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The end of population aging in high-income countries

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Abstract

Will the population of today's high-income countries continue to age throughout the remainder of the century? We answer this question by combining two methodologies, Bayesian hierarchical probabilistic population forecasting and the use of prospective ages, which are chronological ages adjusted for changes in life expectancy. We distinguish two variants of measures of aging: those that depend on fixed chronological ages and those that use prospective ages. Conventional measures do not, for example, distinguish between 65-year-olds in 2000 and 65-year-olds in 2100. In making forecasts of population aging over long periods of time, ignoring changes in the characteristics of people can lead to misleading results. It is preferable to use measures based on prospective ages in which expected changes in life expectancy are taken into account. We present probabilistic forecasts of population aging that use conventional and prospective measures for high-income countries as a group. The probabilistic forecasts based on conventional measures of aging show that the probability that aging will continue throughout the century is essentially one. In contrast, the probabilistic forecasts based on prospective measures of population aging show that population aging will almost certainly come to end well before the end of the century. Using prospective measures of population aging, we show that aging in high-income countries is likely a transitory phenomenon.

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1 Introduction

What is the likely future of the population aging trends observed in today's high-income and high middle-income countries? Will the populations of these countries grow older continuously? If the answer is "yes", then policy-makers should think about how to adjust to this continuous aging process, perhaps by adjusting regulations with respect to migration. But if the answer is "no", then such adjustments may not be necessary. High-income and high middle-income countries are home to more than half of the world's population, and are the places where the challenges associated with population aging are now the greatest.

The effects of population ageing differ widely by country, as they depend on each country's specific demographic history and policy environment. Our focus in this paper is on providing background information for use in policy discussions, rather than on proposing policies for specific countries. Here, we investigate whether the current aging trends in today's wealthier countries are likely to continue throughout the century using probabilistic population forecasts (Raftery et al. 2012), and examine new measures of population aging that are adjusted for changes in life expectancy (Sanderson and Scherbov 2017, 2013, 2010; Lutz, Sanderson and Scherbov 2008). Our data come from UN (2015b). Previously in Lutz, Sanderson and Scherbov (2008, supplementary material), we presented forecasts of new measures of population aging for the world and its regions without associated probabilities. In Sanderson, Scherbov and Gerland (2017), we presented examples of Bayesian hierarchical probabilistic forecasts of new and conventional measures of population aging, but for four countries only: China, Germany, Iran, and the US.

2 Materials and methods

2.1 Definitions of measures of population aging

Population aging is frequently measured using changes in the proportion of the population categorized as old and changes in the median age. The *conventional proportion of the population categorized as old* is measured as the proportion of people who are above a fixed chronological age. Here, we use age 65 as the conventional old-age threshold. The *prospective proportion of the population categorized as old* is the proportion of people with less than a fixed remaining life expectancy. Here, we use a fixed remaining life expectancy of 15 years (Sanderson and Scherbov 2005; Lutz, Sanderson and Scherbov 2008; Sanderson and Scherbov 2010, 2013).

The conventional median age of a population is the age that divides the population into two subgroups of equal size. The *prospective median age* is defined as the age in the life table of a standard year in which people have the same remaining life expectancy as they have at the median age of the population in the current

year. A mathematical description of how the prospective median age is computed is given Appendix A.1. Both the prospective proportion of the population categorized as old and the prospective median age are specific examples of measures of aging that take the characteristics of people into account. The general framework for the study of characteristic-related ages has been presented in Sanderson and Scherbov (2013, 2017). The conventional median age of the population depends solely on the age structure of the population. Half of the people in the population are older than the conventional median age. But it is also the case that half of the people in the population are older than the prospective median age, when their ages are adjusted to reflect changes in life expectancy. In Sanderson and Scherbov (2005, 2013, 2017), we have shown that when life expectancy increases, the prospective median age could decrease even if the conventional median age has increased.

2.2 Definitions of high-income and upper middle-income countries

Future distributions of conventional and prospective median ages and the conventional and prospective proportions of the population categorized as old were computed from 1,000 stochastic trajectories of population age structures and associated life tables over the 2015-2100 period for high-income countries and upper middle-income countries, as defined by the World Bank. These trajectories were provided by the UN's Population Division (UN 2015b).

