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A Long-run Macro-economic Model of the Austrian Economy (A-LMM 2.0)

New Results (2021)

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We use an updated version of the Austrian Long-run Macroeconomic Model (A-LMM) for a long-term projection of the Austrian economy until 2075. Our baseline scenario is the input for microsimulation models of the Austrian pension insurance system. A-LMM 2.0 is a neoclassical growth model using demographic indicators to determine TFP-growth, the savings and the inflation rate. The model allows for labour saving technological progress and replicates stylised facts about growing market economies with an ageing population. The current model update incorporates the recent population forecast, information from labour market and national accounts data. Compared to the previous report we expect higher labour market participation rates, lower output growth, and a temporary upswing in inflation.

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Table of Contents

1. Introduction[1]

The first version of the Austrian Long-run Macroeconomic Model (A-LMM) was developed in 2004 (*Baumgartner et al.*, 2004) and the model has been used subsequently in 2007 (*Hofer et al.*, 2007), 2010 (*Hofer et al.*, 2010), 2013 (*Kaniovski et al.*, 2013), and 2014 (*Kaniovski et al.*, 2014) for long-term forecasts of the Austrian economy. In this paper we present a new approach to make long-term projections based on the interplay between demographic and technological trends. The aim is to estimate and project the relationship between the future size and the age structure of the population and macroeconomic indicators (*Kaniovski – Url*, 2019). Compared to previous versions of A-LMM, the current model A-LMM 2.0 is more streamlined, i. e. the demand side of the economy as well as the government sector is only partly modelled. Instead, we focus on the supply side of the economy, specifically the relation between total factor productivity growth and demographic variables is now at the core of the simulation model.

Our motivation for restructuring A-LMM with an emphasize on the interaction between demographics and technological progress is based on evidence showing a hump-shaped lifetime productivity profile for individuals (*Skirbekk*, 2004, 2005; *Huber et al*. 2010), but it is also motivated by a series of publications from *Acemoglu – Restrepo* (2017, 2021, 2019) who emphasize the interaction between labour scarcity and investment activity with directed technical progress, i. e. investment into automation and digitisation.

Besides developing a new model A-LMM 2.0, we update the data base for the model. Specifically, the national accounts data and other administrative data are used up to the year 2020 and we calibrate the new model accordingly. Second, the model now includes forecasts for 1-year participation rates (by sex and age) for cohorts aged 15 through 74. Third, the "Opening"-scenario from the short- and medium-term forecasts of the Austrian economy from March 2021 (*Baumgartner – Kaniovski*, 2021) is fully implemented from 2021 through 2025. Fourth, we use the current demographic projections by *Hanika* (2020), i. e. all simulations use the current main variant of Statistic Austria's demographic projections.

After presenting the model in the next chapter, we will show the new trend labour supply forecast in section 3. The final section describes simulation results for three scenarios based on a range of assumptions about the yearly growth rate of long-run labour productivity (low: 1, base: 1.3, high: 1.5 percent). The appendix includes a detailed list of all variables.

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2. Model overview

Motivated by *Acemoglu – Restrepo* (2017, 2021, 2019) who describe the relation between directed technical change and labour scarcity in an endogenous growth model, we focus the core of the new model on the relation between demographic structure, the expected population size and the growth rate of technical progress as well as the automation and digitisation activities. We also follow *Gagnon et al.* (2016), *Eggertson et al.* (2019), and *Lunsford – West* (2019) and implement additional links between demographic variation and macroeconomic core variables, i. e. the total savings rate, the real interest rate and the inflation rate. While the total savings rate is an explanatory factor for total factor productivity growth in our model, the real interest rate explains the variation in the savings rate, and the inflation rate is central for the dynamic adjustment of existing pensions.

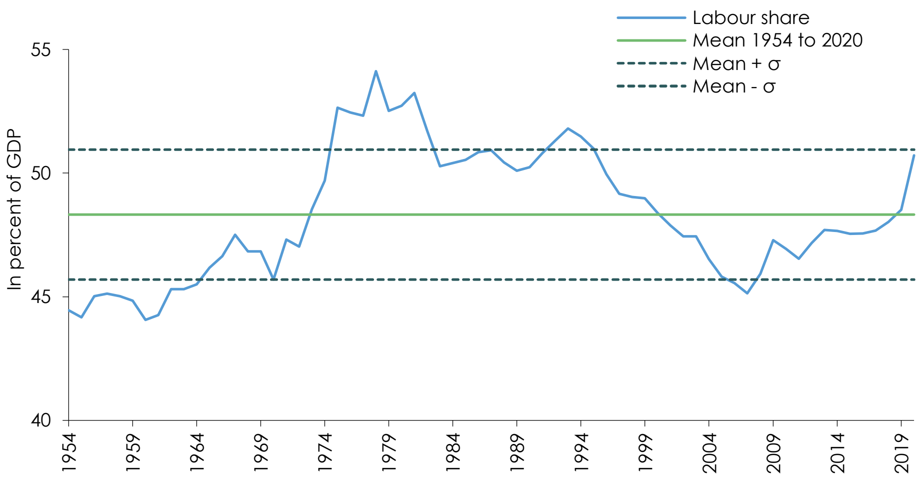
Waldman – Avolio (1986), *Verhaegen – Salthouse* (1997), and *Skirbekk* (2004, 2005) summarise the empirical evidence on the relation between age and individual productivity levels. These studies show a hump-shaped relationship between productivity and age, i. e. individual productivity starts from low levels at young age and increases quickly, but it peaks well before the end of the economically active period and declines afterwards. The individual productivity peak lies between the age of 35 and 54. This relationship is likely to persist, although labour supply will be affected by increasingly complex work tasks, new forms of work organisation, and increases in the statutory retirement age for women starting in 2024. Studies combining the age structure of the aggregate population with aggregate productivity indicators also confirm a negative relation between large cohorts of the youngest and oldest age groups on productivity, while a large share of middle-aged persons improves the overall productivity performance (*Lindh – Malmberg* 1999, 2010; *Feyrer* 2007; *Huber et al*. 2010; *Lindh et al.* 2010). *Vandenbroucke* (2021) suggests a mechanism relating labour productivity growth with the demographic composition. Even under exogenous and constant total factor productivity growth, this link works through the correspondence between human and physical capital stocks and the age structure. Overall, we expect a negative direct effect on aggregate productivity from future ageing due the shrinking size of middle-aged cohorts.

Part of this expected productivity slowdown is likely to be corrected by directed technological progress. Due to the expected shrinking of the working age population and its changing age composition, firms will have large incentives to substitute labour by robots and software. The consequences of automation and digitisation on labour productivity cannot be modelled within the canonical Solow growth model featuring a Cobb-Douglas technology and a constant exogenous rate of total factor productivity growth (*Solow*, 1956; *Swan*, 1956). The Cobb-Douglas technology directly relates factors of production, such as labour, L, and capital, K, to the output of goods and services, Y, using a production function

$$Y = f(A^k K, A^l L), \tag{2.1}$$

where *A* is a symbol for factor-augmenting exogenous technological progress, either enhancing the productivity of capital (A^k) or the productivity of labour (A^l). Variations of this approach are popular in Solow-type growth models assuming exogenous technological progress (*Mankiw et al.*, 1992). Endogenous growth models add the stock of ideas (*Romer*, 1990) or the stock of human capital (*Lucas*, 1988) to traditional capital and labour. *Grossman – Helpman* (1991) use innovation in terms of new goods and services to create endogenous growth based on past spending on research and development. In this model class an increase in the amount of capital per worker will usually result in a higher income share allocated to capital, or equivalently a shift in income from labour towards capital. Over the long-term, *Kaldor* (1961) showed that the income distribution is almost stable, thus contradicting the predictions from endogenous growth models. In a recent update of the so called Kaldor-facts *Jones – Romer* (2010) provide further evidence for a constant distribution of income between capital and labour. Evidence for Austria also hints at a constant long-run share, cf. Figure 2.1.

Figure 2.1: Income share of labour in Austria, 1954 to 2020



S.: WIFO, Statistics Austria – Ratio of compensation to employees to gross domestic product. The mean from 1954 through 2020 is 48.3 with a standard deviation of 2.6 percent.

The endogenous growth model by *Acemoglu – Restrepo* (2021) provides an alternative link between demography and productivity growth. It is based on a two-stage production technology. In the first stage, tasks are performed by combining labour input from middle-aged workers and capital. In the second stage, these tasks are combined with services provided by older workers (56 and older) and intermediate goods. In this model ageing indirectly increases the productivity in industries with greater opportunities for automation relative to industries with smaller potential for automation. Automating firms adopt newly developed technologies and substitute capital for labour in producing a task during the first stage. In the extreme case of full automation, a task will be completed by robots or software without using any labour input, i. e. labour will be displaced by hard- or software. The displacement effect describes the consequence of making labour redundant in the performance of a task and it implies lower labour demand and a smaller share of labour in the value added in automating industries. The wage share will decline in automating industries, although wages for middle-aged workers edge up in line with relative labour scarcity. Because of relative wage inflation, industries employing middle-aged workers more intensively, have stronger incentives to invest into automation and digitisation.

