INSTITUTO NACIONAL DE ESTADISTICA

Population Projections of Spain 2022-2072

Methodology

Madrid, September 2022

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INE. National Statistics Institute

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 2022-2072 period, and the population resident in each of the Autonomous Communities and provinces as at 1 January of each year of the 2022-2037 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 aggregate 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 Short-term Fertility Indicator (SFI), the Average Age at Maternity (AAM) and the Variance of Average Age at Maternity (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, the hypothesis is based on external migratory flows divided into three sections:
  - The first period (4 years) consists of a now-cast estimate for 2022 and an extrapolation of the trend of recent years up to 2025.
  - In the second period (11 years) the migratory flows evolve from 2025 towards levels that are hypothesised for the year 2036, 15 years after the starting point.
  - During the third period (remaining 35 years), both immigration and emigration are projected from 2036 onwards, until by 2071 they reach other previously established projection parameters.

During the month of May 2022, **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.

To the uncertainty usually surrounding population projections, we now add the impact of COVID-19, since 2020, along with the effect of the 2022 heat waves. This requires a rethinking of some of the hypotheses for the future evolution of mortality.

Under these conditions, a higher mortality is projected for 2022, following the trend that marks the mortality observed in the provisional results of the Death Statistics of the Natural Movement of the Population (NMP) for 2021. The year 2023 and successive years are projected with a close to normal mortality rate, free of covid-19 and heat waves, following the trend marking the mortality observed in the final results of the 2019 NMP.

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 $x = 0,1,2,\ldots,98$:

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

where $m_{s,x}^{t}$ 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*; $e_{s,x}^{t}$ 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 $IM_{s,x}^{t}$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*:

[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).

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

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

$$N_s^t = r \cdot \sum_{x=14}^{49} \left(\frac{P_{M,x}^{t} + P_{M,x+1}^{t+1}}{2} \right) \cdot f_x^t$$

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; $P_{M,x}^{t}$ is the population of females of age *x* as at 1 January of year *t*; and f_x^t 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:

$$P_{s,100+}^{t+1} = \frac{\left[1 - 0,5 \cdot (m_{s,99+}^{t} + e_{s,99+}^{t})\right] \cdot (P_{s,99}^{t} + P_{s,100+}^{t}) + IM_{s,99+}^{t}}{\left[1 + 0,5 \cdot (m_{s,99+}^{t} + e_{s,99+}^{t})\right]}$$

Where $P_{s,99}^{t}$ is the resident population in Spain of sex *s* and age 99 as at 1 January of year *t*; $P_{s,100+}^{t}$ is the resident population in Spain of sex *s* of 100 years old or more as at 1 January of year *t*; $m_{s,99+}^{t}$ 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; $e_{s,99+}^{t}$ 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 $IM_{s,99+}^{t}$ 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 $E_{s,-1}^{t}$ is the number of emigrations in year *t* of persons born in Spain of sex *s* and $e_{s,-1}^{t}$ the international emigration rate of such persons.

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

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

where $P_{s,100+}^{t}$ is the resident population in Spain of sex *s* aged 100 years old or over as at 1 January of year *t* and $e_{s,99+}^{t}$ 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 $x = 0,1,\ldots,98$:

$$P_{h,s,x+1}^{t+1} = \frac{\left[1 - 0{,}5 \cdot (m_{h,s,x}^{t} + e_{h,s,x}^{t})\right] \cdot P_{h,s,x}^{t} + IM_{h,s,x}^{t} + \sum_{k \neq h} ei_{s,x,k,h}^{t} \cdot \left(\frac{P_{k,s,x}^{t} + P_{k,s,x+1}^{t+1}}{2} \right) - \sum_{k \neq h} ei_{s,x,h,k}^{t} \cdot \left(\frac{P_{h,s,x}^{t} + P_{h,s,x+1}^{t+1}}{2} \right)}{\left[1 + 0{,}5 \cdot (m_{h,s,x}^{t} + e_{h,s,x}^{t})\right]}$$

where $m_{h,s,x}^{t}$ 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*; $e_{h,s,x}^{t}$ 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*; $IM_{h,s,x}^{t}$ 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 $ei_{s,x,h,k}^{t}$ 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*:

$$P_{h,s,o}^{t+1} = \frac{\left[1 - 0,5 \cdot (m_{h,s,-1}^{t} + e_{h,s,-1}^{t})\right] \cdot N_{h,s}^{t} + IM_{h,s,-1}^{t} + \sum_{k \neq h} ei_{s,-1,k,h}^{t} \cdot \left(\frac{N_{k,s}^{t} + P_{k,s,0}^{t+1}}{2}\right) - \sum_{k \neq h} ei_{s,-1,h,k}^{t} \cdot \left(\frac{N_{h,s}^{t} + P_{h,s,0}^{t+1}}{2}\right)}{\left[1 + 0,5 \cdot (m_{h,s,-1}^{t} + e_{h,s,-1}^{t})\right]}$$

where $m_{h,s,-1}^{t}$ is the mortality rate in year *t* of residents of sex *s* in province *h* born during that year; $e_{h,s,-1}^{t}$ is the rate of emigration abroad in year *t* of residents in province *h* of sex *s* born during year *t*; $IM_{h,s,-1}^{t}$ is the immigration flow from abroad in province *h* of individuals of sex *s* born during year *t*; $ei_{s,-1,h,k}^{t}$ is the emigration rate from province *h* to province *k* during year *t*, of individuals of sex *s* born during the year; and $N_{h,s}^{t}$ are those born of sex *s* in province *h* during year *t*, which are obtained from:

$$N_{h,s}^{t} = r \cdot \sum_{x=14}^{49} \left(\frac{P_{h,M,x}^{t} + P_{h,M,x+1}^{t+1}}{2}\right) \cdot f_{h,x}^{t}$$

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; $P_{h,M,x}^{t}$ is the population of females resident in province *h* of age *x* as at 1 January of year *t*; and $f_{h,x}^{t}$ 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:

$$P_{h,s,100+}^{t+1} = \frac{\left[1 - 0,5 \cdot (m_{h,s,99+}^{t} + e_{h,s,99+}^{t})\right] \cdot (P_{h,s,99}^{t} + P_{h,s,100+}^{t}) + IM_{h,s,99+}^{t} +}{\left[1 + 0,5 \cdot (m_{h,s,99+}^{t} + e_{h,s,99+}^{t})\right]}$$

$$+ \frac{\sum_{k \neq h} ei_{s,99+,k,h}^{t} \cdot \left(\frac{P_{k,s,99}^{t} + P_{k,s,100+}^{t} + P_{k,s,100+}^{t+1}}{2}\right) - \sum_{k \neq h} ei_{s,99+,h,k}^{t} \cdot \left(\frac{P_{h,s,99}^{t} + P_{h,s,100+}^{t} + P_{h,s,100+}^{t+1}}{2}\right)}{\left[1 + 0,5 \cdot (m_{h,s,99+}^{t} + e_{h,s,99+}^{t})\right]}$$

where $P_{h,s,99}^{t}$ is the resident population in province *h* of sex *s* and age 99 as at 1 January of year *t*; $P_{h,s,100+}^{t}$ is the resident population in province *h* of sex *s* aged 100 or over as at 1 January of year *t*; $m_{h,s,99+}^{t}$ 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; $e_{h,s,99+}^{t}$ 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*; $IM_{h,s,99+}^{t}$ 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 $ei_{s,99+,h,k}^{t}$ 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 $x = 0,1,2,\ldots,98$ years old as at 1 January of year *t*:

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

where $e_{h,s,x}^{t}$ 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*:

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

where $E_{h,s,-1}^{t}$ are the emigrations abroad in year *t* of persons born during said year of sex *s* in province *h* and $e_{h,s,-1}^{t}$ 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.

In a final step, the projected population and phenomena results are rounded to six decimal places at their maximum disaggregation level. This means that, in particular, the sum by various aggregations of the projected and rounded migratory flows may differ slightly from the migratory flows initially introduced as inputs, but generally only by a few decimal places.

2 Starting population

The starting population of Population Projections 2022-2072 consists of the provisional Population Figures at 1 January 2022 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

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

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

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.

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

In the survey to the experts carried out in May 2022, 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 2036 (within 15 years) and in 2071 (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 2021) and the median of the values given by the experts in the survey for the years 2036 and 2071, 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 2021.

Once we have a projection of the parameters for each of the years of the long-term projection period 2022-2071, 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

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

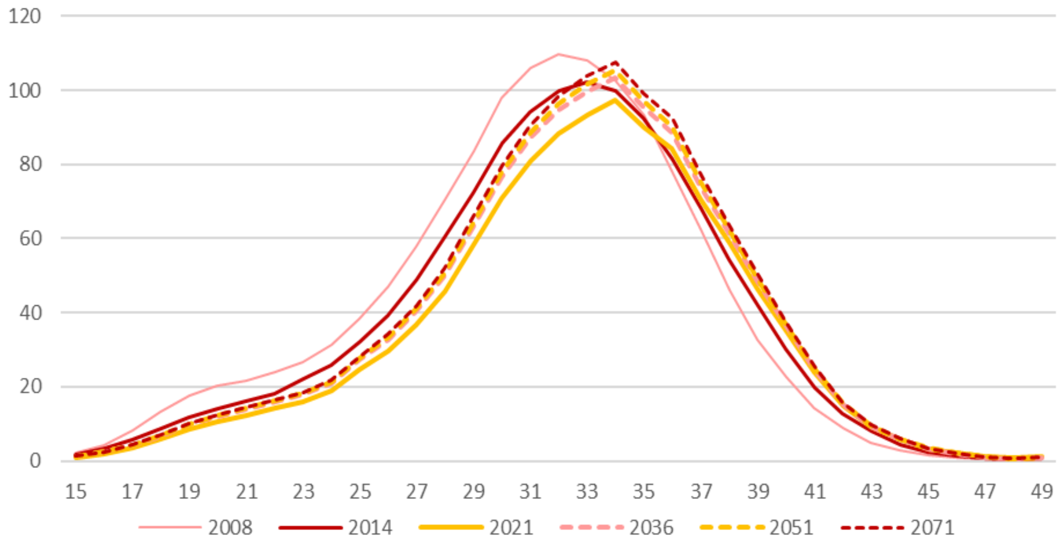
With

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

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.

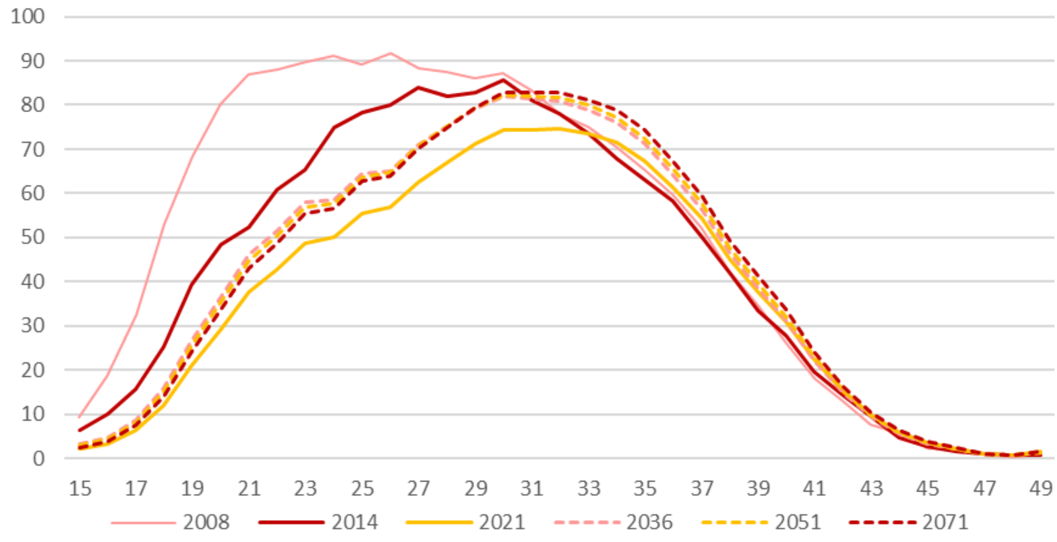
The following graphs include the observed and projected values of the Fertility Rates by age and place of birth of the mother, as well as the Short-term Fertility Indicator and the Average Age at Maternity according to the place of birth of the mother:

Fertility Rates by Age of women born in Spain observed 2008, 2014 and 2021 and projected 2036, 2051 and 2071



2008-2021 Basic Demographic Indicators (2021 provisional data)