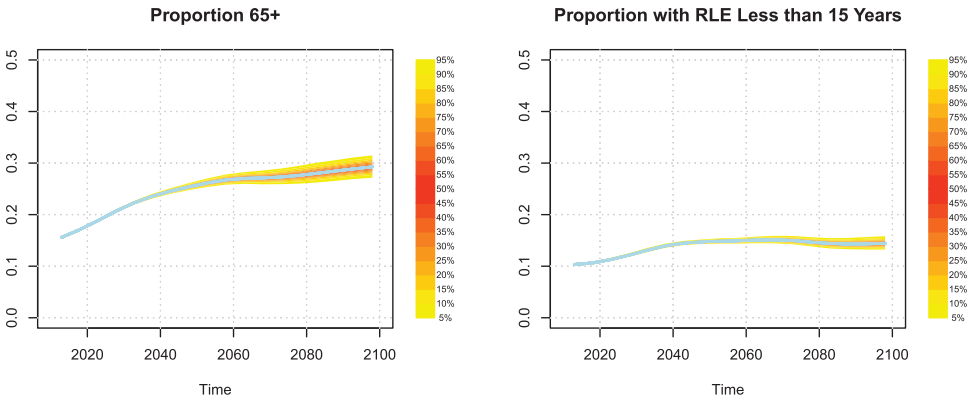
The high-income countries are the 89 countries and territories with the highest levels of Gross National Income per capita in 2014, as measured by the World Bank. In 2015, these countries accounted for 19 percent of the world's population. The upper middle-income countries are the 56 countries with the highest Gross National Income per capita after the high-income countries. That group includes China and the Russian Federation, as well as Albania, Botswana, Iraq, Mexico, Romania, and South Africa. In 2015, these countries accounted for 33 percent of the world's population. The UN mortality trajectories assume that life expectancy at older ages will generally increase throughout the century.

3 Results

3.1 Proportions of populations categorized as old

In Figure 1, we show the evolution over time of the probability distributions of the conventional proportion of the population who are counted as old, and its prospective analog for high-income countries. In 2015, the conventional proportion of the population categorized as old in these countries was 16.3 percent. The median forecast of this proportion rises to 25.8 percent in 2050, with a 90 percent prediction interval of 25.1 to 26.6 percent. The forecasts indicate that the increase in the conventional proportion of old people in the population will slow between 2060 and

Figure 1:
Proportions aged 65+ and proportions with remaining life expectancy (RLE) of 15 years or less. Evolution of probability distributions of the conventional proportion of the population counted as old and its prospective analog, World Bank high-income countries, 2015–2100



Source: 1,000 trajectories from UN (2015b) and authors' calculations.
Note: The thick line in the middle indicates the median of the distribution, and the legend to the right of the chart indicates percentiles.

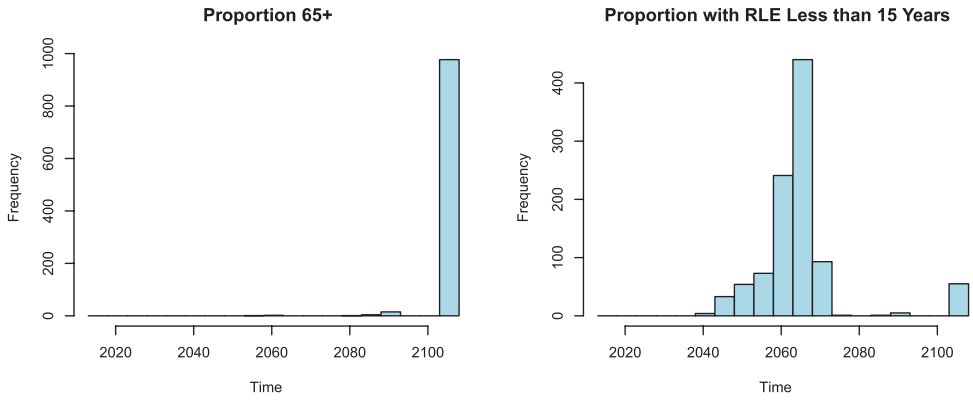
2080, and will then speed up again. By 2100, the median forecast of the proportion of the population categorized as old is 29.4 percent, with a 90 percent prediction interval of 27.2 to 31.6.