Automation and digitisation make feasible a more flexible combination of tasks with labour, machinery, and software, and increase productivity. The productivity effect in turn expands aggregate demand for goods and services, but it will not fully compensate for the job destruction caused by automation. Therefore, *Acemoglu – Restrepo* (2019) stress the role of newly developed technologies for the creation of new tasks for which labour has a comparative advantage. *Acemoglu – Restrepo* (2019) notice the disappearance of white-collar jobs after new computing power and software has been implemented, however, at the same time digitisation creates many new tasks like programming, data base design and management, maintenance of high-tech equipment, or computer security. Acemoglu and Restrepo label this type of automation/digitisation induced job creation as the reinstatement effect. By creating new tasks with a comparative advantage of labour, labour is reinstated into a new range of tasks and consequently labour demand increases. *Kaniovski – Url* (2019) provide a graphical illustration of this process. If the displacement effect is balanced by the combined outcome of the productivity and the reinstatement effect on labour demand, Kaldor's fact of a stable long-term share of labour in income would emerge.

The overall effect of ageing on total factor productivity is ambiguous because ageing dampens individual productivity while it also accelerates automation and digitisation induced productivity growth. The net effect depends on the relative size of these countervailing forces.

2.1 Implementation of age-dependent productivity in the simulation model

Several indicators for automation and digitisation have been suggested in the literature. For example, *Acemoglu – Restrepo* (2021) use the stock and the number of newly installed robots per 1000 manufacturing workers as the measure for automation and explain this variable in a series of cross-country regressions. Alternatively, they use imports or exports of robots and other automation-related machinery or the number of robotics-related patents. To adjust for business cycle variations and considering the long investment horizon for industrial robots, they use long-differences defined as the growth rate from 1990 to 2015 in their regressions. The explanatory variables in a cross section of developed and developing countries are forward-looking demographic variables, e.g. the change in the ratio of older to middle-aged workers between 1990 and 2025, region dummies (World Bank regions), initial log in per capita GDP, the log population, and the average years of schooling in the population. The regression results show a positive and statistically significant relationship between population ageing and automation.

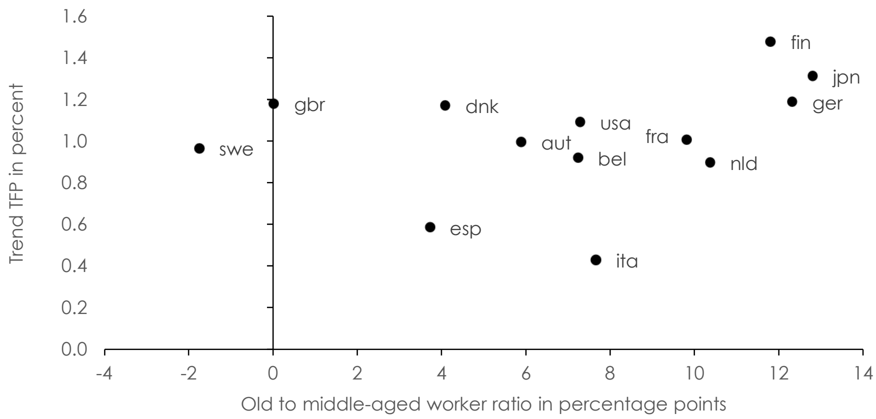
Abeliansky – Prettner (2017) integrate the shrinking working-age population directly into a Solow-type growth model assuming a constant savings rate, inelastic labour supply, full employment, and time periods with a length of 25 years. Firms combine three factors of production: human labour, traditional capital (machines, assembly lines, buildings, automobiles), and automation capital (robots, 3-D-printers, driverless cars). The critical assumption in their model is the degree of substitutability between labour and both types of capital. Whereas traditional capital is an imperfect substitute for labour, automation capital is a perfect substitute. Thus, automation capital takes the role of a production factor that can be accumulated and that is perfectly substitutable for labour. Once a task is automated, human labour becomes part of a reproducible factor. Aggregate saving is a constant fraction of wage income and can be saved either by investing in traditional capital or by accumulating automation capital. A full-arbitrage condition between both types of capital implies that their returns are equal. In this set-up, automation and digitisation offer an opportunity to counteract the expected labour shortages implied by demographic forecasts. In this model the automation density is endogenous and depends on the parameters of the production function, the lagged automation density, the rate of growth of the population, and the savings rate. Instead of long-differences, *Abeliansky – Prettner* (2017) use 3-year time averages from a panel of 60 countries and regress the growth rate of installed robots on the expected change in the population, the investment share in GDP, per-capita income in the starting year of the panel, a measure of openness to international trade, and the gross enrolment ratio in secondary school. The change in robot density and expected population growth are significantly negatively related.

Both approaches motivate the structure of the panel regression models in *Kaniovski – Url* (2019). The share of information and communication technology in the overall stock of capital and trend total factor productivity growth are both related to demographic variables showing the expected change in the demographic structure and the future size of the population. Austria's future population dynamics will drive productivity growth, conditional on a few additional variables suggested in the literature on empirical growth dynamics.

In an ageing society, the number of old aged workers will increase relative to the number of middle- and young-aged workers. If middle-aged workers have a higher productivity as compared to older workers, cf. *Skirbekk* (2004), a negative relation between the old to middle-aged worker ratio and TFP growth rates should emerge. As a first descriptive analysis, we show in Figure 2.2 a cross-plot of average trend TFP growth rates and the extent of ageing over the period 1980 through 2016 for a sample of developed countries. We cannot identify a strong negative relation in Figure 2.2, because Finland, Germany, and Japan form a cluster in the right-hand upper corner of the cross-plot which creates a positive correlation between both variables. On the other hand, directed technological change should emerge in advance of expected declines of the working age population, thereby increasing productivity through the displacement effect mentioned in *Acemoglu – Restrepo* (2021). Figure 2.3 indicates an overall positive relation between historical data for the average rate of change in the working-age population and the change in ICT intensity. Because we find a weak positive relation in this bivariate analysis, we employ a more powerful multivariate analysis in which we use year-to-year variation, a forward-looking concept for the expected change of the working age population which is based on country-specific population forecasts, we account for additional explanatory variables, and we control for country-fixed effects. Panel estimates presented in *Kaniovski – Url* (2019) show a close and statistically significant relation between demographic variables and total factor productivity growth featuring the expected signs.

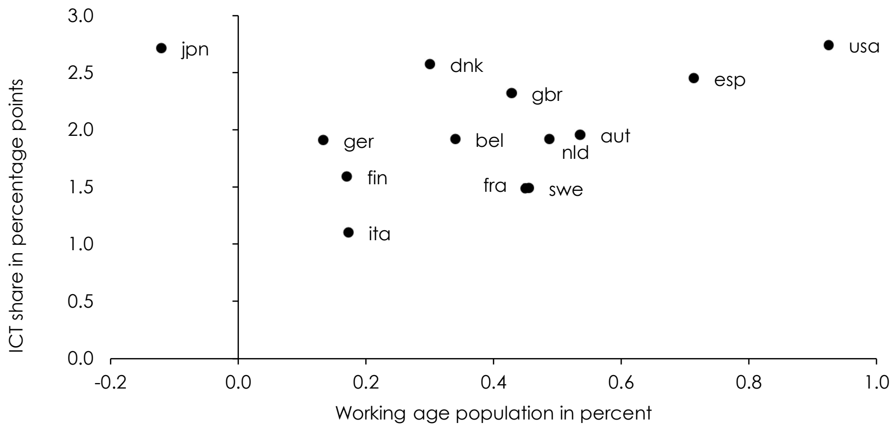
We use trend estimates of TFP-growth derived from the unobserved components model used by the European Commission to produce smooth trends from historic data and the short- and medium-term forecast (*Baumgartner – Kaniovski*, 2021). This approach produces smooth annual observations and removes business cycles from trend growth rates.

Figure 2.2: Historical comparison of average growth rate in trend TFP with the change in the ratio of old to middle-aged population, 1980-2016



S: Eurostat, United Nations, Kaniovski - Url (2019). - Trend TFP computation based on EU-Commission method. The old to middle-aged worker ratio is defined as 55-64 years old to the 25-54 years old population.

