Population Projections of Spain 2020-2070

Methodology

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INSTITUTO NACIONAL DE ESTADISTICA

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Introduction

The Population Projections are a statistical simulation of the population that would reside in Spain, its Autonomous Communities and provinces in the coming years, as well as the evolution of each one of the basic demographic phenomena associated, if the demographic trends and behaviours currently observed are maintained.

In order to correctly interpret the results of the Population Projections it is important to distinguish between demographic forecasts and projections. Although they may use the same calculation method, they differ in philosophy.

Demographic forecasts must express probable trends, based on the past and on highly probable scenarios for the future, which is very complex and subjective, as it depends on a much broader set of parameters (economic, social, etc.), often difficult to quantify.

Demographic projections represent scenarios that would occur if certain assumptions were fulfilled, regardless of their degree of plausibility. They can simply serve to understand the consequences on the population if a certain hypothesis, even an unlikely one, were to be verified.

Therefore, the Population Projections of the National Statistics Institute are not intended to be a "divination" of the future, but rather to provide a support tool for decision-making based on a statistical simulation of the demographic course that the population resident in Spain would take in the coming years, always under the hypothesis that current demographic trends would be maintained.

Results are provided on a two-year basis, with a projection horizon of 50 years for the national total and 15 years for the Autonomous Communities and provinces, according to basic demographic characteristics (sex, age and generation).

In this way, its results provide the population figure resident in Spain as at 1 January of each year of the 2020-2070 period, and the population resident in each of the Autonomous Communities and provinces as at 1 January of each year of the 2020-2035 period. Likewise, they provide the demographic events (births, deaths and migratory movements) that have given rise to the evolution of the volume and structure of the population in each of the geographical areas considered that such population figures represent. Both types of magnitudes, population stocks and demographic flows, are broken down according to basic demographic characteristics, such as sex, age and year of birth (generation).

It should be borne in mind that all the detailed results of this statistical operation are provided with decimal figures, in order to guarantee their total territorial coherence and perfect consistency between demographic flows and population stocks at all the disaggregation levels considered.

In this new edition, practically the same methodological principles were followed as for the previous edition.

- Population is projected by distinguishing birth country, although detailed results are published for the entire population.

- Fertility is projected for the next 50 years by adjusting the calendar of observed and projected fertility through a Beta probability distribution of the parameters SFI, AAM and Var_AAM.
- In the case of mortality, a projection is made based on the general level, synthesized by life expectancy at birth, thereby establishing hypotheses regarding the future evolution of said parameter.
- In the case of migration, results are projected by making a transition between estimated flows for several years, thus dividing the projective period into three periods:
    - The foreign migration flows for the first two years of the projective period (2020 and 2021) are established equal to the flow that is estimated according to the Migration Statistics for the first semester of 2020.
    - In the second period (13 years) the migratory flows evolve from 2021 towards certain hypothetical levels
    - During the third period (35 years), both immigration and emigration are projected from 2034 onwards, until by 2069 they reach other previously established projection parameters.

During the month of May 2020, **a survey was carried out among experts in demography** in order to obtain their opinion on the expected future evolution for the parameters necessary for the projection, such as: for fertility, the average number of children per woman and the average age at maternity; for mortality, life expectancy at birth and for migrations, future levels of immigration and emigration at 15 and 50 years.

The results of this survey can be found in the annex at the end of this document.

Added to the uncertainty generally surrounding population projections is the impact of COVID-19, which necessitates a rethinking of some of the hypotheses for future evolution. Specifically, for these projections, the excess mortality observed through July 2020 has been taken into account, as well as the decrease experienced in immigration and emigration in recent months.

Under these conditions, the effect of COVID-19 taken into account for the projection hypotheses was:

- No impact is projected on births, since there is thus far no evidence of such impact.
- Mortality is projected to be affected only during 2020. The year 2021 and thereafter are projected to have a normal mortality rate.
- A decrease in migratory movements abroad is projected, meaning that the trend of recent years will be broken. From 2021 onwards, a gradual recovery of the migratory balance is projected. This will always be positive, but will fail to reach the levels observed in previous years.
- No impact is projected on internal migration, since thus far there is no evidence of this. Beyond the slowdown observed in 2020, the evidence is insufficient to establish new hypotheses regarding changes in residence between provinces.

1 General method of calculation

The present exercise of Population Projections of Spain is based on the *classical components method*. The application of this method responds to the following scheme: starting from the resident population in a certain geographical area and from the data observed for each one of the basic demographic components, mortality, fertility and migration, the aim is to obtain the resident population at a later date under certain hypotheses about the future of these three phenomena, which determine their growth and their structure by age.

The retrospective analysis of each of the basic demographic phenomena, making use of the most up-to-date demographic information available, has made it possible to establish hypotheses on their future incidence at each territorial level considered in each year of the projection period, quantified in specific fertility rates by generation, specific mortality rates by sex and generation, specific rates by sex and generation of international emigration and inter-provincial internal migration, as well as in international immigration flows for each sex and generation. In addition, since 2018, different hypotheses have been established by place of birth (Spain or abroad), as both groups have different behaviours and demographic dynamics.

Well, the projection of the population of each sex, age and place of birth resident in Spain, and in each of their Autonomous Communities and provinces, as at 1 January of each year of the projection period, has been carried out in accordance with a *multi-regional projection model*[1], which provides as results not only the population figures by sex and age, resident in each of the territorial levels considered, but also the projected figures of births, deaths and migratory movements that would take place in each of the years of the projection period, all of this keeping the necessary coherence between demographic flows and stocks and the due interterritorial consistency. The following is the formulation of the projection model without taking into account the place of birth (Spain or abroad), for simplicity of the formulas.

Starting from the resident population at each territorial level considered of sex s and age *x* as at 1 January of year *t* ($P_{s,x}^{t}$), the projection of resident population of age *x+1* and sex *s* in said geographical area as at 1 January of year *t+1* ($P_{s,x+1}^{t+1}$) is obtained from the following expressions:

A. For the national total:

- For ages as at 1 January $\mathrm{x} = 0,1,2,\ldots,98$:

$$P_{s,x+1}^{t+1} = \frac{\left[1 - 0{,}5 \cdot (m_{s,x}^{t} + e_{s,x}^{t})\right] \cdot P_{s,x}^{t} + IM_{s,x}^{t}}{\left[1 + 0{,}5 \cdot (m_{s,x}^{t} + e_{s,x}^{t})\right]}$$

[1] Willekens, F.J, “Demographic forecasting: state of the art and research needs”, in Emerging Issues in Demographic Research, (Ed) Hazeu and Frinking (1990), and Willekens, F.J. and Drewe, P., “A multiregional model for regional demographic projection”, in Heide, H. and Willekens, F.J. Demographic Research and Spatial Policy, (Ed) Academic Press, London (1984).

where $m^t_{s,x}$ is the mortality rate in year *t* of the generation of individuals resident in Spain of sex *s* and age *x* as at 1 January of year *t*; $e^t_{s,x}$ is the rate of international emigration in year *t* of the generation of individuals resident in Spain of sex *s* and age *x* as at 1 January of year *t*; and $IM^t_{s,x}$ is the immigration flow from abroad in year *t* of individuals of sex *s* and age *x* as at 1 January of year *t*.

- For those born during the current year *t*:

$$P^{t+1}_{s,o} = \frac{\left[1 - 0{,}5 \cdot (m^t_{s,-1} + e^t_{s,-1})\right] \cdot N^t_s + IM^t_{s,-1}}{\left[1 + 0{,}5 \cdot (m^t_{s,-1} + e^t_{s,-1})\right]}$$

where $m^t_{s,-1}$ is the mortality rate of the generation of individuals resident in Spain, of sex *s*, born during year *t*; $e^t_{s,-1}$ the rate of international emigration of individuals resident in Spain, of sex *s*, born during year *t*; $IM^t_{s,-1}$ is the immigration flow from abroad of persons born of sex *s* during year *t*; and N^t_s are those born in Spain of sex *s* during year *t*, which are derived from the following expression:

$$N^t_s = r \cdot \sum_{x=14}^{49} \left(\frac{P^t_{M,x} + P^{t+1}_{M,x+1}}{2} \right) \cdot f^t_x$$

where *r* is the masculinity ratio at birth projected in the case of males and, therefore, *1-r* is the femininity ratio at birth projected in the case of females; $P^t_{M,x}$ is the population of females of age *x* as at 1 January of year *t*; and f^t_x is the fertility rate of the generation of females resident in Spain with age *x* as at 1 January of year *t* during that year.

- For the open age group of 100 years or more:

$$P^{t+1}_{s,100+} = \frac{\left[1 - 0{,}5 \cdot (m^t_{s,99+} + e^t_{s,99+})\right] \cdot (P^t_{s,99} + P^t_{s,100+}) + IM^t_{s,99+}}{\left[1 + 0{,}5 \cdot (m^t_{s,99+} + e^t_{s,99+})\right]}$$

Where $P^t_{s,99}$ is the resident population in Spain of sex *s* and age 99 as at 1 January of year *t*; $P^t_{s,100+}$ is the resident population in Spain of sex *s* of 100 years old or more as at 1 January of year *t*; $m^t_{s,99+}$ is the mortality rate of the generation of individuals of sex *s* resident in Spain of 99 years old or more as at 1 January of year *t* during said year; $e^t_{s,99+}$ is the rate of international emigration of the generation of individuals of sex *s* resident in Spain of 99 years or more as at 1 January of year *t* during said year;

and $\mathrm{IM}_{s,99+}^{t}$ is the immigration flow from abroad of individuals of sex *s* and age 99 years or more as at 1 January of year *t* during said year.

In addition, the number of deaths is obtained of individuals resident in Spain of sex *s* and age *x* as at 1 January of year *t* throughout said year, $D_{s,x}^{t}$, from:

- For individuals of the generation of age $x = 0,1,\ldots,98$ as at 1 January of year *t*:

$$D_{s,x}^{t} = m_{s,x}^{t} \cdot \left(\frac{P_{s,x}^{t} + P_{s,x+1}^{t+1}}{2} \right)$$

- For those born throughout the year *t*:

$$D_{s,-1}^{t} = m_{s,-1}^{t} \cdot \left(\frac{N_{s}^{t} + P_{s,0}^{t+1}}{2} \right)$$

Where $D_{s,-1}^{t}$ is the number of deaths in year *t* of residents in Spain of sex *s* born throughout the year and $m_{s,-1}^{t}$ is their mortality rate in said year.

- For individuals of generations aged 99 or older as at 1 January of year *t*:

$$D_{s,99+}^{t} = m_{s,99+}^{t} \cdot \left(\frac{P_{s,99}^{t} + P_{s,100+}^{t} + P_{s,100+}^{t+1}}{2} \right)$$

where $P_{s,100+}^{t}$ is the resident population in Spain of sex *s* aged 100 years and over as at 1 January of year *t* and $D_{s,99+}^{t}$ the deaths of individuals of sex *s* and aged 99 years and over throughout year *t*.

We also obtain the international emigrations of individuals resident in Spain of sex *s* and age *x* as at 1 January of year *t* throughout said year, $E_{s,x}^{t}$, from:

- For individuals of the generation having age $x = 0,1,\ldots,98$ as at 1 January of year *t*:

$$E_{s,x}^{t} = e_{s,x}^{t} \cdot \left(\frac{P_{s,x}^{t} + P_{s,x+1}^{t+1}}{2} \right)$$

- For those born throughout the year *t*:

$$E_{s,-1}^{t} = e_{s,-1}^{t} \cdot \left(\frac{N_{s}^{t} + P_{s,0}^{t+1}}{2} \right)$$

where $E^{t}_{s,-1}$ is the number of emigrations in year *t* of persons born in Spain of sex *s* and $e^{t}_{s,-1}$ the international emigration rate of such persons.

- For individuals of generations aged 99 or older as at 1 January of year *t*:

$$E^{t}_{s,99+} = e^{t}_{s,99+} \cdot \left(\frac{P^{t}_{s,99} + P^{t}_{s,100+} + P^{t+1}_{s,100+}}{2} \right)$$

where $P^{t}_{s,100+}$ is the resident population in Spain of sex *s* aged 100 years old or over as at 1 January of year *t* and $e^{t}_{s,99+}$ the rate of emigration abroad of residents in Spain of sex *s* and aged 99 years old or over throughout year *t*.

B. For each province *h* the calculation is carried out by solving a system of equations of 52 equations and 52 unknowns in each sex and generation, defined by the following equalities:

- For ages $x = 0,1,\ldots,98$:

$$P^{t+1}_{h,s,x+1} = \frac{\left[1 - 0{,}5 \cdot (m^{t}_{h,s,x} + e^{t}_{h,s,x})\right] \cdot P^{t}_{h,s,x} + IM^{t}_{h,s,x} + \sum_{k \neq h} ei^{t}_{s,x,k,h} \cdot \left(\frac{P^{t}_{k,s,x} + P^{t+1}_{k,s,x+1}}{2} \right) - \sum_{k \neq h} ei^{t}_{s,x,h,k} \cdot \left(\frac{P^{t}_{h,s,x} + P^{t+1}_{h,s,x+1}}{2} \right)}{\left[1 + 0{,}5 \cdot (m^{t}_{h,s,x} + e^{t}_{h,s,x})\right]}$$

where $\mathrm{m}^{\mathrm{t}}_{\mathrm{h,s,x}}$ is the mortality rate in year *t* of individuals residing in province *h* of sex *s* and age *x* as at 1 January of year *t*; $\mathrm{e}^{\mathrm{t}}_{\mathrm{h,s,x}}$ is the rate of emigration abroad in year *t* of individuals residing in province *h* of sex *s* and age *x* as at 1 January of year *t*; $\mathrm{IM}^{\mathrm{t}}_{\mathrm{h,s,x}}$ is the immigration flow from abroad arriving in province *h* in year *t* of individuals of sex *s* and age *x* as at 1 January of year *t*; and $ei^{t}_{s,x,h,k}$ is the rate of emigration from province *h* to province *k* of individuals of sex *s* and age *x* as at 1 January of year *t.*

- For those born during the current year *t*:

$$P^{t+1}_{h,s,o} = \frac{\left[1 - 0{,}5 \cdot (m^{t}_{h,s,-1} + e^{t}_{h,s,-1})\right] \cdot N^{t}_{h,s} + IM^{t}_{h,s,-1} + \sum_{k \neq h} ei^{t}_{s,-1,k,h} \cdot \left(\frac{N^{t}_{k,s} + P^{t+1}_{k,s,0}}{2} \right) - \sum_{k \neq h} ei^{t}_{s,-1,h,k} \cdot \left(\frac{N^{t}_{h,s} + P^{t+1}_{h,s,0}}{2} \right)}{\left[1 + 0{,}5 \cdot (m^{t}_{h,s,-1} + e^{t}_{h,s,-1})\right]}$$

where $\mathrm{m}^{\mathrm{t}}_{\mathrm{h,s,-1}}$ is the mortality rate in year *t* of residents of sex *s* in province *h* born during that year; $\mathrm{e}^{\mathrm{t}}_{\mathrm{h,s,-1}}$ is the rate of emigration abroad in year *t* of residents in province *h* of sex *s* born during year *t*; $\mathrm{IM}^{t}_{h,s,-1}$ is the immigration flow from abroad in province *h* of individuals of sex *s* born during year *t*; $ei^{t}_{s,-1,h,k}$ is the emigration rate from province *h* to province *k* during year *t*, of individuals of sex *s* born during the year; and $\mathrm{N}^{t}_{h,s}$ are those born of sex *s* in province *h* during year *t*, which are obtained from:

$$N^{t}_{h,s} = r \cdot \sum_{x=14}^{49} \left(\frac{P^{t}_{h,M,x} + P^{t+1}_{h,M,x+1}}{2} \right) \cdot f^{t}_{h,x}$$

where *r* is the masculinity ratio at birth projected for each year of the projection period in the case of males and, therefore, *1-r* is the femininity ratio at birth projected in the case of females; $\mathrm{P}^{t}_{h,M,x}$ is the population of females resident in province *h* of age *x* as at 1 January of year *t*; and $\mathrm{f}^{t}_{h,x}$ is the fertility rate in year *t* of females resident in province *h* belonging to the generation aged *x* as at 1 January of that year.

- For the open age group of 100 years or more:

$$P^{t+1}_{h,s,100+} = \frac{\left[1 - 0{,}5 \cdot (m^{t}_{h,s,99+} + e^{t}_{h,s,99+})\right] \cdot (P^{t}_{h,s,99} + P^{t}_{h,s,100+}) + IM^{t}_{h,s,99+} +}{\left[1 + 0{,}5 \cdot (m^{t}_{h,s,99+} + e^{t}_{h,s,99+})\right]}$$

$$+ \frac{\sum_{k \neq h} ei^{t}_{s,99+,k,h} \cdot \left(\frac{P^{t}_{k,s,99} + P^{t}_{k,s,100+} + P^{t+1}_{k,s,100+}}{2} \right) - \sum_{k \neq h} ei^{t}_{s,99+,h,k} \cdot \left(\frac{P^{t}_{h,s,99} + P^{t}_{h,s,100+} + P^{t+1}_{h,s,100+}}{2} \right)}{\left[1 + 0{,}5 \cdot (m^{t}_{h,s,99+} + e^{t}_{h,s,99+})\right]}$$

where $\mathrm{P}^{t}_{h,s,99}$ is the resident population in province *h* of sex *s* and age 99 as at 1 January of year *t*; $\mathrm{P}^{t}_{h,s,100+}$ is the resident population in province *h* of sex *s* aged 100 or over as at 1 January of year *t*; $\mathrm{m}^{t}_{h,s,99+}$ is the mortality rate in year *t* of individuals of sex *s* resident in province *h* belonging to the generation aged 99 or over as at 1 January of that year; $\mathrm{e}^{t}_{h,s,99+}$ the rate of emigration abroad in year *t* of individuals of sex *s* resident in province *h* belonging to the generation aged 99 or over as at 1 January of year *t*; $\mathrm{IM}^{t}_{h,s,99+}$ the immigration flow from abroad during year *t* in province *h* of individuals of sex *s* and age 99 or over as at 1 January of year *t*; and $ei^{t}_{s,99+,h,k}$ is the rate of emigration from province *h* to province *k* of individuals of sex *s* belonging to the generations aged 99 or over as at 1 January of year *t* throughout that year.

In addition, the number of deaths is obtained of individuals resident in province *h* of sex *s* and age *x* as at 1 January of year *t* throughout said year, $D_{s,x}^{t}$, from:

- For individuals of the generation that has $x = 0,1,2,...,98$ years old as at 1 January of year *t*:

$$D_{h,s,x}^{t} = m_{h,s,x}^{t} \cdot \left(\frac{P_{h,s,x}^{t} + P_{h,s,x+1}^{t+1}}{2} \right)$$

where $m_{h,s,x}^{t}$ is the mortality rate in year *t* of residents in province *h* of sex *s* belonging to the generation of individuals of age *x* as at 1 January of year *t*.

- For those born throughout the year *t*:

$$D_{h,s,-1}^{t} = m_{h,s,-1}^{t} \cdot \left(\frac{N_{h,s}^{t} + P_{h,s,0}^{t+1}}{2} \right)$$

where $D_{h,s,-1}^{t}$ are the deaths in year *t* of those born during that year of sex *s* in province *h* and $m_{h,s,-1}^{t}$ are their mortality rate in that year.

- For individuals belonging to the generation of 99 years of age or older as at 1 January of year *t*:

$$D_{h,s,99+}^{t} = m_{h,s,99+}^{t} \cdot \left(\frac{P_{h,s,99}^{t} + P_{h,s,100+}^{t} + P_{h,s,100+}^{t+1}}{2} \right)$$

where $P_{h,s,100+}^{t}$ is the population resident in province *h* of sex *s* belonging to the generations aged 100 or over as at 1 January of year *t*; $D_{h,s,99+}^{t}$ the deaths of individuals resident in province *h* of sex *s* belonging to the generations aged 99 or over as at 1 January of year *t*; and $m_{h,s,99+}^{t}$ the mortality rate of individuals resident in province *h* of sex *s* belonging to the generations aged 99 or over as at 1 January of year *t*.

