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Directorate F: Social statistics
Unit F-2: Population and migration

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ESTAT/F-2/GL*

TECHNICAL NOTE

Subject: Summary methodology of the 2015-based population projections

1. BACKGROUND

In the conclusions of the ECOFIN meeting held on 12 May 2015 on the sustainability of public finances in the light of ageing populations, the Council "…*invites the Economic Policy Committee to update, on the basis of new population projections to be provided by Eurostat, in close cooperation with the National Statistical Institutes (NSIs), its analysis of the economic and budgetary implications of population ageing by the autumn of 2018.*"

In response to this invitation, Eurostat coordinated work, together with National Statistical Institutes (NSIs), aimed at developing models for computing population projections. This coordination took place within a statistical Working Group on Population Projections (WGPP), set up and chaired by Eurostat. The WGPP, composed by representatives of the national statistical authorities in charge of official projections, held four meetings hosted by Eurostat on 8-9 March in Luxembourg, and respectively by the National Statistical Institute (NSI) of Portugal on 6-8 June in Lisbon; of Spain on 26-27 September in Madrid; and of Austria on 17-18 November in Vienna. WGPP members were invited to make technical proposals for discussion at WGPP meetings.

Several NSIs have put forward methodological proposals for the production of assumptions, which have been intensively discussed in the meetings of the WGPP. During these discussions, agreement was reached on the models to be used for fertility and mortality. On migration, it was agreed to further consult the NSIs on the two proposed models via a specific written consultation procedure, which has led to retaining the model for migration assumptions generally supported and accepted by the large majority of NSIs (27 NSIs).

These resulting projections do not replace those produced by the NSIs. Given the intrinsic uncertainty of future population dynamics, such results should be understood as one of the many possible population developments and some national projections may well diverge from these projections. There could be numerous reasons for differences,

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such as alternative views on future background contexts ('scenarios'), adoption of different models, diverse specifications of the same model, different input data.

2. GENERAL FEATURES

The 2015-based projections cover the 29 countries included in the Ageing Report (the 28 EU Member States plus Norway). The following principles constituted the basis for this EU-wide exercise: the use of official statistics available to Eurostat as input data; a common methodology for all participating countries; and a high transparency of the process. These principles have had a large influence on the selection of the methodology for the production of the assumptions by the WGPP.

2.1. Preliminary methodological choices

The WGPP agreed to adopt a deterministic approach, based on assumptions formulated for each of the components of the population change (fertility, mortality and migration), and to produce population projections by sex, single age up to age 100+, and single year until 2080. Projections were to refer only to the entire national territory, without sub-national geographical breakdown, and to the entire population, without additional disaggregation by characteristics such as country of birth, citizenship, or education.

2.2. Data input

Annually, Eurostat carries out a collection of demographic and migration data, which are harmonized in accordance with specific EU regulations[1]. These data are stored in the public Eurostat database and accessible by everybody for free.

While this set of data is as homogeneous as possible, it does not have a complete coverage for past years. The legal obligation of Member States to provide harmonized demographic and migration data has been introduced only recently[2] and data collected previously to the entry into force of the specific EU regulations may have varying degrees of availability and quality.

The input to this projections exercise was therefore not a uniform, complete dataset of fertility, mortality and migration data, but rather a dataset whose time series, looking as back as to the year 1960, where of unequal length and detail across countries. Moving from 1960 rightward along the time axis, these data were more and more comparable in quality and structure. This issue was affecting with a different strength the fertility, mortality and migration data. These latter were the most incomplete, despite an additional special data collection on past migration data run by Eurostat during the current projections exercise[3].

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[1] European Parliament and Council Regulation (EC) No 862/2007 on Community statistics on migration and international protection and repealing Council Regulation (EEC) No 311/76 on the compilation of statistics on foreign workers, OJ L 199, 31.7.2007, p. 23–29; Regulation (EU) No 1260/2013 of the European Parliament and of the Council of 20 November 2013 on European demographic statistics, OJ L 330, 10.12.2013, p. 39–43; and their implementing acts.