Figure 2.3: Historical comparison of average changes in the ICT-investment share and the working age population, 1980-2016



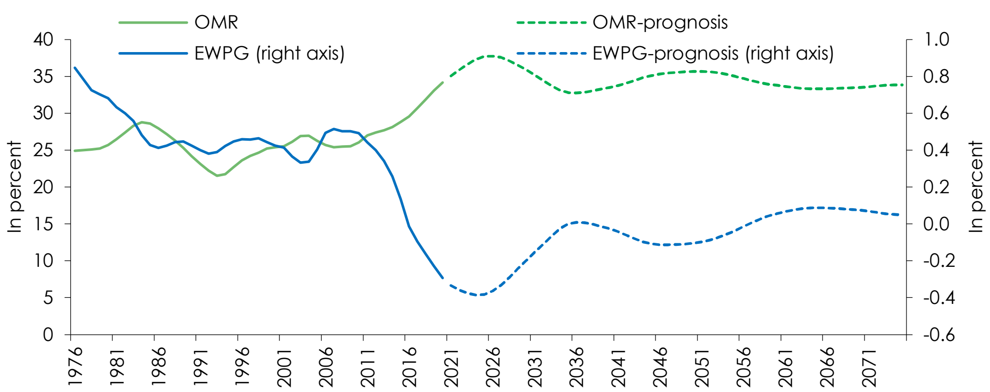
S: Eurostat, OECD, United Nations, Kaniovski - Url (2019). - Share of investment in Information and Communication Technology (ICT) in gross capital accumulation. Working age population is 15-64 years old.

The EC estimates of potential output, and similar estimates by other institutions, typically still include some cyclical fluctuations. The critique of excessive procyclicality of potential output estimates is frequently voiced in their evaluations (*EU IFIs*, 2018). For this reason, we control for the business cycle by adding the output gap to the regression model.

The expected sign of the direct quality effect of ageing on productivity growth is negative, i. e. as an older labour force is expected to be less productive, an increasing share of the old-to-middle aged population will depress productivity growth. The history of the old-to-middle age ratio, *OMR*, shows a more or less flat development at the beginning of the sample in Figure 2.4, it starts to rise after 2007 gathering pace after 2017. This development created more pressure on the rate of total factor productivity growth already since 2007, which coincidentally corresponds to the beginning of the financial market crisis.

In the empirical application we seek to separate the scarcity effect resulting from the expected shrinking of the labour force from the quality effect related to the ageing of the population. The expected scarcity of labour will drive up automation and digitisation investment, thus productivity growth will be increased indirectly through labour augmented technical progress. Figure 2.4 also shows the development of the average expected rate of change of the working age population over the next ten years, i. e. the observation in 2020 shows the expected average growth rate over the period 2021 through 2030. The highest expected growth rate in Figure 2.4 was registered in 2007 at 0.5 percent per year. Afterwards this rate declined towards zero giving rise to an expected shrinking of the working age population over the next ten years since 2016. This implies a positive impact on automation and digitisation investment since 2007. Demographic pressure will continue until 2024, when the rate of change reaches its trough. Afterwards the stress becomes less intensive, but the working age population is still expected to shrink throughout the following decade until the mid-2030s. The effect on productivity growth will only be felt indirectly, because higher ICT-investment has to show up in strengthened productivity numbers.

Figure 2.4: Ratio of old to young aged persons and average expected change



S: Statistics Austria - OMR: population aged 55-64 relative to population 24-54 in percent. EWPG: expected average rate of change in the working age population over the next 10 years.

2.1.1 Information and communication intensity of the aggregate capital stock

We capture the indirect effect of demographic change on technical progress by relating the Information and Communication Technology (including software) intensity of the capital stock (*ICT*) to the expected average rate of change in the working age population over the next ten years (*EWPG*). ICT is our preferred proxy for labour-saving automation investment (*Brynjolfsson – Hitt*, 2000; *Basu et al.*, 2001). Our definition of ICT includes software in addition to information and communication equipment. This is important since software – as a means of production – plays a crucial role in the process of automation and digitisation of business processes (*van Ark*, 2016). The share of ICT equipment and software in the total capital stock tends to be volatile and procyclical like most investment expenditures. We therefore smooth the ICT intensity using an HP-Filter with smoothing parameter ($\lambda = 10$) to remove excessive business cycle induced fluctuations. If the average rate of change in the working age population is positive, firms have a low incentive to invest in labour saving technology. This negative relation implies a positive response of ICT to the expected decline in the working age population. The length of the horizon is 10 years, which is mainly motivated by the depreciation period for automation capital. We add the output gap (*YGAP*), resulting from the unobserved component model to the ICT-regression equation to control for possible remaining business variation. Investment spending is also related to the price of investment capital. In the case of ICT, we use the deflator of information and communication capital in the USA (*USPICT*), cf. *Jorgenson – Stiroh* (2000) and *Gust – Marquez* (2004), and we expect a negative response of investment activity with respect to higher prices. The preferred specification for this relation is based on the results presented in Table A1.2 in *Kaniovski – Url* (2019)

$$ICT_t = \beta_0 + \underbrace{\beta_1}_{-} EWPG_t + \underbrace{\beta_2}_{+} YGAP_t + \underbrace{\beta_3}_{-} USPICT_t. \qquad (2.2)$$

2.1.2 Growth in total factor productivity

The rate of change in trend total factor productivity (*TFP*) depends directly on shifts in the population structure and indirectly – thorough induced ICT-spending – on the expected change in the size of the future working age population. We use the ratio of older (55-64) to middle-aged (25-54) workers (*OMR*) as a measure for the direct structural effect, cf. *Acemoglu – Restrepo* (2021). Due to the hump-shaped productivity profile a rising ratio of older to middle-aged workers should reduce total factor productivity.

$$\frac{TFP_t - TFP_{t-1}}{TFP_{t-1}} \cdot 100 = \beta_0 + \underbrace{\beta_1}_{-} OMR_t + \underbrace{\beta_2}_{+} (ICT_t - ICT_{t-1}) + \underbrace{\beta_3}_{+} YGAP_t + \underbrace{\beta_4}_{+} OPEN_t + \underbrace{\beta_5}_{+} SR_t \qquad (2.3)$$

In view of *Danquah et al*. (2011), we select the savings rate (*SR*) and trade openness (*OPEN*) as additional explanatory variables for which we also expect a positive relation to trend TFP. The more an economy saves, the more it can invest. Conventional wisdom suggests that more open economies feature higher levels of competition on domestic markets, and they have better access to new foreign technology. Some of this technology is embodied in traded goods, but other transmission channels via trade in services and foreign direct investment can also be important. Our forecast for OPEN results from a univariate exponential smoothing method (cf. Kaniovski – Url, 2019). The forecasts show a moderate increase in openness over the next decades. The output gap is expected to be zero after 2025. Table A.1.1 in *Kaniovski – Url* (2019) provides estimates for the β_i in this equation.

2.1.3 Aggregate savings

The aggregate savings rate shows the combined savings activity of private households, enterprises, the general government, and the foreign sector (current account balance). Because all these sectors have very different motivations for their respective saving decision, we have no clear-cut hypothesis on the structure of a possible empirical model and the sign of the parameters, but *Wüger – Url* (2005) and *Huber et al*. (2010) present evidence of an age dependent savings ratio across Austrian households. Based on the discussion and the results in *Kaniovski – Url* (2019) we suggest the following relation:

$$SR_t = \beta_0 + \underbrace{\beta_1}_{-} YPR_t + \underbrace{\beta_2}_{-} OPR_t + \underbrace{\beta_3}_{+} YGAP_t + \underbrace{\beta_4}_{-} PENR_t + \underbrace{\beta_5}_{-} RR_t \qquad (2.4)$$

where the total savings rate depends on the current young dependency ratio (*YPR*) and the old dependency ratio (*OPR*) as demographic indicators. They are defined as the share of individuals aged between 15 and 24, and those 65 or older in the total population, respectively. We prefer two separate measures because the savings behaviour of families with kids may deviate strongly from the behaviour of retirees.

The set of additional control variables in the regression model takes care of factors relevant for either private or public households, and for the behaviour of the business sector. Besides providing a measure for the capacity of private households to save out of their current disposable income, the output gap (*YGAP*) is also relevant for the development of the public sector deficit and the implementation of private sector investment plans. Our model also includes a variable indicating the generosity of the public pension system. We use the retirement replacement rate (*PENR*) for this purpose, which is kept constant at the 2019 value over the projection horizon. The expected sign of the coefficient is negative because a more generous pension system is likely to provide lower savings incentives. The aggregate effect of the real interest rate (*RR*) over all sectors is ambiguous. First, for private households the income and substitution effects of an interest rate shock have opposite effects. Second, with respect to private businesses, a higher interest rate increases the user cost of capital and reduces investment activity. We expect the overall effect of the real interest rate to be negative, especially since investment is likely to be sensitive to the interest rate. Finally, government debt becomes more expensive during times of high interest rates, thus increasing budgetary pressure. The corresponding estimates for the coefficient are given in Table A.1.3 in *Kaniovski – Url* (2019). The preferred specification features the expected negative coefficients for both demographic variables, implying a net-reduction in the savings rate with respect to the expected ageing of the society.

We impose the dynamic efficiency condition on the future path of the real interest rate. This assumption guarantees that no over-accumulation of capital will occur in the future. The future path of the real interest follows:

$$RR_t = RR_{t-1} + 0.25\left(\frac{Y_t - Y_{t-1}}{Y_{t-1}} + 0.25 - RR_{t-1}\right), \qquad (2.5)$$

which forces the real interest rate to converge from the latest observed value towards the growth rate of real output plus a surcharge of 0.25 percentage points.

