EUROPEAN COMMISSION
EUROSTAT

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

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TECHNICAL NOTE

Subject: Summary methodology of the 2018-based population projections (EUROPOP2018)

1. GENERAL FEATURES

EUROPOP2018 refers to the population projections published by Eurostat in June 2019, including all EU and three of the EFTA countries, at national level. The time horizon spans from 2018 (also called the base-year of the projections) to 2100.

The approach used is that of deterministic projections, or 'what-if' population projections, based on assumptions formulated on a future course of fertility, mortality and migration. Population projections are published by sex and age.

The scenario is that of partial convergence among the countries included in EUROPOP2018 in fertility, mortality and migration developments. The methodology applied in EUROPOP2018 builds upon the previous projections exercises[1].

1.1. Data input

Annually, Eurostat carries out a collection of demographic and migration data, which are harmonized in accordance with specific EU regulations[2], and revised as often as necessary to accurately reflect the demographic and migration information from the reporting countries. These data are freely available on the Eurostat website.

The data used as input by EUROPOP2018 was downloaded in May 2019 from the following datasets:

[11] For more information on the methodology used in the previous projections exercise, please see the note "Summary methodology of the 2015-based population projections".

[2] 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.

- Population on 1 January by age and sex [demo_pjan]
- Fertility rates by age [demo_frate]
- Deaths by year of birth (age reached) and sex [demo_mager]
- Life expectancy by age and sex [demo_mlexpec]
- Net migration plus statistical adjustment (CNMIGRAT) from 'Population change - Demographic balance and crude rates at national level' [demo_gind]
- Immigration by age and sex [migr_imm8]
- Emigration by age and sex [migr_emi2].

At that time, the total numbers of live births, deaths and for net migration for 2018 were not available to Eurostat, and not included in the calculation of population projections. Nevertheless, by advancing the data transmission deadline, several countries provided Eurostat with information on total number of live births, deaths, immigration, emigration and statistical adjustment for the year 2018; and of the total population on 1 January 2019. These countries are: BG, CZ, DK, IE, ES, FR, IT, CY, LV, LT, LU, NL, AT, PL, PT, RO, SI, SK, FI, SE, UK; and CH. This information is referred to as the 'nowcast' component of population projections. This component adds a constraint in the computation of projections, namely that the projected population for the year 2018 is, in the instances of available nowcast, equal to the provisional observed 2018 data.

1.2. The scenario

In population projections, the 'scenario' is the description of the context of population developments in the area covered by projections. While being realistic, a scenario is not a forecast, and it is referred to as to a 'what-if' scenario.

For the countries covered by EUROPOP2018, the scenario retained is that of convergence, socio-economic convergence being central to many EU policies. In this scenario, due to the influence exerted by the converging socio-economic drivers, countries are moving together and getting closer from a demographic perspective. The EUROPOP2018 scenario is based upon a partial convergence for any of the components of demographic change: fertility, mortality or international migration. Temporary divergence between countries is not excluded either.

2. MODELS

Having the EUROPOP2018 scenario as starting point, three independent models are used for each component: fertility, mortality and international migration. Unless otherwise stated, each model is applied to all countries in the same way.

The output of the models is expressed in age-specific fertility rates, age-specific and sex-specific mortality rates; and age-specific and sex-specific net migration (including statistical adjustment) for each of the years covered by this projection exercise. The population by age and sex is calculated by recursively applying the changes brought by the stated assumptions on fertility, mortality and migration.

2.1. Fertility

The model combines, for the total fertility rate (TFR), a country-specific trend extrapolation and the convergence assumption. At the beginning of the projections period (up to and including 2020), the trend extrapolation has full weight. Afterwards, the convergence assumption starts operating, with linearly increasing weight towards the end of the projections period.

Country-specific trend extrapolations are obtained from a constrained ARIMA(1,0,1) applied to the time series 1950-2017. Missing Eurostat TFR data have been replaced with data extracted from the Human Fertility Database[3].

Convergence is modelled by assuming a tendency of fertility in all countries towards an ultimate value never reached during the horizon of the projections, namely equal to 1.83. This value represents the maximum TFR that UN's World Population Prospects 2019[4] project for 2100 for the countries included in EUROPOP2018.

