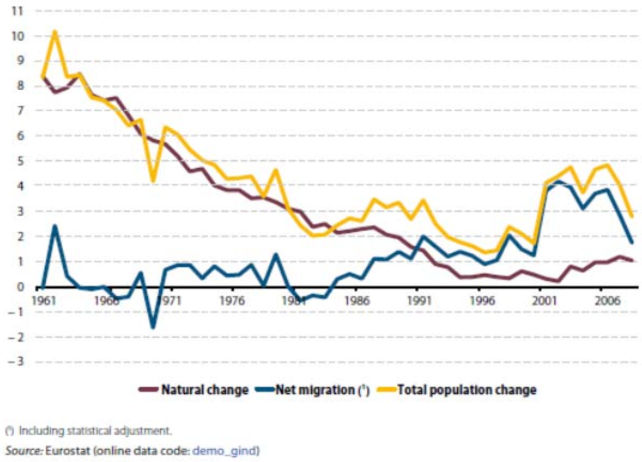
Source: UN, Department of Economic and Social Affairs (2013). Trends in International Migrant Stock: The 2013 Revision-Migrants by Destination and Origin (UN database, POP/DB/MIG/Stock/Rev.2013/Origin).

For European countries it is the South-North and the North-North corridors that have the greatest importance. The North-North corridor includes the EU-internal/EEA migration that has gained importance with the full mobility from the member countries of Central and Eastern Europe. Most future net migration can be expected from the South-North corridor in view of the economic, demographic and other differences in developments. Already nowadays is the change in the demographic structure of the EU dominated by net-migration flows and thus dwarfing or compensating the low or negative natural demographic balances of birth and death (see Ayuso and Holzmann, 2014a, and Figure 18).

17 This number is estimated on foreign born or else foreign citizens. It does typically not include refugees or which it is assumed that they will return to the home country at a moment of time.

18 The internal migration in large countries is quite likely of much larger in absolute numbers. Alone in China is the number of migrant workers living outside their local residency permits estimated at some 250 million.

Figure 18. Population Change by Component, EU 27, 1961-2009 (in 000')



Source: Eurostat 2011: Figure 1.

This subsection will briefly (i) explore the conjectured economic and non-economic determinants of (bi-lateral) migration flows; (ii) highlight the results of empirical studies from OECD-type economies; and (iii) outline how these results can be used to project future net-migration flows in the world and in particular for EU countries.

(i) The economic and non-economic determinants of (bi-lateral) migration flows. Migration is quite likely the oldest and most important risk management instrument in mankind's history. While the main determinants may have somewhat shifted over time from escaping wars to getting jobs, the main driver for migration remains essentially unchanged and an application of the human capital model: migration is risk management instrument to protect and further one's human capital and contribute one's well-being[19].

A traditional and still largely valid conceptualization of migration flows between countries is the push and pulls approach. There are forces that push individuals outside their country, and forces that drag them in, the most important ones being those of demographic, economic and political nature and reflect imbalances and thus arbitrage possibilities for migrants (see Holzmann and Muenz, 2006):

- Demographic imbalances between countries/regions with high and low (or even negative) demographic balance (i.e. births and deaths) are the first main determinant for migration flows. More refined, it is imbalance at the entry to the labor market that matters most as this is also the age when individuals have most to win and least to loose from going abroad. The mere quantitative side is, of course, closely linked with unemployment and with wages levels but is a determinant of its own. Fertility in Europe is low and the population despite increasing longevity projected to decrease without migration. This is in contrast to the MNA and SSA region where fertility will remain well above replacement rate. This leads to projected population gap by 2060 of 100 million in the EU and a surplus of 150 million in MNA and 1.500 million in SSA.
- Economic imbalances are another main migration determinant and include the access to a good job, the wage level it pays, etc, all of which are closely linked to the GDP per capita.
- Economic indicators clearly show two things: the large gap between Europe and neighboring world regions, but also considerable heterogeneity within these regions.
- For example, the maximum ratio of per capita income between the richest European and poorest MENA-20 country is 82:1; for the regional per capita averages, the ratio still amounts to almost 7:1[20]. This income gap is expected and project to be reduced over the coming decades but may not have closed for most countries in the South by 2100.
- Differences in political stability and the rule of law are conjectured to be a third main determinant for migration, a factor that may increase with economic growth in the South and thus countervail lowering immigration pressure.
- Political, ethnic, or religious conflicts exist in all world regions. But as asylum and displacement figures show, only some of these conflicts create migration pressure. A ranking of all EU+EEA, EECA, and MENA countries according to a political stability indicator and a rule of law indicator may serve as a proxy for the level of individually perceived insecurity. The exercise indicates differences in political stability, the human rights situation, and the general rule of law between Europe and neighboring regions, with the EU countries at the top of the score, most Eastern European and Balkan countries in the medium range, and many of the MENA countries in the lower segments.
- Last but not least, a main historical determinant for mass migration were climate changes as documented in the migration flows around the ice age, the dessertation of the Sahara region, and inflows of Asian tribes into Europe triggering the Voelkerwanderung.

Such changes may be in the wing through rising see levels, further dessertation in Africa or Asia or other climatic changes nearby and far.