2.1.4 Consumer price inflation

Finally, in contrast to the assumption of a constant rate of inflation of 2 percent per year in previous versions of A-LMM – corresponding to the threshold for the inflation target from the European Central Bank – we combine the 2 percent ECB-threshold with a robust empirical phenomenon: the development of the consumer price index (*CPI*) depends on demographic factors. Macroeconomic theory regards inflation, by and large, as a monetary phenomenon that can be held in check by providing independence to the monetary authority and establishing an inflation targeting regime (*Ilzetzki et al.*, 2020). This corresponds exactly to the set-up of the European System of Central Banks. Our empirical model for inflation rates uses the young (*YPR*) and old dependency ratios (*OPR*) as demographic indicators. This choice is based on recent work by *Juselius – Takáts* (2018) and *Goodhart – Pradhan* (2020), and the reasoning that an increase in the dependent population ratios (children, adolescents, young adults and retirees) signals pressure on the inflation rates because the dependent population does not fully participate in the production process but still consumes goods and services thus creating potentially a situation of excess demand.

$$\frac{CPI_t - CPI_{t-1}}{CPI_{t-1}} \cdot 100 = \beta_0 + \underbrace{\beta_1}_{+} YPR_t + \underbrace{\beta_2}_{+} OPR_t + \underbrace{\beta_3}_{+} YGAP_{t-1} + \underbrace{\beta_4}_{+} NR_t + \underbrace{\beta_5}_{+} OPEN_t \qquad (2.6)$$

Our empirical results show a positive correlation of both dependency ratios with inflation rates. Periods of high inflation tend to coincide with periods of high demographic dependency ratios. We also include the natural rate of interest (*NR*) into our simulation model to control for the stance of monetary policy. The natural rate of interest is the short-term real interest rate which is compatible with a growth path at the trend level and a stable rate of inflation. If the target rate of the central bank is equal to the natural rate this implies that the output gap is closed and the inflation rate is within the desired range (*Taylor*, 1993). Monetary policy is regarded as restrictive if the target rate is greater than the natural rate. Accommodative monetary policy would set the target rate below the natural rate. The natural rate of interest cannot be directly observed rather it must be estimated indirectly. Recent estimates by *Holston et al.* (2017) show that the natural rates of interest in the USA and the euro area have been decreasing sharply since the global financial crisis, and even became negative in the euro area (*Brand et al.*, 2018).

Future values of the natural interest rate will follow the real rate of interest, RR_t, but will take account of the empirical regularity of a spread between real long- and short-run interest rates. The spread in Austria was roughly 1 percentage point over the period 1973 through 2020. Thus, the corresponding equation for the natural rate is:

$$NR_t = NR_{t-1} + 0.25(RR_{t-1} - 1 - NR_{t-1}) \qquad (2.7)$$

Other control variables include the output gap from the previous year as a measure of inflationary pressure due to business cyclical variations. Finally, we include trade openness (*OPEN*) into the model. In general, a more open economy will show a bigger response to import prices changes and exchange rate fluctuations. The estimates of the parameters for the preferred equation can be found in Table A1.4. in *Kaniovski – Url* (2019).

The demographically determined inflation rate is then combined with the ECB-threshold using a logistic weighting function which centered around 2035. In 2026 the forecast is fully based on the demographically determined inflation rate while year by year the ECB target rate gets a higher weight in the combined forecast such that it converges to 2 percent by 2040.

2.1.5 Production function and real gross domestic product

The long-run growth path is determined by demographic and supply side factors. Firms are assumed to produce goods and services using capital and labour as inputs. It is well known that a constant return to scale production technology under Harrod-neutral technical progress is one of the few specifications consistent with Kaldor's facts. We therefore assume a Cobb-Douglas production function with demography dependent Harrod-neutral technical progress:

$$Y_t = TFP_t \cdot HOURST_t^{ALPHA} \cdot K_t^{(1-ALP \quad)} \qquad (2.8)$$

The Cobb-Douglas production function implies a constant income share of factor inputs in the total value added of the economy. These are given by the shares of gross operating surplus and wages to GDP. Figure 2.1 shows that the income share of labour varies in a narrow range between 45 percent and 55 percent of GDP, rarely crossing the one standard deviation band around the mean from 1954 through 2019 of 50.9 percent. For this reason, the assumption of long-term constancy of the income share of labour over a long run is supported by historic data from Austria. The Cobb-Douglas production function implies a unit elasticity of substitution between capital and labour. This assumption is asymptotically valid given the common INADA assumptions on the production function (*Barelli – Abreu-Pessoa*, 2003; *Litina – Palivos*, 2008).

In exchange for their supply of labour, households receive wage income. A special characteristic of the new A-LMM 2.0 version is the focus on disaggregated labour supply. In general, the labour force can be represented as a product of the population age group and the corresponding labour market participation rate. In the model we implement highly disaggregated (by sex and 1-year age groups) participation rates. This gives us the opportunity to account for the different behaviour of males and females (where part-time work is a major difference) and young and elderly employees (here education and early retirement comes into consideration).

2.1.6 Labour Supply

Labour supply is based on the product of one-year participation rates for males (PRM_i) and females (PRF_i) for age groups i=15 through 75+ with the corresponding current population projections for males ($POPM_i$) and females ($POPF_i$), cf. section 3 for details of the projection of participation rates. We aggregate individual cohorts into the aggregate labour force (*LF*)

$$LF_t = \sum_{i=1}^{75+} \left(PRM_{i,t} \cdot POPM_{it}\right) + \sum_{i=15}^{75+} \left(PRF_{i,t} \cdot POPF_{it}\right), \qquad (2.9)$$

where participation rates are defined as the sum of employees, unemployed persons, and the self-employed (LE+LU+LSS) over the corresponding population group.

Dependent labour supply (*LS*) grows along the path given by the development of the labour force:

$$\frac{LS_t - LS_{t-1}}{LS_{t-1}} = \frac{LF_t - L\ _{t-1}}{LF_{t-1}}. \qquad (2.10)$$

The projection of the self-employed (*LSS*) assumes a constant share of self-employed in the number of gainfully employed persons. Consequently, we can compute this variable by setting its growth rate equal to the current growth rate of the labour force (*LF*):

$$\frac{LSS_t - LSS_{t-1}}{LSS_{t-1}} = \frac{LF_t - LF_{t-1}}{LF_{t-1}} \qquad (2.11)$$

The number of self-employed farmers (*LSSA*) will decline over next decades at a decreasing rate. Starting with -2 percent annually until 2030, the rate of reduction will half every decade until the end of the forecast horizon. This will result in a substitution of farmers leaving the labour force by self-employed persons in other economic activities (LSSNA).

A-LMM 2.0 as a long run model is supply side driven and therefore does not generate business cycle fluctuations. The labour market equilibrium is characterised by a time varying natural rate of unemployment (NAWRU) as implied by the panel data model used by the European Commission for their medium-term forecast. The actual unemployment rate (*U*) converges to the natural rate of unemployment (*NAWRU*) over the medium-term horizon. The value of the long-term structural unemployment rate is based on the results of a cross country panel regression of short-term NAWRUs from old EU member states on unemployment benefit replacement rates, expenditures on active labour market policies, the power of unions proxied by union density, and the tax wedge together with a set of cyclical variables (TFP, fraction of employment in construction, and the real interest rate). We expect no changes in the structural variables in the future and assume that all cyclical variables converge to their mean. Therefore, the final value for the NAWRU does not change.

Labour input provided by dependent labour and measured in persons (*LE*) equals:

$$LE_t = LS_t \cdot \left(1 - \frac{U_t}{100}\right), \qquad (2.12)$$

from which we subtract *LENA*, the number of persons on maternity leave or in military service (Karenzgeld- bzw. Kindergeldbezieher und Kindergeldbezieherinnen und Präsenzdiener mit aufrechtem Beschäftigungsverhältnis), to arrive at active dependent labour input measured in persons (*LEA*):

$$LEA_t = LE_t - LENA_t \qquad (2.13)$$

For the projection, we assume a constant relationship of *LENA* to the population group aged 0 to 4 years. Active labour input (LEA) provides, in combination with the extrapolated number of average working hours per persons according to national accounts standards (*HOURST_AV*), the total number of hours worked (labour volume) in the production function:

$$HOURST_t = (LEA_t + LSS_t) \cdot HOURST\_AV_t. \qquad (2.14)$$

We assume a dampened continuation of the long-term trend towards more part-time jobs, i. e. a further decline in the hours worked per person per year. The increasing share of females in the labour supply is the main motivation for this development although higher education will increase the opportunity costs for parents to stay at home. Starting from 1,745 hours per year in 2019, this variable will decrease towards 1,600 hours in 2075. Compared to the starting value this amounts to a cumulative reduction by 8 percent until 2075.

