Population projections 2021-2070 for France – Method and assumptions

Volume 1

Documents de travail

N°2021-05 – November 2021

Insee
Mesurer pour comprendre

Élisabeth ALGAVA
Nathalie BLANPAIN

Institut national de la statistique et des études économiques

2021-05

Population projections 2021-2070

for France - Method and assumptions

Volume 1

Élisabeth ALGAVA* and Nathalie BLANPAIN*

November 2021

Direction des Statistiques Démographiques et Sociales - Timbre F001

88, avenue Verdier - CS 70058 - 92541 MONTROUGE CEDEX - France

Tél. : 33 (1) 87 69 62 82 - E-mail : dg75-f001@ insee.fr - Insee website: http://www.insee.fr

* Insee, division Enquêtes et études démographiques

Acknowledgements : The authors thank Isabelle Robert-Bobée, Sylvie Le Minez and Christel Colin for their proofreading and comments. We thank the 46 experts consulted for the quality of their analysis which allowed the development of the assumptions of this document: Didier BRETON, Carlo Giovanni CAMARDA, Anne GOUJON, Fanny JANSSEN, Jean-François LÉGER, Philippe LOUCHART, Gilles PISON, Grégoire REY, Jean-Marie ROBINE, Patrick SIMON, Anne SOLAZ, Laurent TOULEMON, Arkadiusz WISNIOWSKI, Didier BLANCHET, CSR Retraites ; Pascale BREUIL, Cnav ; Vianney COSTEMALLE, Drees ; Jérôme LÊ, Insee ; Virginie JOURDAN, Loreline COURT, Florian HATIER, DSED; Gautier MAIGNE, France Stratégie; Anthony MARINO and Amandine BRUN-SCHAMMÉ, COR; Misha KHODABIN, Hamza ZAKRAOUI, Samuel MENARD, DG Trésor; Sylvain PAPON, INSEE; Gwenaël PODESTA, DGEC; Clément ROUSSET, Drees; Bureaux retraites, handicap et dépendance et professions de santé, Drees; Gwenaël SOLARD, INSEE. Antonio ARGUESO, INE, Spain; Kim DUSTAN, Statistics New Zealand; Katarzyna GÓRAL-RADZISZEWSKA, Statistics Poland; Helen HUGHES, ONS, United Kingdom; Raymond KOHLI, OFS, Switzerland; Lena LUNDKVIST, Statistics Sweden; Dragos MONDIRU, INSSE, Romania; Olga POETZSCH and Felix zur NIEDEN, DESTATIS, Germany; Branislav SPROCHA, Slovakia; Astri SYSE and Michael THOMAS, Statistics Norway; Marie VANDRESSE, Federal Planning Bureau, Belgium; Livia VARGA and Zoltan CSANYI, KSH, Hungary, as well as a number of anonymous persons. We are grateful to Vianney Costemalle for providing us his probabilistic projection codes and for allowing us to quote from one of his publications presenting deterministic and probabilistic projections.

Summary

The French National Office for Statistics, INSEE has conducted a new set of population projections for France for the period 2021-2070. Like the previous ones published in 2016, these projections cover France as a whole (including five overseas departments).

The new projections are based on population estimates by sex and age on 1 January 2021, published in March 2021. As the previous ones, these projections are made using the component method, i.e., based on assumptions about the three elements that determine population change: fertility, mortality and migration. Some methodological changes have been made in the projection of each component. In addition, the integration of new data available in the calculation of trends has led to new assumptions on the evolution of these three components. These trends were analyzed excluding the effect of the pandemic since 2020. Specific assumptions were made for 2021 and 2022.

A set of 30 scenarios was established, including a baseline scenario, 26 variants and 3 working scenarios. The variants make it possible to analyze the effects of a change in assumptions on the projected results.

The baseline fertility and mortality assumptions have been significantly revised. Fertility is lower than in the previous exercise (a total fertility rate of 1.80 compared to 1.95 previously). Life expectancy is reduced by 2.6 years for men and 3.0 years for women in 2070 (87.5 years of life expectancy at birth for men compared to 90.1 years in the previous exercise and 90.0 years for women compared to 93.0 years). Given the very high uncertainty surrounding this assumption and the recent data (an average net migration of 73,000 from 2014 to 2017, the last year for which the net migration is available), the level of net migration has been maintained at +70,000 as in the previous projection.

The results were published in an Insee Première (https://www.insee.fr/fr/statistiques/5893969) and in an Insee Résultats (https://www.insee.fr/fr/statistiques/5893969) : On 1 January 2070, according to the baseline scenario of the projection, France would have 68.1 million inhabitants, i.e. 700,000 more than in 2021.

Key-words : population projections, population forecast, fertility, mortality, net migration, France.

Table of Contents

SUMMARY

THE 2021 PROJECTIONS INCORPORATE RECENT DEMOGRAPHIC CHANGES AND UPDATE THE 2016 PROJECTION

This working paper presents the methodology and assumptions for the 2021 population projections for France.

The previous population projections were published in 2016 (Blanpain, Buisson, 2016a, b and c). They were based on the age pyramid on 1 January 2013 and covered France, including the five overseas departments. Associated projections of the working population and households, and regional projections, were subsequently published.

The projections consist in projecting the population living in France (Metropolitan France, Guadeloupe, Martinique, Guyana, Reunion and Mayotte) from 2022 to 2070.

INSEE regularly updates its projections. As before, the 2021 population projections are based upon the component method. This method consists in projecting the population year by year, age by age, for men and women separately. From the age pyramid on 1 January 2021, the age pyramid on 1 January of the following year is projected by aging the population by one year, adding births, removing deaths, and adding net migration. This method therefore requires fertility, mortality and net migration assumptions. It can be described as a trend method in that the assumptions are based on what has happened in the recent past. The geographical coverage has been kept identical to that of 2016 (France including the 5 overseas departements).

The projection horizon is set at 2070, as for previous projections. Proposed for consultation, it has been validated by most of the experts who have expressed their views on the subject.

The choice of assumptions took place from February to September 2021. The procedure began with a consultation of some one hundred experts on the basis of a questionnaire (Volume 2 of this working paper) in order to obtain their opinion on potential changes in fertility, mortality and migration by 2070. The questionnaire contained an annex with a summary of demographic developments since the last projection exercise in 2016. Of the experts consulted, 46 responded. Between March and September 2021, the proposed assumptions, their justifications and their impacts were refined in the course of exchanges with certain experts and users.

THE EXPERTS WHO GAVE THEIR OPINION ON FUTURE DEMOGRAPHIC DEVELOPMENTS

Forty-six responses to the questionnaire were received, 38 of which were accompanied by permission for detailed publication by name in this working paper. The *full text of* their answers is in Volume 2 of the paper.

14 responses were received from researchers specialising in demographic issues: Didier BRETON, Carlo Giovanni CAMARDA, Anne GOUJON, Fanny JANSSEN, Jean-François LÉGER, Philippe LOUCHART, Gilles PISON, Grégoire REY, Jean-Marie ROBINE, Patrick SIMON, Anne SOLAZ, Laurent TOULEMON, Arkadiusz WISNIOWSKI and one anonymous respondent.

17 responses were received from people working in a French organization using or developing projections, most often within the official statistical system: Didier BLANCHET, CSR Retraites; Pascale BREUIL, Cnav; Vianney COSTEMALLE, Drees; Jérôme LÊ, Insee; Virginie JOURDAN, Loreline COURT, Florian HATIER, DSED; Gautier MAIGNE, France Stratégie; Anthony MARINO and Amandine BRUN-SCHAMMÉ, COR ; Misha KHODABIN, Hamza ZAKRAOUI, Samuel MENARD, DG Trésor; Sylvain PAPON, Insee; Gwenaël PODESTA, DGEC; Clément ROUSSET, Drees; Bureaux retraites, handicap et dépendance et professions de santé, Drees; Gwenaël SOLARD, Insee and 4 anonymous persons.

15 responses were written by persons working in a foreign national statistical institute (NSI) and responsible for the development of the projections in their country: Antonio ARGUESO, INE, Spain; Kim DUSTAN, Statistics New Zealand; Katarzyna GÓRAL-RADZISZEWSKA, Statistics Poland; Helen HUGHES, ONS, United Kingdom; Raymond KOHLI, SFO, Switzerland; Lena LUNDKVIST, Statistics Sweden; Dragos MONDIRU, INSSE, Romania; Olga POETZSCH and Felix zur NIEDEN, DESTATIS, Germany; Branislav SPROCHA, Slovakia; Astri SYSE and Michael THOMAS, Statistics Norway; Marie VANDRESSE, Federal Planning Bureau, Belgium; Livia VARGA and Zoltan CSANYI, KSH, Hungary and 3 anonymous.

THE 3 FERTILITY ASSUMPTIONS

Total fertility rate

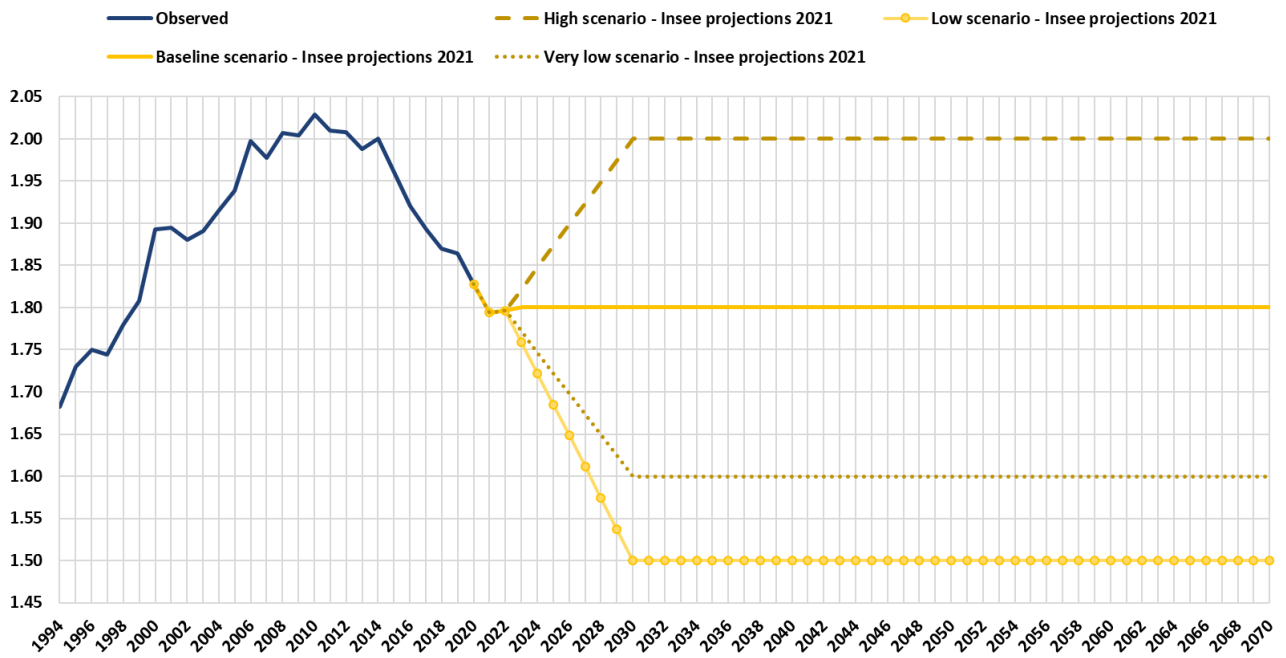
Taking into account recent developments and the position of experts, **a target of 1.80 for the total fertility rate (TFR) has been adopted for the baseline scenario**, slightly below the level currently observed (1.83 in 2020). This target would be reached by 2023. This is a significant revision from the much higher baseline fertility assumption of the previous 2016 exercise, at 1.95.

Compared to the 2016 exercise, the **gap between the baseline assumption and the high and low assumptions has been increased to +/-0.20**, compared to +/-0.15 in the 2016 projections. **The low assumption is at 1.60 and the high assumption at 2.00**, slightly below the replacement level. **The**

working scenario of very low fertility has been set at 1.50, a value close to the European average in 2019. The targets of the alternative assumptions are reached in 2030.

To account for the **pandemic**, based on recent data, specific assumptions, common to all scenarios, have been made for 2021 and 2020: the **TFR decreases from 1.83 in 2020 to 1.79 in 2021 and 1.80 in 2022**.

Observed and projected total fertility rate (TFR)

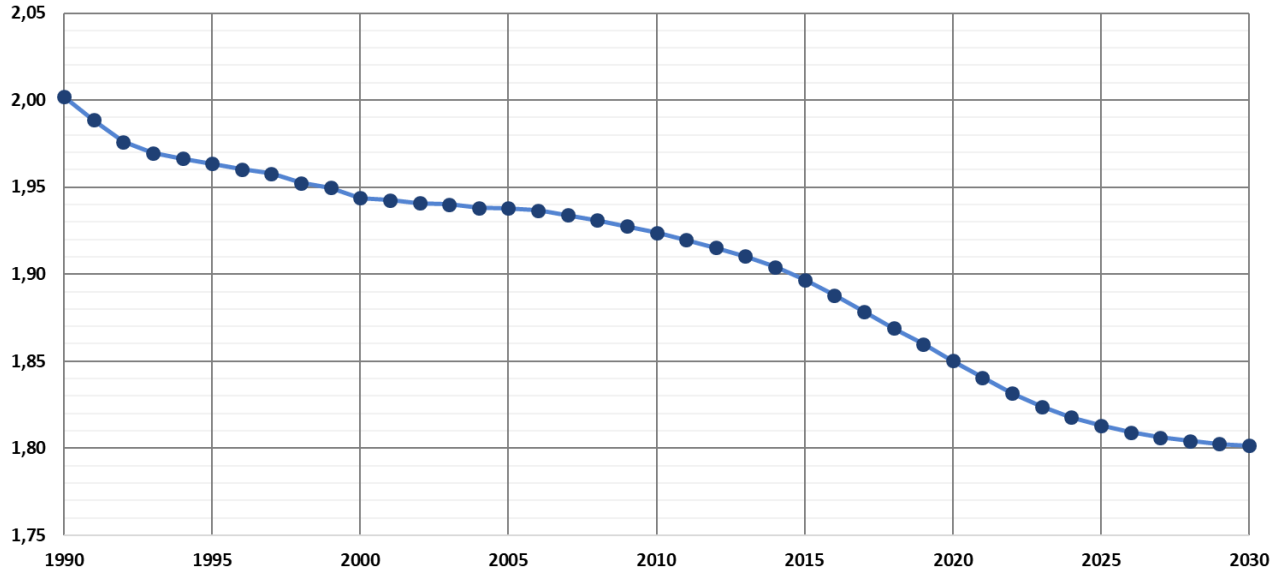


Source: Insee, population estimates and vital statistics until 2021. Population projection 2021-2070 (Insee Résultats).

Mean Age at Childbirth

In the new projection exercise, the mean age at childbirth continues to rise at a steady pace until 2052, when it reaches the level of 33 years, considered as a ceiling. In 2016, the same pattern was adopted, with a ceiling age of 32 years reached in 2040. The application of a ceiling of 33 years, reached in 2052, means that, over the last 18 years of the projection, the phenomena of postponement of childbearing diminish, and, from the 2030 generation onwards, the completed fertility eventually reaches the TFR set at 1.80.

Projected final descent of generations 1990-2030 in the baseline scenario



Source: Insee, population estimates and vital statistics until 2021. Population projection 2021-2070 (Insee Résultats). For the 1990 generation, for example, fertility data are observed before age 31 and projected at 31 and after.

Interpretation: We do not know the final descent of the generations of women born after 2020 because they will not yet be 50 years old in 2070. However, by construction, the final descendants and the TFR eventually merge when the age at maternity is stable: for the generations born in 2030, the final descendants would be equal to the TFR, stabilised at 1.80 children per woman in the baseline scenario.

Coverage: France excluding Mayotte from 2000 to 2013, France from 2014 onwards.

THE 3 MORTALITY ASSUMPTIONS

Baseline scenario

As in previous projections, mortality rates are projected age by age. At each age, the downward trend in mortality observed over the last 10 years excluding the pandemic, i.e. 2010-2019, is extended. A smoothing is performed between 6 and 79 years for women and 10 and 79 years for men, in order to smooth out period and cohort effects.

As in the 2016 projections, the baseline scenario incorporates a cohort effect, observed in the past for men and women born between 1941 and 1955. While, for a given age, mortality decreases from generation to generation, this is almost not the case for these generations in adulthood: their mortality remains almost identical to that of the generations that preceded them (Blanpain, 2020a). The baseline scenario assumes that this cohort effect observed for people born between 1941 and 1955 will persist at higher ages.

Compared to the previous projections, the new projections revise life expectancy at birth in 2070 downwards for women (-3.0 years) and men (-2.6 years). In 2070, life expectancy at birth is

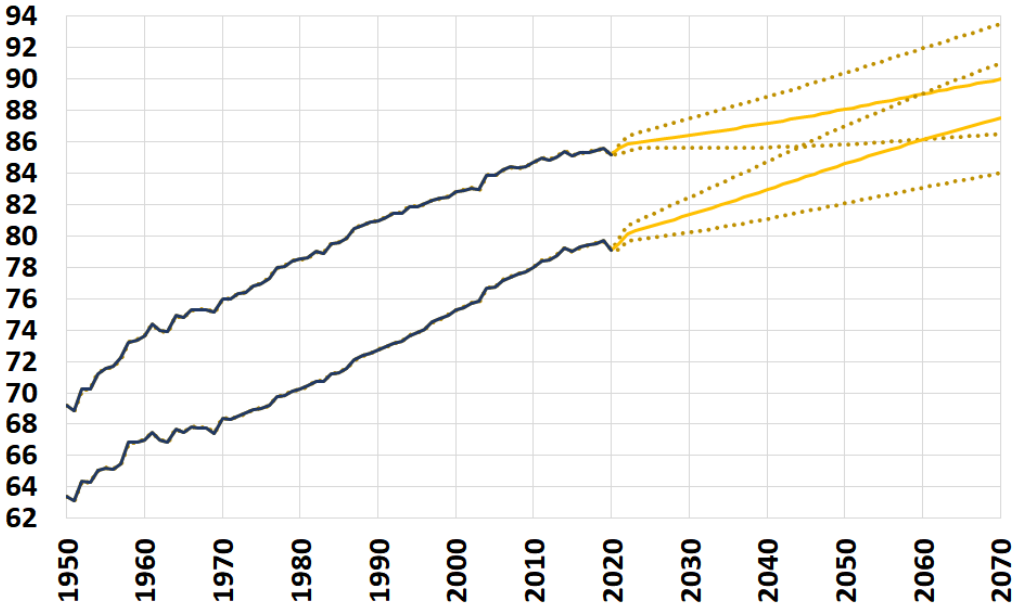
90.0 years for women and 87.5 years for men. This downward revision is explained by a slowdown in the increase in life expectancy since 2014.

The reduction in the gap in life expectancy at birth between men and women is slightly greater than in previous projections: the gap is 2.5 years in 2070, compared to 2.9 years in the last exercise.

High and low life expectancy variants

Under the high life expectancy assumption, life expectancies at birth are 3.5 years higher than those retained for the baseline level in 2070. Symmetrically, in the low assumption, they are, 3.5 years lower than those retained for the baseline level. The gap between the variants has been revised upwards: in the last projections it was 3.0 years compared to the baseline assumption in 2070, the last year of the projection. This upward revision is justified by the increased uncertainty linked to the pandemic and by the recent slowdown in the rise in life expectancy, which may or may not continue in the future.

Life expectancy at birth for men and women



Source: Insee, population estimates and vital statistics until 2021. Population projection 2021-2070 (Insee Résultats).

Coverage: Metropolitan France until 1993, France excluding Mayotte from 1994 to 2013, France from 2014 onwards.

THE 3 HYPOTHESES OF NET MIGRATION

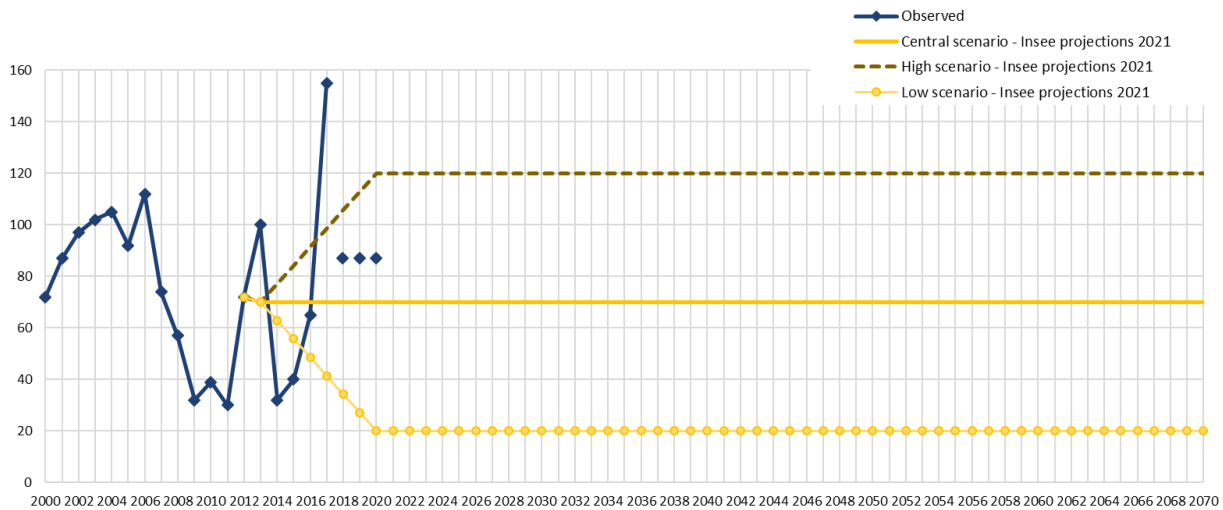
The baseline assumption for net migration has been maintained at +70,000, as in the previous exercise. This has many advantages: it corresponds to the average of the most recent years observed, the UN and Eurostat projections use similar assumptions, and it was also the baseline assumption of the previous projection exercise. It must be emphasised that the baseline assumption concerns the annual average of the migratory balance between now and 2070 and that each year the actual balance varies and will vary greatly. **Even more than for the other components, there is a great deal of uncertainty surrounding the evolution of net migration. This is all the more true in the context of the health crisis.**

The 2016 assumptions have also been maintained for the variants, with a low variant at +20,000 and a high variant +120,000. The 2016 working variant is also retained, with **zero net migration at each age**. The difference between the variants is high, reflecting the high uncertainty. As this uncertainty also weighs on the year 2021, the high and low variants are reached as early as 2021 in the scenarios that use them.

The interpretation by the different categories of flows is instructive because it reminds us that a migratory balance is the result of different migratory movements of entries and exits. Thus its evolution depends on that of these different flows, each influenced by different factors. On the **other hand, it is only illustrative because the evolution of the different flows is even more uncertain than that of the balance, and different situations are compatible with a balance of +70,000.** It could correspond to an immigrant balance of +170,000 and a non-immigrant balance of -100,000, a situation close to the average observed over the decade 2006-2017. But it could also correspond to larger movements that offset each other, as seems to be the trend in recent years.

The target profile by sex and age of the migratory balance that has been adopted is two-thirds female. It is negative between the ages of 18 and 26. In this age group, the inflows are not sufficient to compensate for the outflows, highly concentrated at these ages. Net migration is positive before 18 and after 26.

Observed and projected net migration from 2000 to 2070



Coverage: France excluding Mayotte from 2000 to 2013, France from 2014 onwards.

MAIN INDICATORS ASSOCIATED WITH THE DIFFERENT ASSUMPTIONS

Comparison of the baseline scenarios of the 2016 and 2021 exercises

	Baseline scenario 2016	Baseline scenario 2021
Fertility		
Total fertility rate	1.95 from 2013 to 2070	1.80 from 2022
Mean age at childbirth	32.0 years from 2040	33.0 years from 2052
Life expectancy		
Life expectancy at birth for women	93.0 years in 2070	90.0 years in 2070
Life expectancy at birth for men	90.1 years in 2070	87.5 years in 2070
Migration		
Value of annual net migration	+70,000 people per year	+70,000 people per year

Variants of the 2021 projections exercise

	Situation in 2020	Baseline assumption	Low assumption	High assumption	Working assumption
Fertility					
Total fertility rate	1.83 children per woman	1.80 children from 2022	1.60 children from 2030	2.00 children from 2030	1.50 children from 2030
Mean age at childbirth	30.8 years	33.0 years from 2052			
Life expectancy					
Life expectancy at birth for women	85.1 years	90.0 years in 2070	86.5 years in 2070	93.5 years in 2070	85.6 years from 2021
Life expectancy at birth for men	79.1 years	87.5 years in 2070	84.0 years in 2070	91.0 years in 2070	79.7 years from 2021
Migration					
Value of annual net migration	+ 70,000 per year	+ 70,000 per year	+ 20,000 per year	+ 120,000 per year	0 per year

NUMBER OF SCENARIOS AND VARIANTS

For each component (fertility, mortality, net migration), the projection exercise therefore uses three assumptions: a "baseline" assumption, a "low" assumption and a "high" assumption. As in the previous exercise, the low and high assumptions are symmetrical with respect to the baseline assumption for the total fertility rate, life expectancy and the level of net migration.

The combination of these assumptions leads to 27 population projection scenarios. Among these 27 scenarios, the so-called "baseline" scenario (baseline assumption for each component) is clearly identified and further detailed.

To these 27 scenarios are added 3 so-called "working" scenarios: constant mortality (maintaining the mortality rates by sex and age observed in 2019 throughout the projection period), the same number of entries and exits from the territory (zero net migration throughout the projected period) and a very low fertility, corresponding to the current European level (TFR of 1.5 children per woman from 2030 onwards).

The 30 scenarios obtained by combining assumptions

Name of the scenario	Fertility	Life expectancy	Migration
Baseline	Baseline	Baseline	Baseline
1st group: 6 scenarios that differ from the baseline scenario by only one component			
High fertility	High	Baseline	Baseline
Low fertility	Low	Baseline	Baseline
High life expectancy	Baseline	High	Baseline
Low life expectancy	Baseline	Low	Baseline
High migration	Baseline	Baseline	High
Low migration	Baseline	Baseline	Low
2nd group: 4 scenarios that lead to the highest, lowest, youngest and oldest population in 2070			
High population	High	High	High
Low population	Low	Low	Low
Youth population	High	Low	High
Elderly population	Low	High	Low
3rd group: 16 other scenarios combining baseline, low and high assumptions			
4th group: 3 working scenarios			
Constant mortality	Baseline	Constant=2019	Baseline
Very low fertility	1.50	Baseline	Baseline
Zero migration	Baseline	Baseline	None

This volume 1 of the working paper begins with a presentation of the expert consultation and the general principles adopted (part I): the projection method, the starting point, the time horizon and the scenarios. The following parts detail the construction of the fertility (part II), mortality (part III) and migration (part IV) assumptions. Part V is devoted to dissemination.

A second volume consists of the appendices: documents from the expert consultation and their full responses, question by question.

PART 1 : PROJECTION METHOD

1) CONSULTATION WITH EXPERTS AND THEIR RESPONSES

The preparation of the new projections began with a consultation of some 100 experts on the basis of a questionnaire (Volume 2 of this working paper), in order to gather their views on potential changes in fertility, mortality and migration. This questionnaire contained in its annex a summary of demographic developments since the last projection exercise published in 2016.

We received 46 responses to the questionnaire we sent out, twice as many as in 2016, probably due to the pandemic context. The pandemic was able to stimulate more in-depth discussions on recent trends in mortality and fertility, and to highlight the difficulties inherent in the projection exercise. We are obviously very grateful to the experts who have been very active: relying on their knowledge and skills is all the more crucial for this exercise, given the much greater-than-usual uncertainty about developments, at least in the short term and perhaps in the medium term.

We distinguish three categories of respondents:

- The researchers, specialists in demographic issues, 14 respondents;
- Persons working in a French organization using or developing projections, most often within the Official Statistical System, 17 respondents, referred to as OSS;
- Persons working in a foreign national statistical institute (NSI) and responsible for the preparation of projections in their country, 15 respondents, referred to as NSI.

Eight respondents declined detailed publication by name in this working paper: 1 researcher response, 4 responses from the OSS and 3 responses from NSIs. These will be referred to anonymously in the remainder of the paper, leaving 13 researcher responses, 13 OSS responses and 12 NSI responses that will be used by name.

Respondents were asked whether their response reflected their personal opinion or that of their institution. Researchers chose the "personal opinion" response, rightly emphasizing that it was based on their knowledge of the field(s). Respondents in the OSS and NSI categories were more divided, although the "personal opinion" response was chosen slightly more often. The question

was probably ambiguous: their institution cannot be committed and responsible for their answers, but at the same time, the questionnaire is often completed collectively and discussed within the institution. Moreover, the answers given are closely related to the needs and practices of their institution in terms of projections.

A. RESEARCHERS

1	Didier BRETON	Professor of demography, University of Strasbourg, associate researcher at the Institut national d'études démographiques (Ined)
2	Carlo Giovanni CAMARDA	Researcher, Ined
3	Anne GOUJON	Research Director, Wittgenstein Centre for Demography and Global Human Capital, IIASA, OeAW, University of Vienna and Contract Agent, European Commission Joint Research Centre, Ispra, Italy
4	Fanny JANSSEN	Prof. dr., Senior researcher, Netherlands Interdisciplinary Demographic Institute, The Hague NL and Honorary Professor, Demography Department, Faculty of Spatial Sciences, University of Groningen, the Netherlands
5	Jean-François LÉGER	Professor and researcher, University of Paris 1 Panthéon Sorbonne, Institute of Demography (Idup)
6	Philippe LOUCHART	Demographer, Paris Region Institute
7	Gilles PISON	Professor emeritus at the Muséum national d'histoire naturelle, associate researcher at INED
8	Grégoire REY	Director of CépiDc-Inserm
9	Jean-Marie ROBINE	Professor emeritus Inserm and EPHE, scientific advisor to the management of INED.
10	Patrick SIMON	Research Director, Ined.
11	Anne SOLAZ	Research Director, Ined.

12	Laurent TOULEMON	Research Director, Ined.
13	Arkadiusz WISNIOWSKI	Senior Lecturer in Social Statistics, Social Statistics Department, University of Manchester

B. OFFICIAL STATISTICAL SYSTEM AND USER AGENCIES (OSS)

14	Didier BLANCHET, CSR Pensions	Pensions Monitoring Committee (CSR-Retraites)
15	Pascale BREUIL, Cnav	Director of Statistics, Prospective and Research (DSPR), Caisse nationale d'assurance vieillesse (Cnav). *Response: technical advice from the DSPR*
16	Vianney COSTEMALLE, Drees	Deputy head of the Population Health Status office, Directorate for Research, Studies, Evaluation and Statistics (Drees), Ministry of Solidarity and Health. *Answer: personal opinion*
17	Jérôme LÊ, Insee	Head of the Immigration Unit, Insee. *Answer: personal opinion*
18	Virginie JOURDAN, Loreline COURT, Florian HATIER, DSED	Virginie JOURDAN, Head of the Studies and Statistical Surveys Division Loreline COURT, Research Officer Florian HATIER, Head of the Division for the Valorisation of Administrative Sources Ministry of the Interior *Response: advice from DSED*
19	Gautier MAIGNE, France Stratégie	Director of the Society and Social Policies Department, France Stratégie With Julien ROUSSELON and Mathilde VIENNOT *Answer: contribution not from a specialist in these subjects, but reflecting a 'user experience', built on feedback from the department team in its use of these data over the last 5 years.*
20	Anthony MARINO and Amandine BRUN-SCHAMMÉ, COR	Anthony MARINO, Project Manager Amandine BRUN-SCHAMMÉ, Project Manager, Conseil d'Orientation des Retraites (COR) *Answer: personal opinion* *These responses are not binding on the COR or the COR General Secretariat. However, they have been discussed within the Secretariat General team.*

21	Misha KHODABIN, Hamza ZAKRAOUI, Samuel MENARD, DG Treasury	Misha KHODABIN, Deputy Head of Office Hamza ZAKRAOUI, Deputy Head of Office Samuel MENARD, Head of Office Pensions and redistribution Office Ministry of Economy, Finance and Recovery. *Answer: institution*
22	Sylvain PAPON, Insee	Head of the Demographic Accounting Section, INSEE *Answer: personal opinion*
23	Gwenaël PODESTA, DGEC	Deputy Head of the Emissions, Projections and Modelling Office, Ministry of Ecological Transition. *Answer: institution*
24 a	Clément ROUSSET, Drees	Head of the Microsimulation Unit, Pensions Office, Drees, Ministry of Solidarity and Health *Answer: institution*
24 b	BRET, BHD and BPS, Drees	Pensions, Disability and Dependency, and Health Professions offices, Drees, Ministry of Solidarity and Health
25	Gwenaël SOLARD, Insee	Head of the Census Methods and Processing Division, Insee. *Answer: personal opinion*

26	Antonio ARGUESO, INE, Spain	Director of socio-demographic statistics, INE, Spain. *Answer: The team involved in Population projections at INE (3 people)*
27	Kim DUSTAN, Statistics New Zealand	Senior Demographer, Statistics New Zealand *Answer: personal opinion*
28	Katarzyna GÓRAL-RADZISZEWSKA, Statistics Poland	Consultant, Statistics Poland *Answer: institution*
29	Helen HUGHES, ONS, United Kingdom	Senior Research Officer, Population and Household Projections, Centre for Ageing and Demography, Office for National Statistics, UK *Answer: institution*
30	Raymond KOHLI, FSO, Switzerland	Scientific collaborator (population scenarios, mortality tables, demographic methods), Demography and Migration Section, Federal Statistical Office (FSO), Switzerland *Answer: personal opinion*
31	Lena LUNDKVIST, Statistics Sweden	The form is filled in by the group at Statistics Sweden that works with the population projection. *Answer: The answers are based on our experiences in Sweden in the work with the projection.*
32	Dragos MONDIRU, INSSE, Romania	Expert INSSE, Romania *Answer: institution*
33	Olga POETZSCH and Felix zur NIEDEN, DESTATIS, Germany	Both Assistant Head of Section, DESTATIS Germany *Answer: personal and institutional opinion*
34	Branislav SPROCHA, Slovakia	Head of the Demographic Research Centre in Bratislava *Answer: personal opinion*
35	Astri SYSE and Michael THOMAS, Statistics Norway	Statistics Norway, Department of Research, senior researchers, and responsible for Norway's national projections
36	Marie VANDRESSE, Federal Planning Bureau, Belgium	In charge of population and household projections, Federal Planning Bureau, Belgium *Answer: personal opinion*
37	Livia VARGA and Zoltan CSANYI, KSH, Hungary	Statistician, Census and Population Statistics Department, KSH Hungary *Answer: personal opinion*

2) THE PROJECTION METHOD

A. THE PRINCIPLE OF THE COMPONENT METHOD

Population projections are made using the component method. The projections consist of estimating, year by year, for men and women separately, the number of births, deaths at each age and net migration (entries minus exits from the territory) also at each age.

The starting point for the projection is the population by sex and age on 1 January 2021, the total of which is based on the population estimates and vital statistics published in March 2021 (Papon, Beaumel, 2021). The number of inhabitants is projected for each 1 January, between the starting year (2021) and the fixed horizon (2070). On 1 January n+1, the number of inhabitants is equal to the population on 1 January of the previous year n, increased by births and the balance between population entries and exits in the territory during year n, and decreased by deaths.

$$Pop_{1.1.n+1} = Pop_{1.1.n} + Births_{n} - Deaths_{n} + NetMigration_{n}$$

In some years, this equation includes a fourth component, known as the adjustment component. "The introduction of an adjustment is intended to ensure consistency between, on the one hand, the change in the population of France deduced from the results of two censuses and, on the other hand, the components of this change, i.e. the natural balance and the migratory balance, estimated elsewhere. The adjustment then constitutes a third, fictitious, component of the population change, which makes it possible to adjust the population estimates to the census results. The adjustment thus reflects a lack of comparability between the figures from two censuses. It may be linked to a change in the census method but also to changes in society itself[1].

Due to a change in the population census questionnaire in 2018, aimed at improving knowledge of multi-residence situations, an adjustment was introduced to estimate population changes with unchanged questioning. This questionnaire effect is visible for eight years, from 2015 to 2022, given the census method [Insee, 2021a and b].

The projection assumptions are for net in-migration and out-migration by sex and age (net migration), mortality rates by sex and age, and fertility rates by age.

The number of deaths of women (or men) of age (a) reached in the year is calculated by applying the projected mortality rates by sex and age (reached in the year, Box 1) to the 'average' population of the year. This 'average' population is estimated by the number of women (or men) present on 1 January (of age a-1), to which is added half of the net migration of women (men) of age (a). It thus takes into account variations in population numbers during the year due to exchanges with the outside world, and it is consistent with the definition of mortality rates established in the

[1] Note "Adjustment and population variations", available on the insee.fr website: https://www.insee.fr/fr/metadonnees/source/serie/s1169/documentation-methodologique

demographic situation (Beaumel, Papon, 2021). In year n, the number of deaths of persons of sex s and age a (reached in the year) is thus calculated as follows, if a>0 :

$$Deaths_{n,s}^{a} = \left(Pop_{1.1.n,s}^{a-1} + \frac{1}{2} \; x \; NetMigration_{n,s}^{a} \right) \; x \; MortalityRate_{n,s}^{a}$$

The number of deaths of newborns is calculated, for boys and girls, by applying to the births of the year the mortality rates at age 0, i.e. :

$$Deaths_{n,s}^{0} = Births_{n,s} \; x \; MortalityRate_{n,s}^{0}$$

The number of births is calculated by applying the projected fertility rates by age (attained in the year) to the average population of women of fertile ages (15-50 years). The number of births to women of age (a) in year n is equal to the fertility rate of these women, multiplied by the average number of women of that age. This average number is estimated by the number of women present on 1 January (of age a-1, i.e., on 1 January), to which is added half of the net migration of women of age (a), and from which is subtracted half of the deaths of women of age (a). It thus takes into account variations in the number of women during the year due to exchanges with other countries and deaths, and it is consistent with the definition of fertility rates established by INSEE in the demographic situation (Beaumel, Papon, 2021). The annual number of births is thus calculated as follows:

$$Births = \sum_{a=15}^{50} \left(Pop_{1.1.n,Women}^{a-1} + \frac{1}{2} \left(NetMigration_{n,Women}^{a} - Deaths_{n,Women}^{a} \right) \right) \; x \; FertilityRate_{n}^{a}$$

where a is the age reached in the year and n the year

The births are divided between boys and girls (105 boys for 100 girls).

The population on 1 January of year n+1 by sex and age reached on 1 January n+1 is then deduced from the population by sex and age on 1 January n as follows

$$Pop_{1.1.n+1,s}^{a} = Pop_{1.1.n,s}^{a-1} - Deaths_{n,s}^{a} + NetMigration_{n,s}^{a} + Adjustment_{n,s}^{a} \quad for \; a > 0$$

$$Pop_{1.1.n+1,s}^{0} = Births_{n,s} - Deaths_{n,s}^{0} + NetMigration_{n,s}^{0} + Adjustment_{n,s}^{0} \quad for \; a = 0$$

where *Ajustment* represents the adjustment component, the years for which it was introduced.

Box 1 - Some definitions

- The **age reached in the year** is the age a person reaches in a given calendar year. It is the age on 31 December of that year. It is also the difference between a given year and the year of birth. **Age in completed years** is the number of full years that have elapsed between the person's date of birth and the reference date used.

- The **mortality rate** (or risk of death) at age (a) is obtained by dividing the number of deaths in year n of persons of the generation born in (n-a) by the number of persons of that generation on 1 January of year n, to which is added half the net migration. The mortality rates are calculated by age reached during the year.

  The **life expectancy at birth** represents the mean length of life – i.e. the mean age at death – of a synthetic cohort exposed at each age to the mortality patterns of a given year.. It is a synthetic indicator of the mortality rates for the year in question.
- **Calculation of life expectancy**

In a given year n, life expectancy at birth is the average age at death of a synthetic cohort subject at each age to the age-specific risks of death observed in that year. The method of calculation is the same as that used in the publication of the demographic situation.

It is calculated as follows:

$$E_0^n = 0.5 + \frac{\sum_{i=1}^{120} S^n(i)}{S(0)}$$ where S(i) is the number of survivors at age i . By convention, S(0)=100,000.

The number of survivors of completed age is calculated by applying the proportion of persons who died in the year before their birthday to the number of survivors of completed age.