The corresponding ultimate age-specific fertility rates are derived from an application of Schmertmann's model[5]. The intermediate values between the last observed year (2017) and the rates of the convergence year are obtained by linear interpolation.

Projected values of the TFR are reported in Table 1.

Table 1: assumptions on the TFR at selected years

	2020	2030	2040	2050	2060	2070	2080	2090	2100
BE	1.64	1.66	1.68	1.70	1.71	1.73	1.74	1.75	1.76
BG	1.58	1.61	1.64	1.66	1.68	1.69	1.71	1.72	1.74
CZ	1.71	1.73	1.74	1.75	1.76	1.77	1.78	1.78	1.79
DK	1.74	1.75	1.76	1.77	1.78	1.79	1.79	1.80	1.80
DE	1.56	1.61	1.64	1.67	1.69	1.71	1.72	1.73	1.75
EE	1.62	1.70	1.73	1.75	1.76	1.76	1.77	1.77	1.77
IE	1.76	1.76	1.77	1.78	1.78	1.79	1.79	1.80	1.80
EL	1.36	1.41	1.45	1.49	1.53	1.56	1.59	1.62	1.65
ES	1.31	1.36	1.41	1.45	1.48	1.52	1.55	1.59	1.62
FR	1.89	1.89	1.88	1.88	1.87	1.87	1.86	1.86	1.86
HR	1.43	1.47	1.50	1.53	1.56	1.59	1.61	1.64	1.67
IT	1.33	1.38	1.42	1.46	1.49	1.53	1.56	1.59	1.63
CY	1.34	1.38	1.42	1.46	1.50	1.53	1.56	1.59	1.63
LV	1.68	1.74	1.77	1.78	1.79	1.79	1.79	1.79	1.80
LT	1.62	1.64	1.67	1.69	1.70	1.72	1.73	1.74	1.76
LU	1.41	1.47	1.52	1.56	1.59	1.62	1.64	1.67	1.69
HU	1.55	1.64	1.68	1.71	1.73	1.74	1.74	1.75	1.76

[3] Human Fertility Database. Max Planck Institute for Demographic Research (Germany) and Vienna Institute of Demography (Austria). Available at www.humanfertility.org (data last downloaded on 19.6.2019).

[4] https://population.un.org/wpp

[5] 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.

	2020	2030	2040	2050	2060	2070	2080	2090	2100
MT	1.29	1.41	1.48	1.54	1.58	1.61	1.63	1.65	1.67
NL	1.61	1.63	1.65	1.67	1.68	1.70	1.71	1.73	1.74
AT	1.53	1.58	1.61	1.64	1.66	1.68	1.70	1.72	1.73
PL	1.52	1.56	1.60	1.63	1.65	1.67	1.69	1.70	1.72
PT	1.39	1.44	1.47	1.50	1.53	1.56	1.59	1.62	1.65
RO	1.75	1.77	1.78	1.79	1.79	1.79	1.80	1.80	1.80
SI	1.64	1.67	1.70	1.72	1.73	1.74	1.75	1.76	1.77
SK	1.53	1.56	1.58	1.61	1.63	1.65	1.67	1.69	1.71
FI	1.48	1.52	1.55	1.57	1.60	1.62	1.64	1.67	1.69
SE	1.76	1.78	1.80	1.81	1.81	1.81	1.82	1.82	1.82
UK	1.76	1.81	1.82	1.81	1.81	1.81	1.81	1.81	1.81
IS	1.71	1.72	1.73	1.74	1.75	1.76	1.76	1.77	1.78
NO	1.59	1.61	1.64	1.66	1.67	1.69	1.71	1.72	1.74
CH	1.52	1.55	1.58	1.60	1.62	1.64	1.66	1.68	1.70
AVG[6]	**1.57**	**1.61**	**1.63**	**1.66**	**1.68**	**1.69**	**1.71**	**1.72**	**1.74**

2.2. Mortality

Mortality patterns are modelled separately by sex. For both women and men, mortality rates are projected to gradually decrease (which corresponds to an increase in life expectancy at birth).

The partial convergence is modelled by means of an interpolation between the age-specific mortality rates in the last observed year (2017) and an ultimate (sex-specific) life table. The ultimate life table incorporates some information previous mortality trends.

