Macroeconomic effects of demo-graphic aging

Focus paper

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BertelsmannStiftung

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Impact on productivity growth and macroeconomic variables in selected industrialized countries. Potential gains offered by labor-saving technological progress

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Contents

1 Introduction

Within most developed industrialized countries, demographic change means that populations are shrinking and growing older. This expected shift in population structure, especially the aging and shrinking of the working-age population, has significant consequences for an economy's macroeconomic development. Areas affected include the country's aggregate productivity, savings and investment rates, price-level trends, gross domestic product (both absolute and per capita) and current account balance.

This focus paper outlines the most important findings of a comprehensive study conducted by the Austrian Institute of Economic Research (WIFO) on behalf of the Bertelsmann Stiftung (see also Bertelsmann Stiftung 2019). The study analyzes the influence of expected demographic developments on key macroeconomic variables in seven selected industrialized countries (Austria, France, Germany, Italy, Japan, Spain and the United States). The calculations performed for the simulation run through the year 2050.

Particular attention is given to determining the relationship between demographic aging and technological progress. It emerges here that some of the negative effects of demographic aging on the average level of gross domestic product per capita (GDP per capita) can be mitigated by labor-saving technological progress that is driven by expectations of demographic aging, insofar as more investment in the future is focused on automation and digitalization.

This focus paper summarizes important key findings of our study "Macroeconomic consequences of ageing and directed technological change." In **Chapter 2**, we sketch key interdependencies that illustrate how a change in a society's age structure influences its macroeconomic development. Following the description of these theoretically expected relationships, **Chapter 3** presents the results of regression analyses that empirically estimate these relationships on the basis of past developments. **Chapter 4** initially presents the main findings of the population projections for all seven industrialized countries under examination. It then details some of the results of the macroeconomic simulation calculations, in which the empirically estimated effects of a changed age structure from Chapter 2 are combined with current population projections through 2050. For the purposes of clarity, the comparisons will focus on Germany, Japan and the United States. These simulations show how demographic aging can be expected to change key macroeconomic variables in the three countries through 2050, and how GDP (absolute and per capita) will develop in all seven industrialized countries. Finally, we look at the potential for gain offered by labor-saving technological progress.

2 Macroeconomic effects of demographic aging – theoretical relationships

An aging society is essentially defined by a condition in which the ratio of working-age people relative to people of retirement age is decreasing. On its own – that is, under otherwise unchanged conditions (ceteris paribus) – this kind of demographic development has significant macroeconomic consequences.

2.1 Aging-driven decline in levels of material prosperity per resident

One key indicator of an economy's material prosperity is the gross domestic product (GDP). This gives the total value of all goods and services produced within a country over the course of a year. With regard to the average level of material prosperity experienced by the country's people, GDP per capita (GDP/Pop.) is important. An aging society generally features a declining number in the economically active persons (EAP) in conjunction with a rising number of retired people. The society's overall labor force participation rate (EAP/Pop.), defined as the percentage of people in the overall population (Pop.) who are actively engaged in the workforce, thus trends downward. Assuming other economically relevant conditions remain unchanged, the level of material prosperity per resident also declines in turn. This can be shown through the use of a definitional relationship: GDP/Pop. = GDP/EAP · EAP/Pop., where the expression GDP/EAP stands for productivity per economically active person. An aging-driven decline in the labor force participation rate (EAP/Pop. ↓), paired with an unchanged level of labor productivity (GDP/EAP = constant) implies a decline in per capita GDP (GDP/Pop. ↓): GDP/EAP constant · EAP/Pop.↓ = GDP/Pop. ↓.

2.2 Aging-driven decline in aggregate labor productivity

The relationship between a person's individual labor productivity and his or her age generally describes an inverted-U curve over the course of a life.

- Young people tend to be either still in school or training programs, or at the beginning of their working careers. They have little experience, and typically show comparatively low levels of labor productivity.
- Experience increases with age, with the worker's productivity thus rising as well.
- At older ages, however, physical and cognitive performance slowly declines. Initially, this can still be compensated for through experience. Yet as age increases, a decline in labor productivity must ultimately be expected.

Empirical studies show that individual labor productivity initially increases and then declines with age (Ademmer et al. 2017: 16). On average, people reach their highest level of productivity around the age of 50 (see Bertelsmann Stiftung 2019: 9). If demographic aging leads to conditions in which large portions of the workforce exceed a critical age (here assumed to be 54 years old), this has a productivity-dampening effect on the economy (negative quality effect).

2.3 Aging-driven decline in savings and investment rates

Three age groups can be roughly distinguished with regard to the ability to save:

- Young people and young employed people: These people either do not yet have their own incomes or have at most low levels of income from work. Their ability to save is therefore extremely limited or nonexistent.
- Employed people in middle and older age groups: With rising age and increasing professional experience, income from work also tends to increase. This increases the ability to accumulate savings. Moreover, these age groups also have a significant incentive to create reserves for old age in the form of savings.
- Persons of retirement age: Because pensions are smaller than work incomes, the ability to accumulate savings declines for people of retirement age. At the same time, as occupational and private pension plans take effect, retired persons begin drawing to some extent on assets accumulated during the acquisition in order to maintain their material standard of living. There is thus a reduction in overall savings.

This behavior is called the "**lifecycle theory**" of savings. With regard to the savings rate (that is, the relationship between an economy's aggregate savings and GDP), two fundamental developments can consequently be expected:

- In an **aging society** – understood as a society in which the number of children and youth is declining, and the average age of employed people is rising, but in which there are still relatively few people of retirement age – the economy's aggregate savings rate rises.
- In an **aged society** – understood as a society in which there are many people of retirement age, and in which the share of working-age people is declining in comparison – the aggregate savings rate decreases.