Similarly, we obtain emigrants abroad of sex *s* belonging to the generation aged *x* as at 1 January of year *t* throughout that year, $E_{h,s,x}^{t}$ derived from:

- For individuals of the generation that has $x = 0,1,2,...,98$ years old as at 1 January of year *t*:

$$E^t_{h,s,x} = e^t_{h,s,x} \cdot \left(\frac{P^t_{h,s,x} + P^{t+1}_{h,s,x+1}}{2} \right)$$

where $e^t_{h,s,x}$ is the rate of emigration abroad in year *t* of residents in province *h* of sex *s* belonging to the generation of individuals of age *x* as at 1 January of year *t*.

- For those born throughout the year *t*:

$$E^t_{h,s,-1} = e^t_{h,s,-1} \cdot \left(\frac{N^t_{h,s} + P^{t+1}_{h,s,0}}{2} \right)$$

where $E^t_{h,s,-1}$ are the emigrations abroad in year *t* of persons born during said year of sex *s* in province *h* and $e^t_{h,s,-1}$ the rate of emigration abroad of such persons in said year.

- For individuals belonging to the generation of 99 years of age or older as at 1 January of year *t*:

$$E^t_{h,s,99+} = e^t_{h,s,99+} \cdot \left(\frac{P^t_{h,s,99} + P^t_{h,s,100+} + P^{t+1}_{h,s,100+}}{2} \right)$$

where $E^t_{h,s,99+}$ is the international emigration of individuals residing in province *h* of sex *s* belonging to generations who are 99 years old or older as at 1 January of year *t*; and $e^t_{h,s,99+}$ is the rate of emigration abroad of individuals residing in province *h* of sex *s* belonging to generations who are 99 years old or older as at 1 January of year *t*.

From the figures resulting from this process, the figures by age of each demographic phenomenon are derived under the hypothesis of uniform distribution among the exact ages that the individuals of each generation will have at some time during the year.

Finally, it should be noted that the projection calculation involves an iterative process of consistency check and adjustments of the national results of projected populations and demographic events obtained from the projection of the national total and the aggregation of provincial results, introducing successive provincial correction factors that modify very slightly, to the same degree for all provinces in each generation, sex, place of birth (and therefore without modifying the relative position of each province with respect to the others regarding the incidence of each demographic phenomenon in each sex, age and place of birth), the specific rates of fertility, mortality and emigration abroad until achieving the complete interterritorial consistency of population stocks and projected demographic events.

2 Starting population

The starting population of Population Projections 2020-2070 consists of the provisional Population Figures as at 1 January 2020 available at the time of preparation and dissemination of their results. This guarantees the consistency of the results of this operation with the retrospective series of reference population figures that the INE uses throughout its entire statistical production.

3 Projection of fertility

3.1 Projection of fertility In Spain

The general method of projection of the fertility of women resident in Spanish territory is based on establishing hypotheses on the future evolution of the general level of fertility, synthesised by the Short-term Fertility Indicator (SFI) or average number of children per woman and of the parameters that synthesise its distribution by age, the Average Age at Maternity (AAM) and the Variance of Average Age at Maternity (Var(AAM)).

Therefore, the projection of fertility will consist of establishing certain hypotheses about the future evolution of these three parameters: SFI, AAM and Var(AAM), in order to obtain the fertility rates by age for each year of the projection period by adjusting a Beta probability distribution of the parameters SFI, AAM and Var(AAM).

As was done two years ago, in this edition, fertility is modelled according to the mother's place of birth, in order to take into account the different behaviour of women born in Spain and those born abroad.

Any fertility function[2] by age can be written as

$$f(x) = D(\beta) \cdot g(x)$$

Where

$D(\beta)$ is the final offspring

β is the upper limit of the age range

$g(x)$ is the fertility calendar that determines a probability density defined in the age interval (α, β) such that $\int_{\alpha}^{\beta} g(x)dx = 1$

Therefore, given that the fertility curves by age observed are continuous, bell-shaped, unimodal and slightly deviated to the right, one of the probability distributions that can best adjust the fertility calendar observed in Spain is the Beta Probability Distribution, corrected for the lower age limit α and upper age limit β.

$$f(x) = D(\beta) \frac{1}{B(a,b)} \frac{(x-a)^{a-1}(\beta - x)^{b-1}}{(\beta - \alpha)^{a+b-1}}, \quad 1 < a < b$$

Where

$$a = \frac{[1-m(X)]m^2(X)}{s^2(X)} - m(X) \quad , \qquad b = \frac{[1-m(X)]^2 m(X)}{s^2(X)} - [1-m(X)] \quad \text{and} \quad D(\beta) = ICF$$

And if $\alpha = 15$ and $\beta = 49$ then $m(X) = \frac{EMM-15}{35}$ and $s^2(X) = \frac{Var(EMM)}{35^2}$

[2] Eléments de démographie mathématique. Roland Pressat. Association Internationale des Demographes de la Langue Française. 1995

INE. National Statistics Institute

In this way, for each year t of the long-term projection period 2020-2069 the fertility curve by age and birthplace of mother n will be obtained as a result of adjusting a beta probability distribution of parameters $\widehat{ICF}_n^t$, $\widehat{EMM}_n^t$ and $\widehat{Var}(\widehat{EMM}_n^t)$.

In other words, we need a projection of the parameters of the beta distribution for each of the years of the projection period.

In the survey to the experts carried out in May 2020, explained in the introduction to this document, they were asked about what value they considered that both the Short-term Fertility Indicator and the Average Age at Maternity in Spain would reach in the years 2034 (within 15 years) and in 2069 (within 50 years), separately, for women born in Spain and for those born abroad.

Then, the values of $\widehat{ICF}_n^t$ and $\widehat{EMM}_n^t$ of each of the years of the projection period, necessary to adjust the corresponding fertility curve, will be obtained by linear interpolation between the last observed value (provisional figures for 2019) and the arithmetic mean of the values given by the experts in the survey for the years 2034 and 2069, respectively.

As for the variance of the average age at maternity for each of the years of the projective period, it will be considered constant and equal to the value of the last year observed, which in this edition correspond to the provisional figures for 2019.

Once we have a projection of the parameters for each of the years of the long-term projection period 2020-2069, the fertility rate for each age x and birthplace of mother n is obtained by simply applying the formulas developed on page 14 of this document.

$$f_n^t(x) = \widehat{ICF}_n^t \frac{1}{B(a,b)} \frac{(x-15)^{a-1}(49-x)^{b-1}}{(35)^{a+b-1}}, \quad 1 < a < b$$

Where

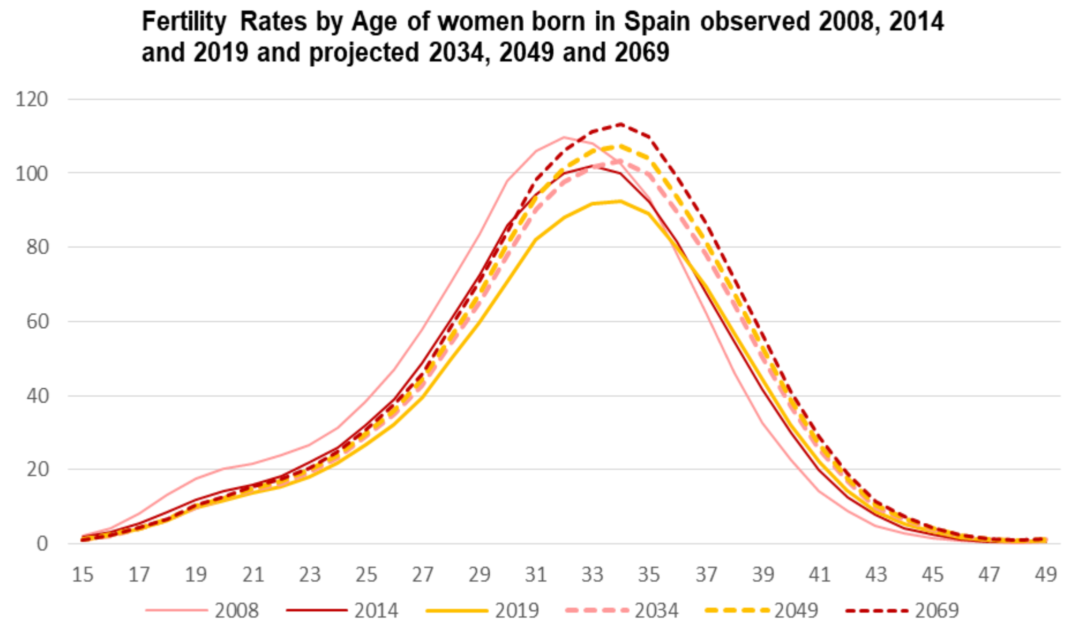
$$a = \frac{[1-m(X)]m^2(X)}{s^2(X)} - m(X) \quad \text{and} \quad b = \frac{[1-m(X)]^2 m(X)}{s^2(X)} - [1-m(X)]$$

With

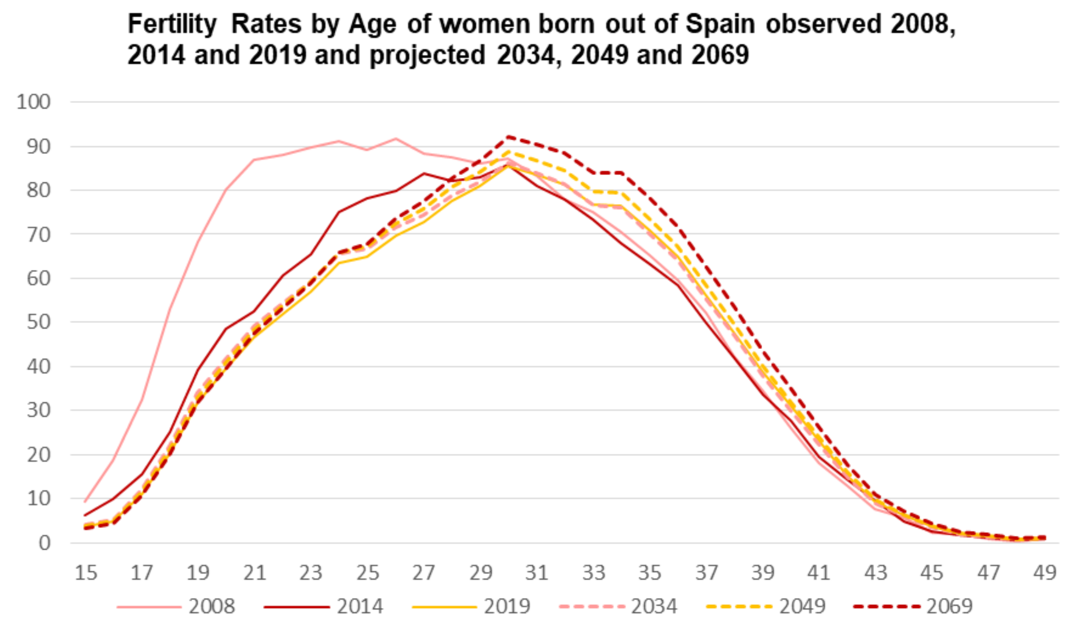
$$m(X) = \frac{\widehat{EMM}_n^t - 15}{35} \quad \text{and} \quad s^2(X) = \frac{\widehat{Var}(\widehat{EMM}_n^t)}{35^2}$$

From this estimate, we obtain the annual growth profile applied from the last period observed. The purpose of applying this correction factor is to enable a smoother transition between the last observed period and the first projected period.

The following graphs include the observed and projected values of the Fertility Rates by age and place of birth of the mother, as well as the Short-term Fertility Indicator and the Average Age at Maternity according to the place of birth of the mother:



Fuente: 2008-2019 Indicadores Demográficos Básicos (2019 datos provisionales)



Fuente: 2008-2019 Indicadores Demográficos Básicos (2019 datos provisionales)

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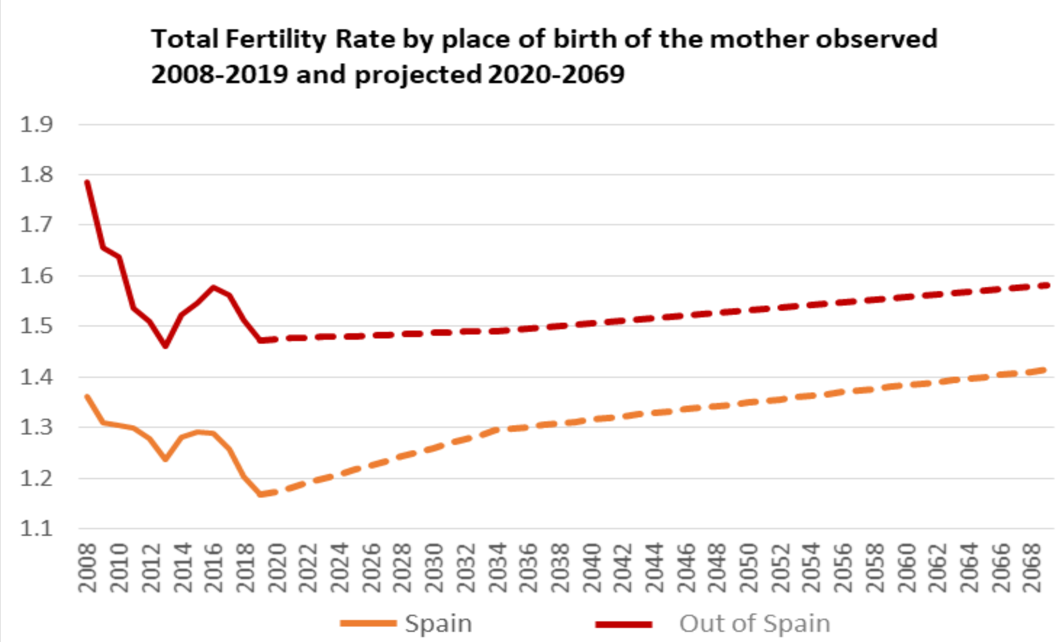
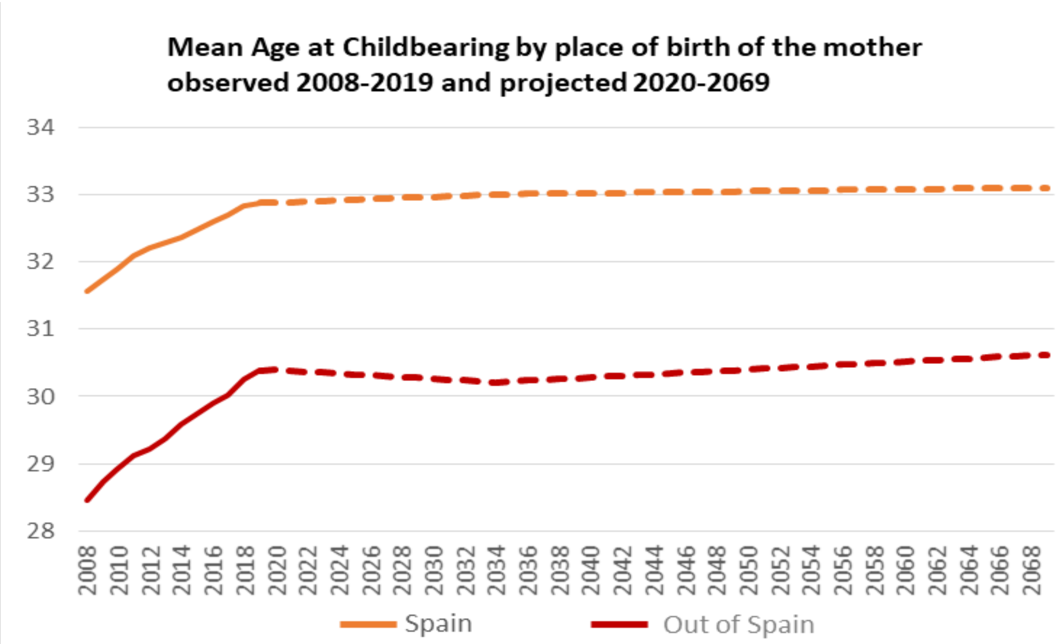


Fuente: 2008-2019 Indicadores Demográficos Básicos (2019 datos provisionales)



Fuente: 2008-2019 Indicadores Demográficos Básicos (2019 datos provisionales)

Finally, the projected fertility rate by year of birth of the mother for each year of the projection period is derived from the semi-sum of the projected rates for that same year corresponding to the two ages that women of each generation may have reached during that year, under the hypothesis of uniform distribution of the birthdays of individuals throughout a calendar year.

$$f^{t}_{g(t-x),n} = \frac{\left(f^{t}_{x,n} + f^{t}_{x+1,n}\right)}{2} \qquad \forall t$$

In order to disaggregate the projected birth figures by sex, the proportion of masculinity is applied to the projected birth as the average of those proportions observed in the last 10 years for which definitive results are available from the Vital Statistics on Births, that is, for the period 2009-2018, at the time of establishing the present projections.

3.2 Projection of fertility in provinces

The projection of the evolution of fertility throughout the period 2020-2034 in each of the provinces of Spain is carried out on the basis of a simulation of the differential behaviour of fertility intensity in each province with respect to the national total, as well as the current evolution of the Median Age at Maternity and the Interquartile Range of the fertility rates of each of them. Based on these parameters, the projected fertility rates by age for each province and for each year of the short-term projection period are derived from the so-called *Brass Relational Gompertz model*, following the methodology proposed by Zeng and others (2001)[3].

In this way, the projection of fertility rates, by province p and place of birth n, is carried out in the following steps:

1. Projection of the Short-term Fertility Indicator by province and place of birth of the mother for the period 2020-2034:

The projected Short-term Fertility Indicator, in each province p and place of birth n, for each year of the short-term projection period t, is derived from that established for the national total for said year multiplied by a coefficient that represents the differential in fertility intensity of each province and place of birth of the mother within Spain, that is to say:

$$IC\hat{F}^{t}_{p,n} = IC\hat{F}^{t}_{España,n} \cdot D\hat{F}^{t}_{p,n}$$

Where $IC\hat{F}^{t}_{España,n}$ is the Short-term Fertility Indicator projected for year t of the national total and place of birth of mother n obtained as explained in section 3.1 of this document.

[3] Zeng Yi, Wang Zhenglian, Ma Zhongdong y Chen Chunjun. 2000. "A simple method for projecting or estimating α and β: An extension of the Brass Relational Gompertz Fertility Model", Population Research and Policy Review 19:525–549.

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The differential coefficient observed is defined for a year t^* as the quotient between the Short-term Fertility Indicator observed for the province *p* and place of birth of the mother *n* and the Short-term Fertility Indicator observed for Spain:

$$DF_{p,n}^{t^*} = \frac{ICF_{p,n}^{t^*}}{ICF_{España,n}^{t^*}}$$

The differential coefficient projected for each year of the period 2020-2034 is obtained from the estimation by Ordinary Least Squares of a logarithmic modelling of the observed evolution of this differential over the last 10 years, according to the following formulation:

$$DF_{p,n}^{t} = \alpha_{p,n} + \beta_{p,n} \cdot \ln(t - aa1) \qquad \forall t = aa1, \ldots, aa10$$

In this way, the estimation of the differential coefficient of each province and nationality for each year of the short-term projection period, $\widehat{DF}_{p,n}^{t}$, is derived from the extrapolation to the future of the estimated logarithmic model.

$$D\hat{F}_{p,n}^{t} = \hat{\alpha}_{p,n} + \hat{\beta}_{p,n} \cdot ln(t - aa1) \qquad \forall t > aa10$$

Finally, the Short-term Fertility Indicator projected for each province, place of birth of the mother and year of the short-term projection period results from:

$$IC\hat{F}_{p,n}^{t} = D\hat{F}_{p,n}^{t} \cdot ICF_{España,n}^{t} \quad \forall t > aa10$$

More information on the observed values is available in Basic Demographic Indicators.

