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

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TECHNICAL NOTE

Subject: **methodology of the Eurostat population projections 2019-based (EUROPOP2019)**

1. GENERAL FEATURES

EUROPOP2019 refers to the population projections published by Eurostat in April 2020 for all the EU and EFTA countries at national level. The time horizon spans from the year 2019 (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 EUROPOP2019 in fertility, mortality and migration developments. The methodology applied in EUROPOP2019 builds upon the previous projections exercises and their methodological reports[1] are useful complements to this note.

1.1. Special events

It is common practice in population projections to neglect future events such as war and famine. Unfortunately, the last decade has seen at least four peculiar events in the EU, here listed in chronological order: a deep economic crisis, the refugees' crisis, the exit of a Member State from the EU ("Brexit"), and the Covid19 pandemic. Each of them is very likely to affect – at least in the short run – the factors of the demographic dynamics. Whilst for the former two at least part of their impact is already embedded in observed data, this is not yet the case for the latter two, and the extent of their effect is hardly measureable at time of production of the current projections. The impact of Brexit is however somehow taken into account using (when relevant) data referring to the EU27. As for the pandemic, it is still too early to try any impact assessment, and any correction to the projected demographic dynamics would be highly speculative. Hence, it remains a high risk that these "no-pandemic" projections are very rapidly departing from reality.

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[1] "Summary methodology of the 2018-based population projections (EUROPOP2018)" and "Summary methodology of the 2015-based population projections", both available in the Eurostat metadata.

1.2. The scenario

In population projections, the 'scenario' is the description of the context of population developments in the geographic 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 EUROPOP2019, the scenario retained is that of convergence, socio-economic convergence being central to many EU policies. 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*. 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 EUROPOP2019 scenario is based upon a partial convergence in each of the components of demographic change: fertility, mortality and international migration. Temporary divergence between countries is not excluded either.

2. DATA SOURCES AND TOOLS

The data used in EUPRO2019 are mostly official statistics as provided by the National Statistical Institutes (NSIs) to Eurostat. Some of them are from the latest regular Eurostat UNIDEMO data collection, whose data were transmitted by the countries in December 2019 and disseminated by Eurostat in early 2020 in the Eurostat public database. These data refer to events occurred in 2018 and to the population at the end of period (that is, on 1 January 2019). These are the latest detailed data available to Eurostat at the time of the projections exercise. Some of those data are collected on voluntary basis, which explains why they are not available in the Eurostat database. Total numbers referring to vital events and migration flows referring to 2019 have also been collected as special input to the projections. However, considering that they are not always entirely based on recorded data and that they are further worked before being used, they are described below in the section on assumptions. Given the need of the fertility model for longer time series, missing past data on total fertility rate have been replaced with data from the Human Fertility Database[2].

Some migration data are taken from a previous work whose results have been used in another projections study[3], of which some methodological features are embedded in the current exercise. Those input data were the outcome of an extensive work of data gaps filling and data disaggregation, where consistency with available official data as well as within data was one of the main targets. The data re-used in this exercise are limited to age or share distributions[4], when considered to be more reliable than currently available data. For sake of simplicity, these complementary data are here referred to as EUDEMES

[2] 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 05.04.2020).

[3] G. Lanzieri (2018): "If nothing would change – Constant-rate projections of the European populations by migration background". Presented at the Eurostat Seminar on Population Projections and Demographic Trends, Luxembourg, 13 November 2018.

[4] Namely they are: country-, sex- and age-specific probabilities of emigrating, further broken down by geographic area of destination; country-, sex- and age-specific immigration profiles, further broken down by geographic area of origin; and share of the EU countries on the total intra-EU immigration. See below for further detail.

(EUrostat DEMographic EStimates). Given the lack of data[5], the only alternative – and not for all cases – would have been the application of theoretical patterns but, while nicely shaped, they would have neglected all sort of national specificities and possibly generated inconsistencies in the intra-EU flows. Further, the choice of the specific theoretical shape could have been questionable as well. The choice has therefore been to adopt those estimated patterns that have been derived using all available official statistics, adjusted for international consistency. These latter country-specific patterns are usually assumed to evolve towards more regular and common patterns and their influence is therefore fading over the time horizon of the projections.

All computations have been done in R[6] version 3.6.3 (2020-02-29, "Holding the Windsock"), using as well the "eurostat"[7] ,"HDMHFDplus"[8], "ipfr"[9], "humanleague"[10], "forecast"[11], "demography"[12] and "pyramid"[13] packages, within the R Studio[14] version 1.2.5042 (2020-04-01, " Double Marigold ").

2.1. Base population

The base from which projections start are the latest available data[15] transmitted by the countries on population by sex and single age up to 100+.

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[5] For instance, emigration data simply broken down by single age and sex are not provided by several countries.

[6] R Core Team (2020). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

[7] Leo Lahti, Janne Huovari, Markus Kainu, Przemyslaw Biecek (2017). "Retrieval and analysis of Eurostat open data with the eurostat package". R Journal 9(1):385-392, 2017. R package version 3.6.1.

[8] T. Riffe. Reading Human Fertility Database and Human Mortality Database data into R. MPIDR, TR-2015-004, 2015.

[9] Kyle Ward (2020). ipfr: List Balancing for Reweighting and Population Synthesis. R package version 1.0.2.

[10] Andrew Smith (2020). humanleague: Synthetic Population Generator. R package version 2.1.2.

[11] Hyndman R, Athanasopoulos G, Bergmeir C, Caceres G, Chhay L, O'Hara-Wild M, Petropoulos F, Razbash S, Wang E, Yasmeen F (2020). "forecast: Forecasting functions for time series and linear models". R package version 8.12.

[12] Rob J Hyndman with contributions from Heather Booth, Leonie Tickle and John Maindonald. (2019). "demography: Forecasting Mortality, Fertility, Migration and Population Data". R package version 1.22.

[13] Minato Nakazawa (2019). pyramid: Draw Population Pyramid. R package version 1.5.

[14] RStudio Team (2019). RStudio: Integrated Development for R. RStudio, Inc., Boston, MA URL http://www.rstudio.com/.

[15] Table "Population on 1 January by age and sex" (*demo_pjan*).

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.

Having the convergence scenario as reference, four independent models are used for each component: fertility, mortality, immigration and emigration. Unless otherwise stated, each model is applied to all countries in the same way. The output of the models is expressed respectively in age-specific fertility rates, age- and sex-specific mortality rates; age-, sex- and geo-specific emigration rates; and age-, sex- and geo-specific immigration levels 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.

The projections methodology is developed mainly with regard to the EU Member States, which remain the main focus of the exercise. Results are however also produced for EFTA[16] countries, but the migration model needs to be adapted in their case.

3.1. Nowcast

The nowcast data are used to incorporate the latest empirical evidences into the computations of assumptions. These data are provided by the national statistical institutes (NSIs) in the regular Eurostat data collection carried out each year in November and they cover at least the first six months of vital events occurred in the same year. The NSIs may also – on voluntary basis – provide data which cover the entire year, especially when nowcast data are revised later in time, as well as migration data. By the time of the final computations of this exercise, all countries have provided data covering the entire year 2019, but Estonia (data covering 6 months only), Italy (10 months) and Liechtenstein (11 months); migration data were not provided by Belgium, Estonia, Greece, France, Portugal (only emigration missing), Romania and Liechtenstein.

Whilst they are a valid input helping to better calibrate the assumptions, these values are not necessarily exactly replicated in the final projections computations. This primary input needs indeed to be further worked before being used into the models. First of all, the nowcast data provided by the countries must be corrected for their provisional nature and/or possible differences in the applied definitions (this latter mainly concern migration data). This is done according to a procedure described elsewhere[17], but such adjustment is not applied when the country declares those nowcast data as final or alike. Secondly, data covering only a part of the year must be expanded to cover the whole period. Thirdly, the data must be disaggregated by sex, and for migration flows they are further split by geographic partner (i.e., EU and non-EU flows). Lastly, the intra-EU migration flows so estimated may need to be adjusted for exact matching between the EU sum of emigrations to other EU Member States and immigrations from other EU Member States. For all these reasons, the final nowcast data might differ from the original data provided by the NSIs. The following sections describe in more detail the last three parts of the

[16] In general, given the relatively small size of all sort of demographic events in Liechtenstein, projections results for this country must be taken with an even higher caution.

[17] See the Technical note of 20.04.2020 on "Correction of provisional nowcast data".

procedure above. The Table 1 reports the nowcast data as transmitted by the NSI in their latest version (for some countries last data transmission on 24 April 2020).