Empirical evidence for the influence of different age groups on the aggregate savings rate can be found in Lindh, Malmberg und Petersen (2010), for example, and is also confirmed in Bertelsmann (2019).

A lower savings rate in itself has further implications for an economy's investment. Savings correspond to an economy's domestic capital supply. The total supply of capital is used by companies in order to finance investments. However, if the domestic capital supply decreases for demographic reasons, the scope for investment is also reduced, unless additional capital flows in from foreign sources.

2.4 Aging-driven rise in the inflation rate

The influence of demographic aging on a country's inflation rate can be estimated with reference to the overall quantity of goods produced by the various age groups in comparison with the quantity of goods consumed:

- If a certain age group consumes more goods and services than it produces, this has a price-increasing effect. This applies to children, youth and retired people; thus, an inflationary effect is to be expected from these groups of people or age groups.
- By contrast, the age groups whose members are of working age, and therefore participate in the production of goods in large numbers while also accumulating savings, tend to have an inflation-dampening effect.

If these relationships pertain, an increase in inflation can be expected particularly in an aged society that features a rising number of people of retirement age. Empirical support for the influence exerted by population age structure on the inflation rate can be found in Edo and Melitz (2019), as well as in Juselius and Takáts (2018).

2.5 Aging-driven decline in the current account balance

A country's balance of payments encompasses all of its external economic transactions with the rest of the world (see box).

Balance of payments: The **balance of payments** captures an economy's core economic activities with the rest of the world. By some distance, the largest item within the balance of payments relates to the cross-border trade in goods and services – thus, a country's **exports** and **imports.** When only exports and imports are being considered, economists refer to this as the **trade balance.** Additional items include the primary and secondary income accounts. The **primary income** account records income payments that the country receives from the rest of the world, and which it pays to persons and companies in other countries. The **secondary income** account reflects payments which are not associated with goods or services (such as transfer payments). If the revenue generated by a country's exports, foreign income and transfer payments is lower than its expenditures in these areas, there is a **current account deficit** – that is, the current account balance is negative. If the revenue generated by exports, foreign income and transfer payments exceeds the amount of expenditure in these areas, there is a **current account surplus**. Empirically, foreign-trade activities constitute by far the largest component of the current account; thus, changes in exports and imports are crucial to the development of the current account balance.

The aging of the population influences the relative volumes of a country's exports and imports through various channels. The two most important are **domestic demand** and **international competitiveness**:

- As described above, a higher share of older people leads to a decline in a country's aggregate **savings rate**. This also means that the **consumption share** (that is, final consumption expenditure as a percentage of GDP) increases. If a larger share of domestic value creation is consumed by domestic consumers, there are fewer goods and services available for export. At the same time, consumers' demand for imports rises. The current account balance, which is primarily determined by the difference between exports and imports, thus declines as a consequence of demographic aging.
- If, as also previously shown, an aging society is characterized by a rise in the **price level**, this demographically driven **inflationary pressure** alone reduces the economy's international competitiveness relative to that of younger economies. Therefore, an aging society will export fewer goods and services, and import more instead. This in itself results in an aging-driven decline in the current account balance. However, this can be offset by monetary-policy measures or exchange-rate adjustments.

In Germany, which has long run a large current account surplus, the aging of the population is likely to lead to a demographically driven decline in these surpluses in the coming decades. It is even conceivable that current account deficits might result over the long term.

The macroeconomic effects of demographic aging described thus far will tend to reduce the average level of material prosperity per resident (that is, GDP per capita). However, these demographic trends can also promote technological progress, which could in turn increase overall economic productivity and thus GDP per capita.

2.6 Effects of demographic aging on technological progress and productivity

A changed age structure can increase productivity in an aging society through two central channels of influence:

1. **Wage-induced increase in capital input:** The aging of the population has the consequence of decreasing the economy's labor supply. This results in a rise in wages. Companies react to a higher price for this production factor by replacing the now-more-expensive production factor with capital – that is, with machines, robots, software and so on. Jobs become more capital-intensive. This means that labor productivity increases. However, the production technology used in this regard remains unchanged.
2. **Wage-induced technological progress:** Increasing their input of capital relative to labor is not the only way that companies can decrease their production costs. Another reaction by companies to an expected contraction in the labor force and associated rise in wages is to increase research and development expenditures with the goal of accelerating labor-saving technological progress. This implies that the production technologies themselves are being changed in such a way that capital compensates for the lack of labor. This technological progress also serves to increase labor productivity (see Acemoglu-Restrepo 2019).

Both channels have a positive effect on the growth of total factor productivity (TFP) and labor productivity. This helps to cushion the aging-driven reduction in GDP per capita. At least theoretically, it is even conceivable that this productivity-increasing effect could be large enough to result in a net increase in GDP per capita. Whether this is in fact the case cannot be answered theoretically. Rather, it is necessary to carry out simulations based on the demonstrated macroeconomic effects of demographic change as observed in past periods.

Total factor productivity: There are essentially three sources of change in a country's real GDP: a change in the quantity and/or quality of the **labor production factor**, a change in the quantity and/or quality of the **capital production factor**, and **technological change.** The portion of economic growth that cannot be attributed to the two production factors of labor and capital is "seen as the expression of technological progress and efficiency gains" (Belitz and Mölders 2013: 14). This is expressed by total factor productivity.