2. Projection of Average Age at Maternity by province and place of birth of the mother for the period 2020-2034:

The projected Median Age at Maternity for each year t of the projection period in each province p and place of birth of mother n, $EMeM_{p,n}^{t}$, is obtained analogously from the estimation by Ordinary Least Squares of a logarithmic modelling of the observed evolution of this indicator over the last 10 years, according to the following formulation:

$$EMeM_{p,n}^{t} = \gamma_{p,n} + \delta_{p,n} \cdot ln(t - aa1) \qquad \forall t = aa1, \ldots, aa10$$

In this way, the projection of the Median Age at Maternity in each province

and place of birth of the mother, $EMeM_{p,n}^{t}$, , is extrapolated to the future from the estimated logarithmic model.

$$EMe\hat{M}^{t}_{p,n} = \hat{\gamma}_{p,n} + \hat{\delta}_{p,n} \cdot ln(t - aa1) \quad \forall t > aa10$$

3. Projection of the Interquartile Range of specific fertility rates by age, province and place of birth of the mother for the period 2020-2034:

The estimated Interquartile Range of fertility rates by age for each year of the projection period in each province and place of birth of the mother, $RI^{t}_{p,n}$, is obtained analogously from the estimation by Ordinary Least Squares of a logarithmic modelling of the observed evolution of said indicator throughout the last 10 years, according to the following formulation:

$$RI^{t}_{p,n} = \mu_{p,n} + \rho_{p,n} \cdot ln(t - aa1), \quad \forall t = aa1, \dots, aa10$$

In this way, the Interquartile Range used in the projection for each year of the short-term projection period is extrapolated to the future from the estimated logarithmic model:

$$R\hat{I}^{t}_{p,n} = \hat{\mu}_{p,n} + \hat{\rho}_{p,n} \cdot ln(t - aa1) \quad \forall t > aa10$$

4. Calculation of fertility rates by age, province and place of birth of the mother, projected for each year in the period 2020-2034 using the *Brass Relational Gompertz* model:

We derive the specific fertility rates by age projected for each year from the short-term projection period, for each province and place of birth of the corresponding mother, from the fertility indicators established in the previous steps and from the fertility rates by age observed in the last year for which we have results from the Vital Statistics on Births previously smoothed by means of a moving averages process of order 5 (5 consecutive ages) in order to introduce the least possible noise into the projection. The latest available information at the time of establishing these projections is the provisional results for 2019.

Given:

$H(x) = \sum_{i=15}^{x} f_i^{p,n,t}$, where $f_i^{p,n,t}$ is the specific fertility rate at the ith age of province p according to the place of birth of mother n in year t.

$$T = ICF = \sum_{i=15}^{49} f_i^{p,n,t} \quad \text{and} \quad Y(x) = -ln(ln(x))$$

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The Brass Relational Gompertz Model establishes a monotonous function that relates the cumulative sum of fertility rates up to age x of one year t, $H^{t}(x)$, to that of the previous year, $H^{t-1}(x)$. It is done recursively for each t of the short-term project period.

$$Y\left(H_{p,n}^{t}(x)/T_{p,n}^{t}\right)=\alpha_{t,n}+\beta_{t,n}\cdot Y\left(H_{p,n}^{t-1}(x)/T_{p,n}^{t-1}\right)$$

Once we have estimated α and β, we obtain the projected fertility rates for year t with nothing else to apply:

$$H_{p,n}^{t}(x)=\hat{T}_{p,n}^{t}\cdot exp\left(-exp\left(-\frac{Y\left(H_{p,n}^{t}(x)\right)}{\hat{T}_{p,n}^{t}}\right)\right)$$

and

$$f_{x,p,n}^{t}=H_{p,n}^{t}(x)-H_{p,n}^{t}(x-1)$$

Where $\hat{T}_{p,n}^{t}$ is the SFI we have projected as a result of the logarithmic modelling of the differential in fertility intensity of each province and place of birth of the mother in Spain for year t in point 1 of section 3.2 of this document.

Zeng Yi[4], Wang Zhenglian[5], Ma Zhongdong[6] and ChenChunjun[7], obtained a simple method to estimate α and β from the Brass Relational Gompertz model based on median age, interquartile range, and specific fertility level[8].

$$\hat{\alpha}_{t,n}=Y(0,5)-\hat{\beta}_{t,n}\cdot Y\left(H_{p,n}^{t-1}\left(EMe\hat{M}_{p,n}^{t}\right)/ICF\hat{F}_{p,n}^{t-1}\right)$$

$$\hat{\beta}_{t,n}=\frac{R\hat{I}_{p,n}^{t-1}}{R\hat{I}_{p,n}^{t}}$$

The specific fertility rates by age projected for each year of the short-term projection period, by province according to the place of birth of the mother, undergo a smoothing process of moving averages of order 5 (5 consecutive ages) in order to introduce the least possible noise into the projection.

[4] Duke University and Peking University;
[5] Sanford Institute for Public Policy of Duke University;
[6] Hong Kong University of Science and Technology;
[7] University of Wisconsin-White Water;
[8] A simple method for projecting or estimating α and β; an extension of the Brass Gompertz Fertility Model.

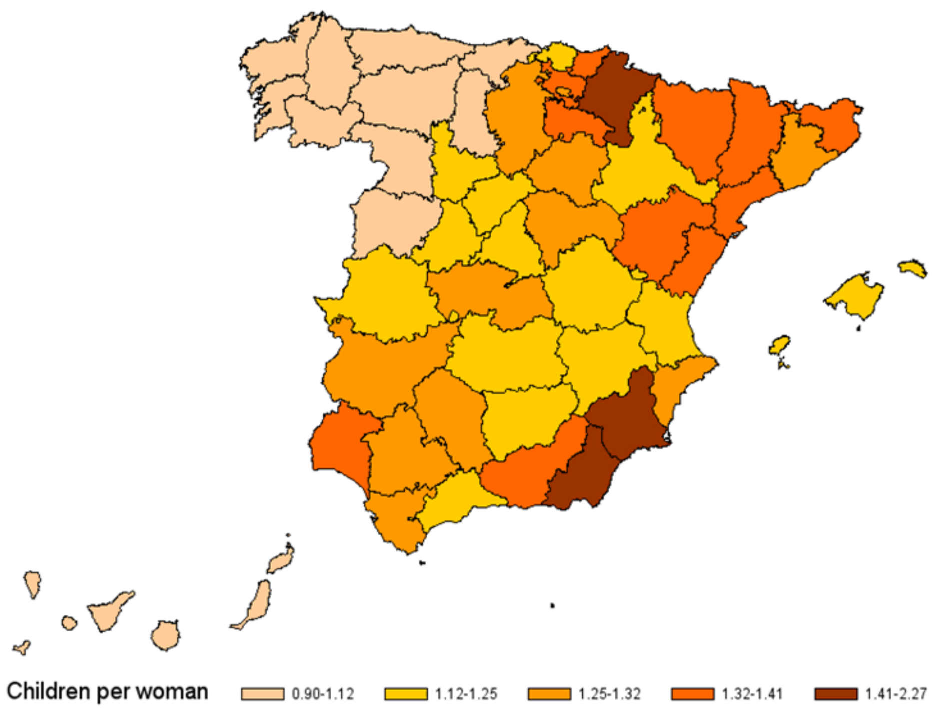
From this estimation we derive the annual growth profile for each province that is applied from the last period observed. The purpose of applying this correction factor is to enable a smoother transition between the last observed period and the first projected period.

More information on the observed values is available in Basic Demographic Indicators.

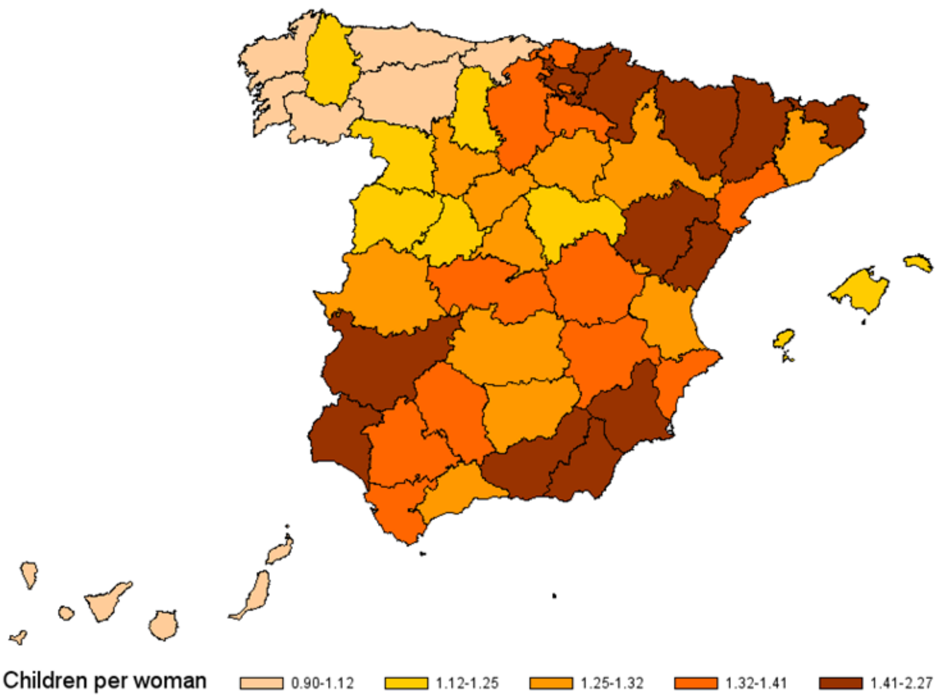
Finally, the projected fertility rates by generation, province and place of birth of the mother are derived from the semi-sum of the projected rates for the same year corresponding to the two ages that women of that generation may have met during that year.

The short-term fertility indicator and the average age at maternity projected in each province and its evolution are reflected in the following maps.

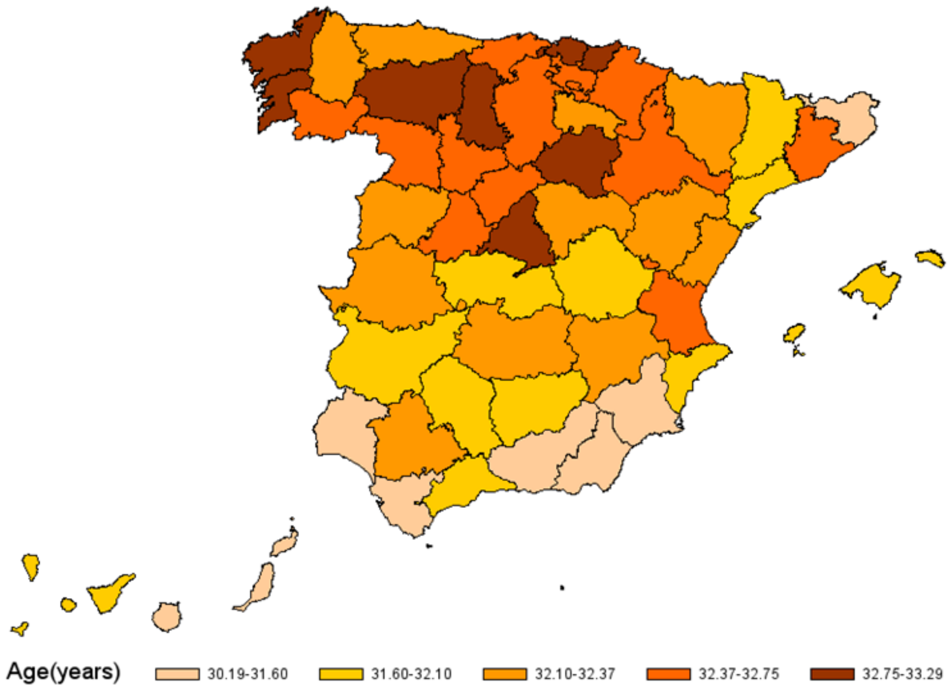
Total Fertility Rate 2020



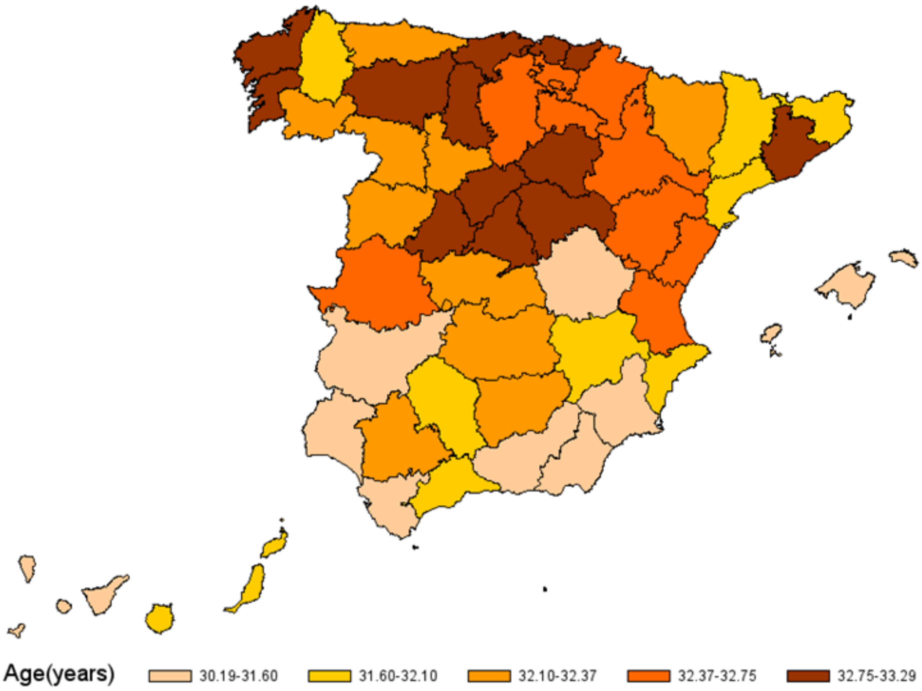
Total Fertility Rate 2034



Mean Age at Childbearing 2020



Mean Age at Childbearing 2034



4 Projection of mortality

4.1 Projection of Mortality In Spain

Although the projection hypotheses are incorporated separated by place of birth in all phenomena, in the case of mortality, the same projection parameters are used for those born in Spain and for those born abroad. This is due to the low number of deaths registered among the foreign-born population resident in Spain, which results in little or no number of deaths when disaggregating them by sex, age and province.

The situation caused by COVID-19 makes it necessary to include its effect in the 2020-2070 Population Projections. In the case of mortality, projections show that it will only be affected during 2020 and 2021, and subsequent years are projected to return to normal mortality.

For the year 2020, a now-cast estimate of deaths has been made that includes the excess mortality observed through July 1, 2020.

The estimation of deaths in the first semester was carried out following the same methodology and using the same sources as the new experimental operation "Estimate of Weekly Deaths during the COVID-19 outbreak (EoWD).

The estimation of deaths in the second semester of 2020 was carried out by taking the deaths observed during the second semester in the Death Statistics of the Natural Population Movement (NPM) from the provisional 2019 statistics.

Based on this now-cast estimate of deaths for the entire year 2020, the projected mortality table for said year is constructed following the methodology of the Mortality Tables prepared by the INE each year, with some modifications:

1. The risk of death for children under 1 year of age is estimated equal to the Infant Mortality Rate (IMR) for 2018, as -at the time of preparing these projections- this is the year for which the last definitive NPM is available. The IMR series of the definitive Basic Demographic Indicators (BDI) is quite stable. It is thus preferable that this be taken as the 2020 IMR to control the effect that an overestimation of infant mortality would have on life expectancy: it would force us to make a now-cast estimate of births this year, for which we have little information.
2. As the average number of years lived, we take the last year of life for those who die (a_x) for 2020 the series observed in the provisional mortality table of 2019.
3. And we calculate the specific mortality rates by sex and age for 2020 as the quotient between the estimated deaths and the population figures as of January 1, 2020, simulating the latter as the mid-period population.

From the Mortality Table projected for 2020, the 2020 mortality rates by generation are obtained. These constitute the input used in these population projections.

In order for the projected mortality from 2021 to correspond to a normal mortality, for the projection of the 2021-2069 period, we take as a starting point the deaths observed in the last provisional NPM of 2019. The mortality rates by generation projected for 2020 will thus be those obtained from the aforementioned now-cast estimate.

The projection methodology for the incidence of mortality in Spain is carried out from a projection based on the general level synthesised by life expectancy at birth and subsequently mortality tables are derived in accordance with these values through the use of model tables. It is carried out in the following stages[9]:

1. Life expectancy at birth is projected for each of the years of the long-term projection period 2020-2069, through a linear regression of a logistical function versus time or calendar year, to a maximum that would be reached in a theoretical future fixed at infinity, i.e., far from the horizon year. For this purpose, the Logit function recommended by the World Bank is used:

$$Logit(e_0^t) = \left(\frac{e_0^{max} - e_0^t}{e_0^t - e_0^{min}}\right)$$

2. The maximum value of life expectancy at birth, or its asymptote e_0^{max} , is chosen as the value that allows that in the last year of the long-term projective period considered, life expectancy at birth to be equal to the arithmetic mean of the answers given by the experts, in the survey carried out in May 2020, to the question of what value they considered that life expectancy at birth would reach for men and women resident in Spain, separately, within 50 years.

3. The minimum value of life expectancy at birth e_0^{min} , considered in the logit function of point 1 will be the one that provides the best adjustment when associated with the maximum value that is considered as limit.

4. The estimation by OLS of the parameters α and β of the linear model.

$$Logit(e_0^t) = \alpha + \beta \cdot t$$

Based on the evolution of the logit function of life expectancy observed since 1991, it will provide an estimate of life expectancy at birth for each of the years of the projection period, just by substituting in the following equation.

$$\widehat{e_0^t} = e_0^{min} + \frac{e_0^{max} - e_0^{min}}{1 + exp^{\widehat{Logit(e_0^t)}}}$$

5. With the objective of further fine-tuning the projection of life expectancy at birth for each year of the long-term projection period given by the logit function, a progressive distribution is made in 20 years, for women, and in 40 years, for men, of the difference obtained between the life expectancy at birth observed and estimated for the last year observed, which in this edition is 2017.

[9] Demography, analysis and projections. Julio Vinuesa. 1997. Ed. Synthesis

The following is the mortality table for each of the years of the long-term projection period 2020-2069, adapted to the level of life expectancy at birth that we have projected from the logit regression in points 4 and 5 of this section, through the use of Mortality Model Tables. It is developed in the following stages:

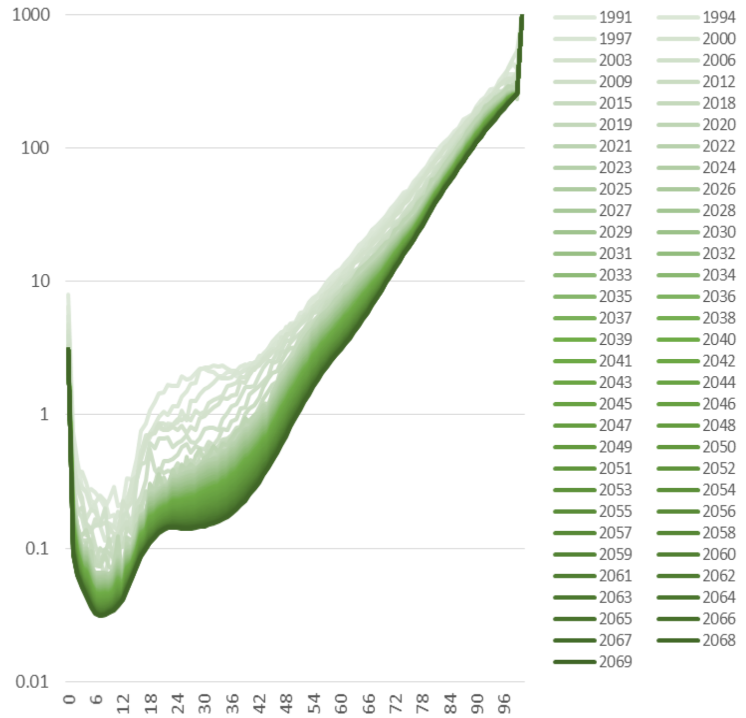
1. The series of mortality risks q_x projected for the last year of the long-term projection period, which in these population projections is 2069, will be obtained by linear interpolation between the Model Tables of Ansley *Coale* and Paul *Demeny* published by the United Nations, the East Sector for men and the West Sector for women, which determine the one-year range interval $[e_1,e_1+1]$ with e_1 being the entire part of the level of life expectancy at birth projected by the logit regression for the last year of the long-term projection period, which in this case is 2069 and has been established as the arithmetic mean of the responses given by the experts, in the survey carried out in May 2020, to the question of what value they considered that the life expectancy at birth of residents in Spain would reach within 50 years, separately for each sex.