The number of survivors at each completed age is calculated by recurrence:

$$S^n(i) = S^n(i-1) * (1 - q^n{}_{i-1})$$ with i>=1 and qi-1 is the mortality rate at age i-1 (completed age) observed in year n.

In the same way, life expectancies can be defined at a given age x. This is the average age at death of the persons still alive at the completed age x, for a synthetic cohort.

$$E_x^n = 0.5 + \frac{\sum_{i=x+1}^{120} S^n(i)}{S(x)}$$

Box 1 - Some definitions (continued)

- In a given year n, the age-specific **fertility rate** (a) relates the number of births to mothers of age (a) to the average number of women of that age in that year (midpoint population).
  Fertility rates are calculated by age reached in the year.

- The **total fertility rate** is the sum of the age-specific fertility rates. This indicator is interpreted as the average number of children per woman for a synthetic cohort of women who would have the fertility rates observed at each age in year n throughout their fertile life. It thus mixes the behaviour of various generations of women. It is a synthetic indicator of fertility rates for year n.

- The **average age at maternity** is also deduced from the age-specific fertility rates. It completes the total fertility rate: it corresponds to the average age at which the fictitious generation in question gives birth to its children.

- The **completed fertility** of a given generation is the average number of children born to women of that generation.

- The **natural balance** in a given year is the difference between the number of births and the number of deaths during the year. Net migration is the difference between the number of people entering the territory and those leaving.

B. THE POSITION OF THE EXPERTS ON THE METHOD

The question was:

Q6 We do not plan to change the projection method for this exercise: it will be based on the component method (births, deaths, migration). However, do you have any advice on changes to improve the projections in the future or examples of practical use of different methods?

Some twenty responses emphasised their satisfaction with the method used. Jean-François Léger (5) underlines the main arguments: " À cette échelle géographique, cette méthode a tout de même l'avantage d'être simple à mettre en œuvre et elle peut s'appuyer sur une bonne documentation sur les évolutions des trois composantes de l'évolution d'une population. Cette simplicité rend cette méthode transparente et facilite l'appropriation des résultats par les utilisateurs potentiels de ce travail. "

The component method in particular is unanimously supported and does not seem to have any real alternative. The experts also agree on the importance of conveying to users and the general public the uncertainty inherent in the projection exercise.

This can be done through variants further away from the baseline scenario, in order to communicate the idea that extreme values could also be reached (12, 35).

For others, such as Kim Dustan (Statistics New Zealand, 27), this means using **probabilistic or stochastic models** to project one or more components: "Conveying uncertainty in a meaningful way is an obvious area for improvement. Alternative deterministic projections convey uncertainty in a qualitative way, but stochastic projections convey uncertainty in a quantitative way. The stochastic projections are actually more intuitive for users to interpret, and also convey what trends are more certain than others. This perspective is reflected in the responses on scenarios. Thus, Giovanni Carlo Camarda (2) thinks that we shoud use a probabilistic approach: "travailler avec des scénarios déterministes n'est pas la meilleure façon de produire des prévisions adéquates. Je pense que l'utilisation d'une approche probabilistique est plus appropriée et la littérature récente offre une longue série d'options, notamment en ce qui concerne les prévisions de mortalité". Kim Dustan (Statistics New Zealand, 27) notes, however, that even as a complement to a probabilistic approach, working scenarios, supported by a particular hypothesis (what if?) remain of value.

Other experts suggest comparing probabilistic and deterministic approaches (Box 2) in an experimental way, including using the responses of the expert panel to calibrate the probabilistic models (13). Vianney Costemalle carried out this comparison exercise for the 2016 French projections (Costemalle, 2020).

On the contrary, several experts state that they do not believe it is necessary to use probabilistic models (6, 7, 14).

Didier Blanchet, of the CSR Retraites (14), thinks that communicating the results of these models is not easy and Philippe Louchart (6) that adequate past series are lacking for France: "L'utilisation de méthodes de **projections probabilistes** est souvent évoquée mais bute encore sur l'absence de données sur longue période à l'échelle de la France entière (sauf à projeter séparément et avec des méthodes différentes la France métropolitaine et l'outre-mer) et sur la **difficulté à modéliser les migrations** faute de données détaillées sur longue période relatives aux entrées et aux sorties du territoire français. Cette limite est encore plus nette à une échelle infranationale".

Some experts stress the importance of using appropriate methods for each component (4, 16), even if it means combining deterministic and stochastic models (37).

The projection exercise is particularly difficult for migration, as Jérôme Lê of INSEE reminds us (17). To improve the quality of the projection, several experts suggest that we project inflows and outflows separately, possibly distinguishing by sex and place of birth (14, 15, 19, 26, 36). Marie Vandresse (Federal Planning Bureau, Belgium, 36) and José Argueso (INE, Spain, 26) draw on their national experiences in this regard. Gautier Maigne (France Stratégie, 19) nevertheless pointsout that the data on inflows and outflows need to be made more reliable and suggests a few ways of improving them. Astrid Syse and Michael Thomas (35) suggest communicating more about the uncertainty of migration: "We agree that volatile changes in net migration is difficult to project, and perhaps not warranted, but instead focus on communicating that there will be annual changes not accounted for in the "smooth" long-term trends?".

Virginie Jourdan, Loreline Court and Florian Hatier (DSED) suggest to take into account the link between migration and fertility: " tenir compte de l'impact des migrations (et des ICF plus élevés de femmes issues de l'immigration) sur l'ICF global selon les hypothèses retenues". In a similar vein, and even more detailed, Gautier Maigne (France Stratégie, 19) suggests making differentiated fertility and mortality projections according to the country of birth.An anonymous person also suggests that scenarios should include the interactions between components, as it seems unlikely to assume that the components move independently from each other.

Other suggestions are made in isolation:

- Philippe Louchart (6) is considering integrated national and sub-national projections: " une projection intégrée et simultanée de la population des grandes régions dans leur ensemble pour aboutir in fine à la population de France […] constitue une autre voie qui, pour l'instant, pâtit encore d'un manque de données rétrospectives sur les migrations interrégionales";
- Anne Goujon (3) would like to add a multi-state perspective to the projections, distinguishing between urban and rural population, by education level, etc. (see also Goujon, 2020);
- Michal Thomas and Astrid Syse (35) suggest testing the use of a model to project TFR;
- Gautier Maigne (France Stratégie, 19) suggests making household projections and intermediate revisions of the projections.

Laurent Toulemon (12) insists on the positioning of the new projections in relation to the previous ones: "1. Modifier au minimum les projections par rapport aux projections précédentes, pour éviter de faire le yoyo derrière la conjoncture; 2. Justifier les changements de manière explicite et présenter leur ampleur de manière lisible".

Box 2 - Deterministic approach, probabilistic approach
Different ways of looking at the future

This box contains an extract from Vianney Costemalle's article presenting the deterministic and probabilistic approaches [Costemalle, 2020].

- ### Deterministic approach

"In the first instance, what we are looking to project depends, from a deterministic standpoint, on certain parameters. The selection of these parameters represents a hypothesis that is also referred to here as a scenario. A scenario is then given detailing the way in which these parameters are considered most likely to develop on the basis of accumulated knowledge, expert opinions and intuition. A given scenario corresponds to one single possible projection, and the relationship between the two is deterministic. In cases where the scenario plays out as expected, the projection will be certain. Deterministic projections answer the question: "What would happen in the future if such a scenario were to occur?". Extreme scenarios can therefore be created to see how the future would pan out if they were to come true. Deterministic projections are thus a formidable tool when it comes to exploring the future on the basis of predefined scenarios. Any uncertainty in the projection then relies on the scenario coming true. Possible scenarios are formulated, but it is impossible to know how likely they are to occur. It could even be argued that the probability of them coming true is zero (if the values are continuous) or very low (if the values are discrete). The degree of probability is estimated intuitively and is reflected in the terms used to describe these scenarios: demographers refer to the "central" scenario, which is the scenario considered the most plausible based on current knowledge, and "extreme" scenarios." To this extract from Costemalle's article, we can add that several scenarios, deviating from the baseline scenario, are presented in the deterministic approach, in order to illustrate the uncertainty inherent in the exercise.

- ### Probabilistic approach

"Conversely, probabilistic projections are based on models that attempt to take account of the uncertainty stemming from a lack of knowledge of certain aspects of the projections. These models are based on assumptions made on the basis of expert judgement and intuition. The underlying assumptions on which models for probabilistic projections are based are the equivalent of the scenarios used for deterministic projections. The advantage of probabilistic projections is that they make it possible to quantify the uncertainty based on past developments and to extrapolate it into the future to provide confidence intervals for the projections. The interpretation and use of probabilistic projections therefore differs from that of deterministic projections. By way of an example, weather forecasts have long been making use of probabilistic projections: we are not only told whether or not it will rain the next day, but also the probability that rain will fall (Raftery, 2014). Since future events are inherently uncertain, indicating the probability of their occurrence in view of current knowledge provides more information than a deterministic projection based on a scenario. In economics in particular, time series are used as a means of producing probabilistic projections: in the case of a simple random sampling method, for example, we know that the variance increases with the square root of time."

"By adding error terms to the models, it is therefore possible to create stochastic probabilistic projections. Another method for quantifying uncertainty is to use the Bayesian paradigm. Under this method, the model parameters are viewed as random variables, in the same way as error terms in stochastic models. Bayesian inference then involves estimating the *a posteriori* distribution of these parameters, i.e. after the data have been observed. This distribution gives possible values for the parameters, together with their degree of probability. It differs from the *a priori* distribution, which is the distribution given by the modeller and which is intended to reflect the knowledge of the problem before any data has been observed." In addition to Costemalle, we can say that, like deterministic projections, probabilistic projections are also based on assumptions.

The question was phrased this way:

The projections published in 2016 included 27 projection scenarios (combination of 3 fertility assumptions, 3 mortality assumptions, 3 migration assumptions), supplemented by three working scenarios (zero migration, European fertility, constant mortality). The baseline scenario was highlighted, and the other 26 scenarios were prioritized according to 3 levels, focusing on 10 of these 26 scenarios (Table 1, and

https://www.insee.fr/fr/statistiques/2496228?sommaire=2496793).

Q7. Do you think it is necessary to reproduce the same types of scenarios and keep the same order of presentation? If not, what adjustments would you suggest (deleting or adding scenarios, modifying the workings scenarios, modifying the hierarchy of presentation of the scenarios, etc.)?

Table 1: The 30 scenarios obtained by combining assumptions

Name of the scenario	Fertility	Life expectancy	Migration
Baseline	Baseline	Baseline	Baseline
1er group: 6 scenarios that differ from the baseline scenario by only one component			
High fertility	High	Baseline	Baseline
Low fertility	Low	Baseline	Baseline
High life expectancy	Baseline	High	Baseline
Low life expectancy	Baseline	Low	Baseline
High migration	Baseline	Baseline	High
Low migration	Baseline	Baseline	Low
2ème groups: 4 scenarios that lead to the highest, lowest, youngest and oldest population in 2070			
High population	High	High	High
Low population	Low	Low	Low
Youth population	High	Low	High
Elderly population	Low	High	Low
3rd group: 16 other scenarios combining baseline, low and high assumptions			
4th group: 3 working scenarios			
Constant mortality	Baseline	Constant	Baseline
European fertility	1.65	Baseline	Baseline
Zero migration	Baseline	Baseline	None

Sixteen experts find it useful to have a wide variety of scenarios and their adapted hierarchy. They correspond to pedagogical uses for researchers like Didier Breton (1): " Je pense que la gamme des scénarii ci-dessous est très pertinente et utile. Avoir un nombre important de scénarii est vraiment utile, même si au final, dans un cadre pédagogique ou didactique on en retient bien moins et on se concentre sur les extrêmes et le central". The variety of scenarios is also useful for people working in institutions, such as Anthony Marino and Amandine Brun-Schammé (COR, 20): " Nous

sommes d'avis à ce que vous conserviez les mêmes types de scénarios et le même ordre de présentation. Il nous semble très utile de disposer de tous les scénarios, même si l'accent peut être en effet mis davantage sur les extrema ou les changements d'une seule composante. Cela permet de faire des tests de sensibilité sur le solde du système de retraite par exemple en modifiant les seules chroniques de fécondité et/ou mortalité et/ou migration".

On the contrary, some experts find that there are too many scenarios, a potentially confusing factor (3, 34). They use only a few of them themselves (23) or propose not to publish them all on the Internet (35, anonymous).

Many of the NSI respondents describe their own scenario system without commenting on the French variants.

Two experts (2, 27) recommend abandoning scenarios and replacing them with probabilistic modelling: these responses have been included in the "method" section.

For his part, Jean-François Léger (5) proposes, from a pedagogical perspective, a different logic for constructing the various scenarios, with a basic scenario without migration that would highlight the evolution of the population through the natural balance alone, and then a scenario with the same fertility and mortality assumptions, adding the migratory component: " Selon moi, le solde migratoire devrait être intégré a posteriori, comme une composante dépendant de la dynamique naturelle et d'objectifs démographiques, et non comme une composante définie a priori".

Philippe Louchart suggests considering non-symmetrical assumptions: "réfléchir à des hypothèses non symétriques de part et d'autre du scénario central, notamment pour la fécondité, au regard des projections probabilistes existantes".

Proposals for alternative working scenarios:

Anne Goujon (3) suggests adding a COVID-19 scenario to show the effects of the shock on the components, assuming a return to normal within a few years. This is in line with the suggestion of Helen Hughes (ONS, UK, 29), citing a paper by Charles-Edwards et al. (2020). In this paper, the authors simulate different scenarios for the consequences of the pandemic on the Australian population, with the major impact being related to the cessation of international migration, which is more or less prolonged depending on the scenario. "Results suggest that Australia's population could be 4 per cent lower by 2040 in a *Severe* scenario than in the *No Pandemic* scenario, driven by a massive reduction in international migration. Impacts on population ageing will be less severe, leading to a one percentage point increase in the population aged 65 and over by 2040."

Didier Breton (1) suggests a Southern European fertility scenario that would be even more contrasting, with lower fertility and, above all, a much later calendar.

Laurent Toulemon (12) invites to better justify the working scenarios in the publications (European fertility, no migration, no progress in the fight against death) He proposes a scenario with the average components of European projections also for mortality and migration.

Gautier Maigne (France Stratégie, 19) suggests creating new working scenarios, or creating a new category of so-called breakthrough scenarios: "scénario de baisse de l'espérance de vie, calibré par exemple sur ce qu'on observe aux États-Unis sur la période récente, […], scénarii à solde migratoire négatif (« émigration massive ») et […] très positif (« réfugiés climatiques »). Afin de ne pas apparaitre comme des prévisions ou pouvoir être interprétées politiquement, ces 'ruptures' pourraient être situées à un horizon de moyen terme (2030 par exemple)".

3) THE HORIZON OF THE POPULATION PROJECTIONS

The experts were asked:

Q4. We are considering 2070 as the horizon of the projections. Do you think we need another horizon? Do you think it would be useful to disseminate results for a longer time horizon (e.g. 2100), even if we only comment on the 2070 horizon?

The responses are quite mixed (table).

Figure 1.1 - Positioning of experts on the projection horizon

	Do we need a horizon further away than 2070?		
	No or rather no	Yes or rather yes	Neither yes nor no
Researchers	6	5	2
OSS	4	7	1
NSI	8	2	2
Anonymous	2	3	2
Total	20	17	7

The experts stress the greater uncertainty beyond the 50-year horizon. Jean-François Léger even suggests reducing the horizon to 2050: "2050 (soit un bond de 30 ans, l'équivalent d'une génération en démographie" (5).

Few of the NSI respondents make projections further out. Sweden comments on the projected situation in 2070 but releases a database with extended series to 2120. New Zealand similarly distinguishes between the main release and extended series for specific purposes.

Although, as Didier Blanchet - CSR Retraites (14) points out, it is in practice inexpensive to extend the series, some experts point out that the validity of these extrapolations is limited if the projection period is longer than the past period used to calculate the trends (4, 37). This could even be risky by affecting the credibility of the exercise (34).

Several experts stress the importance of highlighting the growing uncertainty that exists as the horizon moves further out (Vianney Costemalle, Drees - 16). This can be done by associating longer-term projections with a measure of uncertainty (estimated from the model's backward-looking predictive capacities) (Grégoire Rey - 8) or by proposing a set of alternative scenarios (Jean-Marie Robine - 9).

Extending the series can have several methodological interests: comparing the results of the projection with those obtained by the United Nations (13, 16, 22) (see United Nations, 2019a); observing the timing of certain phenomena, for example the crossing of life expectancies for women and men, and calculating life spans by generation (35); checking that the results obtained remain reasonable over a more distant horizon and testing the sensitivity to assumptions (4, 22). But it is above all the question of the uses of longer-term projections that is discussed, particularly by the public authorities.

Many NSI respondents cite the absence or scarcity of users of projections for a time horizon longer than 50 years (e.g. 30, 35): "a look 50 years into the future is not as abstract as 100 or 150 years and fits the period that is relevant for long-term labor market and environmental policy decisions" (Olga POETZSCH and Felix zur NIEDEN, DESTATIS, Germany, 33).

But in the French case, users involved in the evaluation of pension schemes and their past and future reforms are almost all of the opinion that projections should be extended (14, 15, 19, 20, 21, 24a), until 2080 or even 2120. Indeed, changes in legislation can have very long term effects: “modifications de la législation relative à l’acquisition des droits retraite concernant la population active peuvent avoir des effets sur très longue durée et il est utile d’avoir une vision de la dynamique de ce type de changements sur les dépenses (profil et fin de la montée en charge de la mesure…)" (Pascale Breuil, Cnav, 15). More specifically, it is a question of calculating the length of retirement by generation (20), of carrying out prospective studies: " études prospectives par génération couvrant complètement des générations nées jusqu’à la fin du dernier siècle" (Didier Blanchet, CSR Retraites, 14), of preparing during the year 2026 the Ageing *2027* report, which will have a 2080 horizon (21), or even of modelling the impact of a possible pension reform concerning newcomers, which requires an far enough horizon to include their their retirement date (24a).

For energy policies, however, a time horizon of 50 years may be sufficient (23). In the area of transport, different choices are possible and "the socio-economic evaluation of transport projects varies greatly depending on whether a period of 30, 50 or 70 years is used to evaluate them. If 70 years is chosen, it will be 2090" (Philippe Louchart, 6).

4) IN THE SHORT TERM: HOW TO INTEGRATE THE COVID-19 PANDEMIC?

A. WHAT DO WE KNOW WHEN WE FINALIZE THESE PROJECTIONS?

It is important to note that the experts were consulted in March-April 2021, at the time of the 3rd wave of the Covid-19 epidemic in France, and when the vaccination rate was still low, except among the elderly (at the end of April 2021, 12% of adults were fully vaccinated[2] and about three quarters of those over 70 years of age[3]). Only deaths in 2020 and January 2021 were known. The significant drop in births in December 2020-January 2021 was mentioned in the consultation document, but not the rebounds in March-April and summer 2021, which were not yet known.

By the time the projection exercise is finalized in September 2021, more recent data are available.

The 2020 demographic report was first published in January 2021 and a second one in March in order to take into account observed and not estimated data from November and December 2020 (Papon, Beaumel, 2021). Indeed, this period corresponded to the second wave of deaths of the Covid-19 epidemic in France, but also to part of the births of children conceived during the first containment in March-April 2020.

Provisional data on monthly births[4] and deaths[5] are also available until August 2021. This makes it possible to observe at least partially the effects on mortality of the fourth wave of Covid-19 in the summer of 2021. Since the August 2021 births essentially correspond to November 2020 conceptions, it is possible to observe the effects of the pandemic until the second containment, which took place from October 30 to December 15, 2020.

The results of the 2018 population census were released in June 2021[6].

The population is thus known definitively up to 2018 and the difference between the 2017 and 2018 populations makes it possible to estimate the 2017 net migration, as shown in the demographic balance published in March 2021. More detailed data on net migration in 2017 (including a breakdown by place of birth) can be found in Insee Première 1849, published in April 2021 (Lê, 2021).

[2] https://solidarites-sante.gouv.fr/actualites/presse/communiques-de-presse/article/vaccination-contre-la-covid-en-france-au-29-avril-2021-pres-de-21-500-000
[3] https://covidtracker.fr/vaccintracker/, consultation of 20/10/2021
[4] https://www.insee.fr/fr/statistiques/5400320?sommaire=5348638
[5] https://www.insee.fr/fr/statistiques/4487854
[6] https://www.insee.fr/fr/information/2008354

B. THE POSITION OF THE EXPERTS ON THE STARTING POINT OF THE PROJECTION

The question was phrased as follows:

Q5. In order to take account of recent developments, we plan to use the estimated population on 1 January 2021[7] as the starting point for the projections, and not on 1 January 2018, which is the most recent final population estimates. Revisions between provisional and final data are generally modest. Do you think this choice is justified? Does it have any disadvantages in your view?

The vast majority of the experts consider that it is preferable to use the latest known data, even if they are provisional: 34 against 3 who do not approve the choice of a starting point of 1 January 2021, and 8 who provide elements without really expressing an opinion.

Figure 1.2 - Positioning of experts on the starting point of the projection

	Do you think that choosing a starting point of 1er January 2021 is justified?		
	Justified choice	The choice has some disadvantages	Other
Researchers	12	1	0
OSS	8	1	2
NSI	7	1	4
Anonymous	6	0	2
Total	33	3	8

Many experts emphasize that this is all the more justified in the current context, in order to integrate as much as possible the impact of the health crisis, particularly the excess mortality (3, 7, 13, 15, 19, 21). But the health context also requires specific treatment to project the first few years and calculate non-crisis trends (10, 11, 12, 37): "[...]les données 2021 et 2022 peuvent être estimées spécifiquement (impact de la Covid) mais les tendances devraient être estimées sans tenir compte des effets de court terme de l'épidémie de Covid (pour se concentrer sur les variations de long terme)". (Laurent Toulemon, 12). Anne Solaz (11) reminds us of possible catch_ups : "il faudra envisager de possibles rattrapages dans la situation post-Covid : moins de morts si les morts qui auraient dû mourir à partir de 2021 sont morts du Covid en 2020, davantage de naissances en cas de report des intentions".

On the side of the arguments that could lead to not using the population of 1 January 2021 as a starting point:

- the importance of using final statistics, so as not to risk reproducing or amplifying the inaccuracy incorporated into the provisional data used as a starting point (23, 34, 35, 36);

- the symbolic preference for "round" starting points such as 2020 or 2025;

[7] We will use the provisional data published in the "Bilan démographique 2020", exceptionally updated in March 2021 to account for the second wave of the Covid-2019 epidemic in late 2020 (Papon and Beaumel, 2021). In the detailed files of the projection results, the 2018-2020 data from the "Bilan démographique 2020", which are provisional, will be included. The latest published final data are for 1 January 2018.

- the need to wait for the 2021 or even 2022 data in order to better take into account the health crisis (7), but this would require us to postpone the projection exercise.

Didier Blanchet, of the CSR Retraites (14), reminds us that even if we were to take a starting point in 2018, recent trends would be integrated: "Si je comprends bien l'alternative serait d'avoir un 2018-2021 projeté comme le reste mais avec les vraies évolutions de fécondité/mortalité et soldes migratoires, plutôt que de la population mesurée. L'écart doit être de 2eme ordre en effet. Autant prendre l'observé, même provisoire". Indeed, for the 2016 projections, the provisional changes in fertility and mortality for the years 2013 and 2014 had been integrated, even though the starting point was 1 January 2013. However, this was not true for net migration, and the method of calculating the 2016 fertility and mortality rates produced a lag (Box 3).

Net migration is a point of difficulty because it is usually subject to more revisions (19, 25). Gwenaël Solard (Insee, 25) also points out that only a rough estimate is available in the 2020 annual demographic report (« Bilan démographique »): "L'estimation est réalisée à partir d'une estimation du solde apparent qui est entouré d'une marge d'incertitude encore plus grande que d'habitude avec la crise sanitaire (et la fermeture des frontières) ". The estimate of the 2020 migration balance was made by taking the average of the balances observed in 2015, 2016 and 2017, i.e. a positive balance of 87,000 people.

On the other hand, starting from 1 January 2021 is rather advantageous for taking into account the adjustment linked to the change of the census questionnaire in 2018[8](22, 25), which induces a population adjustment spread out from 2015 to 2022: the 2021 and 2022 adjustments are residual compared to those integrated in the population change from 2015 to 2020 (Insee 2021a and b).

Finally, some experts raise the issue of the starting point for territorial projections: national projections define the trends that are subsequently applied to the population in different parts of the territory. It is necessary to rely on a census in order to have definitive populations at the municipal level (and sometimes even sub-municipal level for the most populated municipalities), and thus to have coherent populations, whatever the territory chosen, to carry out the projection. The 2018-2020 populations will therefore be integrated into the data sets disseminated for the projections.

Laurent Toulemon (12) underlines the interest of having data prior to 2018, in order to be able to reconstruct series from observed years to projected years.

[8] On the population adjustment related to the change of census questionnaire in 2018, see Insee 2021a and Insee 2021b

Box 3 - Final, provisional, or trend data: the starting point of the projection

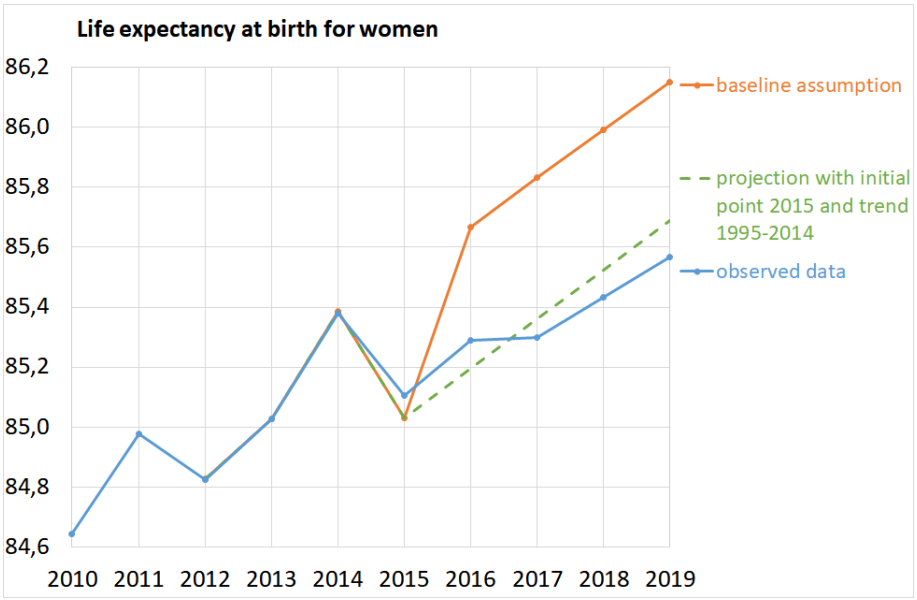
- In the latest INSEE projection for 2016

In 2016, the starting point for the projection was the population on 1 January 2013.

To calculate the populations on 1January 2014, 2015 and 2016, the provisional fertility and mortality rates for 2013, 2014 and 2015, published in the 2015 annual demographic report (”Bilan démographique 2015”), were applied. The net migration applied for 2013, 2014 and 2015 was the one used as the baseline assumption of the projection (+70,000) and not the net migration estimated for the ”Bilan démographique 2015” (+47,000).

Since the revisions of fertility and mortality rates were very small and the average net migration in 2013-2015 was +57,000, close to +70,000, the "projected" population for 1 January 2016 was very close to the final population published in the 2018 population report.

In contrast, the fertility and mortality rates for 2016 and beyond were calculated by taking the final 2012 rates and applying the trend observed from 1995 to 2014. With this method, the rates calculated for 2016 were far removed from the rates observed for the same year 2016, because the last observed level was not taken into account. There is therefore a break in life expectancy between the projected value for 2015 which incorporated provisional data, and the higher projected value for 2016 (figure).



- For the 2021 projections

The population on 1 January 2021 is that published in the ”Bilan démographique 2020” in March 2021 (Papon, Beaumel, 2021). Compared to the previous projections published in 2016, this means that the net migration estimated for 2018, 2019 and 2020 in the ”Bilan démographique 2020” is used, i.e. the average of the 2015-2017 balances, and not the central assumption of the projections.

For fertility and mortality, the starting points are the estimated fertility for 2020 and the estimated mortality for 2019. Then, they evolve according to the assumptions of the projection based on the trends observed in the past. This allows all available information to be taken into account. The application of this principle excludes the transitional effect of the pandemic, which is treated separately for mortality in 2021 and for fertility in 2021 and 2022.

Having projections with a starting point of 1 January 2021 is also more advantageous in terms of communication: the studies published from 2016 to 2020 were based on mortality and fertility rates with a starting point of 2012 (i.e. 8 years earlier than the publication for the article in *Économie et Statistiques* - Blanpain, 2020).

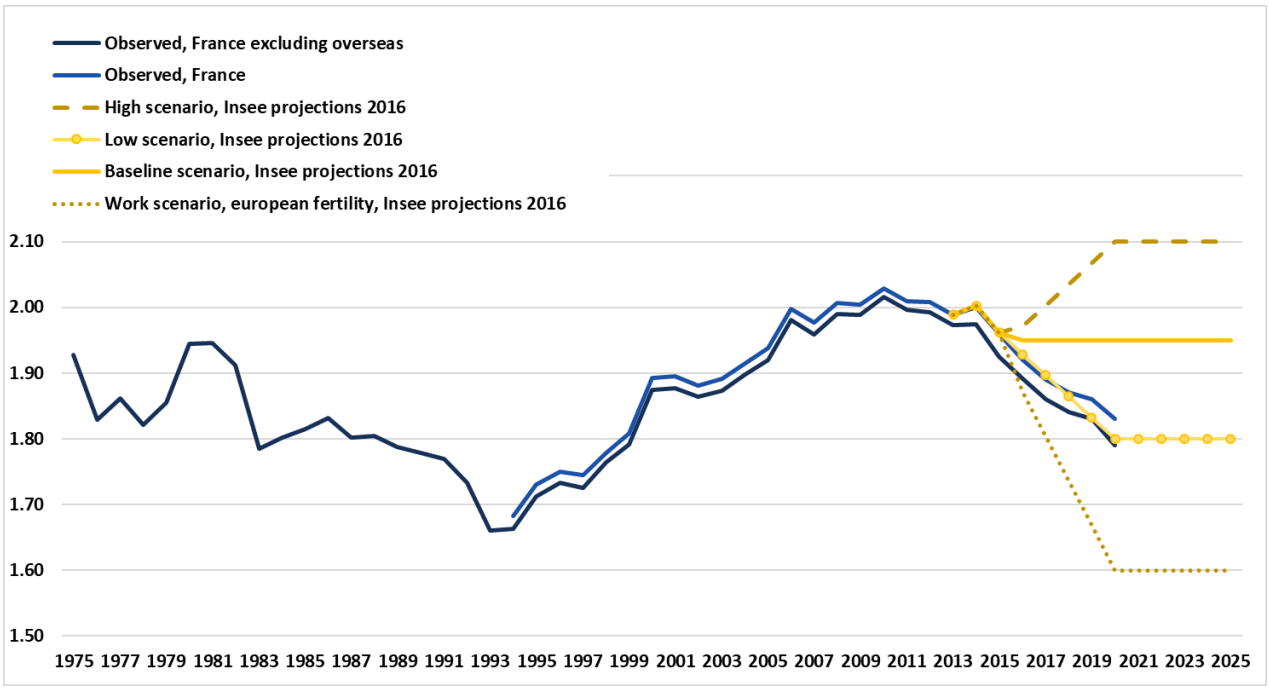
PART 2 : THREE ASSUMPTIONS ABOUT FERTILITY

A. RECENT CHANGES IN FERTILITY IN FRANCE

The previous projections in 2016 used a total fertility rate (TFR) of 1.95 children per woman until 2070 for the baseline assumption. Two alternative assumptions of high and low fertility were retained, which deviate by 0.15 from this baseline assumption: 2.1 and 1.8. A so-called European convergence assumption explored the assumption of a fertility of 1.6 children per woman in 2070. In the different assumptions, convergence was assumed to be rapid towards the target values, reached in 2020.

The TFR in France was stable at around 2 children per woman between 2006 and 2014 (**Figure 2.1**), then has declined each year since 2015 to reach 1.83 in 2020, the latest data available (1.79 in metropolitan France). In view of recent fertility trends, the baseline assumption of the 2016 Insee projections therefore seems high and recent developments are in line with their lower assumption. Recent projections by institutions covering France also use a lower TFR, for example 1.84 for Eurostat in its projections published in 2020[9] and 1.85 for the UN in 2019 (United Nations, 2019b).

Figure 2.1 - Changes in the total fertility rate



Coverage: France excluding Mayotte until 2013 and France from 2014 onwards
Source: INSEE, population estimates and vital statistics, final data until 2017, provisional data in 2018, 2019 and 2020, INSEE population projections 2016.

[9] Eurostat (2020) for a summary and for the detailed fertility assumptions of the projections (EUROPOP2019): https://ec.europa.eu/eurostat/databrowser/view/proj_19naasfr/default/table?lang=fr

Over the past decade, France has seen a greater decline in its TFR (-0.15) than the European Union as a whole (-0.03), but it remains an exception for its high level of fertility, a specificity that has been built up since the 1990's (**Figure 2.2**). Unlike other countries, French fertility was not affected by the economic crisis of 2008-2009 (Masson, 2015; Papon, 2021b), which could be explained in particular by the moderating role of the socio-fiscal system (Pison, 2020). The latter could also cushion the impact of the Covid-19 pandemic and the ensuing economic difficulties on fertility in the short and medium term, although the situation is rather uncertain.

At the time of the expert consultation, the first estimates of births recorded in December 2020 and January 2021 showed a particularly sharp decline in births nine months after the start of the first containment. The rectifying "Bilan démographique 2020" published in March 2021 incorporated the year-end 2020 data and revised the 2020 fertility rate to 1.83. It can be estimated that if the evolution had been similar in November-December 2020 to what it was from January to October 2020, the TFR would have been 1.84. The impact for 2020 is therefore moderate.

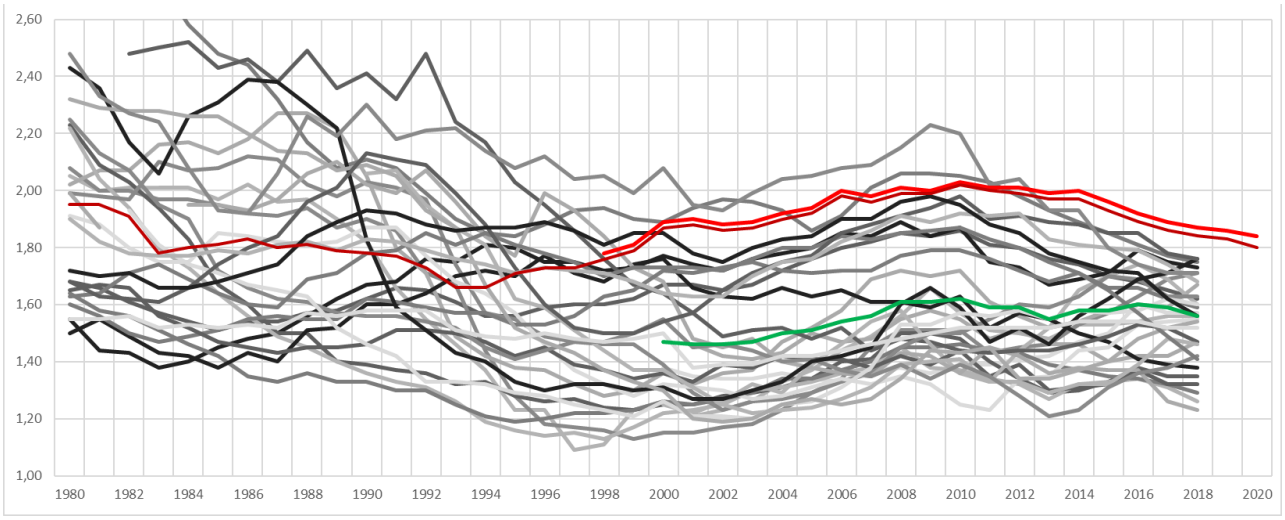
New elements have since[10] been published by INSEE and confirm the drop in births in December 2020 and especially in January 2021 (-7% and -13% compared to December 2019 and January 2020 respectively). In February 2021, births increased compared to the previous month, and were "only" 5% lower than a year earlier (with the same number of days, February 2020 having one day more than February 2021). In March and April, births continue to increase and are slightly higher than in March and April 2020: +1% in March and +4% in April. In May and June, births decline moderately (2%) compared to the same months in 2020, returning to the pre-pandemic rate of decline. In July 2021, they are at the same level as in July 2020, while births rebound in August (+3.3%), which corresponds to conceptions during the second containment: the impact of the second containment on births is therefore different from that of the first containment. In total, over the period from January to August 2021, births finally fell by 1.5% compared to the same period a year earlier.

[10] Births in 2021: https://www.insee.fr/fr/statistiques/5400320?sommaire=5348638

Figure 2.2 - Changes in the total fertility rate in the European Union since 1980

France — France (metropolitan) — European Union - 28 countries

(The trajectories of the other EU-28 countries are shown in grey).

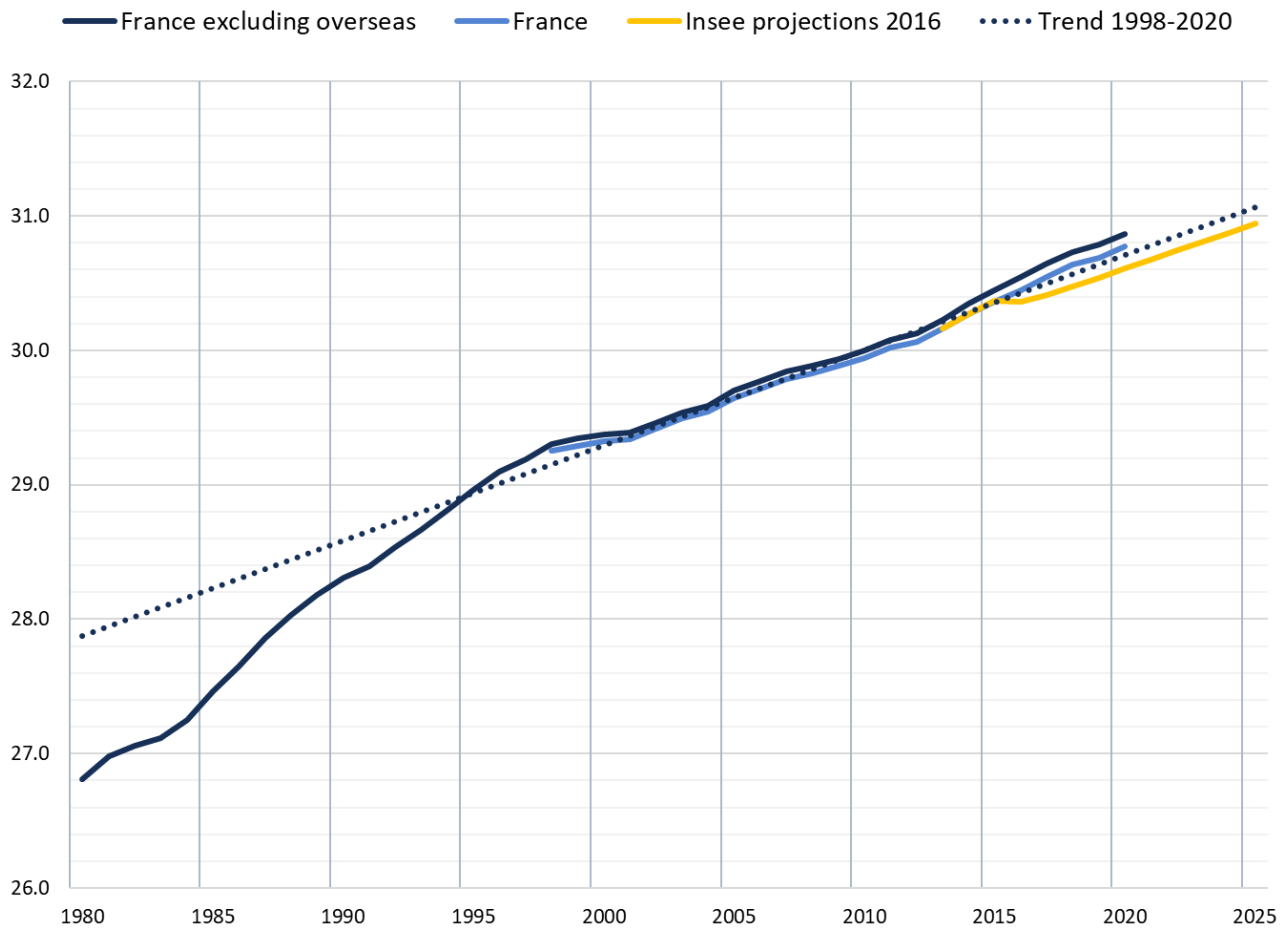


Source: Eurostat, 2020 Demographic Review for French data 2017-2020.