The median forecast of the prospective proportion of the population counted as old is around 10.4 percent in 2015. This proportion increases to around 14.6 percent in 2045, with a 90 percent prediction interval of 14.2 to 15.1; and is roughly stable for the following three decades. The median forecast of this proportion is 15.1 in 2070, with a 90 percent prediction interval of 14.4 to 15.9 percent; and falls to 14.5 in 2100, with a 90 percent prediction interval of 13.3 to 15.8.

In Figure 2, we show the histograms of the dates at which the conventional and prospective proportions of the population reach their maxima. Over 95 percent of the stochastic trajectories of the conventional proportion of the population counted as old peak in 2095 or beyond. In contrast, around eight percent of the stochastic trajectories of the prospective proportion of the population counted as old peak after 2070. The conventional proportion of the population categorized as old suggests that aging will likely continue throughout the century. In contrast, the prospective proportion of the population categorized as old indicates that aging will likely end well before the end of the century.

If the prospective old-age threshold was based on a remaining life expectancy of 10 years, the proportions of old people in the populations of high-income countries would peak later, with almost all trajectories reaching a maximum by 2075. If the

Figure 2:
Histograms of dates of reaching a maximum. Histograms of the dates at which the conventional and the prospective proportions of populations counted as old (with remaining life expectancy (RLE) of 15 years or less) reach their maximum, World Bank high-income countries, 2015–2100



Source: 1,000 trajectories from UN (2015b) and authors' calculations.

prospective old-age threshold was based on a remaining life expectancy of 20 years, the maxima would be reached slightly earlier. Regardless of which prospective old-age threshold is used, the proportion of trajectories peaking beyond 2095 in high-income countries never exceeds one percent. We present these findings in more detail in Appendix A.2.

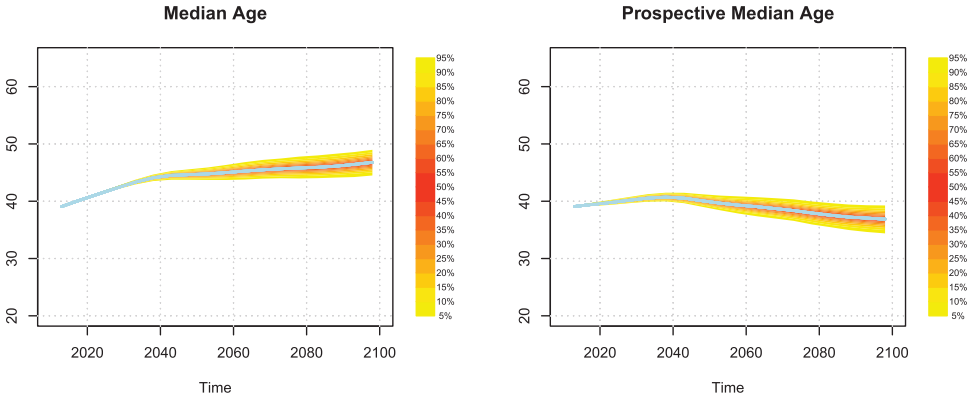
In Appendix A.3, we provide the analogs to Figures 1 and 2 for upper middle-income countries. We show that in these countries, the prospective proportions of the population categorized as old also generally peak before the end of the century.

3.2 Median ages

In Figure 3, we show the probability distributions of the conventional and the prospective median ages for high-income countries. We compute the prospective median ages as the ages in the life table of 2015, in which people have the same remaining life expectancy as at the median age in specific years (see Appendix A.1 for a mathematical exposition). The 2015 life table was interpolated on the basis of the UN life tables for 2010–15 and 2015–20 (UN 2015b).