   Similarly, we will obtain the average number of years lived in the last year of life for those who die at age x years a_x for the last year of the long-term projection period.

2. The q_x and a_x series corresponding to each of the years of the projection period are obtained by linear interpolation between the series corresponding to the last year observed, 2019 in these projections for which provisional results are available, and those projected for the last year of the long-term projection period, 2069 in these projections. In order to avoid carrying forward short-term fluctuations in mortality, we will start from the series of mortality risks (q_x) and the series of average years lived in the last year of life for those who die (a_x) corresponding to 2019, smoothed twice by a process of moving averages of order 5.

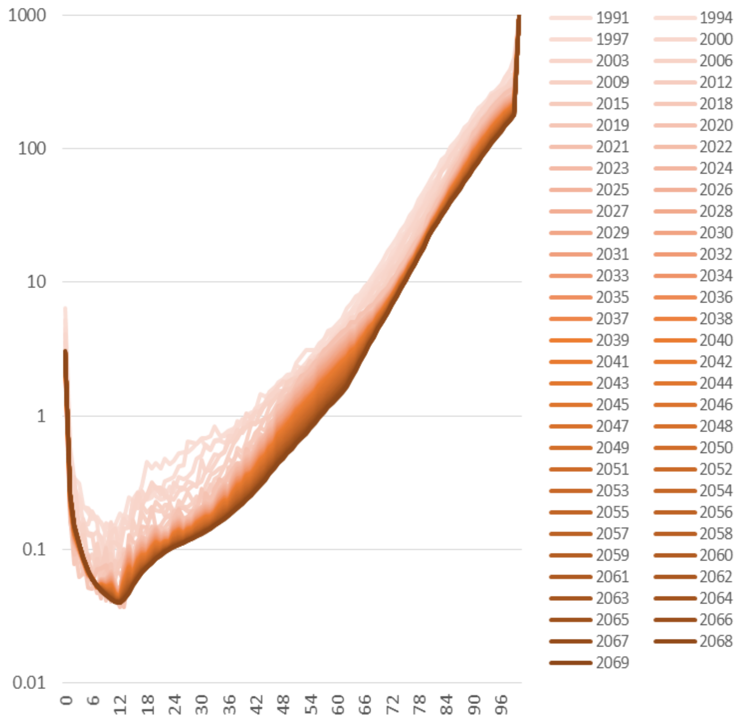
   In the following two graphs, we show the profiles of death risks by age observed and projected, for men and for women.

Evolution of mortality risks Males observed 1991-2019 and projected 2020-2069



Fuente: 1991-2019 Tablas de Mortalidad (2019 datos provisionales)

Evolution of mortality risks Females observed 1991-2019 and projected 2020-2069



Fuente: 1991-2019 Tablas de Mortalidad (2019 datos provisionales)

More information on the values observed regarding the risks of death by age is available in Mortality Tables.

3. Finally, based on the projected annual death risks qx and the average number of years lived in the last year of life for those who die ax, the remaining biometric functions are derived from a complete mortality table, one of whose parameters, the mortality rate by generation, constitutes the input used in these projections to calculate survivors by sex and age.

Thus, starting from a fictitious generation of $l_{s,0} = 100.000$ individuals, for each sex s, the following series are calculated by age x, being $x = 0,1,2,...99,100$:

- Survivors at each exact age:

$$l_{s,x+1} = (1 - q_{s,x}) \cdot l_{s,x}$$

- Deaths between each exact age x and x+1:

$$d_{s,x} = l_{s,x} - l_{s,x+1}$$

The years lived with age x or stationary population of age x:

$$\mathrm{L}_{s,x} = \mathrm{l}_{s,x+1} + \mathrm{a}_{s,x} \cdot \mathrm{d}_{s,x}$$

- Mortality rates by generation, corresponding to ages $x = 0,1,2,...100$ as at 1 January of year t+1, are calculated using the following expressions:

For x = 0,

$$m_{s,g(t)} = \frac{l_{s,0} - L_{s,0}}{\frac{l_{s,0} + L_{s,0}}{2}}$$

For $x = 1,2,...99$,

$$m_{s,g(t-x)} = \frac{L_{s,x} - L_{s,x+1}}{\frac{L_{s,x} + L_{s,x+1}}{2}}$$

For x=100+

$$m_{s,g(t-100+)} = \frac{L_{s,99}}{\frac{L_{s,99} + 2 \cdot L_{s,100+}}{2}}$$

- Time lived since age x:

$$\mathrm{T}_{s,x} = \sum_{i=x}^{100+} \mathrm{L}_{s,i}$$

- Life expectancy at each exact age x:

$$\mathrm{e}_{s,x} = \frac{\mathrm{T}_{s,x}}{\mathrm{l}_{s,x}}$$

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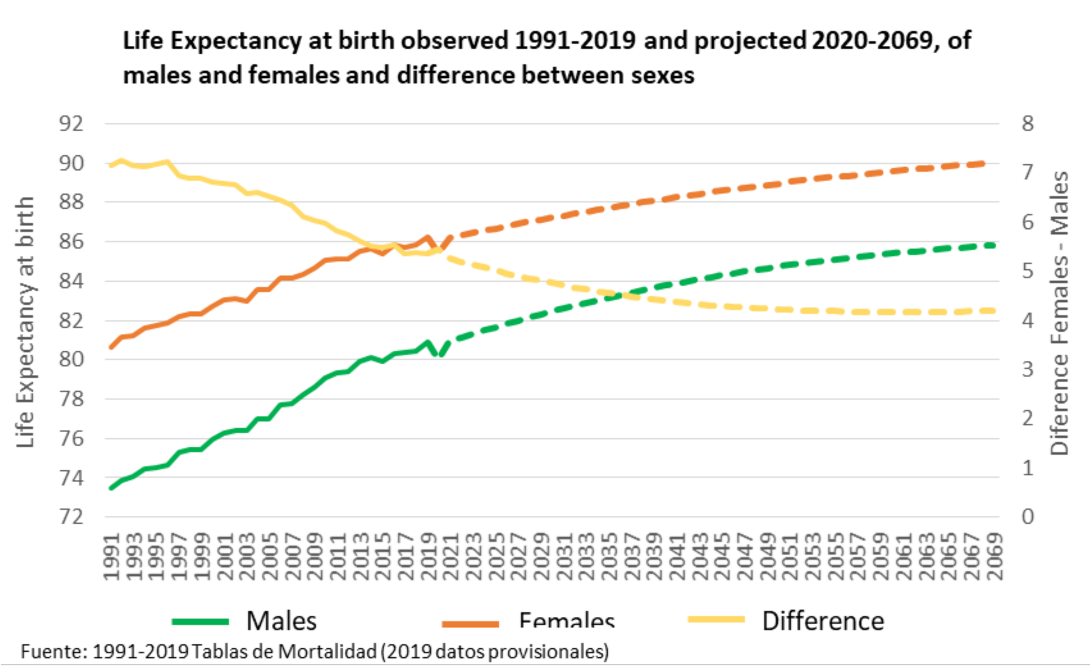
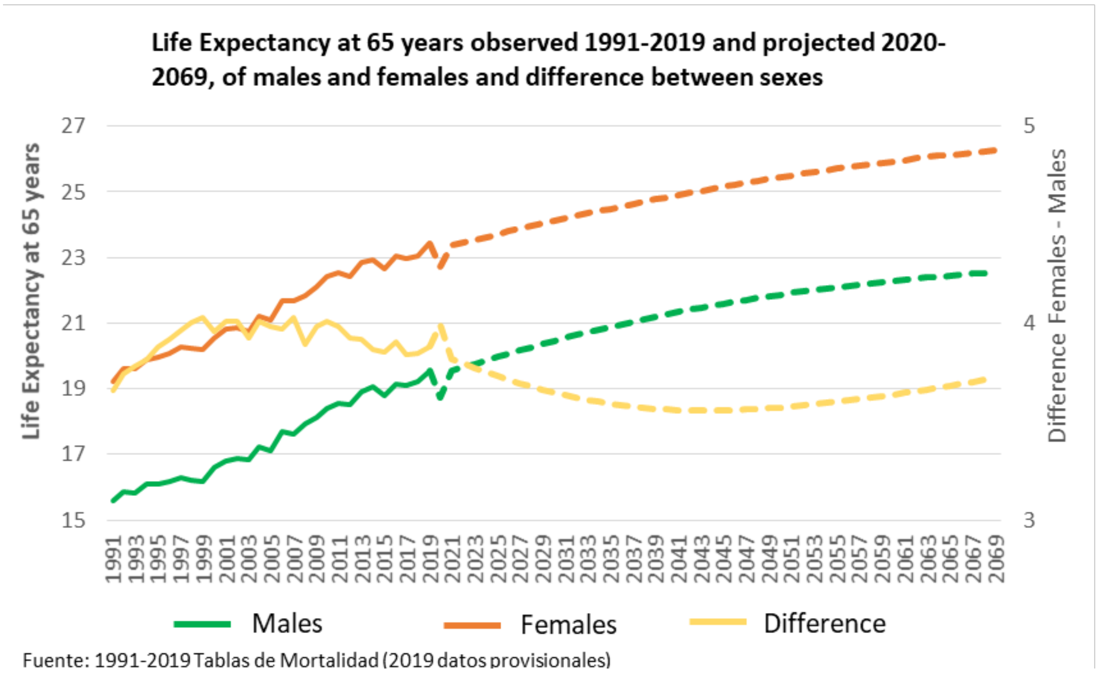
As a summary of the projection of mortality in Spain, with a time horizon of 50 years, the following graphs show the life expectancy at birth and at 65 years of age, by sex, observed and projected up to the year 2069, as well as the difference between men and women, resulting from the adjustment and extrapolation procedure used.





More information on the observed values of life expectancy by age is available in Mortality Tables .

4.2 Projection of Mortality in provinces

The projection of the incidence of mortality in the provinces for the period 2020-2034 is developed from a relational methodology following the *Brass logits*[10] method.

As with the national level, we will include COVID-19's effect on provincial mortality only during the year 2020. To do this, we will project the mortality table for each province from the now-cast estimate of deaths for that year, as explained in section 4.1 of this document.

The remaining years of the short-term projective period, 2021-2034, are projected with normal mortality and the projection procedure follows the following steps:

1. We start from the series of survivors by age x, of each sex s, of complete annual mortality tables[11] for each province and for Spain, which we denote by $l_{s,x}^{Provincia}(t)$ and $l_{s,x}^{España}(t)$ for each year t, respectively from 2010 through the 2020 now-cast estimate.

2. Applying a transformation to the function of survivors, the logits are calculated for each province and for Spain:

$$Logit\ l_{s,x}^{Provincia}(t) = \frac{1}{2}\ln\left(\frac{l_{s,0}^{Provincia}(t) - l_{s,x}^{Provincia}(t)}{l_{s,x}^{Provincia}(t)}\right)$$

$$Logit\ l_{s,x}^{España}(t) = \frac{1}{2}\ln\left(\frac{l_{s,0}^{España}(t) - l_{s,x}^{España}(t)}{l_{s,x}^{España}(t)}\right)$$

3. Next, a linear model is adjusted that relates the series of survivors of each province with that of the national total and two alpha and beta parameters:

$$Logit\ l_{s,x}^{Provincia}(t) = \alpha_s^{Provincia} + \beta_s^{Provincia} \cdot Logit\ l_{s,x}^{España}(t)$$

   In the adjustment of these models, only the values of the series ranging from 40 to 95 years old have been used (Ceuta and Melilla up to 90). The aim is for the model to gain in stability.

   The function of survivors is an unstable function in the early ages because it is exposed to strong oscillations due to the influence of rare events and random phenomena, especially in small populations such as provinces.

   As this is a growing recursive function, this instability of the survivor function is corrected as the age increases and the size of the population from which mortality intensity is calculated grows.

[10] William Brass, (1975), *Methods for estimating fertility and mortality from limited and defective data.*

[11] Source: INE, Mortality Tables.

4. Then, a logarithmic evolution of the alpha and beta parameters in each province and sex according to time is established, which is estimated by Ordinary Least Squares, which makes it possible to derive the estimate for the entire projective period. For t=2020,..,2034 we have:

$$\hat{\alpha}_s^{Provincia}(t) = \lambda_s^{Provincia} + \rho_s^{Provincia} \cdot \ln(t)$$
$$\hat{\beta}_s^{Provincia}(t) = \pi_s^{Provincia} + \vartheta_s^{Provincia} \cdot \ln(t)$$

5. The logit projected for each province, sex and age are calculated from the estimation of alpha and beta obtained in the previous point and from the logit of the survivors by sex and age projected for the national total for each year of the short-term projection period and as explained in section 4.1 of this document:

$$Logit\ \hat{l}_{s,x}^{Provincia}(t) = \hat{\alpha}_s^{Provincia} + \hat{\beta}_s^{Provincia} \cdot Logit\ \hat{l}_{s,x}^{España}(t)$$

6. We reconstruct the mortality tables projected by sex, age and province for each year t of the 2020-2034 projection period from the expression:

$$\hat{l}_{s,x}^{Provincia}(t) = \frac{l_0}{1 + e^{2 \cdot Logit\ \hat{l}_{s,x}^{Provincia}(t)}}$$

   which provides the series of survivors by age x, $\hat{l}_{s,x}^{Provincia}(t)$, for each sex and province, from which the rest of the biometric functions of the mortality tables are derived. Thus, the following series are calculated:

   - The series of deaths by age of the mortality table:

$$d_{s,x} = l_{s,x} - l_{s,x+1}$$

   - The series of probabilities of death by age is deduced by the expression:

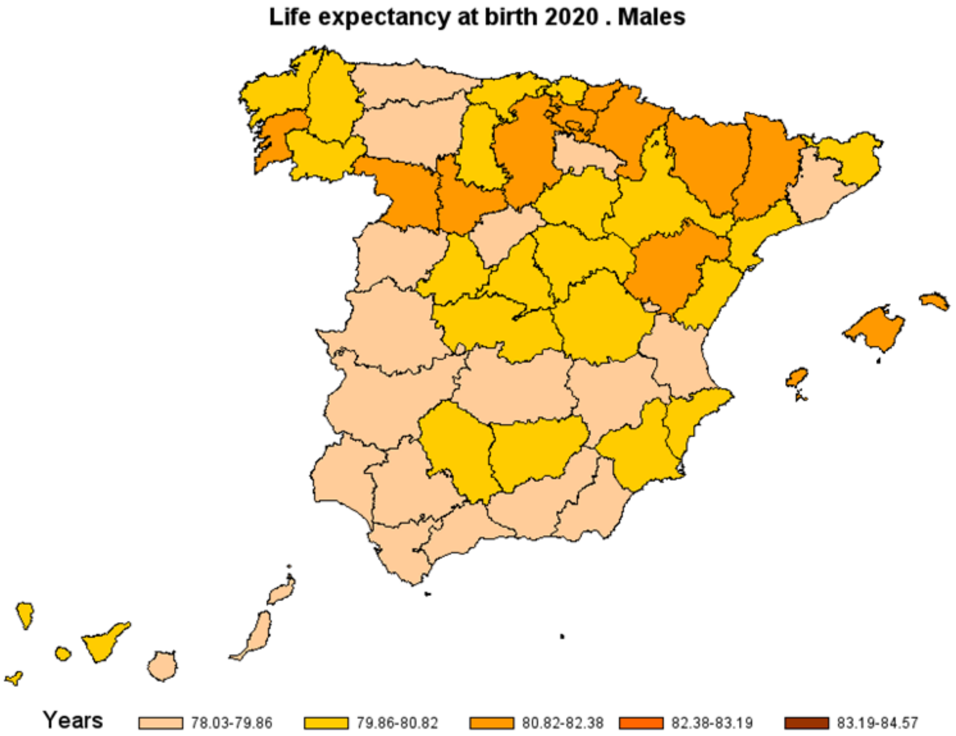
$$q_{s,x} = \frac{d_{s,x}}{l_{s,x}}$$

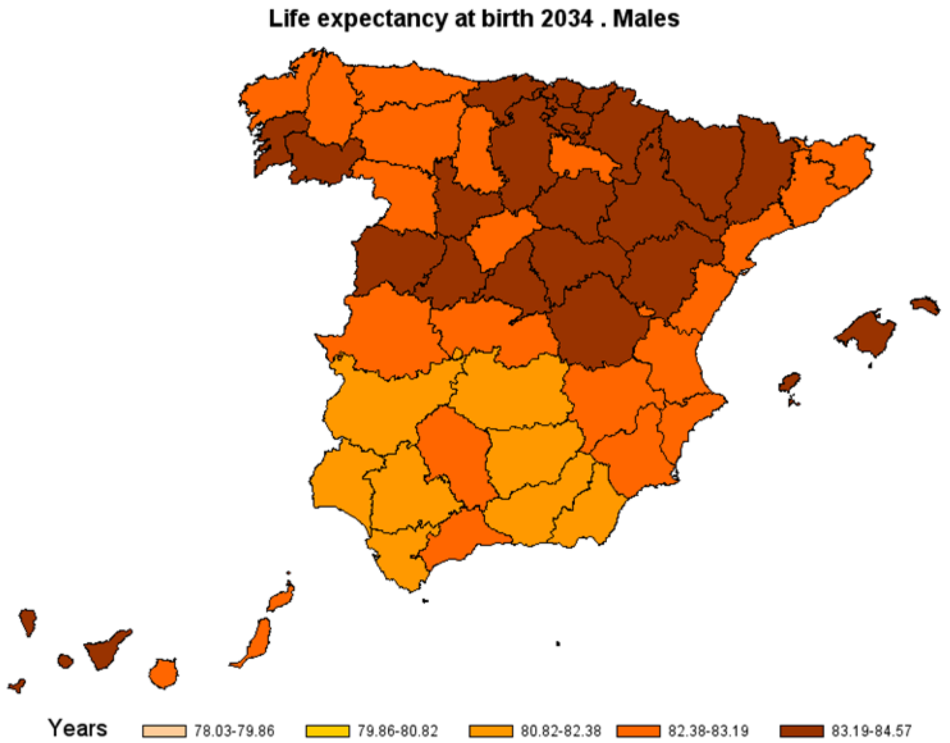
   - With the same expressions used for the mortality tables of Spain, the remaining series are calculated: years lived with age x or *stationary population of age* x, mortality rates by generation, and life expectancy.

Finally, the 2020 projected mortality table for each province is replaced by that of the now-cast estimate for that year, which has been carried out as explained in section 4.1 of this document.