[2] Since the reference year 2009 for migration statistics and since the reference year 2013 for demographic statistics.

[3] All input data can be downloaded from the Eurostat database: http://ec.europa.eu/eurostat/data/database

Additionally, the requirement to provide the projections by February 2017 has obliged to use the population on 1 January 2015 as base population, and fertility, mortality and migration data up to the year 2014 as input to the assumptions. However, despite these constraints, technical solutions have been found to incorporate the very latest information in the projections (see below).

2.3. Decomposition of the time horizon of the projections

For the choice of the model used for the formulation of the assumptions, the time horizon of these projections has been broadly split in three periods: 'current' time (2015-2016), short-/medium-term (about 2017-2050), long-term (from 2050 onwards).

The first time segment, i.e. the first two years after the start-off date of the projections (1 January 2015), for which some information was already available, has been approached with now-casting techniques. In particular, for the calendar year 2015, the total numbers of live births, deaths and net migrants, available from the regular Eurostat data collection, have been used as constraint to be met in the projections calculations. For the calendar year 2016, countries were already disposing of some preliminary data (usually monthly data covering the first part of the year) and on this basis they have then provided[4] their forecast ('nowcast') of the total number of live births, deaths and net migration for the entire year. Like for the year 2015, these forecasts have been used as constraint in the computation of the projections. The result of the projected total population for the years 2016 and 2017 is therefore equal to the provisional observed (2016) and nationally projected (2017) data.

For the second time segment (the short-/medium-term), it has been privileged an approach based on trends extrapolation. This technique takes into account past demographic trajectories and projects them in the near future. Therefore, it is assumed that the factors driving the demographic dynamic in the past will continue to exert their influence for the short and – to a less extent – medium term ahead.

A long-term vision of the population dynamics requires however something beyond a mere extrapolation of recent trends, as this latter may appear to be less plausible when extended over long periods. Such speculative view of the future is assumed to drive the population developments in the long term. As the demographic dynamics derived under this long-term assumption may lead to paths different from those derived by trends extrapolation, a progressive transition is assumed to occur in the decades after the current period. Taking this approach, it is important to express in a clear way what the scenario of reference is.

2.4. The scenario

In population projections, the 'scenario' is the description of the context of the population developments and it usually refers to the main assumption(s) adopted for those specific projections. For the 2015-based projections, it is the assumption of 'convergence' that has been retained. This main assumption can be summarised as follows: *socio-economic differentials among EU Member States are expected to be fading out in the very long term*.

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[4] Exceptions: Belgium and France did not provide any nowcast for 2016; Germany, Hungary, Romania, Slovakia and the United Kingdom have provided only some of the nowcast data for 2016.

'Convergence' is a concept which is central to many EU policies. For instance, the Structural Funds, among the most important EU funding, have as first purpose to narrow the gap between the development levels of the various EU regions, improving their social cohesion and economic well-being. 'Convergence' is therefore a natural conceptual framework for assumptions in the context of the European Union[5].

It should be noted that it has never been assumed that full convergence would be achieved, leading to countries equal in their demographic elements. It is rather an assumption of countries moving together and getting – demographically speaking – closer, due to the influence exerted by the (converging) socio-economic drivers. This does not exclude temporary divergence between countries.

2.5. Non-demographic drivers

While demographic dynamic is influenced by a variety of non-demographic factors, it is difficult to incorporate these relations in formal models. In fact, this creates the challenge of forecasting the values of the non-demographic predictors over a very long time horizon, usually far ahead of those available from external sources. Sometimes, the forecasted values of these predictors are in turn depending on future population values. Additionally, the identified statistical relations should equally apply also in the future, and they must be enough fit for all the countries covered by the exercise. Tests run to incorporate economic variables have led to the WGPP consensus to put aside for this projections exercise the statistical use of non-demographic drivers and to focus on pure demographic mechanisms.