Table 1: national nowcast 2019

Country	Births	No. of months	Deaths	No. of months	Immigration	No. of months	Emigration	No. of months
BE	115565	12	108745	12	NA	0	NA	0
BG	61538	12	108083	12	37929	12	39941	12
CZ	112231	12	112362	12	65571	12	21301	12
DK	61167	12	53958	12	83918	12	70597	12
DE	778129	12	939536	12	870892	12	576811	12
EE	6693	6	7690	6	NA	0	NA	0
IE	60220	12	30383	12	90665	12	56613	12
EL	83639	12	125432	12	NA	0	NA	0
ES	354599	12	410619	12	747647	12	301117	12
FR	753578	12	612127	12	NA	0	NA	0
HR	36143	12	52327	12	37800	12	39500	12
IT	362556	10	539584	10	255251	10	138124	10
CY	9625	12	6000	12	25874	12	17373	12
LV	18786	12	27719	12	11281	12	14641	12
LT	27729	12	38378	12	40067	12	29273	12
LU	6230	12	4283	12	26668	12	15593	12
HU	92900	12	130000	12	88600	12	49800	12
MT	4346	12	3711	12	20209	12	7194	12
NL	169059	12	151815	12	215903	12	106737	12
AT	84667	12	83431	12	148797	12	101179	12
PL	375000	12	410000	12	83169	12	63088	12
PT	86557	12	111757	12	72725	12	NA	0
RO	185733	12	259506	12	NA	0	NA	0
SI	19199	12	20545	12	30877	12	14578	12
SK	57054	12	53232	12	7016	12	3384	12
FI	45613	12	53949	12	32827	12	14633	12
SE	114523	12	88766	12	115805	12	47718	12
IS	4430	12	2240	12	11910	12	7080	12
LI	299	11	214	11	NA	0	NA	0
NO	54495	12	40684	12	50853	12	25547	12
CH	83975	12	67307	12	170803	12	123213	12

3.1.1. Nowcast of vital events (births and deaths)

In order to take into account the seasonality of births and deaths, the partial nowcast data on vital events transmitted by the countries are expanded to cover the entire calendar year as follows:

$$V_{[n+1,12]}^{2019} = V_{[n+1,12]}^{2018} \cdot \frac{\sum_{i=1}^{n} v_i^{2019}}{\sum_{i=1}^{n} v_i^{2018}}$$

being n the latest month for which data are available, v the monthly data and V their sum over a defined period. From which:

$$V^{2019} = V_{[1,n]}^{2019} + V_{[n+1,12]}^{2019}$$

The 2018 monthly data are available in the Eurostat database[18].

3.1.2. Nowcast of migration flows (immigration and emigration)

The nowcast of the migration flows for 2019 is computed by extrapolating the available data for the first months of 2019 to cover the entire year (there are no monthly data available from previous years), using the following formula:

$$M^{2019} = \frac{12}{n} \cdot M_{[1,n]}^{2019}$$

where M are either immigration or emigration flows in 2019 and n is the last month covered by the available partial sum. For instance, if available data cover the first 6 months of 2019, the total migration flow for the entire year is projected to be double the size of the first half year. When $n = 0$, i.e. if the country has not provided any preliminary migration data, the flow is estimated to have a size equal to the previous year ($M^{2019} = M^{2018}$).

3.1.3. Breakdown of vital events by sex

The number of vital events by sex are taken from the 2018 data available from the Eurostat database[19]. These country-specific proportions by sex are applied to the total nowcast of vital events to derive the 2019 breakdown for births and deaths.

3.1.4. Breakdown of migration flows by sex and geo partner

These total flows are broken down by sex and EU27 origin/destination ('geographic partner') using the corresponding proportions from the previous reference year (2018). However, those proportions are not directly available in the Eurostat database, neither for immigration nor for emigration. More precisely, the distribution by sex alone is available[20] as well as the one by EU27 geographic partner[21], but their crossed breakdown is only available with reference to the EU28[22]. In fact, for each country there are two tables, either be for immigration or for emigration:

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[18] Tables "Live births (total) by month" (*demo_fmonth*) and "Deaths (total) by month" (*demo_mmonth*).

[19] Tables "Live births by mother's age and newborn's sex" (*demo_fasec*) and "Deaths by age and sex" (*demo_magec*).

[20] Tables "Immigration by age and sex" (*migr_imm8*) and "Emigration by age and sex" (*migr_emi2*).

[21] Tables "Immigration by broad group of country of previous residence" (*migr_imm12prv*) and "Emigration by broad group of country of next usual residence" (*migr_emi5nxt*).

[22] Tables "Immigration by age group, sex and country of previous residence" (*migr_imm5prv*) and "Emigration by age group, sex and country of next usual residence" (*migr_emi3nxt*).

		migr_imm8, migr_emi2		
migr_imm12prv, migr_emi5nxt		**F**	**M**	**Total**
	Other EU27 MS	not available	not available	available
	Outside EU27	not available	not available	available
	Total	available	available	

		migr_imm5prv, migr_emi3nxt		
migr_imm5prv, migr_emi3nxt		**F**	**M**	**Total**
	Other EU28 MS	available	available	available
	Outside EU28	available	available	available
	Total	available	available	1.000

To find cell values in the first table above which fit the marginal values is a common problem solved by the iterative proportional fitting (IPF). For countries that do not have data by EU27 origin/destination (Cyprus and Malta), these are replaced with the EU27 average of available data. For countries that do not have emigration data by sex and EU28 destination (Cyprus, Czechia, Greece, France, and Portugal), the cell values are derived under the independence hypothesis, i.e. by multiplication of the marginal values. Hence, the immigration and emigration values by sex and geographic partner are obtained by multiplying the respective total nowcast by those proportions. These are not yet the final nowcast values, because, for the whole EU27, the nowcast immigration from another EU27 Member State must match the nowcast emigration to another EU27 Member State. As this is not the case, the net $N_{oms}^{2019} = I_{oms}^{2019} - E_{oms}^{2019}$ is redistributed across Member States proportionally to their EU27 weight in the flow of smaller size[23]. This latter correction is applied by sex and the corresponding total nowcast migration flow to/from Member States is increased accordingly. The Figure 1 and Figure 2 show the resulting breakdown of the migration nowcast 2019 by sex and geographic partner.

The Table 2 reports the nowcast total values used for the assumptions, derived from the original nowcast data provided by the NSIs. They are a relevant input, for they are here considered as last observed values and assumptions formulated in terms of rates or probabilities are modified to match those values for 2019.

[23] The net for women was +50,502, while for men was +44,226. Each of them has been redistributed across Member States raising the sex-specific emigration nowcast in proportion to the country sex-specific share of emigration to other Member States. In case the net would have been negative, it would have been redistributed across Member States raising the immigration nowcast in proportion to the country share of immigration from other Member States. Any difference between intra-EU migration flows translates in an increase of the one or the other nowcast flow.

Table 2: adjusted nowcast 2019

Country	Births	Deaths	Immigration	Emigration
BE	115565	108745	137860	92861
BG	61538	108083	37928	41873
CZ	112231	112362	74324	30132
DK	61167	53958	62142	63781
DE	778129	939536	870892	593517
EE	13269	14723	17547	10997
EL	83663	125413	119489	105803
ES	357932	412089	748398	309867
FI	45613	53949	32827	15221
FR	754163	607750	386911	348840
HR	36143	52327	37800	41577
HU	92900	130000	88600	52281
IE	60268	30279	90666	58016
IS	4430	2240	9870	4009
IT	437342	645094	306301	171566
CY	9626	6000	25873	18067
LI	327	230	649	484
LT	27729	38378	40067	30010
LU	6230	4283	26669	16479
LV	18786	27719	11280	15221
MT	4346	3711	20208	7451
NL	169059	151815	215903	110517
AT	84667	83431	148798	104547
PL	375000	410000	230331	227021
PT	86557	111807	72725	32635
RO	200487	260281	172578	246124
SI	19301	20575	30660	14980
SK	57054	53232	7015	3579
SE	114523	88766	115805	49134
NO	54495	40684	50853	25547
CH	86534	67745	144134	127180