The gains in life expectancy are assumed to be more rapid in the beginning of the projections period, in line with the scenario where progresses in medicine and healthy life styles are more likely to spread more rapidly across the EU, while latter gains are relatively smaller.

The initial mortality patterns are derived from the period-cohort age- and sex-specific rates reported for the year 2017. In order to remove random fluctuations, these patterns have been smoothed over age using a monotonic regression spline. Because the smoothing of the observed rates may have an impact on the estimated life expectancy at birth, the smoothed patterns have been shifted upwards or downward in such a way that the corresponding life expectancies match the life expectancies at birth as from the observed rates in 2017.

Projected values of the life expectancy at birth for men and women are reported respectively in Table 2 and in Table 3.

[6] AVG stands for the simple (non-weighted) average values of the values at selected years in the 31 countries

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

	2020	2030	2040	2050	2060	2070	2080	2090	2100
BE	79.6	81.1	82.5	83.8	85.1	86.2	87.2	88.2	89.2
BG	72.1	74.6	77.0	79.2	81.2	83.0	84.7	86.2	87.6
CZ	76.6	78.5	80.2	81.9	83.4	84.8	86.1	87.4	88.5
DK	79.6	81.1	82.5	83.8	85.0	86.1	87.2	88.2	89.1
DE	79.1	80.7	82.1	83.5	84.8	86.0	87.1	88.1	89.0
EE	74.5	76.7	78.8	80.7	82.5	84.2	85.7	87.0	88.3
IE	80.8	82.1	83.4	84.5	85.7	86.7	87.7	88.6	89.5
EL	79.3	80.9	82.4	83.8	85.1	86.3	87.4	88.4	89.4
ES	81.0	82.3	83.6	84.8	85.9	86.9	87.8	88.7	89.6
FR	80.1	81.6	83.0	84.3	85.5	86.6	87.6	88.6	89.4
HR	75.5	77.5	79.3	81.1	82.7	84.2	85.7	87.0	88.2
IT	81.2	82.4	83.6	84.7	85.8	86.8	87.7	88.6	89.4
CY	80.6	81.9	83.1	84.3	85.4	86.4	87.4	88.3	89.2
LV	70.6	73.4	76.0	78.4	80.6	82.6	84.5	86.1	87.6
LT	71.5	74.1	76.6	78.9	81.0	82.9	84.7	86.2	87.7
LU	80.3	81.8	83.2	84.4	85.6	86.6	87.6	88.6	89.4
HU	73.2	75.6	77.8	79.9	81.8	83.6	85.2	86.7	88.0
MT	80.6	82.1	83.4	84.6	85.7	86.8	87.7	88.6	89.4
NL	80.6	81.9	83.2	84.3	85.4	86.5	87.5	88.4	89.3
AT	79.8	81.3	82.6	83.9	85.1	86.2	87.3	88.3	89.2
PL	74.6	76.8	78.9	80.9	82.7	84.3	85.8	87.2	88.4
PT	78.9	80.4	81.9	83.3	84.6	85.8	86.9	88.0	88.9
RO	72.5	75.0	77.4	79.7	81.7	83.5	85.2	86.7	88.1
SI	78.6	80.2	81.7	83.1	84.4	85.7	86.8	87.9	88.9
SK	74.5	76.7	78.7	80.7	82.5	84.1	85.6	87.0	88.3
FI	79.3	80.9	82.3	83.6	84.9	86.0	87.1	88.1	89.1
SE	81.1	82.4	83.6	84.7	85.7	86.7	87.6	88.5	89.4
UK	79.9	81.4	82.8	84.0	85.2	86.3	87.4	88.4	89.3
IS	81.4	82.7	83.8	84.9	85.9	86.9	87.8	88.7	89.5
NO	81.3	82.6	83.7	84.8	85.9	86.8	87.8	88.6	89.5
CH	81.9	83.1	84.3	85.3	86.3	87.2	88.1	88.9	89.7
AVG	**78.1**	**79.8**	**81.4**	**82.9**	**84.3**	**85.6**	**86.8**	**87.9**	**88.9**