2.6. Overall synthetic description

The resulting statistics are the outcome of cohort-component deterministic international projections for the entire population at national level by age and sex, using nowcasting, trends extrapolation and long-term assumption of partial convergence, with a transition period between these two latter components. No model has explicit non-demographic factors.

3. MODELS

Being applied on countries with varying data availability and quality, the models must be flexible and, at the same time, robust enough to deal with a diversity of demographic profiles without requiring *ad-hoc* adjustments for individual countries.

3.1. Fertility

The fertility assumptions are based on the extrapolation of four parameters derived from a model of fertility age patterns[6]. These parameters are the overall level of fertility

[5] More on the convergence assumption in population projections can be found in Lanzieri G. (2009): "*EUROPOP2008: a set of population projections for the European Union*". Paper for the XXVI IUSSP International Population Conference, Marrakech (Morocco), 27 September – 2 October 2009.

[6] See Marsili M. and G. Corsetti (2016): "*Fertility trends in European Countries through the Schmertmann's model*". Presentation at the meeting of the Working Group on Population Projections, Madrid, 26-27 September 2016; and Marsili M. and G. Corsetti (2016): "*Fertility trends in European Countries through the Schmertmann's model – A new variant*". Presentation at the meeting of the Working Group on Population Projections, Vienna, 17-18 November 2016.

(summarised by the total fertility rate – *TFR*), the starting age α of fertility, the age P at which fertility reaches its peak level and the youngest age H above P at which fertility falls to half of its peak[7].

From each combination of these four parameters it is possible to derive the entire age pattern for fertility. The model uses as input observed data from 1977 to 2014, deriving, for each country, time series of these parameters. These time series have been used as input for the extrapolation of the values until 2080 using ARIMA models for all parameters but α, for which the same value observed for 2014 is used for all the years. The choice of the models for trends extrapolation has been based on a mix of criteria, such as statistical performances and demographic soundness of the outcomes.

These parameters are however constrained to partially converge[8] in the long run towards those of a set of countries whose fertility behaviour is considered as forerunner in Europe. For this exercise, these countries are: Belgium, Denmark, France, the Netherlands, Finland, and the United Kingdom. Their fertility data have been pooled and the same procedure described above has been followed again, by applying ARIMA models.

The parameters' trends projected above for each single country are then progressively forced towards the parameters of the 'super-population' composed by the selected six countries, without however imposing full convergence. The use of a 'super-population' allows avoiding the reference to a specific country and takes into account the fact that changing fertility forerunners have been recorded over time in Europe in the past. From the extrapolated parameters are then derived the projected age-specific fertility rates.

Therefore, the projected fertility rates are predominantly obtained from the country-specific trend extrapolation at the beginning of the projections period, and more influenced by the convergence assumption towards the end. The fertility rates for 2015 and 2016 are proportionally modified in order to meet the constraint of the total number of live births reported by the countries. The modification has no impact on the rates projected for the years following 2016. Projected values of the TFR are reported in the Table 1.

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7 For details on the model, see Schmertmann C. (2003): "A system of model fertility schedules with graphically intuitive parameters", *Demographic Research*, 9(5):81-110.

8 On the convergence in fertility, see also Lanzieri G. (2010): "*Is fertility converging across the Member States of the European Union?*" Proceedings of the Joint Eurostat-UNECE Work Session on Demographic Projections, Lisbon (Portugal), 28-30 April 2010.