Figure 1: mosaic plot of nowcast immigration 2019

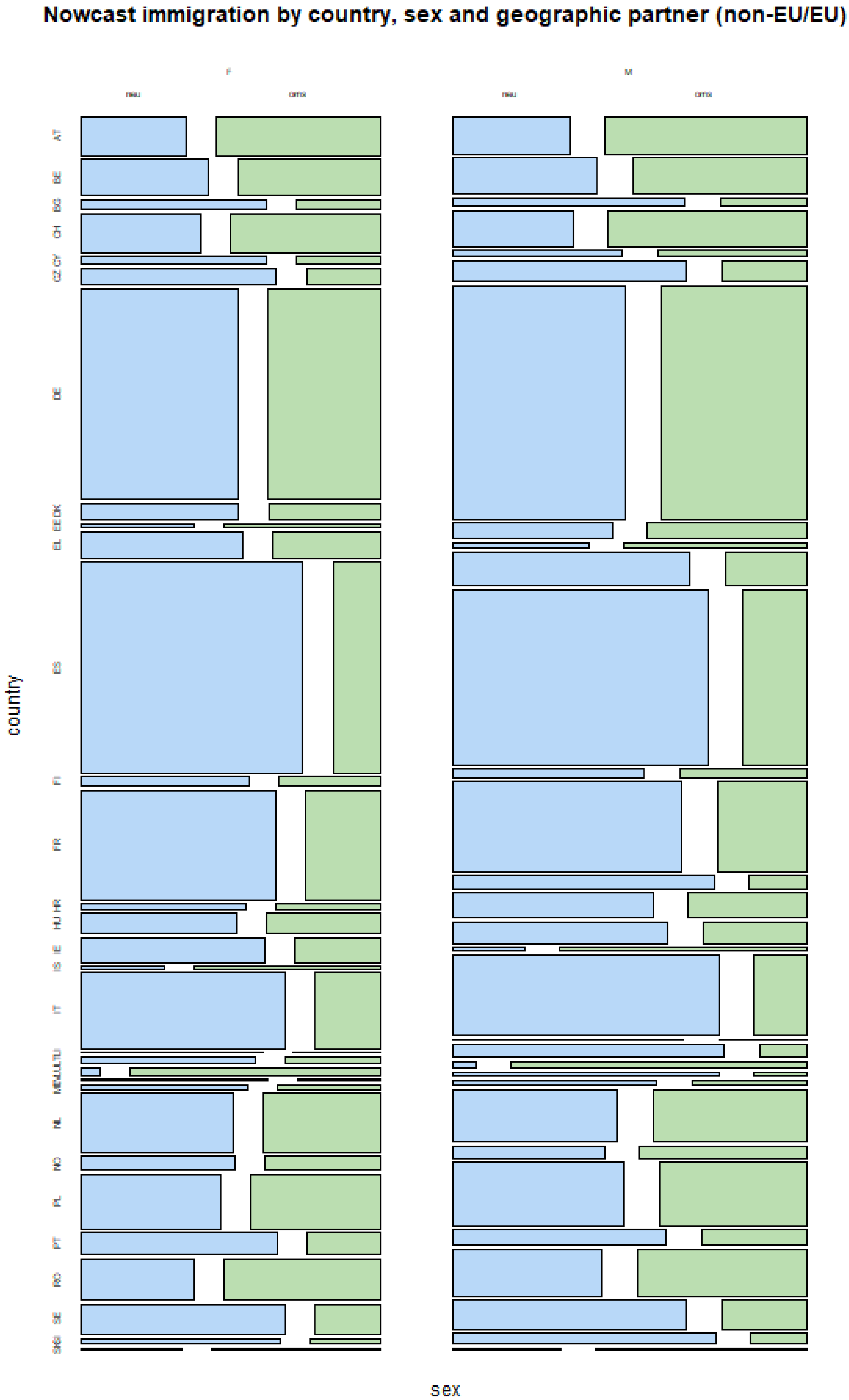
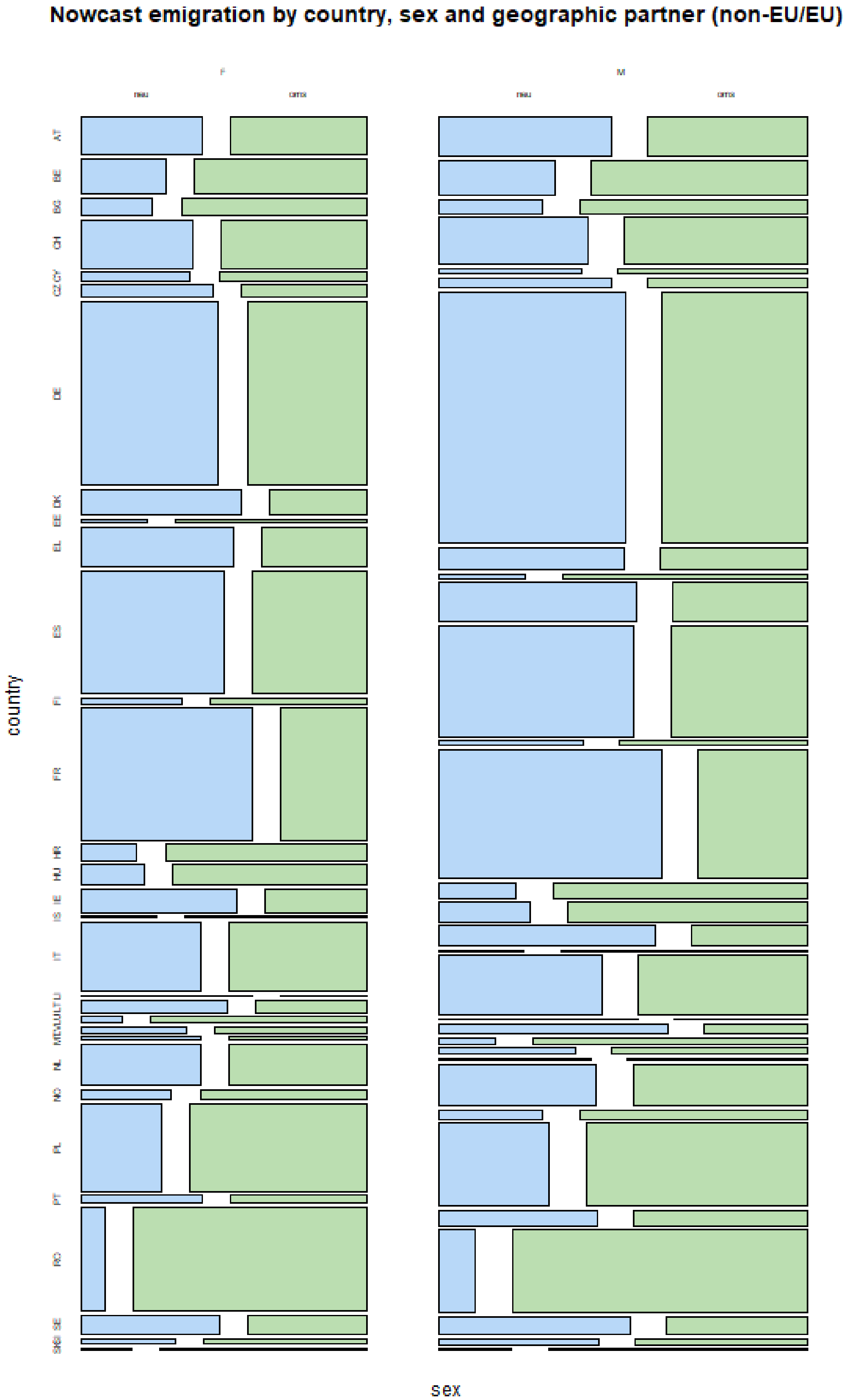


Figure 2: mosaic plot of nowcast emigration 2019



3.2. Fertility

The model applied for fertility has almost no changes as compared to the previous exercise, one being the inclusion of the nowcast in the time series used for the extrapolation of trends and the other a faster increase of the weight of the convergence component (see below).

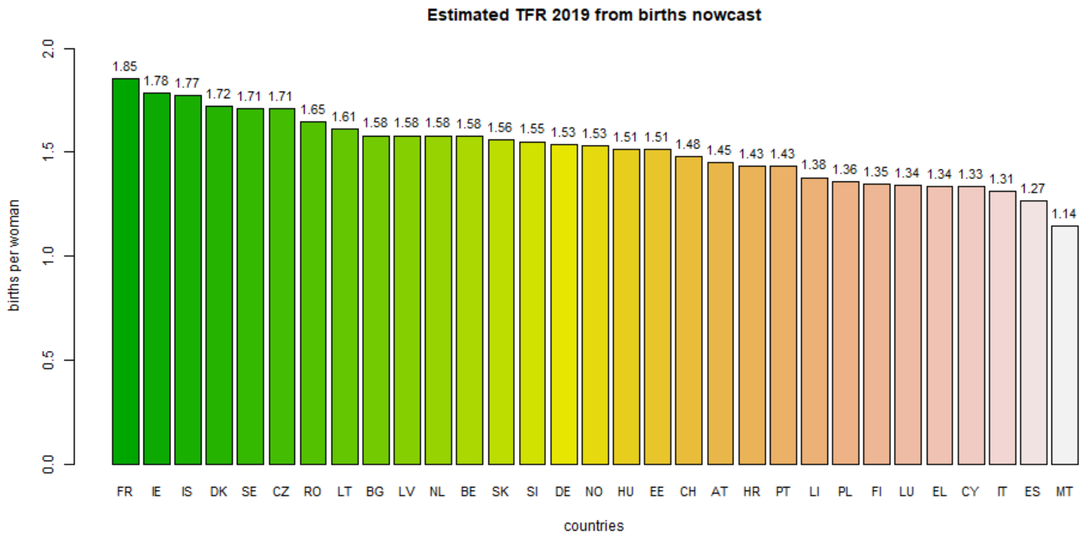
To incorporate the nowcast, firstly the age distributions are derived for each country from the latest observed data on births[24] (by age reached) and population[25]. In order to reduce the randomness in the age patterns (more visible in countries with fewer events), data referring to the three latest years (2016-2018) have been pooled before computing the fertility rates:

$$f_x^c = \sum_{t=2016}^{2018} b_{t,x}^c \Big/ \sum_{t=2016}^{2018} \bar{p}_{t,x}^{c,f}$$

where b is the number of live birth in the country c from mothers of age x (between 14 and 50 years old) reached during the year, and $\bar{p}$ is the corresponding average female population. These age-specific fertility rates (ASFRs) have been smoothed by a weighted regression B-splines with a concavity constraint[26] (see Annex I).

These smoothed patterns are then proportionally inflated or deflated such to match the births nowcast figure when applied to the base population. The values obtained for 2019 from the sum of these ASFRs, i.e. the total fertility rate (TFR), are shown in the Figure 3.

Figure 3



Note: TFR of BG, CZ, LV, LU, NL, SK, FI, SE, NO and CH provided by the countries.

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[24] Table "Live births by mother's year of birth (age reached) and legal marital status" (*demo_fager*).

[25] Table "Population on 1 January by age and sex" (*demo_pjan*).

[26] Methodology based on He and Ng (1999): "COBS: Qualitatively constrained smoothing via linear programming". *Computational Statistics*, 14, pages 315–337.

In the second step, assumptions are formulated for the future values of the TFR. The model combines, 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[27] ARIMA(1,0,1) applied to the time series 1960-2019 (see Annex II). Missing Eurostat TFR data[28] have been replaced with data extracted from the Human Fertility Database[29].