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

	2020	2030	2040	2050	2060	2070	2080	2090	2100
BE	84.3	85.7	86.9	88.1	89.2	90.2	91.1	92.0	92.8
BG	79.0	81.0	82.8	84.6	86.2	87.7	89.1	90.3	91.5
CZ	82.4	83.9	85.4	86.7	88.0	89.1	90.3	91.3	92.3
DK	83.5	85.0	86.3	87.6	88.8	89.8	90.8	91.8	92.7
DE	83.8	85.2	86.5	87.7	88.8	89.9	90.9	91.8	92.7
EE	83.1	84.6	86.0	87.3	88.5	89.6	90.7	91.7	92.6
IE	84.5	85.8	87.0	88.2	89.3	90.3	91.2	92.1	92.9
EL	84.3	85.6	86.9	88.0	89.1	90.1	91.1	92.0	92.9
ES	86.5	87.5	88.5	89.4	90.3	91.1	91.9	92.6	93.3
FR	86.0	87.2	88.2	89.2	90.2	91.0	91.8	92.6	93.3
HR	81.5	83.1	84.6	86.0	87.3	88.6	89.8	90.9	91.9
IT	85.6	86.7	87.8	88.8	89.8	90.6	91.5	92.3	93.1
CY	84.5	85.7	86.8	87.8	88.8	89.7	90.6	91.5	92.4
LV	80.3	82.2	83.9	85.6	87.1	88.5	89.7	90.9	92.0
LT	81.0	82.8	84.4	85.9	87.3	88.6	89.8	91.0	92.0
LU	84.9	86.3	87.5	88.6	89.7	90.7	91.6	92.4	93.2
HU	79.9	81.8	83.7	85.4	87.0	88.4	89.8	91.0	92.1
MT	85.1	86.4	87.7	88.8	89.8	90.7	91.6	92.4	93.2
NL	83.8	85.2	86.5	87.7	88.8	89.8	90.8	91.7	92.6
AT	84.4	85.7	86.9	88.0	89.1	90.1	91.0	91.9	92.7
PL	82.3	84.0	85.5	86.9	88.2	89.4	90.5	91.6	92.5
PT	85.0	86.2	87.3	88.4	89.4	90.3	91.2	92.1	92.9
RO	79.7	81.7	83.6	85.4	87.0	88.4	89.8	91.0	92.1
SI	84.4	85.7	86.9	88.1	89.1	90.1	91.1	91.9	92.8
SK	81.2	83.0	84.6	86.1	87.5	88.9	90.1	91.2	92.3
FI	84.9	86.1	87.3	88.4	89.4	90.4	91.3	92.1	92.9
SE	84.5	85.8	87.0	88.1	89.2	90.1	91.1	92.0	92.8
UK	83.5	85.0	86.3	87.6	88.8	89.9	90.9	91.8	92.7
IS	84.8	86.0	87.2	88.2	89.2	90.2	91.1	92.0	92.8
NO	84.7	86.0	87.2	88.3	89.3	90.3	91.2	92.1	92.9
CH	86.0	87.1	88.1	89.1	90.0	90.8	91.6	92.4	93.1
AVG	**83.5**	**85.0**	**86.3**	**87.5**	**88.7**	**89.8**	**90.8**	**91.8**	**92.6**

2.3. 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[7].

Given that 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

[7] 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

flows, the input dataset consisted of the time series of net migration including statistical adjustment, which was available in most cases starting from 1960.

In a first step, the input dataset has been 'winsorised', this technique reducing therefore the effects of possibly spurious outliers. The country-specific trends were identified and extrapolated by applying ARIMA models as selected by an automated model specification procedure. For countries without the nowcast component, net migration including statistical adjustment in 2018 is fully the result of the trend extrapolation.

These extrapolated values (the 'trend' component) were progressively fading within values derived from the convergence component of the model. This transition is set to be completed by 2050 for most countries, and by 2030 for a specific cluster of countries, as it will be explained below.

In the short term, the 'convergence' component is actually country-driven and acts as a convergence of the series towards an intermediate point corresponding to 2022. The first linear interpolation is between the net migration value in the year 2017 and an intermediate value estimated for the year 2022. This intermediate point is calculated as the average of the net migration observed in the last 20 years (1998-2017), and winsorised on the period 1995-2017. By doing so, the potential impact of an extreme starting value in 2017 is smoothed by forcing it towards a more 'stable' value derived from a much longer time period.