In 2015, the conventional and the prospective median ages were both 39.6 years. The median forecast of the conventional median age is 44.7 for 2050, with a 90 percent prediction interval of 43.7 to 45.7; and is 47.0 in 2100, with a 90 percent prediction interval of 44.8 to 49.3. The median probabilistic forecast of the conventional median age increases rapidly from 2015 to 2040, and the probability

Figure 3:
Conventional and prospective median ages. Evolution of the probability distributions of the conventional median age and its prospective analog, World Bank high-income countries, 2015–2100

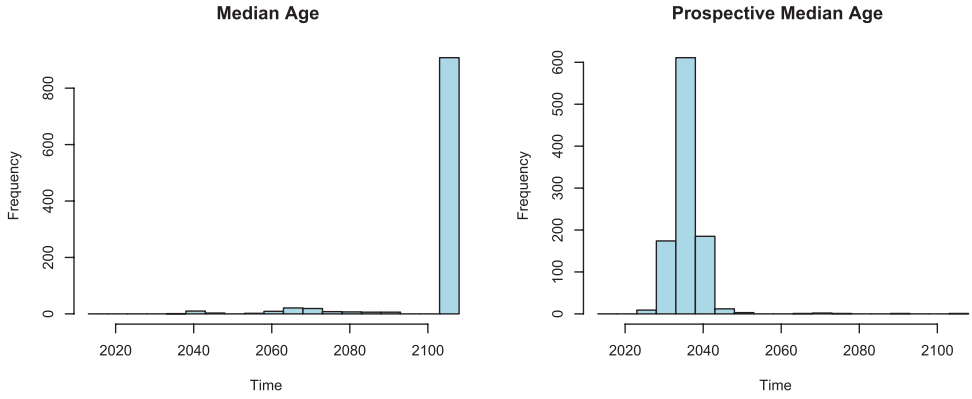


Source: 1,000 trajectories from UN (2015b) and authors' calculations.
Note: The thick line in the middle indicates the median of the distribution, and the legend to the right of the chart indicates percentiles.

that it would ever be lower than its 2015 value at any time during this century is essentially zero. The median forecast of the prospective median age also tends to increase between 2015 and 2040. In 2040, the median forecast of the prospective median age is 40.7, and the 90 percent prediction interval for the prospective median age is between 39.9 and 41.5. By 2100, the median forecast of the prospective median age is 36.7, and the 90 percent prediction interval is between 34.3 and 39.2. On the basis of the UN's probabilistic forecasts, it is highly unlikely that the prospective median age of the population of the high-income countries will be higher in 2100 than it was in 2015.

In Figure 4, we show the corresponding histograms of the years in which the conventional and the prospective median ages reach a peak in the high-income countries. In 89 percent of the stochastic trajectories, the peak of the conventional median age is reached in 2095 or beyond. The increases in the conventional median age do not suggest that population aging will come to a clear end in the high-income group during this century. The data for the prospective median age do, however, indicate that population aging will come to a clear end in these countries during this century. It is expected that by 2050, over 99 percent of the stochastic trajectories of prospective median ages will reach their peak. When measuring population aging using the prospective median age, the end of population aging in the high-income group is projected to be less than four decades away. It is also expected that the prospective median age in upper middle-income countries will peak well before the end the century. We present these findings in Appendix A.4.

Figure 4:
Histograms of dates of reaching maximum. Histograms of the dates at which the conventional and the prospective median ages reach their maximum, World Bank high-income countries, 2015–2100



Source: 1,000 trajectories from UN (2015b) and authors' calculations.

4 Conclusion

Changes in age structure measures in high-income and middle high-income countries are primarily driven by changes in fertility and mortality rates. In the long run, holding mortality and migration rates fixed, a decrease in fertility results in faster aging because it both increases the proportion of older people in the population and increases the population's median age. Moreover, in the long run, holding fertility and migration rates fixed, a decrease in mortality rates at older ages increases both the conventional proportion of the population who are old and the population's median age, but it decreases the prospective proportion of the population who are old and the population's prospective median age (Sanderson and Scherbov 2015).