Convergence is instead 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[30] project for 2100 for the countries included in EUROPOP2019. Whilst the trend component, besides taking into account the fertility history of the country, aims to captures as well the potential speed of TFR recovery due to the catching up of cohorts of women who have postponed their childbearing, the convergence component flats such recovery when too rapid as compared to a linear increase.

Future TFR values at selected years are reported in the Table 3. The assumptions for the TFR in each country together with the interaction between the trend and the convergence component are shown in the Annex III, and the Annex IV reports the graphs of the projected TFRs by group of countries. The influence of the additional two observations (2018 and nowcast 2019) is possibly noticeable in the first years of the projected TFRs when they mark a change compared to previous years, whilst the faster joining of the two components (trends and convergence) is barely visible, but still it has generally the effect of lowering the TFR values particularly in the long term. This reflects a general concern about the capacity of the European countries to recover to much higher level of fertility, as well as the recent tendency of the Northern Europe countries towards lower levels of fertility (so far mostly unexplained[31]). The Table 3 reports the TFR assumptions in selected years.

3.2.1. Age-specific fertility rates

The smoothed ASFRs for 2019 are linked to an ultimate age distribution of fertility rates, derived in the previous exercise from an application of Schmertmann model[32]. Therefore, the intermediate ASFRs between the first year (2019) and the rates in the convergence

[27] 'Constrained' meaning here that the specification of the model embeds a target value (TFR = 1.829) and its AR coefficient cannot take values higher than 0.99. See also Lee R.D. (1993): "Modeling and forecasting the time series of US fertility: Age distribution, range, and ultimate level". *International Journal of Forecasting*, 9, p.187-202.

[28] As from the table "Fertility indicators" (*demo_find*).

[29] Human Fertility Database. Max Planck Institute for Demographic Research (Germany) and Vienna Institute of Demography (Austria). URL: www.humanfertility.org.

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

[31] See also dedicated sessions in the 21st Nordic Demographic Symposium, 13-15 June 2019, Reykjavík (IS). URL: https://www.nds2019.net/

[32] 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.

year are obtained by linear interpolation. These interpolated rates are then proportionally inflated or deflated such that their sum match the projected TFR in the corresponding year. The ASFRs assumptions are shown in the Annex V.

Table 3: TFR assumptions at selected years

	2020	2030	2040	2050	2060	2070	2080	2090	2100
AT	1.45	1.49	1.52	1.55	1.57	1.60	1.62	1.65	1.68
BE	1.56	1.59	1.62	1.64	1.66	1.68	1.69	1.71	1.73
BG	1.59	1.65	1.68	1.70	1.71	1.71	1.72	1.73	1.73
CH	1.46	1.50	1.53	1.56	1.59	1.61	1.64	1.67	1.70
CY	1.34	1.38	1.42	1.46	1.49	1.53	1.56	1.60	1.64
CZ	1.71	1.75	1.77	1.78	1.78	1.78	1.78	1.78	1.78
DE	1.52	1.57	1.60	1.63	1.65	1.67	1.68	1.70	1.72
DK	1.72	1.74	1.75	1.76	1.77	1.77	1.78	1.78	1.79
EE	1.46	1.59	1.66	1.68	1.69	1.70	1.70	1.70	1.71
EL	1.34	1.39	1.43	1.47	1.50	1.54	1.57	1.60	1.64
ES	1.28	1.33	1.37	1.41	1.45	1.49	1.53	1.57	1.61
FI	1.33	1.38	1.42	1.46	1.50	1.53	1.57	1.61	1.65
FR	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84	1.84
HR	1.44	1.48	1.51	1.54	1.56	1.59	1.62	1.65	1.68
HU	1.51	1.61	1.67	1.69	1.69	1.70	1.70	1.70	1.71
IE	1.80	1.80	1.80	1.80	1.80	1.81	1.81	1.81	1.81
IS	1.79	1.79	1.79	1.79	1.80	1.80	1.80	1.80	1.81
IT	1.33	1.37	1.41	1.45	1.48	1.52	1.55	1.59	1.63
LI	1.50	1.51	1.53	1.55	1.56	1.58	1.60	1.63	1.66
LT	1.60	1.63	1.65	1.67	1.69	1.70	1.72	1.73	1.75
LU	1.34	1.40	1.46	1.49	1.53	1.56	1.58	1.61	1.64
LV	1.59	1.64	1.67	1.69	1.70	1.71	1.72	1.72	1.73
MT	1.15	1.26	1.34	1.39	1.44	1.47	1.50	1.53	1.57
NL	1.58	1.60	1.62	1.64	1.66	1.68	1.69	1.71	1.73
NO	1.52	1.55	1.58	1.60	1.62	1.65	1.67	1.69	1.71
PL	1.34	1.40	1.45	1.49	1.53	1.56	1.59	1.62	1.65
PT	1.44	1.47	1.51	1.53	1.56	1.59	1.62	1.65	1.68
RO	1.60	1.66	1.70	1.72	1.73	1.74	1.75	1.75	1.76
SE	1.69	1.75	1.78	1.78	1.78	1.78	1.78	1.78	1.78
SI	1.54	1.59	1.62	1.65	1.67	1.68	1.69	1.71	1.72
SK	1.57	1.59	1.61	1.63	1.65	1.67	1.69	1.71	1.73

3.3. Mortality

Mortality patterns are assumed to partially converge from the latest observed values[33] towards a common (sex-specific) life table (the 'ultimate' life table), which incorporates some information from previous mortality trends of selected countries[34].

The partial convergence takes place by log-linear interpolation of the age- and sex-specific probabilities of dying within the reference calendar year from the initial country-specific mortality age patterns (for men and women). Such interpolation returns a higher pace of mortality decrease at the beginning of the period and a slower pace in the long term, coherently with the assumption of a decreasing speed of mortality improvements. Likewise in fertility, the initial mortality patterns are derived from the period-cohort age- and sex-specific deaths reported by the country for the last three years including the last available (i.e., 2016-2018):

$$\begin{cases} q_{s,0}^{c} = \sum_{t=2016}^{2018} d_{t,s,0}^{c} \Big/ \sum_{t=2016}^{2018} b_{t,s}^{c} & x = 0 \\ q_{s,x}^{c} = \sum_{t=2016}^{2018} d_{t,s,x}^{c} \Big/ \sum_{t=2016}^{2018} p_{t,s,x-1}^{c} & x \in [1,99] \\ q_{s,100+}^{c} = \sum_{t=2016}^{2018} d_{t,s,100+}^{c} \Big/ \sum_{t=2016}^{2018} \left(p_{t,s,99}^{c} + p_{t,s,100+}^{c}\right) & x = 100+ \end{cases}$$

where d is the number of deaths in the country c of sex s and age x reached during the year from a population p at the beginning of the year of reference of sex s and age $x-1$, when age is above 0; the deaths at age 0 are instead related to the birth cohorts[35] of the same years. In order to remove random fluctuations, these probabilities of dying $q_{s,x}^{c}$ have been smoothed over age using a monotonic regression spline[36] (see Annex VI). Given their peculiar pattern due to the very small number of events, the mortality distributions of Liechtenstein have been replaced with those of Switzerland.

These smoothed mortality patterns are then proportionally inflated or deflated such to match the deaths nowcast figure when applied to the base population 2019, with birth cohorts taken from their nowcast. These age patterns are the starting values for a first interpolation with the ultimate life table. However, in order to reduce the potential influence of nowcast outliers into the projected mortality, a second interpolation is computed between the smoothed observed mortality patterns, set in the last observed year

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33 The lack of adequate data for all the countries covered by these projections is still an impeding factor for considering the extrapolation of past country-specific mortality trends for the short/medium term (in the medium/long term it would anyway apply the hypothesis of convergence). Ongoing work on improving data input is expected to remove this constraint in future exercises.

34 For further information about the ultimate life table, 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.

35 Table “Population change - Demographic balance and crude rates at national level” (*demo_gind*)

36 See Wood S.N. (1994): "Monotonic Smoothing Splines Fitted by Cross Validation", *SIAM Journal on Scientific Computing*, 15(5):1126-1133.

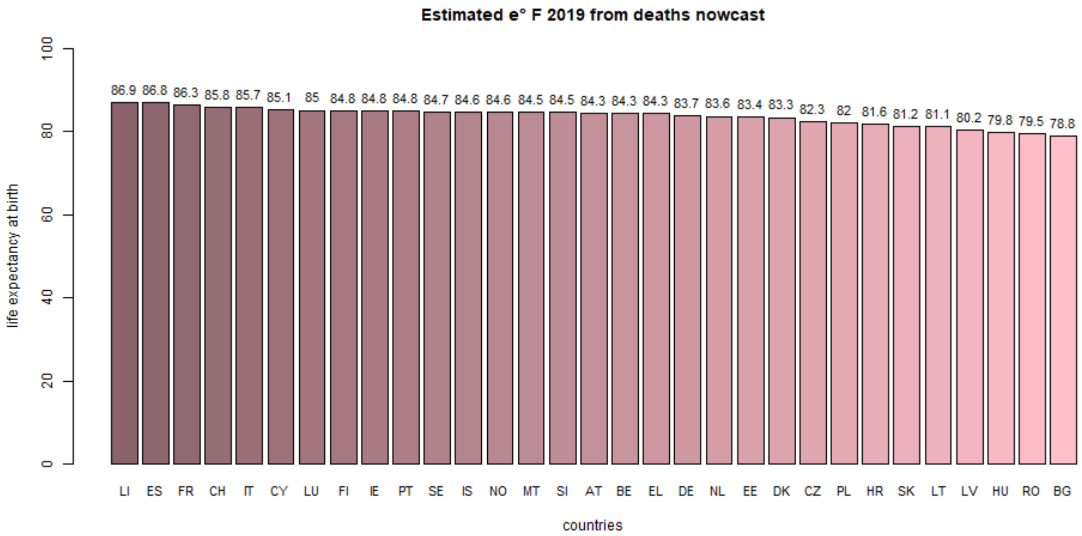
(2018), and the ultimate life table. The final assumptions for mortality are then the average between these interpolated probabilities of dying, but for the year 2019 where only the nowcast value applies. The figures in the Annex VII show the evolution of the assumed $q_{s,x}^{c}$ over the projections period.