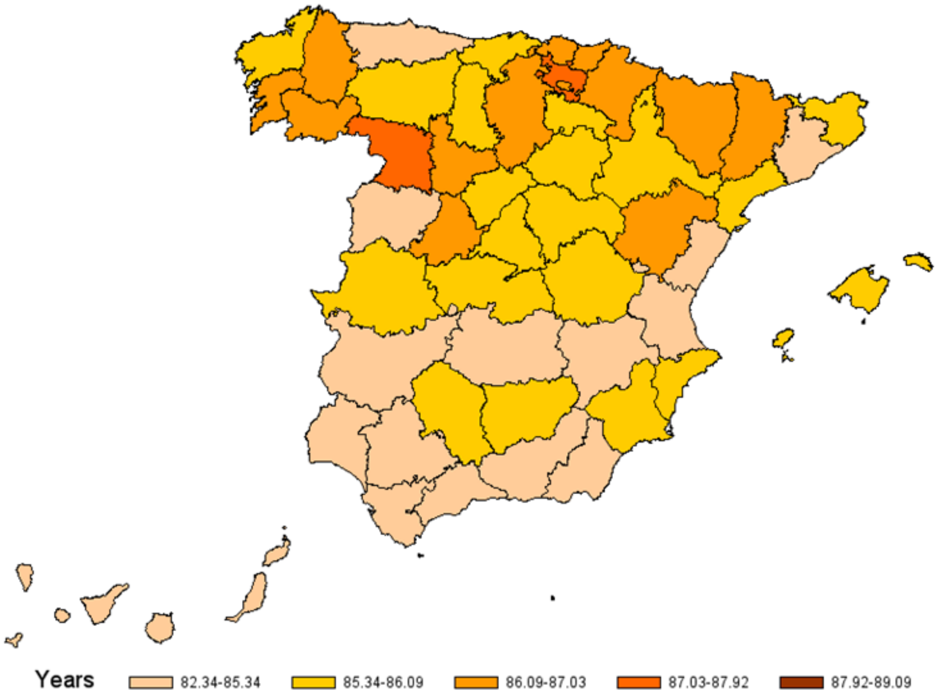
More information on the observed values is available in Basic Demographic Indicators and Mortality Tables.

The projected life expectancy at birth in each province and sex and its evolution is reflected in the maps below.

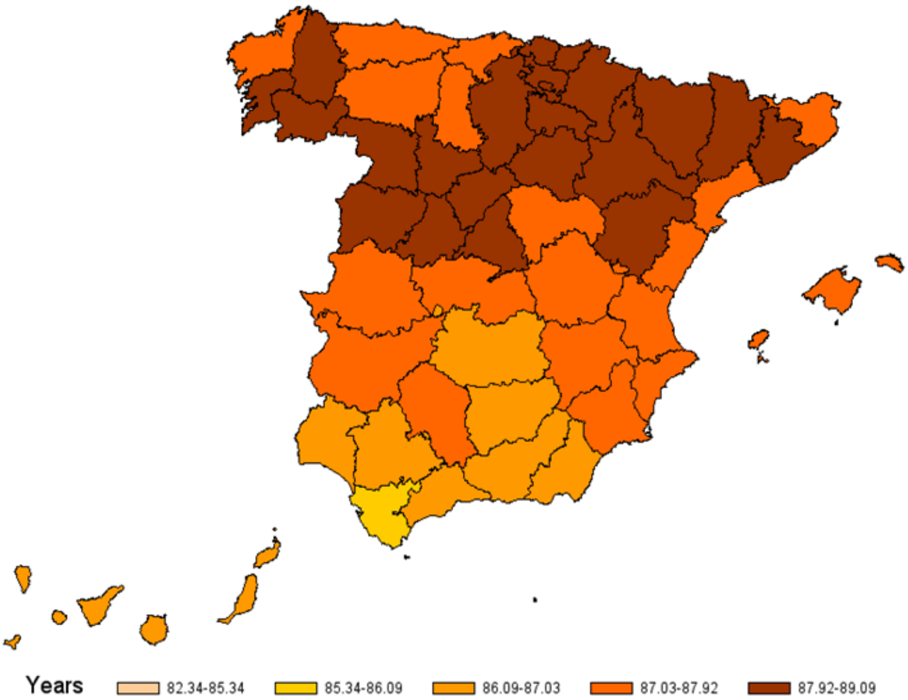

Life expectancy at birth 2020 . Males
Years
78.03-79.86
79.86-80.82
80.82-82.38
82.38-83.19
83.19-84.57


Life expectancy at birth 2034 . Males
Years
78.03-79.86
79.86-80.82
80.82-82.38
82.38-83.19
83.19-84.57

Life expectancy at birth 2020 . Females

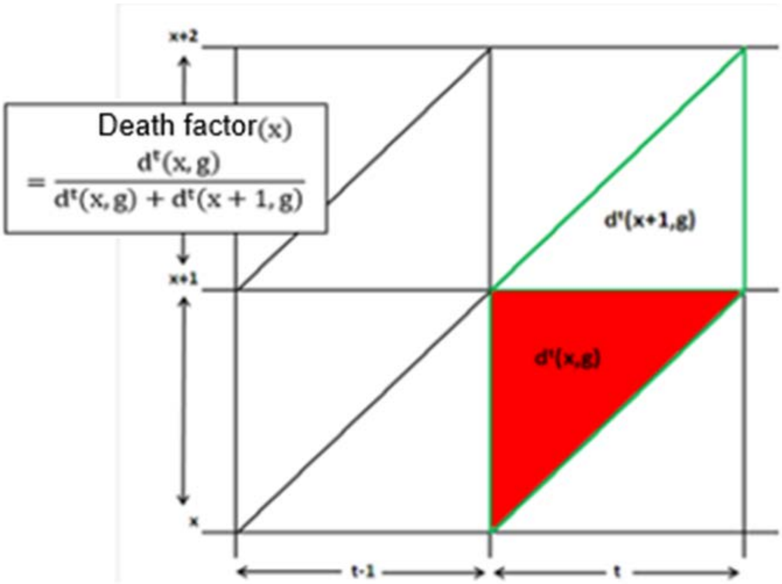


Life expectancy at birth 2034 . Females

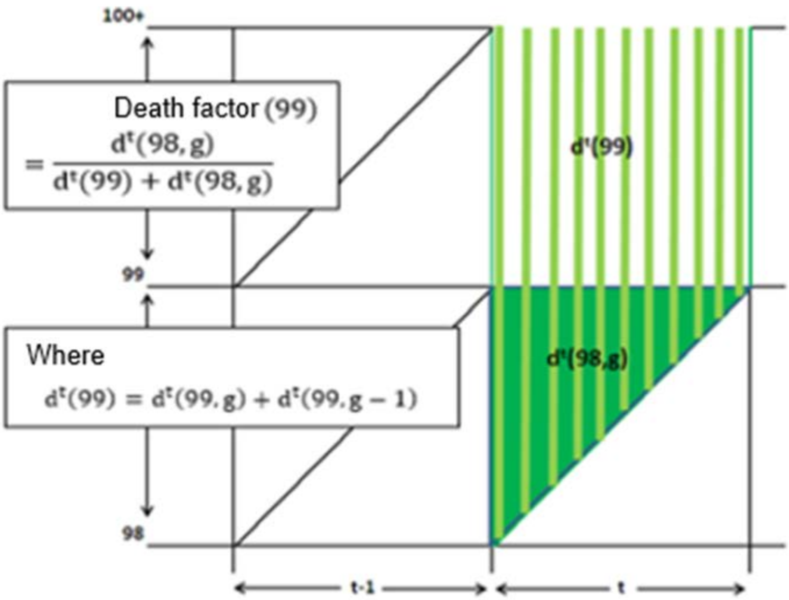


In order to disaggregate the projected death figures by sex and age, a death factor is applied that determines how the deaths of a generation are distributed between the two ages that constitute it.

We call the death factor the quotient whose numerator is constituted by the deaths of the bottom triangle of the parallelogram of the generation in question in year t, $d^t(x,g)$ and the denominator is constituted by the deaths of the parallelogram of the generation in question in year t, $(d^t(x,g)+ d^t(x+1,g))$, for all ages of x=1, ...,98.



At age x=0 there is only one generation so the distribution factor at that age will be identically 1 and for the open group of 100 years and over the distribution factor is referenced to age x=99 so in this case the denominator must also include the deaths of individuals of 99 years of the other generation (g-1).



This distribution factor is extrapolated to the future from the logarithmic evolution over time of its annual values observed in the last 10 years for which results are available from the Vital Statistics on Deaths, that is, from the 2010-2019 period, at the time of establishing the present projections. That is,

$$Fd_{s,x}^{t} = \alpha_{s,x} + \beta_{s,x} \cdot ln\Big(t - (aa1 - 1)\Big) \qquad \forall t = aa1, \dots, aa10$$

where $aa1 = 2010, \dots, aa10 = 2019$

The parameters $\alpha_{s,x}$ and $\beta_{s,x}$ are estimated by Ordinary Least Squares and the death distribution factor projected for all the years of the projection period, $\widehat{Fd}_{x,s}^{t}$, is obtained by simply replacing in the estimated regression line.

$$\widehat{Fd}_{s,x}^{t} = \hat{\alpha}_{s,x} + \hat{\beta}_{s,x} \cdot ln\Big(t - (aa1 - 1)\Big) \qquad \forall t > aa10$$

5 Projection of international migration

5.1 Projection of international migration

In the analysis and formulation of the hypotheses of international immigration, a distinction has been made between the inflows of people born in Spain and abroad, as is advised by the fact that these are migrations of a very different nature and dynamic.

International immigration is introduced into the projection process through the projected flows for each year of the projection period by sex, generation, place of birth and, for the first 15 years, also by province.

Firstly, a global immigration intensity is established for each year of the projection period, distinguishing between those born in Spain and those born abroad. These flows are in turn distributed by sex, generation and, where appropriate, by province, with average distributions starting from those corresponding to the last five years (2015-2019) of the Migration Statistics, in order to avoid the inherent variability of a greater level of detail for a lower set of data. These projected distributions remain constant throughout the projection.

Thus, the projection of the international immigration flow by place of birth, broken down by sex and generation, which would reach Spain in the next 50 years and their respective provinces in the next 15 years, is carried out through the following steps:

1. Projection of annual flows of international immigration for each place of birth (Spain and outside Spain):

In the previous edition, a now-cast or current year estimate was made for the first year of the projection, and the next three years were obtained by extrapolating the trend of the previous years.

However, border closing related to the COVID-19 pandemic produced a drastic reduction in migratory flows, and due to the subsequent economic crisis, they are not expected to recover quickly. This also introduces great uncertainty about short-term migrations. The extrapolation of recent trends thus does not make sense for this edition, and this component has therefore been eliminated.

As such, different projected values have been established for each year, and the projective period was divided into several sections:

Period 1 (2020-2021): now-cast or current year estimation for the year 2020 and projection for 2021.

In order to obtain the estimate for the first year of the projection, 2020, the Migrations Statistics methodology was applied and an estimate of the international immigration flow for the first half of 2020 was obtained with the information available at the time of the estimation (June 2020), distinguishing between those born in Spain and those born abroad.

Due to COVID-19's impact on migratory flows and the increased uncertainty, the flows for the second half of 2020 were established as null. The entire year 2020 was thus estimated through the data recorded for the first half of the year. By applying the same criteria to emigration, a zero migratory balance can be estimated for the second semester.

As such, the year 2021 was estimated with the same values as the year 2020.

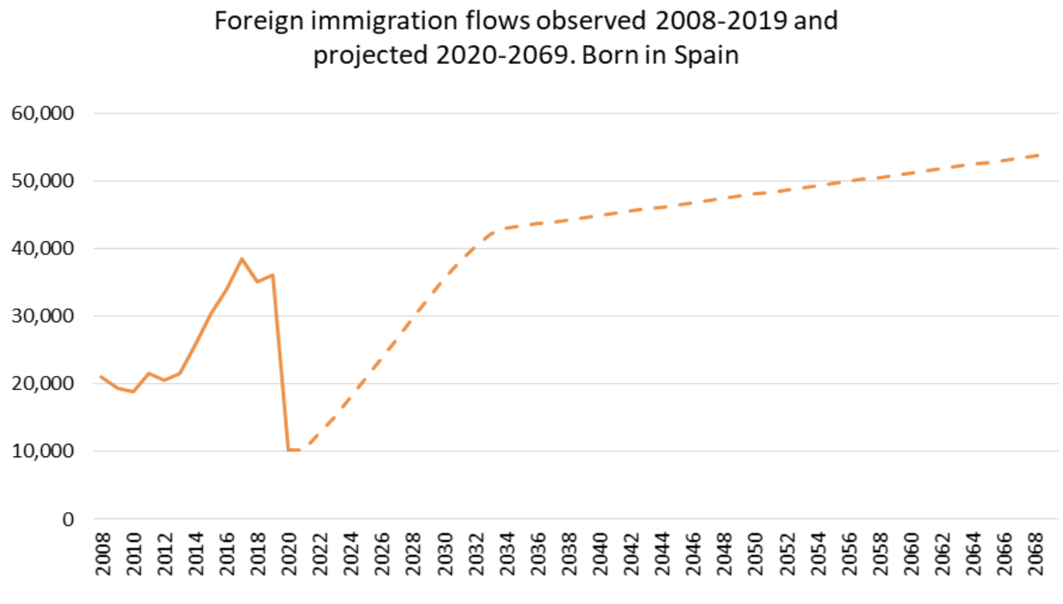
Using these hypotheses, the estimated values for 2020 and 2021 were obtained: 10,152 immigrations of persons born in Spain and 235,067 immigrations of persons born abroad, giving a total of 245,219 total immigrations from abroad.

Period 2 (2022-2034): linear interpolation between the value obtained for 2021 and the value assigned for the year 2034 according to the survey of the experts, obtained as the arithmetic mean of the responses.

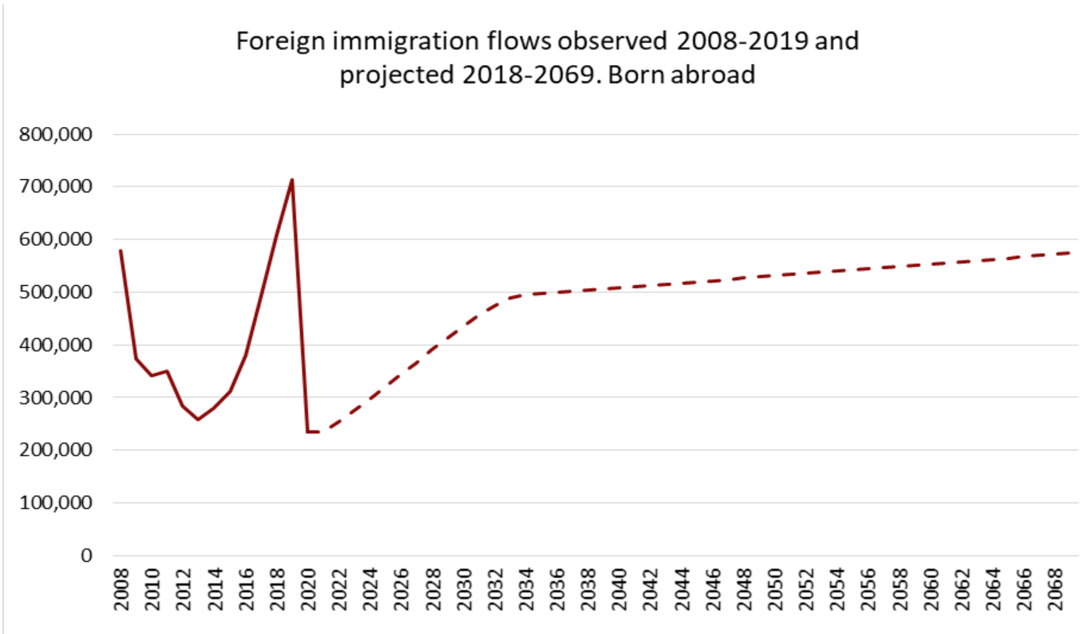
Period 3 (2035-2069): linear interpolation between the values assigned for the years 2034 and 2069 according to the survey of the experts, obtained as the arithmetic mean of the answers.

Finally, values for the year 2034 have been smoothed so that the transition between the second and third periods is more gradual.

The immigration flows thus projected can be seen in the following graph:



Fuente: 2008-2019 Estadística de Migraciones (2019 datos provisionales)



Fuente: 2008-2019 Estadística de Migraciones (2019 datos provisionales)

2. Distribution by sex:

The total immigration flows of each place of birth are distributed by sex according to the average of the proportions by sex for each place of birth observed in the last five years of the Migration Statistics, taking into account the stability observed in said distribution. These distributions remain constant throughout the projection period, and are 53.0% of men for immigrations of persons born in Spain and 49.2% of men for immigrations of persons born abroad.

3. Distribution by generations[12]:

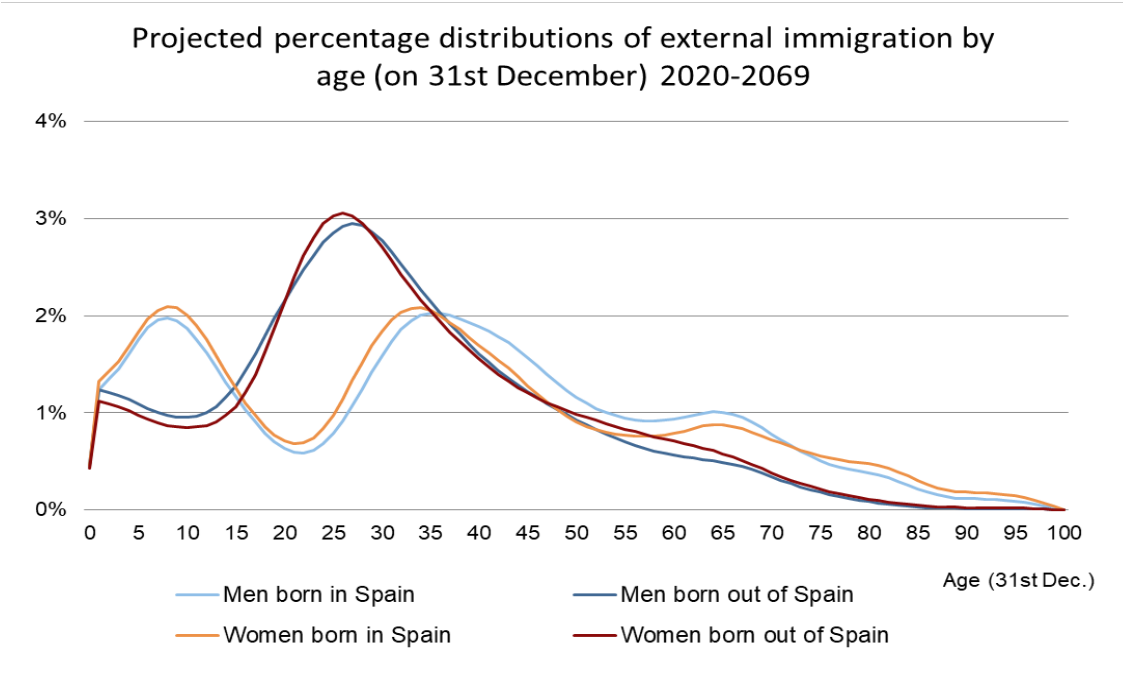
The international immigration flow from Spain for each place of birth and sex projected is distributed by generations applying a profile by constant generation throughout the projection period, and is obtained as follows:

We start from the structures by generations of the immigrations of the last five years of the Migrations Statistics and obtain the average structure. A transformation is applied to this structure to obviate the extreme variability presented by the data at the most advanced ages. The proportion of people aged 85 and over is thus distributed by simple ages constantly from 85 to 95 years old, and it thereafter decreases until reaching zero for the open group 100 years and above group.

Subsequently, the resulting structure undergoes a smoothing procedure that extends over the entire range of generations consisting of a triple process of moving averages of five consecutive generations, with the aim of avoiding possible random or circumstantial behaviours.

