Demographic change, immigration and the potential output of the German economy

An economy's potential output is determined by labour input, capital services and production technology. The ratio of actual output to potential output is an indicator of capacity utilisation over the business cycle, and the percentage rate of change in potential output expresses the trend rate of growth in an economy. Both are key variables of macroeconomic analysis that are also incorporated into the assessment of the monetary policy stance. A projection for the German economy shows that the available supply of labour will be influenced by two major factors over the coming ten years. First, demographic change will lead to a marked numerical decline in the resident population and also to a progressive ageing of the population. All other things being equal, natural population developments will reduce the working-age population, ie the number of persons aged between 15 and 74 years, by almost 2½ million by 2025, while the percentage of persons aged between 55 and 74 years in the working-age population will rise by 7 percentage points to almost 40%. Second, this process is likely to be counteracted by impulses generated by immigration, which is expected to remain at a high level.

In the baseline, the potential labour force in 2025 will approximately match its 2016 figure. Within this period, it will rise up to 2020, with demographic developments then making themselves felt more strongly. This will also have an impact on the growth rate of potential output: according to the projections, demographic trends affecting potential hours worked will play a crucial role in potential growth falling from almost 1¼% on average between 2011 and 2016 to well below 1% per year over the coming decade. The implied shrinking of the labour supply over the medium term, along with progressive demographic ageing, is also likely to affect capital accumulation and technological progress: subdued growth in the potential labour force in future could mean that less capital will be required in the corporate sector, and the shift in the age structure in Germany could dampen labour productivity growth.

The role of demographic change in macroeconomic projections

Currently high level of immigration counteracting demographic decline in native-born population

While the German economy's current situation and its short-term outlook appear favourable at the moment, demographic developments are placing a strain on its medium to long-term growth prospects. The native-born population in Germany, as determined by the ratio of births to deaths, has been in decline for some time, and the size of the total population is currently being maintained solely by strong immigration. The average age of the population is also on the rise, and demographic change in Germany is set to continue gaining pace over the coming years. Therefore, its significance for medium-term economic forecasts has increased.

Medium-term potential growth based on updated population projections

The key factors for an economy's medium-term growth outlook are labour input, capital services and production technology in the context of the underlying institutional and demographic conditions. The Bundesbank's projections presented here quantify the medium-term potential growth of the German economy up to 2025 on the basis of updated estimates of expected demographic developments.[1] Estimates of prospective immigration and emigration in the German labour market play a prominent role in this connection. Moreover, the relatively rapid ageing of the population is likely also to be reflected to a growing and wider extent in the age structure of the working-age population.

Demographically determined labour supply trends

Demographic change will have an impact on labour pool and composition of labour supply

Under the existing underlying institutional conditions, economic growth will be chiefly affected by how much the pool of labour and the composition of the labour supply are transformed as a result of demographic change as well as by how far domestic growth is influenced by immigration. The potential labour force is derived from the working-age population and potential labour force participation. Over the past 50 years, "baby boomers" have been expanding the labour supply upon reaching working age, while labour force participation has gradually increased. Added to this is the substantial contribution made recently by positive net migration. This large-size generation will be leaving the labour market in the years to come for reasons of age. Moreover, there has already been a considerable increase in labour force participation over the past few decades – the participation rate of women is already fairly high compared with other countries – and the continued activation of domestic labour reserves is likely to be reaching its limits.[2] This development will be counteracted by immigration, which is expected to stay at a high level. Although Germany is likely to remain attractive to foreign workers, immigration will probably be more moderate in the medium term compared with its exceptionally high levels in recent years.

Potential labour force broadly reaching its initial level over projection horizon

This means that steady growth in the potential labour force is not to be expected over the next ten years. However, given the baseline assumptions about a cumulative net immigration of 2½ million persons and as a result of rising labour force participation, the potential labour force in 2025 should roughly match its 2016

1 Demographic developments also have a major bearing on public finances, although the effects will be felt only in the much longer term. See Federal Ministry of Finance, Vierter Bericht zur Tragfähigkeit der öffentlichen Finanzen, February 2016; and European Commission, Fiscal Sustainability Report 2015, Institutional Paper 18, January 2016. Given that public finances are currently in good shape with structural primary surpluses (positive, cyclically adjusted budget balance excluding interest expenditure), sustainability risks are perceived as low for Germany over the long term, too – despite the country's high cost of ageing by international standards. Regarding aspects of pension developments, see Deutsche Bundesbank, Excursus: longer-term pension developments, Monthly Report, August 2016, pp 68-77.

2 On women's employment, see, for example, Organisation for Economic Co-operation and Development (2017), Dare to share: Germany's experience promoting equal partnership in families, OECD Publishing, Paris, pp 45 f.

level.[3] The labour supply will still be edging upwards in the first half of the projection period, however, with growth levelling off in around 2021. Thereafter, it is likely that the retarding effects of demographic change will outweigh the effects of rising labour force participation and the migration gains.[4]

Workforce members aged between 15 and 74 years relevant to calculating potential output

When calculating potential output, the working-age population is defined as persons aged between 15 and 74 years. Among other things, this takes into account the fact that a significant number of persons above the statutory retirement age continue to participate in the labour force.[5] In connection with the progressive ageing of the population in future, this group of persons is likely to make a non-negligible contribution to potential output growth.