The projected values of the life expectancy at birth for women and men are reported respectively in the Table 4 and in the Table 5, as well as for the nowcast 2019 in the Figure 4 for women and Figure 5 for men[37]. The computation of the life table has been adapted to the different input (the probability of dying in the calendar year) and therefore the resulting values may differ from what could be obtained with the regular Eurostat life table methodology or other methods. This aspect is irrelevant for the projections, because their calculation is based on the probabilities of dying and not derived from the life expectancies. Such adapted values of life expectancies at birth are here reported for the sake of using a summary indicator of mortality and they should preferably be compared with values computed with the same methodology. However, in order to improve the comparability with the past values of the life expectancy at birth computed by Eurostat, the projected values are adjusted by applying the average gap observed between past life expectancy at birth computed with the regular Eurostat methodology and the ones from the alternative method[38]. The projected trends of the male and female life expectancy at birth for each country are shown in the Annex VIII, while the Annex IX shows the same trends by group of countries.

[37] Values for Liechtenstein are more subject to random variability and therefore the results for 2019 should not be interpreted as a well-established level of mortality in that country.

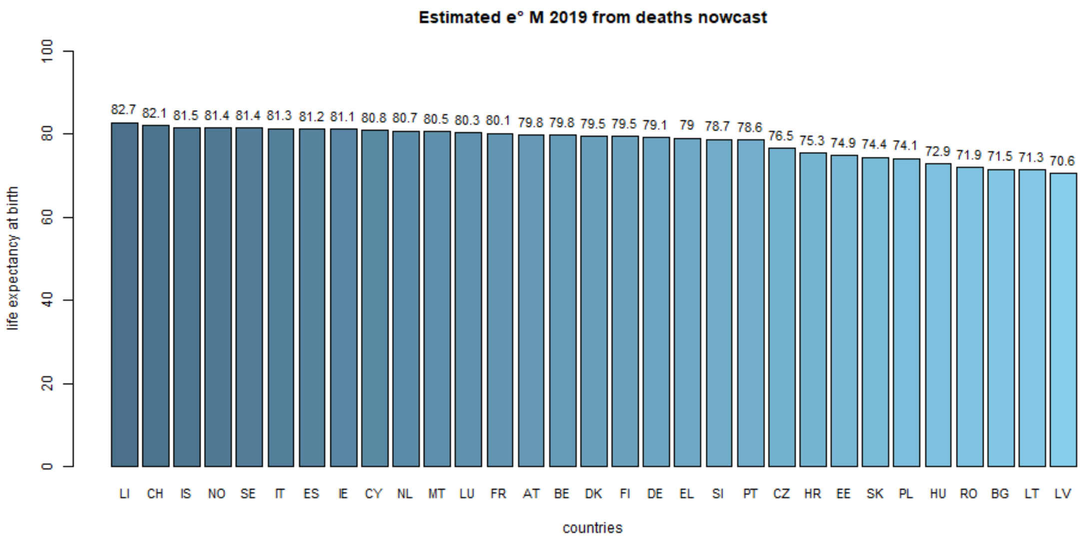
[38] See Technical note of 14.04.2020 on "An alternative life table based on probabilities of dying within the calendar year (annual period-cohort life table)".

Figure 4



Note: see footnote 37.

Figure 5



Note: see footnote 37.

Table 4: e° assumptions for women at selected years

	2020	2030	2040	2050	2060	2070	2080	2090	2100
AT	84.3	85.7	86.9	88.1	89.2	90.2	91.1	92.0	92.9
BE	84.3	85.7	87.0	88.2	89.3	90.3	91.3	92.2	93.0
BG	78.9	80.9	82.8	84.6	86.2	87.8	89.2	90.4	91.6
CH	85.8	87.0	88.1	89.1	90.1	90.9	91.8	92.6	93.3
CY	85.0	86.1	87.2	88.3	89.3	90.2	91.1	92.0	92.8
CZ	82.3	83.9	85.4	86.7	88.0	89.3	90.4	91.4	92.4
DE	83.7	85.1	86.4	87.7	88.9	89.9	90.9	91.9	92.8
DK	83.3	84.8	86.2	87.5	88.7	89.8	90.8	91.8	92.7
EE	83.1	84.7	86.1	87.5	88.7	89.9	91.0	91.9	92.9
EL	84.3	85.7	86.9	88.1	89.3	90.3	91.3	92.2	93.0
ES	86.6	87.7	88.7	89.7	90.6	91.4	92.2	93.0	93.7
FI	84.8	86.1	87.3	88.4	89.4	90.4	91.4	92.2	93.0
FR	86.2	87.4	88.6	89.6	90.6	91.4	92.3	93.0	93.7
HR	81.6	83.2	84.7	86.2	87.5	88.8	90.0	91.1	92.1
HU	79.9	81.8	83.7	85.4	87.0	88.5	89.9	91.1	92.2
IE	84.5	85.8	87.1	88.3	89.4	90.4	91.4	92.2	93.1
IS	84.4	85.8	87.0	88.2	89.3	90.4	91.3	92.2	93.0
IT	85.7	86.9	88.0	89.0	90.0	90.9	91.8	92.6	93.3
LI	86.4	87.5	88.5	89.5	90.4	91.2	92.0	92.8	93.5
LT	81.0	82.8	84.4	86.0	87.4	88.8	90.0	91.1	92.2
LU	84.9	86.3	87.5	88.7	89.8	90.8	91.7	92.6	93.4
LV	80.1	82.1	83.9	85.6	87.1	88.5	89.8	91.0	92.1
MT	84.5	85.9	87.2	88.4	89.5	90.6	91.5	92.4	93.2
NL	83.6	85.1	86.4	87.6	88.8	89.9	90.9	91.8	92.7
NO	84.6	85.9	87.1	88.2	89.3	90.3	91.2	92.1	92.9
PL	82.1	83.8	85.4	86.9	88.3	89.6	90.7	91.8	92.7
PT	84.8	86.0	87.2	88.3	89.4	90.4	91.3	92.2	93.0
RO	79.5	81.6	83.5	85.3	87.0	88.5	89.9	91.1	92.2
SE	84.6	85.9	87.1	88.2	89.3	90.3	91.2	92.1	92.9
SI	84.5	85.8	87.1	88.3	89.4	90.4	91.4	92.3	93.1
SK	81.1	82.9	84.6	86.2	87.6	89.0	90.2	91.3	92.4

Table 5: e° assumptions for men at selected years

	2020	2030	2040	2050	2060	2070	2080	2090	2100
AT	79.7	81.2	82.6	84.0	85.2	86.3	87.4	88.3	89.3
BE	79.6	81.2	82.6	83.9	85.2	86.3	87.4	88.4	89.3
BG	71.7	74.3	76.7	79.0	81.0	82.9	84.6	86.2	87.6
CH	82.0	83.2	84.3	85.4	86.4	87.3	88.2	89.0	89.8
CY	80.8	82.1	83.3	84.5	85.6	86.6	87.6	88.5	89.3
CZ	76.5	78.4	80.2	81.8	83.4	84.8	86.2	87.4	88.5
DE	79.1	80.7	82.1	83.5	84.8	86.0	87.2	88.2	89.1
DK	79.5	81.0	82.4	83.7	84.9	86.1	87.2	88.2	89.1
EE	74.5	76.7	78.9	80.8	82.6	84.3	85.8	87.1	88.4
EL	79.1	80.8	82.4	83.8	85.2	86.4	87.5	88.5	89.5
ES	81.1	82.4	83.7	84.9	86.0	87.1	88.0	88.9	89.7
FI	79.3	80.9	82.3	83.7	85.0	86.1	87.2	88.3	89.2
FR	80.0	81.6	83.0	84.3	85.6	86.7	87.7	88.7	89.6
HR	75.3	77.4	79.3	81.1	82.7	84.3	85.7	87.0	88.2
HU	73.0	75.4	77.7	79.8	81.8	83.6	85.3	86.7	88.1
IE	80.8	82.1	83.4	84.6	85.7	86.8	87.7	88.7	89.5
IS	81.2	82.5	83.7	84.9	85.9	86.9	87.9	88.8	89.6
IT	81.3	82.6	83.8	84.9	86.0	87.0	87.9	88.8	89.6
LI	82.3	83.5	84.6	85.6	86.6	87.5	88.3	89.1	89.9
LT	71.1	73.9	76.4	78.8	80.9	82.9	84.7	86.3	87.7
LU	80.2	81.7	83.1	84.4	85.5	86.6	87.7	88.6	89.5
LV	70.5	73.3	75.9	78.4	80.6	82.6	84.5	86.1	87.6
MT	80.5	82.0	83.3	84.6	85.7	86.8	87.8	88.7	89.6
NL	80.6	81.9	83.2	84.4	85.5	86.6	87.5	88.5	89.3
NO	81.3	82.5	83.7	84.8	85.9	86.9	87.8	88.7	89.5
PL	74.2	76.5	78.7	80.7	82.6	84.3	85.8	87.2	88.4
PT	78.6	80.2	81.7	83.2	84.5	85.7	86.9	87.9	88.9
RO	72.1	74.7	77.2	79.5	81.6	83.5	85.2	86.7	88.1
SE	81.2	82.5	83.7	84.8	85.8	86.8	87.8	88.6	89.5
SI	78.6	80.3	81.8	83.3	84.6	85.9	87.0	88.1	89.1
SK	74.3	76.5	78.6	80.6	82.4	84.1	85.6	87.0	88.2

3.4. Emigration

The model for emigration for the years after the midterm follows the same approach of mortality, but with a further disaggregation related to the ‘geographic partner’, i.e. the geographic area of destination, here considered broken down only in EU and non-EU areas.