Table 1: assumptions on the TFR at selected years

	2020	2030	2040	2050	2060	2070	2080
BE	1.73	1.75	1.76	1.78	1.80	1.82	1.84
BG	1.62	1.69	1.73	1.76	1.78	1.80	1.82
CZ	1.68	1.74	1.76	1.78	1.80	1.82	1.84
DK	1.71	1.73	1.75	1.77	1.79	1.82	1.84
DE	1.50	1.53	1.57	1.60	1.64	1.68	1.72
EE	1.67	1.75	1.77	1.78	1.80	1.81	1.83
IE	1.96	1.96	1.96	1.96	1.96	1.97	1.97
EL	1.33	1.40	1.46	1.52	1.58	1.64	1.70
ES	1.57	1.80	1.87	1.88	1.88	1.88	1.89
FR	2.01	2.00	1.99	1.99	1.99	1.99	1.99
HR	1.47	1.51	1.54	1.58	1.61	1.65	1.70
IT	1.36	1.42	1.48	1.54	1.60	1.66	1.71
CY	1.35	1.40	1.45	1.51	1.56	1.62	1.67
LV	1.83	1.85	1.85	1.85	1.86	1.87	1.88
LT	1.71	1.76	1.79	1.81	1.82	1.84	1.85
LU	1.54	1.57	1.60	1.63	1.66	1.69	1.73
HU	1.61	1.68	1.72	1.75	1.77	1.80	1.82
MT	1.54	1.62	1.67	1.70	1.72	1.75	1.77
NL	1.73	1.74	1.76	1.77	1.79	1.81	1.84
AT	1.49	1.53	1.56	1.59	1.62	1.66	1.70
PL	1.45	1.56	1.61	1.65	1.68	1.71	1.74
PT	1.28	1.34	1.40	1.47	1.53	1.59	1.65
RO	1.72	1.81	1.85	1.87	1.88	1.89	1.90
SI	1.62	1.66	1.70	1.74	1.78	1.81	1.85
SK	1.47	1.60	1.68	1.74	1.79	1.82	1.85
FI	1.71	1.72	1.74	1.76	1.78	1.80	1.83
SE	1.87	1.91	1.95	1.98	2.01	2.03	2.04
UK	1.80	1.81	1.83	1.84	1.86	1.87	1.89
NO	1.74	1.76	1.77	1.79	1.81	1.83	1.85
Average	**1.62**	**1.68**	**1.71**	**1.74**	**1.76**	**1.79**	**1.82**

3.2. Mortality

Mortality patterns are assumed to partially converge towards a common (sex-specific) life table[9] (the 'ultimate' life table). The trends extrapolation for the first years of projections is not applied here mainly because of a lack of historical data. However, the ultimate life table of reference incorporates already some information from mortality trends.

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[9] On the way the ultimate life table has been derived, see Lanzieri G. (2009): "*EUROPOP2008: a set of population projections for the European Union*". Paper for the XXVI IUSSP International Population Conference, Marrakech (Morocco), 27 September – 2 October 2009. Discussions at the WGPP on the possible update of the ultimate life table have led to the conclusion that such updating would better be made only once the current input mortality data have been enriched (also using mortality estimates).

The partial convergence takes place by exponential interpolation of the age- and sex-specific mortality rates from the initial country-specific mortality age patterns (for men and women). The initial mortality patterns are derived from the period-cohort age- and sex-specific rates reported by the country for the year 2014. In order to remove random fluctuations, these patterns have been smoothed over age using a monotonic regression spline[10].

Because the smoothing of the observed rates may have an impact on the estimated life expectancy, the smoothed patterns have been shifted upwards or downward in such a way that the corresponding life expectancies at birth match the life expectancies at birth as from the observed rates in 2014. This avoids introducing a fictitious jump in the time series of life expectancy moving from the last observed value to the projected ones[11]. The shift is obtained by simple multiplication of the smoothed rates with a correction coefficient.

The adjusted smoothed age- and sex-specific mortality rates for 2014 are the initial mortality patterns used for the interpolation. However, the rates for the years 2015 and 2016 are proportionally modified in order to meet the constraint of the given total number of deaths. The mortality rates 2015 and 2016 so modified have no influence on the rates projected for the following years. Projected values of the life expectancy at birth for men and women are reported respectively in the Table 2 and in the Table 3.

[10] See Wood S.N. (1994): "Monotonic Smoothing Splines Fitted by Cross Validation", *SIAM Journal on Scientific Computing*, 15(5):1126-1133. Method implemented in the R package 'demography' of R.J. Hyndman with contributions from H. Booth, L. Tickle and J. Maindonald.