Impending shifts in age structure

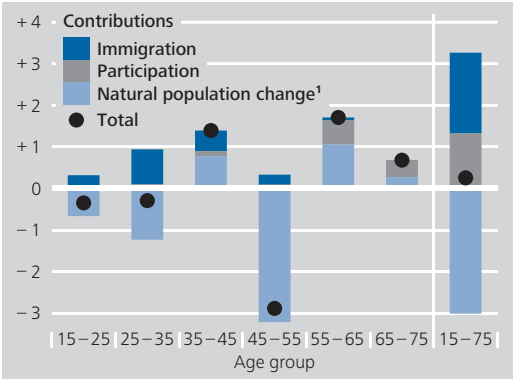
All other things being equal, demographic change will reduce the working-age population by 2½ million persons within the next nine years. Impending demographic developments in Germany are largely predetermined up to 2025, as all the children who will have reached working age then have already been born and working-age mortality can be estimated fairly accurately. Significant shifts in the age structure will arise in this process. For example, there will be an especially sharp rise of 3 million in the number of older persons aged between 60 to 74 years, while the age group comprising 45 to 54-year-olds will shrink substantially by 3½ million due to the slump in the number of births in the late 1960s and early 1970s. The number of adolescents and young adults aged between 15 and 29 years will also have fallen by just over 2½ million persons by the end of the projection period.

Declining population figures and age structure effect placing strain on future labour supply

These changes in age groups will be reflected in the potential labour force. The increasing share of older persons, who display a below-average propensity to participate in the labour force, will curtail aggregate labour force participation, while there will be a decline in the number of the population in the core working age group (25 to 55-year-olds), which has the greatest presence on the labour market. If labour force participation remains unchanged, the 3 million increase in the number of over-60s by 2025 will result in only one million additional members of the workforce. Furthermore, the decline in the number of persons aged between 45 and 54 years – an age group

Potential labour force by age group

Cumulative change between 2016 and 2025
in millions of persons



Source: Bundesbank calculations based on data from the Federal Statistical Office. **1** Including the effect of the change in the age structure.

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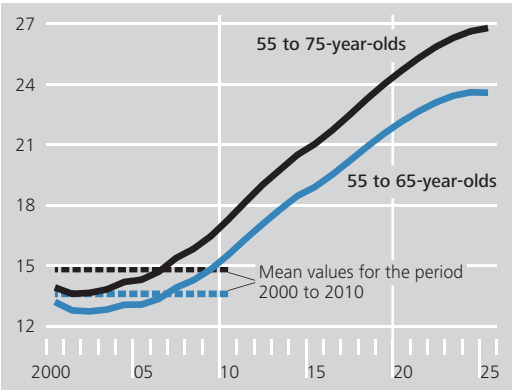
3 The population projection is based on the 13th coordinated population projection by the Federal Statistical Office and the regional statistical offices by age and gender group given balanced net migration (model calculation: net migration rate is zero) and is augmented by the Bundesbank's migration assumptions. As immigrants are, on average, younger than emigrants, migration movements also have a dampening effect on ageing even in the scenario without net positive migration.

4 The latest calculations of long-term trends in the potential labour force up to 2060 by the Institute for Employment Research (IAB) are based on a broader definition of persons in the labour force. See J Fuchs, D Söhnlein and B Weber (2017), Arbeitskräfteangebot sinkt auch bei hoher Zuwanderung, IAB-Kurzbericht 6/2017, Nuremberg; and Deutsche Bundesbank, Potential growth of the German economy – medium-term outlook against the backdrop of demographic strains, Monthly Report, April 2012, p 19, footnote 7.

5 As many as around one-seventh of persons aged between 65 and 74 are in gainful employment, which is about three times as many as in 2000. The participation rate of persons aged between 60 and 64 has more than doubled since then and is likely to have been at roughly 63% in 2016. The participation rates, measured as the sum of employed and unemployed persons in relation to the working-age population, are based on microcensus data and broken down by age group and gender, as well as by native-born and foreign-born populations. As a result of the under-reporting of employment in the microcensus, they are adjusted to the level indicated by national accounts data.

Share of older employed persons in the potential labour force

As a percentage



Source: Bundesbank calculations based on data from the Federal Statistical Office.
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in which the participation rate is particularly high – will lead to 3¼ million fewer potential members of the labour force. The demographically driven fall in the labour supply is set to accelerate as time goes on. While the potential labour force will contract by around 220,000 persons in 2017 on account of the demographic effect and excluding the contribution made by migration, the decline will be more than twice as high in 2025. The effect, which stems solely from unfavourable shifts in the age structure, will – all other things being equal – lower the overall participation rate by 0.4 percentage point per year from roughly 2021 onwards.