First, sex- and age-specific probabilities of emigration, broken down by geographic partner, are retrieved from EUDEMES. For any given year, these emigration probabilities o can be expressed in the following form:

$$\begin{cases} o^c_{s,0,g} = \dfrac{e^c_{s,0,g}}{b^c_s} & x = 0 \\ o^c_{s,x,g} = \dfrac{e^c_{s,x,g}}{p^c_{s,x-1}} & x \in [1,99] \\ o^c_{s,100+,g} = \dfrac{e^c_{s,100+,g}}{p^c_{s,99} + p^c_{s,100+}} & x = 100+ \end{cases}$$

where e is the number of emigrations in the country c of sex s and age x reached during the year from a population p at the beginning of the year of reference of sex s and age $x-1$, when age is above 0; the emigrations at age 0 are instead related to the birth cohort of the same year[39]. The index g refers to the geographic partner (“oms”: other Member State; “neu”: non-EU) and it is not specific in the sense that it refers to the same population by age and sex, whatever the destination. Therefore, $o^c_{s,x} = o^c_{s,x,oms} + o^c_{s,x,neu}$, i.e. the probability of emigrating at given age and sex is the sum of the probability of emigrating towards another Member State and of the probability of emigrating outside the EU. Such a distinction by geographic partner only applies to EU Member States. The profiles are shown in the Annex X.

The four emigration age patterns (by sex and geo partner) are modified in the base year such to match the corresponding nowcast emigration figures. However, in order to reduce the influence of the nowcast on the projected emigration, emigration values for the first years ahead are computed by linear interpolation between the latest value (nowcast) and the country-specific average of the winsorized time series of emigration levels since 2000[40] (when available). Such return to average is assumed to occur by the midterm year[41], which is set 5 years ahead from the base year (see Annex XI). The age profiles specified for the base year are then proportionally adjusted to match the reference values

[39] Table “Population change - Demographic balance and crude rates at national level” (*demo_gind*).

[40] In general, the quality of migration data is considered improved from the entry into force of the EU regulation on migration statistics (2009) and further enhanced from the entry into force of the EU regulation on demographic statistics (2013). Data referring to earlier years might raise some concerns about their accuracy. They have nonetheless been included in the model due to the higher need of identifying a migration average level less dependent from the latest evidence.

[41] The choice of the midterm year has been driven by the analysis of the variability of the time series of emigration levels. Assuming annual changes equal to the observed standard deviation, the target level would be crossed by all countries within a 5-year time frame (at the latest). For some countries, setting the midterm in 2024 rather than in an earlier year (such as 2022), may lead to an apparently unnatural prorogation of current levels into next years; for others, it may avoid an abrupt projected return to average levels. The choice of the 5-year time frame is consistent with the approach taken in the previous EUROPOP exercise.

of emigration until the midterm. The adjusted profiles bring the emigration level closer to the average, but without exact matching with the short-term emigration forecasts because the population of reference in those years most probably will not be equal to the base population; nonetheless, they serve the purpose of levelling the influence of the emigration nowcast. The exact matching is achieved with a recalibration during the projections computations.

These profiles applied to the midterm are then linearly interpolated with the corresponding ultimate distribution. This latter, taken as well from EUDEMES and derived from the aggregation over the EU of all emigration events, represents the ultimate level of emigration probability. Therefore, the country profiles are set moving towards a common (probabilities) profile, progressively removing national peculiarities. For some countries, the move towards the common profiles implies an increase from current emigration probabilities, for others the opposite. The resulting changes in emigration levels are not at odds with the ageing process in the population, first because the probabilities return levels of emigration coherent with the size of the specific population age groups; secondly because there is empirical evidence of increase of emigration rates in ageing populations (see the Annex XII). The evolutions of the sex- and age-specific probabilities of emigrating over the projections period are shown in the Annex XIII.

3.5. Immigration

The assumptions on immigration are derived from the time series as available in the Eurostat database. Because the intra-EU immigration is generated from the intra-EU emigration assumptions, for the EU27 Member States the series of reference is the immigration from non-EU countries[42]; for the non-EU countries, it is the total immigration[43]. As non-EU27 immigration is available only for the years 2013-2018, values for previous years have been estimated by applying the average share of non-EU27 immigration in the total inflow during the latest 6 years to past total immigration. Further, to the observed time series it is added the value from the immigration nowcast. The immigration time series are then spanning from 2000 to 2019, that is 20 years of observations.

Given the high volatility and well-known unpredictability of immigration, the assumptions are based on the average value of the available time series. However, considering that, in the time interval for which observation are available, there have been exceptional level of arrivals of people in some countries (mostly as asylum seekers), as well as a long-lasting economic crisis in others with likely repercussions on inflows, the immigration time series are winsorized, that is their maximum and minimum values are replaced respectively by the second maximum and second minimum values.

The assumptions for the first years ahead are computed by linear interpolation between the latest value (nowcast) and the country-specific average of the winsorized time series. Such return to the average is assumed to occur within 5 years from the base year[44], which

[42] Table "Immigration by broad group of country of previous residence" (*migr_imm12prv*), category "NEU27_2020_FOR". Unknowns have been attributed to this category.

[43] Table "Immigration by broad group of country of previous residence" (*migr_imm12prv*), category "TOTAL".

[44] See footnote 41.

is in 2024 (see Annex XIV). At that point, in order to express the tendency to equal attractiveness of the countries for (non-EU) immigrants, the average values are translated in per-capita base population. Assumptions for the years following the intermediate point in 2024 are then formulated as partial convergence of those per-capita values to a common value, estimated as the sum of all the non-EU (average) inflows in 2024 on the EU base population. This means that, at the current stage (further below is described an additional adjustment mechanism), the average inflows to the EU are kept steady and redistributed across countries in a way to reflect their observed and – progressively – projected migration attractiveness.

3.5.1. Breakdown by sex

This tendency to equal migration attractiveness is applied by sex, so that national immigration sex imbalances, whilst still applied over the projections time horizon, are progressively changing to shared patterns. Past evidence[45] shows that non-EU immigration can have sex-specific shares varying over time and across countries (see Annex XV).

For each Member State, the total immigration from outside EU is broken down by sex by applying the same country-specific weights identified for the breakdown of the immigration nowcast. Their country-specific weight are so computed:

$$w_f = I^{2019}_{non-EU,f} / I^{2019}_{non-EU,t} \quad ; \quad w_m = I^{2019}_{non-EU,m} / I^{2019}_{non-EU,t}$$

For non-EU countries, it is the total immigration to be broken down by sex by applying the same country-specific weights identified for the breakdown of the immigration nowcast. Their country-specific weight are so computed:

$$w^{neu}_f = I^{2019}_f / I^{2019}_t \quad ; \quad w^{neu}_m = I^{2019}_m / I^{2019}_t$$

The Figure 6 shows the countries sorted by decreasing male weights in the base year. The weights in the midterm year are instead set equal to the average values as estimated by past sex-specific shares (see Figure 7). Last, the ultimate sex-specific shares are set equal to 0.5, i.e. an equal number of male and female non-EU immigrants. All intermediate values of the weights are derived by linear interpolation. By doing so, the model captures the latest empirical evidences without letting them to influence the sex ratio in the medium/long term, where instead the average shares are progressively evolving towards equality. This is particularly relevant for countries that report large differences in the latest sex-specific shares, considered of occasional rather than permanent nature and whose prolongation over time could affect the sex balance in the population.

The Figure 8 shows the sex-specific per-capita immigration values at midterm. Those values are linearly interpolated with the ultimate share, equal to 4.4 x1000 for men and women. For non-EU countries, the sex-specific total immigration values at the midterm are kept constant all over the projections period. For all countries, the totals by sex are then broken down by age, as described in the next section.