[11] Another element of difference is due to the fact that the life expectancy is currently computed by Eurostat using age-period mortality rates, while these mortality projections use period-cohort mortality rates. These latter have been translated into age-period rates before computing the corresponding life expectancies, but imprecisions may still be present in the transformed data.

Table 2: assumptions on the male life expectancy at birth at selected years

	2020	2030	2040	2050	2060	2070	2080
BE	79.5	81.0	82.4	83.8	85.0	86.2	87.2
BG	72.6	75.1	77.4	79.5	81.5	83.3	84.9
CZ	76.8	78.6	80.3	82.0	83.5	84.9	86.2
DK	79.5	81.0	82.4	83.7	84.9	86.1	87.2
DE	79.4	80.9	82.3	83.6	84.9	86.1	87.1
EE	73.8	76.1	78.3	80.3	82.2	83.9	85.4
IE	80.1	81.5	82.9	84.1	85.3	86.4	87.5
EL	79.6	81.2	82.6	84.0	85.3	86.5	87.5
ES	81.0	82.3	83.6	84.8	85.9	86.9	87.9
FR	80.2	81.7	83.1	84.3	85.5	86.6	87.6
HR	75.8	77.8	79.6	81.3	82.9	84.4	85.8
IT	81.2	82.5	83.7	84.8	85.9	86.9	87.8
CY	81.4	82.7	83.8	84.9	86.0	87.0	87.9
LV	70.7	73.5	76.1	78.5	80.7	82.7	84.5
LT	70.8	73.6	76.2	78.6	80.8	82.8	84.6
LU	80.0	81.5	82.8	84.1	85.3	86.4	87.4
HU	73.7	76.0	78.2	80.3	82.1	83.9	85.5
MT	80.5	82.0	83.4	84.7	85.8	86.8	87.8
NL	80.7	82.0	83.2	84.4	85.5	86.5	87.5
AT	79.8	81.3	82.7	84.0	85.2	86.3	87.3
PL	74.9	77.1	79.2	81.1	82.8	84.4	85.9
PT	78.9	80.5	82.0	83.4	84.7	85.9	87.0
RO	72.9	75.4	77.8	79.9	81.8	83.6	85.3
SI	78.9	80.4	81.9	83.3	84.6	85.8	87.0
SK	74.6	76.8	78.9	80.8	82.6	84.2	85.7
FI	79.1	80.6	82.1	83.4	84.7	85.9	87.0
SE	81.1	82.3	83.5	84.6	85.7	86.7	87.6
UK	80.2	81.6	83.0	84.2	85.4	86.5	87.5
NO	80.8	82.1	83.3	84.4	85.5	86.6	87.5
Average	**77.9**	**79.6**	**81.3**	**82.8**	**84.2**	**85.5**	**86.7**