The calculation of the intermediate points allows at the same time the identification of the cluster of countries[8] for which the convergence component starts in 2030 already. In fact, a negative value for the intermediate point corresponds to high emigration in the period of the last two decades (or in any case immigration flows less significant than the emigration flows).

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.

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 (2013-2017). 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. The two time series so derived (immigration and emigration flows 2018-2100) have then been divided in equal parts 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 (corresponding to a 3-years average) and common age profiles derived for the longer term. Data is rounded to the closest integer value by sex and by age for both immigration and emigration and for each projection year.

The results are shown in Table 4 for selected years.

[8] They were: Bulgaria, Croatia, Latvia, Lithuania, Poland, and Romania.

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

	2020	2030	2040	2050	2060	2070	2080	2090	2100
BE	33,855	35,988	34,607	31,809	28,624	25,849	22,829	19,408	16,880
BG	-10,145	3,292	5,744	4,289	1,163	1,890	2,278	1,234	1,262
CZ	23,479	20,613	24,467	18,377	13,272	12,532	12,375	9,568	8,255
DK	24,358	22,082	17,398	12,821	13,016	10,628	8,977	8,682	7,076
DE	293,484	262,379	206,105	195,835	168,908	143,398	136,101	117,752	94,050
EE	4,742	360	599	740	139	272	345	188	175
IE	10,125	13,139	15,534	15,883	14,273	13,220	11,568	9,520	8,452
EL	13,674	14,669	15,396	10,394	8,223	8,726	7,569	5,480	5,069
ES	165,408	210,278	237,296	215,073	192,416	181,020	157,192	129,757	113,354
FR	37,319	86,405	75,735	67,779	61,002	61,940	48,086	42,510	43,194
HR	-12,404	2,565	2,330	2,340	1,931	1,727	1,312	1,050	948
IT	90,109	151,408	172,111	163,834	146,778	138,620	118,493	99,514	86,948
CY	6,193	5,977	5,471	4,817	4,721	4,024	3,450	3,130	2,605
LV	-6,538	608	967	1,016	-2	286	613	105	122
LT	-23,252	1,254	1,336	1,469	592	531	1,161	350	238
LU	9,333	8,346	7,082	5,453	4,924	4,359	3,823	3,270	2,746
HU	18,237	14,452	19,481	13,916	12,489	10,314	9,201	7,992	6,593
MT	9,601	7,342	5,085	2,868	2,738	2,221	1,939	1,712	1,407
NL	30,834	31,896	25,634	24,293	24,018	21,443	18,065	16,914	14,721
AT	44,798	43,520	36,896	31,246	28,148	24,165	22,004	19,165	15,673
PL	8,980	11,073	23,201	28,919	10,354	6,008	9,556	6,863	4,542
PT	9,887	11,129	15,237	12,920	11,782	11,483	9,057	7,812	6,994
RO	-59,946	3,132	13,537	9,323	2,696	5,327	4,936	2,980	3,045
SI	3,673	3,907	4,271	3,895	2,832	2,685	2,633	1,943	1,768
SK	3,751	2,458	4,479	4,480	1,930	1,703	2,285	1,536	1,192
FI	14,069	12,945	11,587	10,109	9,431	8,604	7,582	6,282	5,549
SE	93,300	86,094	68,228	38,455	34,606	30,757	27,201	23,075	19,408
UK	278,607	256,807	224,666	181,195	163,079	145,913	128,806	110,792	97,374
IS	807	1,453	1,324	1,092	1,036	919	776	690	594
NO	21,666	23,002	22,839	21,345	19,305	17,412	15,442	13,283	11,405
CH	44,494	46,157	44,961	41,347	37,079	32,949	29,391	25,386	20,962

3. FURTHER INFORMATION

For data and visualisations, please access the Eurostat website: https://ec.europa.eu/eurostat/web/population-demography-migration-projections/population-projections-data

For methodological questions, please write to: ESTAT POP PROJECTIONS ESTAT-Pop-Projections@ec.europa.eu