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Population ageing: how does it impact the macroeconomy?

This article quantifies the impact of past and future demographic change on real interest rates, house prices and household debt in a calibrated overlapping-generations model. Falling birth and death rates across advanced economies can explain a large part of the fall in world real interest rates and the rise in house prices and household debt observed since the 1980s. Since households tend to maintain relatively high wealth levels throughout their retirements, these trends will persist as the population continues to age. Countries that age relatively slowly, like the United States, will see their net foreign liability position grow. The availability of housing as a store of value attenuates these trends, while raising the retirement age has limited effects.

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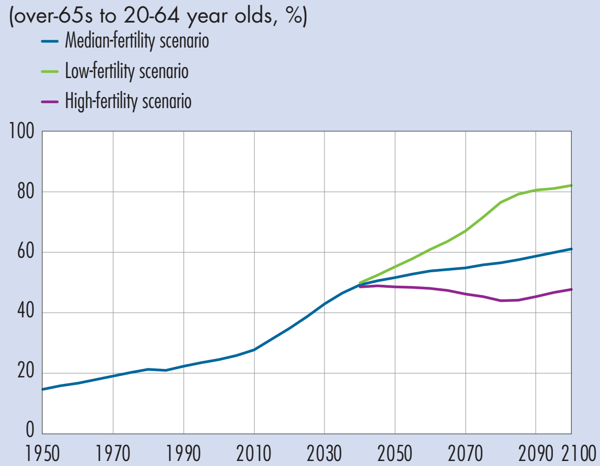
55%
the old-age dependency ratio projected for 2100 for advanced economies

More than half
of the fall in the natural interest rate observed since the 1980s can be explained by population ageing in our model.

20%
of the cross-country variations in net foreign assets-to-GDP can be explained by demographics in our model

Old-age dependency ratio in advanced economies
(over-65s to 20-64 year olds, %)



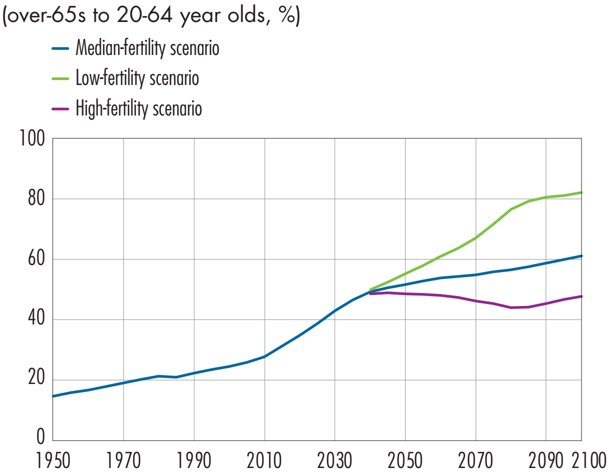
Source: United Nations, population statistics.
Note: The advanced economies are listed in footnote 1.

The population of advanced countries has aged rapidly over the past half-century, with life expectancy and the old-age dependency ratio having already reached unprecedented highs and projected to continue to rise for several decades. At the same time, long-term real interest rates have been on a downward trend, while house prices and household debt have risen dramatically. This paper quantifies the link between these important trends and examines the wider macroeconomic implications of demographic change using an overlapping-generations model calibrated for 23 advanced economies.

1 Population ageing over the past fifty years

The old-age dependency ratio (henceforth OADR), defined as the ratio of over-65s to 20-64 year olds, is a convenient way of summarising demographic evolution. Focusing on advanced economies,[1] the observed and United Nations' predicted OADR increases from around 15% in 1950 to over 40% in 2100 if assuming a high fertility scenario, and up to 55% in the medium-fertility scenario (see Chart 1).

C1 Old-age dependency ratio in advanced economies
(over-65s to 20-64 year olds, %)



Source: United Nations, population statistics.
Note: The advanced economies are listed in footnote 1.

An explanation often mentioned for the ageing of the population is the baby boom: as the large baby-boom cohorts grow old, the age distribution becomes skewed towards the older age groups. This is amplified by the smaller size of the younger generations entering the population as birth rates have declined. Nonetheless, being essentially a transitory phenomenon, the baby boom cannot account for the long-run trend in the OADR. Indeed, OADR predictions keep increasing once the baby-boom cohorts have faded out of the population, say after 2050. Instead, the key determinant of the rise in the OADR is increasing longevity. While a sixty year old in 1950 would not expect to live past the age of 77, by 2015 a sixty year old can expect to live until close to 85.[2] By the end of the century this number rises past 90. As people face lower mortality rates later in life, and their life expectancy rises, older age groups account for a growing proportion of the total population.