The UN forecasts for high-income and upper middle-income countries generally assume nearly constant or slowly rising fertility. While past fertility declines will lead to increases in aging in the next few decades, fertility is generally forecast to change slowly after 2015. Conventional measures of aging indicate that aging will increase relatively rapidly in the short run because of past fertility declines, and then more slowly due to increases in life expectancy at older ages. While prospective measures of aging also show that aging will rise relatively rapidly in the short run because of past decreases in fertility, these measures project that aging will decrease in the long run due to increases in life expectancy at older ages.

In the high-income and upper middle high-income groups, some increases in the prospective proportion of the population who are old and in the prospective median age could occur after the middle of the century. However, almost all of the predicted

increases in these measures will have occurred by then, as those regions are currently experiencing their most rapid periods of population aging.

We began by asking whether high-income countries as a whole will experience a century of population aging. When we use measures of aging that take changing life expectancy into account, the answer is that such a scenario is unlikely, as the application of these adjusted measures indicates that the speed of aging is currently at its peak. We have shown that in high-income countries, the pace of population aging will soon slow, and will very likely come to an end well before the end of the century. This does not mean that all of the problems associated with population aging will magically disappear. Adjusting to population aging will still be challenging, but there is no point in exaggerating the challenge through mis-measurement.

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Appendix

A.1 Formal definition of prospective median age

Let $e(a,t)$ be remaining life expectancy age a in year t, and let $a_m(t)$ be the median age of the population in year t. Using the life table of year t, life expectancy at age $a_m(t)$ is $e(a_m(t),t)$. It is possible to find the value of life expectancy at age $a_m(t)$ in other years as well. In year s, that life expectancy would be $e(a_m(t),s)$. For example, the median age in year t could be 40. In year t, life expectancy at age 40 could be 35. In this case, $e(a_m(t),t) = 35$. Now, we can also find life expectancy at age 40 in another year, denoted by s. Let us suppose that life expectancy at age 40 in year s is 37 years. In this case, $e(a_m(t),s) = 37$.

The prospective median age is the age in the standard year, denoted by s, where people have the same remaining life expectancy as at the median age in year t.

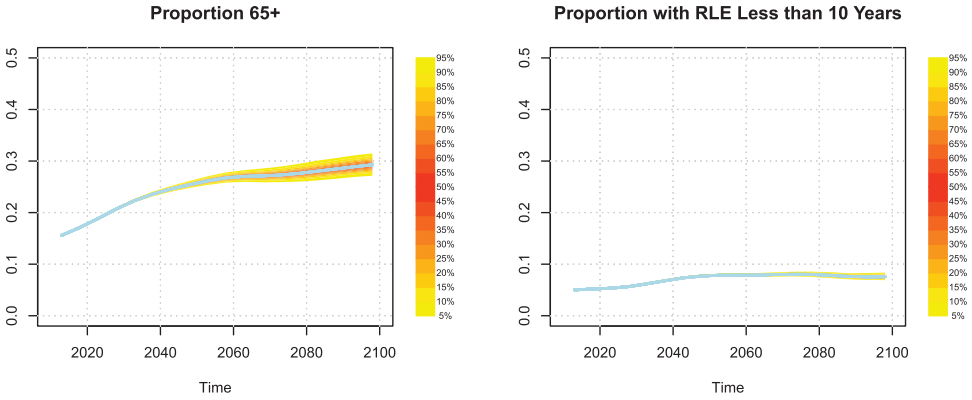
Formally, the prospective median age can be derived from the following equation:

$$e(pma(t,s),s) = e(a_m(t),t)$$

where $pma(t,s)$ is the prospective median age in year t using year s as a standard.