2.1.7 **Aggregate capital stock**

In line with the assumption by the European commission, the real capital stock (*K*) adjusts such that the capital output ratio remains constant. This rule implicitly determines gross capital formation (investment volumes):

$$\frac{K_t - K_{t-1}}{K_{t-1}} = \frac{HOURST_t - HOURST_{t-1}}{HOURST_{t-1}} + \frac{TFP_t - TFP_{t-1}}{TFP_{t-1}} \cdot \frac{1}{ALPHA}, \qquad (2.15)$$

2.1.8 **Hourly real wage growth**

The development of real hourly wages (*W*) is derived directly from the marginal productivity of labour:

$$\frac{W_t - W_{t-1}}{w_{t-1}} = ALPHA \cdot g\left(TFP_t \cdot \left(\frac{K_t}{HOURST_t}\right)^{(1-ALP \quad)}\right), \qquad (2.16)$$

Where g(.) represents the growth rate of the term inside the bracket. Another feature of the Cobb-Douglas technology is that the marginal and the average products of input factors grow at identical rates, their levels differing by the respective factor shares. In the baseline, we assume an age-dependent time varying development of TFP and consequently the annual rate of change of labour productivity varies over time. In combination with the development of the worktime and the inflation rate, the change in hourly wages defines the path for the compensation for employees at current prices (*YLN*):

$$\frac{YLN_t - YLN_{t-1}}{YLN_{t-1}} = \frac{HOURST_t - HOURST_{t-1}}{HOURST_{t-1}} + \frac{W_t - W_{t-1}}{W_{t-1}} + \frac{CPI_t - CPI}{CPI_{t-1}}. \quad (2.17)$$

2.1.9 Nominal gross domestic product

Nominal GDP (YN) growth is equal to the sum of real GDP growth (YR) and the development of the GDP deflator (PY) which itself grows in line with consumer price inflation after 2025:

$$\frac{YN_t - YN_{t-1}}{YN_{t-1}} = \frac{Y_t - Y_{t-1}}{Y_{t-1}} + \frac{PY - P\ _{t-1}}{PY_{t-1}}. \quad (2.18)$$

3. Update of (Trend) labour supply scenario

This section describes the update of the labour supply projections. We use the dynamic cohort method to project the labour force for the period 2020 to 2070.[2] In this model version the previously used 5-year participation rates (by sex and age) have been replaced by 1-year participation rates. The new labour supply scenario shows the outcome of extrapolating recent trends in the labour market behaviour (entry and exit rates) and assumes a continuation of the educational expansion prevalent in Austria during recent decades. The projection also includes the expected effects of the increase in the statutory retirement age of women and the impact of more demanding requirements for the corridor pension (40 years of contributions).

The dynamic cohort method (*Scherer,* 2002) is based on a model that calculates the rates of entry and exit in the labour market for each cohort for a certain time period and assumes that future lifetime participation profiles are parallel to those observed in the past. Formally, the dynamic projection method is based on the observed distribution of entry and retirement probabilities by age. Let there be 1-year age groups, then the length of the periods considered is also one year. To calculate the rates of entry and exit in the labour market for each age group, the average of these probabilities for the years 2015 until 2019 is taken. Let PR_x^t be the participation rate of age group x in period *t* (e. g., the participation rate of the age group 15 in 2015), then the probability of persons aged x to retire before period *t*, WX_x^{1519}, is the mean of the retirement probabilities from 2015 to 2019, WX_x^t:

$$WX_x^t = 1 - \frac{PR_{x+1}^t}{PR_x^{t-1}} \geq 0,$$
$$WX_x^{1519} = \frac{1}{5} \sum_{t=2015}^{2019} WX_x^t \qquad (3.1)$$

the probability to enter into the job market, WN_x^{1519} is the mean of the probabilities from 2015 to 2019 to enter into the job market, WN_x^t

$$WN_x^t = 1 - \frac{\overline{PR} - PR_{x+1}^t}{\overline{PR} - PR_x^{t-1}} \geq 0,$$
$$WN_x^{1519} = \frac{1}{5} \sum_{t=2015}^{2019} WN_x^t \qquad (3.2)$$

where $\overline{PR}$ is an upper limit on participation rates of 99 percent (95 percent for females).

We use the male and female participation rates in 1-year age groups for the years 2014 until 2019, to calculate the mean entry and retirement probabilities for the years 2015 until 2019 for men and women separately. Based on the assumption that these probabilities will not change

[2] We exclude data for 2020, because the COVID-19 pandemic probably distorted labor supply decisions.

during the projection period 2020 to 2075, the projected participation rates for this period are given by (*t* = 2020, ..., 2075):

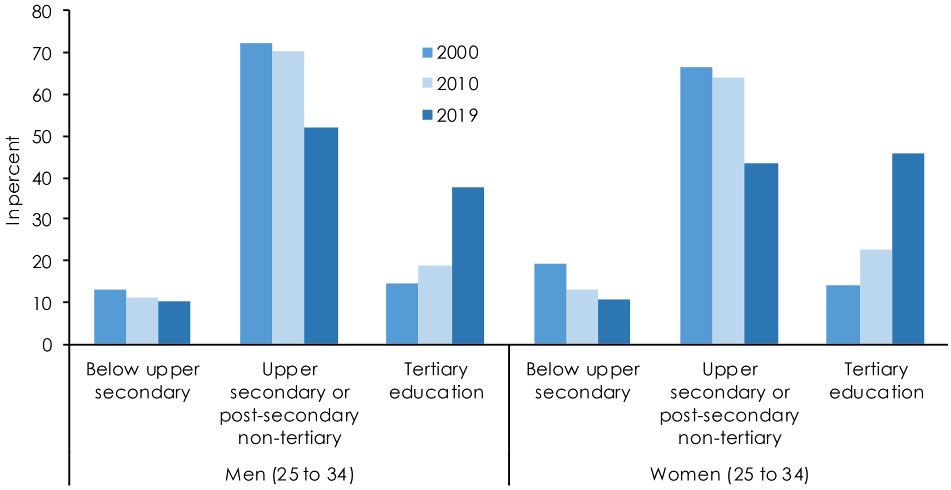
$$
\begin{aligned}
&PR_{x+1}^{t} = PR_{x}^{t-1}(1 - WX_{x}^{1519}), && \text{if } WX_{x}^{1519} > 0,\\
&PR_{x+1}^{t} = \overline{PR} \cdot WN_{x}^{1519} + PR_{x}^{t-1}(1 - WN_{x}^{1519}), && \text{if } WN_{x}^{1519} > 0, \qquad (3.3)\\
&PR_{x+1}^{t} = PR_{x}^{t-1}, && \text{otherwise.}
\end{aligned}
$$

An adjustment mechanism is introduced for young cohorts. We assume that the participation rates of the persons aged 15 to 24 remain at their 2019 level. A decrease in the participation rate of the young age groups, which is due to the extended duration of full-time education, would automatically imply a negative trend for the participation rates of prime-age persons in the future. Additionally, we assume that the participation rate of females aged 25 will increase by 2½ percentage points within the next five years to take the stronger labour market attachment of females into account. We made a further adjustment of one percentage point for females aged 35 through 45. We increased the participation rate of these cohorts gradually between 2026 and 2035 by 0.1 percentage point per year. Without this adjustment female participation rates in these cohorts would slightly decrease after 2030.

Further adjustments are necessary to include potential effects of pension reforms. First, later labour market entries due to longer formal education (fewer contribution years at the age of 62) will reduce the possibility of early retirement (corridor pension) due to the minimum requirement of 40 years (Figure 3.1). Therefore, we assume that the participation rates of males aged 62 to 65 will increase by 4 percentage points in the period from 2025 to 2034.

We expect that the increase in the statutory retirement age of females will result in higher participation rates. To model the effects of pension harmonisation we make the assumptions that the exit rates of elderly females will converge towards the exit rates of males of the same age. For the females aged 56 to 59 we assume partial convergence, which implies an increase in the participation rate of 1, 2½, 4, and 5½ percentage points until the year 2035, respectively. For older females we assume full convergence. Table 3.1 shows the estimated impact of the pension reforms on the participation rates of the elderly. For males aged 60 to 64 we estimate an effect of 2 percentage points. The increase in the statutory retirement age of females should yield to considerable higher labour market attachment of older women. We project an increase of 4 percentage points in the age group 55 to 59. In the age group 60 to 64 participation rates should rise by 26 percentage points. To allow a comparison with the next EU-Ageing report (*European Commission*, 2020), we combine both age groups into the group of 55 to 64 years old. For this age group the resulting increase in male participation rates is 1 percentage point, while females will lift their labour supply by 15 percentage points. The participation rates for the next EU-Ageing report are almost identical, cf. the lower panel in Table 3.1.

Figure 3.1: Development of Educational attainment among groups at age 25 to 34 in Austria



S: OECD, Education at a Glance 2020.