2 Macroeconomic implications in closed economy

To uncover the macroeconomic effects of ageing, we use the general equilibrium overlapping-generations model detailed in the box below. We introduce demographic change as observed in the data in terms of cohort size and death probabilities and we solve for the transition path of the economy, assuming perfect foresight. In this section, all advanced countries in the sample are considered as a single large, closed economy. Here, we first focus on the natural interest rate before moving on to housing prices and household debt. Further implications are discussed in Lisack et al. (2017).

1 Western Europe (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom), North America (Canada and the United States), Australia, Japan, and New Zealand.

2 Source: United Nations Population Statistics (life expectancy at age 60, projections based on medium-fertility scenario).

Theoretical framework and calibration

We set up a general equilibrium framework including overlapping-generation households and a representative firm producing in a perfectly competitive environment.

The main characteristics of the households' problem are as follows:

- Agents enter the model at age 20 when they start working, face a probability of death at (after) each age and die with certainty at the maximum age, 90. Each period lasts 5 years and the retirement age is fixed at age 65.
- Throughout their life, agents supply labour inelastically until they retire, and gain utility from consuming, owning housing and leaving bequests for future generations. Their labour productivity changes with age exogenously.
- Agents are born without any assets, can borrow or save throughout their life and can leave bequests.
- There are a fixed number of periods when (before which) the household is able to "move house", i.e. re-optimise their housing wealth. Hence outside of these "move dates" the household has to keep its housing assets fixed. The "move dates" correspond to ages 20, 40 and 70. We assume that agents are born without any housing wealth, and do not leave any housing wealth when they die.

The representative firm hires labour and rents capital in order to produce the homogeneous good used for both consumption and investment. Capital is financed from the households' savings and depreciates at a constant rate every period. Since we are in a perfect competition environment, the firm earns zero profit in equilibrium.

Housing supply is fixed in per capita terms, meaning that the stock of housing is growing with the population.

Since the population may grow over time, the model is stationary in per capita terms. At each time period, the equilibrium on the capital, labour, housing and goods markets is ensured by adjusting their respective prices: interest rate, wage and housing prices relative to the price of the good taken as the numeraire.

We calibrate the household preference parameters so as to match the evolution of labour productivity, housing wealth and net worth over the life cycle. Given the limited data availability for the broad sample of countries and the time period we consider, we use United States data and calibrate household preferences symmetrically in all countries (because we are including only developed economies, this is a reasonable enough approximation). We target average life-cycle patterns reported in the Survey of Consumer Finance over the years 1989-2013, corresponding to the "wage income" for productivity, "primary residence" and "other residential real estate" for housing and "net worth" for financial assets. On the macroeconomic side, we take three aggregate variables as targets: the real interest rate, housing wealth-to-GDP and debt-to-GDP. In order to allow the model to determine the evolution of these variables over the last few decades, we target their average value in the 1970s.

We introduce demographic variables via two channels: (i) the size of each successive cohort; (ii) the death probabilities faced by households in each cohort at each age. Using data from the United Nations population statistics, we set these two series so as to match the evolution of the age structure of the population from the 1950s, and projected until 2100. Specifically, we set the cohort growth rate as the relative size of consecutive 20-24 year old cohorts over time. We then set the death probabilities to match the observed evolution of each cohort throughout their life, meaning that the rate of decline in the size of a given cohort from one period to the next is taken to be the death rate.

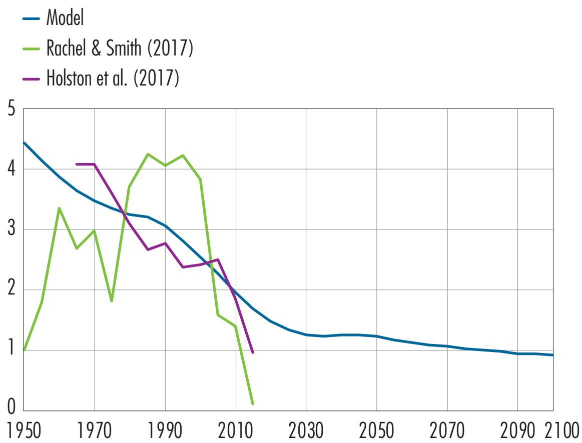
A decrease in the natural interest rate

Our framework considers only the risk-free interest rate, as opposed for instance to Marx et al. (2017) who examine the evolution of both the risk-free rate and the risk premium. We compare the main outcome of our model, namely the natural real interest rate – the interest rate consistent with constant inflation and a closed output gap – to two empirical counterparts (see Chart 2): the world real interest rate as estimated by Rachel and Smith (2017) and the model-based estimates of the natural interest rate from Holston et al. (2017). Because they take into account additional, potentially shorter-term factors than the demographic trends included in our model, these measures of realised interest rates are clearly more volatile than the natural interest rate that comes out of our model.