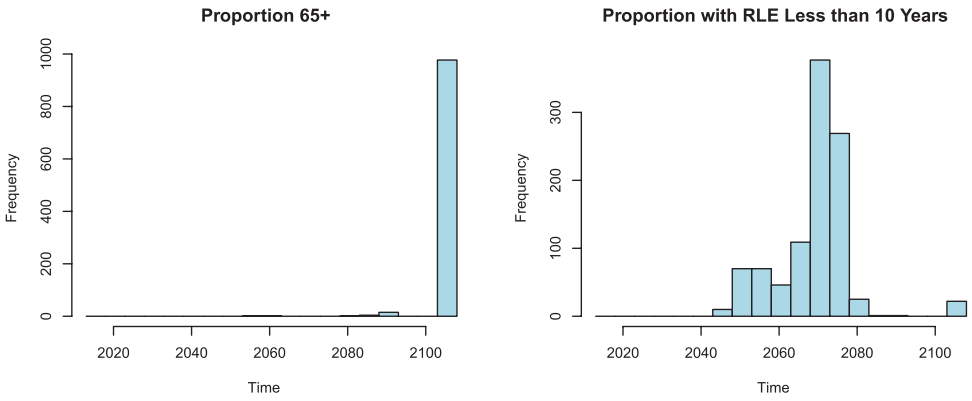
A.2 Sensitivity to the choice of the old-age threshold

Figure A.1:
Proportions aged 65+ and proportions with remaining life expectancy (RLE) of 10 years or less. Evolution of the probability distributions of the conventional proportion of the population counted as old and its prospective analog, World Bank high-income countries, 2015–2100



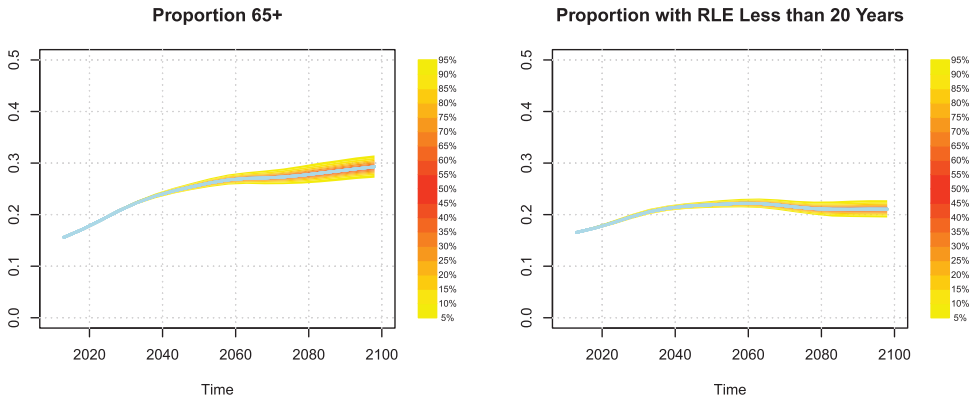
Source: 1,000 trajectories from UN World Population Prospects (UN 2015b) and authors' calculations.
Note: The thick line in the middle indicates the median of the distribution, and the legend to the right of the chart indicates percentiles.

Figure A.2:
Histograms of dates of reaching maximum. Histograms of the dates at which the conventional and the prospective proportions of populations counted as old reach (with remaining life expectancy (RLE) of 10 years or less) their maximum, World Bank high-income countries, 2015–2100



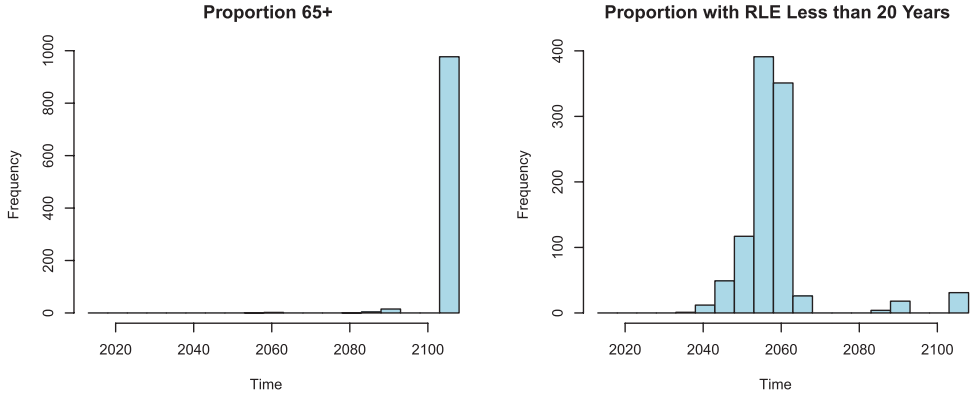
Source: 1,000 trajectories from UN World Population Prospects (UN 2015b) and authors' calculations.