[12]In order for the generational rage to be the same for each year of the projective period, the one-to-one transformation is usually applied between generation and age on December 31. This means that the two are spoken of indistinctly throughout the document.

The profiles by generation (or age as at 31 December) resulting from such procedures, which will be applied to the total international immigration flow for each place of birth and sex, are shown in the following graph:



More information on the projected values is available in Population Projections 2018-2068.

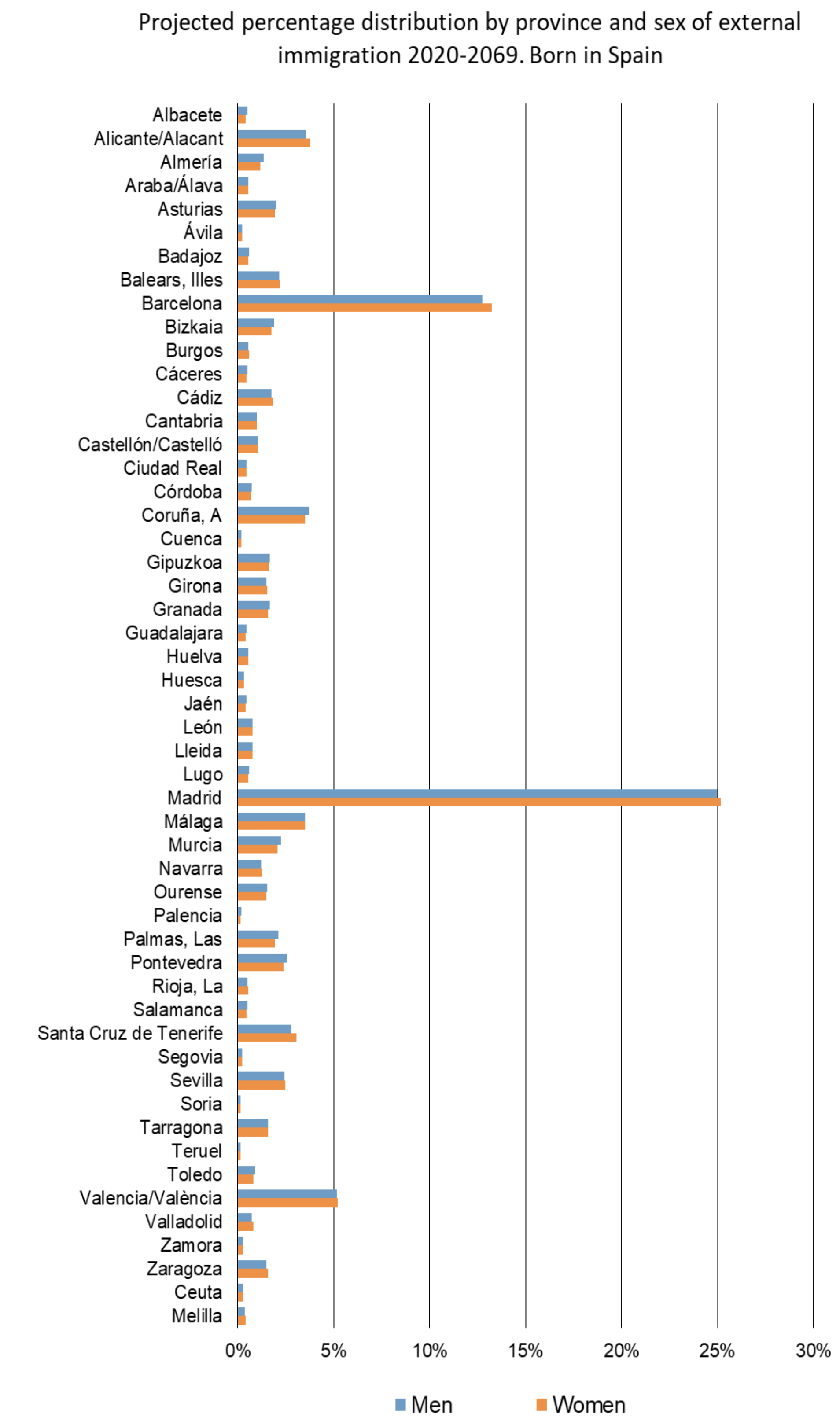
4. Distribution by provinces:

The international immigration flows from Spain for each projected place of birth, sex and generation are distributed by province, for the first 15 years of the projection, applying a provincial distribution coefficient that is constant throughout the projection period, and is obtained as follows:

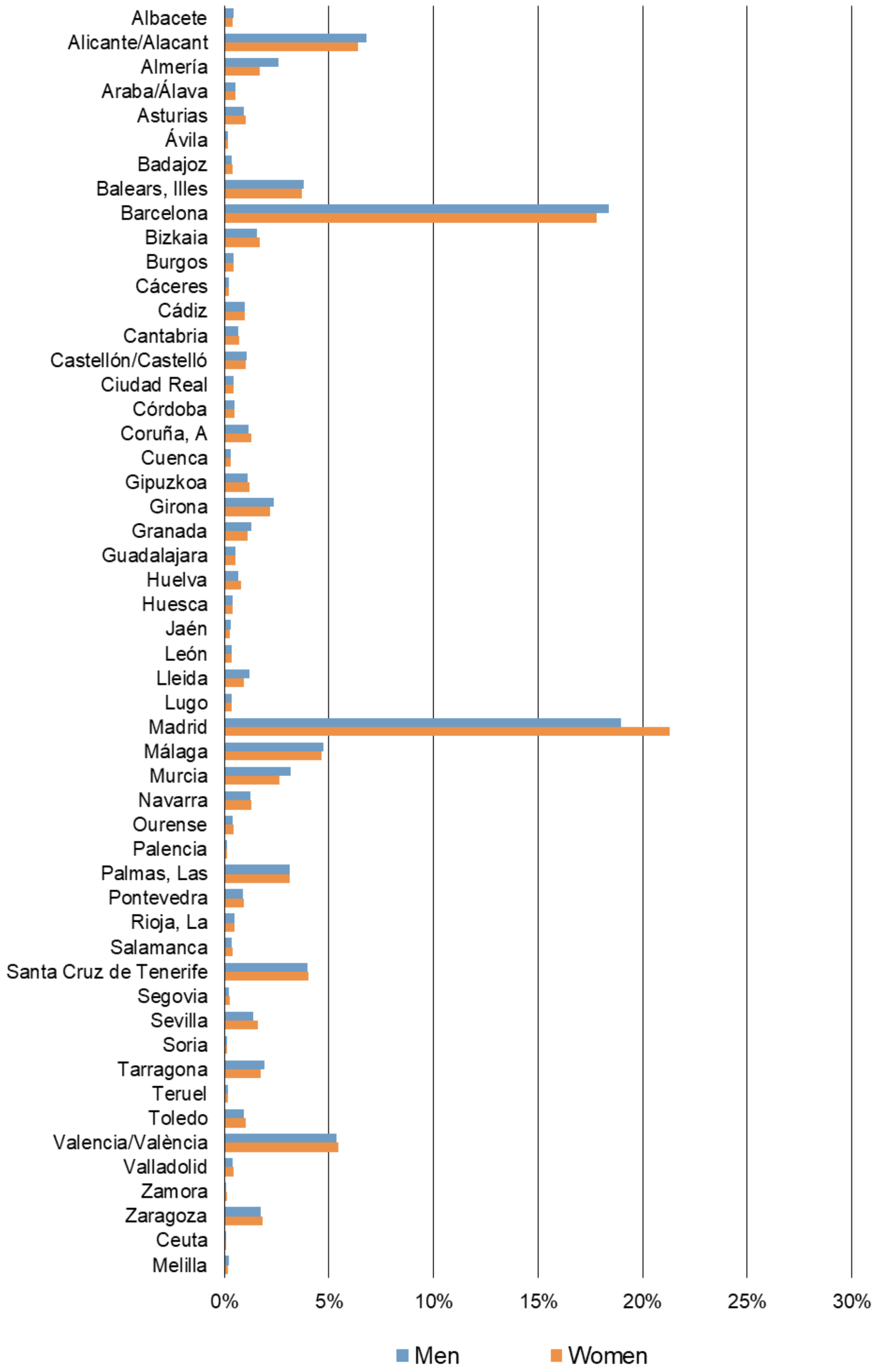
For each year of the last five of the Migrations Statistics, we obtain, on the one hand, the immigration flows by place of birth, sex and generation and, on the other hand, the same flows but also broken down by province. Both collections of flows are subjected to the same process that was applied to the structures by cohort in the previous step: constant transformation of the corresponding generations between 85 and 95 years as of December 31, and decreasing for the last 5 ages. Smoothing is then applied using the triple five-element moving average process.

After processing these flows, the distribution coefficient is obtained for each year, by means of the quotient between the flow by province for a determined place of birth, sex and cohort, and the same flow for the national total. The projected provincial distribution coefficient will be the average of the distribution coefficients of the last five years of the Migration Statistics.

Indirectly, through these flows already disaggregated by all variables, we obtain the following provincial distribution of the projected international immigration flows which, due to the way in which the distribution by the different variables is constructed, will be constant for the entire projection period:



Projected percentage distribution by province and sex of external immigration 2020-2069. Born out of Spain



5.2 Projection of international migration

The simulation of the future behaviour of international emigration in Spain has been carried out differentiating between emigration of persons born in Spain and those born outside Spain, as they are groups with different behaviours.

In the process of population projection, international emigration takes the form of emigration rates by generation for each sex and place of birth for each year of the projection period and, in addition, for the years in which the population is projected at the provincial level, the rates by generation for each sex, place of birth and province are also necessary for each year of the projection period.

First, we will take into account that any type of rate by generation can be broken down into the product of several factors. For example, for each place of birth *n*, the international emigration rates by generation *x* for each sex *s* of a year *t* can be expressed as:

$$e^t_{s,n,x} = ISE^t_{s,n} \cdot c^t_{s,n,x}$$

where:

$ISE^t_{s,n} = \sum_x e^t_{s,n,x}$ is the Synthetic Index of International Emigration for each year *t*, place of birth *n* and sex *s*

$c^t_{s,n,x} = \frac{e^t_{s,n,x}}{\sum_x e^t_{s,n,x}}$ is the calendar by generation *x* for each year *t*, place of birth *n* and sex *s*

Provincial emigration rates, in turn, are obtained as the product of three factors: the intensity of emigration for the year (measured through the synthetic index) for each place of birth and sex, a provincial differential and a distribution by generations of said intensity (calendar by generation) in each province, also obtained on the basis of data from the last five years of the Migrations Statistics. In this way, in order to project emigration rates, whether national or provincial, we can do so by projecting each of its components.

However, given that the approach to emigration intensity via synthetic indices (sum of rates) is not very intuitive, this hypothesis has been established through flows, in a similar way to immigration, in order to also be able to include the opinions of the experts gathered by the survey.

Instead of the Synthetic Index of Emigration by place of birth and sex, global emigration flows are established for each year of the projection period, distinguishing between those born in Spain and abroad. These flows will be distributed by sex from the last five years (2015-2019) of the Migration Statistics. The distribution by generations of this intensity (calendar by generation) will also be obtained from the data of the last five years of the Migrations Statistics, in order to avoid the variability inherent in a greater level of detail.

Finally, the projected emigration flows abroad and the emigration calendar will undergo an iterative process in the execution of the projective exercise at the national level that allows deriving, from a starting solution, a Synthetic Emigration Index for each year of the projection period consistent with the projected flows and calendars, and thus obtaining the emigration rates necessary for the calculation of the projection.

In more detail, the process for projecting the various components is as follows:

1. Projection of annual flows of international emigration for each place of birth (Spain and outside Spain):

In previous editions, a constant Synthetic Index of International Emigration was maintained for the entire projection period. However, this time the emigration hypothesis has been established in terms of flows, and it has been projected in a variable way for each year of the projection throughout the projection period, according to the following process:

First, three curves are drawn, one for each of the following periods:

As with the projection of foreign immigration, the trend component for the first years has been eliminated. The procedure is analogous to immigration, with the projective period divided into several sections:

<u>Period 1 (2020-2021)</u>: now-cast or current year estimation for the year 2020 and projection for 2021.

In order to obtain the estimate for the first year of the projection, 2020, distinguishing between those born in Spain and those born abroad, the Migrations Statistics methodology was applied and an estimate of the flow of international emigration for the first half of 2020 was obtained with the information available at the time of the estimation (June 2020).

Due to COVID-19's impact on migratory flows and the increased uncertainty, the flows for the second half of 2020 were established as null. The entire year 2020 was thus estimated through the data recorded for the first half of the year. By applying the same criteria to immigration, it is thus possible to estimate a zero migratory balance for the second semester.

As such, the year 2021 was estimated with the same values as the year 2020.

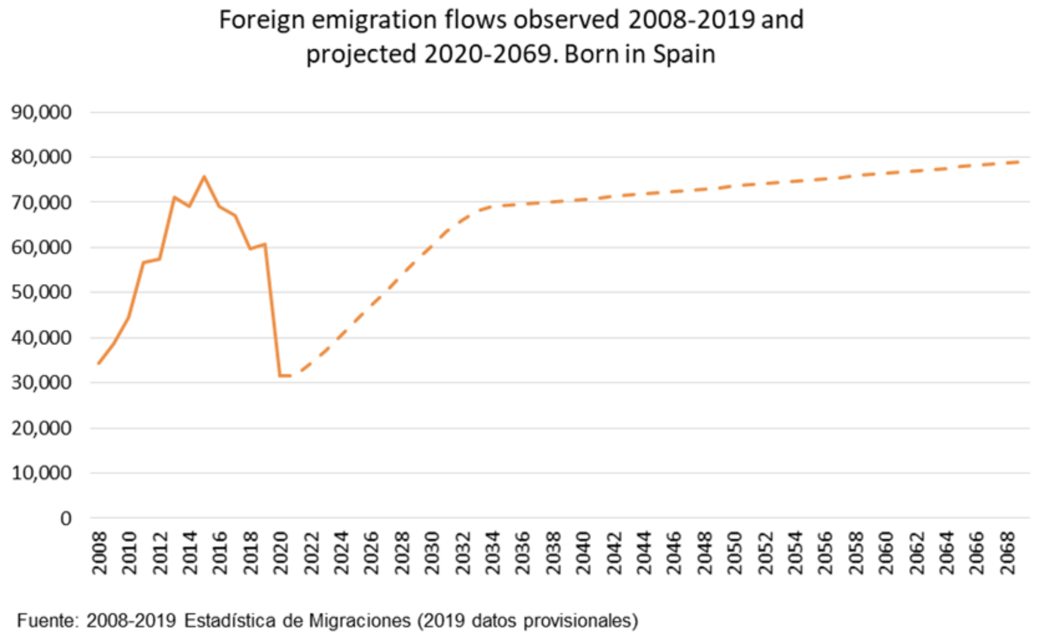
Using these hypotheses, the estimated values for 2020 and 2021 were obtained: 31,483 emigrations of persons born in Spain and 104,165 emigrations of persons born abroad, giving a total of 135,648 total emigrations from abroad.

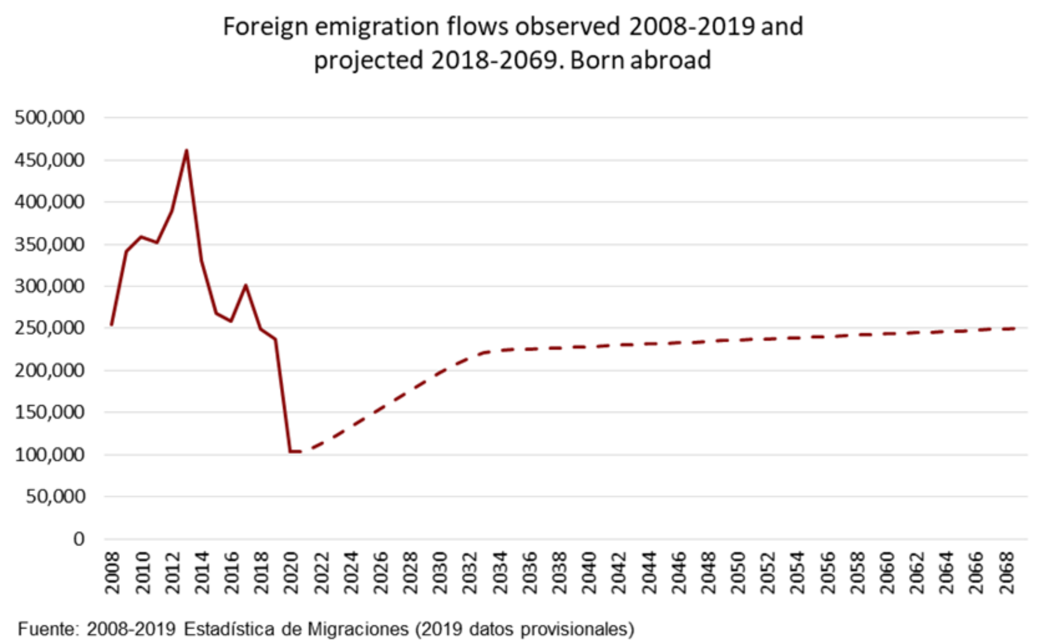
<u>Period 2 (2022-2034)</u>: linear interpolation between the value obtained for 2021 and the value assigned for the year 2034 according to the survey of the experts, obtained as the arithmetic mean of the responses.

<u>Period 3 (2033-2069)</u>: linear interpolation between the values assigned for the years 2034 and 2069 according to the survey of the experts, obtained as the arithmetic mean of the answers.

Finally, in order for the transition between the curves of the different periods to be smooth, the values projected around the years in which the curves change are a combination of the adjacent curves, where the curve on the left loses weight over the years and gradually gives priority to the curve on the right.

The emigration flows thus projected can be seen in the following graph:





2. Distribution by sex:

The total emigration flows of each place of birth are distributed by sex according to the average of the proportions by sex for each place of birth observed in the last five years of the Migration Statistics, taking into account the stability observed in said distribution. These distributions remain constant throughout the projection period, and are 53.0% of men for emigrations of persons born in Spain and 54.9% of men for emigrations of persons born abroad.

3. Provincial differential:

For the first 15 years, a provincial differential of the intensity of emigration abroad is projected for each sex and place of birth, which remains constant in each year of the projection period. It is obtained from the international emigration flows of the last years (2015-2019) of the Migrations Statistics, taking into account the stability in time that this indicator also presents..