Rising labour force participation among older persons and persons with family commitments

However, labour force participation is expected to rise further in some age groups, and thus, taken by itself, counteract the effect of demographic decline and the shift in age structure.[6] In view of saturation effects, simply extrapolating positive developments in labour force participation in the past does not seem immediately relevant. Nevertheless, the prospective extended average working life of persons aged 55 years and above will be reflected in rising participation rates. Raising the statutory retirement age should also bring about an increase in the actual age of retirement. The greater incentives under the flexible pension act to work while drawing an old-age pension could have broadly similar effects. Added to this are the declining percentage of physically demanding jobs, increasingly high levels of education and the existing tendency to retire at a later age, arguably regardless of the institutional framework in place. Better conditions for combining work and family life have already led to a sharp increase in labour force participation among women. By contrast, labour force participation among men in younger and middle age groups is unlikely to show any growth potential. In the light of this, it is assumed here that age-group-specific participation rates will continue to rise in some cases, leading to the potential labour force being boosted by 1¼ million additional persons by 2025. The number of persons in the labour force aged over 55 years old by itself could be one million as a result.

Increased labour-market-oriented immigration since 2010

Immigration is also likely to counteract the dampening effects of demographic developments on the available labour supply. This factor, however, is difficult to predict. With the exception of 2015 – a year for which the extremely high net positive migration figure of 1.1 million persons is likely to be attributable to the extremely high percentage of refugees – labour-market-oriented immigration, chiefly from eastern and southern EU countries, has predominated since 2010.[7] Net immigration to Germany had risen to 550,000 persons by 2014, following slight net emigration as recently as 2008 and 2009. Since 2010, almost nine out of ten immigrants have been of working age and al-

6 Besides employed and unemployed persons, the potential labour force also includes persons who are available to the labour market in the short term but are classified as persons outside the labour force for statistical purposes. These are essentially persons participating in active labour market policy measures, insofar as these measures are not combined with employment. Owing to differences in the speed of labour market integration between refugees (uninterrupted transitional period of 15 years until employment behaviour matches that of the native-born population) and other immigrants (transitional period of 8 years), a distinction is made between types of immigrant over the projection period. See Deutsche Bundesbank, The current influx of refugees – projected impact on the labour market and public finances, Monthly Report, December 2015, pp 24-28.

7 At present, there are no external migration statistics available for 2016.

most half of all immigrants aged between 20 and 30 years.

Expected immigration increasing potential labour force

In the baseline projection, cumulative net positive migration is expected to total almost 2½ million persons in the period from 2017 to 2025, which will boost the potential labour force by just under 2 million. If it is assumed that the age structure of immigrants can be extrapolated on the basis of the pattern observed in previous years, the predominantly young immigrants will significantly alleviate the otherwise anticipated decline in numbers in the younger age groups.[8]

Regionally disaggregated migration flows

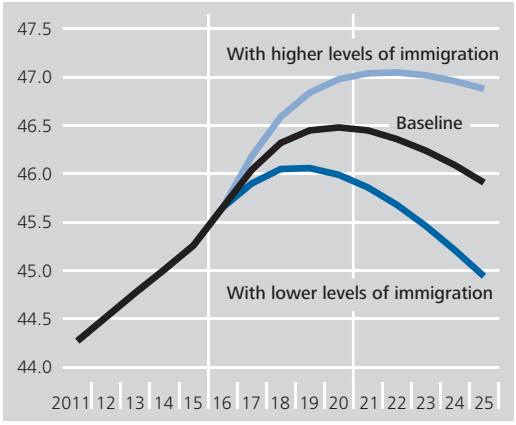
Assumptions about immigration and its age structure over the projection horizon are based on recent gross migration flows disaggregated by region of origin. The forecasts assume a subsidence in the projection period of the earlier forces driving immigration, which were linked to the gradual easing in the free movement of workers as more member states joined the EU and to the difficult economic situation in a number of euro-area countries. Moreover, refugee migration is incorporated into a separate calculation. Some 280,000 persons sought refuge in Germany in 2016. However, offsetting this figure against the number of refugees entering Germany who go on to exit the country or who are passing through would probably result in a significantly lower net effect on Germany's population. Overall, the projections assume a positive net migration rate of 500,000 persons in 2016, which will have fallen to 200,000 persons per year by 2025.

Alternative immigration scenarios

Compared with natural population changes, assumptions about migration are subject to considerable uncertainty. If the rate of immigration is only half as high as assumed in the baseline, the potential labour force will start to contract from as early as 2020. In cumulative terms, this would result in roughly one million fewer persons being available to the labour market by 2025. However, if around 1¼ million (or 50%) more persons immigrate than in the baseline, one million additional persons will be available to the labour market by 2025. Even in this scenario, however, the demographic trend makes itself felt from 2023 onwards, although it would reduce the labour supply only marginally overall.