The low and high assumptions used by INSEE in 2016 appear to differ less from the baseline assumption (+/-0.15) than the assumptions used by international institutions: +/-0.5 children per woman for the UN in 2019, a low assumption at -0.37 children from the baseline assumption for Eurostat.

Insee's 2010 projections, as well as those made by Eurostat and the UN in 2019, stabilized the mean age at childbirth rapidly. The 2016 projections stood out by extending the growth of the mean age at childbirth to 32 years (assumed to be reached in 2040). In this respect, they anticipated the continuation of the trend: since 2013, the mean age has grown faster than anticipated by the 2016 projections, with no sign of slowing down (**Figure 2.3**). The mean age considered to be the ceiling in 2016, i.e. 32 years old, is now well over in two departments: Paris (34.0 years old in 2019) and in Hauts-de-Seine (32.6 years old). Val-de-Marne, Haute-Garonne and Rhône are close to it (31.7 years).

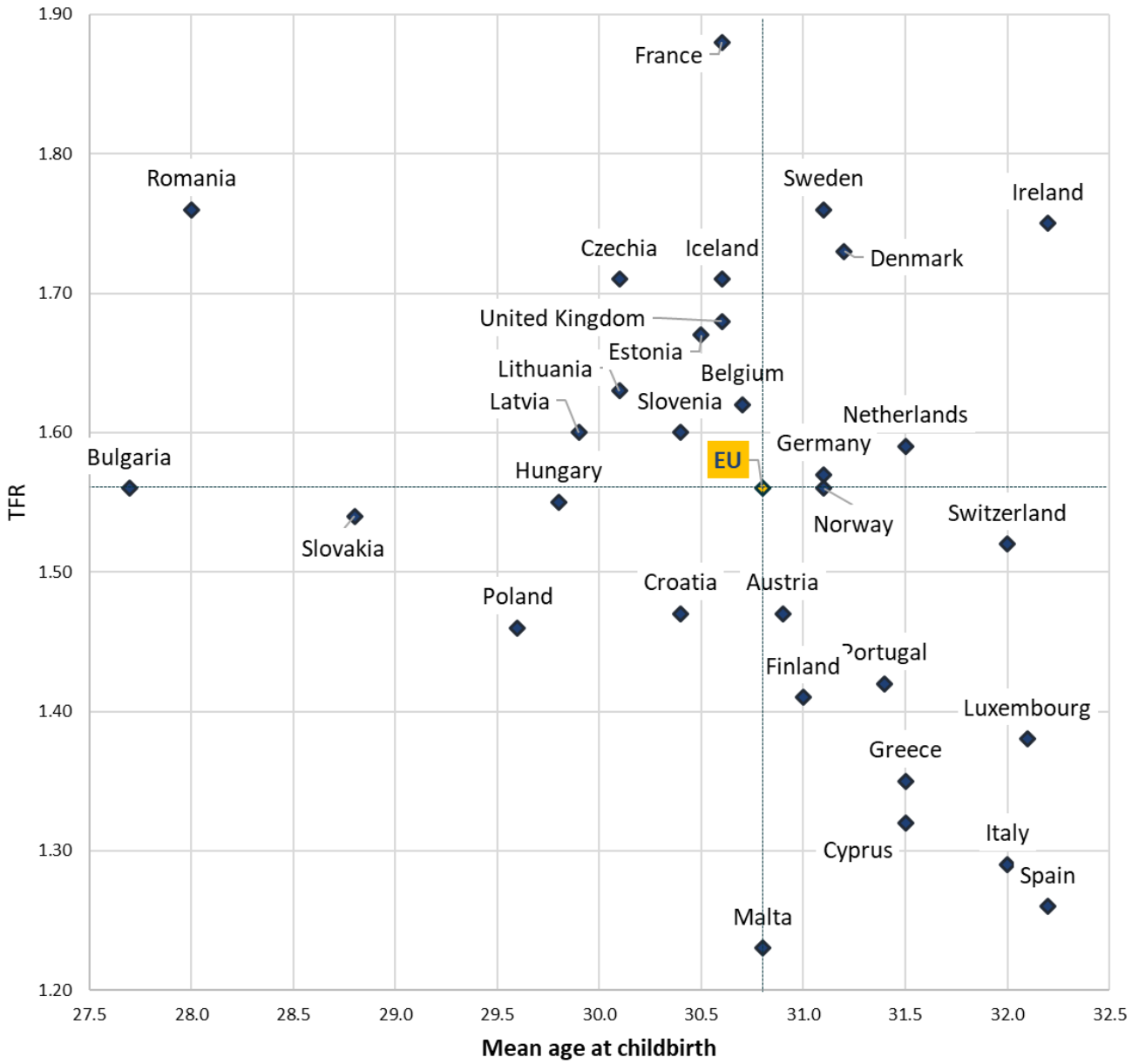
Figure 2.3 - Changes in the mean age at childbirth in France since 1980



Note: 'France' excludes Mayotte until 2013 and includes Mayotte from 2014 onwards.
Source: INSEE, population estimates and vital statistics, provisional data in 2018-2019 and 2020, final before, INSEE population projections 2016.

At the departmental level, there is no obvious link between fertility intensity and mean age at childbirth (Daguet, 2021). Similarly, in the EU, some countries have an mean age at childbirth above the European average and maintain a high TFR (Ireland, Denmark, Sweden - **Figure 2.4**). Among the low fertility countries, some have a high average age (Spain, Italy) and others a low one (Poland). The Romanian TFR is similar to that of Ireland, but the mean age is 28, compared to 32.2 in Ireland. The high fertility rate in France does not therefore seem to imply a halt in the growth of the mean age at childbirth.

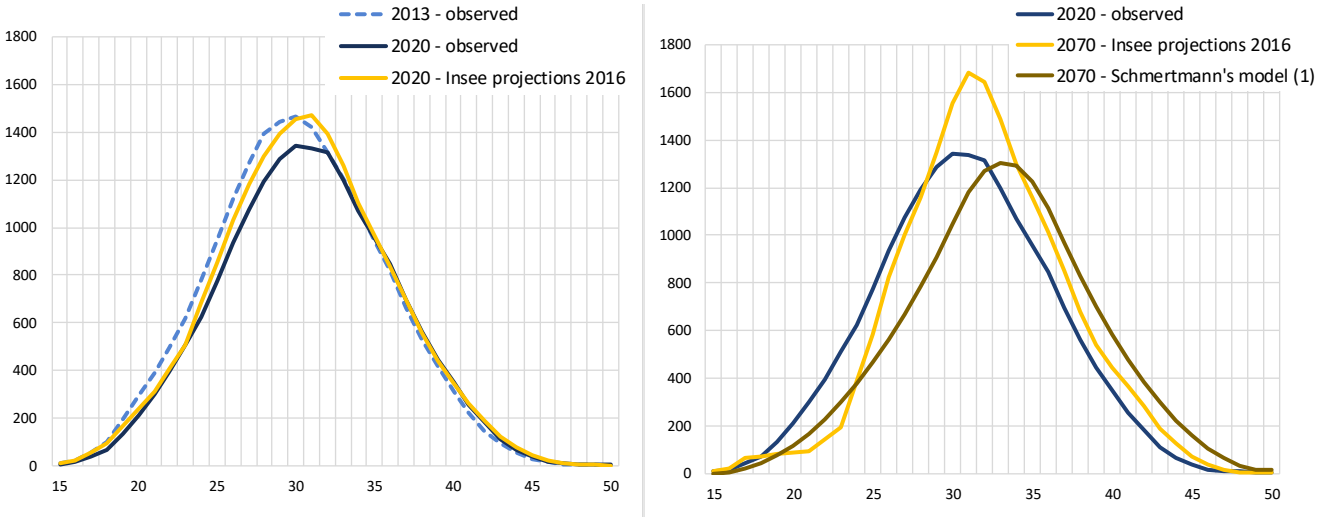
Figure 2.4 - Mean age at birth and TFR in European countries in 2018



Source: EUROSTAT, https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=demo_find&lang=fr

Over the long term, the profile of age-specific fertility rates is shifting towards greater symmetry and a greater spread of high fertility ages (Costemalle, 2020). This evolution is visible over the period 2013-2020 (**Figure 2.5**). However, the technique of projecting age-by-age rates used by INSEE in 2016 leads to the projection of an increasingly sharp shape. The application of a Schmertmann (2003) model, following the example of Eurostat, Italy or Belgium, would make it possible to obtain a more plausible profile with the same mean age and TFR assumptions. In this model, the profile of fertility rates is obtained from calibrated splines, according to 4 parameters: the minimum age at which the fertility rate is strictly greater than 0, the age of maximum fertility (modal age), the fertility at this modal age and the age at which the fertility reaches half of the maximum value.

Figure 2.5 - Age-specific fertility profile in 2013, 2020 and projected with the 2016 projection exercise assumptions for 2020 and 2040



(1) Age profile corresponding to an age of 33 years and a TFR of 1.80 children per woman, obtained by applying the model described in Schmertmann (2003).

B. THE POSITION OF EXPERTS ON THE EVOLUTION OF FERTILITY

There were six questions on fertility change:

- Q8 over the TFR's long-term horizon (baseline scenario) ;
- Q9 on short-term fertility trends in the pandemic context ;
- Q10 on the high and low variants to be retained on the TFR ;
- Q11 on the evolution of the long-term mean age at childbirth ;
- Q13 on the changing age profile of fertility.

Finally, Q12 was a table to be filled in to summarize and quantify the previous answers.

WHAT TARGET FOR THE TOTAL FERTILITY RATE IN THE BASELINE SCENARIO?

From a quantitative point of view, 24 experts gave their opinion.

Figure 2.6 - Experts' position on the TFR of the baseline scenario in 2070

	1.4	1.6	1.8	1.85	1.9	Number of responses	**Average**
Researchers	1	0	2	2	0	5	**1.74**
OSS	0	1	2	5	0	8	**1.81**
NSI	0	0	2	3	2	7	**1.85**
Anonymous	0	0	1	2	1	4	**1.85**
Total	**1**	**1**	**7**	**12**	**3**	**24**	**1.81**

The mode is 1.85, but the average is 1.81. The 1.85 mode was cited by 12 respondents, while the 1.80 TFR assumption received 7 votes.

The answers are based mainly on an analysis in terms of completed fertility and fertility by birth rank.

A central question is to assess the role of the timing of births in the decline in the TFR in recent years. If this is the main explanation for the decline, then as long as the increase in the mean age at childbearing continues, the TFR will decline or remain at a low level. If age stops increasing and the completed fertility remains the same, it will gradually rise to the level of the completed fertility.

For Jean-François Léger (5) and an anonymous person, this implies the possibility of an increase in the TFR in the long term. Since the completed fertility is only known for generations that have reached 50 years of age, experts question the evolution by analysing the number of children already had and future intentions (20, 22). For Jean-François Léger (5), the completed fertility is not (yet) declining: "La descendance finale ne fléchit pas (encore) : Par exemple, la génération 1979, qui n'a pas encore terminé sa vie féconde, a déjà atteint les 2 enfants par femme à 40 ans, soit plus précocement que la génération 1969. Or cette génération 1979 était encore « en retard » sur la génération 1969 à 32 ans. La génération 1984 qui est en retard à 35 ans par rapport aux générations 1969 et 1979 n'a pas non plus nécessairement dit son dernier mot".

On the contrary, Didier Breton (1) believes that the current drop is not simply a shift in the calendar. He stresses the importance of fertility by birth rank to explain the French specificity, since in France infertility is low and the transition from 2 to 3 children is fairly frequent: "La probabilité d'avoir un troisième enfant parmi les femmes ayant deux enfants [a été] longtemps légèrement supérieure à 0,4. Toutes choses égales par ailleurs, un passage à 0,3 voire 0,25 (ce qui est le cas dans de nombreux pays européens) inscrirait définitivement la France dans une fécondité durable proche de 1,8 enfant par femme. C'est une r de dire cela. Or le passage de 2 à 3 enfants est lié à de très nombreux facteurs très mouvants actuellement : les histoires d'unions, la précarité et vulnérabilité économique, la politique familiale, mais aussi l'âge à l'entrée en parentalité. La question de l'infécondité me semble […] moins centrale dans le cas français – sauf si les prises de conscience écologique et environnementale dans les générations nées après les années 2000 se traduisent par des comportements plus radicaux que les générations précédentes et notamment la diminution drastique du désir puis de la réalisation de projets de parentalité".

Sylvain Papon (Insee, 22) also discusses the evolution of infertility, which could increase if two emerging movements gain momentum: the rise of ecological considerations among the younger generations on the one hand, and the demand for a "social right" not to have children on the other: "les femmes vont de plus en plus avoir l'opportunité de choisir d'avoir des enfants ou non. Les générations du baby-boom ont acquis le droit « physique » de maîtriser leur fécondité (contraception, IVG…), la génération actuelle se bat pour en avoir le droit « social » ".

Some experts believe that the role of family policies and the greater ease of reconciling family and professional life should allow the persistence of a "French exception" (22, 30).

Anne Goujon (3) stands out by anticipating, on the contrary, a very sharp decline: "Je pense que la fécondité en France va continuer de diminuer en deçà des 1,85 ou 1,80 envisagés, et que

l'exceptionnalisme français bientôt ne sera plus. La principale raison à cela : l'incertitude croissante des jeunes couples face à l'avenir – économique, environnemental, sociétal, géopolitique – renforcée par la crise sanitaire. J'envisage un ICF en dessous de 1,5 enfants à l'horizon 2050. » Comme dans les pays nordiques, « le généreux système de protection sociale n'est pas suffisant pour contrecarrer la tendance qui est non seulement de grossesses plus tardives mais aussi moindres (Hellstrand et al., 2020)".

Anne Solaz (11) is less radical, but she too believes that the drop in fertility in the Nordic countries could herald a drop in French fertility: " J'ai donc du mal imaginer un scénario à la hausse : ce serait plutôt forte baisse (comme en Norvège), moyenne baisse comme en Suède ou stabilité, d'autant que l'âge à la naissance continue d'augmenter".

Philippe Louchart (6) points out that the reasons for the decline in the TFR over the past few years have not been clearly established and that the recent decline in the fertility rate of Ile-de-France women born in France (Louchart, 2021b) raises questions about whether this "French exception" will continue over time.

Some experts also believe that the health and economic crisis could have a lasting impact. Laurent Toulemon (12), on the other hand, stresses the importance of the stability of assumptions from one projection to the next and Didier Blanchet (CSR Retraites, 14) the risk of "giving the impression of over-reacting to the recent fall".

Finally, two experts discuss the role of migration and its interaction with fertility (6, 37).

THE HEALTH CRISIS AND THE EVOLUTION OF THE CIF IN THE SHORT AND MEDIUM TERM

Most experts imagine a return to the trend in 2022 or 2023, with no lasting impact of the pandemic on long-term fertility : a drop in fertility in 2021 and sometimes 2022, before a return to normal (5, 8, 12, 13, 14, 16, 19, 21, 22, 26, 30, 33). Sylvain Papon (Insee, 22) sums up this widely shared position well: " Nous sommes au cœur de l'ouragan, mais sur le très long-terme, l'ouragan peut n'avoir que peu de conséquences."

Astri SYSE and Michael THOMAS (35) discuss the link between the evolution of the vaccination campaign and fertility: "The answer presumably depends on the speed at which large-scale vaccination can be performed in France. Given the relatively high skepticism of vaccination, it is hard to know precisely". Misha Khodabin, Hamza Zakraoui and Samuel Ménard (21) expect a return to normal and cite foreign examples : "Certains pays ayant déjà réussi à enrayer l'épidémie Covid-19 (Nouvelle-Zélande, Australie), auraient retrouvé des niveaux de natalité comparables à ceux enregistrés en 2019". Anthony Marino and Amandine Brun-Schammé (COR, 20) cite the example of the 1993 economic crisis, whose influence was transitory.

For Didier Breton (1), if the effect already observed is due to economic uncertainty rather than health concerns, it could last until 2023. Indeed, experts who insist on economic factors envisage a slightly longer-lasting effect (23, 27, 35), as Gwenaël Podesta (DGEC, 23): " l'impact de la crise

peut être appréhendé via les anticipations sur le PIB (baisse forte en 2020, rattrapage lent jusqu'à 2022 voire 2024, puis reprise des tendances passées) ". However, a recent publication (Papon, 2021b) shows that French fertility was little affected by the 2008 economic crisis, unlike in neighbouring countries, which raises the question of the impact on fertility of an economic crisis accompanying the health crisis. In the short term, the impact appears to be small (Brée et al., 2021).

Marie Vandresse (Federal Planning Bureau, Belgium) reports on the assumptions made for the projections published in January 2021 in Belgium: "Cependant, suite à l'impact de l'épidémie de la COVID-19 sur la situation socio-économique, la projection table sur une nouvelle baisse de la fécondité en 2021. Les projets de naissances seraient de nouveau reportés pour certains, voire abandonnés. Dans ce contexte, la fécondité à moyen terme a par ailleurs également été revue à la baisse. Elle reste inférieure à 1,6 dans les cinq prochaines années. La crise sanitaire vient en effet ajouter un élément d'incertitude supplémentaire quant à l'évolution future de nos sociétés (Duyck et al., 2021 a and b)".

For Lena Lundkvist (Statistics Sweden, 31), the decline in fertility anticipated in Sweden for 2021-2022 is linked to the decline in immigration: "In Sweden we do specific estimations for 2021 and 2022 because of the covid-19. It is above all because lower immigration and lower fertility for foreign-born women due to that".

It is obviously difficult to quantify the decrease to be expected in 2021 or 2022. Antonio Argueso (INE, Spain) suggests a decline of around 15% in 2021 in Spain before returning to normal. Dragos Mondiru (Insse, Romania) suggests a 13% drop in births in Romania in January 2021 compared to January 2020, identical to that observed in France.

While the prospect of a transitional decline is shared by all the experts, many raise the question of a possible catch-up and therefore a transitional increase in 2021 or 2022, before the return to normal (7, 11, 12, 20, 34, 35, 37). Gilles Pison (7) is considering such a catch-up : "Les naissances qui n'auront pas eu lieu en 2021 du fait de l'épidémie de Covid-19 seront sans doute rattrapées en sortie de crise. Mais en mars 2021, il est trop tôt pour savoir si le rattrapage sera total ou partiel, et quand il aura lieu". Anne Solaz has the same opinion (11) : " Il y a souvent eu rattrapage après des crises économiques. Je pense qu'il faut prévoir une estimation « d'attente » encore en 2021 tant qu'il y a incertitude sur l'avenir sanitaire et économique, ce qui peut diminuer le nombre total car pour certaines femmes ayant des enfants tard, il sera trop tard en raison de l'horloge biologique."

Several experts also point out that the decline in births due to Covid-19 is part of a downward trend that has already begun (1, 3, 6).

Jean-François Léger (5) suggests updating the projections in 2022 if the fertility trend in 2021 turns out to be too different from that anticipated.

22 experts have given numerical proposals for variants. For the high assumption the average is 2.02 and for the low assumption it is 1.58.

A very large majority of the experts (15 out of 25) agree that the range should be +/- 0.2 points, rather than +/- 0.15 points, the range chosen by only four anonymous experts. Some experts even propose a wider range, such as +/- 0.35 for Laurent Toulemon (12): " L'incertitude est gravement sous-estimée avec des écarts de +/- 0.15 enfant par femme. Je propose dans l'idéal de passer à +/- 0.35 (soit des hypothèses haute et basse de 2.2 et 1.5". For Misha Khodabin, Hamza Zakraoui and Samuel Ménard (21), the width of the interval should be defined according to past fluctuations: " la largeur de l'intervalle doit être définie en fonction de la variabilité de la natalité, si la tendance passée s'est éloignée significativement des projections qui avaient été établies, il convient de l'élargir". This argument is also cited by an anonymous expert. In the French case, if we start the period in 1975, after the very rapid fall in the early 1970's (from 2.5 in 1971 to 1.93 in 1975), we find an interval of 0.37 between a minimum of 1.66 in 1993 and a maximum of 2.03 in 2010.

Several experts propose a non-symmetrical range around the baseline assumption, with a decrease in the TFR seeming more likely than a sharp increase (6, 11, 16, 28, 31, 36). Katarzyna Góral-Radziszewska (Statistics Poland, 28) "recommends considering asymmetrical variants with low one even lower". Philippe Louchart (6) shares this idea: "Au regard des éléments précédents, je préconiserais +/- 0.2 comme vous le proposez ou plutôt un écart de 0.4 entre les deux scénarios extrêmes avec un scénario bas, plus bas et un scénario haut moins haut, l'incertitude à la baisse paraissant supérieure à celle à la hausse au regard des évolutions passées et des évolutions ailleurs dans le monde ou d'un strict point de vue probabiliste".

Livia VARGA and Zoltan CSANYI (KSH, Hungary, 37) recommend adapting the variants to different policy options: "It may be appropriate to adjust the extent of the interval according to expected government decisions. It is useful to consider the probability and durability of new family support measures and the importance of migration regarding fertility".

Sylvain Papon (INSEE, 22) suggests reaching the target TFR in the variants in 5 years, unless this implies too much variation. Jean-François Léger (5) for his part would move the scenarios towards their final value in a progressive manner: the target of 1.80 that he proposes for the baseline scenario is reached around 2025-2030, that of the high scenario at 2.0 around 2030-2035 and that of the low scenario around 2035-2040.

Figure 2.7 - Expert Positioning on TFR Variants

Difference between baseline and low and high assumptions

	0.15	0.2	0.25	0.3	0.35	0.4	Number of responses	**Average**
Researchers	0	5	0	1	0	0	6	**0.22**
OSS	0	5	0	0	1	0	6	**0.23**
NSI	0	5	1	2	0	0	8	**0.23**
Anonymous	4	0	0	0	0	1	5	**0.20**
Total	**4**	**15**	**1**	**3**	**1**	**1**	**25**	**0.22**

High assumption

	1.59	1.8	2	2.05	2.1	2.15	2.2	Number of responses	**Average**
Researchers	1	0	2	1	0	1	0	5	**1.96**
OSS	0	1	1	3	1	0	0	6	**2.01**
NSI	0	0	3	1	2	1	0	7	**2.06**
Anonymous	0	0	2	0	1	0	1	4	**2.08**
Total	**1**	**1**	**8**	**5**	**4**	**2**	**1**	**22**	**2.02**

Low assumption

	1.21	1.4	1.5	1.55	1.6	1.65	1.7	1.8	Number of responses	**Average**
Researchers	1	0	0	1	2	1	0	0	5	**1.52**
OSS	0	2	0	0	1	3	0	0	6	**1.56**
NSI	0	0	2	1	1	2	1	0	7	**1.59**
Anonymous	0	1	0	0	0	0	2	1	4	**1.65**
Total	**1**	**3**	**2**	**2**	**4**	**6**	**3**	**1**	**22**	**1.58**

We also questioned the experts on the usefulness of a **working scenario called "European convergence" or "European fertility"**, which in 2016 was based on a target TFR of 1.65. We wondered what role to give to this scenario when one of the targets proposed for the low variant in the 2021 projections is 1.65.

Some experts consider that it is not useful to make a different scenario (5, 6, 14, 20, 2 anonymous). Philippe Louchart (6) considers that a TFR at the generation replacement level could be the subject of a working scenario since he proposes scenarios with lower TFRs.

Some experts contest the very idea of European convergence (3, 26, 35). Anne Goujon, for instance, relies on a recent article for this (Castiglioni et al., 2021). Marie Vandresse (Federal Planning Bureau, Belgium, 36) is close to this position since, in her view, such a scenario is in contradiction with our projection approach 'if recent demographic trends were to continue'.

Several experts find it useful to add a very low fertility scenario. Anne Solaz (11) speaks of a "sharp decline in the Norwegian style, to 1.56", Gilles Pison (7) suggests 1.50 or 1.55, Sylvain Papon, from INSEE, 1.5. For Laurent Toulemon, "the European convergence scenario should converge towards the value projected by Eurostat for 2070, not towards the current value of the TFR for European countries". Jérôme Lê (Insee, 17) proposes to take the current average for the EU excluding France. The average TFR in the EU (weighted by the total population) is 1.52 in 2019 and 1.65 in 2070 in

the Eurostat projections. The average TFR excluding France is 1.46 in 2019 and projected by Eurostat to be 1.62 in 2070.

MEAN AGE AT CHILDBIRTH

25 researchers commented on the value of the mean age at childbirth in 2070. Most (17) agree with our proposal of 33 years, and some propose a higher age, bringing the mean proposal to 33.2 years.

All the experts believe that the mean age will increase, and they put forward various reasons for this. Anthony Marino and Amandine Brun-Schammé (COR, 20), for example, insist on the uninterrupted growth of the mean age, which is more dynamic for the first child and faster than the evolution of the age of entry into working life. For some experts, the 33-year ceiling is likely to be exceeded: " Quant au palier proposé à 33 ans dans 30 ans, je peux juste signaler que ce palier reste inférieur à celui observé à Paris en 2018 (33.8 ans en 2018))" (Philippe Louchart, 6), or "la PMA devient déjà de plus en plus fréquente. Les progrès techniques peuvent tout à fait permettre de dépasser ce « plafond » " - Sylvain Papon, Insee, 22.

Several experts (16, 24b, 27, 32) even consider that past trends and future prospects do not justify the setting of a ceiling, beyond which the age would stop increasing, as Vianney Costemalle of the DREES (16): "Je ne vois pas pourquoi plafonner l'âge à 32 ans. La tendance d'avoir des enfants de plus en plus tard dans la vie va selon moi se poursuivre, et les progrès médicaux vont faire en sorte de rendre cette tendance possible (par exemple congélation des ovocytes, réparation du génome des embryons avec Crispr-Cas9 [indépendamment des questions éthiques et politiques que cela peut soulever]) ".

Some experts (3, 5, 6, 22) find it difficult to retain the same mean age for the three scenarios, especially if the TFR assumptions are more differentiated than in 2016 (3, 6, 24b). For example, Anne Goujon (3) says: "Je comprends l'idée de fixer l'âge à la maternité pour des raisons de simplicité, toutefois, si vous adoptez des intervalles plus larges au niveau de l'ICF, cela parait moins bien défendable. Peut-être envisager un plafond à 33 ans pour l'hypothèse centrale, 32 pour la haute et 34 pour la basse ?". Branislav Sprocha (Slovakia, 34) believes "that setting the same aging of fertility age-profile for all scenarios is not the best solution. Not only different intensities of fertility should be reflected in different scenarios, but also different developments in the aging process of the fertility profile should be included".

The link between fertility intensity and age at childbirth seems to be more important in other European countries such as Germany, as pointed out by Olga Poetsch and Felix zur Nieden (DESTATIS, Germany, 33): "In this respect, the situation in Germany is apparently not comparable. Postponing of births resulted so far in lower fertility. Therefore, the stronger the mean age at birth will increase the lower the assumption for the TFR will be". This explains why foreign experts are more sensitive to this link, like Astri Syse and Michael Thomas (Statistics Norway, 35): "[A mean age at 33] seems reasonable, however, perhaps in the low fertility scenario, the cap could be extended to 35 years? With medical advances in the area of infertility, it may be possible for

women to extend childbearing ages (something to consider if you are thinking so far into the future, e.g. 2040-2070)."

It is true that the assumption of independence between the mean age and the level of the TFR is unlikely, but it is practical for comparing scenarios, and has relatively little influence on the results of the projections, as Gilles Pison (7) reminds us: "Quant à appliquer la même évolution de l'âge à la maternité quelle que soit l'hypothèse sur l'ICF, c'est la solution la plus simple. On pourrait raffiner en introduisant une relation entre tendance de l'ICF et tendance de l'âge à la maternité - au cours des dernières décennies, les périodes de hausse de l'ICF ont souvent été des périodes de ralentissement du retard des maternités, et à l'inverse, celles de baisse de l'ICF, des périodes d'accélération du retard des maternités. Mais ce type de raffinement ne me parait pas avoir d'intérêt pour les projections de long terme que vous préparez". Laurent Toulemon shares the same opinion: "La variation de l'âge moyen n'a que très peu d'impact sur le nombre des naissances, à ICF fixé. Vous avez raison de faire la même variation pour tous les scénarios".

"A specific effort on mean ages is justified if you want to look at the completed fertility of generations and if you have assumptions about that."

Didier Breton (1) insists on the importance of the age at first child : "[C'est l'indicateur] le plus important et pertinent sur lequel il faudrait élaborer les scenarii. En effet, de lui dépend fortement l'infécondité d'une part, mais aussi l'agrandissement des familles".

Figure 2.8 - Experts' views on the mean age at childbirth in 2070

	32-33	33	33-34	34	35
Researchers	1	3	1	1	
OSS		5	1	1	1
NSI	1	7			
Anonymous		2			1
Total	**2**	**17**	**2**	**2**	**2**

THE EVOLUTION OF AGE-SPECIFIC FERTILITY RATES

In the 2016 projections, fertility was modeled age by age, assuming a linear change in the rate at each age. Some adjustments were then made to obtain a plausible age profile, with fertility rising to an age of maximum fertility corresponding roughly to the mean age at childbirth, and then declining. This method led to a concentration of fertility at a few key ages that became more and more pronounced as the years passed. For the 2021 projection, the experts were asked their opinion on the modelling of age-specific rates using the method described by Schmertmann (2003), which deduces a likely fertility profile from a few assumptions and leads to a greater spread of fertility, with identical TFR and mean age at childbirth (**Figure 2.5**).

Several experts are in favour of it (1, 6, 12, 20, 21, 22, 28, 37, one anonymous), for various reasons. For Didier Breton (1), it would correspond to the idea of a 'reproductive divide': [Cela] irait dans le sens d'une « fracture reproductive » c'est-à-dire de tenir compte du développement de deux

modèles de calendrier de fécondité, très lié à la trajectoire scolaire". For Philippe Louchart (6), the change in the age profile could also be explained by differences according to the country of birth: "l'analyse séparée de la fécondité par âge des femmes nées en France (ou non immigrées) et des femmes nées à l'étranger (ou immigrées) depuis une vingtaine d'années ". Anthony Marino and Amandine Brun-Schammé, from the COR, support the change in method.

Some experts (11, 35, 36, two anonymous) dispute the idea of a spread, such as Anne Solaz (11): « Je ne crois pas trop à un étalement. Je ne sais pas si l'âge à la première maternité retarde encore, on risque plutôt d'avoir plus de concentration pour les âges centraux » Olga Poetzsch and Felix zur Nieden (DESTATIS, Germany, 33) share this idea: "From our point of view, postponing births to a higher age leads to a greater concentration of fertility in the fourth decade of life. We tested Schmermann's model for deriving assumptions and decided against it".

Anne Goujon (3) suggests considering an alternative approach, the one proposed by Joop de Beer in 2011, called TOPALS (de Beer, 2011). Indeed interesting, this approach gives slightly better results in the case of France in 2008 than those of Schmertmann (2003). However, the difference is small and the main advantage of TOPALS is that it makes it possible to assume that the projected age profile converges towards a standard profile (for example, the average European profile or the profile of a country considered to be a precursor). In the French case, it seems to us that the Schmertmann model prolongs the phenomenon observed in the past of spreading out, which moreover corresponds to a convergence towards the European average, since Joop de Beer clearly shows the French singularity of a more concentrated profile around the age of 30 in 2008.

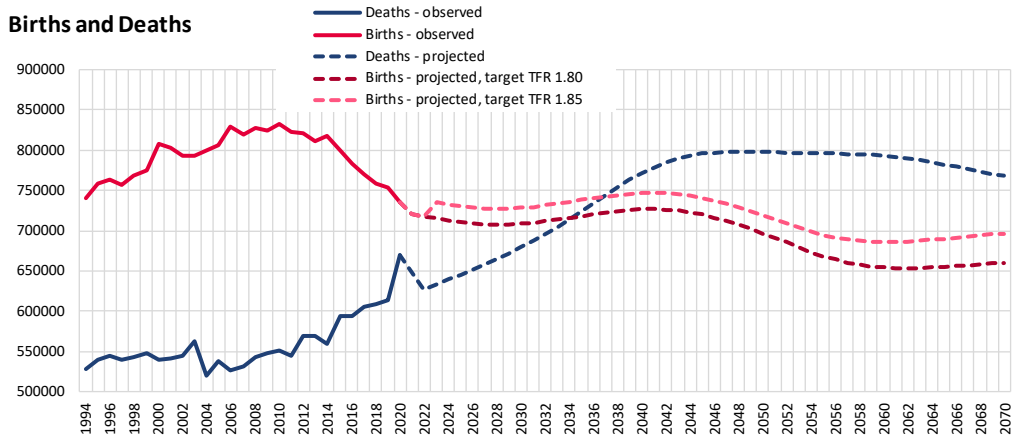
Jean-François Léger links the age profile to the intensity of fertility: " Un ICF faible (en dessous de 1.7) […] pourrait éventuellement correspondre à une fécondité concentrée autour de 30 ou 35 ans comme c'est le cas aux Pays-Bas par exemple".

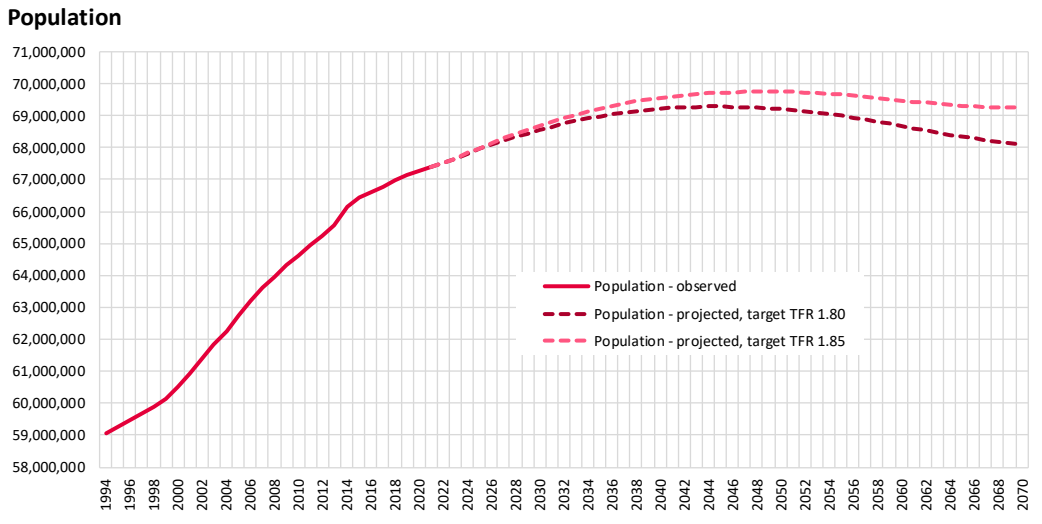
Several experts (7, 12, 14) point out that the age profile of fertility has little influence on the projection results. Consequently, Gilles Pison (7) argues for the adoption of a simple age-specific fertility rate curve model: "un âge moyen à la maternité correspondant au mode de la courbe des taux de fécondité par âge, et une courbe symétrique de part et d'autre".

Box 4 - Setting a TFR target of 1.80 or 1.85, what difference will it make by 2070?

It may seem that a baseline assumption of 1.80 or 1.85 does not fundamentally change the projection, but it actually affects the results quite significantly. In both cases, given the mortality assumptions of the baseline scenario presented in Part III, the natural balance becomes negative fairly quickly (2035 and 2037), even if births are higher around 2035-2045, when the children of the larger generations of the 2000-2010 period are born. The positive migratory balance (+70,000 in the central scenario, see part IV)) is sufficient to compensate for the negative natural balance until 2049 with a TFR of 1.85; but only until 2044 with a TFR of 1.80. By 2070, the population would be 1.1 million higher with a TFR of 1.85 than with a TFR of 1.80. The impact on the completed fertility (CF) is quite quickly visible: the 1997 generation would have a CF of 1.96 children per woman with a target TFR of 1.80 and 2.00 children per woman with a target TFR of 1.85; the 2028 generation would have CFs equal to the target TFRs of 1.80 and 1.85.

	TFR 1.80	**TFR 1.85**
Negative natural balance from ...	2035	2037
The population decreases from	2044	2049
In 2070		
Births (in thousands)	660	697
Total population (in thousands)	68,104	69,252
Share of under-20s (%)	20.2	20.8
Ratio of over 65s to 20-64s (%)	56.8	56.0





Source: Insee, population estimates and population projections 2021-2070.

TOTAL FERTILITY RATE: BASELINE ASSUMPTION AT 1.80, VARIANTS AT +/-0.2

It was difficult to decide between a TFR of 1.80 and 1.85 on the basis of expert responses. The difference seems small, but a total fertility indicator that is 0.05 children per woman higher in the long term nevertheless changes the results of the projection (**Box 4**). **For the baseline scenario, a TFR assumption of 1.80 was finally retained**, slightly below the current value of 1.83 and close to the average of the experts' responses, at 1.81. The target, very close to the current level, would be reached by 2022.

Experts have mostly urged against over-reacting to the **pandemic**, and the data have so far proved them right: the period of declining births in December 2020, January 2021 and February 2021 coincides with a decline in conceptions restricted to the period of the first containment, but a partial catch-up was observed in March-April 2021, and births rebounded in July and August 2021. The evolution of births is since then less easy to relate to the sanitary conditions 9 months before. Different assumptions can be made about the evolution of the remaining 4 months of 2021 and 2022. The assumption adopted for 2021 is that the trend between September and December 2021 will be similar to that observed between May and August, before returning in 2022 to the pre-crisis trend path(**Box 6).** This would lead to **a TFR that would decrease from 1.83 in 2020 to 1.79 in 2021 and 1.80 in 2022**. These values should be compared with those that would have been observed if the downward trends from 2017 to 2019 had continued, i.e. 1.84 in 2020, 1.82 in 2021 and 1.80 in 2022.

The vast majority of experts recommended increasing the interval between variants. The update of the probabilistic work of Vianney Costemalle (**Box 5**) also encourages increasing the interval between variants[11]: With an average of the *a priori* law set at 1.80, the long-term TFR would be 1.81, and the TFR would stay between 1.55 and 2.06 children per woman in 2070 with a 95% probability." These two arguments lead us to retain a **difference of +/-0.20 between the baseline assumption and the two variants**, compared with +/-0.15 in the 2016 projections. **The low variant will be at 1.60 and the high variant at 2.00**, slightly below the generation replacement level[12]. **The working scenario of very low fertility will be set at 1.50**, a value close to the European average in 2019 (the total population-weighted average of the TFRs of the EU countries is 1.52 in 2019).

In 2016 projections, convergence towards the TFR target was rapid in the different variants. The baseline assumption of 1.80 corresponds almost to the current level, and for 2022 the assumptions used lead to a total fertility rate of 1.80 (**Box 6**). It is therefore logical to assume in the baseline scenario that the TFR will stabilise at its target level of 1.80 by 2022. On the other hand, reaching 2.0, 1.6 or even 1.5 in two or three years' time is tantamount to assuming a very rapid reversal of

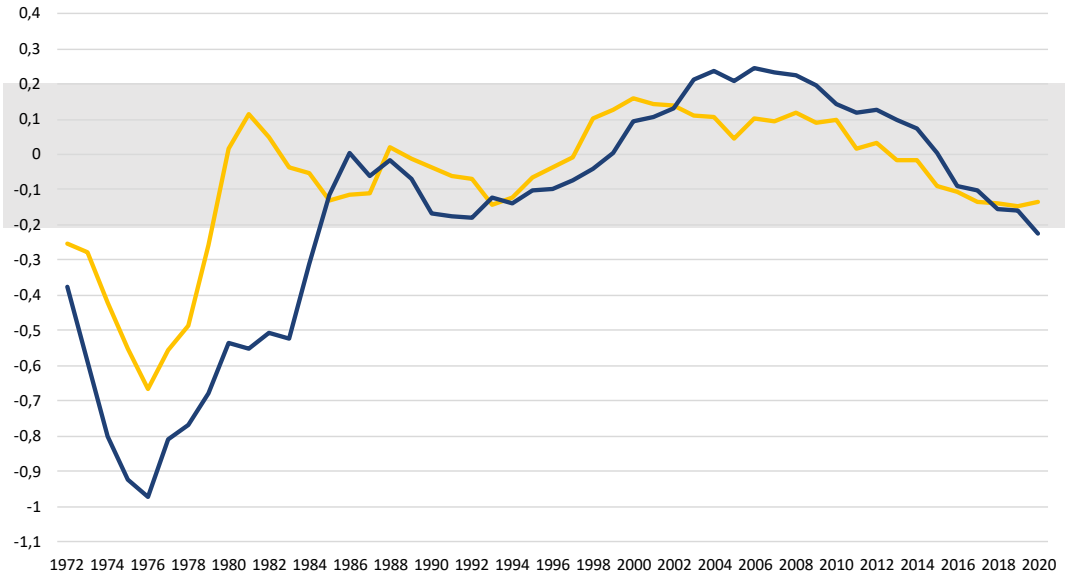
[11] This update does not help much in the choice of the target TFR in the chosen probabilistic modelling, as the projected median TFR in 2070 is highly dependent on the long-term assumption set a priori.