In the model, the annual interest rate is decreasing by 157 basis points (bps) between 1980 and 2015, and is forecast to decrease by a further 76 bps by 2100. Compared to measures of the natural interest rate evolution between 1980 and 2015 obtained from the data, demographics are able to replicate 75% of the roughly 210 bps drop estimated by Holston et al. (2017), and around 45% of the fall in the Rachel and Smith (2017) measure.

C2 Real interest rate in advanced economies

(%)



Sources: Rachel and Smith (2017), Holston et al. (2017) and authors' calculations.
Note: The advanced economies included in the model are listed in footnote 1. Holston et al. (2017) shows the average of the results for the United States, the United Kingdom, Canada and the Euro Area.

The key mechanism triggered by the demographic transition is the following. First, households anticipate that they will live longer and spend more time in retirement. They are therefore willing to transfer more of their income during working life to the future, in order to smooth their consumption.[3] Second, the slower population growth and increased longevity imply that older households make up a larger share of the total population alive at each period. These two changes both increase the level of aggregate savings-to-GDP over time. To keep the capital market balanced given this higher capital supply, the interest rate decreases. In the transition path, it is still possible to see the transitory impact of the baby boom, slowing down the interest rate decrease in the 1990s and accelerating it between 2010 and 2040. However, in the long run, the main driver behind the transition path is the persistent increase in life expectancy.

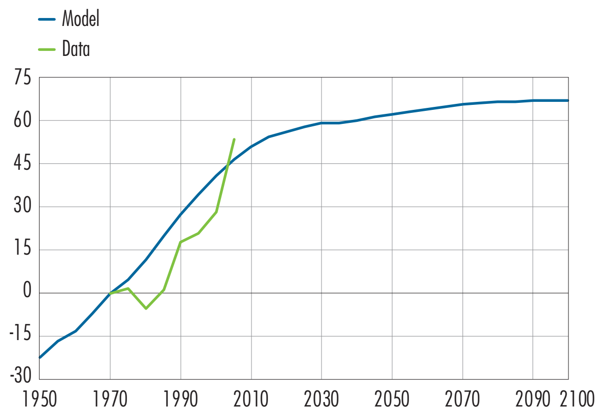
Unsurprisingly, demographic change alone cannot explain the whole interest rate fall since 1980 which leaves room for other, possibly more transitory, explanations of the current low level of interest rates. Yet, the demographic changes themselves do not reverse, and leave the economy with a permanently lower natural interest rate, as highlighted by the slowly decreasing trend in interest rates after 2030.

Higher housing prices

Our theoretical set-up has the advantage of including housing, thus allowing for a diagnostic on the impact of ageing on housing wealth and housing prices. Households directly derive utility from housing, but housing also serves a second purpose, as households can use it as an additional way of transferring wealth over time, in that it is durable and can be sold to fund consumption and bequests. As the interest rate falls, the user cost of housing falls, and so demand for housing rises. This pushes up housing prices

3 There are no pensions in the model. Including a fully funded pension system would preserve the impact of ageing on aggregate savings, with pension savings supplied by pension funds instead of being directly supplied by households. Including a pay-as-you-go system, by redistributing from workers towards retirees via contemporaneous transfers, could reduce incentives to save in anticipation of retirement. It would however not suppress the increase of savings due to ageing, as households tend to top up their pension via private savings.

C3 Real house prices in advanced economies
(deviation from 1970, %)



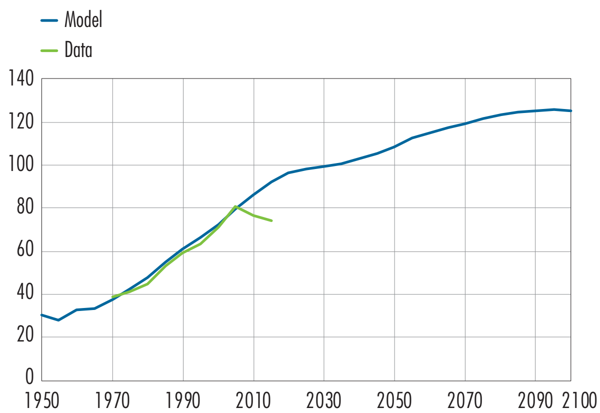
Sources: BIS and authors' calculations.
Note: The advanced economies included in the model are listed in footnote 1. BIS data are available for Canada, Germany, Italy, Japan, the United Kingdom and the United States.