Potential labour force

Millions of persons



Source: Bundesbank calculations based on data from the Federal Statistical Office.
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Developments in working hours set to have slight dampening effect on labour supply

Projections of potential hours worked, taking into account working hours effects, are slightly lower than the results for the potential labour force. In the baseline, it takes until 2025 for the potential labour force, expressed in full-time equivalents, to rebound to a level only just about matching the present-day figure (less 350,000 full-time equivalents, or -¾%), although it will initially continue to increase slightly before downward factors predominate from 2020 onwards.[9] Both age structure effects – age groups with a greater preference to work part-time hours will be more strongly represented – and the expected moderate rise in the desire among younger and middle age groups to work part-time will have the effect of

8 The age-specific participation rates of immigrants are indeed lower than those of the native-born population. However, owing to their age and gender structures as well as refugees' assumed labour market integration, their rate of participation in the labour force will be higher than that of the native-born population by the end of the projection period.
9 See TA Knetsch, K Sonderhof and W Kempe (2013), Potential labor force in full-time equivalents: measurement, projection and applications, Deutsche Bundesbank Discussion Paper, No 26/2013.

slightly reducing the average weekly working hours per employed person.

Supply-side effects of demographic trends

Potential growth in coming decade significantly below 1% per year

The prospective trends in the labour supply can be used to estimate the German economy's medium-term growth outlook.[10] The growth rate of aggregate potential output can be broken down, in mathematical terms, into the contributions from the two primary production factors labour and capital, and the contribution from total factor productivity (TFP). While labour is currently once again making a notably positive contribution to potential growth on account of strong immigration, the demographically driven trends in the potential number of hours worked are the main factor behind the projected fall in potential growth from almost 1¼% on average between 2011 and 2016 to just over ¾% on average between 2021 and 2025.

Uncertainty mainly attributable to immigration

The estimated potential growth path of the German economy is subject to considerable uncertainty, particularly with regard to assumed immigration. For example, actual immigration being higher than assumed in the baseline and these immigrants being available to the labour market would lead to a stronger increase in the potential labour force. Scenario calculations nevertheless indicate that the medium-term growth potential of the economy – even given the higher immigration that is assumed in an alternative scenario – could fall to around 1% on average between 2021 and 2025. In the scenario with lower immigration, the decline in the rate of potential growth would be even more pronounced than in the baseline.

Productivity growth currently muted

Technological progress has a crucial impact on growth potential and labour productivity growth, ie economic output per employed person or per hour worked. Technological progress is, by its very nature, difficult to identify and predict. From an international perspective, productivity growth has been muted in recent years, with special factors amplifying this effect in Germany.[11] First, a large number of low-skilled workers were integrated into the German labour market in the wake of the labour market reforms of the early 2000s. Taken in isolation, this tended to have a dampening effect on aggregate productivity growth,[12] although this effect should have levelled off in the meantime. Second, the labour productivity of a considerable number of recognised refugees, most of whom arrived in 2015 and 2016, is likely to be below average in the short run, at least in the first few years after their arrival. This may be due, for example, to inadequate language skills and qualifications that do not match the demand for labour. Looking ahead, however, it can be assumed that catch-up effects will gradually emerge as refugees with the prospect of remaining increasingly take up employment that better matches their skills and qualifications and progressively overcome language barriers.[13] Both of these considerations indicate that productivity growth – starting from a currently comparatively slow pace – could regain some momentum in future, with growth rates potentially approaching those seen during the first decade of the century. With regard to total factor productivity, the projection is therefore based on the assumption that its contribution to potential growth will gradually rise over time and reach just over

10 The calculations are based on the methodology for determining the German economy's growth outlook beyond the forecast period covered by the Eurosystem's macroeconomic forecast (currently 2017 to 2019). For conceptual details, see Deutsche Bundesbank, Potential growth of the German economy – medium-term outlook against the backdrop of demographic strains, Monthly Report, April 2012, pp 15-19.

11 See, for example, Organisation for Economic Co-operation and Development, 2015, The future of productivity, OECD, Paris.

12 See Deutsche Bundesbank, The macroeconomic impact of labour market reforms in Germany, Monthly Report, January 2014, pp 34-36.

13 See S Bach, H Brücker, K van Deuverden, P Haan, A Romiti and E Weber (2017), Fiskalische und gesamtwirtschaftliche Effekte – Investitionen in die Integration der Flüchtlinge lohnen sich, IAB-Kurzbericht 2/2017, Nuremberg; and Deutsche Bundesbank, The current influx of refugees – projected impact on the labour market and public finances, Monthly Report, December 2015, pp 24-28.

½ percentage point per year on average between 2021 and 2025. This means that it would be roughly as high as it was on average between 2000 and 2010.