[12] The "current" renewal threshold (for a fictitious generation consistent with the TFR measure in 2020) is estimated at 2.06 children. Its theoretical minimum, in the absence of any mortality of women before and during their fertile period, would be 2.045.

the trend. Since the interval between the variants and the baseline scenario has been increased to +/-0.20, this raises the question of the rate at which the assumptions of the variants are reached. In the past, the drop in the TFR in the 1970's was very steep, almost 1 child per woman lower between 1966 and 1976 (**Figure 2.9**). But since the mid-1980's, the 5-year variations do not exceed +/- 0.15-0.16 points (+ 0.16 between 1995 and 2000, - 0.15 between 2014 and 2019). On the other hand, the 10-year variations reach +/- 0.20 to 0.25 points during certain periods (for example + 0.26 between 1996 and 2016, - 0.22 between 2010 and 2020). **This is why, for the variants, a convergence towards the target TFR by 2030, which is slower than in the 2016 projections, is retained (Figure 2.10)**.

Figure 2.9 - Changes in TFR from 5 years ago (yellow) or 10 years ago (blue) since 1972

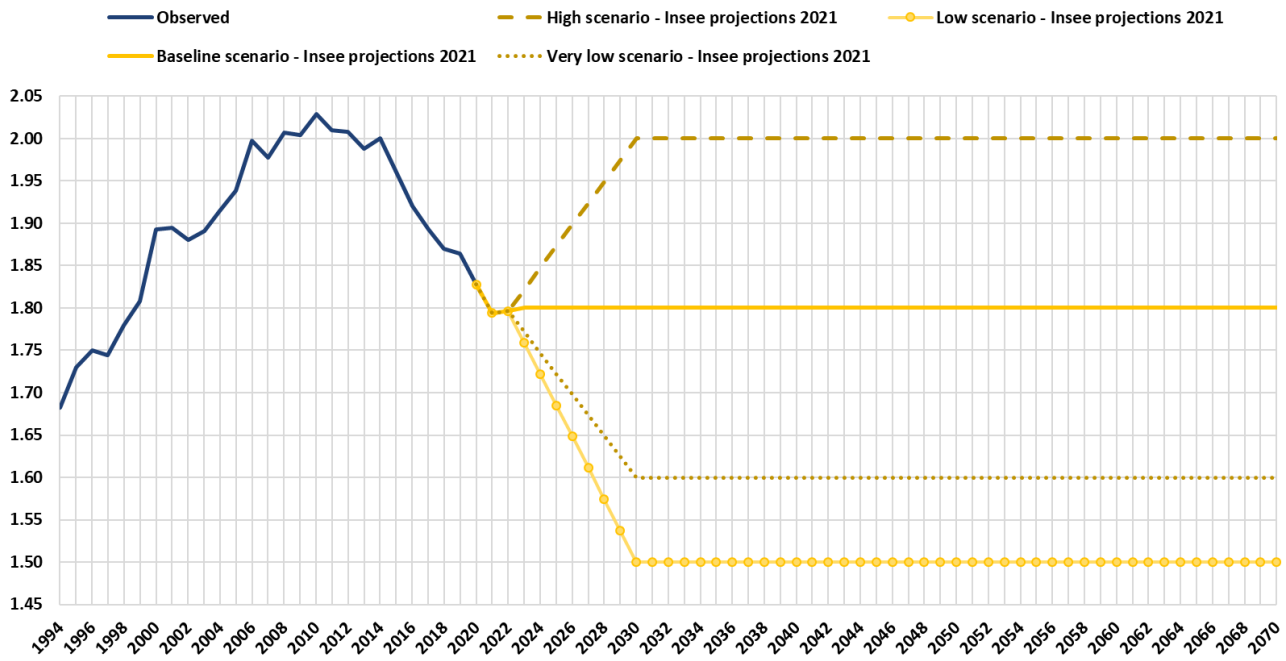
In number of children per woman



Coverage: Metropolitan France

Source: Insee, population estimates.

Figure 2.10 - The TFR from 1994 to 2070

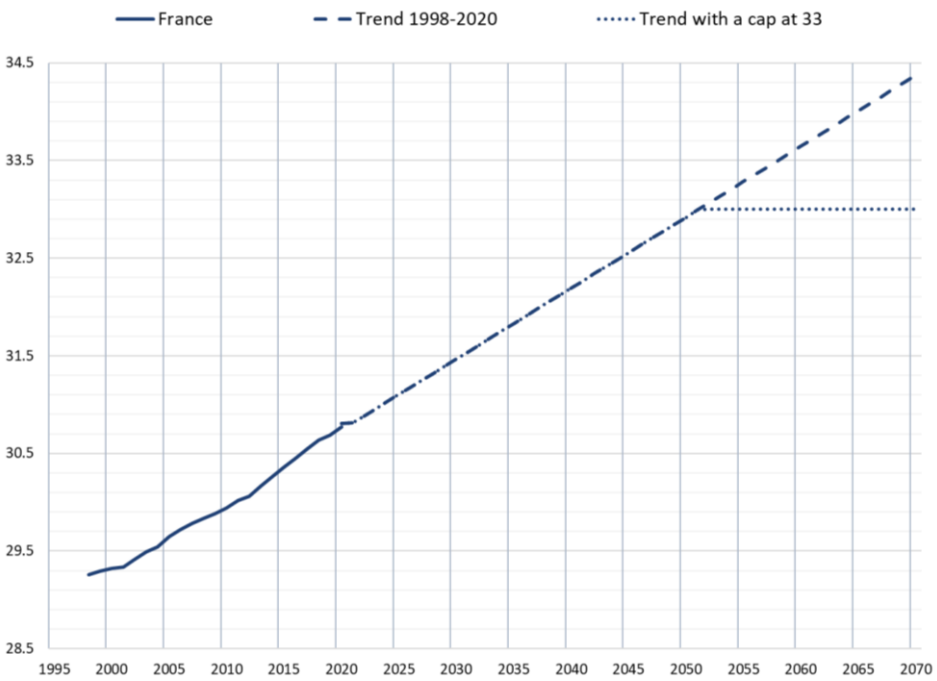


Source: Insee, population estimates and population projections 2021-2070.
Coverage: France excluding Mayotte until 2013, France from 2014 onwards.

THE ASSUMPTION ON MEAN AGE AT CHILDBIRTH : AN INCREASE TO 33 YEARS AND THEN A STABILISATION

Concerning age at chilbirth, the idea of a **ceiling of 33 years in 30 years** is maintained, even if some experts would have let the age increase beyond that. A continuation of the trend would lead to a mean age of 34.4 years in 2070 (**Figure 2.11**) and would limit the decline in completed fertility. The application of a ceiling of 33 years, reached in 2052, means that, over the last 18 years of the projection, the phenomena of postponement of childbearing diminish, and the completed fertility reaches the TFR target level (**Figure 2.13**). The impact of a continued increase in the mean age at childbirth until 2070 would be fairly modest on the results of the projection: changes in the level of the population or in the proportion of elderly people would be insignificant; on the other hand, the completed fertility would remain above 1.90 until the generations of the 2030's.

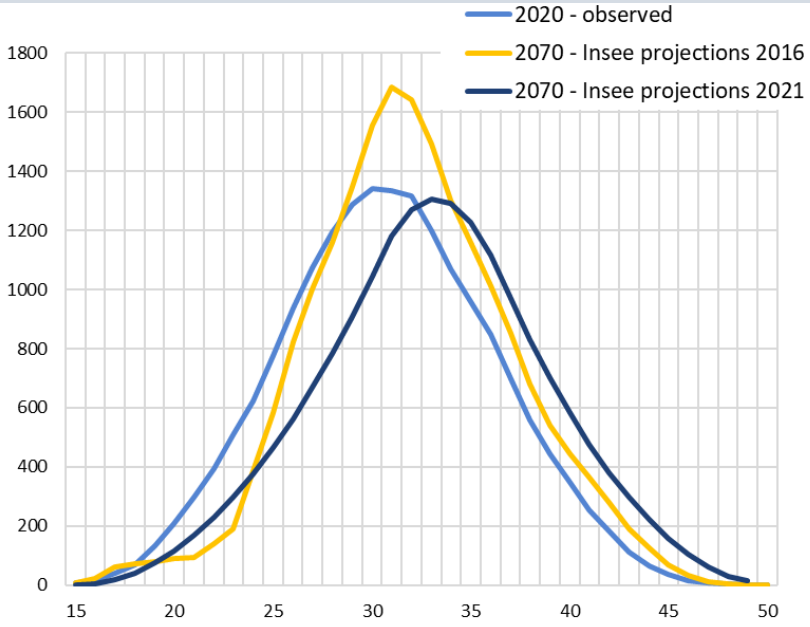
Figure 2.11 - Changes in the mean age at childbirth from 1994 to 2070



Source: Insee, population estimates and population projections 2021-2070.
Coverage: France excluding Mayotte until 2013, France from 2014 onwards.

On the profile of the age-specific fertility rate, several experts rightly pointed out that it does not have a decisive influence on the results of the projection and it was chosen to apply the Schmertmann (2003) model, which gives a fairly plausible profile for age-specific fertility rates (**Figure 2.12**).

Figure 2.12 - Age-specific fertility rates in 2020 and 2070, 2016 and 2021 projection years



Source: Insee, population estimates and central scenario of the 2016-2070 and 2021-2070 population projections.
Coverage: France.

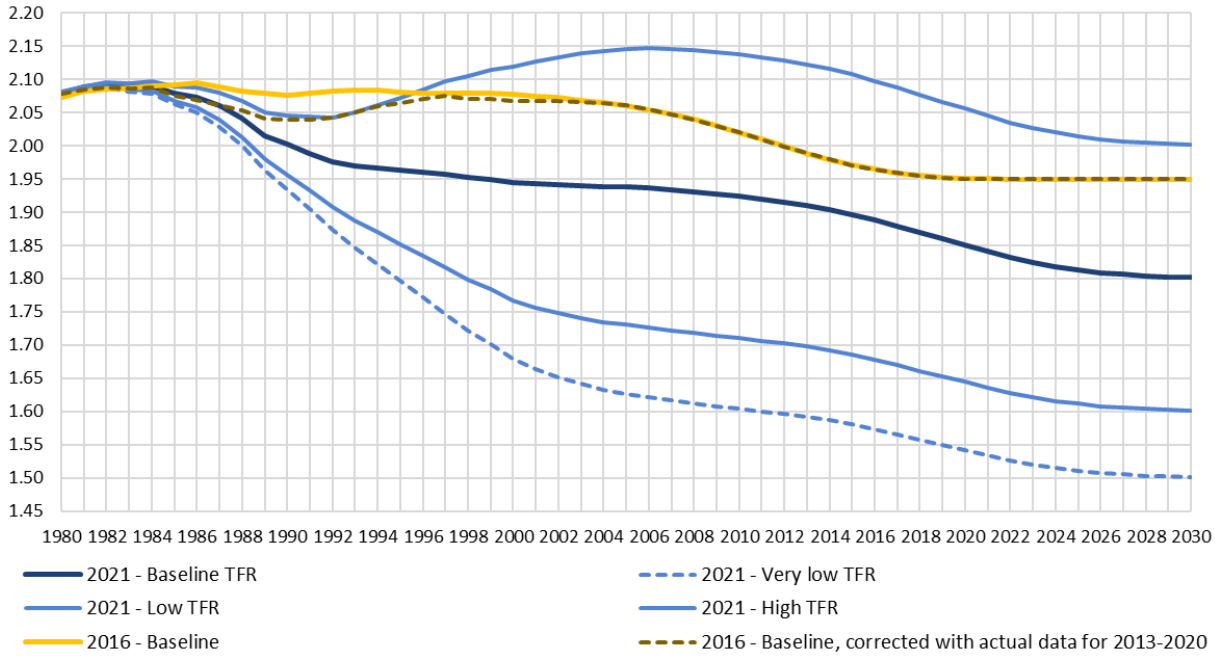
Some experts believe that the increase in the mean age will be achieved through a concentration of fertility at certain ages, rather than a spread, as biological constraints limit fertility at high ages. The spread is more a result of the dispersion of calendars due to the "reproductive divide"

mentioned by Didier Breton and the pursuit of medical progress that makes it possible to increase fertility at advanced ages. Since 1994, there has been more of a spread than a concentration: in 1994, the peak fertility age was 28 years and represented 8.4% of the TFR, and the five peak years were 26-30 years and represented 38.9% of the TFR. In 2020, the modal age is 31 years and represents 7.3% of the TFR, the maximum 5 years are 29-33 years and represent 35.5%.

COMPLETED FERTILITY: 2 CHILDREN PER WOMAN BORN IN 1990, 1.9 AND 1.8 FOR THOSE BORN IN 2015 AND 2030

With the new baseline assumptions, completed fertility would be significantly lower than that projected in 2016. The drop is rapid between the baseline scenarios of the two exercises since, in the previous projections, the completed fertility remained above the generation replacement level until the generations of the early 2000s, and above 2 until the 2012 generation. In the new projections, it falls below 2 as of the 1991 generation. In both exercises, the completed fertility of the 1980-1990 generations is clearly above 2 children per woman, as they had the most children during the high fertility period of the 2000's (Papon, 2021a). The difference in projected completed fertility for the 1990's generations is very largely due to the fact that the 2016 projections overestimated fertility for the years 2013-2020, as can be seen when we replace the projected rates in 2016 with the observed rates for those years (dark yellow dotted line).

Figure 2.13 -Completed fertility of the 1980 to 2030 generations: comparison of the different 2021 scenarios and the baseline scenario of the 2016 projections



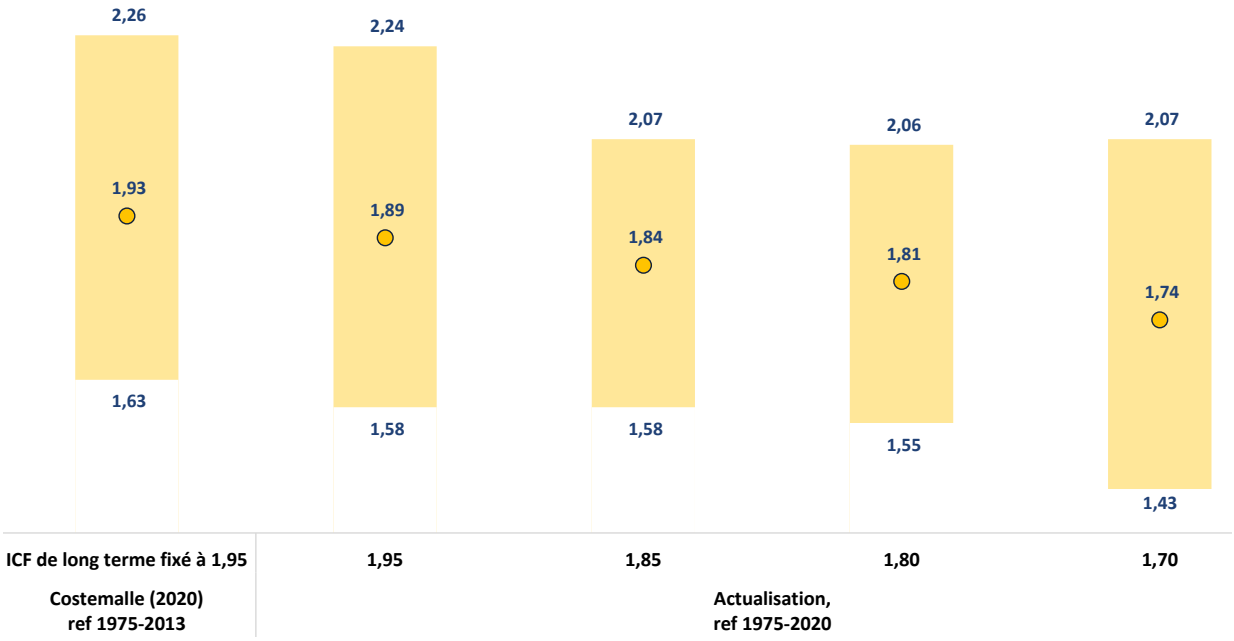
Source: Insee, population estimates and population projections 2016-2070 and 2021-2070.

Coverage: The age-specific fertility rates, from which the completed fertility is calculated, are for metropolitan France until 1993, France excluding Mayotte from 1994 to 2013 and France from 2014 onwards. The field is therefore composite for a single generation.

Box 5 - TFR probabilistic projection, an update of Vianney Costemalle's work

Vianney Costemalle has made Bayesian probabilistic projections for France using the component method (Costemalle, 2020). For fertility, he proceeds in three steps: projection of the TFR, then independent projection of age-specific rates, then reconciliation of the two by recalibration. For the TFR, he uses "first-order autoregressive model. The UN uses the same method for its third stage of fertility change, on the assumption that the TFR tends towards 2.1 in all countries (Alkema et al., 2010)". Compared to the UN method, V. Costemalle had "chosen to estimate the parameters of the model by Bayesian inference, rather than by maximum likelihood". He found a median long-term TFR of 1.93, "slightly below the mean of the *a priori* distribution, which is set at 1.95. According to the model used, the TFR will be between 1.63 and 2.26 children per woman in 2070 at a probability of 95%."We reproduced his model , thanks to his programs, for which we thank him very much. We just updated the results by taking into account the 2014-2020 data (the 2018-2020 years being provisional), and also varying the long-term TFR. Taking the latest data into account reduces the value of the projected TFR in 2070, but the size of the confidence interval increases slightly. By setting the long-term TFR at 1.85, which corresponds to the average over the reference period 1975-2020 (1.86), the confidence interval is significantly reduced: depending on the modelling chosen, the TFR will be between 1.58 and 2.07 children per woman in 2070 with a 95% probability. With a long-term TFR set at 1.80, the results change little: the TFR will be between 1.55 and 2.06 children per woman in 2070 with a 95% probability. A long-term TFR of 1.70 also increases the size of the confidence interval.

Projected TFR for 2070 :
2.5% and 97.5% order quantiles and median of the *a posteriori* distributions



Coverage: Metropolitan France

Long term TFR set at 1.95
Costemalle (2020)
Ref. 1975-2013

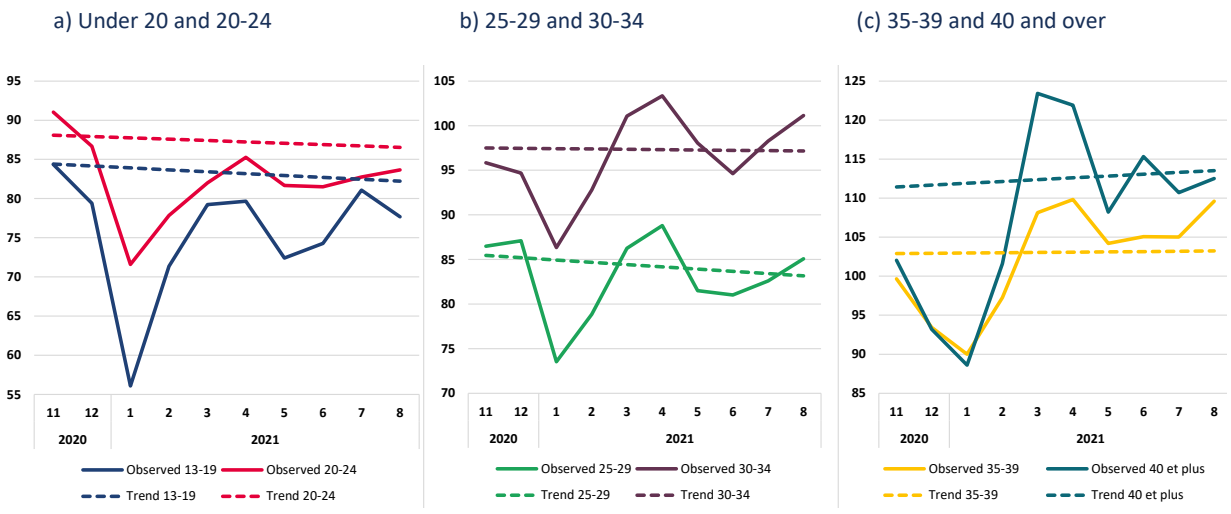
Update
Ref 1975-2020

Box 6 - Estimating births and fertility in 2021

At the time of freezing the assumptions for the projections, the data available for the year 2021 are the number of births from January to August. To measure changes, we chose to relate them to the same months in 2016. For example, in March 2021, there were 4,443 births to mothers aged 40 and over, 23% more than in March 2016 (3,600): the index is 123. The month-by-month comparison compensates for the monthly variations in births. Indeed, as age is measured in age reached in the year, the number of monthly births is structurally higher at the beginning of the year for the oldest mothers and at the end of the year for the youngest. Taking 2016 as a reference year allows us to compare the variations observed following the pandemic with those that have been in place for several years: since 2014, fertility has been falling every year. The trend decline, estimated here over the period January 2017-October 2020, is more marked among the youngest mothers, while the rise in fertility after age 35 continues (Figure 1, dotted lines). With reference to this trend, the decline was strongest in January for all age groups (figure, solid lines) while a catch-up was observed in March-April 2021. Between May and August 2021, the developments are contrasted but in total, compared to May-August 2016, the overall level of births is only 0.1% lower than it would be if it were on the 2017-2020 trend. The deficit remains most noticeable for mothers under 25 (table), as it has since December 2020 (Papon, 2021c).

Figure 1 - Change in births between November 2020 and August 2021 by age of mother

In index base 100 for the same month of 2016



Coverage: France

Estimating 2021 births and fertility (continued)

Therefore, the following assumptions were made:

- Fertility rates move with the same differential to their trend as births between January and August 2021 ;
- From September to December 2021, both fertility rates and births move with the same differential to their trend as births between May and August 2021 ;
- Fertility rates return to their 2017-2020 trend over the whole of 2022: the TFR rises compared to 2021, but remains lower than in 2019.

This leads to the assumption of a TFR of 1.79 children per woman in 2021 and 1.80 in 2022, then a stabilisation at this level, corresponding to the targetTFR of the central scenario, from 2023. From 753,000 births in 2019 and 736,000 in 2020, this would rise to 725,000 in 2021 and 717,000 in 2022.

Figure 2 - Change in births in 2021

Mother's age	Deviation from trend Jan. 2017-Oct. 2020, in %.				
	Jan-Feb	March-April	May-August	Sept-Dec (assumption)	2021 set (assumption)
Under 20 years old	-24.4	-4.6	-7.4	-7.4	-9.3
20-24 years old	-15.0	-4.3	-5.0	-5.0	-6.4
25-29 years old	-10.3	+3.8	-1.1	-1.1	-1.8
30-34 years old	-8.2	+5.0	+0.8	+0.8	+0.0
35-39 years old	-9.3	+5.7	+2.7	+2.7	+1.1
40 years and older	-15.5	+9.1	-1.4	-1.4	-2.3
All	-10.3	+4.1	-0.1	-0.1	-1.1

Coverage: France

PART 3 : THREE ASSUMPTIONS ABOUT MORTALITY

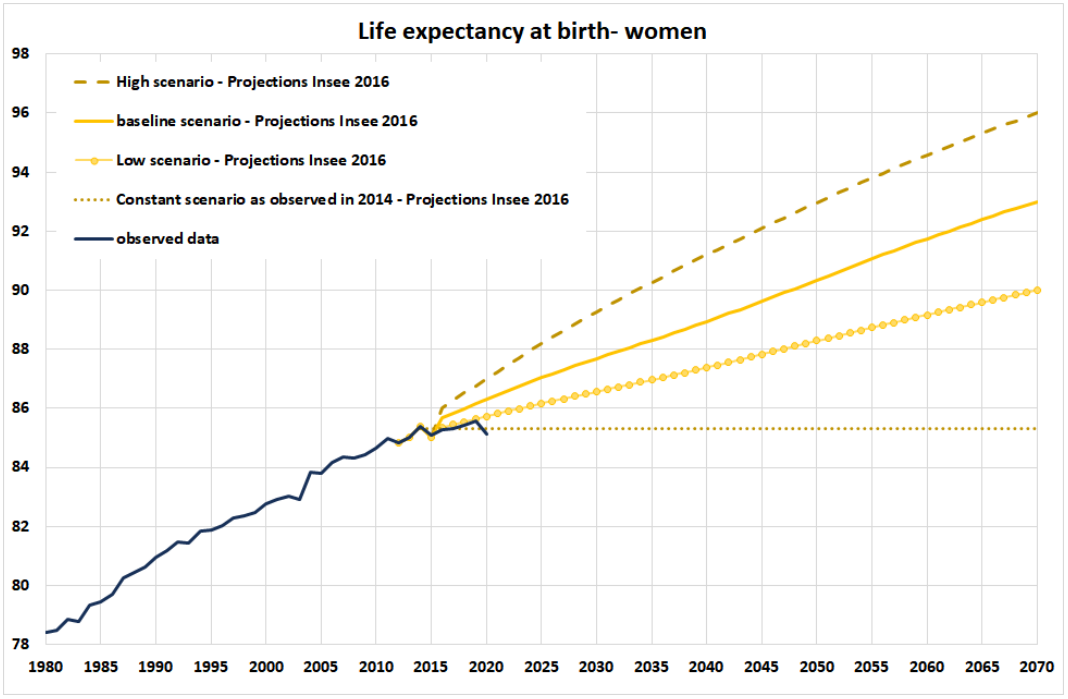
A. RECENT MORTALITY TRENDS IN FRANCE

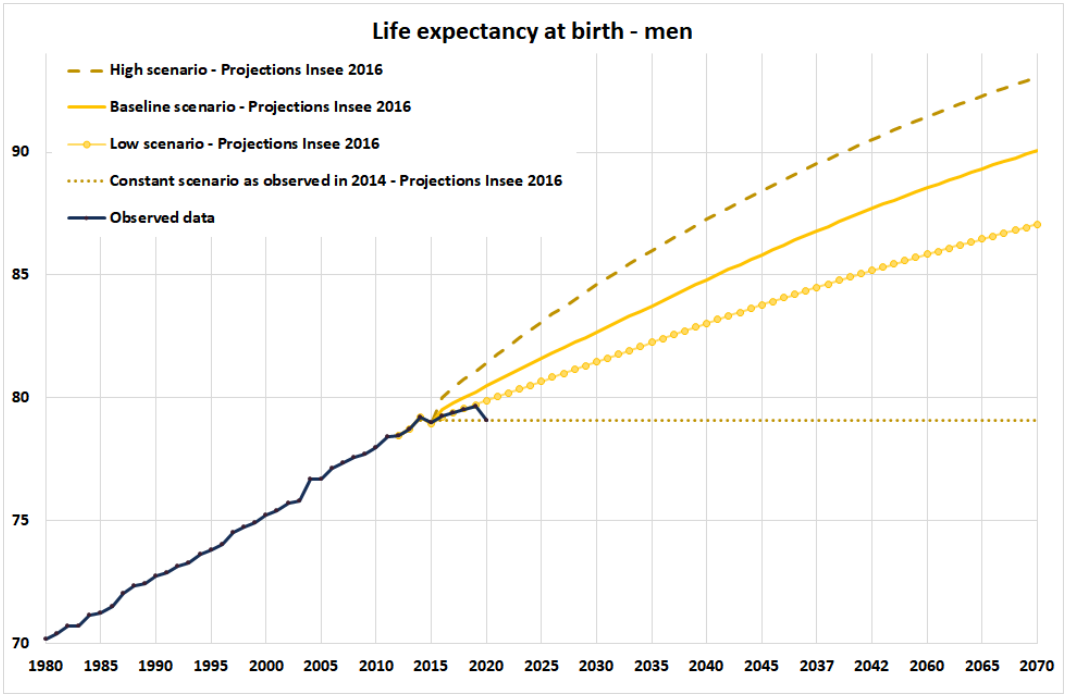
The previous projections retained a baseline assumption of life expectancy at birth of 93.0 years for women and 90.1 years for men in 2070 (**Figure 4.1**). Two alternative assumptions of high and low life expectancy were retained at + or - 3 years from this baseline assumption: 90 years and 96 years for women and 87.1 years and 93.1 years for men. An assumption of constant life expectancy equal to its 2014 level (at 85.3 years for women and 79.1 years for men) had also been used. In addition, the previous projections had extended a cohort effect, visible for the generations born from 1941 to 1955, the so-called "plateau generations". For these generations, mortality stagnates in adulthood while it decreases for the previous and following generations (Blanpain, 2020).

From 2014 to 2019, life expectancy progress slowed in France. In 2020, the year of the health crisis, life expectancy at birth even fell to its 2014 level (85.1 years for women and 79.1 years for men). The cohort effect also continued from 2016 to 2020 and contributed to the slowdown in life expectancy gains. In 2019, life expectancy is equal to the level of the low assumption of the 2016 Insee projections (0 year difference for women and men). In 2020, it is below the level of the low assumption of 2016 (-0.6 years for women and -0.8 years for men). In view of the recent evolution of life expectancy at birth, the baseline assumption of the 2016 Insee projections therefore appears high. Recent projections by institutions covering France also assume a lower life expectancy in 2070, for example 90.9 years for women and 86.2 years for men for Eurostat in its projections published in 2020[13], and 91.5 years for women and 86.1 years for men for the United Nations published in 2019 (United Nations, 2019c). Both of these exercises were conducted before the Covid-2019 pandemic.

[13] Eurostat, 2020 and EUROPOP2019 data online:
https://ec.europa.eu/eurostat/databrowser/view/proj_19nalexp/default/table?lang=fr

Figure 4.1 - The evolution of life expectancy at birth and its projection by INSEE in 2016





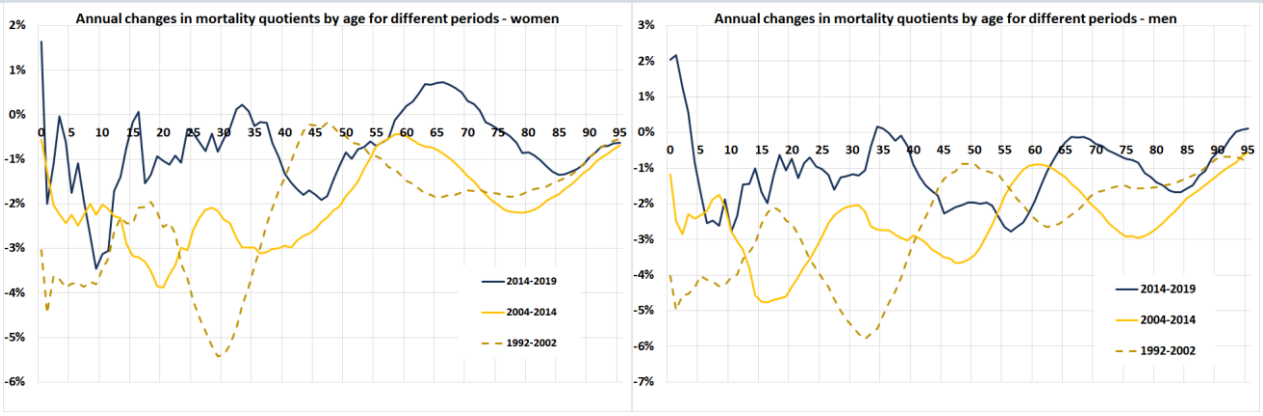
Coverage: Metropolitan France until 1993, France excluding Mayotte from 1994 to 2013 and France from 2014 onwards
Sources: INSEE, population estimates and vital statistics, provisional data in 2018, 2019 and 2020 and INSEE 2016 population projections.

In France, the slowdown in the increase in life expectancy since 2014 concerns all ages: the average annual slope of mortality rates between 2014 and 2019 shows almost at every age a smaller decrease in mortality than in previous periods (**Figure 4.4**).

This lower decrease in mortality affected several causes of death. The decline in mortality is thus less over the period 2008-2016 compared to the period 2000-2007 for the two main categories of

causes of death, tumours and cardiovascular diseases (Boulat et al. , 2019 and data online [14]). This suggests that this slowdown is not only due to short-term causes.

Figure 4.4 - Annual change in age-specific mortality rates for different periods



Coverage: Metropolitan France until 1993, France excluding Mayotte from 1994 to 2013 and France from 2014 onwards
Sources: INSEE, population estimates and vital statistics.

2020 is a high mortality year due to the Covid-19 epidemic. This is a conjunctural phenomenon and not a long-term trend. It does not seem advisable to include the year 2020 in the reference period for the past. The mortality of the year 2020 is taken into account in the age pyramid on 1 January 2021, but the Covid-19 epidemic will also have consequences on the evolution of mortality in 2021, 2022 or even after. Beyond the deaths resulting from a Covid-19 infection, these consequences could be both positive and negative.

Possible positive consequences on mortality: harvest effect (the most fragile people have already died, which leads to a drop in mortality in the following years, as in 2004 following the 2003 heat wave), drop in diseases transmissible by contact thanks to the development of physical distance (and therefore lower influenza lethality, for example), drop in certain causes of death due to the development of teleworking (drop in transport accidents, etc.).

Possible negative consequences: increase in deaths linked to the decrease in screening, consultations, the postponement of operations, increase in certain causes of death due to the economic crisis (deterioration in mental health, difficulties in accessing care, etc.) or the development of teleworking (deaths linked to sedentary lifestyle, isolation, etc.), increase in deaths linked to acquired fragility following infection with Covid-19, etc.

France's position in Europe

In Europe (**Figure 4.2)**, France is in 2019 at :

- 5th position for life expectancy of the population, 1.7 years above the EU-27
- 8th position for male life expectancy, 1.4 years above the EU-27.
- 2nd position for female life expectancy, 1.9 years above the EU-27.

[14] Cause of death data: https://www.cepidc.inserm.fr/causes-medicales-de-deces/interroger-les-donnees-de-mortalite)

In Europe, female life expectancy converged somewhat from 2009 to 2019: in general, countries with low life expectancy made more progress (**Figure 4.3**). For France, female life expectancy was high in 2009 and increased less than the EU-27 from 2009 to 2019 (+0.9 years, compared to +0.4 years for French women).

In Europe, male life expectancy has converged very little from 2009 to 2019 (**Figure 4.3**). For France, male life expectancy was slightly above the EU average in 2009 and increased by 1.9 years, slightly less than the EU-27 from 2009 to 2019 (+2.1 years).

The impact of the health crisis on the differences in life expectancy between European countries is currently difficult to assess (Ourliac, 2021).

Figure 4.2 - Life expectancy at birth by country in 2019

total	
Spain	84.0
Switzerland	84.0
Italy	83.6
Sweden	83.2
France	**83.0**
Norway	83.0
Ireland	82.8
Netherlands	82.2
Belgium	82.1
Finland	82.1
Austria	82.0
Portugal	81.9
Greece	81.7
Slovenia	81.6
Denmark	81.5
EU27	**81.3**
Germany	81.3
Czech Republic	79.3
Albania	79.1
Turkey	79.1
Estonia	79.0
Croatia	78.6
Poland	78.0
Slovakia	77.8
Northern Macedonia	76.6
Armenia	76.6
Azerbaijan	76.6
Lithuania	76.5
Hungary	76.5
Serbia	76.0
Latvia	75.7
Romania	75.6
Bulgaria	75.1
Georgia	74.1
Ukraine	73.4

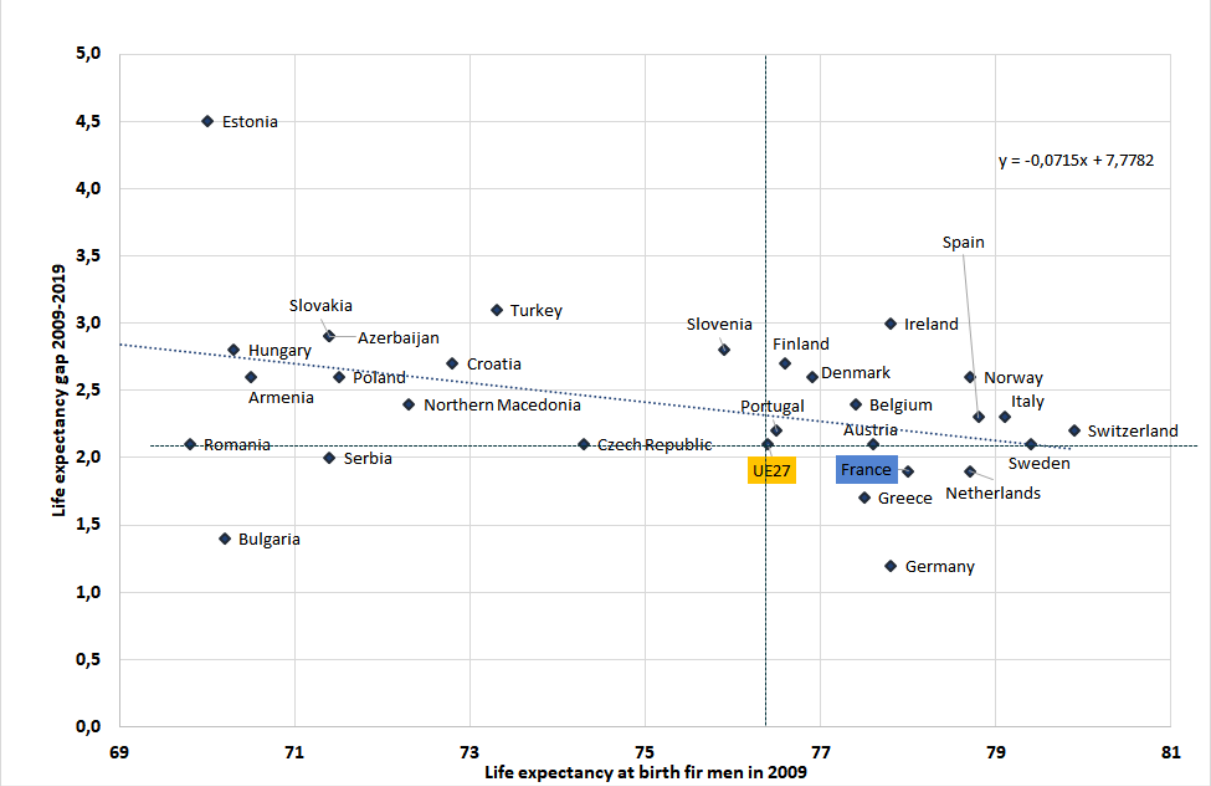
male	
Switzerland	82.1
Sweden	81.5
Italy	81.4
Norway	81.3
Spain	81.1
Ireland	80.8
Netherlands	80.6
France	**79.9**
Belgium	79.8
Austria	79.7
Denmark	79.5
Finland	79.3
Greece	79.2
Germany	79.0
Portugal	78.7
Slovenia	78.7
EU27	**78.5**
Albania	77.6
Czech Republic	76.4
Turkey	76.4
Croatia	75.5
Northern Macedonia	74.7
Estonia	74.5
Slovakia	74.3
Azerbaijan	74.3
Poland	74.1
Serbia	73.4
Hungary	73.1
Armenia	73.1
Romania	71.9
Bulgaria	71.6
Lithuania	71.6
Latvia	70.9
Georgia	69.8
Ukraine	68.4

female	
Spain	86.7
France	**85.9**
Switzerland	85.8
Italy	85.7
Portugal	84.8
Finland	84.8
Sweden	84.8
Ireland	84.7
Norway	84.7
Slovenia	84.5
Belgium	84.3
Greece	84.2
Austria	84.2
EU27	**84.0**
Germany	83.7
Netherlands	83.7
Denmark	83.5
Estonia	83.0
Czech Republic	82.2
Poland	81.9
Turkey	81.8
Croatia	81.6
Lithuania	81.2
Slovakia	81.2
Albania	80.7
Latvia	80.1
Hungary	79.7
Armenia	79.7
Romania	79.5
Azerbaijan	78.9
Bulgaria	78.8
Northern Macedonia	78.6
Serbia	78.6
Georgia	78.4
Ukraine	78.3

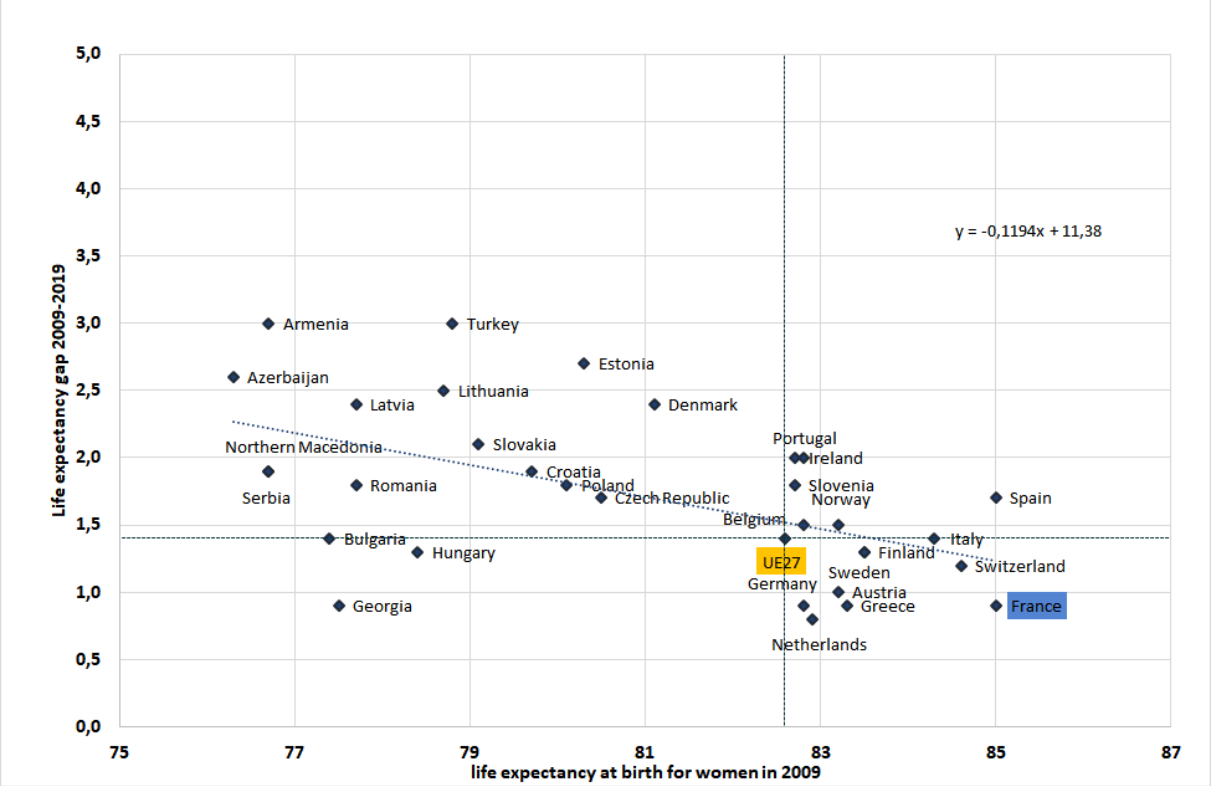
Source: Eurostat, extracted on 15 July 2021,
https://ec.europa.eu/eurostat/fr/web/main/data/database

Figure 4.3 - Life expectancy at birth in 2019 and life expectancy gain 2009-2019 by country

Male



Female



Source: Eurostat.