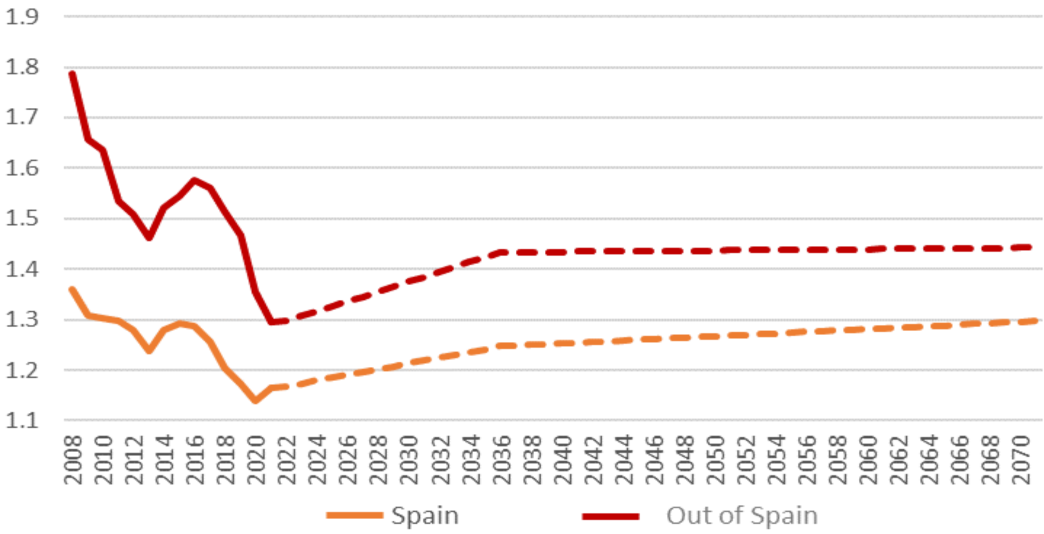
Fertility Rates by Age of women born out of Spain observed 2008, 2014 and 2021 and projected 2036, 2051 and 2071



2008-2021 Basic Demographic Indicators (2021 provisional data)

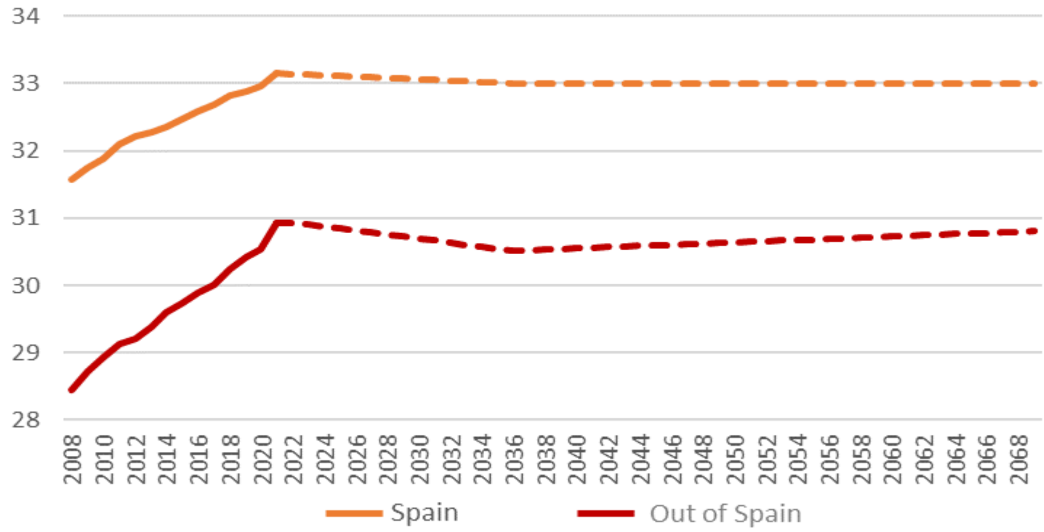
INE. National Statistics Institute

Total Fertility Rate by place of birth of the mother observed 2008-2021 and projected 2022-2071



2008-2021 Basic Demographic Indicators (2021 provisional data)

Mean Age at Childbearing by place of birth of the mother observed 2008-2021 and projected 2022-2071



Fuente: 2008-2021 Basic Demographic Indicators (2021 provisional data)

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.

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

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 2011-2020, 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 2022-2036 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 2022-2036:

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:

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

Where $IC\hat{F}_{España,n}^{t}$ 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.

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 2022-2036 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:

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

[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.

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

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

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 2022-2036:

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:

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

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.

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

3. Projection of the Interquartile Range of specific fertility rates by age, province and place of birth of the mother for the period 2022-2036:

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, $RI_{p,n}^{t}$, 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:

$$RI_{p,n}^{t} = \mu_{p,n} + \rho_{p,n} \cdot \ln(\text{t-aa1}), \qquad \forall t = aa1, \dots, aa10$$

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:

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

4. Calculation of fertility rates by age, province and place of birth of the mother, projected for each year in the period 2022-2036 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 2021.

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.

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

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].

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

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

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 y β;An extension of the Brass Gompertz Fertility Model.

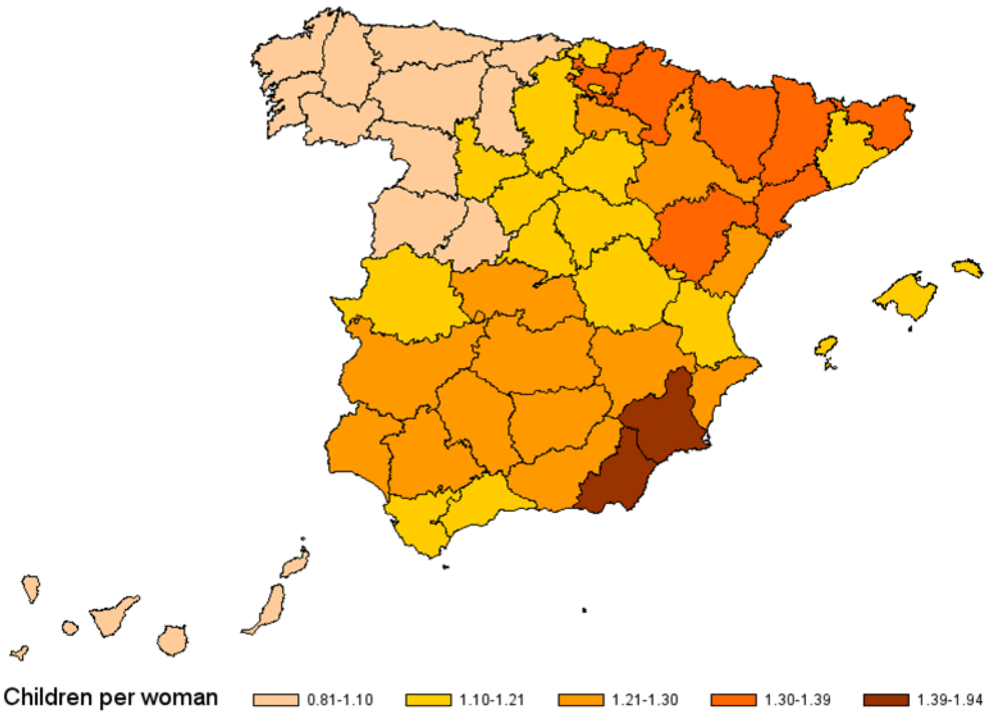
From this estimation we derive the annual growth profile for each province that is applied from the last period observed. The purpose of applying this correction factor is to enable a smoother transition between the last observed period and the first projected period.

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

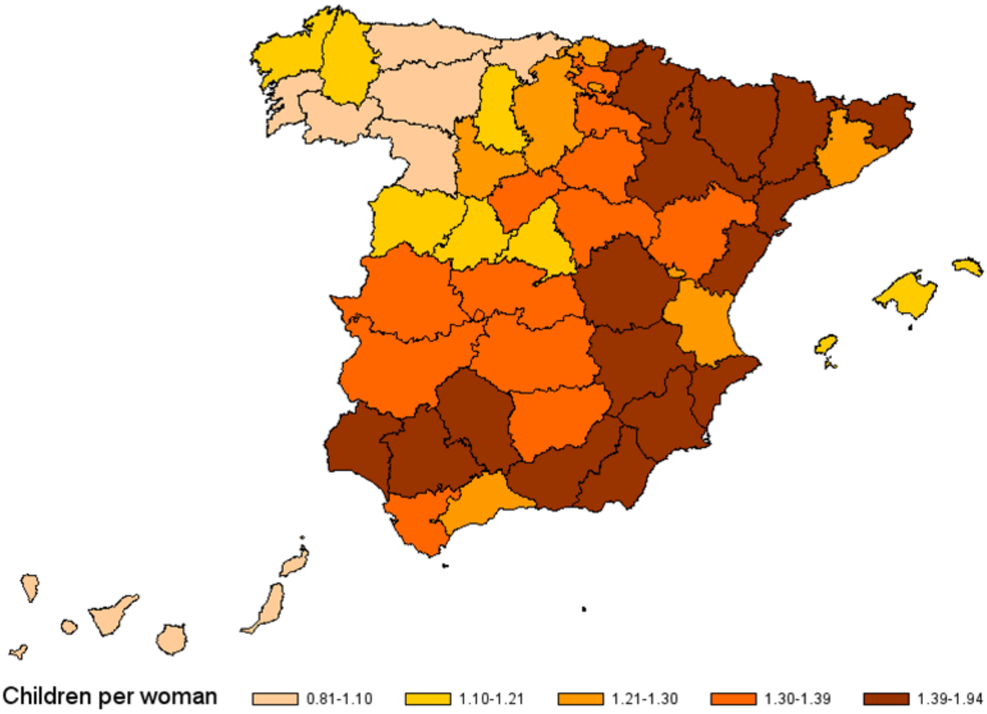
Finally, the projected fertility rates by generation, province and place of birth of the mother are derived from the semi-sum of the projected rates for the same year corresponding to the two ages that women of that generation may have met during that year.