Labour productivity and wage dynamics with an ageing population

Age-specific productivity effect not easily identified

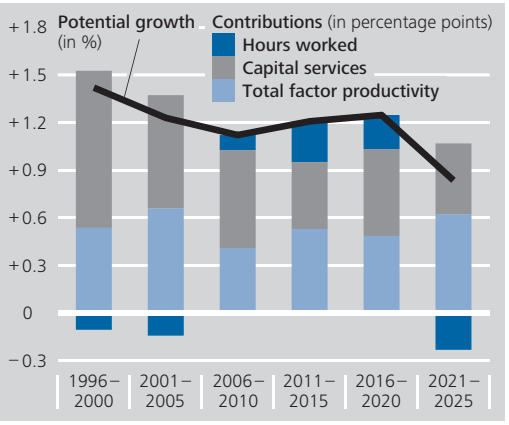
In the medium term, the macroeconomic growth potential expected in the baseline stems chiefly from productivity growth. In mathematical terms, the trend development of total factor productivity is derived from the trend increase in labour productivity, taking into account the cyclically adjusted contribution of capital deepening.[14] One key question is, therefore, the extent to which labour productivity is affected by ageing effects. However, for various reasons, it is difficult to arrive at a clear empirical answer to this question.

Labour productivity in medium term somewhat less dynamic than in the past decade

In most cases, the output of groups or individuals for which precise age data are available is not captured well in the statistical data.[15] This contrasts with productivity at the firm level, defined as the ratio of value added to hours worked by the workforce of an enterprise, which can be clearly identified in the data. However, selection effects, along with other factors, mean that labour productivity determined in this way cannot simply be traced back to the underlying age profile. For example, more productive, older employees as well as more efficient enterprises with an older workforce are probably overrepresented in the collected statistical data, since less productive market participants are likely to leave the market earlier. Even so, there is apparent agreement in the academic literature that preference should be given to studies at firm level when it comes to weighing up the quality of available

Medium-term projection of potential output

Year-on-year change



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Medium-term projection of potential output and its components

Period	Annual potential growth in %	Contributions in percentage points: Total factor productivity	Capital services	Hours worked
	Baseline			
1996 to 2000	1.4	0.5	1.0	– 0.1
2001 to 2005	1.2	0.7	0.7	– 0.1
2006 to 2010	1.1	0.4	0.6	0.1
2011 to 2015	1.2	0.5	0.4	0.3
2016 to 2020	1.2	0.5	0.5	0.2
2021 to 2025	0.8	0.6	0.4	– 0.2
	with lower immigration			
2016 to 2020	1.2	0.6	0.5	0.1
2021 to 2025	0.7	0.7	0.4	– 0.4
	with higher immigration			
2016 to 2020	1.3	0.4	0.6	0.3
2021 to 2025	1.0	0.6	0.5	– 0.1

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14 The measure of productivity used in the calculations relates to gross value added per hour worked. See Deutsche Bundesbank, On the technical relationship between the trend rate of hourly productivity, the trend growth of total factor productivity and capital deepening, Monthly Report, April 2012, pp 24-25.

15 Direct measures of individual productivity, which usually relate to the fields of the arts, sciences and sport, are only of limited applicability for activities that generate steady labour remuneration. Indirect measures of productivity, such as individual employee earnings or survey findings, are likely to give no more than an incomplete or biased impression of an employee's contribution to productivity. See German Council of Economic Experts, Herausforderungen des demografischen Wandels, Expertise im Auftrag der Bundesregierung, May 2011, pp 106-110.

productivity data and their relationship to the age structure of employees.[16] Analyses which try to offset biasing effects using statistical methods show that there is a tendency for individual productivity in Germany to rise up to the age of about 55, after which it stays more or less unchanged at its heightened level.[17] Experience-based skills, which become more important over the course of working life, compensate for the age-related decline in physical and cognitive abilities. These findings suggest that, all else being equal, the ageing of employees and the decreasing growth rates of individual productivity over the course of working life have a dampening effect on macroeconomic productivity growth.[18]

Shift in value added from goods production to services production

Another channel through which population ageing affects productivity consists in the shifts in the structure of the economy that accompany ageing. Through this channel, consumers' preferences, too, have an impact on supply-side productivity growth. In ageing societies, there is likely to be a shift in the shares of value added from goods production to services production, especially as more resources tend to be spent on certain services such as support and care for older generations.[19] As the productivity of service providers is typically lower than that in the production sector, ageing economies might exhibit lower macroeconomic productivity growth, at least during the demographic transition process. However, the shifts in the sector-specific shares of value added towards the services sectors could be dampened by external demand for goods from the production sector. This would be especially true if the pace of demographic change in the societies of Germany's trading partners were significantly different to that of Germany.

Population decline with wage-boosting effect

The shift in the age structure could also impact aggregate wage dynamics. Generally, trend wage growth is likely to be linked to the development of labour productivity, as remuneration for labour and capital, as primary factors of production, should be in line with their marginal yield, at least in the long term. The numerical fall in the potential labour force caused by demographic change points, from a macroeconomic perspective, to increasing marginal yields of labour over the medium term.[20]

Ageing tends to dampen wage growth

Labour productivity and remuneration can, however, diverge over the course of an individual's working life. First, spending on education and training at the start of a person's working life, which in some cases continues to have an effect in the later years of their employment, initially implies a comparatively high wage level from an employer's perspective, which would exhibit a rather flat trajectory over the life cycle.[21] Second, from the employers' perspective, incomplete information about the actual productivity of employees as well as motivational considerations suggest that wages start from a rather low level and increase more strongly than productivity. According to the figures for Germany, the individual level of real wages during a person's working life tends to go up at declining rates, with it stagnating only after at least 20 years of job experience and