Taken together, demographic aging thus has **direct** and **indirect effects** on productivity trends and macroeconomic variables, and thus also the country's material prosperity. Direct negative effects arise due to the contraction of the labor force, the associated reduction in the supply of workers, and the simultaneous increase in the number of people of retirement age. Indirect negative effects appear when the share of older economically active people (aged 55 to 64) in the labor force rises, thereby reducing the economy's overall labor productivity. Finally, an indirect positive effect of demographic aging comes as the expected aging and contraction of the labor force increases incentives for companies to invest more strongly in labor-saving capital and technological progress, seeking in this way to compensate for labor shortages, increase labor productivity and avoid higher production costs as a consequence of rising wages.

3 Estimate of the age structure's past influence on key macroeconomic indicators

In order to better gauge the expected effects of a changed size and age structure of the working-age population on a country's overall economic development, we started by conducting regression analyses that are based on data from 1980 to 2015. For example, they estimate the degree to which productivity or the aggregate savings rate changes when the proportion of a certain age group within the overall population rises by one percentage point.

3.1 Trends in total factor productivity (TFP) growth

An increase of one percentage point in the ratio of older economically active persons (aged 55 to 64) to those within the middle age group (aged 25 to 54) (see Fig. 3) has a negative effect on the average growth rate of total factor productivity due to the lower productivity of the older workers. According to the regression analysis, it reduces average annual TFP growth by 0.02 percentage points. At the same time, according to theory and empirical research, an expected contraction of the labor force within the following 10 years (see Fig. 2) increases the incentive for companies to invest in automation and digitalization, in this way compensating for labor shortages and counteracting rising production costs. In this study, the percentage share of information and communication technologies (ICT capital) and software within the total capital stock will serve as an indicator of investment in automation and digitalization. The estimates reveal a negative relationship between population growth and labor-saving ICT investment. Estimates derived from the regression analysis indicate that an expected contraction of the working-age population by 1% will be associated with an increase in the share of ICT capital in the total capital stock of around 0.1 percentage point. The projected contraction of the working-age population in Germany by about 5% by 2028 (see Fig. 2) would accordingly increase the share of ICT capital by about 0.5 percentage points.

Because TFP growth in the simulation model in turn depends on the share of ICT in the total capital stock, TFP growth also reacts indirectly to demographic changes. The estimates indicate that a rise in the share of ICT capital in the total capital stock of one percentage point increases the average growth rate of total factor productivity by 1.3 percentage points. A look at Figure 2 shows that according to this logic, the significant contraction in the working-age population through 2050 would produce a positive boost to labor-saving technological progress and thus also to TFP growth only in Japan, Italy, Germany and Spain. For Germany, the expected shrinking of the labor force in the coming decades, along with the resulting aging-driven rise in the ICT capital share (by 0.5 percentage points), would increase the TFP growth rate by 0.65 percentage points per year.

3.2 Development of the aggregate savings rate

With regard to the development of the aggregate savings rate, the following conclusions can be derived from the regression analysis. The youth dependency ratio represents the ratio of the population between 0 and 24 years of age to the population of working age. If this rises by one percentage point, the overall savings rate falls by 0.2 percentage points. By contrast, a rise in the old-age dependency ratio (ratio of the over-65 population to the working-age population) of one percentage point reduces the overall savings rate by 0.34 percentage points. In Austria, Germany and the United States, the youth dependency ratio is projected to decline by about one percentage point over the next 10 years, which should accordingly increase overall savings rates by 0.2 percentage points. At the same time, according to the population projections, the old-age dependency ratios in these countries will increase by about 3.5 percentage points over the same time period; this would have the effect of reducing the savings rate by 1.2 percentage points. Both effects taken together produce a decline in the overall savings rate of one percentage point in these three countries.

By contrast, changes in the savings rate prove to have only minimal consequences for TFP growth. A rise in the savings rate of one percentage point increases the total factor productivity growth rate by 0.01 percentage point; a decline in the savings rate has the reverse effect on TFP growth. This would mean that the decline in aggregate savings rates of one percent over the next 10 years in Austria, Germany and the United States would reduce each of these countries' TFP growth rates by 0.01 percentage point. The mildness of this effect can largely be explained by the lack of capital controls and the influence of global financial markets.

3.3 Development of the inflation rate

As with the aggregate savings rate, changes in the youth and old-age dependency ratios also have an effect on the inflation rate. If the youth dependency ratio rises by one percentage point, the inflation rate increases by 0.2 percentage points. A rise in the old-age dependency ratio by one percentage point in turn produces an increase in the inflation rate of 0.1 percentage point. This means that once members of the baby boomers' demographic bulge reach retirement age on a broad basis, the rapidly aging countries of our sample will be exposed to increasing inflationary pressure.