Based on the specific international emigration rates[13] by generation for each sex and place of birth of each province and of the national total, for each year of the 2015-2019 period, we have calculated the Synthetic Emigration Indices by sex *s* and place of birth *n* of each province *h* ($ISE^t_{s,n,h}$) and of the national total ($ISE^t_{s,n}$), adding their corresponding rates by generation. From these Synthetic Emigration Indices we obtain the provincial differential for each year *t*, sex *s*, place of birth *n* and province *h* as the quotient:

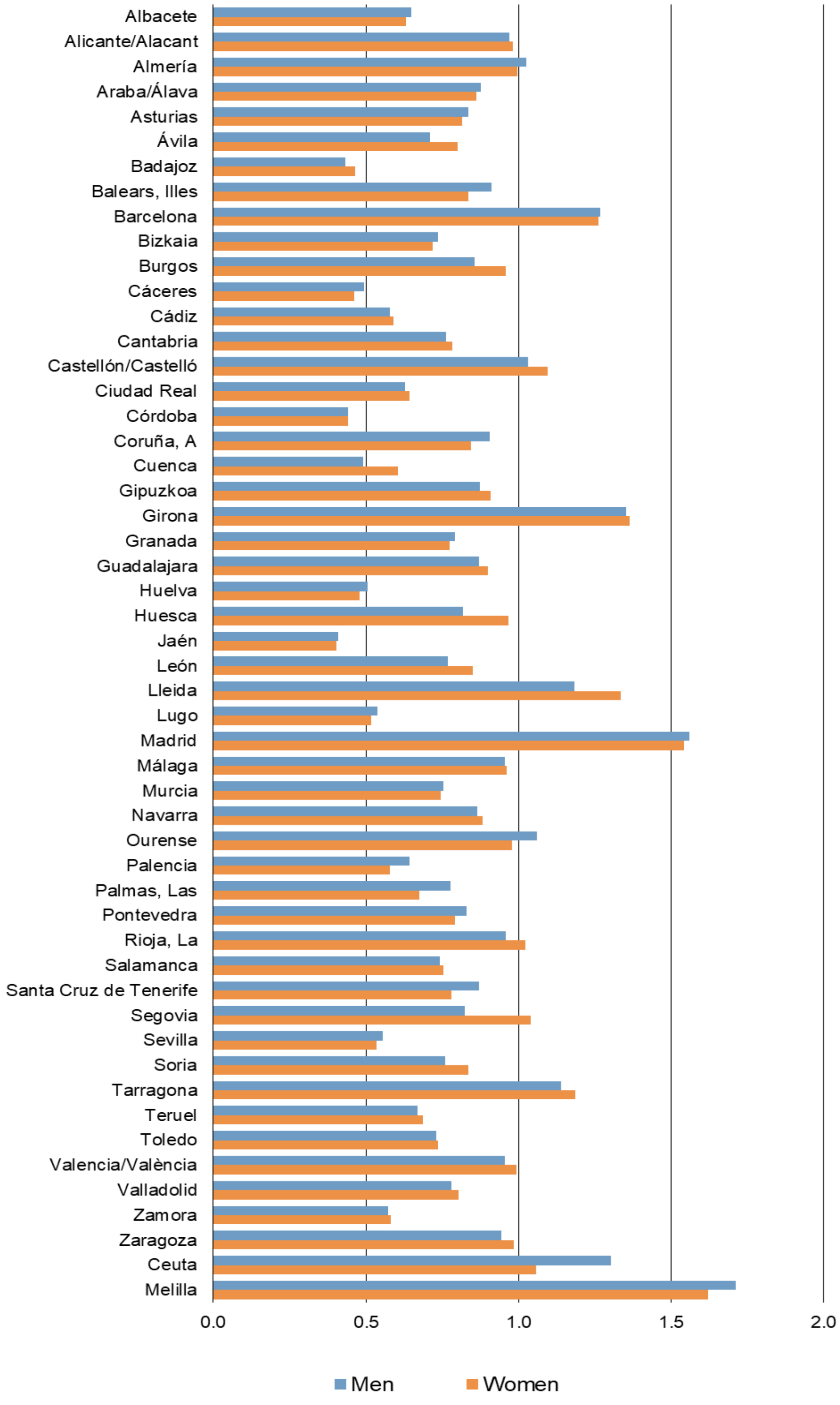
$$DE^t_{s,n,h} = \frac{ISE^t_{s,n,h}}{ISE^t_{s,n}}$$

Finally, the projected provincial differential will be the average of the differentials of the last five years (2015-2019) obtained from the Migration Statistics, for each sex and place of birth. These differentials can be seen in the following graphs:

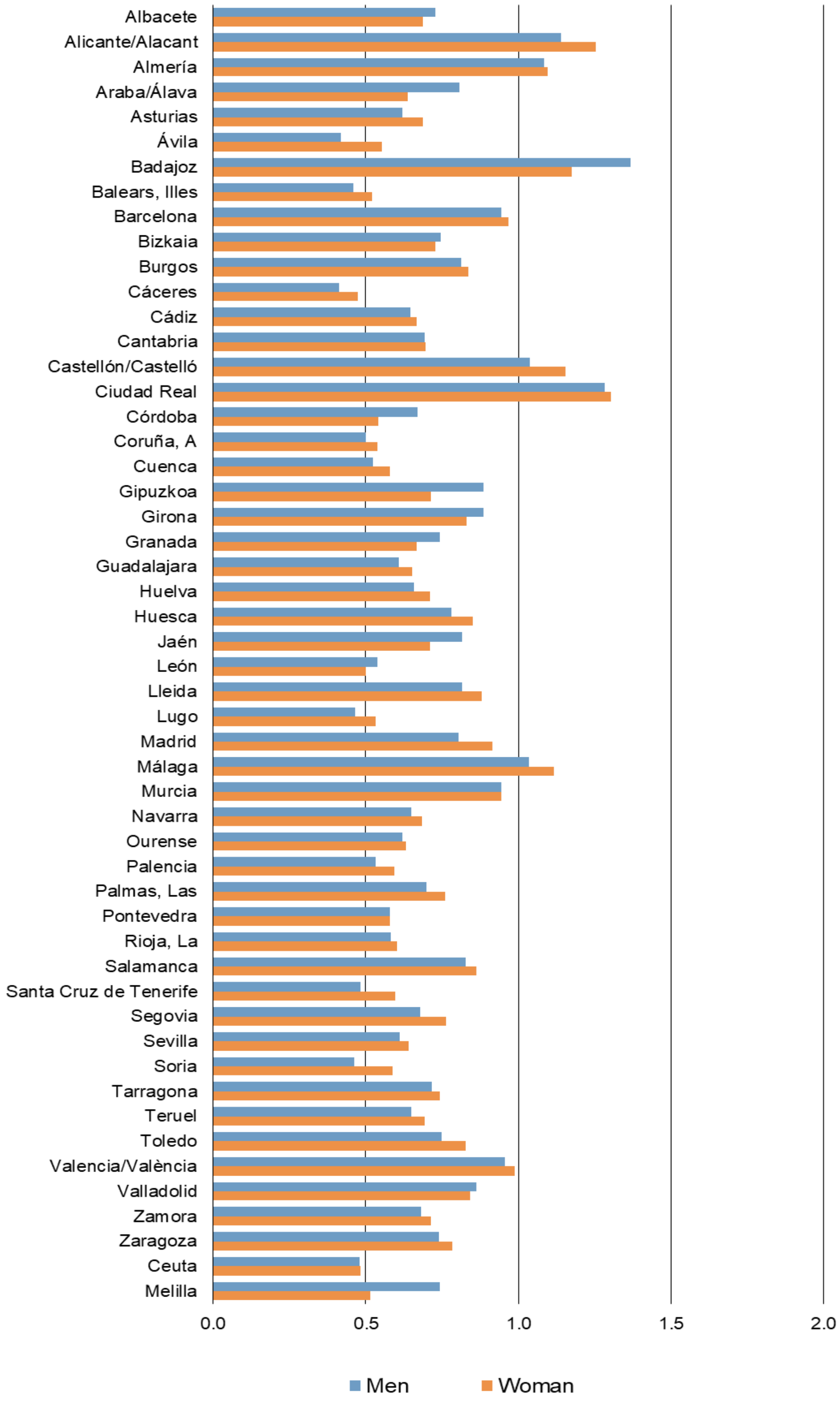
INE. National Statistics Institute

[13] The international emigration rates for a specific population group are obtained as the quotient of the corresponding international emigration flows collected in the Migrations Statistics (provisional data for 2019) among the population resident in Spain as at 1 July of that year for said group according to the *Population Figures* (provisional figures for 2019).

Projected differential intensity of external emigration by province and sex 2020-2069. Born in Spain



Projected differential intensity of external emigration by province and sex 2020-2069. Born out of Spain



INE. National Statistics Institute

4. Calendar by generation:

The emigration calendar by generation or year of birth for each sex and place of birth is projected from the international emigration flows of the last few years (2015-2019) of the Migration Statistics, and will remain constant for each year of the projection period, taking into account its observed stability in recent years. It has been derived in the following steps:

1) Obtaining of the specific rates of emigration abroad[14] by generation *x*, for each sex *s* and place of birth *n* for each year t in the period 2015-2019, $e_{s,n,x}^{t}$.

2) On the basis of the previous rates, we obtain the calendar by generation of international emigration for each sex and place of birth of each year, dividing each specific rate by generation of that year by the sum of all of them, that is, by the Synthetic Index of International Emigration of each year for each sex and place of birth:

$$c_{s,n,x}^{t} = \frac{e_{s,n,x}^{t}}{\sum_{x} e_{s,n,x}^{t}} = \frac{e_{s,n,x}^{t}}{ISE_{s,n}^{t}}$$

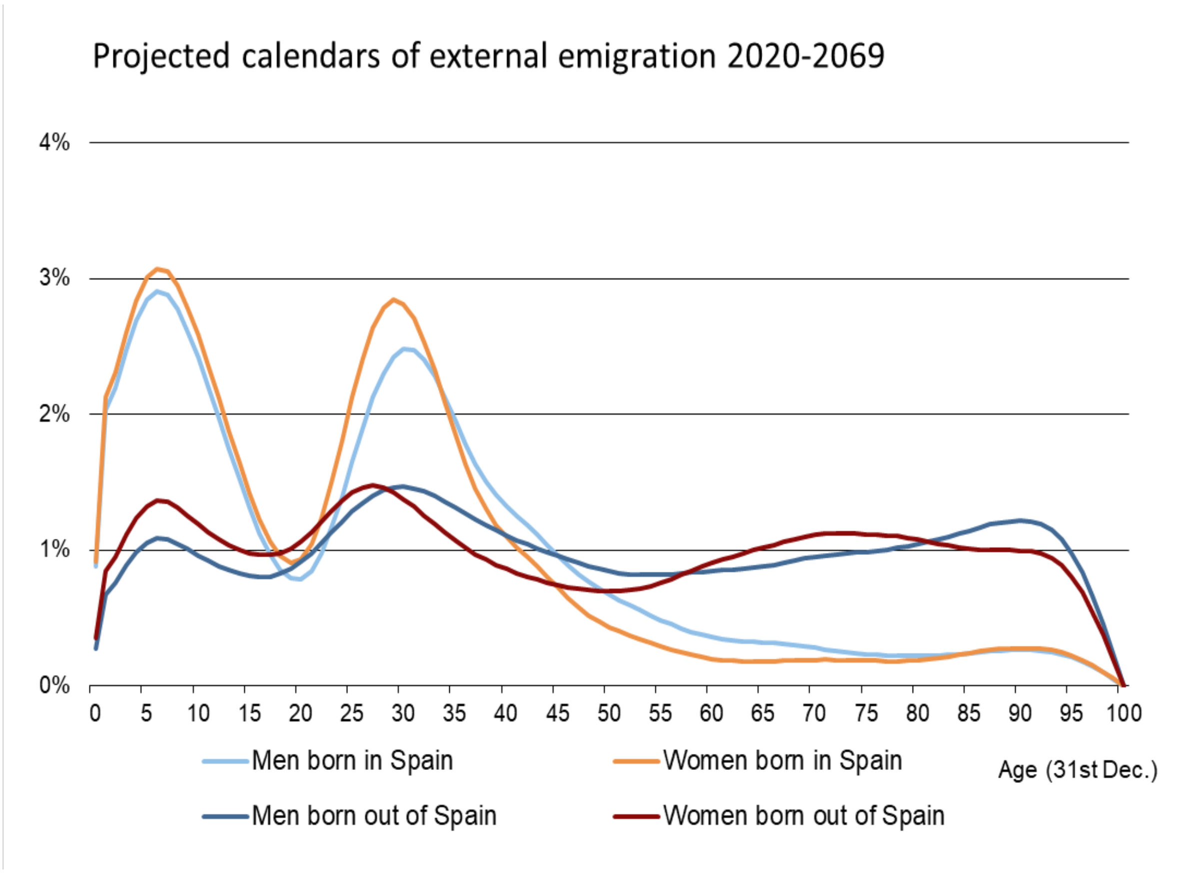
3) We obtain the calendar by average generation from the calendars of each year obtained in the previous step.

4) This calendar undergoes a transformation to obviate the extreme variability presented by the data at the most advanced ages, due solely to random factors. To do this, the sum of the emigration rates of people aged 85 and over is thus distributed by simple ages constantly from 85 to 95 years old, and it thereafter decreases until reaching zero for the open group 100 years and above group.

5) Finally, the projected calendar, which will remain constant for each year of the projection period, is derived from a smoothing procedure of the calendar obtained in the previous point, consisting of a triple process of moving averages of five consecutive generations.

The calendar of international emigration from Spain projected for each sex and place of birth can be seen in the following graph:

[14] The international emigration rates for a specific population group are obtained as the quotient of the corresponding international emigration flows collected in the Migrations Statistics (provisional data for 2019) among the population resident in Spain as at 1 July of that year for said group according to the *Population Figures* (provisional figures for 2019).



Similarly, we obtain provincial calendars from the average provincial calendars for the years 2015-2019.

More information on the projected values is available in Population Projections 2020-2070.

6 Projection of internal migration

The simulation of the future evolution of the phenomenon of internal (inter-provincial) migration in Spain has been carried out differentiating between people born in Spain and abroad, as they have different behaviours.

As described in the calculation method, in order to project the population at the provincial level it is necessary to provide specific internal migration rates by generation for each sex, place of birth, province of origin and province of destination for each year of the projection period.

In the first place, we will take into account that these rates can be broken down into the product of several factors that will be, broadly speaking: the intensity of emigration from each province to the rest of Spain (measured through the synthetic index), a differential by sex, a distribution by generations of this intensity (calendar by generation) and a distribution by province of destination. In particular, the specific internal migration rates of generation *x*, for each sex *s* and place of birth *n*, from province *h* to province *k* and for each year *t* of the projection period, $ei_{s,n,x,h,k}^{t}$,can be expressed as follows:

$$ei_{s,n,x,h,k}^{t} = ISEint_{n,h}^{t} \cdot DEint_{s,n,h}^{t} \cdot c_{s,n,x,h}^{t} \cdot a_{s,n,x,h,k}^{t}$$

Where:

$ISEint_{n,h}^{t}$ is the Synthetic Index of Internal Migration from province *h* for each place of birth *n* and for each year *t*

$DEint_{s,n,h}^{t}$ is the differential by sex s, of province of origin *h* for each place of birth *n* and for each year *t*

$c_{s,n,x,h}^{t}$ is the calendar by generation *x* of emigration to the rest of Spain in year *t* of the population of sex *s*, place of birth *n* and resident in province *h*

$a_{s,n,x,h,k}^{t}$ is the coefficient of distribution of internal migration for each sex *s*, generation *x* and place of birth *n* from province *h* to province *k* in year *t*

These rates are projected constant for the whole period, projecting, also in a constant way, each of its components. The intensity of internal migration is obtained from internal migration data from the last three years of the Migration Statistics, trying to collect the most recent trend, but at the same time seeking to avoid the inherent variability in the data of smaller geographical areas. For the rest of the components, whose stability is greater, data from the last five years of the Migration Statistics (2013-2017) are used.

The process is described in more detail below:

1. Projection of emigration intensity to the rest of Spain from each province according to place of birth:

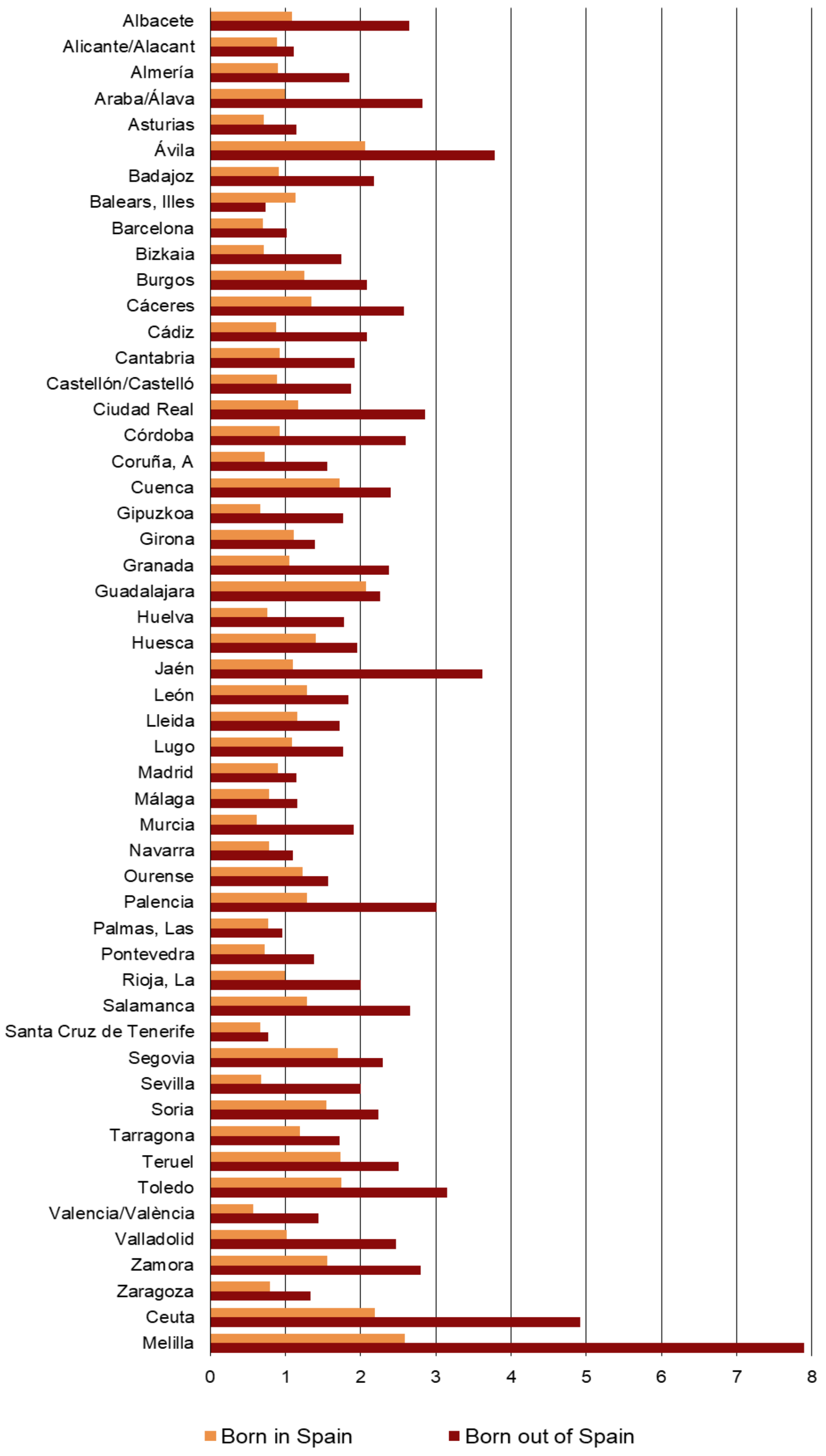
The emigration intensity from each province to the rest of Spain for each place of birth is measured through the Synthetic Internal Emigration Index (ISEInt), which is projected constant for the entire projection period, as the average of the Synthetic

Internal Emigration Indices obtained for each of the last three years from the internal migration data collected by the Migration Statistics. For each of those years, the Synthetic Internal Emigration Index is obtained as the sum of the specific rates by generation[15] for each place of birth and province of origin of that year.

In this way, the following projected Synthetic Indices of Internal Emigration are established:

[15] The emigration rates from each province to the rest of Spain for a specific population group are obtained as the quotient of the corresponding internal emigration flows collected in the Migrations Statistics (provisional data for 2019) among the population resident in Spain as at 1 July of that year for said group according to the *Population Figures* (provisional figures for 2019).

Projected Total Internal Emigration Rate 2020-2034



2. Differential by sex of internal emigration intensity

A differential by sex is projected for the emigration intensity from one province to the rest of Spain for each place of birth, which remains constant for the entire projection period and is obtained as follows:

- For each year of the 2015-2019 period, specific emigration rates are calculated from one province to the rest of Spain by generation for each sex and place of birth, the sum of which gives rise to the Synthetic Internal Emigration Index for each sex and place of birth for that province of origin.
- Similarly, for each year of the 2015-2019 period, specific rates of emigration from one province to the rest of Spain by generation (and both sexes) are calculated for each place of birth, the sum of which results in the Synthetic Internal Emigration Index for each place of birth for that province of origin.