16 See A Börsch-Supan (2013), Myths, scientific evidence and economic policy in an aging world, The Journal of the Economics of Ageing 1-2, pp 3-15.
17 See C Göbel and T Zwick (2009), Age and productivity: evidence from linked employer-employee data. Centre for European Economic Research, Discussion Paper, No 09-020; and A Börsch-Supan and M Weiss (2016), Productivity and age: evidence from work teams at the assembly line, The Journal of the Economics of Ageing 7, pp 30-42.
18 Even so, the growing share of the workforce made up of older workers with higher individual productivity might, ceteris paribus, boost macroeconomic productivity to a certain extent.
19 See D Bloom, D Canning and J Sevilla (2001), Economic growth and the demographic transition, National Bureau of Economic Research, Working Paper No 8685.
20 From the point of view of the employees, however, related net pay could nevertheless fall, as demographic change in Germany without any changes to the rules on social security benefits will probably lead to rising social security contributions on the part of employees, which in turn will depress net earnings. See M Gasche and J Rausch (2016), Beitragssatzentwicklung in der Gesetzlichen Krankenversicherung und der Sozialen Pflegeversicherung – Projektionen und Determinanten, Zeitschrift für Wirtschaftspolitik 65 (3), pp 195-238; and A Börsch-Supan et al (2016), Szenarien für eine nachhaltige Finanzierung der gesetzlichen Rentenversicherung, MEA Discussion Paper 03-2016.
21 See A Gelderblom, The relationship of age with productivity and wages, in European Commission (2006), Ageing and employment: Identification of good practice to increase job opportunities and maintain older workers in employment, Final Report.

remaining at an elevated level more or less unchanged in the period thereafter.[22] On the one hand, a gradually increasing percentage of members of the workforce in the upper age groups on a rather high wage level would thus, all other things being equal, increase macroeconomic wage growth. On the other, the typically lower wage increases among older members of the workforce are likely to have a dampening effect.

Impact of demographic change on fixed capital formation and capital deepening

Enterprises' fixed capital formation muted in recent years

Enterprises' fixed capital formation has been muted over the past five years. The restrained willingness to invest could also be linked to impending demographic change.[23] In the projections, it is assumed that the level of capital investment will adjust sluggishly to the numerical decline in the potential labour force in line with the rather gradual depreciation and obsolescence of the capital stock.[24] After all, over the longer term, fixed capital formation is likely to be geared to supply-side factors, which are primarily reflected in the trend labour supply and productivity, as well as the rate of physical and economic depreciation. The expected future decline in the potential labour force means that less capital will be required in the corporate sector.

Capital deepening only temporarily higher

Starting from an almost neutral level during the period from 2014 to 2016, capital deepening could increase at least temporarily on account of the sluggish adjustment of capital services to the declining potential labour force, thus bolstering labour productivity. Nevertheless, its contribution to labour productivity over the forecasting horizon is likely to be smaller than it was on average between 2000 and 2010.

Housing investment also affected by demographic change

Housing investment is likely to be affected by demographic change through different transmission channels than in the case of corporate fixed capital investment. First, housing is included in households' consumer goods and therefore tends to be subject to the user perspective of households. Second, residential properties are usually homeowners' most valuable assets, without directly feeding into the process of the provision of goods. Accordingly, housing investment in the medium term is likely to be influenced chiefly by the demographic-related demand for housing, which is made up of the number of households and the demand for housing per household.

Demographic-related demand for housing weakening investment dynamics

The declining native-born population is likely to be accompanied, as a general tendency, by falling numbers of households, although this will be offset by net migration, which looks set to remain positive. According to the results based on a model that differentiates between different age and population groups, including differences in household size, and which takes into account the housing needs of asylum seekers, a total of over 500,000 additional dwellings will be required between 2017 and 2025. That said, the rates of change in demographic-induced housing demand are nevertheless likely to enter negative territory over time. Furthermore, a household's demand for housing usually falls slightly in old age owing to changes in the family situation and

22 See D Lagakos, B Moll, T Porzio, N Qian and T Schoellman (2016), Life-cycle wage growth across countries, The Journal of Political Economy, forthcoming; R Orlowski and R Riphahn (2011), Lohnentwicklung im Lebenszyklus. Eine Analyse von Ausmaß, Begründung und Heterogenität von Lohnsteigerungen, Zeitschrift für Arbeitsmarktforschung 44, pp 29-41; and V Steiner and J Geyer (2010), Erwerbsbiografien und Alterseinkommen im demografischen Wandel – eine Mikrosimulationsstudie für Deutschland, DIW Berlin, Politikberatung kompakt.

23 See also the box on pp 44-46 on investment in the German corporate sector.

24 In mathematical terms, trend growth in fixed capital is derived from estimates of trend growth in the number of hours worked and of the rate of labour-augmenting technological progress. The theoretical model framework that underpins the medium-term projections is based on the assumption that labour input and capital services are complementary.