Figure A.3:
Proportions aged 65+ and proportions with remaining life expectancy (RLE) of 20 years or less. Evolution of the probability distributions of the conventional proportion of the population counted as old and its prospective analog, World Bank high-income countries, 2015–2100



Source: 1,000 trajectories from UN World Population Prospects (UN 2015b) and authors' calculations.
Note: The thick line in the middle indicates the median of the distribution, and the legend to the right of the chart indicates percentiles.

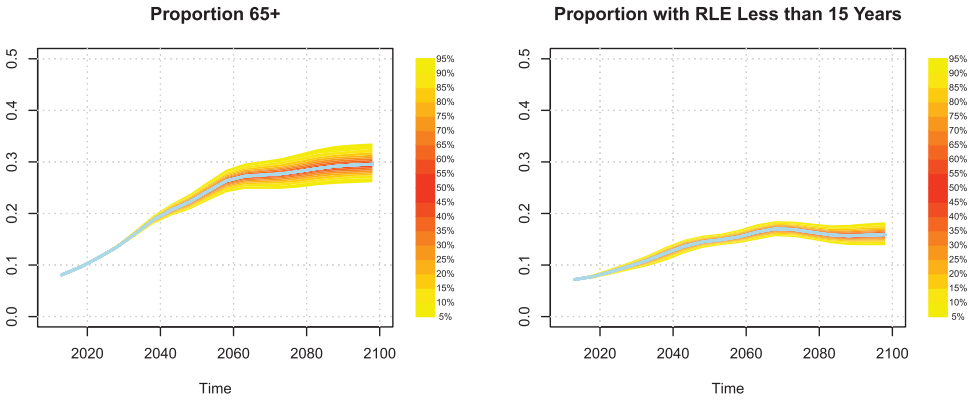
Figure A.4:
Histograms of dates of reaching maximum. Histograms of the dates at which the conventional and the prospective proportions of populations counted as old reach (with remaining life expectancy of 20 years or less) their maximum, World Bank high-income countries, 2015–2100



Source: 1,000 trajectories from UN World Population Prospects (UN 2015b) and authors' calculations.

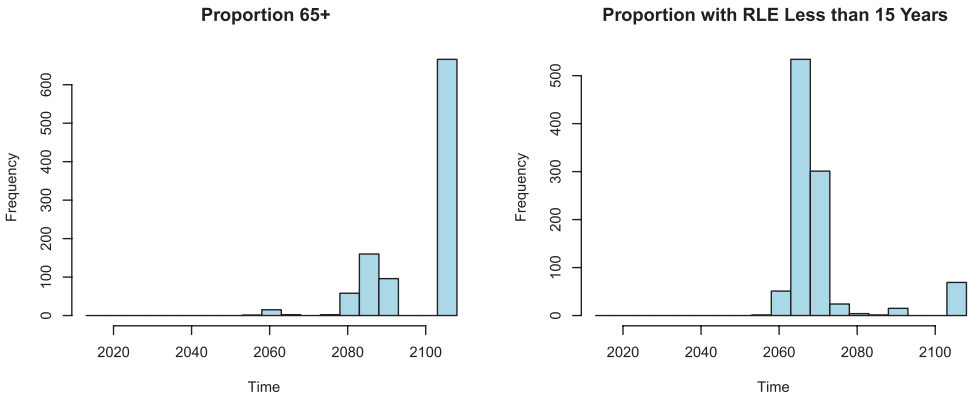
A.3 Conventional and prospective proportions of upper middle-income countries counted as old

Figure A.5:
Proportions aged 65+ and proportions with remaining life expectancy (RLE) of 15 years or less. Evolution of the probability distributions of the conventional proportion of the population counted as old and its prospective analog, World Bank upper middle-income countries, 2015–2100



Source: 1,000 trajectories from UN World Population Prospects (UN 2015b) and authors' calculations.
Note: The thick line in the middle indicates the median of the distribution, and the legend to the right of the chart indicates percentiles.