(ii) Empirical determination of the key drivers of migration. The empirical testing of the determinants of bi-lateral flows relies in most cases of an adjusted gravity model that has been borrowed and adjusted from the investigation of trade flows and works pretty well also in migration (e.g. Crespo Cuaresma et al., 2013, Ortega and Peri, 2013). The adjusted model application has the still the traditional gravity components at the center – GDP/capita in sending in receiving country,

[19] For a human capital inspired economic approach to explain the determinants if international migration, see for example Bodvarrsson and Van den Berg (2013); for a development science inspired approach that stresses capabilities and aspirations of migrants, see de Haas (2011) and the related project International Migration Institute (University of Oxford); for the risk management approach, see Holzmann and Jorgensen (2001).

[20] At current exchange rates.

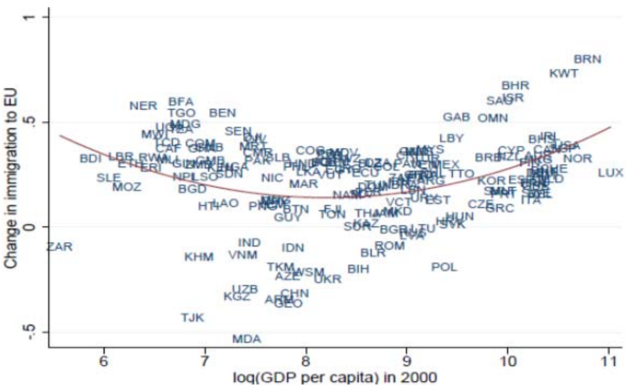
distance, common border and language, but also unemployment rate in sending and receiving country, share of young population origin), human capital differences (years of schooling). To our knowledge, the differences and political stability and the rule of law have not yet been subject to or added to existing investigation (except in country cases studies). More refined models and estimation approaches together with the emerging availability of long panel data between countries compared to the prior cross-section data only have sharpened empirical results. A sample of such recent studies and their results can be summarizes as follows[21]:

- The income per capita at the destination country matters importantly and is in all studies statistically highly significant, that of the source country matters little and is typically weak or insignificant. This does not mean that the income gap is irrelevant as the parameter for the destination country is estimated given the income level of the source country.
- A 1 percent increase in income per capita at a given destination is associated with a 0.76 percent increase in bi-lateral migration flows. This elasticity is twice as large for intra-EU migration flows, reflecting the higher degree of labor mobility within the EU (Ortega and Peri, 2013).
- The share of young population in the origin country is a push factor and typically significant (+), that of the years schooling at the destination a distraction and highly significant (-), and years of schooling at the origin insignificant (Mayda, 2010).
- The costs of migration matter for the size of the flows. Mostly significant coefficient include distance (-), common language (+), common currency (+), common legislation (+), and colonial ties (+) (Mayda, 2010, Ortega and Peri, 2013, Chiswick and Miller, 2015)
- National immigration policies play a large role in determining the size of migration flows Hatton and Williamson, 2005). The estimates for (non-European) immigrant destination such as Australia, Canada and Australia suggest that a tightening of laws leads to a fall in immigration flows by 6 percent (Ortega and Peri, 2013).
- The Maastricht treaty with a common currency and strengthened labor market mobility has increased migration by around 10 percent while the Schengen treaty has decreased immigration from the outside of the EU (Ortega and Peri, 2013).

(iii) How may an empirical approach to estimate future migration flows look like? The available empirical estimates offer important and useful indications what drives migration flows and what determines the net migration of a country. These estimates are, however, only the result for a select number of high income countries and there bi-lateral flows. For most other countries the detailed data on inflows and outflows are not available, only estimates on the net-balance.

Recently an estimation approach was proposed to estimate the bi-lateral flows between countries employing the fact that available net migration flow figures for a country are nonlinear aggregates flows from and to all other countries (Cuaresma, Moser and Raggl, 2013). Using simple specifications based on the gravity model their results confirm for a very large cross country data set covering 172 countries the typical determinants GDP differences, distance and joint borders with high statistical significance. Using data for population and GDP developed under the 5th Assessment Report of the Intergovernmental Panel for Climate Change (IPCC) they construct projections for future migration flows. Figure 19 presents the projected percentage changes in migration flows towards Europe for the period 2010-2050 (by country of origins) against the current GDP per capita levels of the source countries. The concentration is here on the old EU 15 countries to explicitly address the changes from Central and Eastern Europe. The results suggest that under the projected demographic and economic developments at the global level the flows of migration to Europe over the next 40 years are expected to increase. The U-shaped relationship between current income levels and expected increases in migration flows indicates a change in source country composition of migrants to Europe. But this reflects also the underlying income convergence trends assumed in the middle-of-the road scenario investigated.

Figure 19. Projected Change in Migration to EU15 from Current Source Countries



Source: Cuaresma, Moser and Raggl (2013)

21 Drawing on Kim and Cohen (2010), Mayda (2010), Cuaresma, Moser and Raggl (2013), Ortega and Peri (2013), Chiswick and Miller (2015).