A reference value for business investment in Germany

Even though the underlying conditions have been favourable, the German economy has experienced muted investment activity for quite some time now. However, when exploring the question as to the appropriate level for the investment-to-output ratio, possible structural adjustments to demographically-induced lower potential output growth should also be taken into account. In answering this question, a suitable theoretical framework can be found in growth theory.

According to an empirically well documented finding, the relationship between an economy's capital stock and output is virtually constant over time.[1] Following this logic, the trend growth rates of the capital stock and output must be the same. The necessary (gross) investment in the capital stock must ensure that the capital stock can grow in line with potential output and that the depreciation of the existing capital stock is offset.

In formal terms, based on those theoretical considerations, the investment-to-output ratio in a growth equilibrium, $i^*(t)$, reflects the expenditure necessary to maintain a constant, equilibrium capital-to-output ratio, κ^*:[2]

$$i^*(t) = [n(t) + g(t) + \delta(t)]\kappa^*. \qquad (1)$$

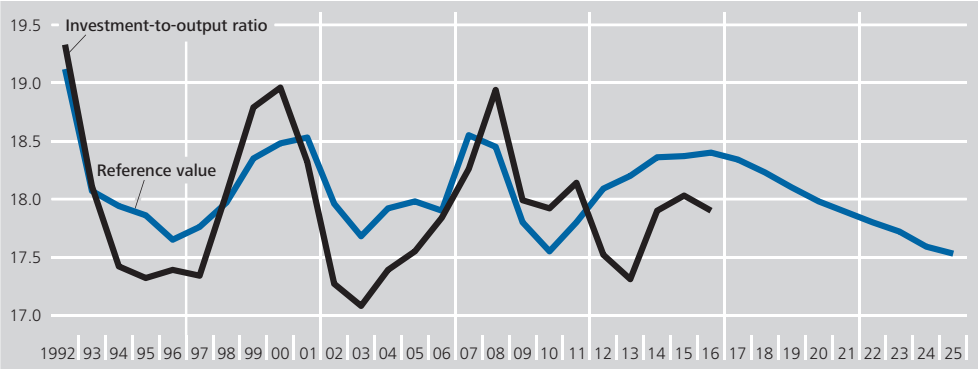
The reduction in the capital-to-output ratio otherwise envisaged over time is attributable to the trend growth in the number of hours worked, $n(t)$, the technology component in the production process, $g(t)$, and the rate of physical and economic depreciation, $\delta(t)$. Through its impact on the development of the number of hours worked and labour-augmenting technological progress, demographic change plays a significant role for the investment-to-output ratio in a growth equilibrium.

A growth theory-based reference value for the investment-to-output ratio can be derived from the variables $[\kappa^*,\ n(t),\ g(t),\ \delta(t)]$ calculated for the German business sector.[3] The potential output growth of the business sector, including the growth rates of the trend number of hours worked and (labour-augmenting) technological progress, can be obtained from the disaggregated approach to estimating German potential output growth.[4] In addition, depreciation rates for productive assets in the business sector can be determined using national accounts data.[5] The capital-to-output ratio is calculated on the basis of the business sector's capital services, which are obtained by weighting the fixed assets by asset class according to their user costs.[6] Aggregate capital services, however, are only available as an index series to which a level must be assigned in order to determine the ratio.[7] Output is measured in

1 See, for example, D Romer (2001), Advanced Macroeconomics, New York: McGraw-Hill, p 26.
2 See R Solow (1956), A contribution to the theory of economic growth, The Quarterly Journal of Economics, Vol 70, pp 65-94.
3 Defined here as the overall economy excluding real estate activities, agriculture, forestry and fishing, public service providers, education, health and other service providers.
4 See Deutsche Bundesbank, Advances in strengthening the economy's growth potential, Monthly Report, October 2007, pp 35-45.
5 The depreciation rate on productive assets in a growth equilibrium is regarded as being constant over time and is approximated by its long-term average.
6 See T A Knetsch (2013), Ein nutzungskostenbasierter Ansatz zur Messung des Faktors Kapital in aggregierten Produktionsfunktionen, Jahrbücher für Nationalökonomie und Statistik 233 (5+6), pp 638-660.
7 Capital services are measured in such a way that equation (1) reproduces the business sector's average investment-to-output ratio for the average values of the determinants from 2003 to 2011. Taking into account data up to and including 2011 ensures that the assessment of the investment activity is not distorted by the level assignment either at the current end or over the forecast horizon. Furthermore, the period selected ensures, first, that at least one full economic cycle is covered. Second, the output gap for the period from 2003 to 2011 is on average virtually closed.

Business investment-to-output ratio*

%



Source: Bundesbank calculations based on Federal Statistical Office data. * The investment-to-output ratio for 2010 is calculated as the ratio of nominal gross fixed capital formation to nominal gross value added of the business sector. Extrapolation is based on the real growth factors of both components. Investment-to-output ratio for 2016 estimated.

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terms of the real gross value added of the business sector.