4 Simulation of the expected effects of demographic aging on key macroeconomic indicators

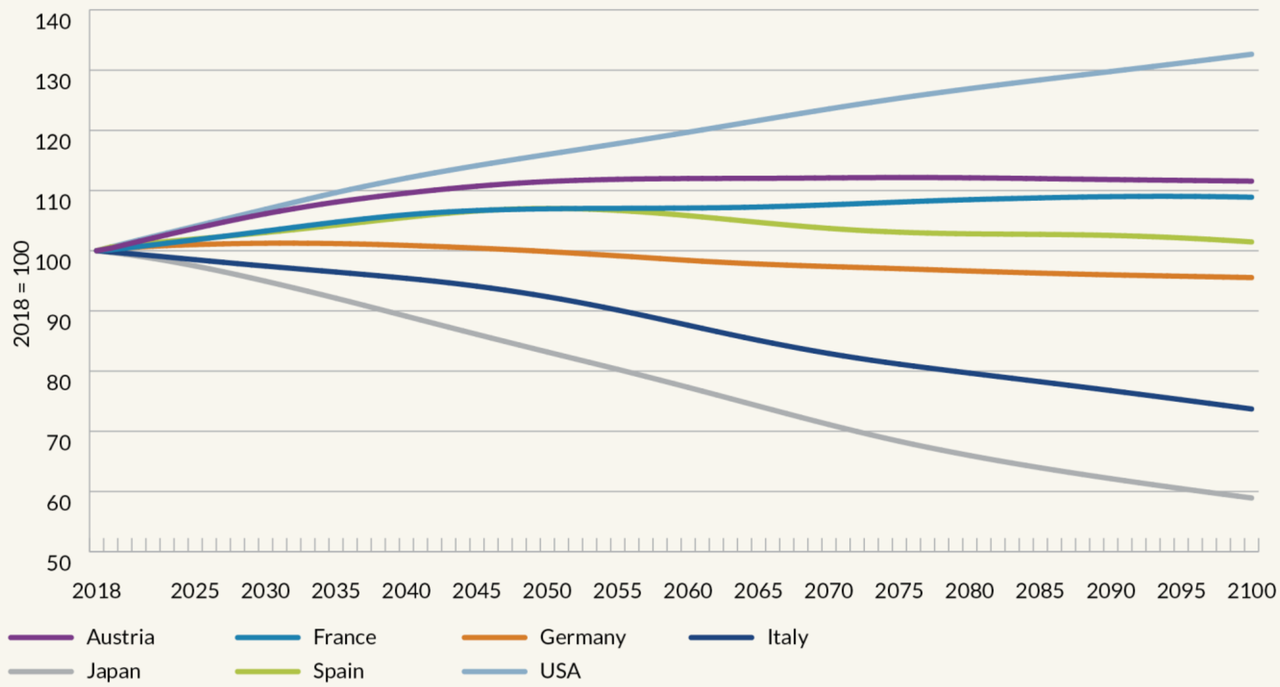
For the next section of the study, we combined the statistical relationships calculated in Chapter 2, between a changed population age structure and various macroeconomic variables, with the current population forecasts for seven countries as published by Eurostat and the United Nations. In this regard, the European Commission's methodology for long-term projections – used, for example, for the EU Aging Report – was supplemented by a system of simultaneous equations employing the coefficients derived from the regression analysis (see Description of methodology section). This approach makes it possible to forecast future values for key macroeconomic indicators (development of GDP per capita, aggregate investment rate relative to GDP, current account balance relative to GDP, etc.). The results are simulation-based calculations for the expected development of key indicators through 2050.

4.1 Key population-projection results for all seven industrialized countries

For the five European countries, the population forecasts used here correspond to Eurostat's current population projections, while for Japan and the United States, they draw on population projections produced by the United Nations. Generally, for all of the countries considered here, it can be roughly said that the underlying assumptions include a stabilization or a slight increase in the fertility rate, a further increase in life expectancy (by an average of almost 10 years by the end of the century) and, from 2020 onwards, a consistently positive net migration rate (see Bertelsmann Stiftung 2019: 21).

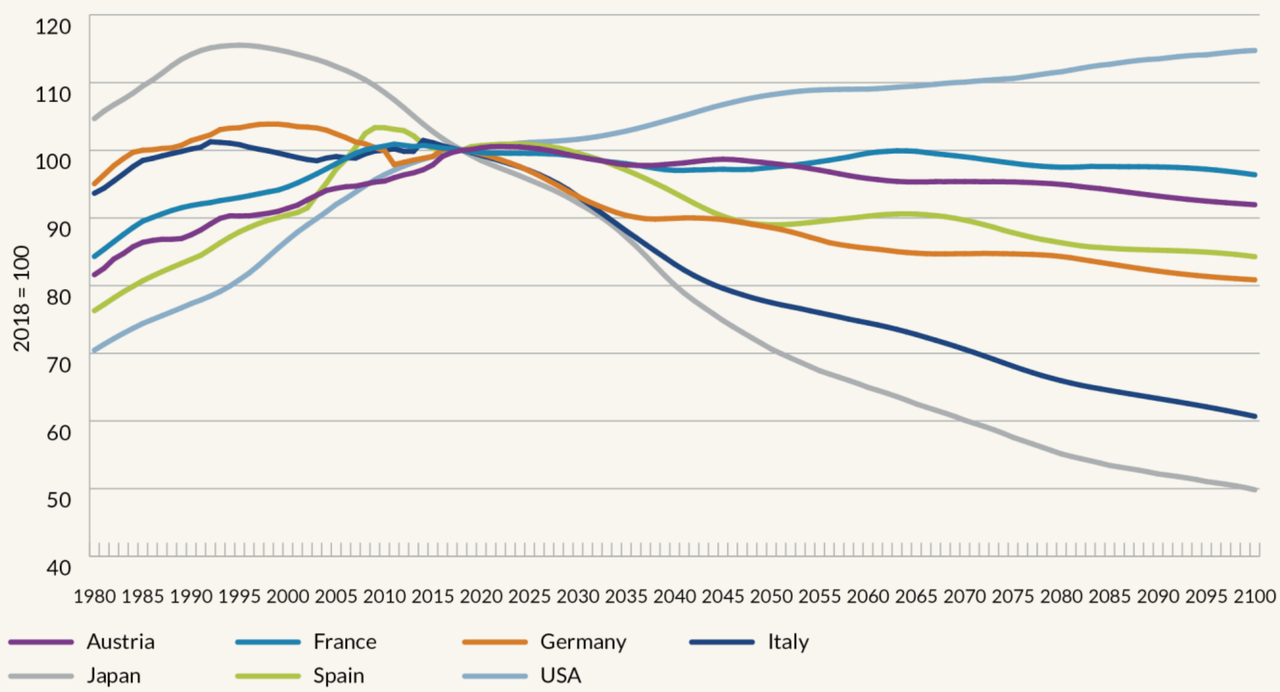
Figure 1 shows that the populations in Japan and Italy are expected to shrink significantly over the course of this century, respectively by 16.8% and 7.7% by 2050, and by 41.1% and 26.3% by 2100. By contrast, the United States stands out with significant population growth (of 16% by 2050, and 32.6% by 2100). The population sizes of the other European countries are expected either to decline slightly by 2050 (Germany) or increase moderately (Spain, France, Austria). By contrast, the trends shown by working-age populations – here defined as people aged between 15 and 64 – appear somewhat different (Figure 2). This population group is expected to grow further only in the United States, while in the other countries it will essentially stagnate (France and Austria) or contract significantly (Spain, Germany, Italy and Japan) by the middle of the century.