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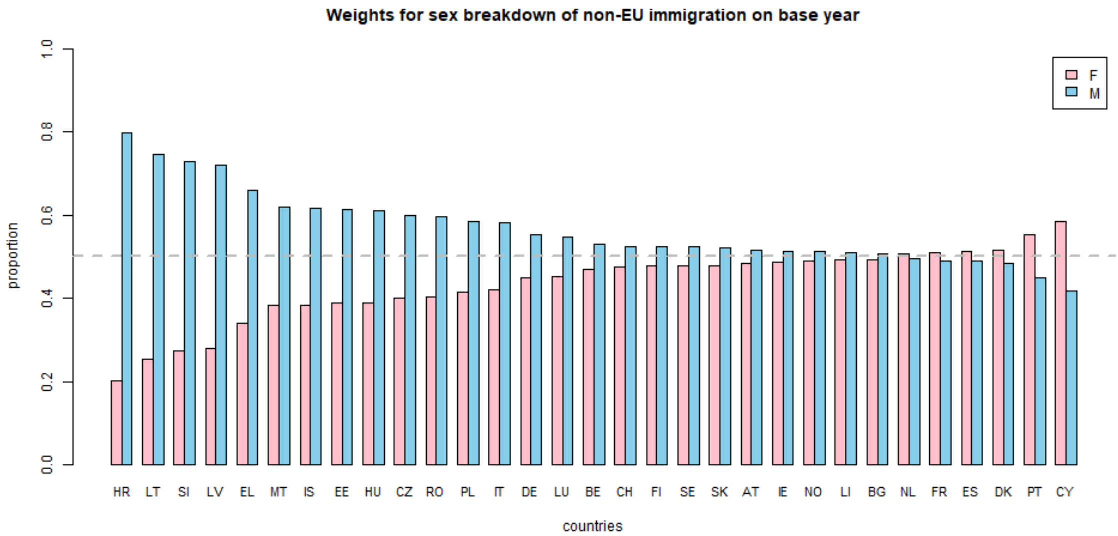
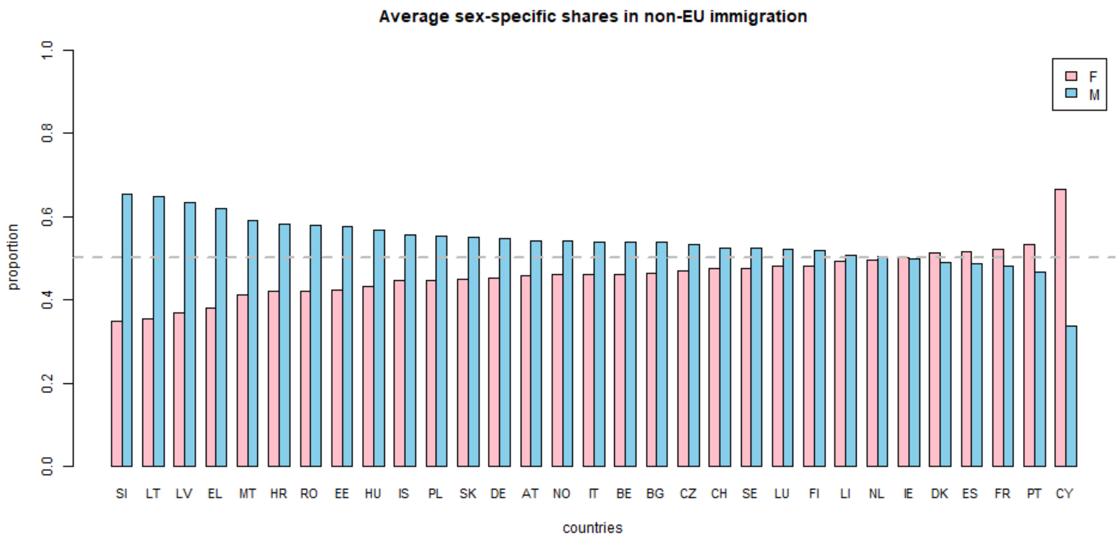
[45] The past sex-specific shares in the non-EU immigration are estimated from the Eurostat table "Immigration by age group, sex and country of previous residence" (*migr_imm5prv*) and selecting the category "NEU27_2007_FOR" for the years 2008-2012 and the category "NEU28_FOR" for the years 2013-2018. For EFTA countries they are estimated from the total immigration over the same period.

Figure 6



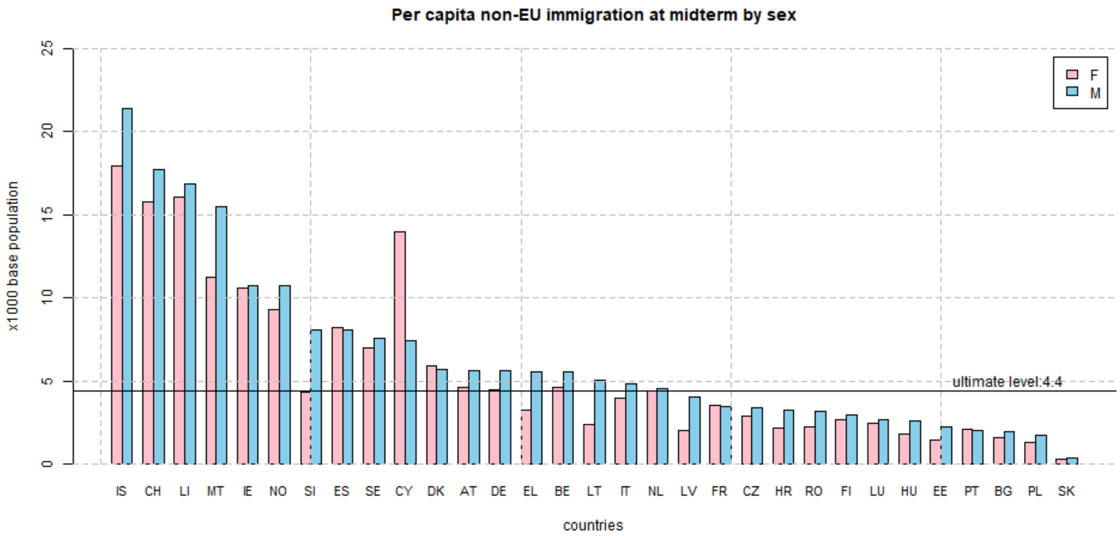
Note: total immigration for EFTA countries.

Figure 7



Note: total immigration for EFTA countries.

Figure 8



Note: total immigration for EFTA countries.

3.5.2. *Age patterns*

The country-specific immigration age profiles by sex and geographic partner (both non-EU and overall) are derived from EUDEMES, normalized such that the sum of the age-specific proportion is equal to one; likewise for the EU age profiles, which serve the purpose of ultimate sex-specific distributions for immigration assumptions. The formers, country-specific, are used as starting sex and age distribution of immigration. The distributions for intermediate years are derived by linear interpolation between the start and ultimate values, as represented by the EU profiles.

For each year in the time horizon of the projections, these normalized country- and sex-specific age profiles are then multiplied by the corresponding extrapolated sex-specific value for immigration from outside the EU; for the other countries, the values are those of the overall immigration.

3.5.3. *Intra-EU immigration*

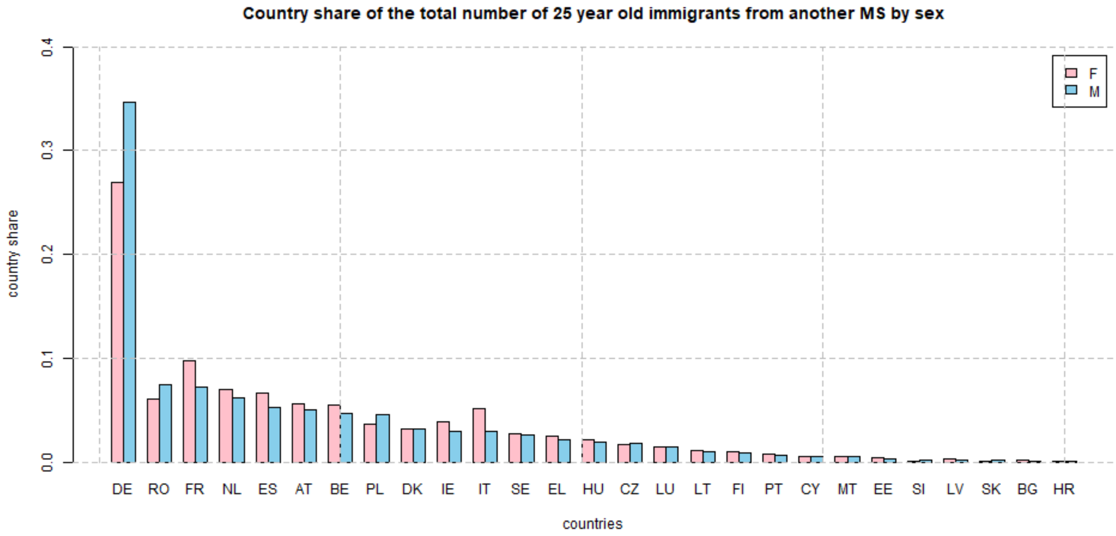
The assumptions for the immigration from another Member State are generated from the corresponding emigration probabilities. The annual total number of emigrations to another Member State are pooled and redistributed as immigration to the single Member States in accordance to age- and sex-specific shares. These profiles are taken from EUDEMES. The shares are so computed:

$$p_{s,a}^{c} = i_{s,a}^{c,oms} / i_{s,a}^{oms}$$

where c is the selected EU Member State, s the sex, a the single age, and i^{oms} the immigration flow from another Member State.