A new feature of the current projection is the full integration of the medium term WIFO forecast (*Baumgartner – Kaniovski*, 2021) into the long-term projection. This fully determines the first years of the simulation (2021-2025) because the medium-term WIFO-forecast is treated like exogenous data. The long-term forecasts of participation rates, on the other hand, are based on the cohort model with base years 2015-2019 and starting already in 2021. Therefore, we adjust the forecasts for 1-year participation rates of males and females resulting from the cohort model to the levels implied by the medium-term WIFO forecast. In practice we multiply 1-year participation rates from the cohort model for the years 2021 through 2026 by positive factors for each year (2021: 0.999, 2022: 1.009, 2023: 1.020, 2024: 1.031, 2025: 1.044, 2026: 1.053) such that the forecast of the participation rate of a specific cohort does not surpass the 99 percent upper limit $\overline{PR}$ and the resulting aggregate labour force still matches the WIFO medium-term forecast.

Table 3.2 compares the adjusted participation rates from the current projection with the previous projections in *Kaniovski et al.* (2014). We now, project considerably higher participation rates for the elderly. In our last projection from 2014, we strongly underestimated the increase in the participation rates of the elderly between 2014 and 2019: Until 2019 the participation rates of females aged 55 to 64 increased from 35 to 49 percent, and for males from 55 to 67 percent. Overall, the current participation rates are by 10 and 8 percentage points, for females and males respectively, above the values we expected in 2014. The medium-run forecast by WIFO implies a further increase of the participation rates of the elderly of around 6.5 (females) and 3.3 (males) percentage points until 2025. Over the following ten years the participation rates of the elderly males will increase by a further 5 percentage points, in response to lower new pension entitlements in case of early retirement. Driven mainly by the harmonisation of the statutory retirement age, the participation rates of females aged 60 to 64 should increase by 27 percentage points, for the age group 55 to 59 we expect an increase of 6 percentage points.

Figure 3.2 presents the overall effects of the cohort method and our assumptions on the effects of past pension reforms on participation rates. The biggest advances will be in the age groups close to the statutory retirement age. Figure 3.3 shows the development of participation rates for both sexes and aggregate age groups over time. Owing to the mechanics of the cohort method, most of the adjustment will be completed by 2040.

Table 3.1: The impact of pension reforms on participation rates in 2070

	Projection year			
	2014[1])	2017[2])	2020[3])	2021[4])
	Percentage points			
	A-LMM			
Females 55 to 59 years	15	-		4
Females 60 to 64 years	27	-		26
Males 55 to 59 years	3	-		0
Males 60 to 64 years	17	-		2
Females 55 to 64 years	21	-		15
Males 55 to 64 years	10	-		1
	Ageing Report			
Females 55 to 64 years	-	14	14	
Males 55 to 64 years	-	7	0	

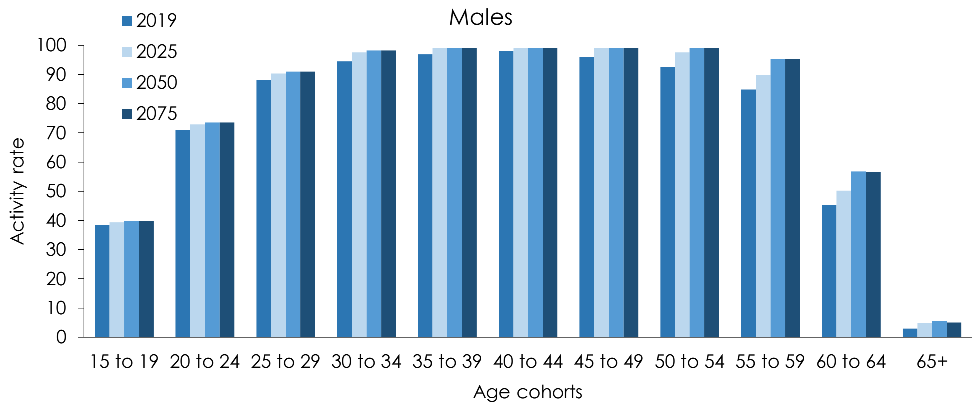
Notes: Numbers are differences in the projections for 2070 using corrected participation rates and projections based on the cohort method. - [1]) Kaniovski et al. (2014) using base year 2013. - [2]) European Commission (2017) using base year 2016. - [3]) European Commission (2020) using base year 2019. - [4]) Own calculations using base year 2019.

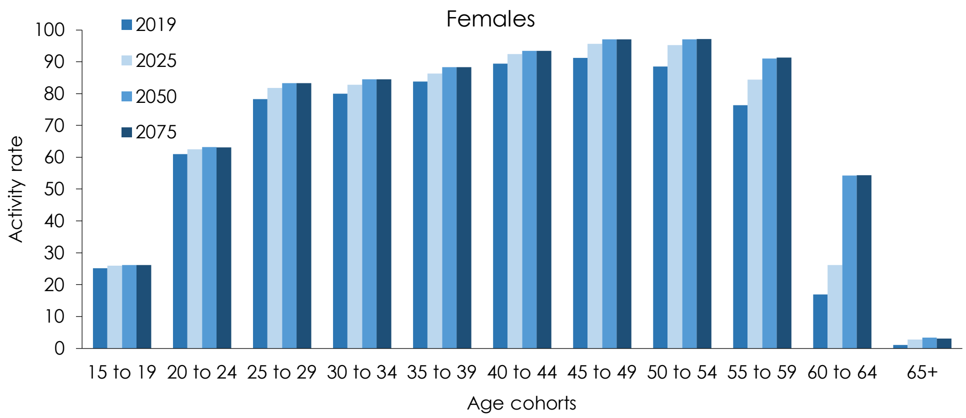
Table 3.2: Comparison of current (2021) with previous (2014)

	Projection from year					
	2014[1])			2021		
	Projection for year					
	2019	2020	2075	2019[2])	2020	2075
	Percentage points					
Females 55 to 64 years	39.1	39.5	63.2	49.2	50.6	73.0
Males 55 to 64 years	58.9	59.3	69.2	67.2	68.2	76.3

S: Own calculations. - [1]) Kaniovski et al. (2014). – [2]) Realised value for 2019.

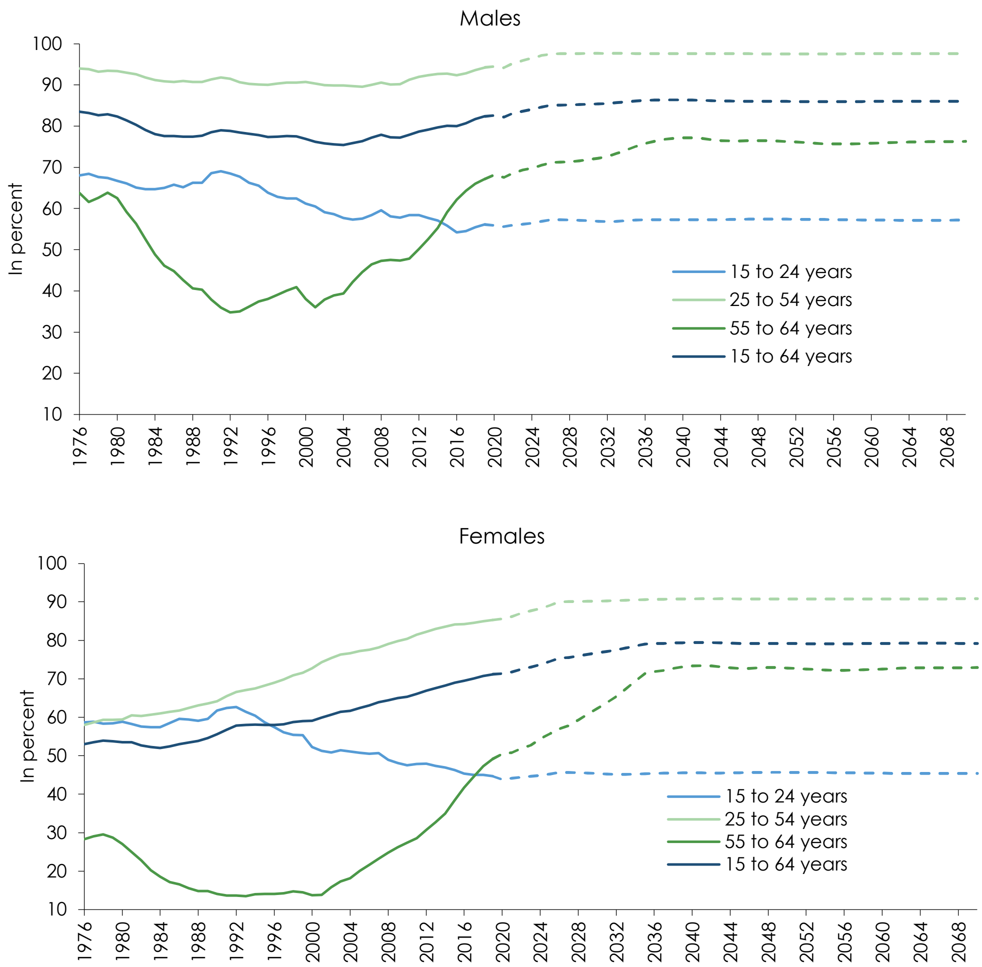
Figure 3.2: Participation rates by sex and 5-year age groups





S: WIFO, own calculations.

Figure 3.3: Labour force participation rates by sex and age groups



S: WIFO, own calculations.