Table 3: assumptions on the female life expectancy at birth at selected years

	2020	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**
BE	84.3	85.7	86.9	88.1	89.2	90.2	91.2
BG	79.2	81.2	83.0	84.7	86.3	87.8	89.2
CZ	82.6	84.1	85.5	86.8	88.1	89.3	90.4
DK	83.6	85.0	86.4	87.7	88.9	90.0	91.0
DE	84.2	85.5	86.7	87.9	89.0	90.1	91.0
EE	82.5	84.1	85.6	87.0	88.3	89.5	90.6
IE	84.2	85.5	86.9	88.1	89.2	90.3	91.3
EL	84.5	85.8	87.0	88.2	89.3	90.3	91.3
ES	86.3	87.4	88.4	89.4	90.3	91.2	92.0
FR	86.1	87.3	88.4	89.4	90.3	91.1	92.0
HR	81.8	83.4	84.9	86.3	87.6	88.9	90.0
IT	85.8	86.9	88.0	89.0	90.0	90.9	91.7
CY	85.0	86.2	87.2	88.3	89.3	90.2	91.1
LV	80.4	82.3	84.1	85.7	87.2	88.6	89.9
LT	81.0	82.8	84.5	86.0	87.4	88.8	90.0
LU	85.3	86.6	87.8	88.9	89.9	90.9	91.7
HU	80.4	82.3	84.0	85.7	87.2	88.6	89.9
MT	84.8	86.1	87.4	88.5	89.6	90.6	91.5
NL	84.1	85.5	86.7	87.9	89.0	90.1	91.0
AT	84.5	85.8	87.0	88.2	89.2	90.2	91.2
PL	82.4	84.0	85.6	87.0	88.3	89.5	90.6
PT	84.9	86.1	87.3	88.4	89.4	90.4	91.3
RO	79.9	81.8	83.6	85.3	86.9	88.3	89.7
SI	84.4	85.7	86.9	88.0	89.1	90.1	91.1
SK	81.4	83.2	84.8	86.3	87.8	89.1	90.3
FI	84.6	85.8	87.0	88.1	89.2	90.2	91.1
SE	84.8	86.1	87.2	88.3	89.4	90.3	91.3
UK	83.9	85.3	86.7	87.9	89.0	90.1	91.1
NO	84.8	86.1	87.2	88.3	89.4	90.4	91.3
Average	**83.5**	**85.0**	**86.3**	**87.6**	**88.8**	**89.9**	**90.9**

3.3. Migration

Besides being notoriously the most volatile and the most difficult element of the population change to be forecasted, in recent years migration flows towards the EU have been characterized by a large number of asylum seekers, a migration component even more volatile. Additionally, current national practices on the inclusion/exclusion of asylum seekers and/or persons granted protection ('refugees') in the migration statistics are not fully harmonized at EU level[12].

Hence, the available data on immigration and emigration flows were very limited over time (in general covering only few years), with high variability and affected by the latest

[12] See Eurostat (2016): "*Classification of Asylum Seekers and Refugees in the EU Annual Demographic and Migration Statistics*". Doc. ESTAT/F2/POP(2016)05/GL of 12 May 2016 for the Working Group on Population Statistics, Luxembourg, 2-3 June 2016.

flows. An additional special data collection on past immigration and emigration data has been launched to address the former issue, but its outcome has led to consider net migration[13] as the only viable information on past trends in migration. In order to tackle the latter issues (variability and asylum seekers), the WGPP agreed to replace the highest and the lowest values in the entire time series 1960-2016[14] of net migration respectively by the second highest and the second lowest value. By doing so, extreme peaks and troughs, usually due to special events (including the above-mentioned latest high inflows), would not affect the identification of migration trends. The input dataset consisted then of 'winsorized'[15] time series of total net migration starting from 1960, but for Portugal (1976) and Malta (1996), for which data referring to previous years were not adequate.

The net migration trends were identified and extrapolated by applying ARIMA models as selected by an automated model specification procedure[16]. These extrapolated values were progressively fading within values derived from a long-term vision. This latter was based on the assumption of equal attractiveness[17] in the very long term of migration flows by the countries, except for the different population structures projected in the future, factor which was differently tackled (see below). The tendency of the national pull forces to converge leads to assume a trend towards equal immigration and emigration rates across countries in the very far future[18]. While in principle these rates may take different values, the high uncertainty of the far future and the large number of factors which may impact on the model[19] have suggested considering a long-term tendency towards common equal rates of immigration and emigration. While this translates in the 'easy-to-implement' assumption of zero net migration in the far future, it would be misleading to refer to these migration assumptions as 'migration going to zero' (as shown in Table 4 as well). A few points are worth noting in this respect:

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[13] By definition, net migration is the difference between immigration and emigration numbers. However, it may be computed also as residual component from the demographic balance (i.e., as population change minus the natural change). Using this method – the only feasible in lack of data on separated flows – net migration incorporates also any sort of statistical adjustments made to fit the demographic balance.

[14] These time series included the migration nowcast 2016 provided by the countries.

[15] 'Winsorizing' or 'winsorization' is the transformation of data by limiting extreme values to reduce the effect of possibly spurious outliers.