The empirical implementation of the equilibrium relationships based on the neoclassical growth model assumes that the German economy was in a growth equilibrium during the period under consideration. However, the ratio of capital services to output in the business sector shows – at least in the 1990s – a trend increase, with trend growth rates declining over time. This suggests that, following German reunification, the German economy set out on a convergence path towards a new equilibrium. At the beginning of the 1990s, the production capacity of the east German economy is likely to have suffered considerably in terms of marketability as a result of the regime change. Moreover, the fall of the Iron Curtain entailed in some cases significant adjustments in the west German economy's production patterns.

The adjustment process towards the new balanced growth path is also likely to have been reflected in the development of the actual investment-to-output ratio. To ensure that the benchmark can be interpreted as a "steady-state" value for the entire period, the contribution of the convergence process is taken into account when determining the reference value.

The difference between the actual investment-to-output ratio and the reference value according to growth theory exhibits a procyclical path for the most part.[8] At the beginning of the 1990s, the actual investment-to-output ratio was above the reference value, whereas in the second half of the same decade, the deviation was close to zero. An investment gap – characterised by the actual investment-to-output ratio being below the reference value – predominantly occurs in times of economic slack, such as after the end of the "new economy" boom at the turn of the millennium.

Although the actual investment-to-output ratio has been below the equilibrium ratio according to growth theory over the past few years, it is likely that deteriorating supply-side conditions will dampen macroeconomic growth prospects in the medium term, particularly as a result of the declining potential labour force. According to the results, the reference value for the development of business investment could drop from almost 18½% at present to around

8 The investment-to-output ratio for 2010 is calculated as the ratio of nominal gross fixed capital formation to nominal gross value added of the business sector. The development of the real ratio is based on an extrapolation using the real growth factors of both components.

17½% by 2025, mainly due to the expected decline in the potential output growth of the business sector. It would then be at roughly the same level as in 2010, when it had reached its lowest value since German reunification.[9] Against the backdrop of the demographically-induced decline in the reference value by the middle of the next decade, the current investment-to-output ratio does not appear to be excessively low.

The trajectory of the reference value is subject to significant uncertainty, *inter alia* with regard to the assumed development of the potential labour force. If, say, actual immigration turned out to be higher than assumed in the baseline scenario, and if these migrants were available to the labour market, the potential labour force would show a more dynamic development. The reference value would thus be higher than in the baseline scenario.[10] In addition, a long-term change in the relative scarcity in the factor markets is likely to result in an adjustment of the optimum factor input relationship. However, even if a perceptibly higher equilibrium ratio of wages and capital costs (measured in terms of historical volatility) is assumed whilst disregarding the repercussions for economic output, the calculated reference value would reach a level below that of the prevailing reference value by the end of the projection period.[11]

9 In the baseline scenario, the analysis assumes a constant ratio of the two production factors labour and capital.
10 For more information on the underlying assumptions for both alternative scenarios regarding immigration, see pp 39ff.
11 Assuming a 2% higher equilibrium ratio of wage and capital costs, for example, the calculated reference value, assuming a "steady-state", would still be just over ½ percentage point lower at the end of the projection period than at present. This is based on the simplifying assumption that the relative price will increase linearly up until 2025 and, moreover, that the economy will fully adjust to changes in the relative price in each period.

levels of income.[25] By contrast, statistical data indicate that the share of expenditure allocated to housing for a typical household in the 65-80 age group showed a sharp increase in the ten-year period to 2013.[26] Ultimately, investment in adapting existing accommodation to make it more suitable for elderly persons is likely to give an additional boost to the housing sector, the main impact of which could be felt in the coming years. Overall, looking ahead, the amount of residential construction needed from a demographic perspective could become smaller and then have a retarding effect on housing investment.

Conclusion

Demographic change depressing growth rates of labour, capital and technological progress

The population decline and the ageing of the labour force in Germany will significantly lower trend growth over the medium term. Immigration, which is assumed to remain at a high level, and the higher labour force participation expected, particularly among the upper age groups, will continue to generate positive stimuli. However, under the existing underlying institutional conditions, the demographically induced decline in the supply of labour will, on balance, broadly offset the growth-promoting influence of both of these factors over the coming decade. Demographic change will also dampen capital accumulation and productivity growth. While capital intensity is likely to go on increasing somewhat for a while, fixed capital formation over the long term will be oriented to the future fall in the labour supply. From the point of view of enterprises, this aspect could already be playing a role in their cautious attitude towards making longer-term investments.

25 According to current statistical data, households whose principle wage earner is older than 65 have roughly 10% less living space than households with a principle wage earner aged between 35 and 45. See Federal Statistical Office, Einkommens- und Verbrauchsstichprobe, Einnahmen und Ausgaben privater Haushalte, Fachserie 15, Heft 4, Wiesbaden.
26 See Federal Statistical Office, op cit.

The projections indicate that medium-term growth will essentially be driven by advances in productivity. While productivity growth in the coming years will initially benefit from the positive contribution made by capital deepening, it will slow down as the labour force continues to age. In future, the dampening effects on productivity due to population ageing mean that the contribution of capital deepening to growth will probably be no higher than in the first decade of this century.