4. Long-term Projections using the Austrian long-term macro model (A-LMM 2.0)

The adjustment mechanisms in the new A-LMM 2.0 depend mainly on demographic measures and therefore they change the development of economic key indicators only slowly. The stability of the model is fully visible in the base scenario up to 2075, which represents the end of our main projection horizon. In the very long run the model tends to a steady state solution for real output growth, the participation rates, the marginal product of capital, and the capital-output ratio, cf. Table 4.1. In the following, we discuss the baseline scenario using the main variant of the latest Austrian population forecast (*Hanika,* 2020). Compared to the population forecast used in *Kaniovski et al.* (2014) two major revisions of the basic assumptions on fertility, mortality and migration have been made over the years. In the long-term, the period fertility rate will converge 1.6 children per women. Life expectancy at birth for men will increase from 79.5 years in 2019 towards 89.4 years (2080) and for women from 84.2 years to 92.2 years (2080). Net immigration into Austria starts from 41,000 persons in 2019 and will slowly decline towards 27.600 persons per year in 2080 further slowing to 26,400 persons in 2100.

The main results of the baseline simulation are summarised in Table 4.1, where we choose 2019 as the base year for the presentation because realisations for the year 2020 are highly distorted by the COVID-19 pandemic. A comparison with the population projection from 2013 reveals that the size of the working age population in 2019 was bigger than expected. About 175,000 more persons lived in Austria than were expected by *Hanika* (2013). In comparison to the main variant from 2013, the new population projection expects plus 240,000 persons until 2075. Expectations for the dynamics of the working age population in *Hanika* (2020) are still showing a peak in 2020 (Figure 4.1). Between 2020 and 2038, the working age population will steadily decline, reaching a through at 5.64 million. Afterwards, it will temporarily increase towards 5.66 million around 2045. The minimum over the full projection horizon will be reached in 2062 at 5.57 million when a recovery will set in, leading to a working age population of 5.63 million persons in 2075 (Table 4.1).

The medium-term WIFO forecast implies a marked upswing in participation rates between 2021 and 2025. This leads to a concentration of the rise in participation rates within the next five years: nearly half of the total increase in participation rates from 2019 to 2075 will happen during 2021 and 2025 (2.6 percentage points, cf. Table 4.1). The increase of male participation rates by 3.6 percentage points over the full projection period is particularly concentrated in the first five years (2 percentage points). As a consequence, the number of economically active will increase until 2075 by 182,400 persons despite the shrinking working age population (Table 4.1). Again, most of this increase already happens over the medium-term forecast horizon in the years from 2019 to 2025 (+170,900 persons). The unemployment rate remains close to previous expectations in *Kaniovski et al.* (2014) and converges to the same long-term value, however, the short-term COVID-19 related upswing in unemployment in 2020 is clearly visible.

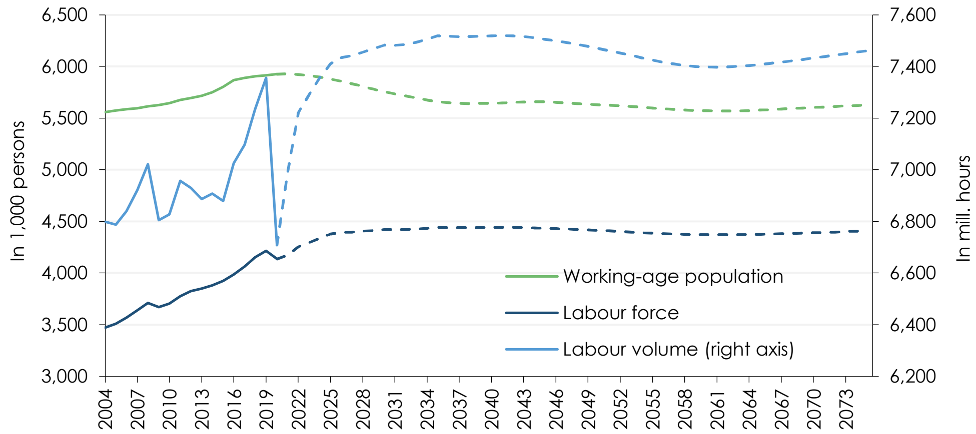
WIFO

Table 4.1: Baseline

	2019	2020	2025	2030	2040	2050	2060	2075	Avg. Change 2019/2075 (in %)	Cum. change 2019/2075 (in % points)
	1,000 persons									
Working Age Population (15-64)	5,915.8	5,928.5	5,881.2	5,757.7	5,645.3	5,631.0	5,573.1	5,629.0	-0.1	
Economically active population (Labour force)	4,581.6	4,606.5	4,752.5	4,775.1	4,797.1	4,767.6	4,724.1	4,764.0	0.1	
Economically active employees	3,720.0	3,643.9	3,876.4	3,916.2	3,935.6	3,909.0	3,871.7	3,904.4	0.1	
	In percent									
Participation rate, total	76.9	77.1	79.6	81.1	82.9	82.6	82.6	82.6	0.1	5.8
Women	71.2	71.4	74.5	76.8	79.5	79.2	79.2	79.2	0.2	8.0
Men	82.4	82.7	84.7	85.4	86.4	86.1	86.0	86.0	0.1	3.6
Unemployment rate	7.4	9.9	7.5	7.0	7.0	7.0	7.0	7.0	-0.1	-0.4
Old age dependency ratio	28.3	28.6	32.0	37.0	43.9	46.8	49.1	50.5	1.0	22.3
	Bill. €									
Gross domestic product at constant 2015 prices	374.1	349.4	390.9	411.2	470.1	530.6	596.4	732.2	1.2	
Gross domestic product at current prices	397.6	375.6	454.7	529.4	753.2	1,036.4	1,420.0	2,346.6	3.2	
	1,000 €									
GDP per capita at constant 2015 prices	42.2	39.2	43.1	44.6	49.8	55.3	61.7	74.4	1.0	
	2019 = 100									
Real wage per hour, (MPL)	100.0	106.2	102.0	107.1	122.1	138.8	157.6	192.0	1.2	
	Percentage change against previous year									
Gross domestic product at constant 2015 prices	1.4	-6.6	1.5	1.2	1.4	1.1	1.3	1.4	1.2	
Compensation to employees, at current prices	4.2	-1.8	2.9	3.5	3.4	3.2	3.3	3.4	3.2	
Real wage per hour	1.2	6.2	0.4	1.1	1.4	1.3	1.3	1.3	1.2	
Average hours worked	0.2	-7.1	-0.2	0.0	0.0	0.0	0.0	0.0	-0.1	
GDP deflator	1.7	1.1	1.7	2.2	2.0	2.0	2.0	2.0	2.0	
Consumer price index	1.5	1.4	1.7	2.2	2.0	2.0	2.0	2.0	2.0	
	Ratio									
Marginal product of capital	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.0	0.00
Capital-output-ratio	3.49	3.78	3.65	3.68	3.69	3.69	3.69	3.69	0.1	0.20

S: Statistics Austria, own calculations.

Figure 4.1: Development of working-age population, labour force, and labour volume



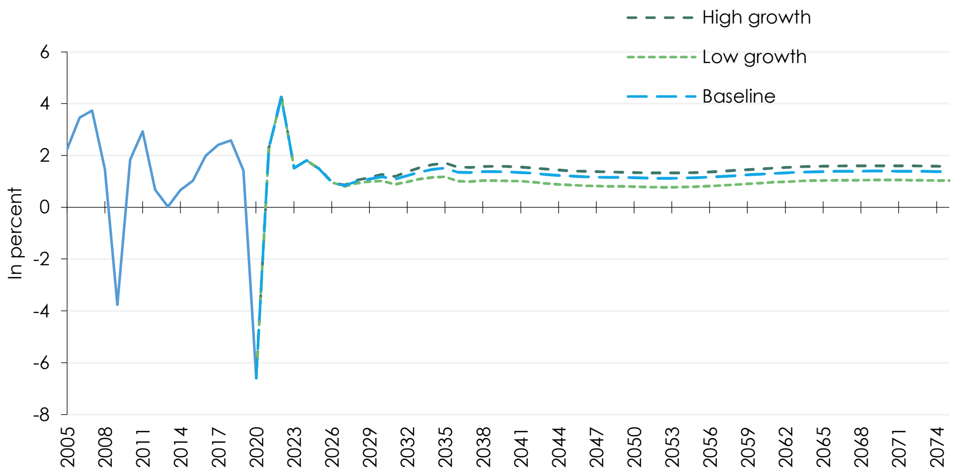
S: Statistics Austria, own calculations.

In comparison to the demographic forecast from *Hanika* (2013), Statistics Austria now shows a slightly lower value for the realised old age dependency ratio in 2019 (-1.1 percentage points). Although the ageing process was slower than expected, the ratio between 65+ year olds and the 15-64 years olds will surpass the 50 percent threshold by 2071, implying that there will be more than one person in pension age for every two persons of working age by then.