[16] See Hyndman R. and Y. Khandakar (2008): "Automatic Time Series Forecasting: The forecast Package for R". *Journal of Statistical Software*, 27(3):1-22. Method implemented in the R package 'forecast' of R.J. Hyndman.

[17] For more detail on the rationale of such assumption, see Lanzieri G. (2009): "*EUROPOP2008: a set of population projections for the European Union*". Paper for the XXVI IUSSP International Population Conference, Marrakech (Morocco), 27 September – 2 October 2009.

[18] For more detail on the original approach of the methodology, see Lanzieri G. (2007): "*EUROPOP2007 Convergence Scenario: Summary Note*". Doc. ESTAT/F1/PRO(2007)/02/GL of 26 November 2007 for the joint meeting of the Working Group on Population Projections and Working Group on Ageing Populations and Sustainability, Luxembourg, 29-30 November 2007.

[19] For instance, the impact of high migration flows on the population composition of low-fertility countries or emerging aspects of economic production which may affect migration (e.g., delocalisation of production, increasing use of robotics, etc.).

1. The long-term assumption of zero net migration applies only to the part of the migration model based on the scenario of convergence: different components of the model deal with the short-medium term and with the population structure factor, this latter always increasing the net flows.

2. Zero net migration is never reached within the time horizon of the projections: this is only a hypothetical value of reference necessary to enforce convergence in the national pull forces.

3. Zero net migration does not imply no migration at all: immigration and emigration flows may well be much different from zero, implying a relevant migration turnover.

4. The constraint only applies on the total size, and not to the age- and sex-specific flows.

In practice, the values of net migration based on the convergence assumption for the long term are derived by double interpolation between the last observed value (2015) and the common reference value in the far future. In order to reduce the influence of the last observation, a linear interpolation has been applied first between the net migration value in the year 2015 and an intermediate value estimated for the year 2020, obtained as the average of the net migration observed in the last 20 years (1996-2015). Afterwards, a second linear interpolation was done between the intermediate value of 2020 and the reference value of convergence. By doing so, the potential impact of an extreme starting value in 2015 is smoothed by forcing it towards a more 'stable' value derived from a much longer time period. Additionally, for the six countries[20] for which the intermediate point was negative and thus with negative convergence net migration projected for the following period, the convergence was assumed to occur by 2035, avoiding the prolongation over the entire time horizon of the projections of such negative net migration assumption (for the convergence part of the migration model).

As mentioned above, countries are characterized by different demographic profiles, including their population structure and the way it is projected to change over time. In countries where the size of the population in working ages (conventionally 15-64 years old) is projected to shrink, a 'feedback' correction factor for immigration is applied. This additional immigration is limited to 10% of the projected shrinkage of the working-age population and it is estimated as overall volume, without specific age profiles and once in all over the entire projections period. Such procedure requires to project a first time the population, to compute the projected shrinkage, to estimate the additional immigration and finally to re-run the projections computations. This demographic feedback mechanism is only applied for the shrinkage of the working-age population (thus increasing immigration) and not on its growth (thus increasing emigration).

Therefore, the assumptions on total net migration are derived from observed data for 2015, from national nowcasting for the year 2016[21], from a mix of trends extrapolation and long-term convergence between 2017 and 2050, almost exclusively from the trends

[20] They were: Bulgaria, Estonia, Latvia, Lithuania, Poland, and Romania.

[21] Belgium, Estonia, France, Hungary, Romania, and Slovakia have not provided the net migration nowcast for 2016. This year is then included in the following projections time period with the related methodology, thus their migration assumption for 2016 is basically taken from the trend extrapolation.

component at the beginning and progressively more from the 'convergence' values, until entering the long-term period (2050 onwards) in which the convergence assumption defines the migration values. All over the projections horizon, net migration flows may be increased due to the additional feedback mechanism depending on populations structures. The results are shown in the Table 4 for selected years.