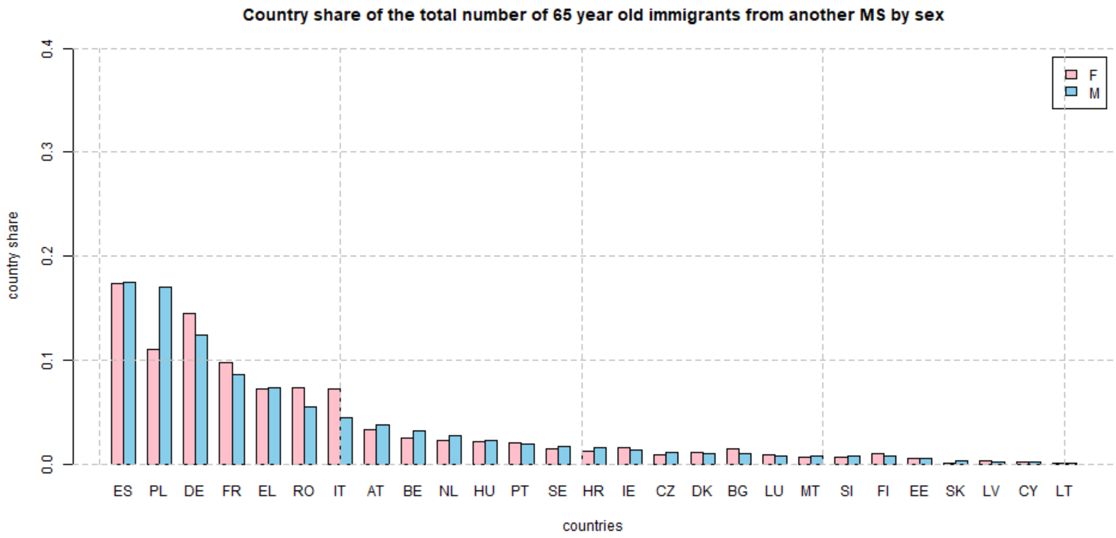
For instance, the Figure 9 shows the share attributed to EU Member States of the total number of 25-years old immigrants coming from another EU Member State, where it is noticeable the predominant position of Germany that receives over one third of those immigrants. The Figure 10 displays instead the countries shares at age 65: the different ranking of the countries as compared to the previous figure makes it visible the effect of post-retirement migration, either as return to the country of origin or as emigration to countries with more favourable climate and environmental conditions.

Figure 9



Source: own computations from EUDEMES data.

Figure 10



Source: own computations from EUDEMES data.

Such attractiveness may well change over time, following the socio-economic development of the countries. This perspective is introduced by assuming that the current sex- and age-specific population share of a country in the EU is a proxy measure of its long-term capacity of intra-EU migration attraction, basically reflecting the size of its economic assets. Under the overall assumption of convergence of socio-economic conditions, the size would be one of the remaining differentiation factor. This tendency is introduced in the model by progressively flattening the sex- and age-specific shares towards the current population share of the country in the EU (see Annex XVI).

3.5.4. Working-age feedback mechanism (WAFM)

For each year in the time horizon of projections, the difference in the working-age population (conventionally between 15 and 64 years old) between the beginning and the end of the year is assumed to trigger an additional non-EU immigration flow in the same year. This additional immigration is not meant to be a precise "replacement migration", thus bounded to (young) working ages, but rather a broader pull factor which materialises in immigration at all ages (the 'additional' immigrants can indeed bring their families as well).

The additional non-EU immigration is assumed to be the 10% of the shrinkage in the working-age population measured in the calendar year. This overall value is then broken down by sex and age in accordance with the profiles adopted for that year.

3.5.5. Total immigration

The assumptions on immigration are therefore the sum of three components:

- The non-EU immigration before applying the WAFM. These assumptions are derived from the latest observed data.
- The additional non-EU immigration generated by the WAFM. This component is calculated during the projections computations, as it depends upon the projected shrinkage of the population in working ages.
- The immigration from other EU Member States. Also this component is computed during the projections computations and it is generated from the corresponding emigration probabilities.

The total immigration assumptions, likewise those on emigration levels, are thus available only once completed the projections computation.

4. PROJECTIONS COMPUTATION

The computations for each year of the projections time horizon are run as follows:

1. Prepare the population by sex and age at the beginning of the year (base population at the beginning, otherwise the population at the end of the previous year).
2. Compute the number of deaths by sex and age (but age 0).
3. Compute the number of emigrants by sex, age and geographic partner (but age 0).
4. Compute the number of immigrants from another Member State by sex and age (but age 0).

5. Add the assumptions on the number of immigrants from non-EU countries by sex and age.

6. Compute the population at the end of the year by sex and age (but age 0).

7. Compute the size of the population in working ages at the beginning and at the end of the year and derive its shrinkage.

8. Compute the number of additional immigrants from non-EU countries by sex and age.

9. Re-compute the population at the end of the year by sex and age (but age 0).

10. Compute the average population in the year by sex and age (but age 0).

11. Compute the number of live births by age of the mother and break them down by sex (for the first year of projections, births nowcast by sex).

12. Compute the number of deaths by sex at age 0.

13. Compute the number of emigrants by sex and geographic partner at age 0.

14. Compute the number of immigrants from another Member States at age 0.

15. Compute the population at the end of the year by sex at age 0.

All computations are rounded to the nearest integer. Age for events is intended as age reached during the year.

5. METHODOLOGICAL CHANGES FROM EUROPOP2018

The methodology of the EUROPOP is constantly evolving. The former approaches were considered the best option at the time of their respective exercises, taking into account data availability and quality. As these latter improve over time, more elaborated models can find their place in the general methodological framework of EUROPOP, once they are judged to be reliable and robust enough. In this round, it is the migration component that has been the most reviewed, thanks to the improved – still rather limited though – data on migration. Here below a short list of methodological changes from the previous EUROPOP exercise:

- Inclusion of nowcast values into the models for computation of assumptions.

- In fertility, minor changes only: earlier start of the transition to convergence and earlier completion of the transition to convergence.

- In the mortality model, use of probabilities of dying within the calendar year instead of mortality rates. There is also a double interpolation to smooth the impact of the nowcast value.

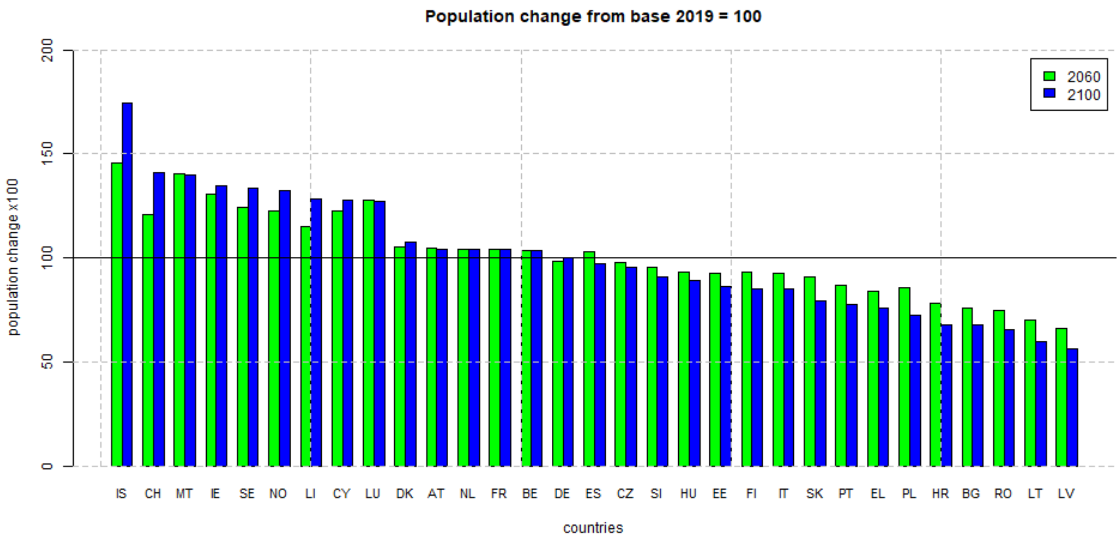
- A new migration model, now built on separated migration flows. It ensures consistency for intra-EU flows and takes better into account sex differentials. It works on immigration levels and emigration probabilities.

- A new way of computing projections, adapted to the different input data.

6. MAIN RESULTS

The analysis of the projections results is beyond the scope of this note and therefore only a few main illustrative graphs are here reported. The Figure 11 shows the countries by decreasing order of their population change from 2019 to 2100, setting the population size in 2019 equal to 100.

Figure 11



The projected population sizes are shown in the Annex XVII. The projected trends for the main components of population change are presented in the Annex XVIII (births), Annex XIX (deaths) and Annex XX (net migration). The remaining annexes focus on the projected population structures, namely on the old age dependency ratio (Annex XXI) and the population sex and age percentage distribution (known as "population pyramids") at selected years (Annex XXII).

7. List of annexes

7.1. On fertility

Annex I: ASFR 2016-2018 smoothed

Annex II: TFR trends extrapolation

Annex III: TFR assumptions and their components

Annex IV: TFR by group of countries

Annex V: ASFR assumptions

7.2. On mortality

Annex VI: qx 2016-2018 smoothed by sex

Annex VII: qx assumptions

Annex VIII: e0 trends

Annex IX: e0 by group of countries

7.3. On emigration

Annex X: ox by sex and destination

Annex XI: emigration levels until midterm year

Annex XII: past crude emigration rate and median age

Annex XIII: ox assumptions

7.4. On immigration

Annex XIV: non-EU immigration without WAFM until midterm

Annex XV: shares of male and female past non-EU immigration

Annex XVI: countries shares of EU immigration by sex and age

7.5. On projections results

Annex XVII: projected total population

Annex XVIII: projected total births

Annex XIX: projected total deaths

Annex XX: projected total net migration

Annex XXI: projected old age dependency ratio

Annex XXII: projected population pyramids at selected years