4. Evaluation of current population projections, suggested extensions, and next steps

This final Section offers summary evaluation of the projected demographic drivers – fertility, mortality, and migration – by the UN and Eurostat against the background of broader approaches of projections that include economic and other socio-economic determinants, not only prior trends or demographic transition priors. The basic assessment that existing medium/central variants for these drivers offer projections that urgently need revision provides natural suggestions for extension and proposed next steps.

Both the UN projections as well as those by Eurostat that seem to follow closely the international projection leader apply methods and assumptions that may be convenient but are little credible. This assessment applies in particular for the projections of fertility and migration; the assumptions about mortality/life expectancy are seemingly less concerned, but this may be also mistaken. The key objections against each demographic driver projection can be summarized as follows:

Fertility projections

- There are strong indications that many developing countries may remain on a high fertility trajectory and not converge quickly to replacement level, or below.
- Introducing different convergence levels already in the medium variant is strongly suggested and technically easily possible but may politically not be convenient. It would exhibit the unsustainability of the demographic course in many African countries.
- There are no indications that in high income countries the fertility rate will re-increase (without policy changes) in a sustainable manner and converge toward the projected higher levels. This is supported by very rigorous analyses introducing economic and other non-demographic determinants, large scale data and cutting-edge econometrics.
- There are strong conjectures that countries may converge toward country-specific fertility rates, with much of Europe perhaps to lower rates also currently projected by UN and Eurostat, and, perhaps, also by some national population projections.
- The differences between the UN/Eurostat projections of EU for the total fertility rate of Portugal and Spain by 2080/2100 and those from more credible approaches, already practiced by a number of national statistical offices, is sizable: 1.82/1.88 compared to some 1.12 children per women.

Mortality/life expectancy projections

- The mortality assumptions in both UN as well as Eurostat population projections seems to be the closest to the projection frontier, in particular as the link to other than demographic determinants are empirically not well established and mortality modelling beyond Lee and Carter is still a constructions site (albeit with interesting contributions).
- Given the stark linearity of best practice life expectancy trends it would be sensible to calculate, at least for EU countries, a variant that uses this frontier for every country as a probable and current upper limit.
- A further variant to consider is to model the impact of breakthroughs in communicable and non-communicable diseases, the diffusion of such breakthroughs, and the implications for mortality rates. The analytical and empirical basis for such an approach may, however, not yet be fully developed.
- The differences between UN/Eurostat and alternative projections approaches for life expectancy by 2080/2100 cannot yet be put into firm numbers. Using simple linearity assumptions the difference may amount to some 10 years, i.e. essentially doubling the change in life expectancy from now to 2100 in Europe.

Migration Projections:

While the most promising area for improvement of population projections, as the weakness of the current approach is blatant, this may be also the most demanding one with regard to data requirements and modelling complexity.

- A starting point will need to be to get the stock and flow data for the three key groups in EU countries and their immigration/emigration flows - Nationals, EEA citizens, and non-EU citizens for a long time period.
- Disaggregating the non-EU citizens into refugees, labor migrants, family unification, and illegal migrants would help with projections as the policies to manage stocks and flows are different. A special complication is the naturalization process as it shifts category compositions while parameters may be kept constant.
- For non-EU citizens working on the current key corridors would help with data and parameter estimations.
- Joint modelling and estimation across EEA would substantially improve approach and parameter estimation.

- Modelling may be inspired by the existing models of bi-lateral determinants of migration flows and the use in integrated estimation approaches.
- These models would need to be based on separate forecasts for economic growth and other determinants, take account of economic convergence literature and demographic projections outside Europe, be based on historic estimates of gross migration flows (immigrants and emigrants), and include estimation of past policy effects on migration flows to to capture demographic push and pull effects. Further sophistications may include estimating the effects of policy changes or stock/flow interactions[22].
- Such models in this direction are under elaboration and are hitting major data and conceptual stumbling blocks but first promising results are out. At one not too distant moment they will need to be the base for migration projections in national and international demographic projections.
- How much the differences between current and alternative approaches of net migration projection would amount to only speculative questimations allow to answer. They may to amount to a multiple of the decade averages in most EU countries with possible rising trend.

Differences in projected demographic drivers lead to different population projections and measured aging outcomes, and have consequences for pension systems and their financial sustainability. The impact is not fully predictable as an underestimation of population aging from underestimated fertility and life-expectancy trends is potentially counterbalanced by underestimated net migration streams. Yet rough calculations suggest that this may not be the case - both quantitatively (as the fertility and mortality effects are likely to dominate the net migration effect) - and politically (as a too high net migration flow may not be acceptable).

Thus a suggested next step is to offer broad estimates from current scenario projections on the likely effect of mis-projections on population dynamics and aging. A suggested second step will be to undertake alternative demographic driver projections that take account of the issues and alternative projection approaches outlined above. A suggested last step will be to assess the impact of substantiated different demographic projection results on population aging, the financial consequences, and the proposed policies to counteract. They may range from pro-natal policies to even more aggressive increase in effective retirement age.

[22] For example, while network effects seem to increase migration flows initially, there are indications that to high stocks of migrants may have opposite effects.

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