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

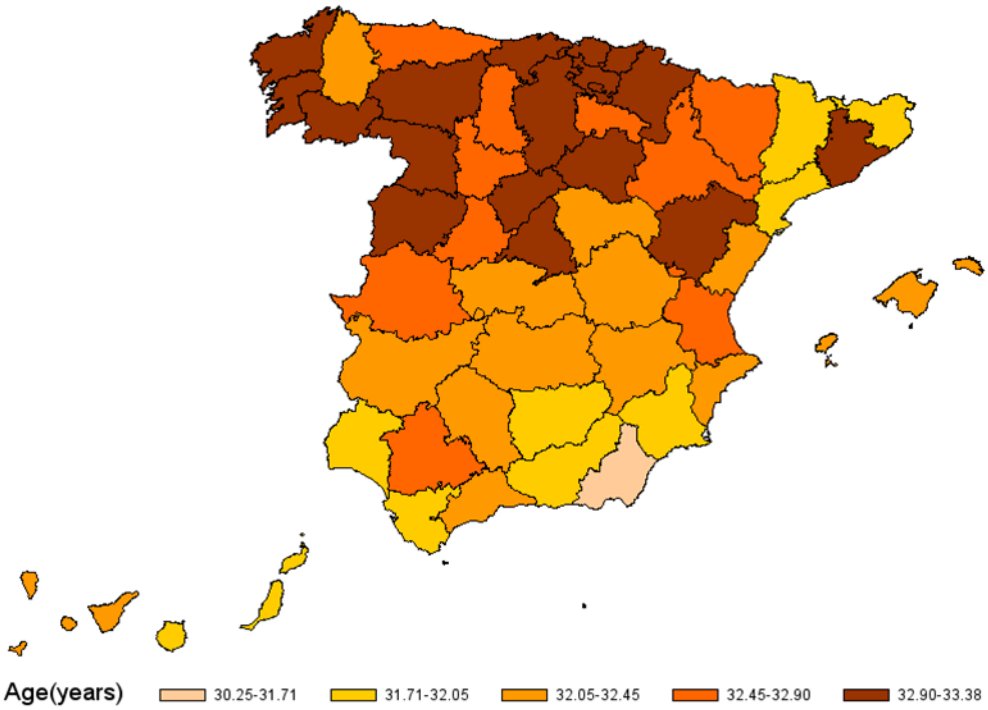
Total Fertility Rate 2022



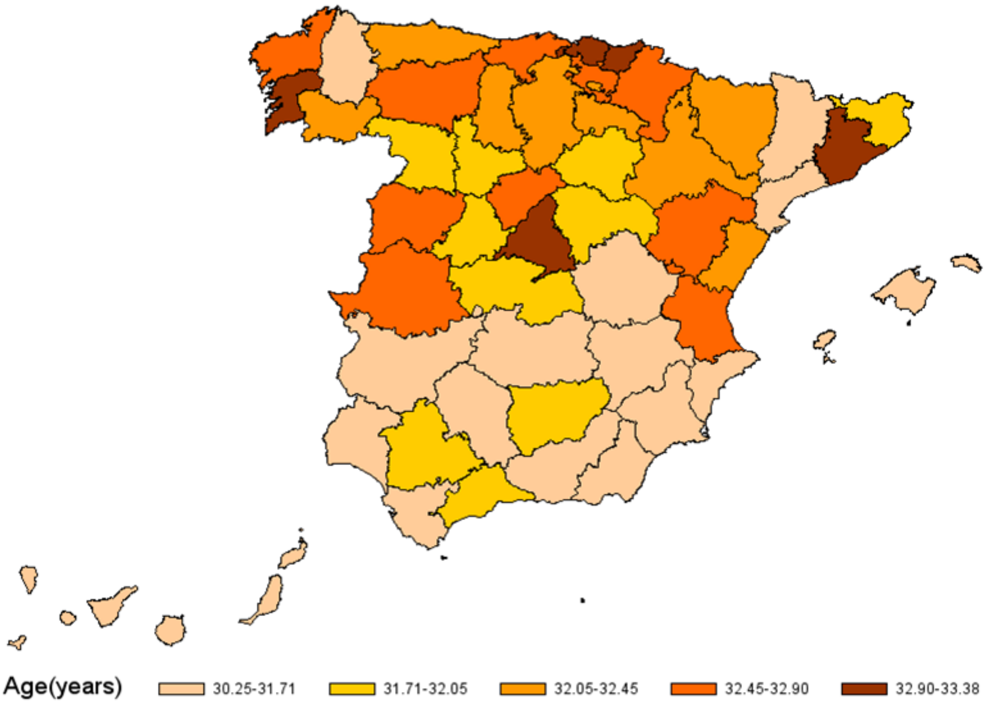
Total Fertility Rate 2036



Mean Age at Childbearing 2022



Mean Age at Childbearing 2036



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 and the heat waves that occurred this year makes it necessary to include its effect in the 2022-2072 Population Projections. In the case of mortality, projections show that it will only be affected during 2022 and 2023, and the following years are projected with the usual mortality.

Given that 2021 has been a year of considerable mortality as a result of covid-19, we use the provisional results of the NMP as a starting point to project mortality for 2022, thus continuing the trend of high mortality.

Then, in order for the projected mortality for 2023 to correspond to a normal mortality - free of covid-19 and heat waves - as a starting point for the projection of this phenomenon in the 2023-2071 we take the deaths observed in 2019 in the MNP Death Statistics, which are now definitive results.

In both cases, the projection methodology used is the same and is explained below.

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 median of the answers given by the experts, in the survey carried out in May 2022, 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.

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

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

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, in the case of the 2022 projection, is 2021, and in the case of the projection for the period 2023-2071, is 2019.

The following is the mortality table for each of the years of the long-term projection period 2022-2071, 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 2071, 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 2071 and has been established as the median of the responses given by the experts, in the survey carried out in May 2022, 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.

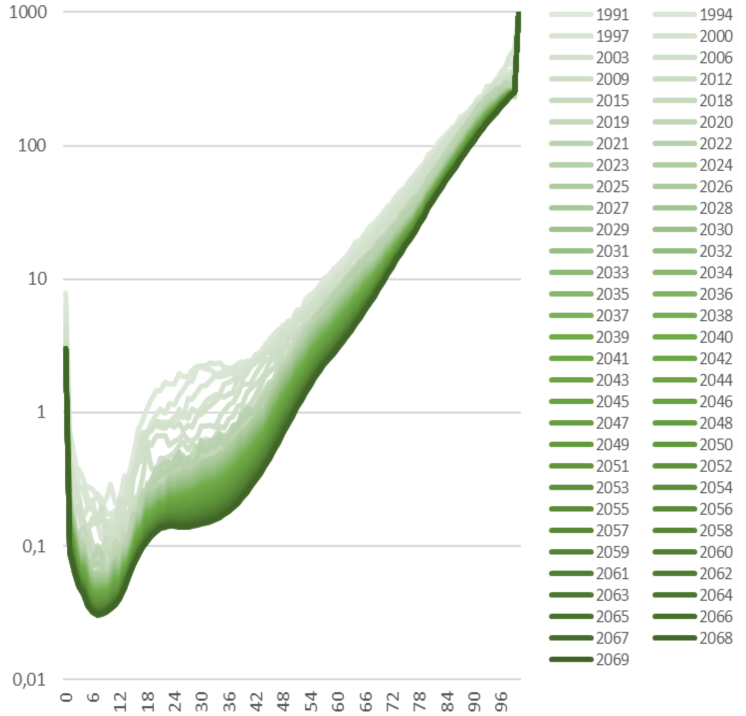
2. The q_x and a_x series corresponding to each of the years of the projection period are obtained by linear interpolation between the series corresponding to the last year observed, and those projected for the last year of the long-term projection period, 2071 in the present projections. In order to 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 case of the 2022 mortality projection, the last year observed is 2021, for which provisional results are available. In the case of the projection of mortality for the 2023-2071 period, the last year observed is 2019, for which definitive results are available.

   In short, two mortality projection processes are carried out with the same methodology in which the starting point and the length of the projection period change. The projected mortality rates for the year 2022 are obtained by projecting mortality over the next 50 years based on the provisional results of the 2021 NMP Death Statistics. In turn, the projected mortality rates for the years of the 2023-2071 period are obtained from projecting mortality over the next 52 years from the final results of the 2019 NMP Death Statistics.

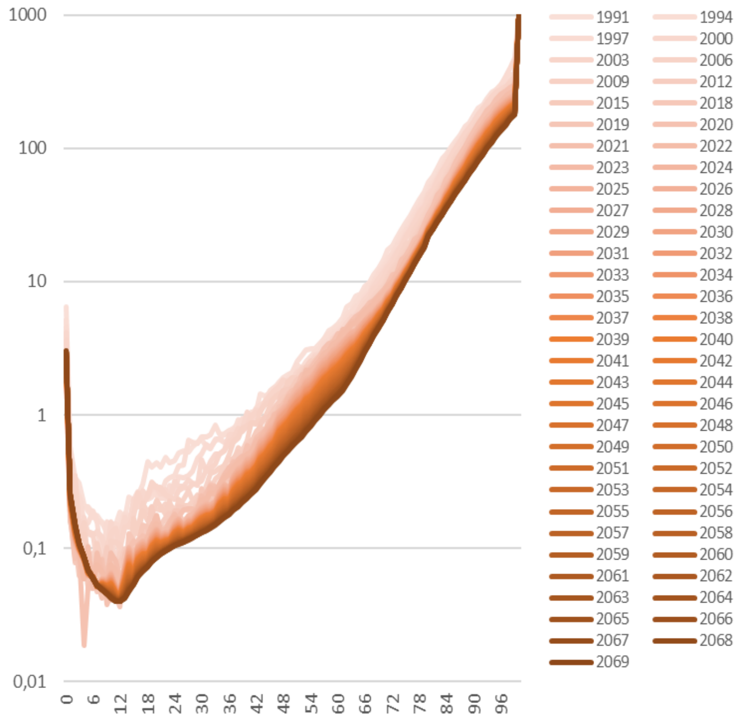
In the following two graphs, we show the profiles of death risks by age observed and projected, for men and for women.

Evolution of mortality risks Males observed 1991-2021 and projected 2022-2071



1991-2021 Mortality tables (2021 provisional data)

Evolution of mortality risks Females observed 1991-2021 and projected 2022-2071



1991-2021 Mortality tables (2021 provisional data)

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 $x = 0,1,2, \ldots 99,100$:

– 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:

$$L_{s,x} = l_{s,x+1} + a_{s,x} \cdot d_{s,x}$$

Mortality rates by generation, corresponding to ages $x = 0,1,2, \ldots 100$ 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 $x = 1,2,\ldots 99,$ $m_{s,g(t-x)} = \frac{L_{s,x}-L_{s,x+1}}{\frac{L_{s,x}+L_{s,x+1}}{2}}$

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:

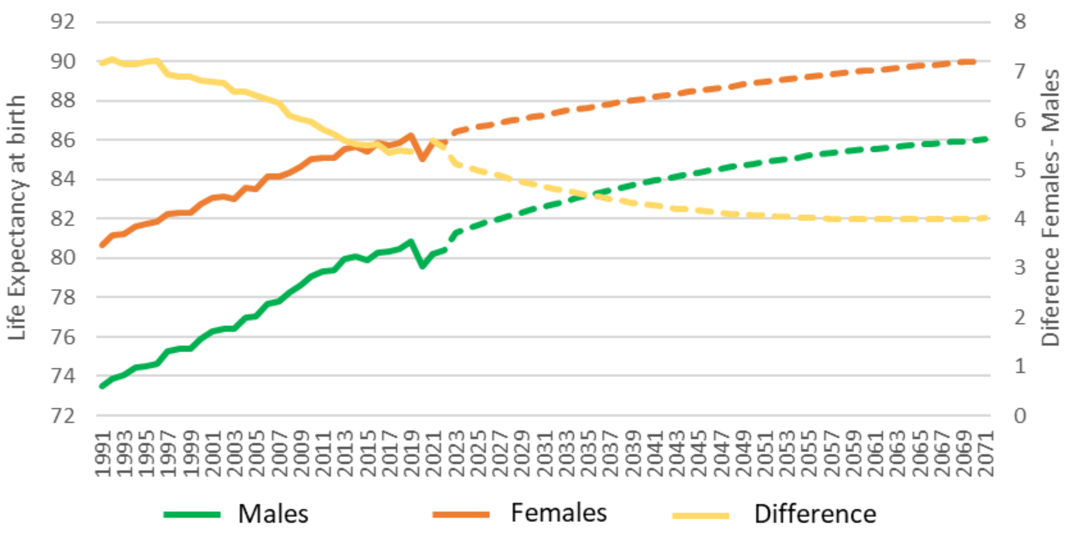
$$T_{s,x} = \sum_{i=x}^{100+} L_{s,i}$$

– Life expectancy at each exact age x:

$$e_{s,x} = \frac{T_{s,x}}{l_{s,x}}$$

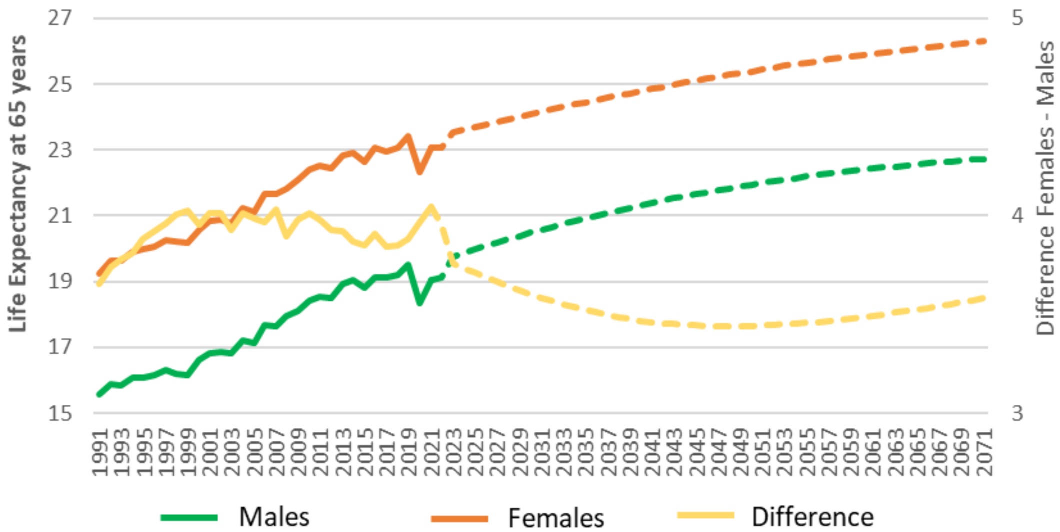
As a summary of the projection of mortality in Spain, with a time horizon of 50 years, the following graphs show the life expectancy at birth and at 65 years of age, by sex, observed and projected up to the year 2071, as well as the difference between men and women, resulting from the adjustment and extrapolation procedure used.

Life Expectancy at birth observed 1991-2021 and projected 2022-2071, of males and females and difference between sexes



1991-2021 Mortality tables (2021 provisional data)

Life Expectancy at 65 years observed 1991-2021 and projected 2022-2071, of males and females and difference between sexes



1991-2021 Mortality tables (2021 provisional data)

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 2022-2036 is developed from a relational methodology following the *Brass logits*[10] method.

As with the national level, we will include COVID-19 and heat waves' effect on provincial mortality only during the year 2022.

The remaining years of the short-term projection period, 2023-2036, are projected with mortality following the same trend as observed until 2019.

The projection procedure for both cases 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 for the last 10 years.

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

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

[10] William Brass, (1975), *Methods for estimating fertility and mortality from limited and defective data*.
[11] Source: INE, Mortality Tables.