FIGURE 1 **Expected development of total population, 2018–2100**



Source: UNO – Department of Economic and social Affairs, Eurostat database. | BertelsmannStiftung

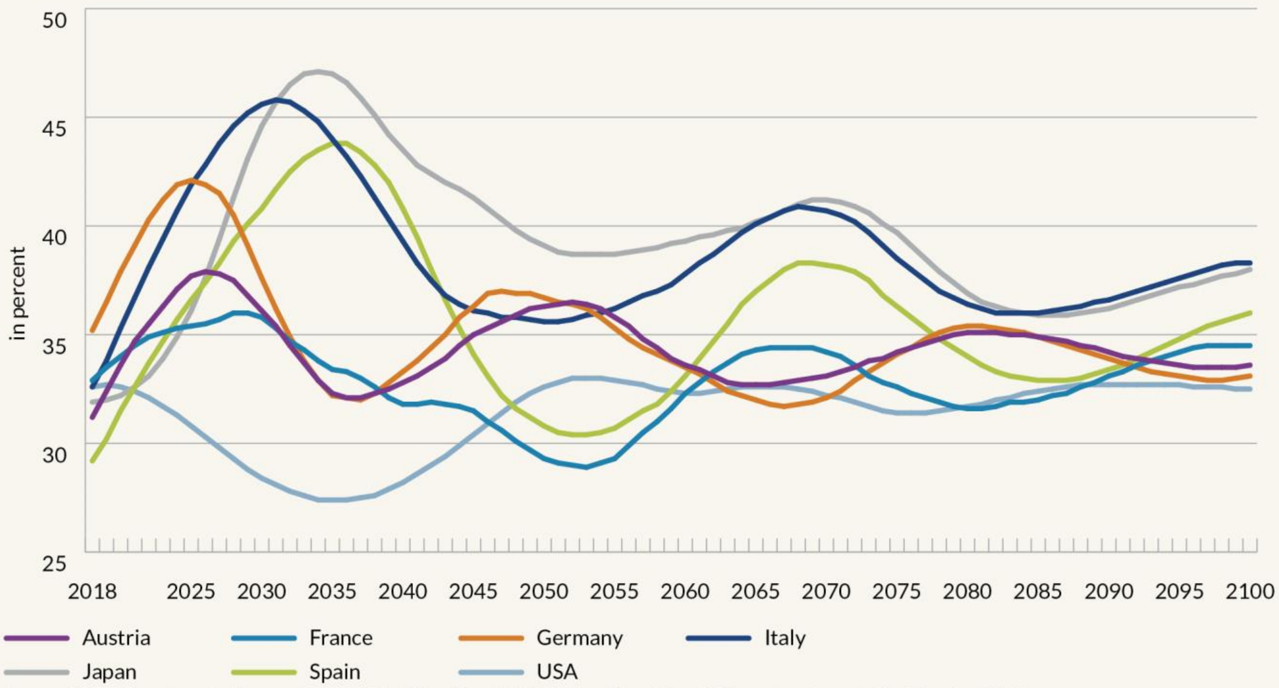
FIGURE 2 **Historic and expected development of working-age population, 1980–2100**



Source: UNO – Department of Economic and social Affairs, Eurostat database. | BertelsmannStiftung

The ratio of older economically active people (55- to 64-year-olds) to people in the middle age group (25- to 54-year-olds) is also of significance (Fig. 3) with regard to the issue of aging-driven technological progress. While the aging and shrinking of the working population results in a decline in labor productivity, it also boosts wage levels for economically active people in the middle age group, thus also increasing the incentive for companies to invest in automation and digitalization. Figure 3 clearly shows that in all countries examined here – with the exception of the United States – the ratio of older economically active people to those in the middle age group increases by the middle or end of the 2030s. While the magnitude of this increase varies, a high point is reached in each case. After this point, the curve becomes wave-shaped, which implies that in the future there will probably be phases of demographically driven strengths and weaknesses with regard to incentives for investment in labor-saving technological progress.

FIGURE 3 **Expected development of the share of old to middle-aged workers, 2018–2100**



Source: UNO – Department of Economic and social Affairs, Eurostat database. – The old to middle-aged worker ratio is defined as 55–64 years old to the 25–54 years old population.

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4.2 Effects of demographic aging on key macroeconomic indicators – Results for Germany, Japan and the United States

In order to present the consequences of demographic change for key macroeconomic indicators in Germany, Japan and the United States,[1] we initially examined two different scenarios:

1. Under the “constant population (2018)” baseline scenario, the population is held constant at its 2018 level. The calculations indicate how macroeconomic variables would develop through 2050 if there were no demographic changes whatsoever through 2050.
2. In the “population projection” scenario, current population forecasts are used instead of holding population figures at a constant level. Here, we see repercussions in the macroeconomic variables stemming both from the direct negative effects of a shrinking labor force, and from the indirect negative effects arising from an aging labor force’s declining labor productivity. In comparison to the baseline scenario, the macroeconomic developments calculated in this way reflect the macroeconomic effects of demographic change without including companies’ reactions in the form of labor-saving investments in automation and digitalization.