B. THE POSITION OF EXPERTS ON THE EVOLUTION OF MORTALITY

Six questions addressed mortality trends:

- Q14 on the long-term horizon of life expectancy (baseline scenario) ;
- Q15 on the low and high variants to be retained on life expectancy ;
- Q16 on the evolution of short-term life expectancy in the pandemic context ;
- Q17 on the gender gap in life expectancy ;
- Q18 on the cohort effect for the 1941-1955 generations.

Finally, Q19 was a table to be filled in to summarize and quantify the previous answers.

WHAT TARGET FOR LIFE EXPECTANCY IN THE BASELINE SCENARIO?

From a quantitative point of view, 14 experts gave their opinion.

Figure 4.4 - Experts' views on life expectancy at birth in 2070

			2070	
			female	**male**
researchers	5	Jean-Francois LÉGER	88.1	83.5
	7	Gilles PISON	87.0	84.0
	12	Laurent TOULEMON	92.0	89.0
	13	Arkadiusz WISNIOWSKI	90.5	
OSS	14	Didier BLANCHET, CSR Pensions	90.5	86.5
	20	Anthony MARINO and Amandine BRUN-SCHAMMÉ, COR	90.0	87.1
	22	Sylvain PAPON, Insee	90.0	86.0
NSI	28	Katarzyna GÓRAL-RADZISZEWSKA, Statistics Poland	89.0	85.0
	30	Raymond KOHLI, FSO, Switzerland	90.5	87.5
	31	Lena LUNDKVIST, Statistics Sweden	89.7	87.6
	35	Astri SYSE and Michael THOMAS, Statistics Norway	92.0	90.0
	37	Livia VARGA and Zoltan CSANYI, KSH, Hungary	90.5	87.5
anonymous		anonymous 1	90.5	87.5
		anonymous 2	88.9	82.9
		average	**89.9**	**86.5**
		minimum	**87.0**	**82.9**
		maximum	**92.0**	**90.0**

Figure 4.5 - Experts' position on the reference period for extending mortality rates

	rather 2000-2019	rather 2010-2019	rather 2015-2019	other
researchers	2	1	1	3
OSS	1	7	0	1
NSI	4	3	0	4
anonymous	1	2	0	1
total	**8**	**13**	**1**	**9**

Among the 14 experts who spoke quantitatively, the average life expectancy in 2070 is 89.9 years for women and 86.5 years for men. The minimum is 87.0 years and the maximum 92.0 years for women and 82.9 years and 90.0 years for men.

Thirteen experts, a majority of them, favour a 10-year period (2010-2019) to extend the trends in mortality rates (8, 14, 19, 20, 21, 22, 23, 24b, 30, 32, 34, 2 anonymous). Eight experts favour a longer period (20 years, from 2000 to 2019). One expert (5) prefers a shorter period.

The arguments in favour of a 10-year period are as follows:

- Sylvain Papon of INSEE (22) thinks that the increase in life expectancy will not regain the pace observed in the second half of the 20th century: « Tant qu'une nouvelle innovation médicale ne viendra pas bouleverser l'état des choses, il est à craindre que la hausse de l'espérance de vie ne retrouve pas le rythme observé lors de la seconde moitié du XXème siècle. Je pense ainsi qu'utiliser la moyenne des 10 dernières années est plus prudent. »
- Grégoire Rey (8) believes that there is no major trend identified that would allow us to think that life expectancy will resume its rise: « Sur les 60 dernières années, la situation a rarement été aussi incertaine qu'aujourd'hui. Il n'y a pas de tendance majeure identifiée qui permettrait de penser que l'espérance de vie va reprendre sa hausse. Je privilégierais une tendance sur 10 ans »
- For Anthony Marino and Amandine Brun-Schammé, COR (20), the decline in mortality has become, at almost all ages, less rapid during the recent period 2013-2018 than during the previous period 1998-2013. The only exception concerns the 50-65 age group, the "plateau generations": « La baisse de la mortalité est devenue, à presque tout âge, moins rapide durant la période récente 2013-2018 que durant la période antérieure 1998-2013. La seule exception concerne la tranche d'âge de 50 à 65 ans, « générations palier », qui s'est d'abord traduit par une baisse ralentie de la mortalité vers 55-60 ans durant la période 1998-2013 puis par une baisse ralentie - voire une hausse - de la mortalité vers 65 ans durant la période 2013-2018. Ainsi le ralentissement récent de la progression de l'espérance de vie correspond à un effet de période, qui affecte la plupart des générations au cours de la période récente. Une période relativement récente, 2010-2019, pourrait ainsi être retenue. Cette tendance semblerait conduire au scénario bas actuel, qui deviendrait de fait le scénario central

et conduirait donc en 2070 à réviser à la baisse l'espérance de vie à la naissance de 3 ans pour les femmes comme pour les hommes. »

The arguments in favour of a 20-year period are as follows:

- Gilles Pison (7) suggests considering the longest period, which makes it possible to smooth out the effect of "accidents: « Comme période de référence pour la tendance, je suggère de considérer la période la plus longue, ce qui permet de lisser l'effet des « accidents » - canicule de 2003, grippes saisonnières meurtrières lors de quatre des six derniers hivers. »
- Laurent Toulemon (12) would be conservative: « Je serais conservateur : l'Insee a fait un effort pour remonter ses hypothèses après des décennies de pessimisme, autant ne pas baisser trop les projections pour l'espérance de vie. »
- Vianney Costemalle of the Drees (16) wishes to avoid prolonging conjunctural effect: « On peut penser qu'elle va continuer à augmenter et que la santé sera une préoccupation de plus en plus majeure de la société. Pour prolonger mieux vaut prendre une longue période sur le passé (20 ans) pour éviter de prolonger des effets conjoncturels. »

Jean-François Léger (5), who advocates a short recent period, believes that as we approach the limit values of human life span, annual gains should therefore a priori continue to decrease, unless spectacular discoveries are made : « La croissance de l'espérance de vie a ralenti ces dernières années, ce qui est normal. À mesure que l'on approche des valeurs limites de la durée de vie humaine, les gains annuels devraient donc a priori continuer de diminuer, sauf découvertes spectaculaires. »

Carlo Giovanni Camarda (2) would prefer "to use probabilistic and data-driven methods". "À moins que quelqu'un ne soit vraiment spécialisé sur le cas français, il est difficile de « deviner » les valeurs de l'espérance de vie future, et tout choix peut toujours être considéré comme subjectif. »

For Jean-Marie Robine (9) thinks that it becomes difficult to read the trends, especially over short periods such as the last ten years : « de nombreux prévisionnistes prévoient pour l'avenir une accélération des vagues de chaleur avec le réchauffement climatique ou des épidémies avec la globalisation des échanges. Entre une tendance dont la pente est moins forte pour la croissance de l'espérance de vie féminine et des fluctuations annuelles de mortalité plus fortes et plus fréquentes, il devient difficile de lire les tendances surtout sur des courtes périodes comme par exemple les dix dernières années. Le point clef pour la poursuite de la croissance de l'espérance de vie (surtout féminine) repose sur notre capacité à gérer la fragilité les personnes très âgées (+ de 85 ans). L'avis des biologistes et des gériatres me

semble donc essentiel pour pouvoir argumenter les différentes hypothèses que l'on peut faire pour le futur. »

Olga Poetzsch and Felix zur Nieden, Destatis, Germany (33) use different reference periods, one that reflects the long-term trend and one that reflects the short-term trend as well as a combination of both: "We consider different reference periods to derive different assumptions - one that reflects the long-term trend (e.g. 50 years) and one that reflects the short-term trend (e.g. years 10) as well as a combination of both".

Gwenaël Podesta, DGEC (23) would appreciate if INSEE could provide some information on the impact of climate change on mortality: « il serait appréciable que l'INSEE apporte quelques éléments sur l'impact du changement climatique sur la mortalité. A minima, une hypothèse d'un réchauffement de +2°C (borne supérieure de l'accord de Paris sur le climat, et hypothèse du Plan national d'adaptation) ou +3°C (trajectoire découlant des objectifs actuels des pays) pourrait être faite pour estimer l'impact sur la mortalité »

THE HEALTH CRISIS AND THE EVOLUTION OF LIFE EXPECTANCY IN THE SHORT AND MEDIUM TERM

Figure 4-6 Expert opinion on the level of short-term life expectancy

	2022=2019	2021, 2022 or 2023 = return to recent trend	Return to 2019 level after 2022	2022= faster than recent trend	Other or don't know
researchers	1	5	0	1	3
OSS	0	4	1	0	3
NSI	1	4	1	0	4
anonymous	2	3	0	0	1
total	**4**	**16**	**2**	**1**	**11**

Sixteen experts, i.e. a very large majority are in favour of a return of life expectancy in 2022 (sometimes in 2021 or 2023) to the level obtained by extending the mortality rates according to the recent trend before 2020 (4, 5, 6, 7, 12, 15, 20, 22, 23, 28, 30, 31, 36, 3 anonymous). One expert (9) thinks that the 2022 level will be higher than that obtained by extending the recent trend.

Four experts (8, 26, 2 anonymous) believe that life expectancy in 2022 will only reach its 2019 level. Two experts (21, 32) think that the 2019 level will only be reached again after 2022.

Why might life expectancy in 2022 return to the level obtained by extending mortality rates according to the recent trend?

- Because of the harvest effect (6, 15, 20, 22). Thus for Pascale Breuil (Cnav, 15): « Si l'on suppose que la crise sanitaire s'est accompagnée d'un effet moisson important (personnes particulièrement fragiles), et sous réserve que la crise prenne fin, on peut supposer qu'il y aurait un effet rebond puis que les effets de la crise s'estomperaient sauf si vous avez des éléments objectifs indiquant un impact durable sur l'ensemble de la population. »
- Better vaccination coverage (7, 36): « Une hypothèse à prendre en compte éventuellement aussi : suite à l'épidémie de Covid-19, une adhésion plus importante en France aux vaccinations de manière générale. Il pourrait en résulter que lors des futurs épisodes de grippe saisonnière, la surmortalité serait plus faible qu'au cours des derniers épisodes, du fait d'une meilleure couverture vaccinale » according to Gilles Pison (7),
- Less transmission of other diseases with the wearing of masks according to Anthony Marino and Amandine Brun-Schammé of the COR (20)

Why life expectancy in 2022 could be at its 2019 level ?

- Continuation of degraded care during the peaks of Covid-19, economic crisis : « Il peut y avoir des conséquences à la hausse (un renforcement des soins, un effet moisson qui s'étale, une faible circulation des autres maladies infectieuses), et à la baisse (suite de soins dégradés pendant les pics de Covid-19, crise économique). Très difficile de savoir lesquelles prendront le dessus, je mettrai le niveau de 2019. » according to Grégoire Rey (8)

Why would the 2019 level not be reached until after 2022?

- For the experts from DG Trésor (21), we should consider a pessimistic scenario that would foresee a slow rise in vaccination, and the potential ineffectiveness against certain variants: « Pour 2022, il paraît encore optimiste de fixer un retour au niveau 2019. Sous réserve des données encore à intégrer, jusqu'à l'échéance la plus tardive qui précède la fixation des hypothèses, il nous paraît plus central de prolonger légèrement les tendances sur 2022 voire 2023. Ces scénarii pourront évoluer en fonction des éléments à venir et en fonction du recul acquis au moment de la fixation des hypothèses, mais il parait sain d'envisager un scénario pessimiste qui prévoirait une montée en charge lente de la vaccination, et la potentielle inefficacité contre certains variants. »

Why might life expectancy in 2022 be higher than the level obtained by extending mortality rates according to the recent trend? :

- For Jean-Marie Robine (9), we can think by analogy with the year 2004 (very strong gains), which followed the 2003 heat wave: « On peut réfléchir par analogie avec

l'année 2004 qui suivit la canicule de 2003. Les très forts gains de longévité observés en 2004 dépassent largement la somme des récupérations sur 2003 (effet de moisson ou autres) et des gains attendus pour 2004. Un saut de longévité s'est produit en 2004 qui peut expliquer un certain ralentissement des années suivantes. Ce saut de longévité s'explique sûrement par un changement dans l'attention portée aux personnes très âgées et à leurs besoins, surtout dans les EHPAD, après la canicule de 2003. Verra-t-on en 2022 et les années suivantes un nouveau changement dans notre attention portée aux personnes très âgées et aux personnes fragiles entrainant un saut similaire de longévité ? C'est très probable, surtout et à nouveau dans les EHPAD. »

VARIANTS: HIGH AND LOW LIFE EXPECTANCY TARGETS

Figure 4-7 Expert opinion on the gap in life expectancy at birth in 2070 compared to the baseline assumption

	rather 3.0 years	rather 3.5 years	no preference	based on the past	rather confidence interval	other
researchers	0	2	0	2	2	3
OSS	1	5	0	0	1	0
NSI	1	2	3	2	0	0
anonymous	0	2	0	2	0	0
total	**2**	**11**	**3**	**6**	**3**	**3**

Eleven experts, i.e. the majority (7, 12, 14, 20, 21, 22, 24b, 30, 35, 2 anonymous) prefer a range of +/-3.5 years for the low and high variants of life expectancy in 2070, which is justified by an increase in uncertainty. Thus, for Didier Blanchet (14), of the CSR-Retraites is mostly symbolic, but may be a way of indicating that we think that uncertainty has increased: « passer à +/- 3,5 est surtout symbolique à vrai dire, mais peut constituer une façon de marquer qu'on pense que l'incertitude s'est accrue ». For DG Trésor (21), the Covid-19 health crisis, or the increase in heat waves argue for an expansion « à long terme, on note des événements probables pouvant avoir un impact significatif sur cette valeur, la crise sanitaire Covid-19 par exemple, ou encore l'augmentation des épisodes de canicule à prévoir en lien avec le réchauffement climatique. Ces éléments plaident pour un élargissement. »

Two experts (25, 26) prefer an interval of +/- 3 years, in order to facilitate comparisons with previous projections (26). For Pascale Breuil of the Cnav (15), in general, a certain inertia in the assumptions is to be preferred : « De manière générale, en cas d'incertitude, une certaine inertie dans les hypothèses est à privilégier, afin que les ajustements se fassent progressivement tous les cinq ans et d'éviter tout sur-ajustement, susceptible d'avoir des conséquences fortes (en matière de pilotage des retraites par exemple). »"

Six experts (4, 19, 31, 33, and 2 anonymous) suggest the idea of using the past to define the low and high variants, rather than retaining a predefined interval, which is summarised by

Fanny Janssen (4): "for example for the high variant it could consist of an extrapolation of the modal age at dying. For the low variant it could consist of an extrapolation of the more recent trends in age-specific mortality". In Sweden (31), the new projections are based on the average of the 25 highest and lowest variations in life expectancy over the period 1970-2020, "we use the mean value of the 25 observations of highest and lowest annual change in life expectancy in the 51-year period 2070-2020."

Gautier Maigne of France Stratégie (19) also suggests planning for two work/breakdown scenarios: stable life expectancy (at the 2019 level), falling life expectancy: « prévoir deux scénarios de travail / rupture : stabilité de l'espérance de vie (au niveau 2019), baisse de l'espérance de vie. »Three experts (2, 13, 27) were in favour of a confidence interval rather than a predefined interval.

For Jean-François Leger (5), the low scenario would be the maintenance of life expectancies at their current level or almost" with a high scenario of +2.5 years for women and +3.7 years for men : « le scénario bas serait le maintien des espérances de vie à leur niveau actuel ou presque » avec un scénario haut à + 2,5 ans pour les femmes et +3,7 ans pour les hommes. »

Vianney Costemalle of the Drees (16) pleads for round figures +/-3 years or +/- 4 years to facilitate communication.

THE GENDER GAP IN LIFE EXPECTANCY

From a quantitative point of view, 13 experts gave their opinion.

Figure 4-8 Expert opinion on the gender gap in life expectancy in 2070

researcher	5	Jean-Francois LÉGER	4.6
	7	Gilles PISON	3.0
	12	Laurent TOULEMON	3.0
OSS	14	Didier BLANCHET, CSR Pensions	4.0
	20	Anthony MARINO and Amandine BRUN-SCHAMMÉ, COR	2.9
	22	Sylvain PAPON, Insee	4.0
NSI	28	Katarzyna GÓRAL-RADZISZEWSKA, Statistics Poland	4.0
	30	Raymond KOHLI, FSO, Switzerland	3.0
	31	Lena LUNDKVIST, Statistics Sweden	2.1
	35	Astri SYSE and Michael THOMAS, Statistics Norway	2.0
	37	Livia VARGA and Zoltan CSANYI, KSH, Hungary	3.0
anonymous		anonymous 1	3.0
		anonymous 2	6.0
		average	**3.4**
		minimum	**2.0**
		maximum	**6.0**

Figure 4-9 Expert opinion on the decrease of the gender gap in life expectancy

	Same pace as before 2021	Slower pace than in the past	other
researchers	7	0	1
OSS	6	1	0
NSI	10	0	1
anonymous	2	0	0
total	**25**	**1**	**2**

Among the 13 experts who expressed themselves quantitatively, the average F/M gap in life expectancy at birth in 2070 is 3.4 years, with a minimum of 2 years and a maximum of 6 years.

Almost all the experts (4, 5, 6, 7, 8, 9, 12, 14, 19, 20, 21, 22, 24b, 26, 27, 28, 30, 32, 33, 34, 35, 36, 37) are in favour of bringing life expectancy for women and men closer together at the same pace as in the past, despite the stagnation of the F/M gap observed from 2017 to 2020.

One of the arguments is the high level of the life expectancy gap in France compared to other OECD or Western European countries. Thus, for Gautier Maigne, France Stratégie (19) « On peut aussi noter que l'écart français d'espérance de vie reste relativement important par rapport à celui constaté dans beaucoup d'économies avancées. ». Similarly, for Kim DUSTAN, Statistics New Zealand (27), "a gap of 6 years is relatively high by OECD standards."

Another argument concerns smoking-related deaths, which Fanny Janssen (4) believes should decrease more rapidly among men than among women: "A further reduction of the sex gap in life expectancy would be logical, especially given that smoking-attributable mortality among French men is expected to continue to decline at a fast rate, whereas smoking-attributable mortality among French women - which was still increasing till recently - will likely decline at a smaller rate (Janssen et al., 2020). Also, within Western Europe, the sex gap in life expectancy in France is currently higher than in other countries, and for a large part affected by sex differences in smoking-attributable mortality (Janssen, 2020)."

On the other hand, for Gautier Maigne, France Stratégie (19), this continued narrowing seems relevant because of social factors (the differences in participation in the labour market, and even in the type of jobs held, are likely to narrow further) and societal and cultural factors: « Ce prolongement du rapprochement semble pertinent sous l'effet :
De facteurs sociaux, notamment si l'on considère que dans un temps long, les écarts de participation au marché du travail, voire de typologie d'emplois occupés, ont bien vocation à se réduire encore.
De facteurs sociétaux et culturels, une partie de la surmortalité masculine étant liée à des conduites à risque (addictions, accidents) parfois associées, soit à une certaine représentation

« viriliste » de la masculinité, soit d'ailleurs au mal être que celle-ci peut induire (fort écart de taux de suicide entre les sexes). Le gradient dans le recours au système de soins et à la prévention semble partiellement relever des mêmes causes. Or les « codes » et l'inconscient collectif semblent quand même plutôt tendre à une forme d'homogénéisation progressive. »

Carlo Giovanni Camarda (2) advises work on what is commonly called consistent mortality prediction : « les travaux sur ce que l'on appelle communément la prévision cohérente de la mortalité. À partir de (Li & Lee, 2005), une pléthore d'articles ont été publiés à ce sujet. J'essaierais d'utiliser ces approches pour, au moins, comparer les résultats data-driven avec ceux que vous proposez. »

THE GENERATIONS 1941-1955

Throughout their adult life, the evolution of the mortality of the so-called "plateau" generations, born from 1941 to 1955, is less favourable than that of the previous or following generations. Over the recent period, we observe for these generations a quasi-stagnation of mortality for men, and a slight increase in mortality for women. The cohort effect will be taken into account in this population exercise. The question was: "It is assumed that female mortality will be stable in the future for the "plateau" generations. What do you think?"

Figure 4-10 Expert opinion on mortality trends for females belonging to "plateau" generations

	No cohort effect taken into account	Rather stable mortality for women	Mortality change less favourable for women than for men	Rather lower mortality for women	No preference	other
researchers	2	1	0	0	0	2
OSS	0	4	1	0	0	0
NSI	0	3	1	1	1	1
anonymous	0	1	0	0	0	1
total	**2**	**9**	**2**	**1**	**1**	**4**

Nine experts, i.e. a majority (8, 14, 15, 16, 21, 28, 34, 35), are in favour of a stable mortality for women of the "plateau" generations.

Two experts (5,7) think that the inclusion of the generation effect is not necessary, for simplification reasons (5,7) and because the effect does not play a long-term role in the projection results (5).

If the mortality of women of the "plateau" generations stagnates, this amounts to taking the same assumption (a stagnation) for women and men of these generations. For this reason, Gautier Maigne of France Stratégie (19) prefers a less favourable evolution of mortality for women than for men for these generations: « Cette question 18 sous-entend qu'on suppose en fait une stagnation pour chaque sexe, et qu'il n'y aurait pour ces générations aucune convergence hommes-femmes, ce qui ne semble pas avoir été le cas jusqu'ici, pas plus que pour les autres générations. ». Similarly, for Livia VARGA and Zoltan CSANYI, KSH, Hungary (37), "the mortality of men and women may vary, so there is no need to make the same assumptions".

On the contrary, for Raymond Kohli, SFO, Switzerland, mortality could also decrease for these generations: « Il ne me paraît pas impossible que la mortalité diminue passablement à nouveau aussi pour ces générations. ».

Carlo Giovanni Camarda (2) suggests that INSEE could propose an age + time approach in which cohort effects could be incorporated (see Renshaw & Haberman, EMI 2006).

Laurent Toulemon (12) would not envisage a stagnation of mortality which continues until the very old ages for these cohorts: « A priori je ferai une projection tous sexes confondus, puis une projection de la différence entre hommes et femmes et je verrais ce que ça donne pour les femmes, mais je n'envisagerais pas une stagnation de la mortalité qui se prolonge jusqu'aux très grands âges pour ces cohortes »

C. ASSUMPTIONS RETAINED

BASELINE ASSUMPTION: DECLINE IN MORTALITY RATES AT THE SAME PACE AS OVER THE LAST DECADE, WITH CONSIDERATION/INTEGRATION OF A COHORT EFFECT

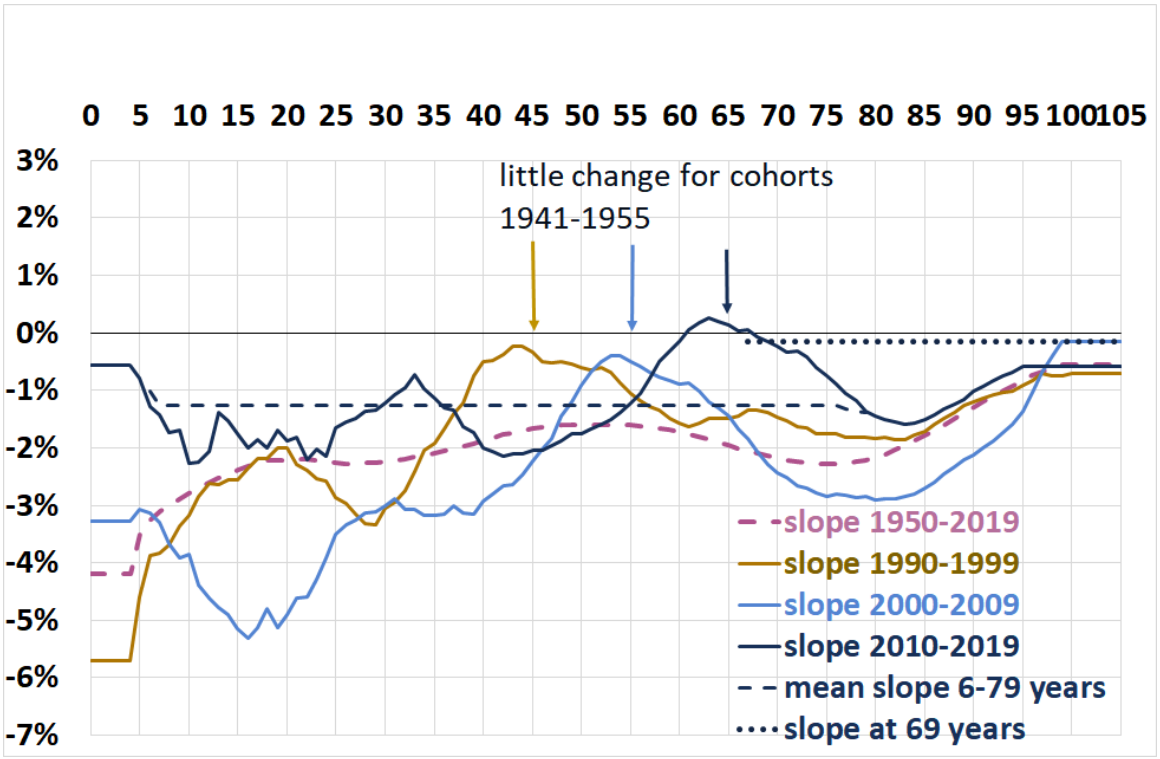
The baseline assumption is that mortality will continue to decline at the same pace as in the past until the projection horizon. This requires defining a reference period for the past. A majority of experts (13) have chosen a 10-year period, from 2010 to 2019, in order to take into account the slowdown in life expectancy observed since 2014. A significant number of experts (8) favour a longer period of 20 years, i.e. 2000-2019, in order to smooth out conjunctural and cohort effects, to avoid major changes in assumptions compared to the previous projection exercise and to take into account the fact that health will be a major concern for society.

We use a 10-year period for the past, 2010-2019. This significantly changes the baseline assumption compared to the previous exercise, but it is closer to the baseline assumption of Eurostat and the UN. We also propose to **smooth out the age-specific evolutions in** order to avoid conjunctural and cohort effects.

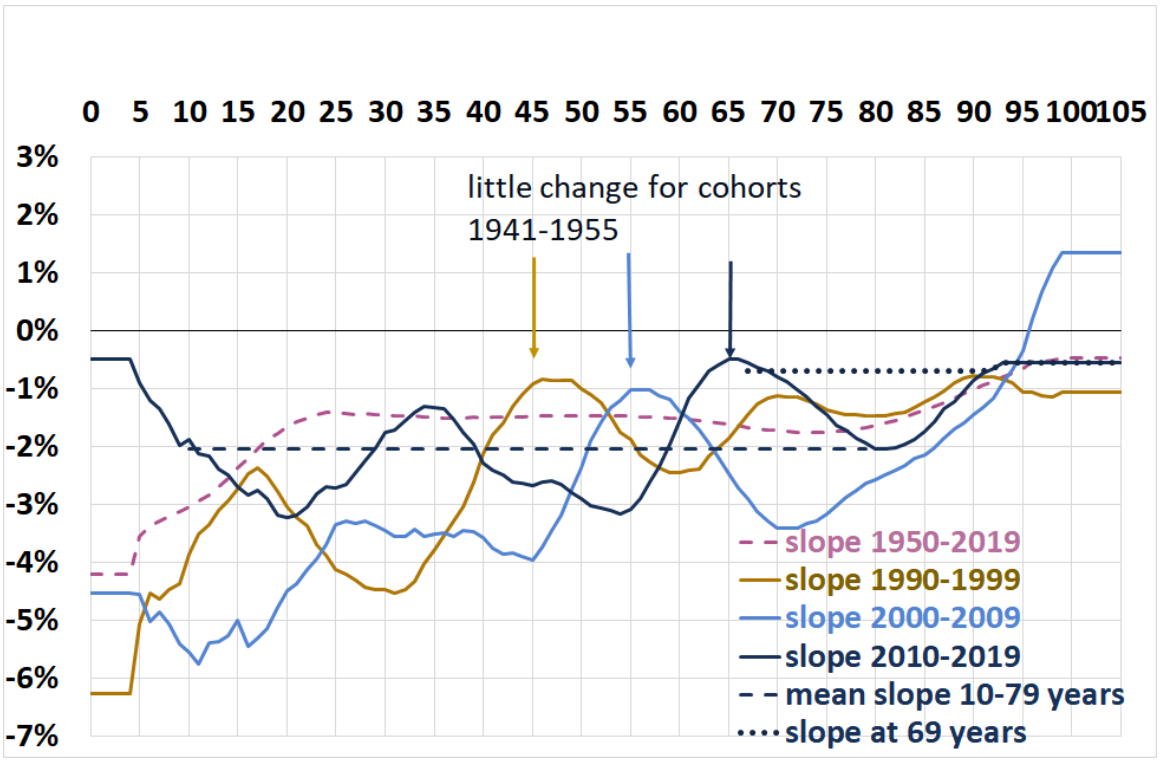
Other methods have been tested in order to compare the level of projected life expectancy in 2070. They all lead to a downward revision of the level of life expectancy in 2070 compared to previous INSEE projections (Box 7). However, life expectancy in 2070 would be at a slightly higher level if the 2000-2019 slope were used to extend the mortality rates, instead of the 2010-2019 slope.

Figure 4.11 - Annual change in mortality rates by age and period

Female

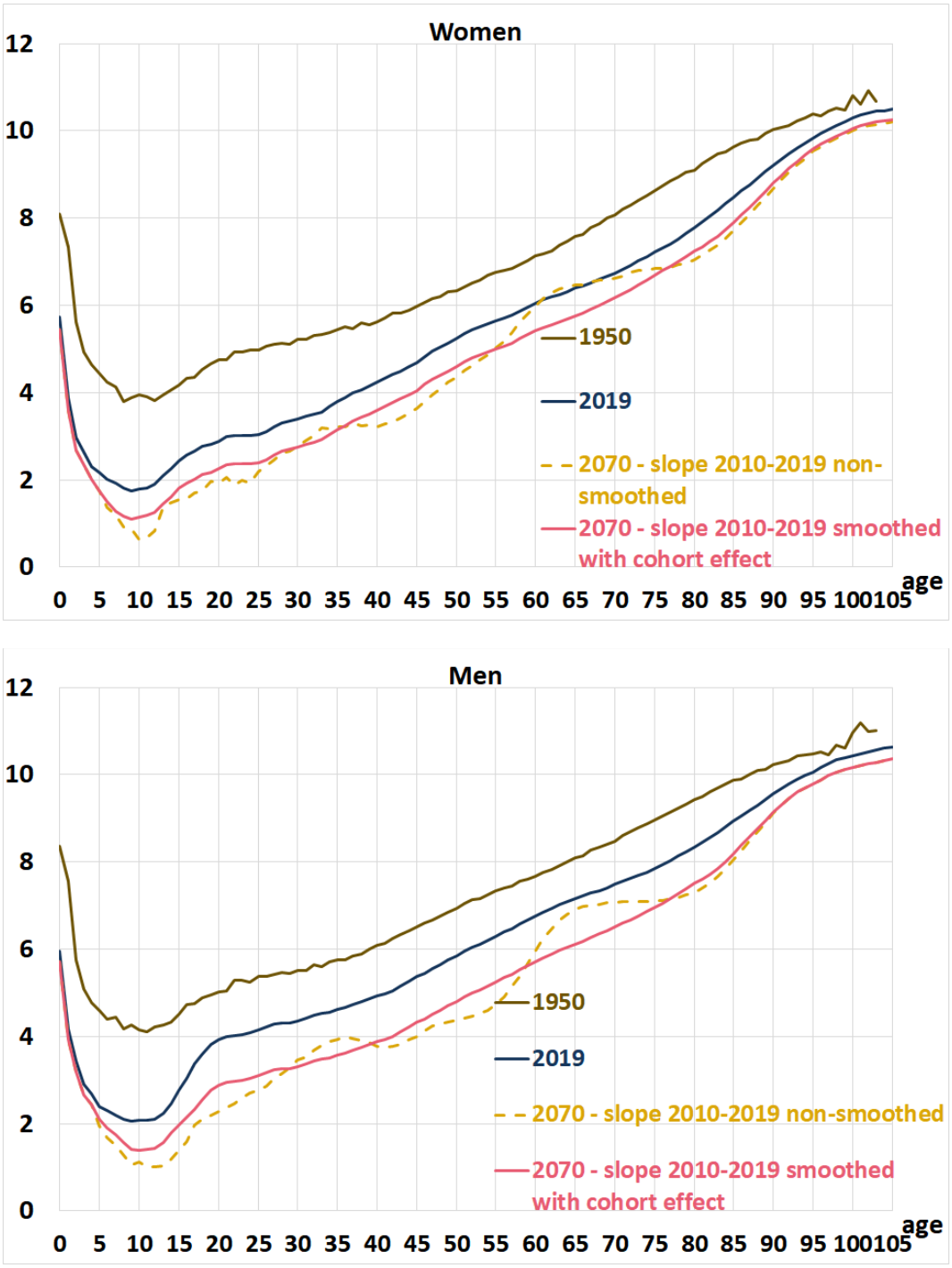


Male



Coverage: Metropolitan France until 1993, France excluding Mayotte from 1994 to 2013, France from 2014 onwards.
Sources: INSEE, population estimates and vital statistics.

Figure 4.12 - Mortality rates in 1950, 2019 and 2070



Note: Mortality rates are trend logistically adjusted beyond 105 years for women and 101 years for men.
Coverage: Metropolitan France in 1950, France in 2019 and 1970.
Sources: INSEE, population estimates and vital statistics in 1950 and 2019, Population projection 2021-2070 in 2070.

The application without smoothing of the rate of decline of mortality rates over the period 2010-2019 would lead to a distortion of the curve of mortality rates by age in 2070 (**Figure 4.12**): female mortality would be durably the same at age 65 and at age 75, which is unlikely. This is due to the long-term repercussion of the stagnation of mortality, characteristic of the “plateau” generations (1941-1955) which is prolonged. It is therefore necessary to smooth the rates in order to avoid such distortions.

Over a very long period, for example from 1950 to 2019, the annual change in mortality rates is almost stable from 10 to 80 years. For men, a constant annual change in mortality rates from age 10 to 80 of -2.0% by 2070 is therefore assumed. This corresponds to the average annual change observed at all these ages from 2010 to 2019. For women, we assume an annual change in mortality rates from age 6 to 80 of -1.2% by 2070, which corresponds to the average annual change observed at all these ages from 2010 to 2019. Before 10 years for men and 6 years for women, as well as after 80 years for all, we retain the annual change by age between 2010 and 2019 (**Figure 4.11**).

Mortality stagnates in adulthood for the "plateau" generations, born from 1941 to 1955 (Blanpain, 2020). We retain as a baseline assumption that the cohort effect will continue until the very high ages. The mortality rates for women increase slightly around age 65 over the 2010-2019 period. A majority of experts validated the assumption of a stable mortality rate for women in the future for the "plateau" generations. However, two experts indicated that a greater decline in the rates for men than for women should be taken, in order to continue the narrowing of the gender gap in life expectancy for the “plateau” generations.

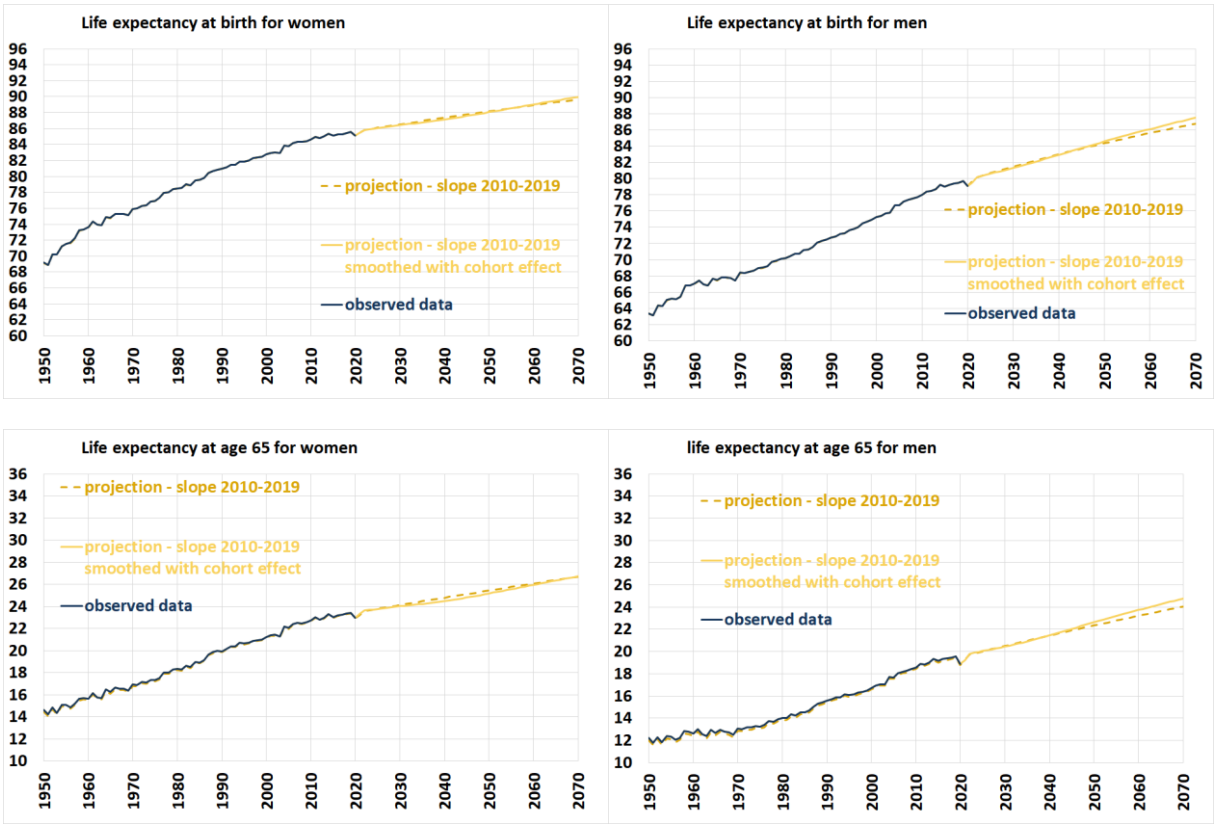
For the "plateau" generations, we use the average annual change 2010-2019 at age 69, the last age at which the "plateau" generations are fully observed over the period. This makes it possible to retain a lower slope for women than for men (**Figure 4.11**) and to have a quasi-stagnation of mortality rates for women (-0.1% per year).