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

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.

4. 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.

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=2022,..,2036 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 2022-2036 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:

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

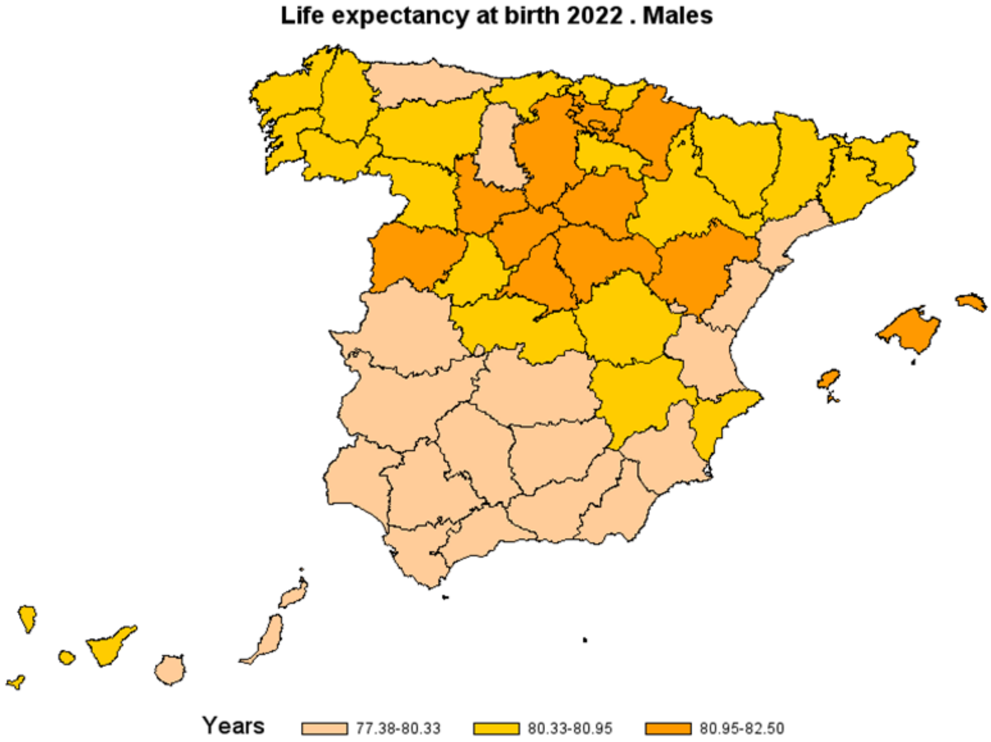
– The series of probabilities of death by age is deduced by the expression:

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

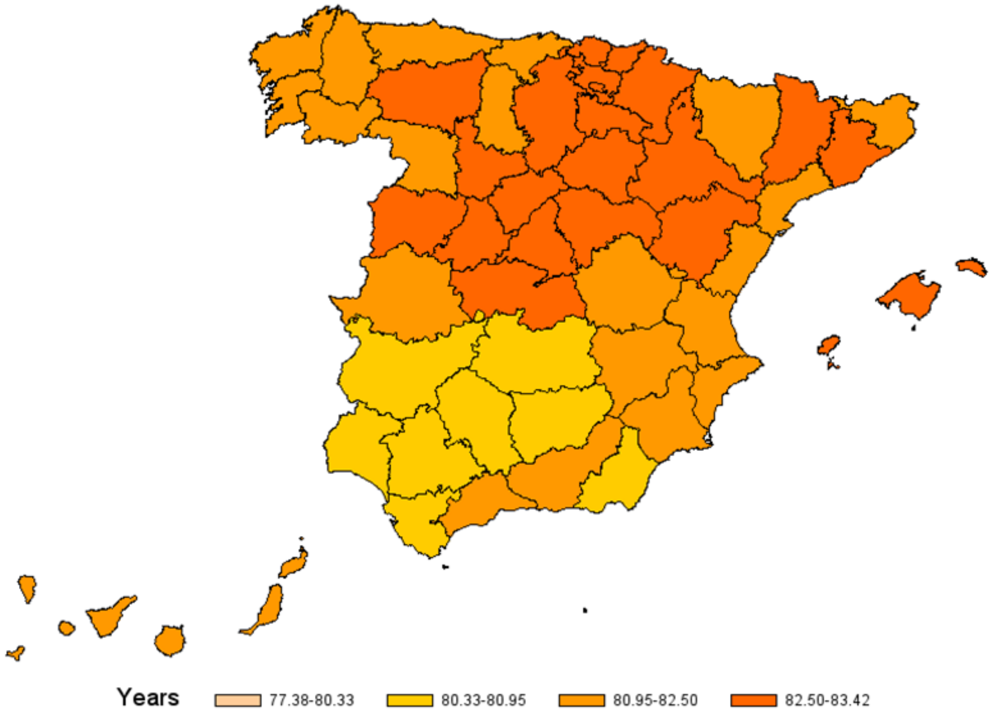
– With the same expressions used for the mortality tables of Spain, the remaining series are calculated: years lived with age x or *stationary population of age* x, mortality rates by generation, and life expectancy.

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

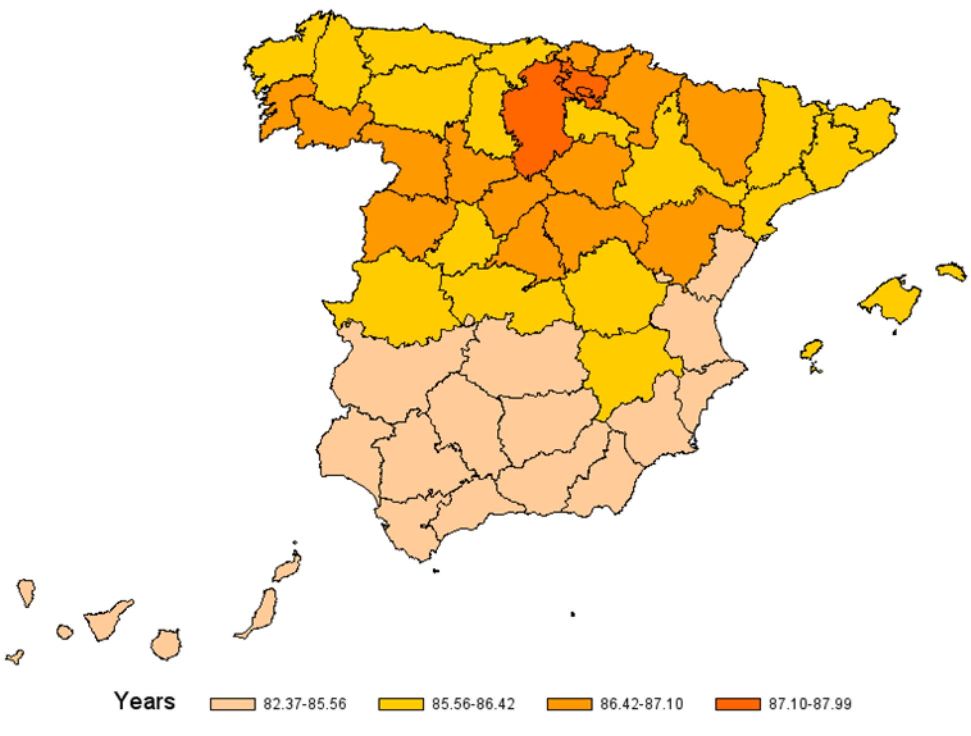
The projected life expectancy at birth in each province and sex and its evolution is reflected in the maps below.



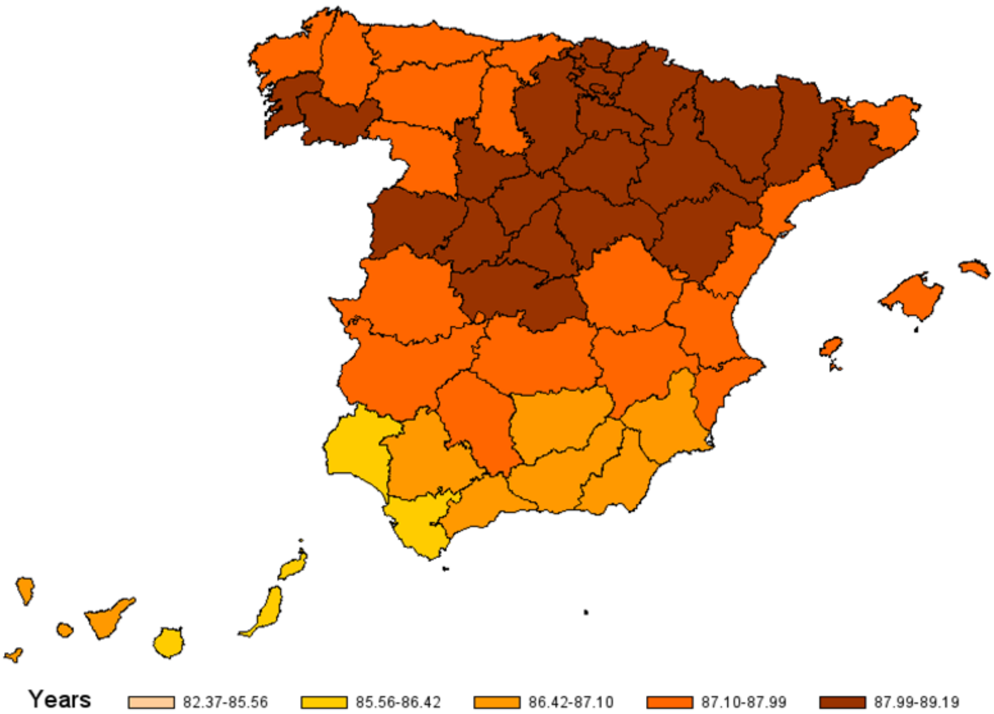
Life expectancy at birth 2036 . Males



Life expectancy at birth 2022 . Females

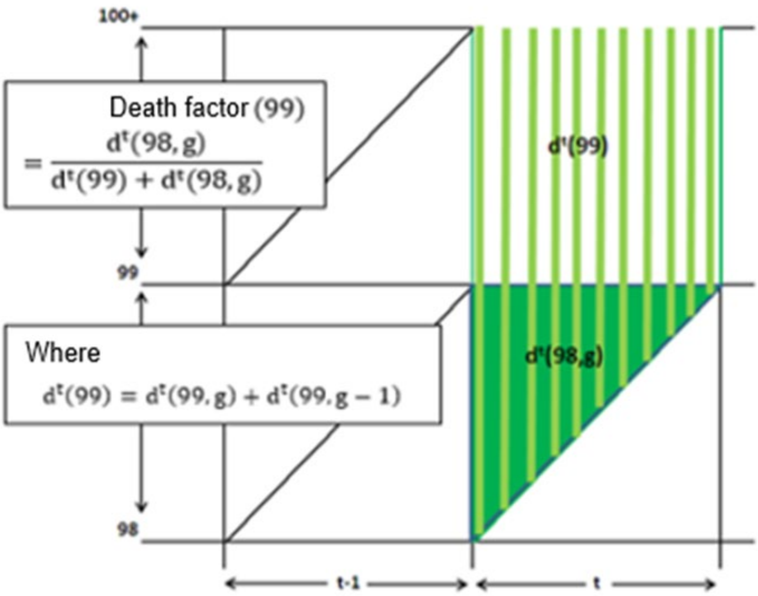


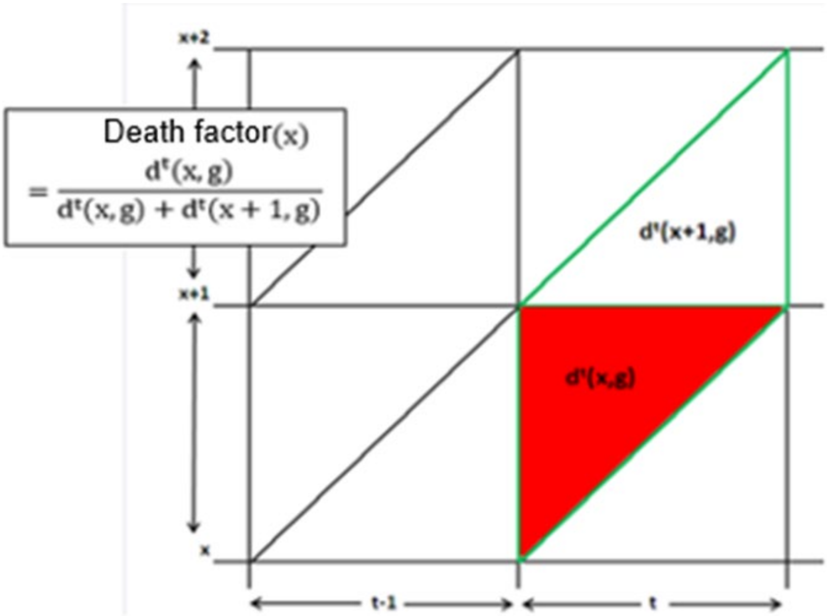
Life expectancy at birth 2036 . Females



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 2012-2021 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 $\quad aa1 = 2012, \dots, aa10 = 2021$

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.