From these indices we obtain the differential by sexes for each year *t*, sex *s*, place of birth *n* and province *h* as the quotient:

$$DEint_{s,n,h}^{t} = \frac{ISEint_{s,n,h}^{t}}{ISEint_{n,h}^{t}}$$

Finally, the projected differential by sex will be the average of the differentials for the last five years (2015-2019) of the Migration Statistics, for each sex, province and place of birth.

3. Calendar by generation:

The calendar by generation of the emigration of the resident population in each province to the rest of Spain is projected for each sex and place of birth. This calendar remains constant for the entire projection period, taking into account the stability observed in recent years. This projection has been obtained through the following steps:

1) Specific emigration rates are obtained from each province *h* to the rest of Spain by generation *x*, for each sex *s* and place of birth *n*, for each year t of the 2015-2019 period, $ei_{s,n,x,h}^{t}$.

2) From the previous rates, we obtain a calendar by generation of emigration from each province, sex and place of birth to the rest of Spain, dividing each specific rate by the sum of all of them, that is, the Synthetic Index of Internal Emigration of each sex, province and place of birth:

$$c_{s,n,x,h}^{t} = \frac{ei_{s,n,x,h}^{t}}{\sum_{x} ei_{s,n,x,h}^{t}} = \frac{ei_{s,n,x,h}^{t}}{ISEint_{s,n,h}^{t}}$$

3) We obtain the calendar by average generation from the calendars of each year obtained in the previous step.

4) This calendar undergoes transformation in order to obviate the extreme variability present in the most advanced ages, due solely to random factors. To

do this, the sum of the emigration rates of people aged 85 and over is thus distributed by simple ages constantly from 85 to 95 years old, and it thereafter decreases until reaching zero for the open group 100 years and above group.

5) Finally, the projected provincial calendar, which will remain constant for each year of the projection period, is derived from a smoothing procedure of the calendar obtained in the previous point, consisting of a triple process of moving averages of five consecutive generations.

4. Distribution coefficient by province of destination:

The distribution coefficient of the specific emigration rates to the rest of Spain from a province of origin to the different provinces of destination for each sex, place of birth and generation has also been derived from that observed in the period 2015-2019 and has remained constant for the entire projection period.

For each year of the 2015-2019 period and for each sex, place of birth, generation and province of origin, this coefficient is obtained as the quotient between the internal emigration rates of origin-destination[16] for each generation, sex and place of birth and the internal emigration rates from each province of origin to the rest of Spain for each generation, sex and place of birth. Both collections of rates are obtained through the procedure described for calendars, that is, applying the transformation of the generations corresponding to 85 years and more as at 31 December, in addition to the subsequent smoothing by means of moving averages.

The projected distribution coefficient, which will remain constant for each year of the projection period, is obtained as the average of the coefficients for the years 2015-2019. This distribution coefficient according to province of destination *k*, in each sex *s*, generation *x* from the province of origin *h* projected for year *t* is denoted by $a^{t}_{s,x,h,k}$.

[16] The emigration rates from a province of origin to a province of destination for a specific population group are obtained as the quotient of the corresponding internal emigration from the province of origin to that of destination for said group collected in the Migrations Statistics (provisional data for 2019) among the population resident in Spain as at 1 July of that year for said group according to the *Population Figures* (provisional figures for 2019).

7 Projection scenarios

As in the previous edition, in the Population Projections 2020-2070 we have carried out the exercise of presenting different scenarios for some of the hypotheses of the phenomena. This simulation is intended to achieve a better interpretation by society of the true meaning of projections, which is not to predict the future, but to simulate what would happen under certain conditions.

The fact of providing different scenarios helps to understand that the central projection, which is the one obtained through the methodology developed in the document, is comprised within an uncertainty interval. This shows the sensitivity to which the projection results are subjected in the face of variations in the initial hypotheses.

Specifically, seven scenarios have been proposed (in addition to the central one), only for the national level, varying the hypotheses of fertility and migratory balance, as well as through a combination of both. Since it is considered the most stable phenomenon over time, making variations regarding mortality is not thought necessary.

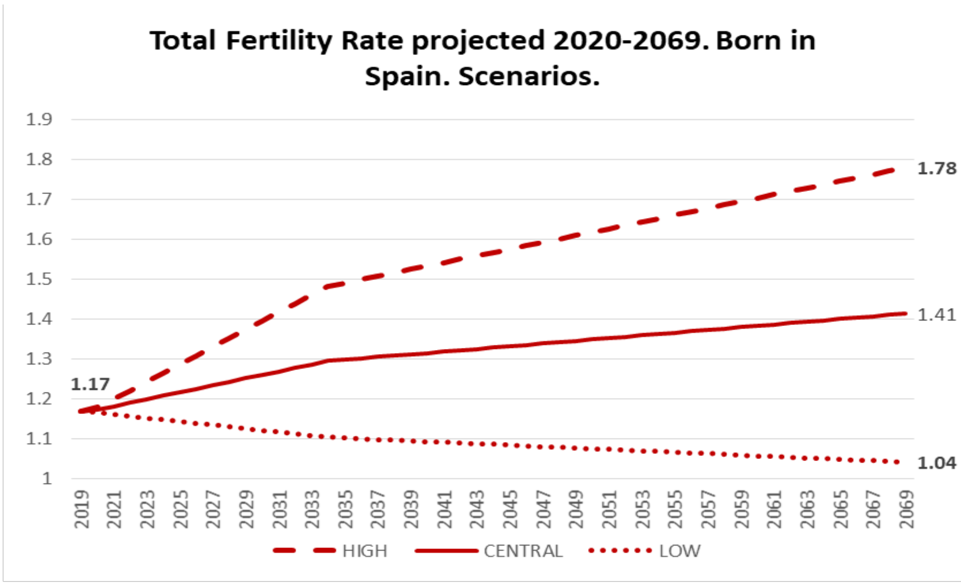
The scenarios considered are as follows:

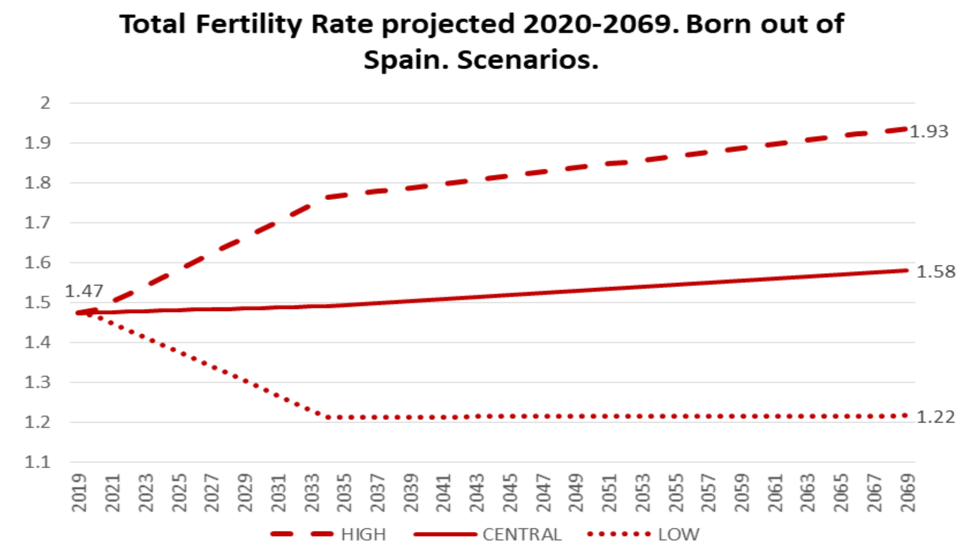
a) High / low fertility:

As explained in detail in section 3.1 of this document, the projection of fertility for the central scenario for each of the years of the long-term projection period has been carried out by adjusting the calendar of fertility observed in Spain by means of a Beta probability distribution of parameters, SFI, AAM and Var_AAM. In such a way that the values of SFI and AAM of each one of the years of the projective period, are obtained by linear interpolation between the last observed value, provisional for 2019, and the arithmetic mean of the values given by the experts in demography, in the survey, for the years 2034 and 2069, respectively. Taking as the variance of the average age at maternity, of each one of the years of the projection period, constant and equal to the value of the last year observed, provisional for 2019.

Therefore, in order to raise/reduce the projected fertility in the central scenario we establish for 2034 (within 15 years) and for 2069 (within 50 years) an SFI equal to 2 times the standard deviation more/less than that established for those years in the central scenario. The same AAM and Var_AAM are maintained as those established for the central scenario in each year of the long-term projection period.

Since the population projection is made separately for each place of birth, the different variants of the SFI would be as shown in the following graphs:





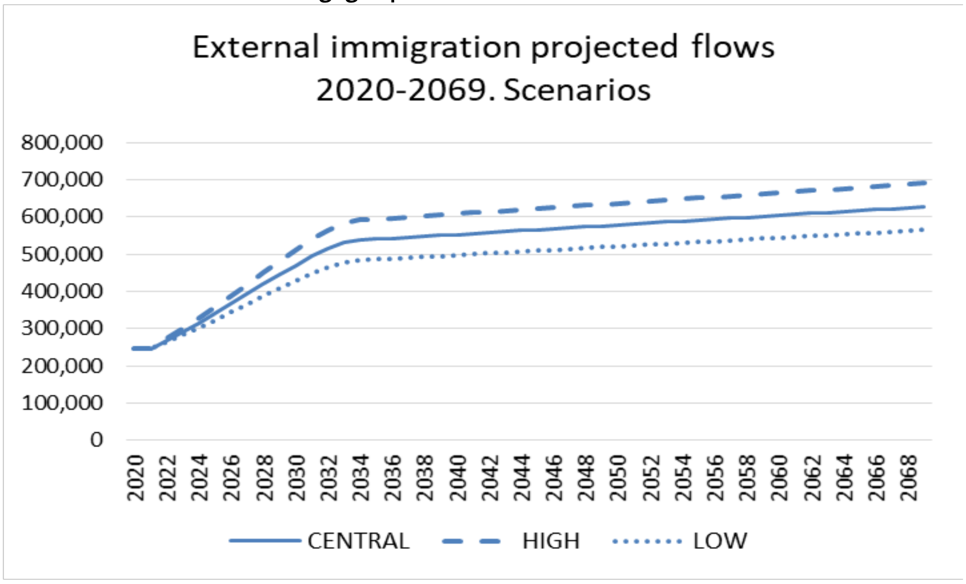
b) Migration balance high/low/nil:

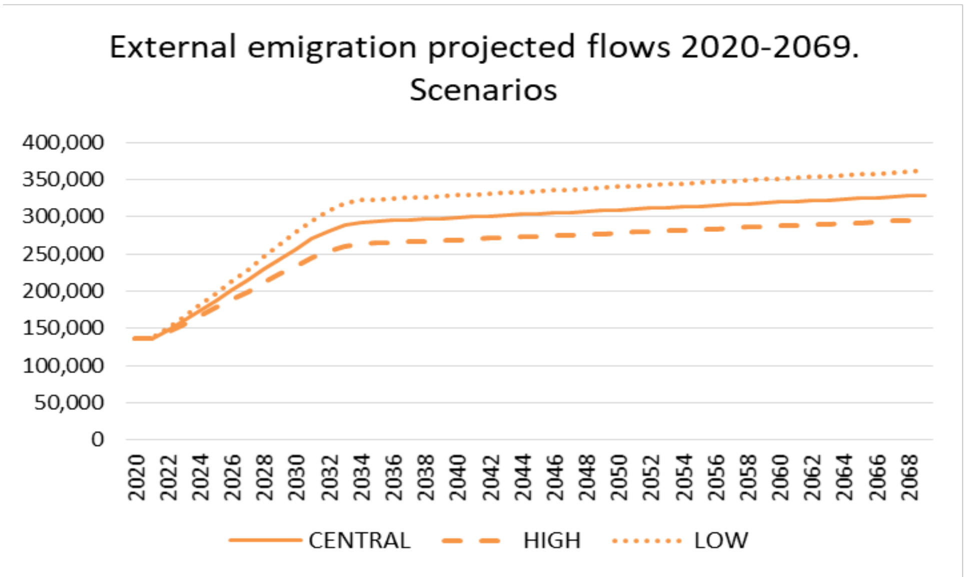
In order to construct different scenarios for the migratory balance, the immigration and emigration values obtained from the survey of experts for 2034 (within 15 years) and for 2069 (within 50 years) have been varied up and down by 10%, for each place of birth. The rest of the series has been constructed using the same methodology as the immigration and emigration flows established for the central scenario. In greater detail, these scenarios are obtained as follows:

- High migration balance scenario: combination of the projected migration series constructed by increasing the immigration values for the years 2034 and 2069 by 10% and reducing the emigration in those years by 10%.

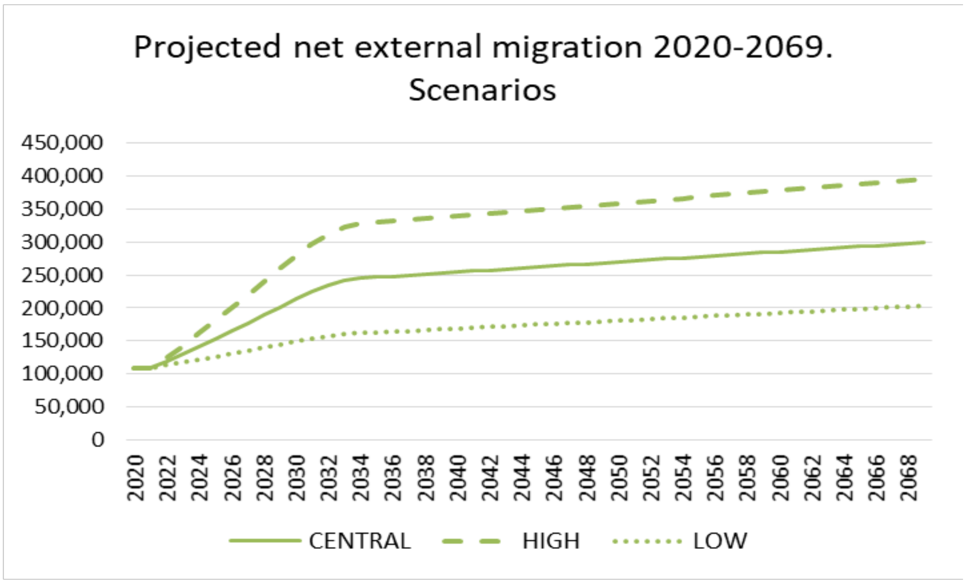
- Low migration balance scenario: combination of the projected migration series constructed by reducing the immigration values of 2034 and 2069 by 10% and increasing the emigration in those years by 10%.

The different immigration and emigration flows projected for each scenario can be seen in the following graphs.





Thus, the different scenarios for the migratory balance are as follows:



Finally, an additional scenario has been constructed to make a projection in the absence of migrations, in which the hypothesis of international migrations has been established as null immigration and emigration flows for the entire projection period, thus giving rise to a scenario of null migratory balance for the whole period.

c) High fertility and high migratory balance/Low fertility and low migratory balance:

The most extreme scenarios will be obtained by combining the high fertility and migratory balance hypotheses for the highest scenario, and a combination of the low fertility and migratory balance hypotheses for the lowest scenario

8 Dissemination of results

Since 2008, the National Statistics Institute has annually produced and disseminated the results of the Short-Term Population Projections for Spain and its Autonomous Communities and provinces in the following 10 years, and every three years, Long-Term Population Projections for Spain in the following 40 years.

As of 2014, both operations were integrated into a single Population Projections, on a biennial basis, which provide results of:

- Resident population as at 1 January of each year according to place of birth and year, by Autonomous Community and province for the years 2020-2035 and for the national total for the years 2020-2070.
- Resident population as at 1 January of each year according to sex, age and year of birth, by Autonomous Community and province for the years 2020-2035 and for the national total for the years 2020-2070.
- Annual births to mothers resident in Spain according to sex and age and year of birth of the mother, by Autonomous Community and province for the years 2020-2034 and for the national total for the years 2020-2069.
- Annual deaths according to sex, age and year of birth, by Autonomous Community and province for the years 2020-2034 and for the national total for the years 2020-2069.
- Annual international migrations according to sex, age and year of birth of the migrant, by Autonomous Community and province for the years 2020-2034 and for the national total for the years 2020-2069.
- Annual inter-regional and inter-provincial migrations according to sex, age and year of birth of the migrant, by Autonomous Community of origin or destination for the years 2020-2034 and for the national total for the years 2020-2069.

Since 2018, a list of Basic Demographic Indicators projected by Autonomous Community and province for the years 2020-2034 and for the national total for the years 2020-2069 has also been disseminated, relating to Birth and Fertility, Mortality, Migration and Growth Indicators and Population Structure.

The calculation methodology used to obtain these indicators is identical to the one used in the operation Basic Demographic Indicators published by the INE every six months.

The sources of information on which these demographic indicators are based are:

- the projected population figures for each of the years of the short-term projection period (2020-2035) broken down by Autonomous Community and province of residence and for the long-term period (2020-2070) for the national total.
- the flows of projected demographic phenomena (births, deaths, immigrations and emigrations) for each of the years of the short-term projection period (2020-2034) broken down by Autonomous Community and province of residence and and for the long-term period (2020-2069) for the national total.

More information on the calculation of Basic Demographic Indicators is available in Basic Demographic Indicators and on the Mortality Tables is available in Mortality Tables.

Additionally, the projection hypotheses of each of the demographic phenomena (fertility, mortality, external migrations, and internal migrations) of the projection period for the national level are disseminated.

9 Annex

As was the case for the Population Projections published two years ago, the main projection hypotheses were submitted to a consultation in the form of a **survey among demographers throughout Spain**. This survey was carried out in May of 2020 with the participation of 33 experts. It was used to obtain values for the parameters necessary for estimations 15 and 50 years ahead: short-term fertility indicator, average age at maternity, life expectancy at birth, and emigration and immigration levels. The following results were obtained.

1. **Fertility hypothesis**

Latest available data (year 2019)	Value
SFI born in Spain	1.17
SFI born abroad	1.47
AAM born in Spain	32.9
AAM born abroad	30.4

Results of the survey to experts:

Parameter	Mean	Standard Deviation
SFI born in Spain within 15 years	1.30	0.099
SFI born abroad within 15 years	1.49	0.144
SFI born in Spain within 50 years	1.42	0.190
SFI born abroad within 50 years	1.58	0.187
SFI born in Spain within 15 years	33.0	0.988
SFI born abroad within 15 years	30.2	1.317
SFI born in Spain within 50 years	33.1	2.327
SFI born abroad within 50 years	30.6	1.805

Hypothesis on mortality

Latest available data (year 2019)	Value
Life expectancy men	80.9
Life expectancy women	86.2

Results of the survey to experts:

Parameter	Mean	Standard Deviation
Life expectancy men within 50 years	85.8	2.619
Life expectancy women within 50 years	90.0	2.386

3. **Hypothesis on migrations**

Latest available data (year 2017)	Value
Immigration born in Spain	36,025
Emigration born in Spain	60,767
Immigration born abroad	712,734
Emigration born abroad	236,601

Results of the survey to experts:

Parameter	Mean	Standard Deviation
Immigration born in Spain within 15 years	43,036	12,315
Immigration born in Spain within 50 years	54,115	25,297
Emigration born in Spain within 15 years	69,034	17,066
Emigration born in Spain within 50 years	78,615	38,136
Immigration born abroad within 15 years	495,172	142,268
Immigration born abroad within 50 years	574,462	199,692
Emigration born abroad within 15 years	223,846	80,004
Emigration born abroad within 50 years	250,208	69,038