Figure 4.12 - Annual change in mortality rates used for the projections (baseline assumption)

Female	Age 0-5 years	Age 6-80 years old	Age 81 or older
'Plateau' generations (1941-1955)		-0.2%, slope at age 69 between 2010 and 2019	
Other generations	from -0.6 to -1.3% / year annual slope of the rate at each age between 2010 and 2019	-1.3 % average slope at all ages from 6 to 80 between 2010 and 2019	from -1.3% to -0.3% / year annual slope of the rate at each age between 2010 and 2019
Male	Age 0-9	Age 10-80	Age 81 or older
'Plateau' generations (1941-1955)		-0.7%, slope at age 69 between 2010 and 2019	
Other generations	from -0.4 to -2.0% / year annual slope of the rate at each age between 2010 and 2019	-2.0 % average slope at all ages from 10 to 80 between 2010 and 2019	from -2.0% to -0.1% / year annual slope of the rate at each age between 2010 and 2019

Taking into account the cohort effect slows down life expectancy slightly, while smoothing the annual evolution of mortality rates increases it slightly. This leads to similar life expectancies before and after smoothing and applying the generation effect (**Figure 4.13**).

Figure 4.13 – Female and male life expectancies at birth and at age 65

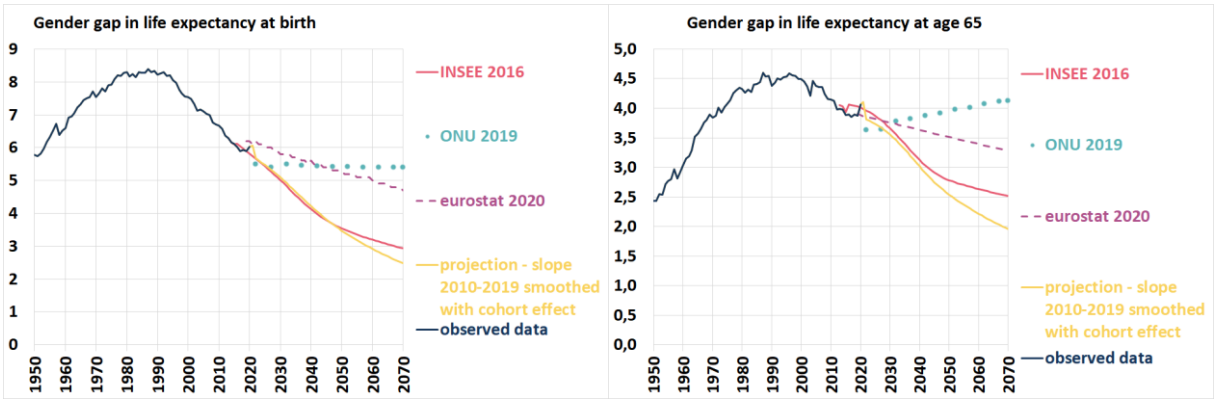


Coverage: Metropolitan France until 1993, France excluding Mayotte from 1994 to 2013, France from 2014 onwards.
Sources: INSEE, population estimates and vital statistics and population projection 2021-2070.

BASELINE ASSUMPTION: A CONTINUED DECREASE OF THE GENDER GAP IN LIFE EXPECTANCY

The gender gap in life expectancy decreased from 1994 to 2017 and remained stable from 2017 to 2020 at around 6.0 years. Almost all the experts recommended extending the convergence of life expectancy between women and men. The chosen assumptions lead to this convergence at birth and at age 65 (**Figure 4.14**).

Figure 4.14 - Gender gap in life expectancies at birth and at age 65



Coverage: Metropolitan France until 1993, France excluding Mayotte from 1994 to 2013, France from 2014 onwards.
Sources: Eurostat, Europop2019; UN, World Population Prospects 2019; INSEE, population estimates, vital statistics and population projection 2021-2070.

BASELINE ASSUMPTION: IN 2022, LIFE EXPECTANCY RETURNS TO ITS 2010-2019 GROWTH TRAJECTORY

For the short-term trend, a large majority of experts have indicated that life expectancy should return to the level it would have had without the Covid-19 epidemic around 2022. The arguments are better vaccination coverage, the harvest effect (fragile people died during the epidemic and this reduces deaths in the following years), and the development of physical distance.

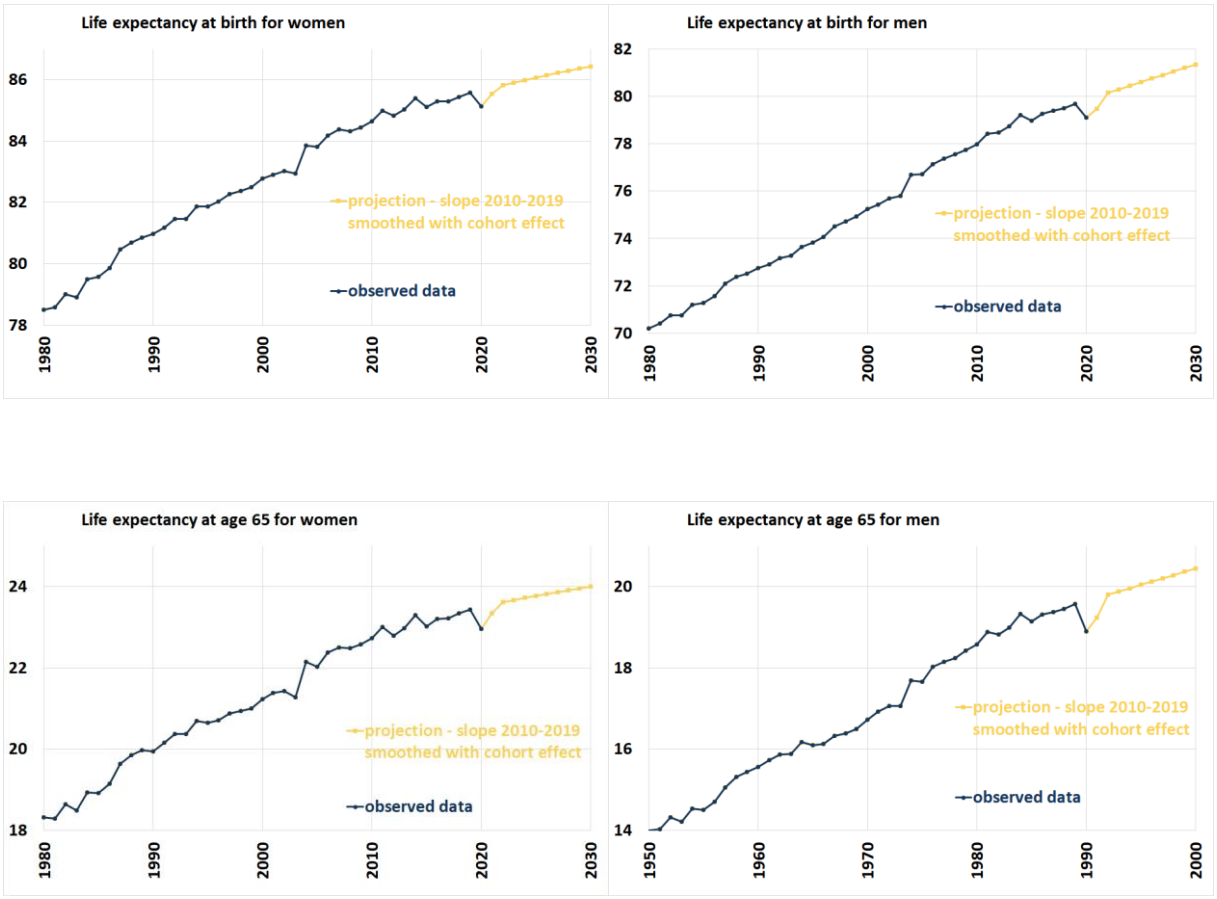
We propose a return of life expectancy in 2022 to its 2010-2019 growth path, i.e. +0.25 years of life expectancy for women and +0.45 years for men between 2019 and 2022 (**Figure 4.9**). The rates in 2021 are estimated from observed deaths from January to August 2021 by sex and an estimate of deaths for the months of September to December 2021 by sex. For the end of 2021, an increase in the number of deaths compared to what would be expected in the absence of an epidemic[15] has been estimated with the help of DREES (Ministry of Health).

[15] Expected deaths in the absence of an epidemic are calculated according to the method detailed in the INSEE blog [Blanpain, 2021]

Indeed, since the beginning of the Covid-19 epidemic, the differences between observed and expected deaths are correlated with the volumes of hospital deaths of patients with Covid-19. Therefore, modelling Covid-19 deaths until the end of the year allowed us to estimate the excess of deaths over the expected based on demographic trends. To do this, from the Covid-19 deaths observed on 15 September, an initial projection to the end of September could be deduced from the observed evolution of the incidence rate of Covid-19 cases. This rate is in fact a good leading indicator of deaths approximately two weeks ahead. Next, for the period from October to December, a baseline scenario for the evolution of Covid-19 deaths was based on assumptions of a continued decline in deaths in October before a stabilisation of their level by the end of 2021. In this scenario, considered the most likely, the number of deaths in 2021 is thus estimated at 648,000 deaths, including 322,000 female deaths and 326,000 male deaths, i.e. a life expectancy at birth of 85.54 years for women and 79.48 years for men (compared with 85.1 for women and 79.1 for men in 2021).

At the same time, alternative scenarios were explored, without being considered as the most probable: a scenario leading to slightly lower numbers of deaths, in the event of a continuation of the decline in deaths until the end of the year; a scenario leading to significantly higher deaths, if in particular a variant appeared that largely escaped the protective effect of vaccination.

Figure 4.15 - Life expectancies at birth and at age 65



Coverage: Metropolitan France until 1993, France excluding Mayotte from 1994 to 2013, France from 2014 onwards.
Sources: INSEE, population estimates and vital statistics and population projection 2021-2070.

LIFE EXPECTANCY IN 2070: 90.0 YEARS FOR WOMEN, 87.5 YEARS FOR MEN AND VARIANTS AT +/- 3.5 YEARS.

For the variants, a majority of experts (11) retained +/- 3.5 years of life expectancy at birth in 2070 compared to the baseline assumption. A significant number of experts (6) suggest using the past as a basis for defining the variants rather than retaining a pre-determined gap.

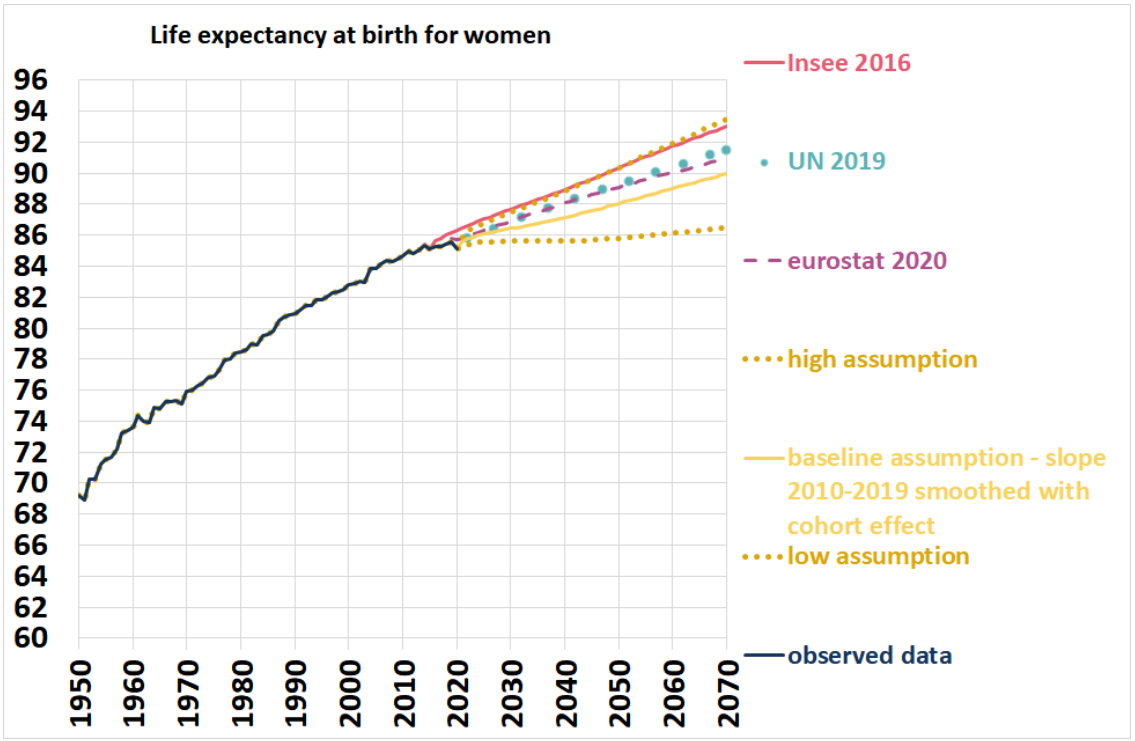
We retain +/- 3.5 years of life expectancy at birth in 2070 compared to the central assumption. For comparison, the 95% confidence interval of the Lee-Carter model is -4.0 years and + 2.8 years for women and -2.9 years and + 2.3 years for men in 2070 (**Box 7**).

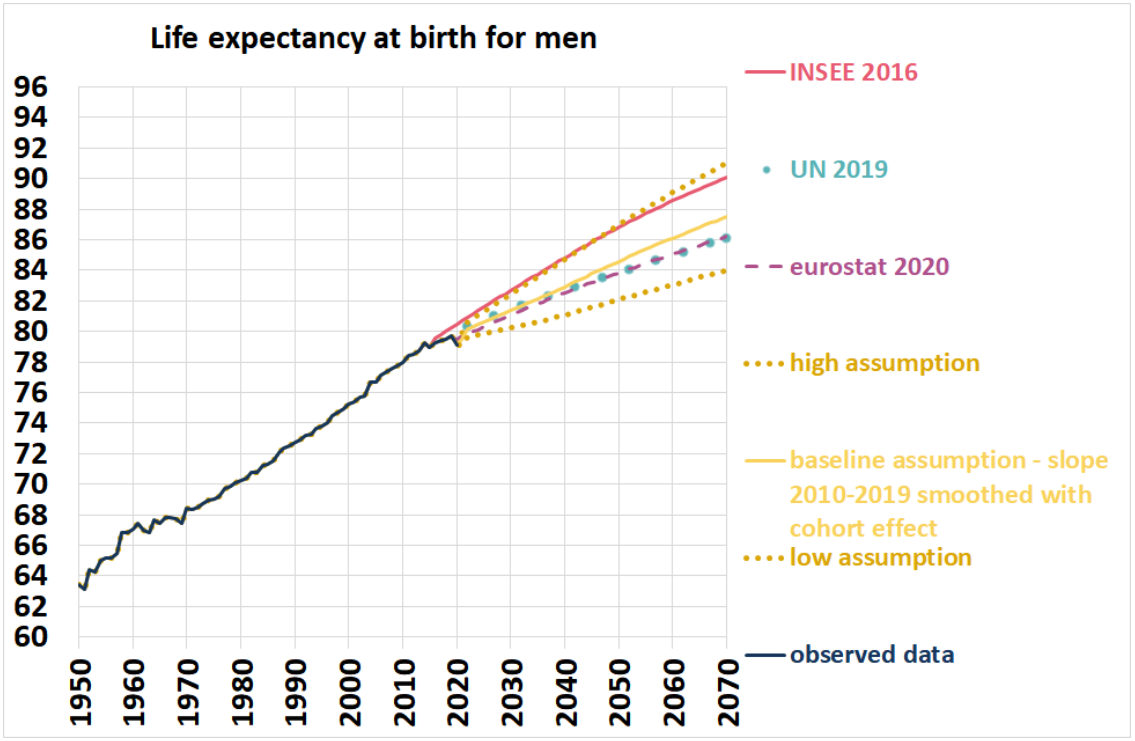
For the low and high assumptions, the annual evolution of the mortality rates by age is slowed down or accelerated at each age. This makes it possible to have mortality rates that are symmetrical with respect to the baseline assumption at all ages. For the low assumption, an annual evolution of mortality rates continuing the trend taken over a shorter and less favourable period, 2014-2019, was tested. But this leads to more chaotic evolution of mortality rates, inconsistent at certain ages compared to those of the baseline assumption.

In order to take into account the uncertainty related to the Covid-19 epidemic, a deviation of +/- 0.5 years in 2022 is retained from the baseline assumption. This corresponds to a slightly faster divergence than in the 2016 projections, where the divergence was +/-0.3 years for women and +/- 0.4 years for men in 2016. For comparison, the confidence interval of the Lee-Carter model is +/- 1.1 year for women and -1.0 year and + 0.9 year for men in 2022 (**Box 7**).

As a working scenario, a projection with a constant life expectancy assumption, equal to its 2019 level, is also carried out.

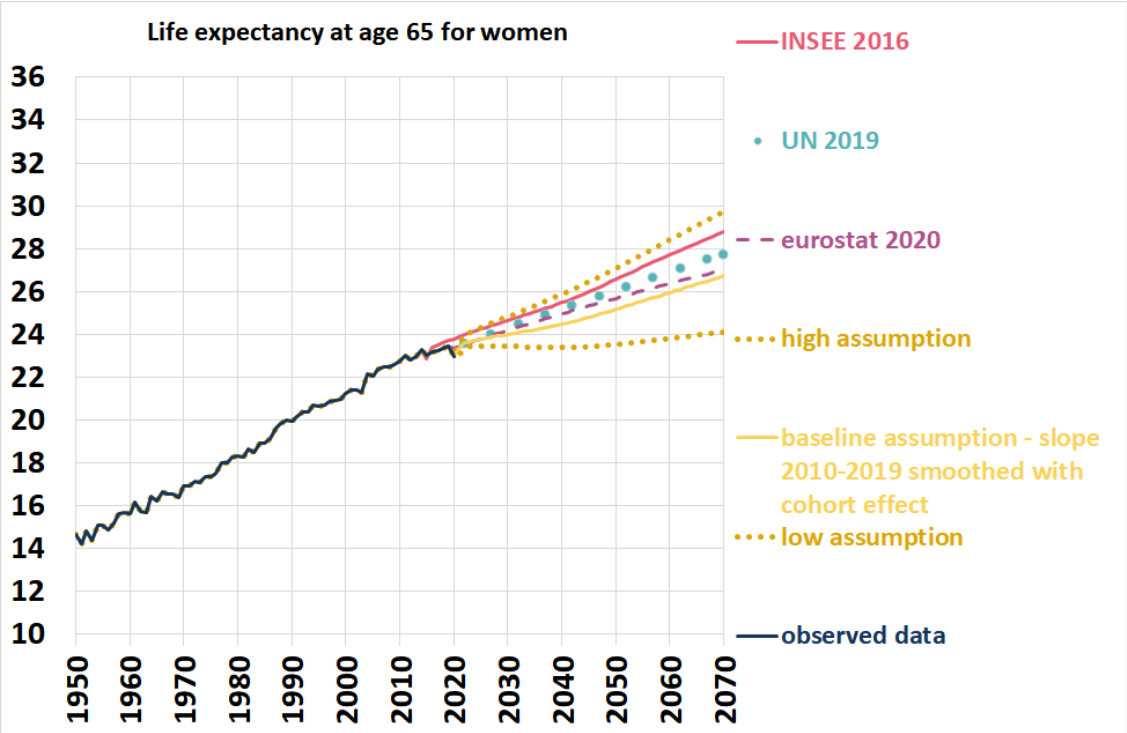
Figure 4.16 Life expectancies at birth and at age 65

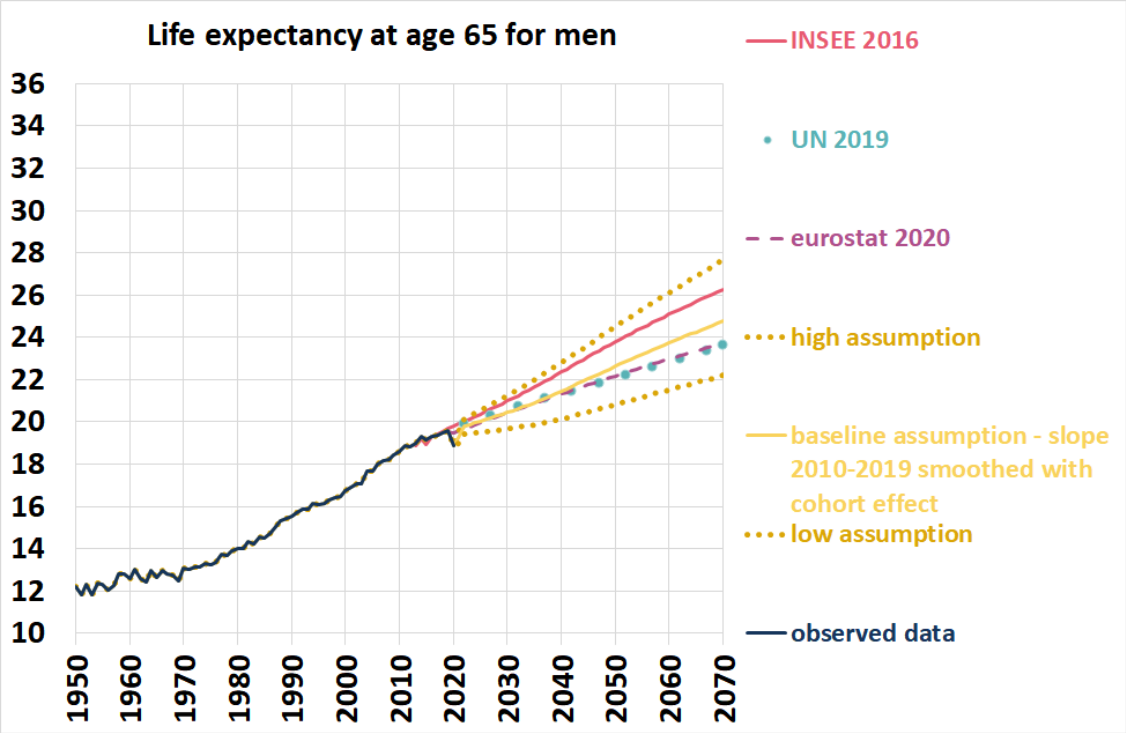




Coverage: Metropolitan France until 1993, France excluding Mayotte from 1994 to 2013, France from 2014 onwards.

Sources: Eurostat, Europop2019; UN, World Population Prospects 2019; INSEE, population estimates and vital statistics, population projection 2013-2070 and population projection 2021-2070.





Coverage: Metropolitan France until 1993, France excluding Mayotte from 1994 to 2013, France from 2014 onwards.
Sources: Eurostat, Europop2019; UN, World Population Prospects 2019; INSEE, population estimates and vital statistics, population projection 2013-2070 and population projection 2021-2070.

The baseline assumption leads to a downward revision of life expectancy at birth compared with the previous projections (**Figure 4.16**): -3.0 years for women and -2.6 years for men in 2070, i.e. the level of the low assumption of the previous projections.

The assumptions of the new projections are relatively close to those of Eurostat and the UN (slightly lower for women and slightly higher for men). The projections of these organizations were made in 2019 and 2020 and were able to take into account the recent slowdown in life expectancy.

Figure 4.17 Projected life expectancy in 2070

	At birth		At 65	
	female	male	female	male
INSEE 2016	93.0	90.1	28.8	26.1
UN 2019	91.5	86.1	27.7	23.6
EUROSTAT 2020	90.9	86.2	27.0	23.7
INSEE 2021	**90.0**	**87.5**	**26.6**	**24.6**

Box 7 - Comparison of projected life expectancy in 2070 using different methods

Three methods were tested.

A Lee-Carter model (Lee-Carter, Carter, 1992):

$$\ln \mu xt = \alpha x + \beta x * kt,$$

- μxt represents the instantaneous death rate at year t and age x,
- αx is the age-specific component x
- βx reflects the sensitivity of instantaneous mortality at age x to the general evolution of kt
- kt describes the evolution of mortality in year t,

The kt were extended using a "Multivariate Random Walk with Drift" time series model over the period 2010-2019.

An age, period, cohort model (Cairns et al., 2009):

$$\ln \mu xt = \alpha x + kt + \gamma(t-x),$$

- μxt represents the instantaneous death rate at year t and age x,
- αx is the age-specific component x
- kt describes the evolution of mortality in year t,
- $\gamma(t-x)$ is the cohort-specific component (t-x)

The kt were extended using a "Multivariate Random Walk with Drift" time series model over the period 2010-2019.
The $\gamma(t-x)$ were extended using an ARIMA(1,1,0) model with drift

An alternative method:

- Extension of mortality rates by sex and age at the rate observed over the 20-year period, 2000-2019.

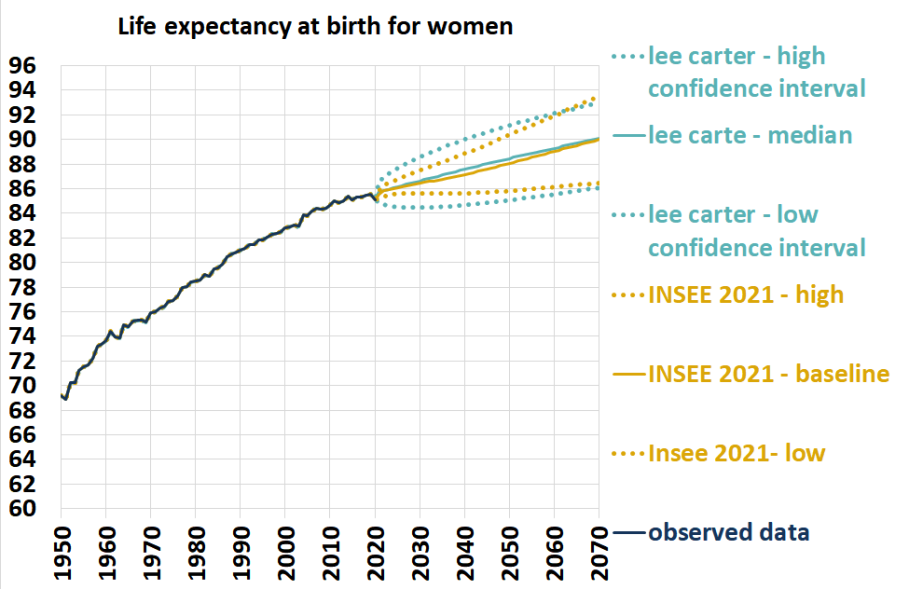
These three methods are compared to the **previous INSEE projections** published in 2016, to the **Eurostat projections** published in 2020, to the **UN projections** published in 2019, and lastly to the method retained for the **new 2021 projections**..

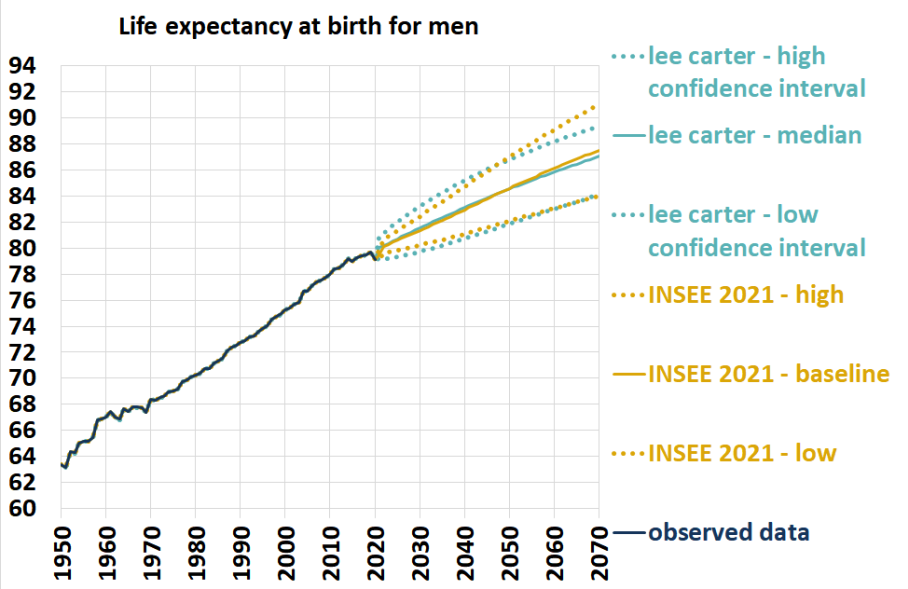
Methods for projecting mortality

	Life expectancy at birth		Population in 2070 (in millions)	Ageing ratio 65+/20-64 (%)
	female	male		
INSEE 2016	93.0	90.1	76.4	57.4
UN 2019	91.5	86.1	66.6 (Metropolitan France)	57.6 (Metropolitan France)
EUROSTAT 2020	90.9	86.2	69.4	56.8
Lee-Carter	90.1	87.0	68.2	57.2
Age, period, cohort	90.5	89.0	69.0	59.1
Slope 2000-2019	91.7	88.5	68.6	57.8
INSEE 2021	**90.0**	**87.5**	**68.1**	**56.8**

The different methods all lead to a downward revision compared to previous INSEE projections published in 2016. Depending on the method, female life expectancy in 2070 is between 90.0 and 91.7 years, and male life expectancy is between 86.1 and 88.5 years.

Box 8 - Confidence interval with the Lee-Carter model





Coverage: Metropolitan France until 1993, France excluding Mayotte from 1994 to 2013, France from 2014 onwards.
Sources: INSEE, population estimates and vital statistics and population projections 2021-2070.

The 95% confidence intervals obtained with the Lee-Carter method on life expectancy at birth in 2070 are :

- 86.1 to 92.9 years for women, i.e. - 4.0 years and + 2.8 years compared to the median hypothesis
- 84.1 to 89.3 years for men, i.e. - 2.9 years and + 2.3 years compared to the median hypothesis

The 95% confidence intervals obtained with the Lee-Carter method on life expectancy at birth in 2022 are :

- 84.7 to 86.9 years for women, i.e. -1.1 years and +1.1 years compared to the median hypothesis
- 79.2 to 81.1 years for men, i.e. -1.0 years and +0.9 years compared to the median hypothesis

PART 4 : THREE ASSUMPTIONS ABOUT NET MIGRATION

A. RECENT CHANGES IN NET MIGRATION IN FRANCE

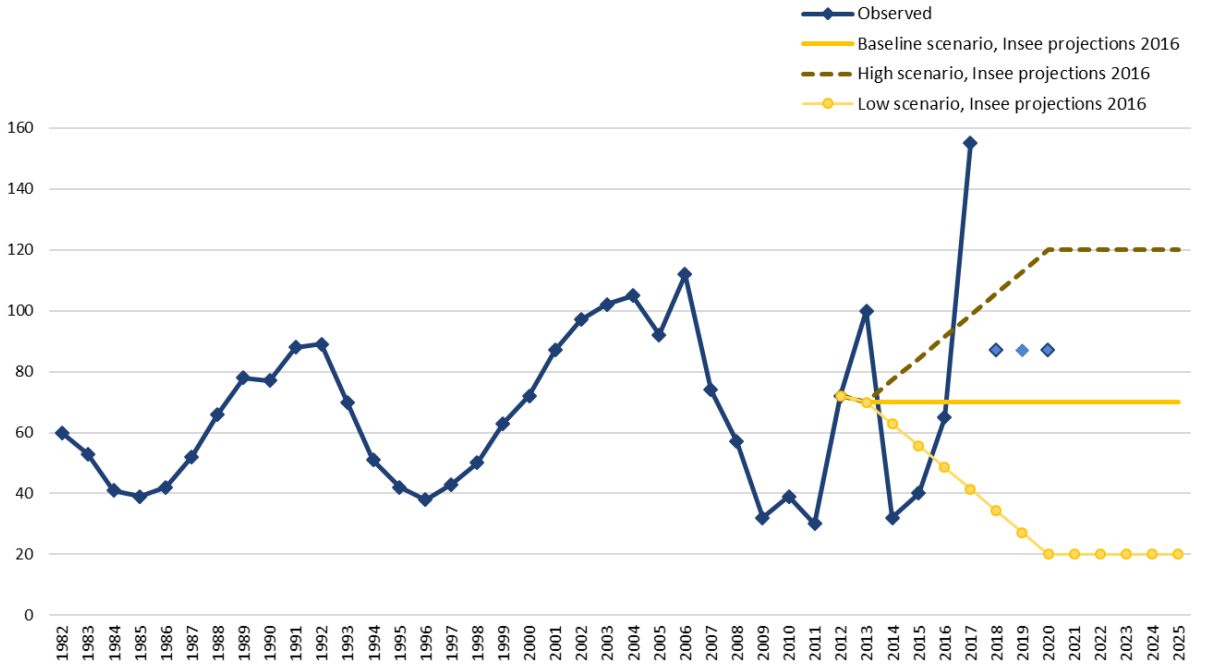
The baseline assumption for the 2016 projections was a positive annual net migration of 70,000 people from 2013 to 2070. The average over the last five years is slightly higher, but it is slightly lower over ten years (**Figure 4.1**). Above all, net migration appears to be increasingly volatile: high in 2013 and especially in 2017, it was low in 2009-2011, 2014 and 2015 (**Figure 4.2**).

Figure 4.1 - Average balance over different periods

		France [1]	Metropolitan France
1 year	*2017*	+ 155	+ 167
5 years	*average 2013-2017*	*+ 78*	+ 91
10 years	*average 2008-2017*	*+ 62*	+ 75
30 years old	*average 1988-2017*	*+ 71*	+ 74
50 years old	*average 1968-2017*	-	+ 72

1: France excluding Mayotte until 2013 and France from 2014 onwards.
Source: INSEE, population estimates and vital statistics.

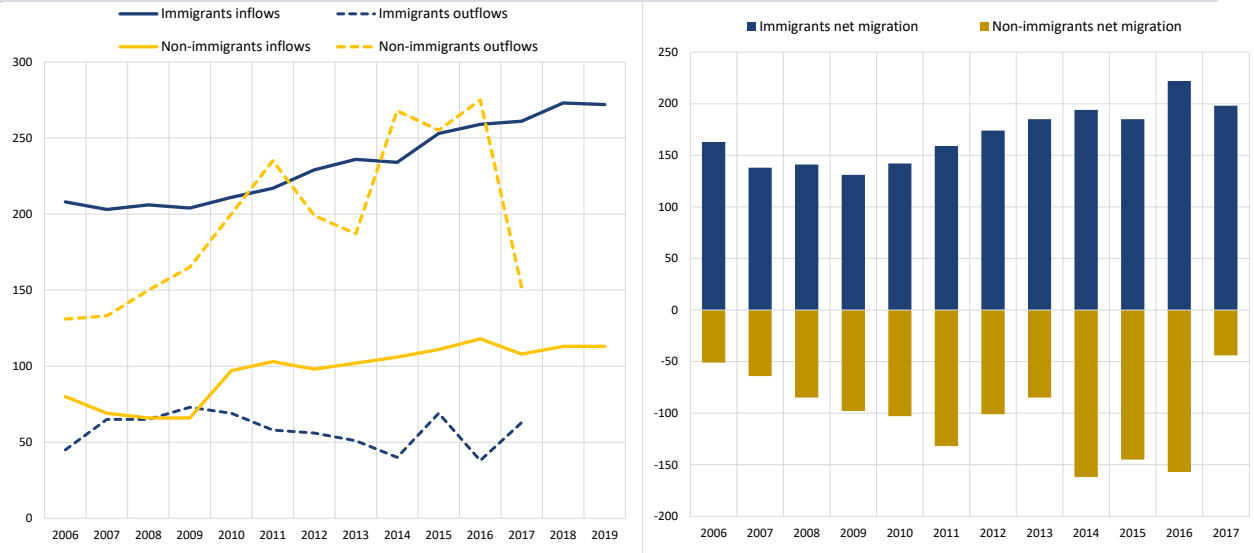
Figure 4.2 - Net migration since 1982



Note: 2018 to 2020 points are provisional, estimated by default as the average of the years 2015-2017.
Coverage: France excluding Mayotte until 2013 and France from 2014 onwards
Source: INSEE, population estimates and vital statistics.

In previous projections, a breakdown of net migration into three population categories was proposed: persons born in France, persons born French abroad and immigrants. Insee now publishes the inflows and outflows each year, distinguishing between two categories: immigrants and non-immigrants (Insee, 2021c). Immigrant inflows and non-immigrant outflows increased from 2006 to 2016 at roughly the same rate. But **non-immigrant outflows seem to have become quite volatile** and would explain, for example, the high level of net migration in 2013 and moreover in 2017 (**Figure 4.3**). There were an estimated 275,000 non-immigrant outflows in 2016 and 152,000 in 2017. Therefore, while non-immigrant net migration was around -150,000 in 2014, 2015 and 2016, it is around -50,000 in 2017. In such a context, it is even more difficult to predict the evolution and the fluctuations of net migration are likely to be more important because outflows and inflows will compensate each other in some years, and in others not.

Figure 4.3 – Inflows, outflows and net migration, immigrants and non-immigrants
(a) Inflows and outflows (b) Net migration



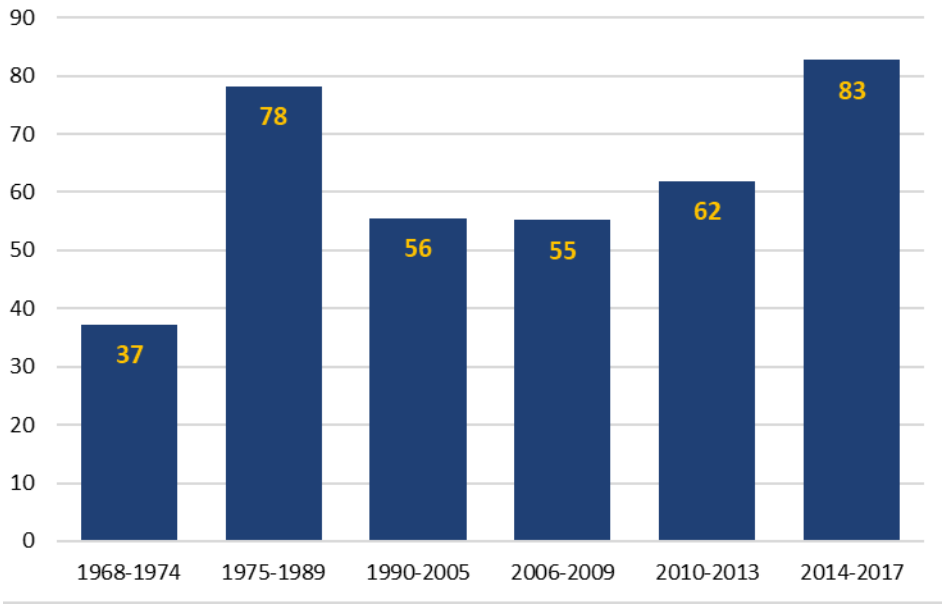
Coverage: France excluding Mayotte until 2013 and France from 2014.
Source: Insee, population, inflows and outflows estimates.

Another notable recent change is that female net migration has been significantly higher than male net migration in recent years. Before 1975, net migration was predominantly male. The change in migration policy in 1975 led to a reduction in labour migration and an increase in migration for family reunification. This explains the strong increase in the share of women: 78% of net migration over the period 1975-1989. The following period saw a rebalancing: on average, 56% of net migration was made up of women between 1990 and 2005, and 55% between 2006 and 2009. The share of women then increased over the period 2010-2013, and even more so over the latest known years (2014-2017): this new imbalance seems to be linked more to outflows than inflows, and to the fact that the increase in outflows concerns men

more than women. Extending recent trends over 4 years (2014-2017) would lead to a **positive net migration, female at 83% and 17% male**, i.e. out of 70,000 people, 12,000 men and 58,000 women (**Figure 4.4**). This represents a difference of 46,000 per year, i.e. after 50 years there will be more than 2 million more women than men, compared with 500,000 in the previous projections, since the annual migration surplus of 70,000 people (baseline assumption) was made up of 40,000 women and 30,000 men.