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

INE. National Statistics Institute

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):

Different projected values have been established for each year, and the projective period was divided into three sections:

Period 1 (2022-2025): now-cast or current year estimate for the year 2022 and extrapolation of the trend of recent years for 2023-2025.

In order to obtain the estimate for the first year of the projection, 2022, the Migrations Statistics methodology was applied and an estimate of the international immigration flow for the first half of 2022 was obtained with the information available at the time of the estimation (June 2022), distinguishing between those born in Spain and those born abroad.

The second semester of the first year of the projection, 2022, is generally estimated by applying the average growth of the increases of the second semester over the first semester of each year compiled in the Migration Statistics (2008-2021).

However, in the second quarter of 2022 there was a strong increase in immigration from Ukraine, an effect that has apparently been punctual or, at least, mainly concentrated in that quarter. For this reason, and in order not to propagate this situation into second semester estimations, a correction was made that consisted of taking the data for the second quarter equal to that of the first, in order to form a corrected first semester that would serve as the basis for estimating the second half of 2022. The estimate of immigration for the year 2022 is thus made up of the first semester, obtained according to the Migration Statistics, and the second semester, estimated with the aforementioned correction.

Using these hypotheses, the estimated values for 2022 were obtained: 30,666 immigrations of persons born in Spain and 906,657 immigrations of persons born abroad, giving a total of 937,323 total immigrations from abroad.

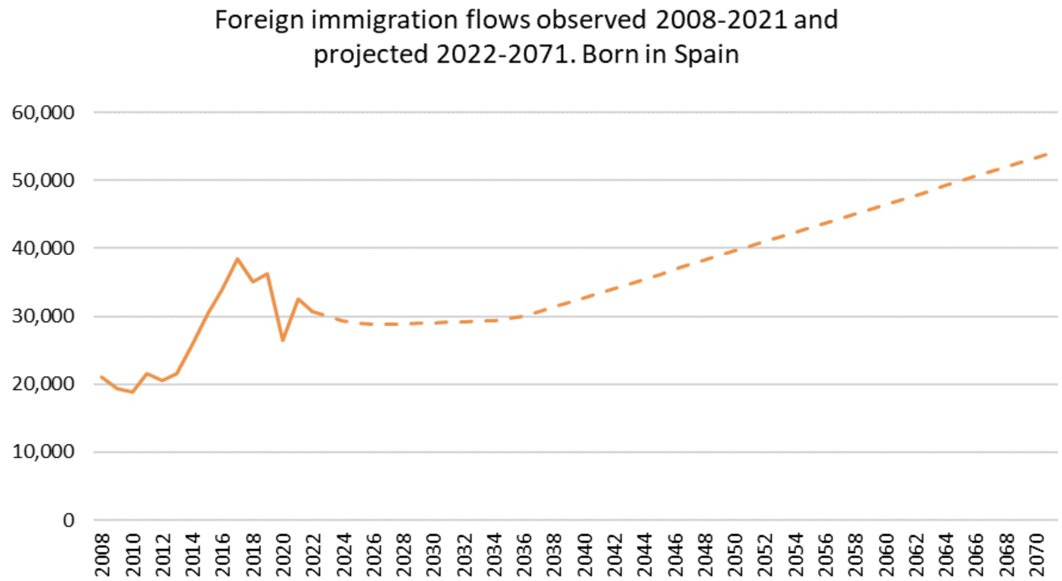
To extrapolate the trend in recent years going forward, the logarithmic curve that passes through the years 2019 and 2022 was used, purposely skipping the years 2020 and 2021, since those years showed unusual migratory flows due to the Covid-19 pandemic. This curve has been applied independently to the four series of flows formed by the combinations of immigration/emigration born in Spain/foreigner. This logistics curve thus allows us to collect the trend for the last three years, and for its growth to smooth over time.

Period 2 (2025-2036): linear interpolation between the value obtained for 2025 and the value assigned for the year 2036 according to the survey of the experts, obtained as the median of the responses.

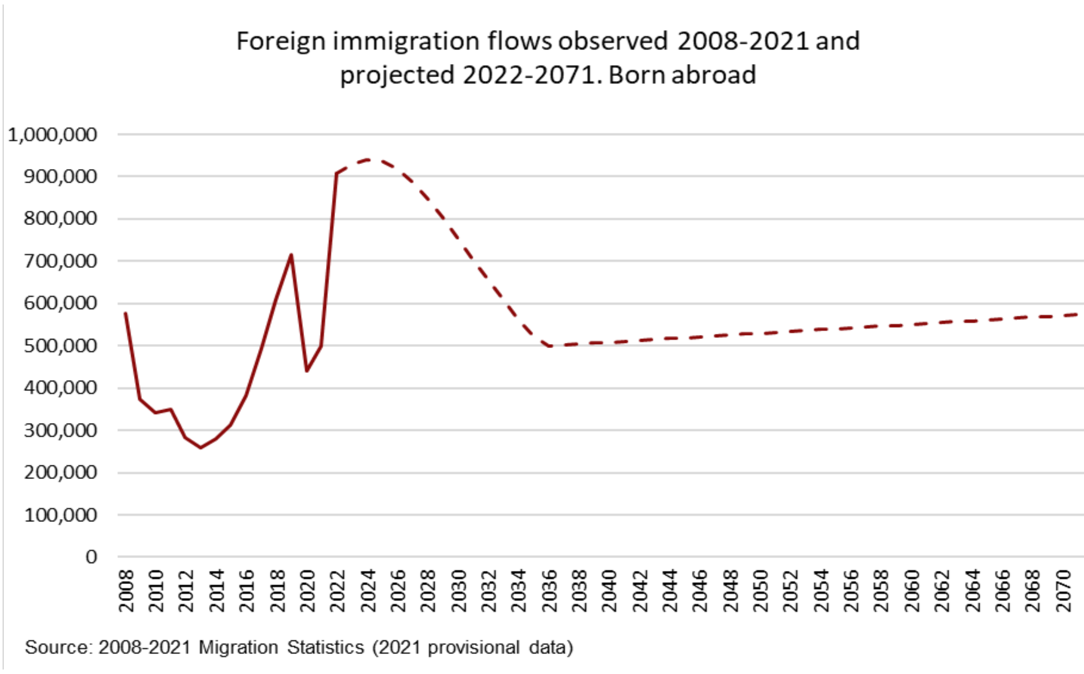
Period 3 (2037-2071): linear interpolation between the values assigned for the years 2036 and 2071. Los datos proporcionados por la encuesta para los flujos migratorios a 50 años no han sido concluyentes, por lo que se han copiado los que arrojó la encuesta empleada para las proyecciones 2020-2070 para el final del periodo proyectivo.

Finalmente, se han suavizado los valores en torno a los cambios de periodo (2025 y 2036), para que las transiciones sean suaves.

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



Source: 2008-2021 Migration Statistics (2021 provisional data)



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]:

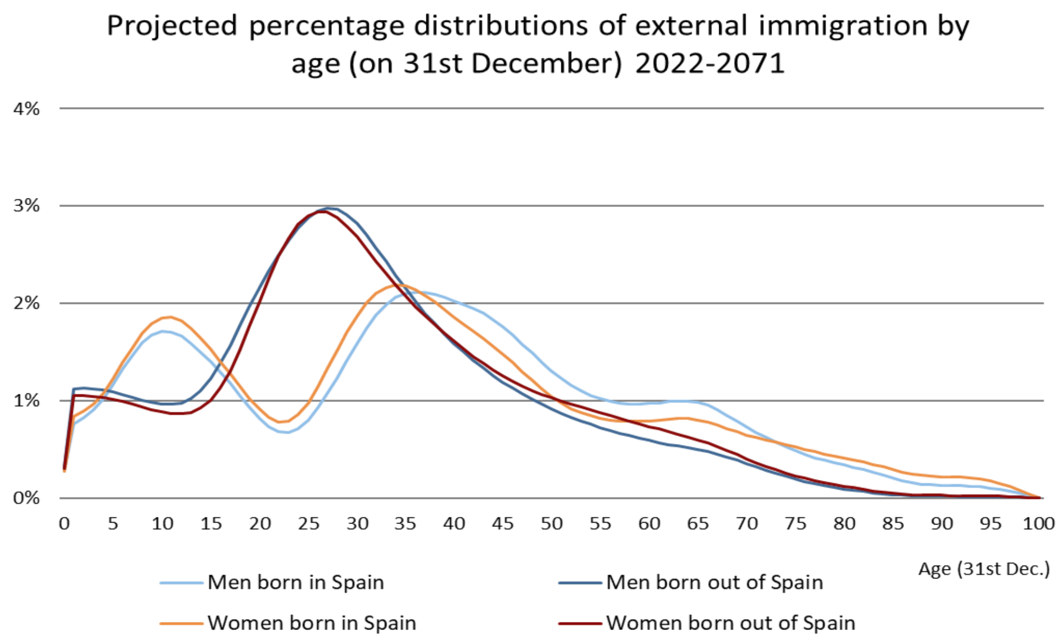
The international immigration flow from Spain for each place of birth and sex projected is distributed by generations applying a profile by constant generation throughout the projection period, and is obtained as follows:

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 2022-2072](#).

4. Distribution by provinces:

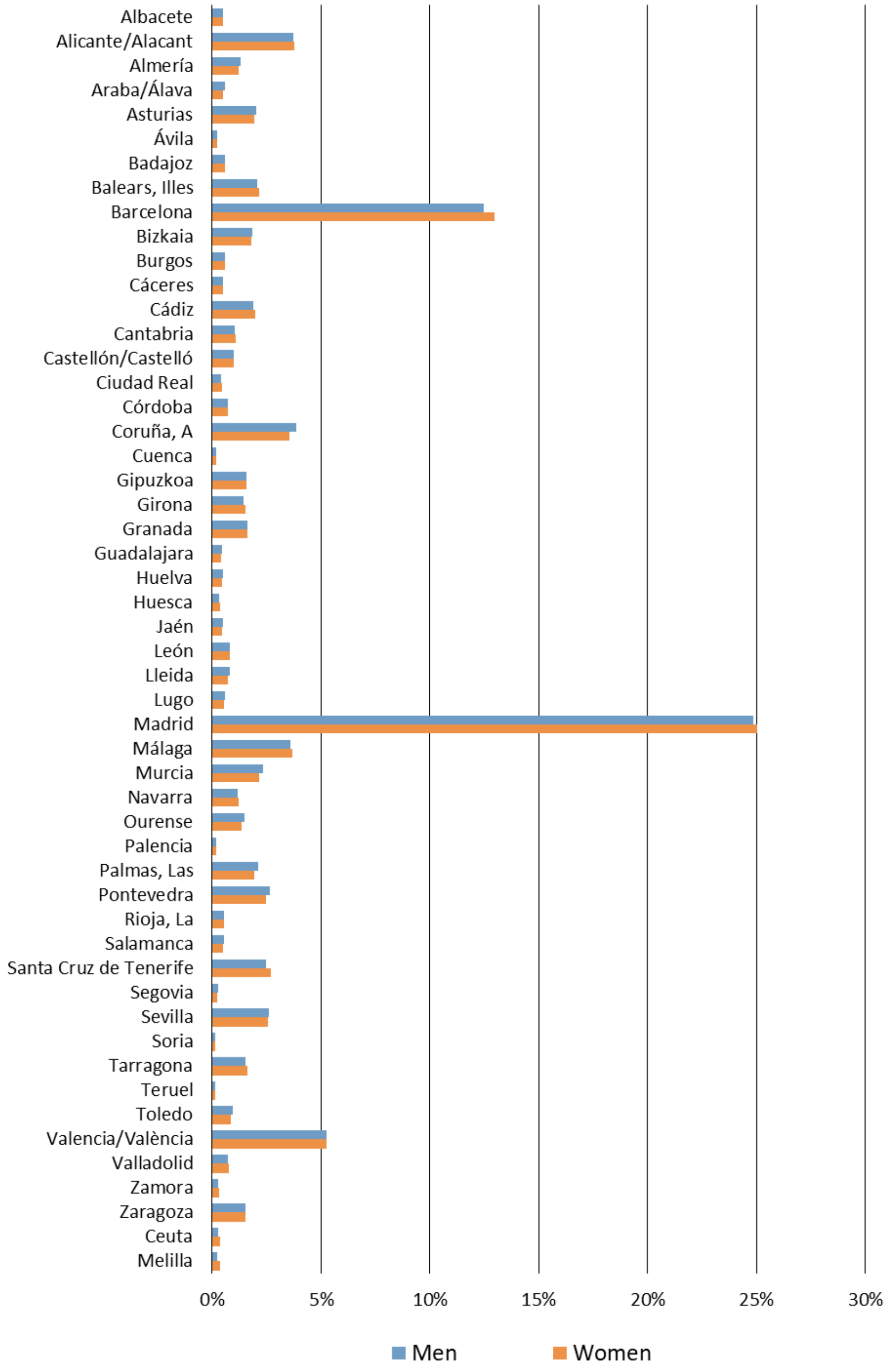
The international immigration flows from Spain for each projected place of birth, sex and generation are distributed by province, for the first 15 years of the projection, applying a provincial distribution coefficient that is constant throughout the projection period, and is obtained as follows:

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.