Finally, a further section looks at the potential offered by labor-saving technological progress motivated by demographic aging. It relates to a scenario in which current population forecasts and the negative direct and indirect effects of demographic aging are taken into account (as in the “population projection” scenario), but which also includes the indirect positive effects associated with demographically induced labor-saving technological progress.

[1] With regard to the effects of demographic development on key macroeconomic indicators in the sample’s other four countries, we refer readers to the individual country sheets available on the project’s website, at www.bertelsmann-stiftung.de/demographic-change.

The aging of the working population depresses the growth in productivity per hour worked. In Japan, productivity per work hour in 2050 following a process of societal aging is €5.5 lower than in the hypothetical baseline scenario without any demographic change. This corresponds to about 8% of the productivity value in the baseline scenario (see Table 1). In Germany, productivity in 2050 following a process of demographic aging is €1.90 or 2.4% under the value seen with an unchanged population structure. The United States by contrast shows (economically) positive labor-force developments, with the working population expected to grow but not age over the next 30 years. As a result, this country can expect a demographically induced increase in labor productivity by 2050 of around €1.10 per hour, or 1.5%.

Table 1: Development of productivity per hour of work in Germany, Japan and the United States through 2050 (in Euro, at 2010 prices)

	2020	**2030**	**2040**	**2050**
Germany				
"Constant population (2018)" scenario	49.4	58.4	68.2	79.5
"Population projection" scenario	49.4	57.6	67.1	77.6
Japan				
"Constant population (2018)" scenario	40.4	47.9	57.5	68.4
"Population projection" scenario	40.4	47.3	54.2	62.8
United States				
"Constant population (2018)" scenario	49.4	56.4	63.4	71.3
"Population projection" scenario	49.2	56.4	64.2	72.4

Source: European Commission, WIFO calculations, detailed evaluation.

In Germany and Japan, the demographically driven weaker increase in labor productivity, combined with a rising number of people of retirement age in relation to the number of working-age people, causes a marked attenuation in the growth of per capita GDP. This means that demographic factors alone are expected to produce a real per capita GDP in Germany in 2050 that will be about €6,050 lower than that found in the baseline scenario (see Table 2). This corresponds to 10.6% of the per capita GDP value under the "constant population" scenario. In Japan, the dampening of per capita GDP growth is even more substantial, at the equivalent of around €12,500 (corresponding to 19.2% of per capita income under the baseline scenario). Even in the United States, in which the favorable development of the labor force is linked to a demographically driven increase in labor productivity, the rise in the number of people of retirement age relative to the number of working-age people produces a lower real GDP per capita. However, the difference relative to the baseline scenario, at around €2,300 or 3.8%, is relatively small.

Table 2: Development of real GDP per capita in Germany, Japan and the United States through 2050 (in Euro, at 2010 prices)

	2020	**2030**	**2040**	**2050**
Germany				
"Constant population (2018)" scenario	36,614	42,184	49,224	57,354
"Population projection" scenario	36,393	40,572	45,508	51,299
Japan				
"Constant population (2018)" scenario	37,257	45,234	54,525	64,825
"Population projection" scenario	36,878	42,396	48,058	52,356
United States				
"Constant population (2018)" scenario	42,348	48,272	54,030	60,584
"Population projection" scenario	42,232	47,148	51,834	58,274

Source: European Commission, WIFO calculations

In all three countries, the savings rate – defined as aggregate savings as a percentage of GDP – is lower in the "population projection" scenario than in the baseline scenario, due to the rising old-age dependency ratio. In Germany, the difference in 2050 is around 2.4 percentage points, while Japan shows a gap of fully 3.5 percentage points (see Table 3). The United States, at 2.2 percentage points, features the smallest absolute difference in 2050.

Table 3: Development of aggregate savings rates in Germany, Japan and the United States (savings as a % of GDP)

	2020	**2030**	**2040**	**2050**
Germany				
“Constant population (2018)” scenario	27.3	27.2	27.1	27.2
“Population projection” scenario	27.2	25.8	24.8	24.8
Japan				
“Constant population (2018)” scenario	24.8	25.1	25.3	25.2
“Population projection” scenario	24.5	24.0	22.7	21.7
United States				
“Constant population (2018)” scenario	17.0	17.3	17.5	17.6
“Population projection” scenario	16.8	15.8	15.5	15.4

Source: European Commission, WIFO calculations

The demographically driven change in investment rates – defined as aggregate investment as a percentage of GDP – varies across the three countries. The expected decline in this rate due to demographic aging is most significant in Japan. Here, the investment rate in the “population projection” scenario is in 2050 around 4.5 percentage points lower than in the baseline scenario (see Table 4). This is mainly due to the strong contraction in the working-age population by 2050. In the United States, demographic forces push the investment rate higher in 2050 than is seen in the hypothetical scenario with population levels held constant. This is due to the increase in the size of the labor force, which would require the creation of new jobs, and a corresponding amount of investment.

Table 4: Development of aggregate investment rates in Germany, Japan and the United States (investment as a % of GDP)

	2020	**2030**	**2040**	**2050**
Germany				
“Constant population (2018)” scenario	20.7	21.4	21.5	21.5
“Population projection” scenario	20.7	20.6	20.1	21.4
Japan				
“Constant population (2018)” scenario	25.1	26.9	26.5	26.2
“Population projection” scenario	24.3	24.4	23.4	21.7
United States				
“Constant population (2018)” scenario	21.0	19.3	19.3	19.5
“Population projection” scenario	21.3	19.7	19.8	20.2

Source: European Commission, WIFO calculations

In Germany, there is virtually no difference between the 2050 investment rates in the two scenarios. This result, though perhaps surprising at first glance, is primarily due to the fact that the shrinking of the working-age population comes to a halt between 2040 and 2050, and the negative effect on investment thus disappears. As a consequence, the investment rate in the “population projection” scenario once again rises slightly between 2040 and 2050. It then finishes about 0.1 percentage points below the corresponding value in the baseline scenario.