Table 4: assumptions on net migration at selected years (in persons)

	2020	2030	2040	2050	2060	2070	2080
BE	53 228	48 304	41 508	32 819	29 538	26 247	22 977
BG	-11 934	-9 082	499	3 858	666	1 258	1 690
CZ	21 499	17 499	20 522	14 037	8 808	8 540	8 985
DK	33 431	26 828	18 872	10 678	11 366	9 295	7 477
DE	327 319	268 069	206 033	199 012	175 047	143 466	135 589
EE	2 334	1 441	1 190	673	91	259	301
IE	9 877	7 504	11 408	13 671	12 179	10 820	9 512
EL	-16 765	-4 149	7 943	13 297	10 464	10 953	9 204
ES	51 185	119 385	163 414	170 939	153 842	136 754	119 658
FR	77 044	85 898	77 328	69 155	62 243	55 322	48 411
HR	-1 732	4 194	5 024	6 016	5 217	4 558	3 858
IT	161 150	209 659	217 702	197 397	176 737	163 777	138 746
CY	1 711	2 911	3 855	4 894	4 396	3 742	3 340
LV	-8 034	-6 138	-1 451	1 192	-2	121	586
LT	-23 791	-16 965	-6 289	1 337	220	-2	818
LU	10 210	8 743	6 992	4 954	4 452	3 963	3 469
HU	19 884	16 221	20 831	15 341	13 836	11 182	9 877
MT	3 214	2 641	1 992	1 402	1 258	1 015	920
NL	66 913	59 482	43 700	29 561	28 609	24 537	20 696
AT	67 802	55 401	40 288	26 342	24 751	20 598	18 524
PL	-33	-2 359	16 243	29 737	11 648	7 300	9 979
PT	2 427	12 804	18 247	15 796	14 601	14 150	11 122
RO	-65 128	-51 088	-8 942	7 746	1 601	2 631	953
SI	4 206	4 126	4 284	3 765	2 831	2 513	2 445
SK	5 919	4 988	6 769	6 466	3 789	3 225	3 222
FI	15 808	13 681	10 723	8 517	7 815	6 765	5 846
SE	67 873	57 155	44 691	30 491	27 439	24 385	21 346
UK	251 507	220 071	180 958	134 178	121 112	107 338	93 924
NO	27 268	26 047	23 684	20 164	18 144	16 128	14 106

The breakdown by age and sex of the projected total net migration has been implemented by temporarily decomposing the net migration in separated flows for immigration and emigration. First emigration levels are taken from the average of last observed 5 years (2010-2014). This level is kept constant all over the projections period and the corresponding immigration level is then derived as the sum of net migration and emigration. In the few cases where this operation was returning negative immigration levels, immigration was taken to be equal to the last observed value (2014) and the emigration level adjusted accordingly to match the projected total net migration. The two time series so derived (immigration and emigration flows 2015-2080) have then been divided by two to obtain the sex-specific flows.

The age pattern for each migration flow (male immigrants, female immigrants, male emigrants, female emigrants) has been obtained by linear interpolation between initial values and common age profiles derived in previous studies[22]. The initial values were computed as the average of the latest observed 3 years (2012-2014) of age-specific migration levels and normalized to give a sum equal to one over the entire age range. The common age profiles at the end of the interpolation period were also standardized in the same way. The linear interpolation between these two sets was then giving also standardized migration age profiles for each projections year. The entire set of migration assumptions was obtained by multiplying these age-, sex- and flow-specific profiles by the projected corresponding sex- and flow-specific migration, and then re-aggregating age- and sex-specific immigration and emigration to get the projected net migration by age and sex.

[22] For details on the way the common migration age profiles have been derived, see Lanzieri G. (2007): "*EUROPOP2007 Convergence Scenario: Summary Note*". Doc. ESTAT/F1/PRO(2007)/02/GL of 26 November 2007 for the joint meeting of the Working Group on Population Projections and Working Group on Ageing Populations and Sustainability, Luxembourg, 29-30 November 2007.