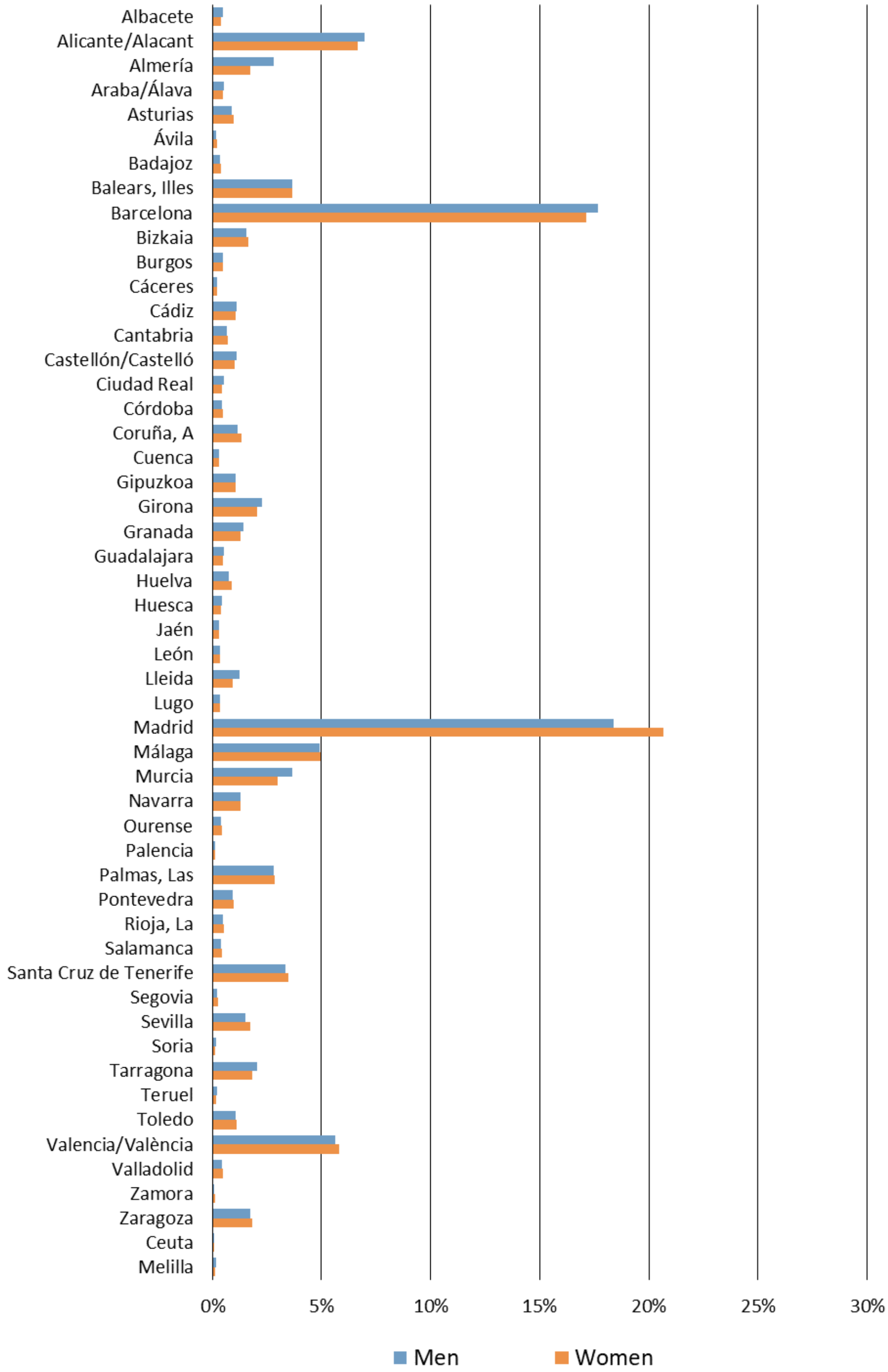
After processing these flows, the distribution coefficient is obtained for each year, by means of the quotient between the flow by province for a determined place of birth, sex and cohort, and the same flow for the national total. The projected provincial distribution coefficient will be the average 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 2022-2071. Born in Spain



Projected percentage distribution by province and sex of external immigration 2022-2071. 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:

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

where:

$ISE_{s,n}^{t} = \sum_{x} e_{s,n,x}^{t}$ is the Synthetic Index of International Emigration for each year *t*, place of birth *n* and sex *s*

$c_{s,n,x}^{t} = \frac{e_{s,n,x}^{t}}{\sum_{x} e_{s,n,x}^{t}}$ 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 (2017-2021) 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):

A similar approach is used for immigration, dividing the projection period into three periods:

Period 1 (2022-2025): now-cast or current year estimation for the year 2022 and extrapolation of the trend of recent years for 2023-2025.

In order to obtain the estimate for the first year of the projection, 2022, 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 (July 2020).

El segundo semestre de 2022 se estimó aplicando el crecimiento promedio de los crecimientos del segundo semestre sobre el primer semestre de cada año recogido en la Estadística de Migraciones (2008-2021).

Using these hypotheses, the estimated values for 2022 were obtained: 65,076 emigrations of persons born in Spain and 388,110 emigrations of persons born abroad, giving a total of 453,186 total emigrations from abroad.

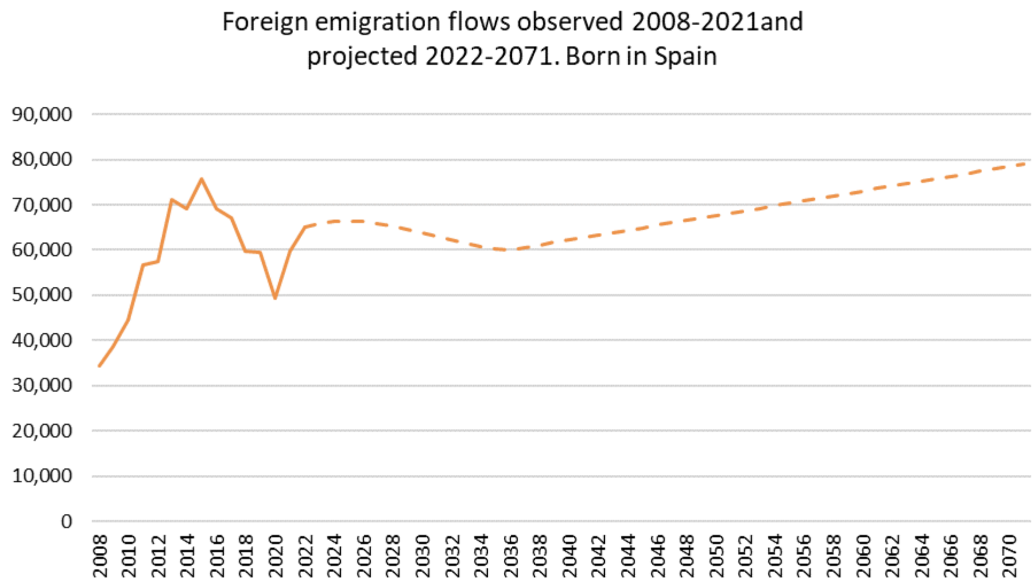
The extrapolation of the trend to project the years 2023 to 2025 has been carried out as with foreign immigration; that is, using logarithmic curves.

Period 2 (2025-2036): linear interpolation between the value obtained for 2025 and the value assigned for the year 2036 according to the survey of the experts, obtained as the median of the responses.

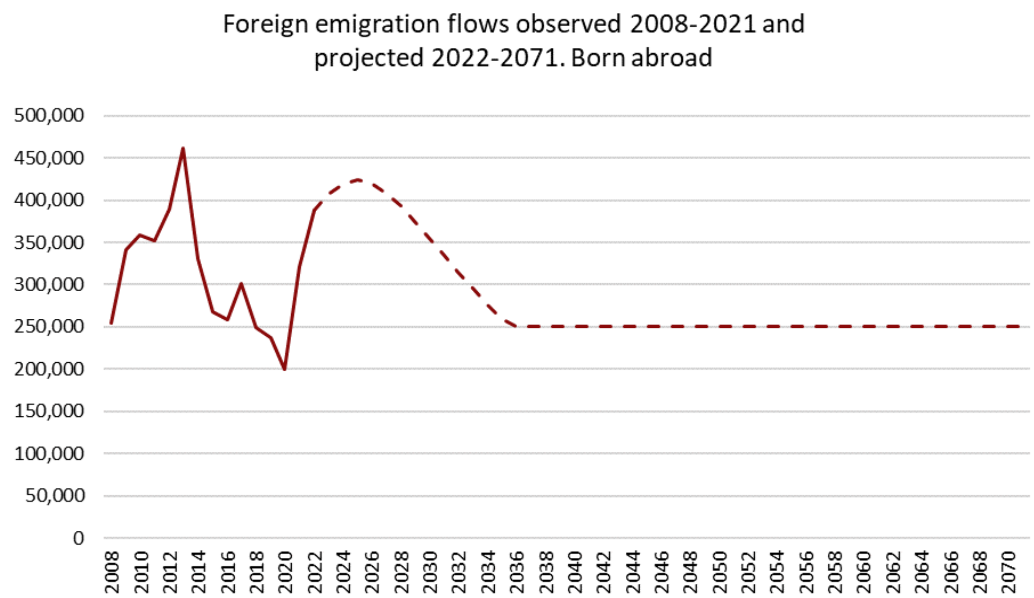
Period 3 (2037-2071): linear interpolation between the values assigned for the years 2036 and 2071. The data provided by the survey for 50-year migratory flows have not been conclusive, so the data provided by the survey used for the 2020-2070 projections for the end of the projection period have been used.

Finally, the values regarding period changes (2025 and 2036) have been smoothed, in order to smooth transitions.

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



Source: 2008-2021 Migration Statistics (2021 provisional data)



Source: 2008-2021 Migration Statistics (2021 provisional data)

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 53.3% of men for emigrations of persons born in Spain and 54.2% 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 (2017-2021) of the Migrations Statistics, taking into account the stability in time that this indicator also presents..