Higher inflationary pressure due to demographic developments is evident in all three countries. The absolute difference between the two scenarios as calculated for 2050 is largest in Japan (see Table 5). It should be borne in mind that the demographically induced inflationary pressure can be counteracted by monetary-policy measures implemented by the given country’s central bank.

Table 5: Development of the annual inflation rate in Germany, Japan and the United States through 2050 (in %)

	2020	2030	2040	2050
Germany				
“Constant population (2018)” scenario	1.7	2.1	2.7	3.0
“Population projection” scenario	1.8	2.7	3.5	3.9
Japan				
“Constant population (2018)” scenario	0.6	0.4	0.3	0.3
“Population projection” scenario	0.7	0.8	1.2	1.6
United States				
“Constant population (2018)” scenario	2.1	1.8	1.6	1.6
“Population projection” scenario	2.2	2.3	2.3	2.4

Source: European Commission, WIFO calculations

The demographically driven development of the current account balance (relative to GDP) corresponds in Germany to the theoretically expected course. The declining savings rate and the associated rising consumption rate leads to conditions in which domestic consumption increases. As a result, fewer goods and services are available for export and, at the same time, imports increase. The rising price level due to the increasing inflation rate has the consequence that foreign demand for German products tends to decline. With these aging-related factors taken into account, the current account surplus for 2050 would be 2.3 percentage points lower than in the baseline scenario (see Table 6).

The Japanese current account is already in a condition of deficit. Due to aging-related factors, a somewhat smaller deficit is to be expected. This surprising result – in principle, aging would normally be expected to expand an existing current account deficit – can be explained in this way: The current account balance is the difference between an economy’s aggregate savings and investments. If, due to changes in the age structure, the investment rate falls more than the savings rate, the current account deficit becomes smaller. This is the case in Japan. There, the investment rate in 2050 is about 4.5 percentage points under the corresponding rate in the baseline scenario (see Table 4), while the savings rate shows a difference of just 3.5 percentage points (see Table 3).

For the United States, by contrast, the calculations show an increase in the already-existing current account deficit. The difference between the baseline scenario and the “population projection” scenario is relatively large by 2050, at 2.9 percentage points. This is primarily due to the fact that an aging-driven increase in the consumption rate takes place in parallel with a demographically driven increase in the investment rate. Both lead to increased domestic demand, which expands the current account deficit.

Table 6: Development of the current account balance in Germany, Japan and the United States through 2050 (current account balance in % of GDP)

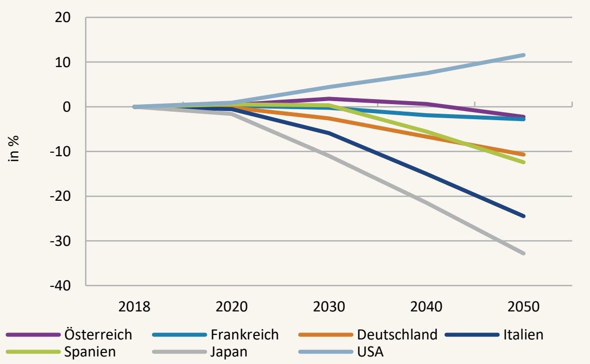
	2020	2030	2040	2050
Germany				
“Constant population (2018)” scenario	6.6	5.8	5.6	5.7
“Population projection” scenario	6.5	5.1	4.8	3.4
Japan				
“Constant population (2018)” scenario	-0.3	-1.8	-1.2	-1.0
“Population projection” scenario	0.2	-0.4	-0.7	0.1
United States				
“Constant population (2018)” scenario	-4.0	-1.9	-1.8	-1.9
“Population projection” scenario	-4.6	-3.9	-4.3	-4.8

Source: European Commission, WIFO calculations

4.3 Effects of demographic aging on economic growth and material prosperity in comparison to other industrialized countries

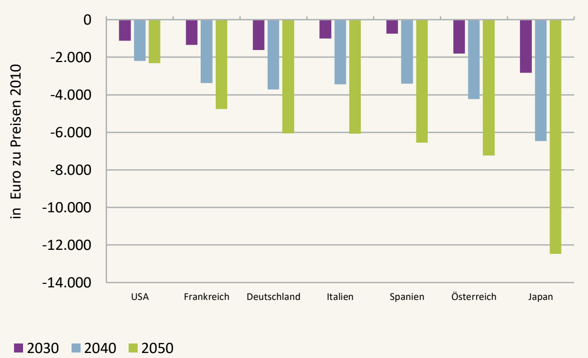
In the following section, in order to better assess how the macroeconomic effects of demographic aging compare across industrialized countries, we examine the development of GDP growth and per capita GDP growth. To do so, we again compare the differences between the baseline scenario and the “population projection” scenario in the various countries.