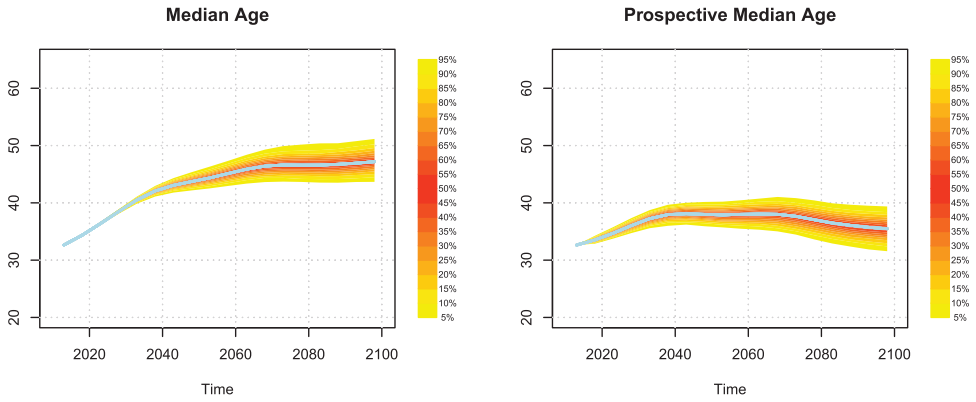
Figure A.6:
Histograms of dates of reaching maximum. Histograms of the dates at which the conventional and the prospective proportions of populations counted as old (with remaining life expectancy (RLE) of 15 years or less) reach their maximum, World Bank upper middle-income countries, 2015–2100



Source: 1,000 trajectories from UN World Population Prospects (UN 2015b) and authors' calculations.

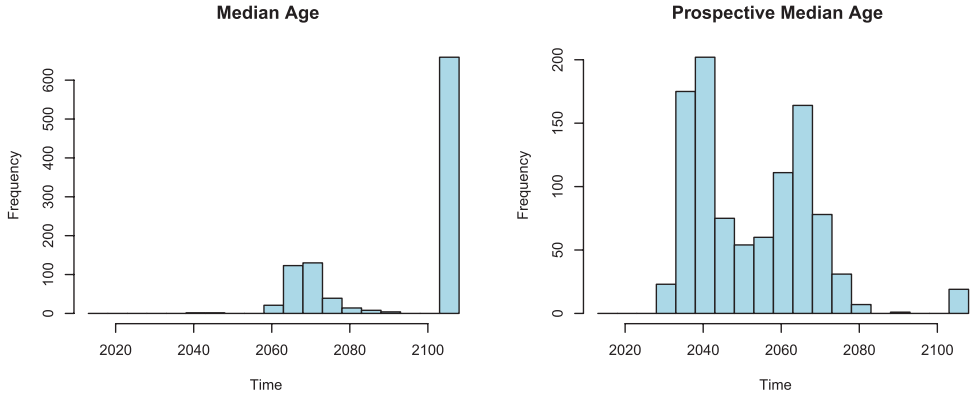
A.4 Conventional and prospective median ages of upper middle-income countries

Figure A.7:
Conventional and prospective median ages. Evolution of the probability distributions of the conventional median age and its prospective analog, World Bank upper middle-income countries, 2015–2100



Source: 1,000 trajectories from UN World Population Prospects (UN 2015b) and authors' calculations.
Note: The thick line in the middle indicates the median of the distribution, and the legend to the right of the chart indicates percentiles.

Figure A.8:
Histograms of dates of reaching maximum. Histograms of the dates at which the conventional and the prospective median ages reach their maximum, World Bank upper middle-income countries, 2015–2100



Source: 1,000 trajectories from UN World Population Prospects (UN 2015b) and authors' calculations.