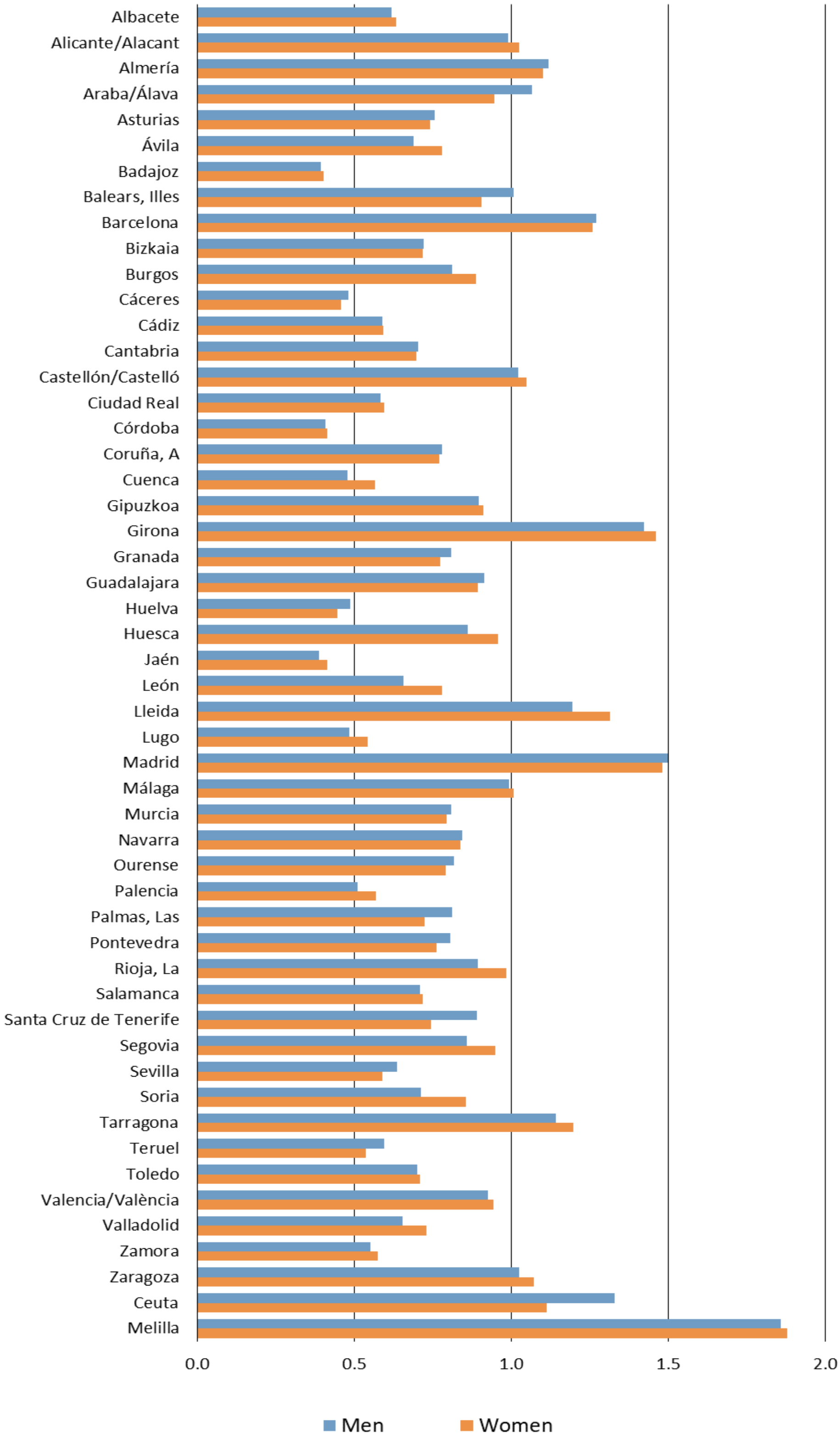
Based on the specific international emigration rates[13] by generation for each sex and place of birth of each province and of the national total, for each year of the 2017-2021 period, we have calculated the Synthetic Emigration Indices by sex *s* and place of birth *n* of each province *h* ($ISE_{s,n,h}^{t}$) and of the national total ($ISE_{s,n}^{t}$), 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:

$$DE_{s,n,h}^{t} = \frac{ISE_{s,n,h}^{t}}{ISE_{s,n}^{t}}$$

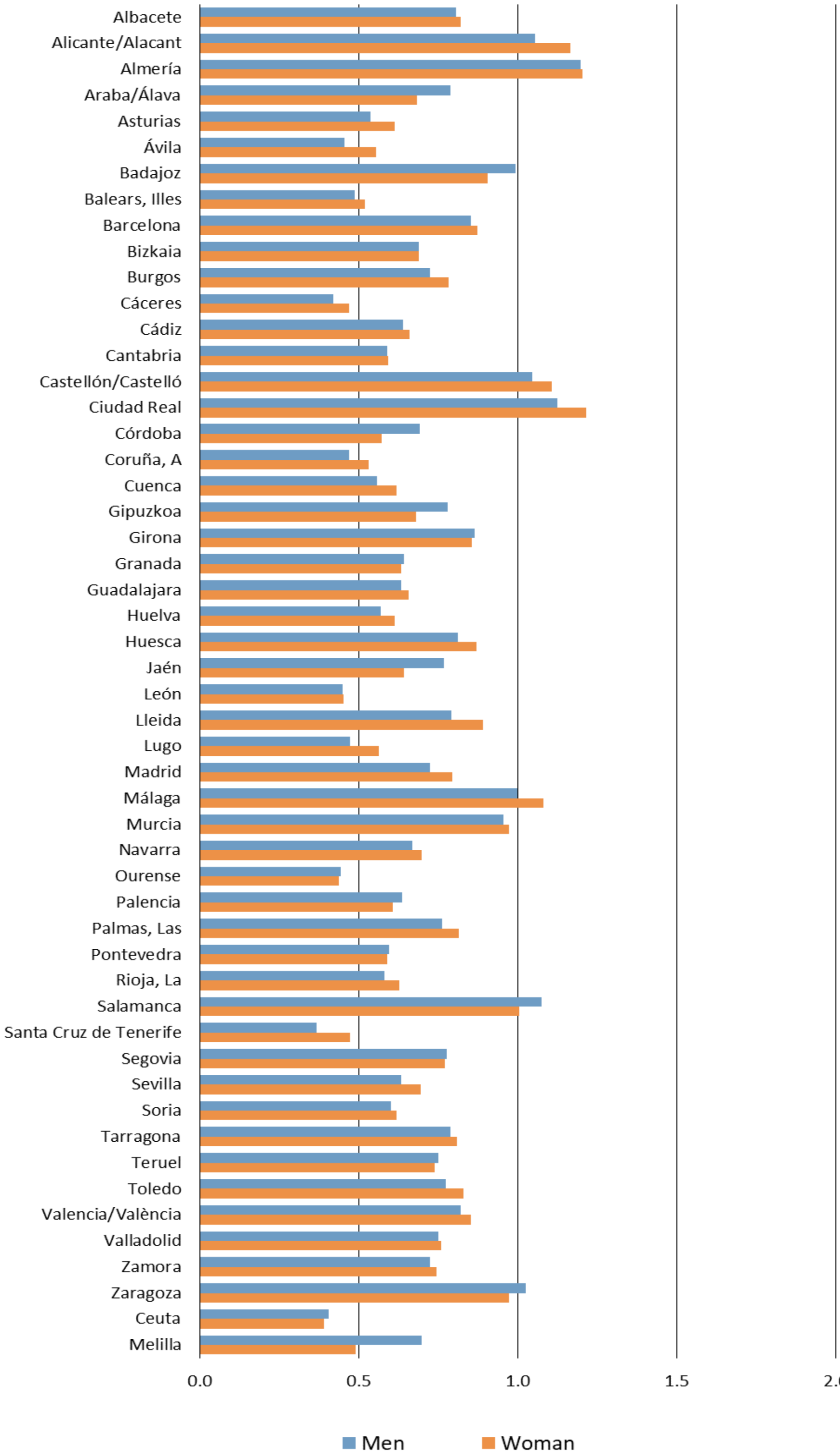
Finally, the projected provincial differential will be the average of the differentials of the last five years (2017-2021) obtained from the Migration Statistics, for each sex and place of birth. These differentials can be seen in the following graphs:

[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 2021) among the population resident in Spain as at 1 July of that year for said group according to the *Population Figures* (provisional figures for 2021).

Projected differential intensity of external emigration by province and sex 2022-2071. Born in Spain



Projected differential intensity of external emigration by province and sex 2021-2071. Born out of Spain



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 (2017-2021) 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 2017-2021, $e^t_{s,n,x}$.

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:

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

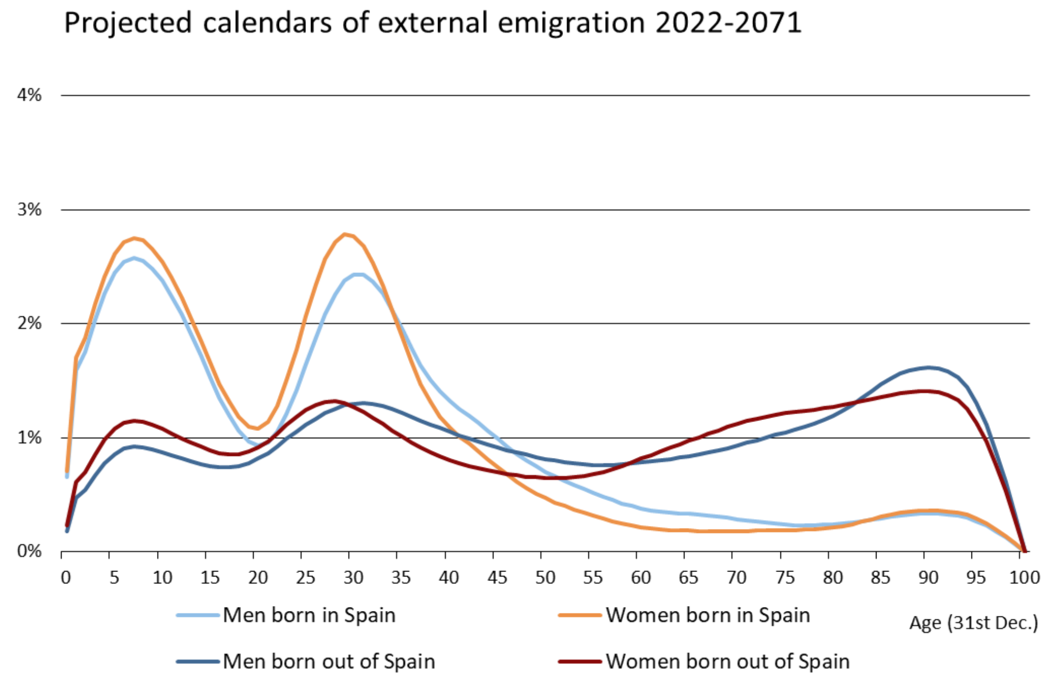
3) We obtain the calendar by average generation from the calendars of each year obtained in the previous step.

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 2021) among the population resident in Spain as at 1 July of that year for said group according to the *Population Figures* (provisional figures for 2021).



Similarly, we obtain provincial calendars from the average provincial calendars for the years 2017-2021.

More information on the projected values is available in Population Projections 2022-2072.

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, $ei^{t}_{s,n,x,h,k}$,can be expressed as follows:

$$ei^{t}_{s,n,x,h,k} = ISEint^{t}_{n,h} \cdot DEint^{t}_{s,n,h} \cdot c^{t}_{s,n,x,h} \cdot a^{t}_{s,n,x,h,k}$$

Where:

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

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

$c^{t}_{s,n,x,h}$ 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*

$a^{t}_{s,n,x,h,k}$ 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 usually 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. However, for this edition, it has been necessary to disregard the 2020 data to construct the migration intensity, as they were strongly affected by the Covid-19 pandemic, and it was not considered appropriate to extend this effect into the future. For the rest of the components, whose stability is greater, data from the last five years of the Migration Statistics (2017-2021) are used.

The process is described in more detail below:

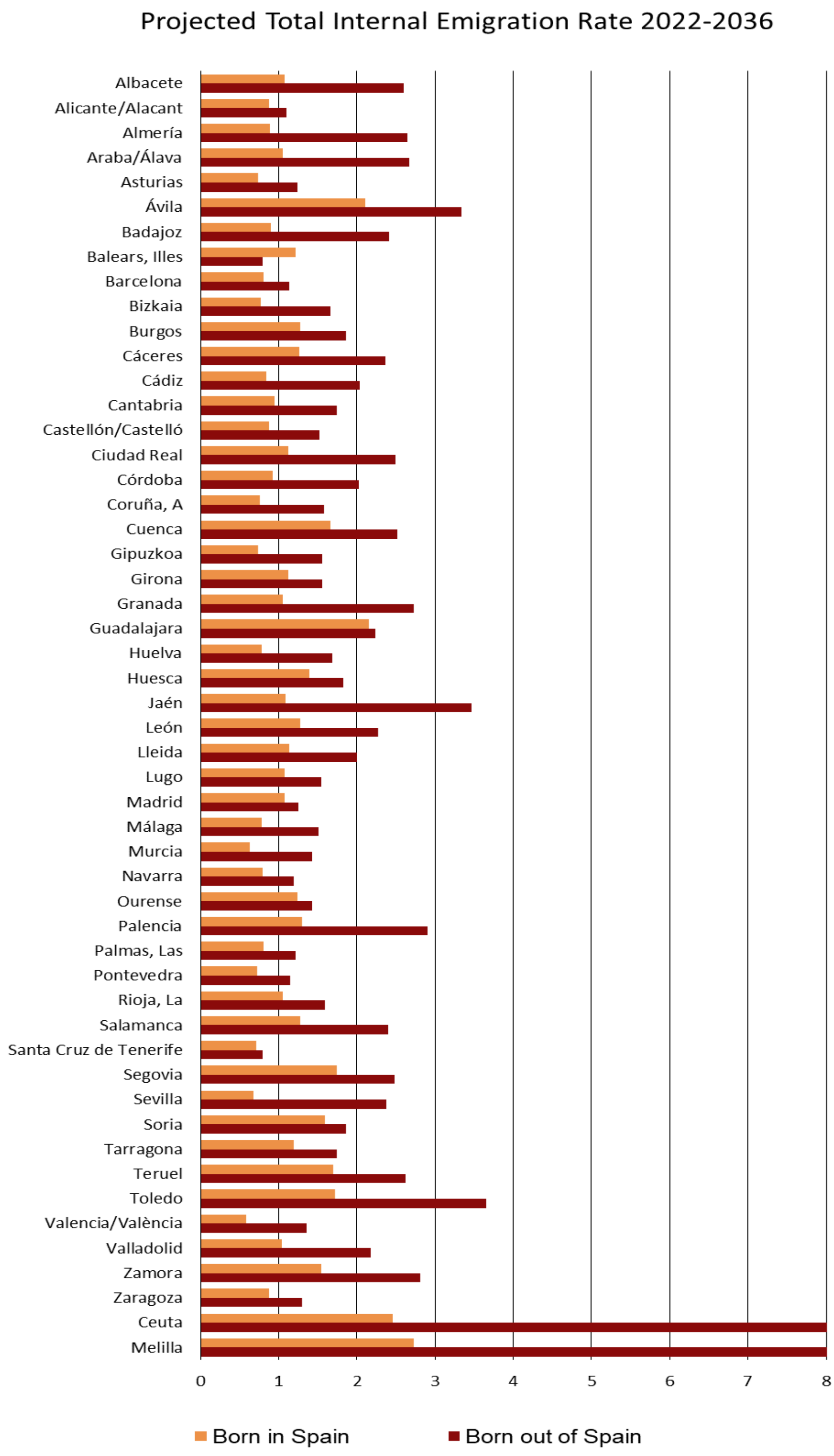
1. Projection of emigration intensity to the rest of Spain from each province according to place of birth:

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, except for the year 2020 for this edition of the projections. That is, it has been obtained as the average of the Synthetic Internal

Emigration Index for 2019 and 2021.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 2021) among the population resident in Spain as at 1 July of that year for said group according to the *Population Figures* (provisional figures for 2021).