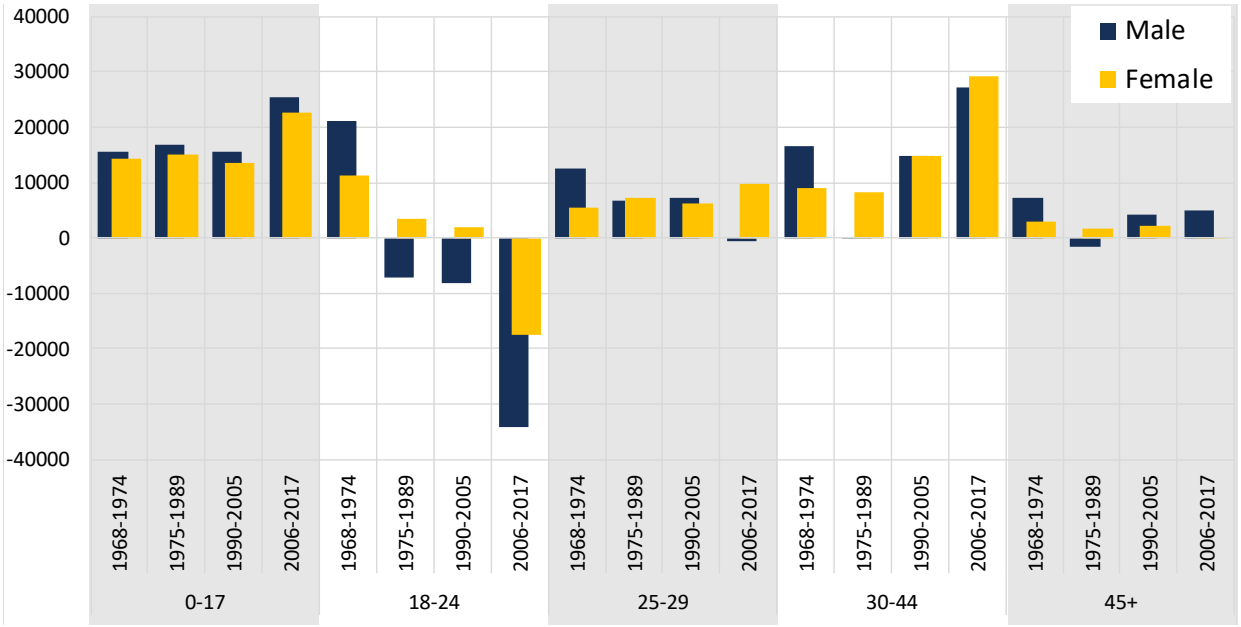
By age, the structure has changed significantly compared to the 1975-2005 period: the slightly negative net migration between 18 and 24 years of age has become much more marked over the 2006-2017 period, with a continued strong gap between men and women (**Figure 4.5**). Between the ages of 25 and 29, the increase in male exits is also apparent, as net migration becomes negative. In the 30-44 age group, on the other hand, the net migration increases and is more balanced between men and women. This does not mean that there is a massive influx of immigrants between the ages of 30 and 44 (most of them enter at younger ages), but that there are few outflows at these ages.

Figure 4.4 - Share of women in the average annual net migration



Coverage: Metropolitan France until 1998, France excluding Mayotte from 1999 to 2013, France from 2014 onwards.
Source: INSEE, population estimates and vital statistics.

Figure 4.5 - Net migration by sex and age

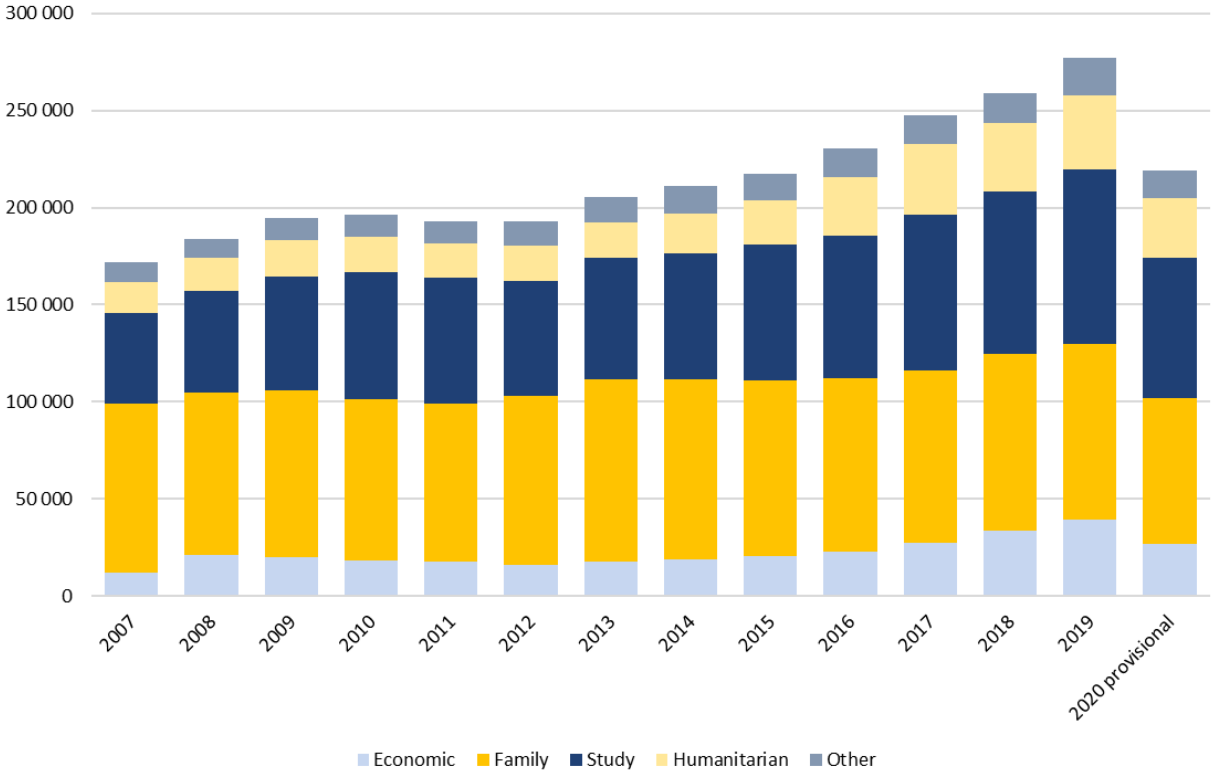


Coverage: Metropolitan France until 1998, France excluding Mayotte from 1999 to 2013, France from 2014 onwards.
Source: INSEE, population estimates and civil status statistics.

All in all, it seems even more difficult than usual to formulate a hypothesis on **future variations given the significant uncertainties on the recent past and the near future** linked to the at least apparent volatility of outflows, the particularly high net migration for 2017 and the difficulty of anticipating the influence of the health crisis linked to covid-19 on international migration in the short and medium term.

In 2020 and 2021, or even 2022, the components of net migration have all been and will undoubtedly be affected: both inflows and outflows from the national territory have been significantly slowed down, or even made almost impossible at certain times. As an indication of the disruption to immigrant inflows, fewer first residence permits were issued in 2020 (**Figure 4.6**). However, the drop in inflows could be offset by a drop in outflows, which makes it very difficult to estimate net migration for 2020 and 2021. It should be remembered that net migration estimate for the year 2020 published in the 2020 demographic report by INSEE (Papon, Beaumel, 2021) is obtained by arithmetical average of the last three known figures on net migration (2015, 2016, 2017), without taking into account any possible impact of the pandemic.

Figure 4.6 - Issuance of first residence permits by type of reasons



Source: MI- DSED data as of 15 June 2021 [16]
Coverage: Non-EEA countries, Metropolitan France.

B. THE POSITION OF EXPERTS ON INTERNATIONAL MIGRATION

The questionnaire consisted of 4 questions and a table to be filled in on the evolution of migration:

- One question asked about the baseline assumption for the average annual net migration (Q20)
- One on high and low variants (Q21)
- One was on the interpretation of the net migration by distinguishing flows by category (immigrants and non-immigrants)
- One on the evolution of female and male net migration, female net migration being increasingly higher than male one.

Finally, the table proposed to give values to be retained as baseline, high and low assumptions for the net migrationat some key dates between 2021 and 2070.

[16] https://www.immigration.interieur.gouv.fr/Info-ressources/Etudes-et-statistiques/Statistiques/Chiffres-cles-sejour-visas-eloignements-asile-acces-a-la-nationalite/Derniers-chiffres-cles

The experts agree on the **high level of uncertainty regarding migration**. Several experts mentioned it earlier in the questionnaire in response to questions on the method or variants.

The experts are therefore wondering how to communicate this uncertainty, so as not to let users think that the net migration could be permanently fixed at the value set as a baseline assumption. A first, fairly simple way of doing this is to present the values as averages or sums over several years (21, 33): Misha Khodabin, Hamza Zakraoui and Samuel Ménard (DG Trésor, 21) suggest presenting data over five years with a positive cumulative net migration of 350,000 persons. Kim Dunstan (27) thinks that this uncertainty is more visible when using stochastic models. Antonio Argueso (INE, Spain, 26), citing the example of Spain, suggests that we insist on the fact that projections are not forecasts: "Migratory movements in Spain have also undergone major changes[17] that are difficult to foresee. For this reason, we have emphasized in the dissemination of the results that the projections are a statistical simulation of what would happen under certain assumptions, instead of a forecast of the future".

For Jean-François Léger, this justifies treating the net migration separately from the other components, in particular in order to emphasise the main result of the projection in his view: a natural balance that is becoming negative, a situation that is unprecedented in France: " les hypothèses relatives aux migrations ne devraient pas être intégrées a priori dans l'exercice de projection démographique mais devraient découler des résultats de la simulation « naturelle » de la population française et « d'objectifs » démographiques. De ce fait, la prise en compte des migrations répondrait à la question suivante : compte tenu des résultats auxquelles conduisent les hypothèses en matière de mortalité et fécondité, quel devrait être le solde migratoire annuel moyen pour que l'accroissement de la population française soit de x personnes ou de y %."

LONG-TERM EVOLUTION: CENTRAL HYPOTHESIS AND VARIANTS

This uncertainty is explained by the **diversity of factors** likely to influence migration, as Misha Khodabin, Hamza Zakraoui and Samuel Ménard (DG Trésor, 21) point out: " Bien que ce chiffre [70 000] puisse paraître conservateur, les tendances migratoires sont particulièrement difficiles à prédire du fait de la multiplicité des dynamiques en jeu (démographiques, économiques, environnementales, politiques). […] Il nous semble cependant, autant que l'on puisse en présager, que les déterminants structurels des migrations à destination des pays avancés ne devraient pas être fondamentalement bouleversés."

[17] The graph provided by Antonio Argueso (INE, Spain, 26) in support of his answer shows that the volatility of the Spanish net migration is extremely high and linked to the economic situation: the net migration was strongly negative following the 2009 crisis (around 250,000 in 2013) but it is estimated to be +450,000 recently.

Experts point out the importance of demographic balances (ageing in Europe, population growth in emigration countries) which suggest that inflows could continue to increase (5, 22, 30). This demographic situation is also likely to affect migration policy decisions (5, 30). For example, Raymond Kohli (OFS, Switzerland, 30) states that in Switzerland, projections assume a higher net migration rate until 2030-2040 to compensate for the retirement of the baby boomers.

The experts stress the importance of analysing long-term trends (34, 31), particularly in terms of migration policy (31, 35). Lena Lundkvist (Statistics Sweden, 31) cites the Swedish example of a massive intake of refugees in 2016, followed by a restrictive immigration policy.

The context of global warming is also cited as a potentially important factor in changing migration flows (5, 13, 22).

Most of the experts who express themselves quantitatively on the baseline assumption support the proposed assumption of 70,000 (10 experts out of 14), which is a prudent assumption, in line with previous projections (6, 14), in line with past observations (18, 20) and similar to that made in international projection exercises (21).

Three experts support the assumption of annual net migration of 80,000 people (12, 13, 19). Jérôme Lê of Insee (17) stands out by proposing a balance of 130,000: "[70 000] me semble trop faible. Même s'il est très fluctuant, depuis 15 ans, le solde migratoire présente quand même des tendances bien marquées. […] Une hypothèse centrale a minima de +100 000 me semble plus réaliste".

7 experts take up the **variants we proposed at 20,000 and 120,000**, i.e. +/-50,000 compared to the baseline assumption. This fairly wide range is considered useful in view of the uncertainty (18, 35). Laurent Toulemon suggests widening it (0-160), as does Jérôme Lê of Insee (20-200). On the other hand, one expert questions the usefulness of such a wide range (37).

Several experts suggest abandoning the **symmetry of the variants** because, in their view, the uncertainty on the upside is greater (13, 17, 22). For Sylvain Papon (Insee, 22), the low assumption should be raised: " Les « pressions » vont plutôt dans le sens d'une hausse que d'une baisse. L'hypothèse basse me paraît peu crédible. Elle peut évidemment être vraie de façon conjoncturelle (on l'a vu à deux reprises dans les années 50 et à deux reprises dans les années 70 – on l'observera peut-être suite à la fermeture des frontières de 2020) mais maintenir ce niveau pendant 50 ans est une hypothèse irréaliste. Un plancher à 30 000 ou 40 000 serait plus plausible. L'hypothèse haute, bien que vraiment élevée, paraît plus atteignable." Arkadiusz Wisniowski (13) suggests instead raising the high assumption: "The high one, though, I believe could be set higher, e.g. at the values observed in the recent past, such as 150,000. This would demonstrate the potential effect of increased attractiveness of France as a destination country."

Olga Poetzsch and Felix zur Nieden (DESTATIS, Germany, 33) explain that in Germany, each assumption corresponds to the net migration observed during a period in the past: "Under each assumption, average net immigration over the entire projection period corresponds to a specific reference period from the past. Although there will be no repeat in the future of migratory movements from the past, such movements do show the range within which net migration might vary under different scenarios. This range is regarded as a hypothetical corridor for the future development of migration."

Some experts find that a net migration fixed from 2021 at the target level of the variants is a good solution (14, 18, 20, 22, 30). As Didier Blanchet (CSR-Retraites, 14) puts it, this is a way of showing uncertainty "une façon de montrer qu'il y a aussi de l'incertitude à court terme, ce que les transitions progressives vers les trajectoires cibles ont tendance à minimiser". Patrick Simon suggests to have a fluctuant target : "moduler les prévisions en ne maintenant pas un solde stable sur toute la période".

Figure 4.7 - Experts' views on net migration and its variants

Assumptions (in thousands)							
baseline	70			80			130
low	no response	20	40	40	25	0	20
high	no response	120	120	120	150	160	200
Number of responses							
Researchers	1	1			1	1	
OSS	1	3	1	1			1
NSI		3					

PANDEMIC AND MIGRATION

The experts provided a lot of input on this complicated topic of the link between the pandemic and migration. The first question is what has happened/is happening in terms of migration in 2020[18] and 2021.

Several experts expect decreases in flows (8, 18, 21, 26, 32, 36), sometimes emphasising the impact on one component, such as the outflow of non-immigrants (21). For Marie Vandresse, from the Federal Planning Bureau, Belgium, there will undoubtedly be an impact: "« À court

[18] Insee has published an estimate of the balance for 2020, based on the arithmetic average of the 2015, 2016 and 2017 balances (Papon, Beaumel, 2021). However, as Gwenaël Solard of INSEE reminded us, this estimate is surrounded by an even greater margin of uncertainty than usual with the health crisis (and the closure of borders).

terme (2020 et 2021), le solde migratoire sera selon moi largement impacté par la crise sanitaire. Beaucoup de mouvements ont été interdits ".

The situation in different countries is mentioned. But each situation seems different. As Helen Hughes (ONS, UK, 29) states: "This point seems to be one of the most critical ones as there are some challenges in getting a clear picture of international migration in 2020 and the scale and timings of any moves will be heavily influenced by policy in different countries (e.g. points at which borders were closed, calls for citizens to return home, etc). "

Thus Marie Vandresse (Federal Planning Bureau, Belgium, 36) cites a Dutch study " sur les flux migratoires en 2020, largement impactés par la Covid-19 (De Jong et al, 2021)". The cited publication shows that **in the Netherlands** there will be a sharp decline in the inflow of "first generation" immigrants and in the outflow of Dutch nationals to other countries. These decreases are observed from January to October 2020 compared to the same months in 2018 and 2019.

In **Sweden**, according to Lena Lundkvist (Statistics Sweden, 35): "Emigration was relatively stable in 2020, while immigration declined significantly, among other factors as a consequence of the pandemic".

Dragos Mundiru (32) rather points to an increase in flows for 2020 in **Romania**: "For 2020 we have signals that immigration flow will be increased compared with the previous years".

Philippe Louchart cites a study that shows signs of a very sharp decline in the **UK** population, estimated to be as much as 1.3 million compared to 2019 (O'Connor et al., 2021), comparing Employment surveys from both years. This decrease would be due to departures of foreigners settled in the UK returning to their country of origin, under the joint influence of the Brexit, the pandemic and the subsequent economic difficulties. In France, there have been no similar developments (at least not on a large scale) in the Employment surveys, and the British development could, on the contrary, lead to an increase in inflows into France: through the return of French expatriates to the UK[19] (29) or through the strengthening of France's attractiveness compared to the UK, particularly for intra-EU migration (13, 35). For Arkadiusz Wisniowski (13): "Another factor might be the aftermath of Brexit. It may make France more attractive as a destination for EU internal movers. This effect will be confounded by the impacts of the pandemic and direct economic aftermath".

In **Australia**, according to a study cited by Helen Hughes (ONS, UK, 29), the pandemic could cause a population decline of 1.4 million, or 4% of the population, by 2040 in the most severe pandemic impact scenario, i.e. a zero balance in 2020 and 2021, a gradual recovery and a

[19] It is estimated that in 2019 there were 185,000 French people living in the UK (Lê, Leservot, 2021).

return to the past average balance after 8 years (Charles-Edwards et al., 2021). The other scenarios are based on a more moderate decline in the balance.

Antonio Argueso (INE, Spain, 26) said that **Spain** assumed zero flows in the second half of 2020 and reproduced the 2020 assumptions for 2021.

However, these exceptional variations in flows are only significant if they do not offset each other, i.e. if the drop in inflows is not made up for by a drop in outflows, or even if the return of additional expatriates to France is not offset by the departure of immigrants to their country of origin (22, 35). This compensation is observed in **Norway** as reported by Astri Syse and Michael Thomas (Statistics Norway, 35): "I believe one alternative should acknowledge that net migration could become negative, although not very likely. In Norway we have observed little effect on net migration, but our immigration and emigration rates have dropped significantly during Covid (thus cancelling each other out in terms of net migration). "

Moreover, the reductions in flows observed in 2020 and 2021 could be offset in the medium term. This is what Marie Vandresse (Federal Planning Bureau, Belgium, 36) says: " On pourrait d'ailleurs assister un effet de récupération à moyen terme. En effet, une partie des projets migratoires non réalisés durant la crise pourrait être reportée (et non définitivement abandonnés) ". Patrick Simon (10) shares this opinion on the possibility of a catch-up: "Il me semble que la contraction des migrations liées à la pandémie risque de provoquer un rattrapage dans les premières années de réouverture des circulations internationales. Il serait mieux d'intégrer ces fluctuations avec plusieurs hypothèses dans les projections".

On the long-term effect of the pandemic, Astri Syse and Michael Thomas (Statistics Norway) suggest drawing on the 2008 crisis: "In terms of any lasting effects of COVID, it could be worth considering the patterns that were observed in the aftermath of the 2008 global financial crisis. There may be a reduction in immigration and emigration, even once things open up, but international migration did recover after a few years".

All in all, all these elements indicate that the years 2020 and 2021 will undoubtedly be totally atypical in terms of migratory flows in France. But it is not clear if net migration will be affected in the long term. Moreover, as Sylvain Papon of Insee points out, the net migration for 2020 and 2021 and their precise breakdown by category of flow will never be known precisely: "L'année 2021 sera a priori une année marquée par la faiblesse des arrivées d'immigrés comme 2020, de retour d'expatriés (?) et de moindre départ (notamment d'étudiants, mais pas seulement). Entre un effet à la baisse et deux effets à la hausse, difficile de conclure sur son niveau. Mais le problème est ailleurs : l'estimation du solde de l'année 2021 ne sera de toute façon jamais mesurable ni mesuré. Le fait de se baser sur les données du recensement (RP), qui « lisse » ce genre d'événements et du bilan démographique, qui moyenne ces événements lissés sur les dernières années observées, ne permet pas d'étudier une (seule) année donnée. Ce solde migratoire n'a de sens que sur un intervalle de temps long : le RP précise bien d'ailleurs qu'il ne faut comparer deux points qu'éloignés d'au moins 5 ans. Ainsi,

élaborer un solde migratoire spécifique pour l'année 2021 me paraît inutile et relève de la divination. Porter le solde à chacune de ces hypothèses dès l'année 2021 paraît plus prudent".

BREAK DOWN THE BALANCE BY CATEGORY AND BY INFLOW AND OUTFLOW

Several experts suggest **projecting inflows and outflows separately** (14, 19, 26, 27, 31, 37) and by category, according to place of birth (distinguishing between immigrants and non-immigrants). For Livia Varga and Zoltan Csanyi (KSH, Hungary, 37), projecting the net migration can only be a last resort. Antonio Argueso (INE, Spain, 26) explained that in Spain, inflows and outflows are projected separately, with a further distinction between people born in Spain and people born abroad. Gautier Maigne (France Stratégie, 19) suggests breaking down inflows and outflows, and within inflows distinguishing between family, humanitarian and economic immigration. Didier Blanchet (CSR-Retraites, 14) stresses expatriates return flows : "l'intérêt d'une modélisation plus fine d'éventuels phénomènes de retour des expatriés, qui nécessiterait d'en projeter le stock". Astri Syse and Michael Thomas (Statistics Norway, 35) stress the opposite phenomenon: immigrants have a higher propensity to leave than non-immigrants. For Arkadiusz Wisniowski (13), "studying the evolution of the specific sub-populations, such as immigrants and non-immigrants as you name them, and their emi- and immigration patterns, is more insightful than looking at net migration of all of them". The article he cites to support his point (Bijak et al., 2020) shows that analysis of the different flows in the UK and modelling tailored to each component can improve the projection: "There is no single forecasting approach that would be well suited for different flows. We therefore recommend adopting a tailored approach to forecasts, and applying a risk management framework to their results, taking into account the levels of uncertainty of the individual flows, as well as the differences in their potential societal impact.

The separate projection of the different flows would even have practical applications: it would be useful for the spatial declination of the projections (Philippe Louchart, 6), for projecting pension expenditure, because people born in France are likely to have contributed even if they live abroad (Pascale Breuil, Cnav, 15). Moreover, in Sweden, Lena Lundkvist (Statistics Sweden) explains that the projections distinguish different populations according to place of birth (Sweden, other Scandinavian or EU countries, Africa, Asia, others) "because there is a demand for this statistics from different governmental agencies."

A separate projection of flows would indeed make it possible to project the evolution of the proportion of people born in France and people born abroad or immigrants. Patrick Simon (10) recalls the potential political and media dimension of such projections: "Je pense qu'il est important d'affiner les paramètres relatifs aux migrations dans les projections, eu égard à la politisation du débat à ce sujet. Il me semble qu'il y aura une lecture des résultats qui ne se limitera pas à l'évolution globale de la population, mais qui s'intéressera à la part des

populations immigrées à chaque période. Ce n'est sans doute pas votre sujet d'intérêt, mais il est inévitable que cette dimension soit fortement médiatisée, donc il faut l'anticiper un peu."

In any case**, such a separate projection of flows seems to us to be out of reach in the French case because it is hampered by the availability of reliable data by type of flow for the past.** It is true that estimates have been available since 2006 of inflows and outflows according to whether or not people are immigrants. But they are fairly volatile and the methods of calculating estimates, particularly for outflows, mean that the variations observed may also be attributable to changes in the census protocol or in the conditions of its collection. The net migration is in fact derived from the change in population between two censuses. Inflows are estimated by counting the persons who indicate that they did not live in France the previous year in their Census questionnaire. The volume of outflows is deduced from the two previous figures. Moreover, we asked the experts for explanations for the recent volatility of outflows, particularly of non-immigrants. A few clues were suggested, such as employment prospects abroad and variations in recruitment by large international companies (10, 24b). But the analysis would require additional data (10), as Philippe Louchart (6) says: "La forte volatilité du solde migratoire des personnes non immigrées mériterait une analyse plus détaillée selon les pays et/ou par grande catégorie (étudiants, expatriés sur contrat court, …) mais ces informations ne semblent pas disponibles ». Jérôme Lê (Insee, 17) reminds us of the uncertainty of the data: " Pour le solde migratoire de 2017, l'effet observé (chute des départs de non-immigrés) me semble être surtout un effet de questionnaire ou de protocole. Il est possible qu'il soit en partie réel mais plusieurs indicateurs semblent montrer qu'il est largement surestimé (retours de non-immigrés stables, sorties négatives au-delà de 65 ans)".

Distinguishing flows according to their main reason is also hampered by the availability of data. The reasons for immigration can be approached by the types of residence permits issued. These residence permits are only required for nationals of countries outside the European Union, which excludes persons of French or European nationality. Moreover, the issue of a residence permit does not always coincide with arrival in France (for example, for people who study in France and then settle there).

For these reasons, we proposed a less ambitious approach, already adopted in 2016, which consists in using the evolution of recent flows to **give an interpretation of the net migration: which decomposition would be compatible with the baseline assumption on net migration and its variants?**

Several experts support this approach more or less explicitly (14, 17, 20), such as Jérôme Lê (Insee, 17) who stresses that immigrant and non-immigrant flows are distinct phenomenon : " Oui ! la distinction entre immigrés et non-immigrés me semble très importante car ce sont deux phénomènes très différents. À moins de changements forts sur la politique migratoire, la tendance sur les immigrés devrait se poursuivre. Pour les non-immigrés, je pense que les départs vont se poursuivre car c'est une tendance mondiale de tous les pays de l'OCDE."

On the contrary, some experts find this approach risky (21, 34), such as Laurent Toulemon (12): "Je n'ai pas l'impression que la décomposition selon le lieu de naissance (très informative et utile par ailleurs) permette de réduire l'incertitude (cela justifie plutôt une augmentation de l'incertitude, puisque deux éléments opposés du solde (sortie de natifs et entrés d'immigrés) augmentent. […] Je ne m'y risquerais pas, compte tenu des grandes incertitudes sur ces estimations issues du recensement ». Il est vrai qu'un même solde est compatible avec plusieurs évolutions des différents flux." It is true that the same balance is compatible with several changes in the various flows.

Interpretations with a different reading grid are proposed. Marie Vandresse (Federal Planning Bureau, Belgium, 36) would favour assumptions based on demographic reasoning: "davantage en faveur d'un scénario qui se justifie sur la base d'arguments « démographiques » /économiques/sociétaux plutôt que sur une hausse de x pourcent (ou unités). Par ailleurs, les implications sont différentes si cette hausse/baisse du solde s'explique par une hausse/baisse de l'immigration ou de l'émigration".

For Misha Khodabin, Hamza Zakraoui and Samuel Ménard (DG Trésor, 21), stress the importance of telling a story: "au-delà des valeurs prises, il serait intéressant de sous-tendre ces hypothèses basses et hautes par un narratif. Un solde migratoire net faible pourrait ainsi être justifié par le développement économique des pays à revenu intermédiaire, qui absorberaient davantage de flux migratoires, ou par un durcissement des politiques migratoires dans les pays avancés. Inversement la crise climatique pourrait induire une intensification des pressions migratoires (selon les hypothèses retenues sur les trappes à pauvreté)."

FEMALE BALANCE, MALE BALANCE

We asked the experts whether they had any explanations for the sex ratio and the growing gap between the female and male net migrations, and how they saw this situation developing. Many experts indicated that they would have liked a more detailed analysis by country of origin and/or reason for entry in order to be able to give an opinion (30, 31, 34, 35, 36, and 2 anonymous) and mentioned family reasons, which are more female. Thus Gautier Maigne (France Stratégie, 19) mentions female shares in different types of flows: "« la part actuelle de l'immigration familiale en France, qui concerne surtout les femmes ", " une féminisation des flux liés aux études ", "les hommes continuent à être surreprésentés dans le cadre de la seule immigration économique, certes assez faible en France. L'immigration dite humanitaire peut aussi plutôt masculine (comme cela a été noté lors de la « crise des réfugiés"Sylvain Papon (Insee, 22) takes up the same categories and adds that women could become an important part of economic inflows : "[si les femmes] sont pour le moment minoritaires pour

les entrées sur critère professionnel, cela pourrait changer dans les années à venir compte tenu de l'augmentation générale du niveau d'éducation des filles dans le monde."

While it is true that the sex ratio could be affected by the evolution of these different categories, it seems that current inflows of **immigrant** are rather balanced, as Virginie Jourdan, Loreline Court and Florian Hatier of the DSED indicate (18): " Au niveau des entrées sur le territoire, sur la base des données sur les titres de séjour délivrés, nous n'observons pas des différences importantes par sexe les flux d'entrées sont plutôt équilibrés. " Overall, according to the latest estimates from the census (Lê, 2021), immigrant entries in 2017 were also balanced (52% female), as indeed were non-immigrant entries (51%). The imbalance can therefore only come from the outflow of non-immigrants, and in particular from the fact that men are more likely to leave than women. But there is little evidence to support this estimate, which is measured indirectly, as mentioned above. Jérôme Lê (Insee, 17) adds that foreign data do not indicate such an imbalance: " C'est assez étonnant en effet. Les hommes non-immigrés quittent plus souvent la France selon les estimations mais pourtant, dans les recensements étrangers, on ne retrouve pas ce déséquilibre entre hommes et femmes nés en France et vivant à l'étranger… ".

Arkadiusz Wisniowski (13) mentions factors that could affect the sex ratio of the various flows: "the duration of the phenomenon will depend on the technological development, composition of job shortages in France, and women emancipation patterns in countries of origin".

In the end, most experts do not really have an opinion on the evolution of this imbalance, but some suggest returning to a more balanced composition of net migration (12, 30, 33, 34), especially since this imbalance could affect the number of births. Misha Khadabin, Hamza Zakraoui and Samuel Ménard suggest that we quantify its impact.

Few comment on net migration by sex and age in the variants. Laurent Toulemon (12) suggests that we keep the same distribution by sex and age in the three scenarios, to keep things simple : « [garder] la même répartition par sexe et âge dans les trois scénarios, tout en expliquant que d'autres profils seraient possibles mais que des scénarios plus sophistiqués n'apporteraient que peu de changement aux résultats et les rendraient moins simples à comprendre et à utiliser."

For Sylvain Papon (Insee, 22), the sex ratio could be different in variants: "dans le cas de l'hypothèse haute, qui serait la conséquence de politiques de migration nouvelles ou de demandes d'asile (climatique ou non) en forte hausse, la part des deux sexes pourrait davantage s'équilibrer. En résumé, conserver le déséquilibre dans le cas des hypothèses basse et centrale paraît plausible, mais beaucoup moins dans le cas de l'hypothèse haute."

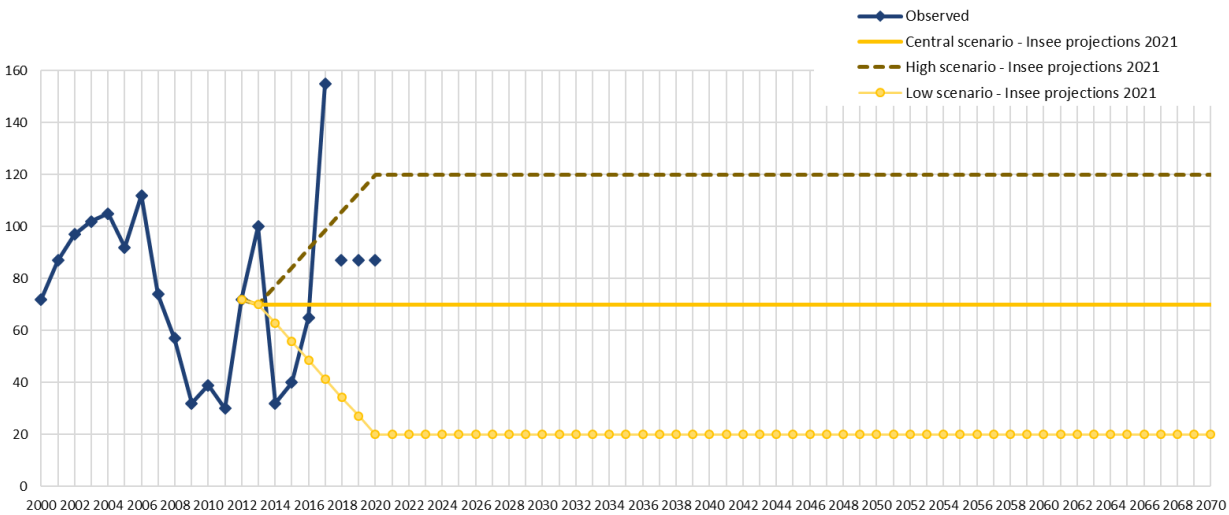
C. ASSUMPTIONS RETAINED

NET MIGRATION: CENTRAL ASSUMPTION OF +70,000/YEAR, VARIANTS AT +/- 50,000

The baseline assumption for net migration has been maintained at 70,000. This has many advantages, given the high uncertainty surrounding the evolution of net migration: it corresponds to the average of the last few years observed, the UN and Eurostat projections use similar assumptions, and it was the central assumption of the previous INSEE projection exercise in 2016.

Several experts have suggested that we raise the low assumption, but the update of the work of Vianney Costemalle (**Box 9**) suggests the possibility of negative net migration. The confidence interval obtained on the basis of the 1995-2017 trend would be [-10,000; + 138,000]. Given these somewhat contradictory arguments, the 2016 assumptions were maintained for the variants, with a low assumption of +20,000 and a high assumption of +120,000. The working scenario is also kept identical to 2016, with zero net migration at each age. It can be interpreted either as an unrealistic and counterfactual scenario: "What would happen if there were no migration at all?", or as a possible scenario, keeping in mind then that it is not a question of assuming zero migrations but flows of entries and exits of the same magnitude, which compensate each other.

Figure 4.8 - Net migration from 2000 to 2070



Coverage: France

NET MIGRATION OF +70,000 BUT SEVERAL INTERPRETATIONS IN TERMS OF INFLOWS AND OUTFLOWS

A separate projection according to different flows is out of reach, even if many experts suggest it and Eurostat has introduced this method**.** The lack of data on outflows makes their estimation dependent on methodological developments in the census, with no corroboration possible**.** As suggested by the experts, one can only hope for progress in the accuracy of the data and the analysis of the different flows by the next projections in 2026. **The interpretation by the different categories of flows is nevertheless instructive**, as it reminds us that net migration is the result of different migratory flows, in and out, and not simply the number of immigrants entering France in a given year. It also reminds us that the annual net migration depends on the evolution of these different flows, each influenced by different factors, and that it is therefore variable, and probably all the more so when it is the result of larger movements that offset each other, as has been the case in recent years. It therefore allows us to insist on the fact that the baseline assumption concerns the average between now and 2070 and that each year the net migration varies and will vary greatly. On the **other hand, it is only illustrative, since the evolution of the various flows is even more uncertain than that of the net migration**.

Various situations are compatible with a balance of +70,000. It may correspond to an immigrant balance of +170,000 and a non-immigrant balance of -100,000, a situation close to the average observed over the decade 2006-2017. But if we continue the linear upward trend in immigrant inflows between 2006 and 2019, these inflows could reach 580,000 in 2070. The same exercise for non-immigrant outflows, extending the 2006-2017 trend, results in 750,000

in 2070. It is likely that these increases would be accompanied by return movements and therefore by an increase in the flow of outflows of immigrants and inflows of non-immigrants. A net migration of +70,000 is thus compatible with much larger flows of immigrants (580,000 inflows, 140,000 outflows, net migration of 440,000) and non-immigrants (380,000 inflows, 750,000 outflows, net migration of - 370,000). This arithmetical exercise simply shows that the same net migration is compatible with quite different, but nevertheless relatively plausible, developments: on the one hand, a stabilisation of flows at their past level, and on the other, an increase in mobility that is in line with recent trends.

THE PANDEMIC LEADS TO A HIGH DEGREE OF UNCERTAINTY ABOUT THE FLOWS IN 2020 AND 2021

There is considerable uncertainty as to what has happened / will happen between the start of the **pandemic** and the end of its effects, with the first data abroad showing very contrasting developments from one country to another. In France, the Brexit and the 2008 crisis seem to have had little influence on migration flows with the UK (Lê and Leservot, 2021) and more generally on net migration. Above all, the measurement of net migration is always marked by strong uncertainties: the 'real' population movements in 2020 and 2021 will never be known. **We therefore propose to maintain in all variants the levels of net at +87,000 in 2020 and +70,000 in 2021, and to apply the values of the variants without transition from 2021.**

In order to estimate the extent to which a revision of the migration balances for 2020-2022 could affect the situation in 2070, we have carried out **sensitivity tests in a variant of the baseline scenario**. The idea is to imagine that there are (or were) movements in 2020-2022 that are not offset by carry-over movements in subsequent years and that do not offset each other. For simplicity, since the projection starts in 2021, we propose two tests that vary the flows in 2021 and 2022[20] and correspond to contrasting situations:

- 1er test case :
  In 2021 and 2022, a significant flow of returning expatriates who do not leave in the following years is added to the other flows, which are not modified. To have an order of magnitude, we propose to assume the "final" return of 10% of the people who left during the past decade 2011-2020, estimated via the 2008-2017 outflow of non-immigrants[21], i.e. 209,000. These returns occur in two years, so 104,500 additional entries in 2021 and the same in 2022. This makes a net migration of 174,500 in 2021 and 2022.

[20] It is more likely that, if there were variations, they occurred mainly in 2020 and 2021. But this does not change the impact much by 2070.
[21] Cross-reference to site data

- 2nd test cases, symmetrical :
  In 2021 and 2022, a significant flow of recent arrivals to France returning to their country of origin is added to the other flows, which are not modified. It is proposed to retain the same order of magnitude of 10% of the people who entered during the 2011-2020 decade, estimated via the 2008-2017 immigrant entries, i.e. 231,000. This makes 115,500 in 2021 and 2022, which brings the net migration in these two years to -45,500.

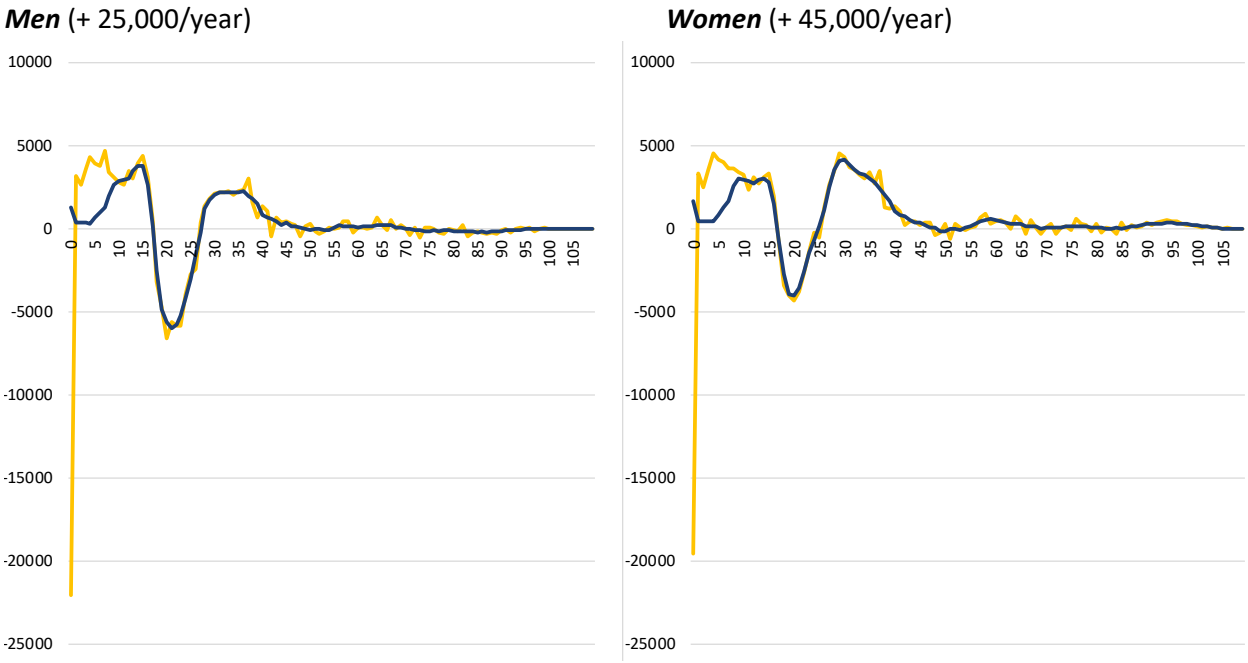
An estimate of the impact on the projection results is shown in **Box 10**.