(see Chart 3) and increases the housing wealth-to-GDP ratio. In fact, demographic change is able to replicate 85% of the observed increase in real house prices.

Larger household debt-to-GDP

To be able to afford the more expensive housing assets, young households have to borrow more, and so the rising house price contributes to the rising household-debt-to-GDP ratio (see Chart 4). The lower interest rate also has a similar effect as it encourages more borrowing by the young, raising net household

C4 Household debt-to-GDP in advanced economies
(%)



Sources: BIS and authors' calculations.
Note: The advanced economies included in the model are listed in footnote 1. BIS data are available for Canada, Germany, Italy, Japan, the United Kingdom and the United States.

debt-to-GDP. Although this pushes down on aggregate savings-to-GDP, it is not strong enough to compensate the increase in savings implied by the change in the structure of the population, hence the increase in aggregate savings and decrease in interest rate along the transition path.

3 From relative ageing speed to net foreign assets

So far we have considered the group of advanced economies as one large closed economy, and looked at the effects of demographic trends at the aggregate population level. While an ageing population is common to all these countries, different countries within this group are ageing at different speeds. For instance, Japan and Germany are ageing much faster than the aggregate, while Australia and the United States are ageing more slowly. The ageing pace in France is fairly close to the advanced-economies average.

To understand the implications of demographic change in terms of capital flows, we amend the model described in the above box and consider each country in our sample as a small open economy trading on fully integrated global capital markets. In other words, each country takes as given the global real interest rate that arises in the aggregate. There is, however, no market-clearing condition for the domestic capital markets, implying that household savings can be above or below the capital demanded by firms. This discrepancy between domestic savings and domestic capital gives rise to a non-zero net foreign asset (NFA) position for the domestic economy. In particular, if domestic savings are higher than domestic capital, then domestic households must place their savings into capital abroad. Conversely, if domestic capital is higher than domestic savings, some of the domestic capital must be owned by foreign households.

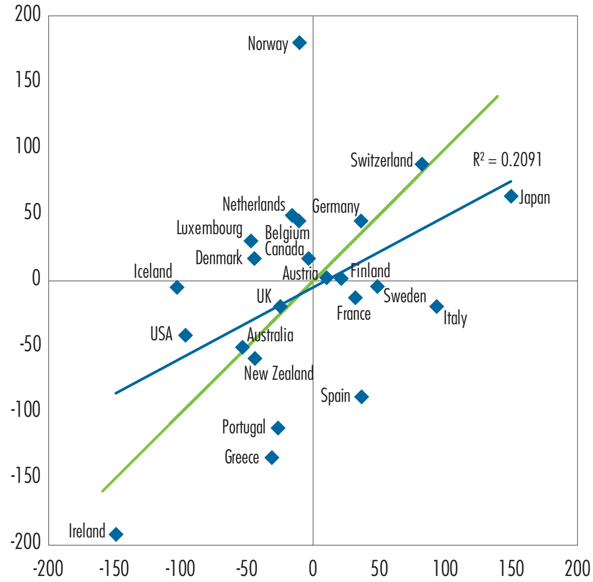
Consider a country such as Australia, which is ageing more slowly than the average. There, demographic trends are putting less upward pressure on savings, and hence the global real interest rate is below the interest rate that would arise were Australia a closed economy. In other words, the savings of domestic households in Australia is below the desired capital level of Australian firms. This translates to a negative NFA position for

Australia, as capital flows into Australia from foreign households. Conversely, for a country such as Germany, which is ageing faster than the average, the global interest rate is above the rate that would balance the domestic capital market, and this translates to capital outflows from Germany and the accumulation of foreign assets by German households.

We solve this version of the model dynamically with the exogenous path of the real interest rate set as the one from the aggregate exercise and feeding in the demographic variables of a given country. Figure 5 plots the level of the NFA-to-GDP ratio in 2015 against the predicted level from the model across all the countries in our advanced economies group. This exercise can be interpreted as a test of the mechanisms of our model against the data.

The model omits any frictions in the international movement of capital, such as capital controls or home-bias in portfolio allocations. Hence, the model predicts slightly larger NFA positions than we observe in the data, with the trend line in Chart 5 being somewhat shallower than the 45 degree line.

C5 Net foreign assets/GDP in advanced economies in 2015
(model vs. data, %)



Sources: IMF and authors' calculations.
Note: Model on x-axis and data on y-axis; grey line is the 45 degree line

Nonetheless, a substantial part of the cross-country differences in NFAs can be explained by the model looking only at differences in demographics.

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