FIGURE 11 **Development of GDP – Difference between baseline scenario and “population projection” scenario**



Source: European Commission, WIFO calculations | BertelsmannStiftung

FIGURE 12 **Dampening of per capita GDP – Difference between baseline scenario and “population projection” scenario**



Source: European Commission, WIFO calculations | BertelsmannStiftung

Once again, the United States represents an exception in this category, as its overall and working-age populations will continue to grow in the coming decades due to higher fertility and immigration rates, while also aging to a significantly lower extent than is true elsewhere in our sample. However, demographic change in the remaining countries will dampen GDP growth to varying degrees (see Fig. 11). In Germany, Italy and Japan, the demographically driven decline in GDP growth rates will begin as early as 2020. In Spain, this decline will appear between 2030 and 2040, but by 2050 will be even more significant than that experienced by Germany. Japan, whose population has been aging markedly and continuously since the 1980s (due to low fertility rates, minimal immigration and a high life expectancy), falls at the opposite extreme from the United States within our sample, with the most significant aging-driven attenuation of GDP growth.

The United States and Japan also serve as the two extremes within our country sample with regard to GDP per capita (see Fig. 12; for the exact values, see above). Germany falls into the middle of the pack along with Italy and Spain.

4.4 Potential gains offered by labor-saving technological progress

Our study's projections of increased investment in automation and digitalization as a response to demographically driven contractions in the working-age population and aging-induced declines in productivity are guided by investment behavior in the past (1980 through 2018). As previously noted, this activity is here measured as investment in information and communications technology and software. Within the past period examined, demographic aging in most of the sample's countries was still relatively moderate. In some cases, working-age populations were still increasing in size. Companies' investment decisions were accordingly focused on the exploitation of technological possibilities for optimizing production processes and the development of new products and services. Therefore, the simulation's estimates of the influence of population-structure developments on ICT investment, as derived from this past period, are correspondingly restrained. In addition, projected working-age population trends, for example in Germany beginning in 2030, follow wave-shaped curves. Because the model for ICT capital as a share of total capital stock reacts to the expected change in the working-age population over the following 10 years, the ICT share and thus also TFP growth decline when growth is expected in the working-age population, but rise in the case of expected contraction. The greater the expected contraction, the stronger is the growth in ICT intensity within the overall capital stock. Accordingly, there will presumably be future phases in which demographic developments alternately provide stronger and less strong incentives for investment in technological progress. Similarly, this means that future periods with correspondingly stronger and less strong positive repercussions for TFP growth can also be expected.

The simulation's calculations for the development of productivity, GDP growth and the other macroeconomic variables produce the following conclusions: The aging-driven decline in productivity and thus in per capita GDP can fundamentally be offset by greater automation and digitalization. However, if investment in technological progress remains at past levels – that is, if the past rate of investment in technological progress remains unchanged in the future – no positive effects can be expected through this channel of influence, despite the impending demographic aging. In order to offset the negative effects of demographic aging on the quantitative and qualitative input of labor, and to compensate for the dampening effect on GDP per capita, investment in information and communications technologies (ICT) and software as a percentage of total capital stock would have to be increased by five to six times in Italy and Spain, and by two to three times in Austria, France and Germany.

We can use the example of Germany to show what this means in concrete terms: Here, investments in information and communications technologies and software totaled 2.6% of the total capital stock in 2018. However, this level must be increased to 5% by 2030, 7% in 2040 and 8.9% by 2050. That means that investment needs in ICT and software will increase from about €54 billion in 2018 to €85 billion in 2030, to €123 billion in 2040, and to €178 billion in 2050 (in constant 2010 prices).

Less investment in technological progress is possible if other measures serve to improve productivity levels, particularly among older workers. Such measures would above all include improvements in the population's education and qualification structure across people's entire lives, as well as programs ensuring that workers remain physically fit and healthy, even at advanced working ages.

Methodology

This study expands on the methodology employed by the European Commission for long-term projections – for instance, as used for the EU Aging Report – by allowing for the interplay of demographic factors and key macroeconomic indicators. The projections of labor inputs and capital accumulation replicate the methods used in the EU Aging Report (European Commission 2017). Drawing on current demographic forecasts for the working-age population, the EU Aging Report projects labor-force participation rates on the basis of a dynamic cohort model that accounts for future labor-market-relevant changes in retirement and pension rights. The second step closes the gap between labor supply and labor demand by estimating the natural unemployment rate on the basis of a Phillips-curve-based unobserved component model. The long-term equilibrium unemployment rate is determined by structural factors and labor-market institutions. Finally, the volume of labor in hours is calculated using the assumption of a gender- and age-specific constant average working time. The long-term projections in the EU Aging Report thus take into account only the direct effect of demographic change, via a reduced volume of work.

Indirect effects of demographic change on productivity arise on the one hand through an aging-driven variability in labor productivity, and on the other, through investments in automation and digitalization triggered by expected contractions in the working-age population. This relationship, along the responses of the savings rate, the current account balance and the consumer price index to demographic change, are analyzed in a panel-data econometric model that simultaneously uses the variation over time and across the cross-section of countries to estimate elasticities. The existence of common trends and cycles creates a structure in the panel-data model's error terms that must be accounted for either explicitly or through a process of robust inference (feasible generalized least squares or a Prais-Winsten estimation). The model selection is based on the Bayesian information criterion.

The elasticities from the panel-data estimates are transferred into a system of simultaneous equations that depict the interplay between demographic factors, technical progress, investments in automation and digitization, the aggregate savings rate, and the accumulation of physical capital. Among other benefits, this allows for the derivation of a future production-potential path – that is, the course of real GDP excluding cyclical fluctuations in capacity utilization, as well as labor productivity and GDP per capita. The projection for the current account balance uses the macroeconomic identity of savings and investments in an open economy under the assumption of constant interest rates.

In addition, necessary exogenous input variables that are not modeled in the EC methodology, such as the degree of economic openness or the price of ICT capital, are projected using exponentially smoothed state-space models. The inclusion of a dampening trend in the smoothing model ensures stable projection values.

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