NET MIGRATION IS TWO-THIRDS FEMALE, NEGATIVE BETWEEN 18 AND 26 AND POSITIVE AT OTHER AGES

Once the target net migration and its variants have been decided, the question arises of its distribution by sex and age. The increase in the share of women seems too sudden and recent to be maintained at the same level until the end of the projection period. **We assume a male net migration of +25,000 and a female net migration of +45,000, which corresponds approximately to a distribution of 1/3 men and 2/3 women.** This is slightly more unbalanced than in the 2016 projections, but slightly less unbalanced than in the latest available data.

Comparisons between the number of young children and the number of births registered in France at the civil registry suggest possible omissions in the census, particularly for newborns, but also, more generally, for young children. This deficit of young children in the census is not specific to France. It distorts net migration by age. For the projections published in 2016, a correction had been applied to spread the deficit over the 0-2 year olds. However, a correction is proposed in a report recently published on on the quality of census estimates, correction that can be applied globally to the age pyramid (Solard 2020, appendix 2, pages 92 and following). **This method makes it possible to correct the net migration at young ages**. The correction, which does not change the size of the population but only its distribution by age, does not modify the results of the projection and, on the other hand, makes it possible to display net migrations by age that are easier to interpret. Compared to the 2016 method, the main change is to smooth the 0-8 year olds rather than the 0-2 year olds. Research has shown that after 6-8 years of age, the deficit of children of a generation in the census is absorbed. Smoothing over this age group makes it possible to obtain net migrations close to zero at young ages, which is more credible than a strongly negative balance at 0 years or between 0 and 2 years if we smooth over this age group alone.

Figure 4.9 - Distribution of the net migration by age in the central scenario

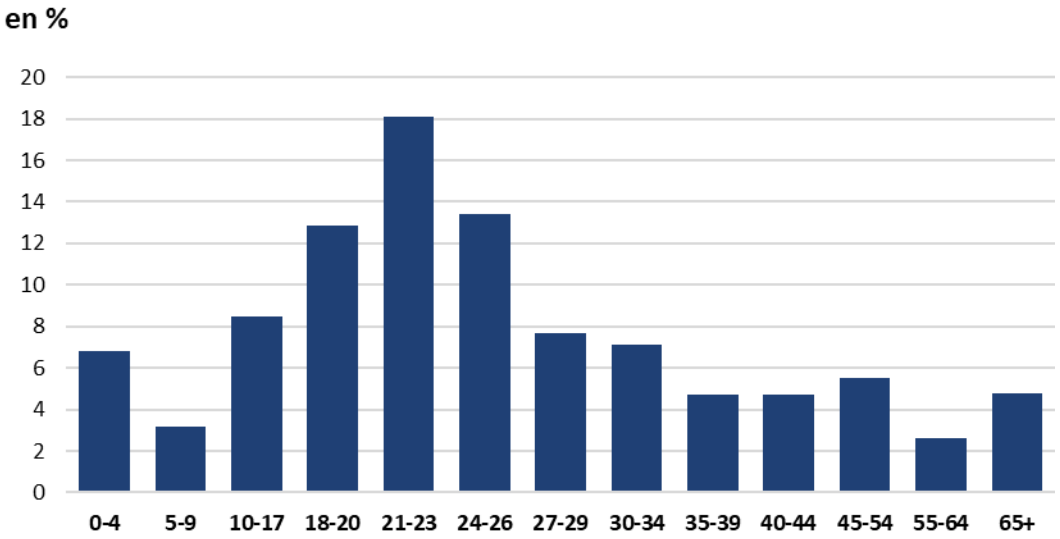


Based on the assumption of a total net migration of +45,000 for women and +25,000 for men, the distribution by age is carried out for each sex according to the distribution key of the average migratory balance for 2015-2017, smoothed by moving average. The net migration of 0-8 year olds is redistributed within the age group according to a distribution key inspired by that obtained for the 2012 net migration by interpolation of the pyramids (Solard, 2020). The correction is applied progressively: the net migration remains at the same level from 2021 to 2030, but its composition by sex and age gradually approaches the target composition shown in Figure 4.9, and reaches it in 2030.

In 2016, the assumption was that the high (resp. low) variant was reached by an increase (resp. decrease) in the volume of inflows, with outflows assumed to be stable. This assumption seems less in line with the evolution of the last years, which shows a high volatility of the outflows. This is why it was chosen to distribute by age the 50,000 additional persons, allowing to switch from the baseline scenario to the high variant, according to the average of inflows and outflows observed over the period 2017-2019[22]. According to these data, during the 2017-2019 period, half of the inflows and seven out of ten outflows were between 18 and 34 years old. This justifies the assumption that changes in the net migration will be due mainly to changes in behaviour at these young ages, whether through immigration or emigration.

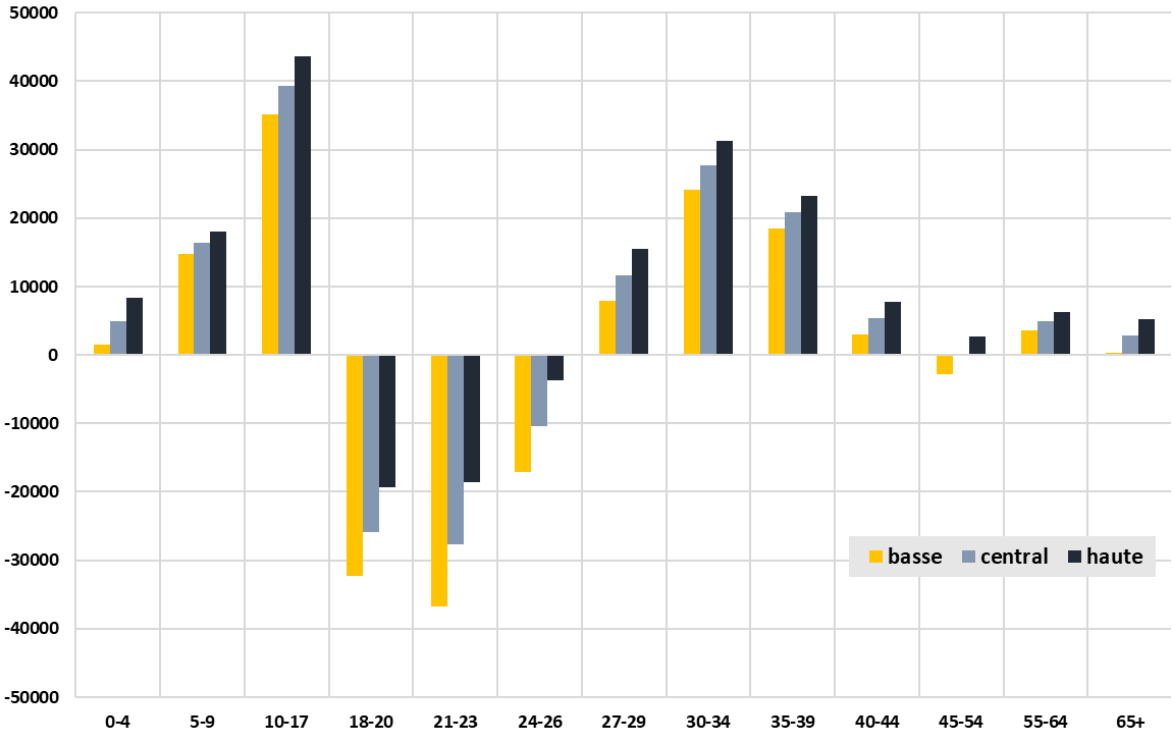
[22] https://ec.europa.eu/eurostat/fr/web/main/data/database

Figure 4-10 Distribution of plus and minus persons for the net migration variants



This distribution key is used for men and women, so as to reach the targets defined for each sex, making it possible to reach approximately one-third men and two-thirds women: 13,000 women and 7,000 men in the low variant; 80,000 women and 40,000 men in the high variant (**Figure 4.10**). As with the baseline assumption, the gender and age distribution of the high and low variants gradually evolves towards its target from 2021 to 2030.

Figure 4-11 Age distribution of net migration in the three variants, 2030-2070



Box 9 - Probabilistic projection of net migration, an update of V. Costemalle's work

Vianney Costemalle carried out Bayesian probabilistic projections for France using the component method (Costemalle, 2020). For net migration, he used a first-order autoregressive model, imposing a stationary process. He explains that "this modelling reflects the fact that it is estimated that net migration will continue to be stable on average and will oscillate around a long-term trend. The amplitude of possible future oscillations is determined by past amplitudes. Furthermore, a very informative a priori is set with regard to the long-term trend by assuming, as was the case in the work of Blanpain & Buisson, that this can be estimated from the average net migration over the recent period, i.e 80,000 people. [...] To project the total net migration, the model parameters are randomly drawn 1,000 times according to their a posteriori distribution and for each set of parameters, the development of the net migration is simulated according to the first order autoregressive process".

We have reproduced his model in its entirety, thanks to the programs he sent us, for which we thank him warmly. The only changes concern the geographical coverage and the past reference period. The net migration projected in the initial article from the 1995-2013 data for metropolitan France "follows a stable trajectory as this was specified in the model. The median of the 1,000 possible trajectories decreases in the first few years of projections before rapidly stabilizing at 79,000. The confidence interval also remains constant over time: at a probability of 95%, net migration will remain at between 29,000 and 129,000 each year. This amplitude is due to the significant fluctuations observed in the past, and slightly exceeds the minimum and maximum observed in 1996 and 2006 respectively". If we reproduce his method for France-wide data over the period 1995-2017, we see an increase in the 95% confidence interval by 2070 (**figure, column 3)**, due to the greater fluctuations of net migration during the 2014-2017 period: the minimum observed over the period 1995-2017 is the net migration of 2014 (+32,000) and the maximum that of 2017 (+155,000). Furthermore, by modifying the long-term average to +70,000, the average observed for France over the period 1995-2017, the result is that at a probability of 95%, net migration will remain at between -10,000 and +138,000 each year.

Net migration in 2070: 2.5% and 97.5% quantiles and median of the a posteriori distributions

Box 10 - Pandemic and net migration in France: sensitivity tests

In comparison with the baseline scenario, two alternative assumptions are tested:

- first test scenario: In 2021 and 2022, a large flow of **returning emigrants,** who do not leave in the following years, is added to the other flows, which are not modified. To get an order of magnitude, we propose to assume the "definitive" return of 10% of the people who left during the past decade 2011-2020, estimated via the outflow of non-immigrants 2008-2017, i.e. 209,000. These returns occur in two years, so 104,500 additional inflow in 2021 and the same in 2022. Net migration is thus of 174,500 in 2021 and 2022.

- second test scenario, symmetrical: In 2021 and 2022, a large flow of people who have recently arrived in France return to their country of origin is added to the other flows which are not modified. We speak of **returning immigrants.** We propose to retain the same order of magnitude of 10% of the people who entered during the 2011-2020 decade, estimated via the 2008-2017 immigrant entries, i.e. 231,000. This means 115,500 additional outflows in 2021 and 2022. **The balance for these two years is negative, at -45,500**.

The population is immediately affected by about +/-200,000 people, which corresponds to the change in net migration. By 2070, the effect is slightly amplified: +350,000 inhabitants in the case of the return of emigrants and - 330,000 in the case of the departure of immigrants. The effects on the ratio between people over 65 and people of working age are moderate and very much linked to the age structure of net migration: the return of immigrants worsens the ratio a little by 2050, while the return of emigrants improves it. However, the situation is reversed in 2070: the ratio between people over 65 and people of working age is 56.8 per cent in the central scenario, 56.7 per cent in the scenario of returning immigrants, and 57.0 per cent in the scenario of returning emigrants.

PART 5 : DISSEMINATION

Experts were also interviewed on then dissemination of the results of the projections. The first question was phrased as follows:

Are you satisfied with the dissemination of the 2016 projection results (accessibility of data, presentation of results, publication materials)?

What improvements do you think could be made?

The majority of experts are satisfied with the dissemination, but many areas for improvement are suggested:

- **Communicate more about results in the short term, rather than in 2070.**
  According to Jean-Francois LÉGER (5), more attention shoud be given to medium term results : " La présentation des résultats devrait moins mettre l'accent sur la situation hypothétique en 2070 mais davantage sur les résultats à un horizon de plus court terme. Se focaliser sur 2070 présente selon moi un seul intérêt pour l'Insee : celui de ne pas avoir à assumer les écarts entre réalité et simulation ! Sinon, sur le plan de l'éclairage de l'action publique, quelle action est mise en œuvre à un horizon de 50 ans et supposerait une information (avec toutes les réserves inhérentes aux projections de long terme) sur la composition de la population française en 2070 ?"
  ➔ We can indicate here that, in the 2016 projections, the emphasis in terms of studies was on the results for 2070 but not only. When presenting the projections, Insee often insisted on the different evolutions to be expected by 2030-2040, for example on the proportion of the elderly population, and those by 2070, when the large generations resulting from the baby-boom will be extinct (Blanpain and Buisson, 2016). We will reproduce this distinction in the first study carried out with the 2021 projections, because as Jean-Francois LÉGER points out, these messages are important in terms of public policy.

- **Update the projections more regularly, especially the starting point.**
  According to Philippe LOUCHART (6), it would be useful to update the starting point : "Il s'agirait moins d'améliorer la diffusion selon moi que de mettre à jour plus facilement les projections réalisées, en actualisant régulièrement le point de départ, voire les hypothèses retenues, pour éviter les décalages importants qui pourraient survenir dès les premières années, en particulier dans ce contexte fortement incertain. Ces travaux sont effet utilisés à la fois pour éclairer le futur lointain dans le cadre de travaux comme les Schémas Directeurs ou les réflexions sur le ZAN (Zéro Artificialisation Nette) comme le ZEN (Zéro Emissions Nettes) mais aussi à plus court-terme dans le cadre d'études scolaires. L'alimentation des modèles de déplacements

(Antonin ou Modus) conduit aussi à mettre à jour chaque année, à une échelle géographique fine, ces travaux de projections destinées aussi bien à éclairer dans ce temps les évolutions attendues à court-terme et à long-terme".

➔ We have indeed found that the gap between the 2016 projections and recent data is sometimes large. Between 2019 and 2021, we frequently advised users to rely on the scenario with the low mortality and fertility assumptions and the baseline migration assumption because it was more in line with recent trends than the baseline 2016 scenario. The large number of scenarios thus gives reason to hope that if a new gap between the new baseline projection and the latest developments were to be observed, at least one of the scenarios would be able to reflect this. The consultation of experts and the production of the projections represent a significant workload that is difficult to implement more frequently than every 5 years.

- **Disseminate results in English** (13 Arkadiusz WISNIOWSKI, 35 Astri SYSE and Michael THOMAS, Statistics Norway)

  ➔ The Insee Première and the working paper will be translated into English. These two documents will be distributed to the experts interviewed. A translation of the web page dedicated to the projections could be envisaged.

- **Disseminate long series including older data** in the same format as the projected series in order to facilitate the use for graphics (15 Pascale BREUIL, Cnav, 12 Laurent TOULEMON)

  ➔ Past data will be made available with projected data indicating their status (final, provisional, projected), as well as changes in geographical coverage.

- **Disseminating results at the household level** (19 Gautier MAIGNE, France Stratégie)

  ➔ In 2006, INSEE carried out a 2005-2030 projection of the number of households for metropolitan France (Jacquot, 2006 a and b).

  In 2012, the Service de l'observation et des statistiques (SOeS) updated these household projections.

  For these new population projections, neither Insee nor, to our knowledge, any other organization, is planning to make a breakdown by household.

- **Disseminate data on the inflow of immigrants.**

  According to Clément ROUSSET, Drees (24), it would be useful for pension models: "Pour les modèles de retraites le solde migratoire ne nous suffit pas car un immigré reparti peut encore toucher une retraite française. Ainsi la donnée du flux entrant d'immigré est primordiale. Il me semble que dans la projection 2016 seul le solde migratoire était donné. Nous aurions vraiment besoin du détail avec le flux entrant seul".

  ➔ INSEE now regularly publishes estimates of immigrant and non-immigrant flows in recent years (Lê, 2021). We fully understand the interest of having such data for

projections, but the data on flows are partly deduced from net migration, which is itself deduced from the difference in the population stock between two censuses. It makes it difficult to use them for projections. Projected net migration data by sex and age will be made available.

- **Disseminate data at a finer geographical level** (region/township / city) even if it is over a shorter period (10 years) (24b BRET, BHD and BPS, Drees).
  ➔ The Omphale model will be updated with the new projections. This INSEE model is used to make medium/long-term population projections for any territory with more than 50,000 inhabitants.

- **Gather projection data on a single page** because the INSEE site is not always easy to access (23 Gwenaël PODESTA, DGEC)

  ➔ The results are posted on a page dedicated to projections (https://www.insee.fr/fr/information/2546485). Users often ask us for help because this page is not easily accessible. Moreover, a different page also points to publications on projections (https://www.insee.fr/fr/metadonnees/source/serie/s1316). The ergonomics could be modified to improve accessibility.

- **Provide data on the confidence interval and/or communicate well that the different scenarios do not represent a confidence interval,** which helps users' understanding (27 Kim DUSTAN, Statistics New Zealand, 36 Marie VANDRESSE, Bureau Fédéral du Plan, Belgium)
  ➔ Some confidence intervals on the assumptions are presented in this working paper.

- **Provide more detailed data for each scenario: population by sex and age** (34 Branislav SPROCHA, Slovakia), **life expectancy by sex** (21, Misha KHODABIN, Hamza ZAKRAOUI, Samuel MENARD, DG Treasury)
  ➔ These results have already been released for the 2016 projections in Insee Résultats (https://www.insee.fr/fr/statistiques/2518406?sommaire=2496793) and will also be made available online for future projections. Improved accessibility would be desirable: for example, it is impossible to know before downloading the results for a given scenario that they are very detailed, and include life expectancy by sex at birth, at age 60 and at age 65 for each projection year.

- **Present the results online.** According to Lena LUNDKVIST (31), Statistics Sweden: "One thing that we received positive feedback in Sweden was online presentations (Skype/Zoom) of the results. Before corona, such seminars were often conducted in person in Stockholm. Digitally, persons from all over Sweden were able to participate at no cost. "
  ➔ At least one presentation seminar will be held.

- **Compare the results of the new INSEE projections with the previous projections and those of Eurostat** (anonymous)
  ➔ Comparisons with the Eurostat assumptions and those of the old projections are available in this document.

- **Provide presentation materials for the methodology to facilitate communication to local actors** (anonymous)
  ➔ A powerpoint will be posted on the seminar intranet page and on the INSEE page dedicated to projections (https://www.insee.fr/fr/information/2546485).

The second question on dissemination was phrased as follows:

Q26. If you or your organization uses INSEE projections, for what types of work do you use them? Which scenario(s) do you use? Has this work been published?

The uses of projections are varied:

- **Monitoring pensions or other public expenditures** (14, 15, 19, 20, 21, 24 a). Anthony MARINO and Amandine BRUN-SCHAMMÉ of the COR detailed its use of projections : "Le Conseil d'Orientation des Retraites utilise les projections de population de l'Insee dans le cadre de ses projections du système de retraite qui sont publiées dans un rapport annuel. Elles sont utiles à la fois pour projeter la situation financière du système et comparer les diverses dimensions de l'équité entre générations ou bien encore entre femmes et hommes, notamment la durée de retraite ».

- **Microsimulation models** used at Drees (24a, Clément ROUSSET, Drees, 24b, BRET, BHD and BPS, Drees) or at INSEE such as Destinie.

- **Response to politicians** (12 Laurent TOULEMON)

- **Scoping data for other projections** (5, 15, 23, 24b).

  For example, as explained by Gwenaël PODESTA, DGEC (23), at the Ministry of Ecological Transition and Solidarity, INSEE projections are used to make climate and energy projections : "Ces projections permettent de dimensionner les stratégies Françaises (Stratégie nationale bas carbone, programmation pluriannuelle de l'énergie) et servent à élaborer les rapports communiqués à la Commission européenne et à la Convention climat des Nations Unies. NB : pour le dernier scénario en date (AME 2021), nous avons utilisé les projections eurostat plutôt que INSEE car

mieux calées sur les données récentes. Mais nous pensons revenir aux données INSEE pour les scénarios 2023".

Another example (BRET, BHD and BPS, DREES, 24b), the data are used in the field of health: "dans le cadre des travaux de projections d'effectifs de professionnels de santé, pour calculer d'une part des densités projetées de professionnels, d'autre part des densités standardisées selon la consommation de soins par âge. Les projections sont également déclinées par anciennes régions. Nous utilisons donc, pour chaque millésime de projection, les populations par sexe x âge (actuellement disponibles en ligne), et pour l'analyse régionale, les populations par sexe x âge x département, fournies par le PSAR Emploi-population".

- **Teaching in demography (university courses, seminars, conferences)** (5, 7, 12)

- **Studies at departmental or regional level** (5, 6, 15).
  National scenarios are broken down by region, for example by Institut Paris Region, as Philippe Louchart (6) explains: " systématiquement les scénarios nationaux en Île-de-France en collaboration avec la DR Insee, la Driea, la Drihl et d'autres organismes régionaux car la déclinaison par région effectuée par l'Insee à l'échelle nationale a tendance à gommer voire à ignorer les spécificités du dynamisme démographique de la région capitale. Nous utilisons ces projections à la fois pour des travaux de long terme (Schéma directeur de la Région Île-de-France, alimentation des modèles de déplacements en Île-de-France, projections des personnes âgées dépendantes …) et des travaux de court ou moyen-terme plus orientés vers les évolutions scolaires (primaire, collèges, lycées)".

- **Very short term** (8 Grégoire REY), **short or medium term** (5, 6, 15) **or long term** (6 Philippe LOUCHART) **studies**

BIBLIOGRAPHY

Aassve, A., Cavalli, N., Mencarini, L., Plach, S., and Livi Bacci, M. (2020). The COVID-19 pandemic and human fertility. Science 369(6502): 370–371 https://science.sciencemag.org/content/369/6502/370/tab-pdf

Alkema L., Raftery A., Gerland P., Clark S.J., Pelletier F., Buettner T., and Heilig G.K., Probabilistic projections of the total fertility rate for all countries, Demography, n°48(3).

Andrasfay T., Goldman N. (2021), Reductions in 2020 US life expectancy due to COVID-19 and the disproportionate impact on the Black and Latino populations https://doi.org/10.1073/pnas.2014746118

Bagavos C. (2019), « On the multifaceted impact of migration on the fertility of receiving countries: Methodological insights and contemporary evidence for Europe, the United States, and Australia », Demographic research, volume 41, article 1, pages 1-36

Berger L.M., Ferrari G., Leturcq M., Panico L., Solaz A. (2021), COVID-19 lockdowns and demographically-relevant Google Trends: A cross-national analysis. https://doi.org/10.1371/journal.pone.0248072

Berrington A., Ellison J., Kuang B., Vasireddy S., Kulu H. (2021), Recent trends in UK fertility and potential impacts of Covid-19, Centre for Population Change at Southampton University, Working paper.

Bijak, J., Disney, G., Findlay, A. M., Forster, J. J., Smith, P. W., & Wiśniowski, A. (2019). Assessing time series models for forecasting international migration: Lessons from the United Kingdom. Journal of Forecasting, 38(5), 470-487. https://onlinelibrary.wiley.com/doi/abs/10.1002/for.2576.

Blanpain N. (2020a), La mortalité stagne à l'âge adulte pour les générations nées entre 1941 et 1955, Insee Première n°1824, novembre 2020. https://www.insee.fr/fr/statistiques/4961641

Blanpain N. (2020b), Is the Ageing of the French Population Unavoidable? *Économie et Statistique / Economics and Statistics*, 520-521, 29–47.

Blanpain N. (2021), Combien y aurait-il eu de décès en France sans l'épidémie de Covid-19 ?, Blog de l'Insee, juillet 2021. https://blog.insee.fr/combien-y-aurait-il-eu-de-deces-en-france-sans-lepidemie-de-covid-19/

Blanpain N., Papon S. (2021), Décès en 2020 et début 2021 : pas tous égaux face à la pandémie de Covid-19, France Portrait Social, Insee Références.

Blanpain, N. & Buisson, G. (2016a), Projections de population 2013-2070 pour la France : méthode et principaux résultats. Insee, Document de travail N° F1606. https://www.insee.fr/fr/statistiques/2400057

Blanpain, N. & Buisson, G. (2016b), Projections de population 2013-2070 pour la France. Insee Résultats N°187-Société. https://www.insee.fr/fr/statistiques/2496793

Blanpain, N. & Buisson, G. (2016c), Projections de population à l'horizon 2070, deux fois plus de personnes de 75 ans ou plus qu'en 2013, Insee Première n°1581.

Boulat T., Ghosn W., Morgand C., Falissard L., Roussel S., Rey G. (2019), Principales évolutions de la mortalité par cause médicale sur la période 2000-2016 en France métropolitaine. Bulletin épidémiologique hebdomadaire, 2019, n°. 29-30, p. 576-584.

Breton D., Belliot N., Barbieri M., d'Albis H., Mazuy M. (2019), L'évolution démographique récente de la France : une singularité en Europe ?, Ined, collection Conjoncture Démographique, 92 p.

Breton D., Belliot N., Barbieri M., d'Albis H., Mazuy M. (2020), L'évolution démographique récente de la France : situations et comportements des mineurs, Ined, collection Conjoncture Démographique, 68 p.

Breton D., Brée S., Ducharne T., Villaume S. (2021), Neuf mois après le premier confinement, une baisse plus marquée des naissances dans les territoires fortement touchés par l'épidémie, France Portrait Social, Insee Références.

Cairns, Andrew J. G. and Blake, David P. and Kessler, Amy and Kessler, Marsha (2020), The Impact of COVID-19 on Future Higher-Age Mortality http://dx.doi.org/10.2139/ssrn.3606988

Castiglioni M., Dalla Zuanna G., Tanturri L. (2021), Are demographic indicators really converging in post transitional countries? Les indicateurs démographiques convergent-ils vraiment dans les pays post-transition ?, NIUSSP.

Charles-Edwards E., Wilson T., Bernard A., Wohland P. (2020), How will Covid-19 impact Australia's future population? A scenario approach, Working paper n°2020/03, Queensland Centre for Population Research.

Costemalle V., 2020, Bayesian Probabilistic Population Projections for France. *Économie et Statistique / Economics and Statistics*, 520-521, 29–47.

D'Albis H., Gobbi P., Greulich A., (2017), Having a Second Child and Access to Childcare: Evidence from European Countries. Journal of Demographic Economics, Vol. 83 Issue 02, pages 177-210.

Daguet F. (2019), En 2016, les femmes cadres ont un peu moins d'enfants que les employées, Insee Première n°1769.

Daguet F. (2021), La fécondité baisse moins dans les grandes métropoles, Insee Première n°1838, février.

De Beer J. (2010), A new relational method for smoothing and projecting age-specific fertility rates : TOPALS, Demographic Research 2010.

De Jong P., Wachter G., Costa R. (2021), Covid-19 en internationale migratie, DEMOS 37-3, NIDI.

Dunstan K. (2019), Stochastic projections: the New Zealand experience, Working paper n°13, presented at the Conference of European Statisticians, Work Session on Demographic Projections, Belgrade, 25–27 November 2019.

Duyck J., Paul J.-M., Vandresse M. (2021a), COVID-19 : faible croissance de la population en 2020 et 2021. Le vieillissement de la population reste présent à long terme, Perspectives Flash 2021, Bureau Fédéral du Plan.

Duyck J., Paul J.-M., Vandresse M. (2021b), Perspectives démographiques 2020-2070 - Scénario de référence et variantes, Forecasts and outlook, Bureau Fédéral du Plan.

Eurostat (2020), Population projections in the EU, *Statistics explained*

Folkman Gleditsch R., Syse A., Ways to project fertility in Europe. Perceptions of current practices and outcomes, SSB discussion papers n°929, mai 2020.

Goldstein J. R., Cassidy T., Wachter K. W.(2021), Vaccinating the oldest against COVID-19 saves both the most lives and most years of life https://doi.org/10.1073/pnas.2026322118

Goldstein J. R., Lee R. D. (2020), Demographic perspectives on the mortality of COVID-19 and other epidemics https://doi.org/10.1073/pnas.2006392117

Goujon A. (2020), Dimensions in Global Projections: An Overview. *Économie et Statistique / Economics and Statistics*, 520-521, 29–47.

Greulich A., Thévenon O., Guergoat-Larivière M. (2017): "Employment and second childbirths in Europe." Population, Vol. 4/2017.

Gruppo di esperti "Demografia e Covid-19" (2020), L'IMPATTO DELLA PANDEMIA DI COVID-19 SU NATALITÀ E CONDIZIONE DELLE NUOVE GENERAZIONI, Primo rapporto.

Hellstrand J., Nisen J., Miranda V, Fallesen P., Dommermuth L., Myrskylä M. (2020), Not just later, but fewer : Novel trends in cohort fertility in the Nordic countries, Max Planck Institute for Demographic Research, Working paper 2020-007.

Hilton J., Dodd E., Forster J.J., Smith P.W.F., Bijak J. (2019), Forecasting Fertility with Parametric Mixture Models, arXiv.

Hyndman R.J., Booth H. (2017), Stochastic population forecasts using functional data models for mortality, fertility and migration, Monash University, Working paper, 2007

Insee (2021a), « Rénovation du questionnaire du recensement de la population 2018. Impact sur les évolutions annuelles de population », NOTE TECHNIQUE, janvier 2021.

Insee (2021b), « Rénovation du questionnaire du recensement de la population 2018. Méthode d'estimation de l'effet questionnaire (ajustement) à partir des enquêtes annuelles de recensement », NOTE TECHNIQUE, janvier 2021.

Insee (2021c), Flux migratoires par catégorie de population, données annuelles de 2006 à 2019, avril 2021. https://www.insee.fr/fr/statistiques/4176348

Jacquot A., 2006a, Des ménages toujours plus petits, Projection de ménages pour la France métropolitaine à l'horizon 2030, Insee Première n° 1106, octobre 2006.

Jacquot A., 2006b, Projections de ménages pour la France métropolitaine à l'horizon 2030 : méthode et résultats, Document de travail n° F0605, octobre 2006.

Jacquot A., 2012a, La demande potentielle de logements à l'horizon 2030 : une estimation par la croissance attendue du nombre des ménages, Ministère de l'Environnement, de l'Énergie et de la Mer - LE POINT SUR, n° 135, août 2012,

Jacquot A., 2012b, Projection du nombre de ménages et calcul de la demande potentielle de logements : méthode et résultats », Ministère de l'Environnement, de l'Énergie et de la Mer - Document de travail n° 7, septembre 2012.

Janssen F. (2020), Changing contribution of smoking to the sex differences in life expectancy in Europe, 1950–2014. *Eur J Epidemiol* 35, 835–841. https://doi.org/10.1007/s10654-020-00602-x

Janssen F., El Gewily S., Bardoutsos A. (2021), Smoking epidemic in Europe in the 21st century, Tobacco Control 2021;30:523-529. https://tobaccocontrol.bmj.com/content/30/5/523

Kearney M.S., Levine P.B, 2020, The coming COVID-19 baby bust: Update, The conversation, https://www.brookings.edu/blog/up-front/2020/12/17/the-coming-covid-19-baby-bust-update/

Lappegård, Kristensen A., Mamelund S. (2020), Covid-19 could generate a baby 'bust' in the Nordic countries, post de blog juin 2020, https://blogs.lse.ac.uk/europpblog/2020/06/26/covid-19-could-generate-a-baby-bust-in-the-nordic-countries/

Lê J. (2021), En 2017, 44 % de la hausse de la population provient des immigrés, *Insee première,* n° 1849.

Lê J., Leservot P., 2021, Annonce du Brexit et crise de 2008 : peu d'impact sur l'immigration depuis le Royaume-Uni, Insee Première n°1833.

Lee, R. D., & Carter, L. R. (1992). Modeling and Forecasting U. S. Mortality. *Journal of the American Statistical Association*, *87*(419), 659–671. https://doi.org/10.2307/2290201

Li N., Lee R. (2005) Coherent mortality forecasts for a group of populations: An extension of the lee-carter method. *Demography* 42, 575–594. https://doi.org/10.1353/dem.2005.0021

Louchart P.(2021), Paris, Londres, New York : regards croisés sur la démographie de trois métropoles mondiales, Institut Paris Région, février.

Louchart P.(2021b), Baisse des naissances et de la fécondité : l'Île-de-France, région la moins touchée, Institut Paris Région, juillet.

Luppi F., Arpino B., Rosina A. (2020), The impact of COVID-19 on fertility plans in Italy, Germany, France, Spain, and the United Kingdom, Demographic Research, Volume 43 - Article 47 | Pages 1399–1412, décembre 2020. https://www.demographic-research.org/volumes/vol43/47/default.htm

Lutz W, Goujon A, Samir KC, Stonawski M, Stilianakis N eds, 2018, Demographic and human capital scenarios for the 21st century, Publications de l'Union Européenne.

Lyman Stone**,** *Eros vs. Thanatos: How will COVID-19 impact fertility in 2020 and 2021? (2020), présentation orale, Wittgenstein Center Conference 2020 on Demographic aspects of the Covid-19 pandemic and its consequences.*

Manuel Aburto J., Schöley J., Kashnitsky I., Zhang L., Rahal C., I Missov T., C Mills M.,B Dowd J., Kashyap R. (2021), Quantifying impacts of the COVID-19 pandemic through life-expectancy losses: a population-level study of 29 countries, INTERNATIONAL JOURNAL OF EPIDEMIOLOGY, https://doi.org/10.1093/ije/dyab207

Marois G., Muttarak R., Scherbov S. (2020) Assessing the potential impact of COVID-19 on life expectancy. https://doi.org/10.1371/journal.pone.0238678

Masson, L. (2015), « La fécondité en France résiste à la crise » in France portrait social 2015, Insee, octobre 2015.

McDonald P., 2020, A projection of Australia's future fertility rates, Report for the centre for population.

O'Connor M., Portes J., 2021, « Estimating the UK population during the pandemic », Economic Stastistics Centre of Excellence (ESCOE), January 14, 2021.

ONS, National and subnational population projections – user feedback: April 2021, https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/articles/invitationtoprovidefeedbackontimescalesforfuturenationalandsubnationalpopulationprojections/april2021

Ourliac (2020), Covid et mortalité en Europe en 2020, des statistiques à regarder de près, blog de l'Insee, février 2021. https://blog.insee.fr/covid-et-mortalite-en-europe-en-2020-des-statistiques-a-regarder-de-pres/

Pailhé A. et Solaz A., 2011 – « Does job insecurity cause missing births in a high fertility European country ? Evidence from France », Documents de travail de l'Ined, n° 169. https://archined.ined.fr/view/AWRIDgOcgpz89Adag5p6

Pailhé A., 2010 – « Effet attendu de la crise économique actuelle sur les naissances : quelques hypothèses », Politiques sociales et familiales, n° 100, p. 97-103.

Panico Lidia, Régnier-Loilier Arnaud, Toulemon Laurent. Fécondité et politiques publiques. Une comparaison entre la France et l'Italie autour des travaux de Valeria Solesin. In: Revue des politiques sociales et familiales, n°124, 2017, pp. 73-83; http://www.persee.fr/doc/caf_2431-4501_2017_num_124_1_3207

Papon S., 2021a, La descendance finale reste légèrement supérieure à 2 enfants par femme pour les femmes nées dans les années 1970, Insee Focus, n°239.

Papon S., 2021b, La fécondité en France a résisté à la crise économique de 2008, contrairement à la plupart de ses voisins, Insee Focus, n°240.

Papon S., 2021c, Baisse des naissances neuf mois après le premier confinement : plus marquée pour les femmes les plus jeunes et les plus âgées , Insee Focus, n°251.

Papon S., Beaumel C., 2021, Avec la pandémie de Covid-19, nette baisse de l'espérance de vie et chute du nombre de mariages, *Insee première,* n° 1846.

Papon, S., Beaumel, C., 2020, Bilan démographique 2019 : La fécondité se stabilise en France, Insee Première n°1789.

Pison G., 2020, France : la fécondité la plus élevée d'Europe, Populations et sociétés n°575, mars 2020.

Pison G., Dauphin S. (2020), Enjeux et perspectives démographiques en France 2020-2050. Un état des connaissances, document de travail de l'Ined n°259, novembre.

Renshaw A. E., Haberman S. (2006), A cohort-based extension to the Lee-Carter model for mortality reduction factors, Insurance: Mathematics and Economics, Volume 38, Issue 3, Pages 556-570, ISSN 0167-6687, https://doi.org/10.1016/j.insmatheco.2005.12.001.

Schmertmann C. P. (2003), A system of model fertility schedules with graphically intuitive parameters DEMOGRAPHIC RESEARCH VOLUME 9, ARTICLE 5, PAGES 81-110, OCTOBER 2003, http://www.demographic-research.org/Volumes/Vol9/5/

Schmertmann C., Zagheni E., Goldstein J.R., Myrskylä M., (2014) Bayesian Forecasting of Cohort Fertility, Journal of the American Statistical Association, 109:506, 500-513, DOI: 10.1080/01621459.2014.881738

Shang, H., Booth, H. Synergy in fertility forecasting: improving forecast accuracy through model averaging. *Genus* 76, 27 (2020). https://doi.org/10.1186/s41118-020-00099-y

Sobotka T., Jasilioniene A., Galarza A., Zeman K., Nemeth L., Jdanov D. (2021). Baby bust in the wake of the COVID-19 pandemic? First results from the new STFF data series. https://doi.org/10.31235/osf.io/mvy62

Sobotka, T., Jasilioniene, A., Galarza, A. A., Zeman, K., Nemeth, L., & Jdanov, D. (2021, March 24). Baby bust in the wake of the COVID-19 pandemic? First results from the new STFF data series. https://doi.org/10.31235/osf.io/mvy62

Solard G. (coord.), Chevalier M., Durier S., Espinasse L., Le Palud V., Lollivier S., Marteau B., Pagès J., Prévot J., Reynaud D., Roux V., Talbot J., Toulemon L., Vanotti L., Volant S., La qualité des estimations de population dans le recensement, Insee Méthodes n° 136, octobre 2020.

Stoeldraijer L. (2020), De invloed van corona op onze levensverwachting, https://www.cbs.nl/nl-nl/longread/statistische-trends/2020/de-invloed-van-corona-op-onze-levensverwachting

Stoeldraijer L., de Regt S., van Duin C., Huisman en Saskia te Riele C. (2021), Bevolkingsprognose 2020-2070: bevolking groeit langzamer door corona, décembre, https://www.cbs.nl/nl-nl/longread/statistische-trends/2020/bevolkingsprognose-2020-2070-

United Nations, Department of Economic and Social Affairs, Population Division (2019a). World Population Prospects 2019: Highlights. ST/ESA/SER.A/423.

United Nations, Department of Economic and Social Affairs (2019b), Population Division. World population prospects 2019—fertility indicators. https://population.un.org/wpp/Download/Standard/Fertility/

United Nations, Department of Economic and Social Affairs (2019c), Population Division. World population prospects 2019. https://population.un.org/wpp/Download/Standard/Mortality/

Vandresse M., Duyck J., Paul J.-M. (2021), Perspectives démographiques 2020-2070 - Scénario de référence et variantes, bureau fédéral du plan https://www.plan.be/publications/publication-2104-fr-perspectives_demographiques_2020_2070_scenario_de_reference_et_variantes

Volant S., Pison G., Héran F., 2019, La France a la plus forte fécondité d'Europe. Est-ce dû aux immigrées ?, Population et Sociétés, n° 568, juillet/août 2019, 4 p.

Vollset S. E et al. (2020), Fertility, mortality, migration, and population scenarios for 195 countries and territories from 2017 to 2100: a forecasting analysis for the Global Burden of Disease Study, the Lancet

Wilde, J., Chen, W., Lohmann, S. (2020), COVID-19 and the future of US fertility: what can we learn from Google?, MPIDR Working Paper WP-2020-034, 34 pages, October 2020. DOI:10.4054/M