Projected Total Internal Emigration Rate 2022-2036
Albacete
Alicante/Alacant
Almería
Araba/Álava
Asturias
Ávila
Badajoz
Balears, Illes
Barcelona
Bizkaia
Burgos
Cáceres
Cádiz
Cantabria
Castellón/Castelló
Ciudad Real
Córdoba
Coruña, A
Cuenca
Gipuzkoa
Girona
Granada
Guadalajara
Huelva
Huesca
Jaén
León
Lleida
Lugo
Madrid
Málaga
Murcia
Navarra
Ourense
Palencia
Palmas, Las
Pontevedra
Rioja, La
Salamanca
Santa Cruz de Tenerife
Segovia
Sevilla
Soria
Tarragona
Teruel
Toledo
Valencia/València
Valladolid
Zamora
Zaragoza
Ceuta
Melilla
0
1
2
3
4
5
6
7
8
Born in Spain
Born out of Spain

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 2017-2021 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 2017-2021 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 (2017-2021) 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 2017-2021 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 2017-2021 and has remained constant for the entire projection period.

For each year of the 2017-2021 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 2017-2021. 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 2021) among the population resident in Spain as at 1 July of that year for said group according to the *Population Figures* (provisional figures for 2021).

7 Projection scenarios

As in the previous edition, in the Population Projections 2022-2072 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.

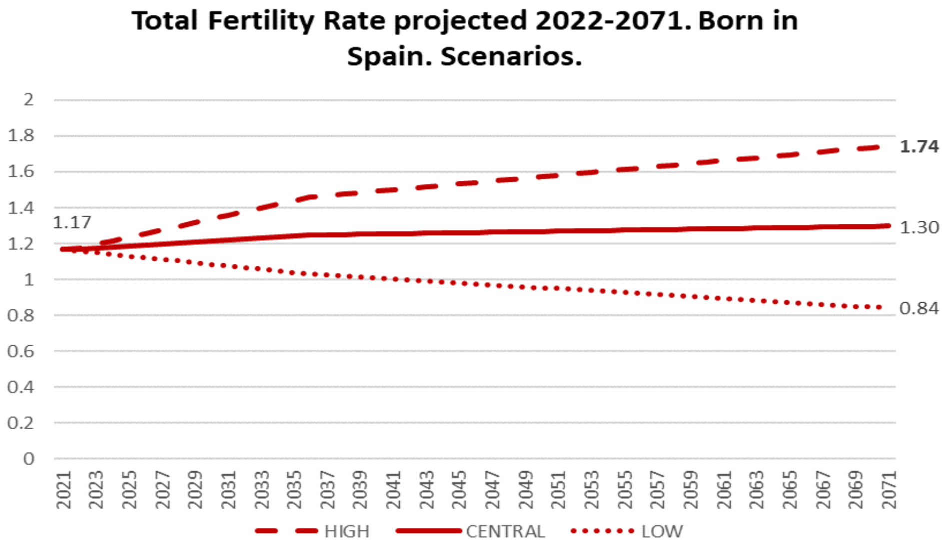
The scenarios considered are as follows:

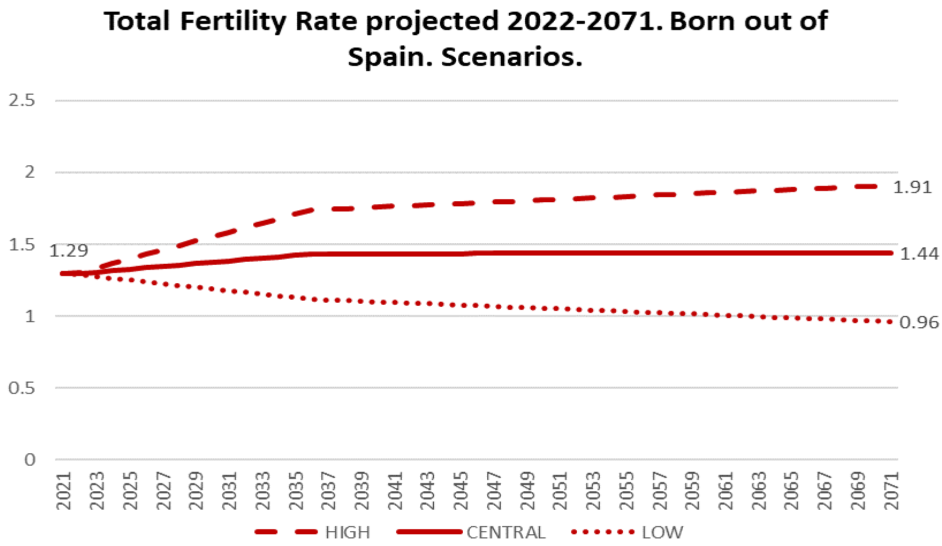
a) High / low fertility:

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 2021, and the median of the values given by the experts in demography, in the survey, for the years 2036 and 2071, 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 2021.

Therefore, in order to raise/reduce the projected fertility in the central scenario we establish for 2036 (within 15 years) and for 2071 (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:





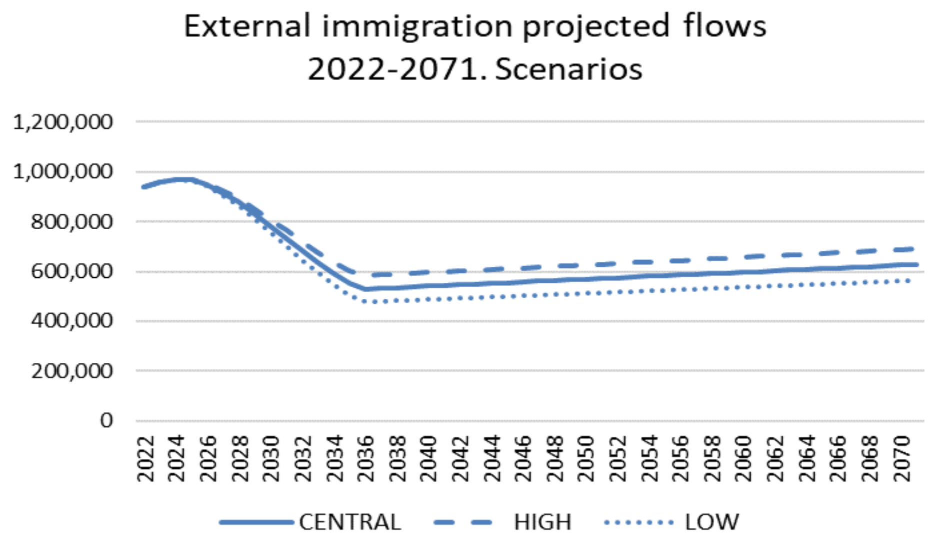
b) Migration balance high/low/nil:

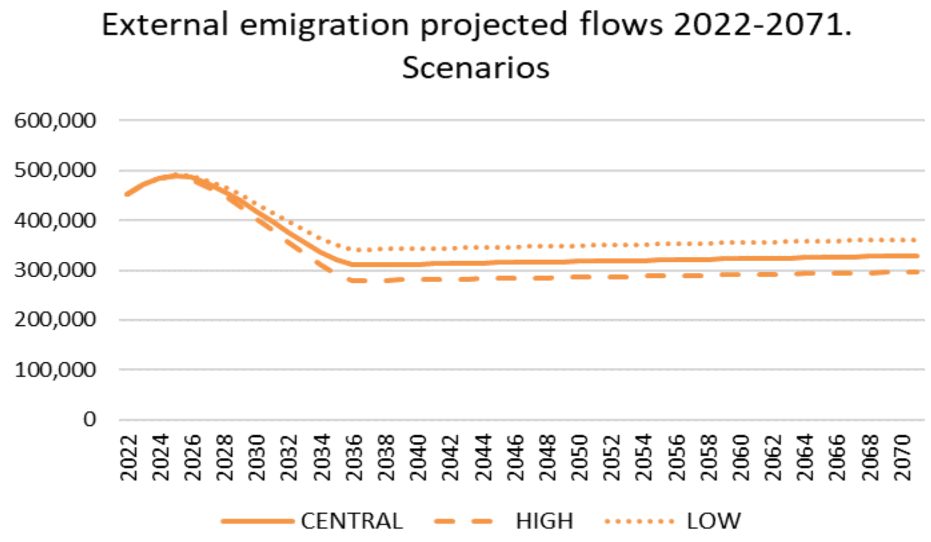
In order to construct different scenarios for the migration balance, the immigration and emigration values set in the central scenario for the year 2036 (15 years from now) and for the year 2071 (50 years from now) for each place of birth have been varied by 10% up and down for each place of birth. The 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 2036 and 2071 by 10% and reducing the emigration in those years by 10%.

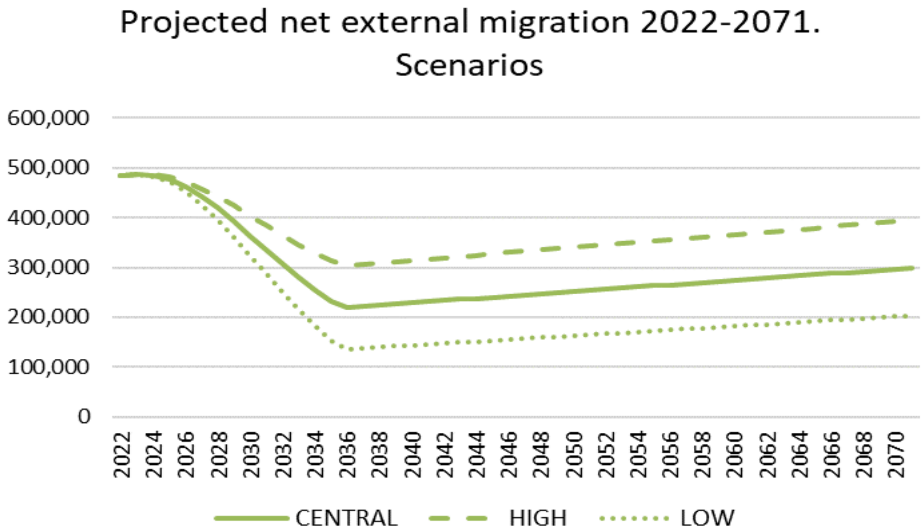
– Low migration balance scenario: combination of the projected migration series constructed by reducing the immigration values of 2036 and 2071 by 10% and increasing the emigration in those years by 10%.

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 2022-2037 and for the national total for the years 2022-2072.

- 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 2022-2037 and for the national total for the years 2022-2072.
- 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 2022-2036 and for the national total for the years 2022-2071.
- Annual deaths according to sex, age and year of birth, by Autonomous Community and province for the years 2022-2036 and for the national total for the years 2022-2071.
- Annual international migrations according to sex, age and year of birth of the migrant, by Autonomous Community and province for the years 2022-2036 and for the national total for the years 2022-2071.
- 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 2022-2036 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 2022-2036 and for the national total for the years 2022-2071 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 (2022-2037) broken down by Autonomous Community and province of residence and for the long-term period (2022-2072) 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 (2022-2036) broken down by Autonomous Community and province of residence and and for the long-term period (2022-2071) 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.