Despite the bleak demographic outlook, the economically active population will increase over the projection horizon (Figure 4.1). The slightly improved outlook for the labour force is due to upward revisions for participation rates and encompasses employees as well as the self-employed. Based on the combination of the medium-term forecast from *Baumgartner – Kaniovski* (2021) and the cohort method, we expect an increase in the total participation rate from 76.9 percent in 2019 to 82.6 percent in 2075. Compared to the previous model update in *Kaniovski et al.* (2014) we start already from a higher realised value in 2019 (1.5 percentage points above the value expected in 2014); the total increase until 2075 amounts to +5.8 percentage points, while the comparable number in *Kaniovski et al.* (2014) was +6.1 percentage points. Both sexes will expand their work activity considerably, as can be seen in the last column of Table 4.1. The more dynamic picture for women is due to the increased statutory retirement age. The adjustment process will start in 2024 and completion at age 65 is scheduled after ten years in 2033. Stricter requirements for early retirement schemes with respect to the minimum years of pension insurance coverage during the work life (40 years) will also affect the retirement behaviour of men in the years before reaching the statutory retirement age.

The COVID-19 crisis will result in the most severe economic recession in Austria after WWII. The expected drop in real output is forecasted to be -6.6 percent in 2020. The baseline scenario follows the medium-term forecast and shows a strong rebound in 2021 which slowly converges to the lower long-term growth rate fluctuating between 0.9 and 1.1 percent, in line with the factors driving productivity growth (Figure 4.2). The average growth rate of real GDP from 2019 through 2075 amounts to 1.2 percent per year (Table 4.1) which is 0.4 percentage points below the average growth rate expected in *Kaniovski et al*. (2014) and 0.1 percentage points below the assumption used in current EU-Ageing report published recently by European Commission (2020).

Figure 4.2: Three scenarios for the growth rate for real GDP with different underlying scenarios for total factor productivity growth



S: Statistics Austria, own calculations. Baseline TFP growth converges to 1.3 percent per year after 2035. In the high growth scenario TFP growth converges to 1.5 percent per year after 2035, and in the low growth scenario TFP growth converges to 1 percent per year after 2035.

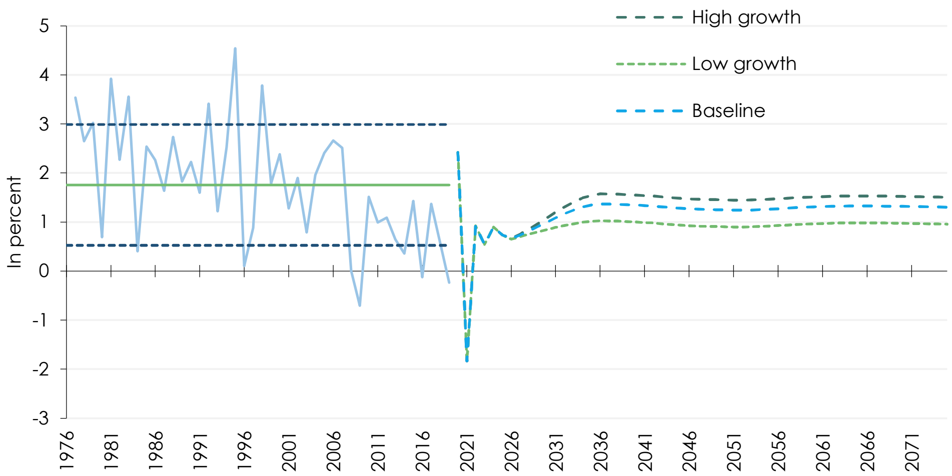
Real wages per hour grow in line with gross domestic product at constant prices, but the significant ageing of the Austrian population dampens the average growth rate of real per capita GDP by an average of 0.2 percentage points each year (Figure 4.3 and Table 4.1). In the current baseline scenario, real output in 2075 will be 96 percent higher as compared to the year 2019. The previous model update in *Kaniovski et al.* (2014) produced an increase in real output of 142 percent over the same period. A shorter projection horizon and lower TFP-growth accounts for most of the downward revision, more than compensating higher participation rates in the current projection.

A look at the development of the average number of hours worked per person in Table 4.1 shows, that the reduction in the average number of working hours per person fades out after 2025. Because the increase in participation rates only compensates for the decline in the working age population, the long-run contribution of labour to GDP-growth is close to zero. Figure 4.4 shows that productivity improvements are the main source of growth in the long-term. With the outbreak of the COVID-19 pandemic in 2020, labour productivity increased sharply due to short-time work, but it will dive far outside the one standard deviation band again in 2021. The development of labour productivity, however, was weak already in the years before.

Figure 4.3: Growth rate of real GDP per capita

S: Statistics Austria, own calculations. Baseline TFP growth converges to 1.3 percent per year after 2035. In the high growth scenario TFP growth converges to 1.5 percent per year after 2035, and in the low growth scenario TFP growth converges to 1 percent per year after 2035.

Figure 4.4: Development of labour productivity (per hour) for the base, low, and high growth scenario



S: Own calculations. Labour productivity is defined as real GDP over total hours worked. The mean for the sample 1976 - 2019 is 1.76 percent (green horizontal solid line), the standard deviation σ=1.23. The dark blue, horizontal, dotted lines show the +/- one standard deviation band around the historic mean.

Between 2008 and 2019 average productivity growth was at 0.58 percent per year; just slightly above the lower bound of the confidence interval. This is distinctly below the long-term average growth rate for labour productivity of 1.76 percent per year (1976-2019). We already pointed towards the depressing effect of the ongoing ageing process on productivity development in Figure 2.4, but high levels of uncertainty and lack of demand during the sequence of three crisis between 2008 and 2020 certainly reinforced the underlying weak productivity performance. Given the adverse demographic development our model predicts weak productivity growth until around 2035, when the ageing process stabilises, and the expected decline of the working age population fades out (Figure 2.4).

We assume no long-term impact of the COVID-19 crisis on labour demand. After a sharp upward move during the COVID-19 crisis, the unemployment rate will decline gradually to 7 percent until 2030 and it will stay there until 2075, because none of the structural variables explaining the NAWRU is assumed to change over the forecasting horizon.

The Austrian inflation rate has stabilised at low levels since a couple of years. In the COVID-19 crisis year 2020 we expect a moderate further drop in inflation which will be corrected over the medium-term forecast horizon. In the current A-LMM 2.0 version, the inflation rate responds to demographic pressure arising from increasing shares of the non-working age population. The demographic projection by Statistics Austria contains a falling share of the young population, *ypr*, while the old population ratio, *opr*, grows in line with the expected old age dependency ratio in Table 4.1. The net effect of these countervailing forces on inflation is positive and will drive the inflation rate above the target threshold of 2 percent per year, as defined by the European Central Bank. The mechanism anchoring the inflation rate at the ECB target level of 2 percent per year will be fully effective from 2040 onwards. Consequently, the inflation rate remains at 2 percent afterwards until the end of the forecast horizon.

4.1 Arguments in favour of a long-term decline in productivity growth

The forecast of low productivity growth in the near as well as the distant future is not the outcome of a simple extrapolation of the mediocre growth performance over the past ten years, rather it results endogenously from the TFP-equation presented and motivated in section 2.1. The parameter estimates for the model are based on a sample of developed countries over the period 1980 through 2015 (*Kaniovski – Url*, 2019). The demographic forecasts for the old to middle aged worker ratio and the expected growth of the working age population are taken from *Hanika* (2020) (cf. Figure 2.4). This set-up is more closely related to the pillar 1 arguments for secular stagnation as discussed in *Teuling – Baldwin* (2014) and *Eichengreen* (2015).

The pillar 1 arguments are supported by the hypothesis of technology pessimism. *Berthold – Gründler* (2015), for example, stress a lack of radically new ideas throughout developed countries after the early 2000s. Similarly, *Gordon* (2015) attributes the decline in productivity growth to diminishing returns to the digital revolution: Improvements in business hardware, software, and best practice had their peak in the late 1990's while their contribution to productivity growth tapered off in the following two decades.

Bloom et al. (2020) reveal substantial decreasing returns to research activities throughout many industries. In endogenous growth models, improvements in productivity result from the creation of new ideas. *Bloom et al.* (2020) illustrate the decreasing productivity using Moore's law, which is an empirical regularity stating that the number of transistors installed onto a computer chip doubles approximately every two years. The number of researchers required to double chip density is now 18-times higher as compared to the 1970s. Given this record, *Bloom et al.* (2020)

estimate the rate of decline in the productivity of research on semiconductors at 7 percent per year. The rate of decline in other idea production functions lies in a range between -5 to -10 percent per year, depending on industry and data set.

Elfsbacka Schmöller – Spitzer (2021) similarly identify a fall in R&D investment and technology adoption in the euro area in the early 2000s as the source of the slowdown in total factor productivity growth. During this period *Gordon* (2015) style lower innovative capacity kept productivity growth low. Interestingly, they find a crisis induced accelerated drop in R&D investment and technology adoption during the Great Recession and the euro area debt crisis in a DSGE model with endogenous total factor productivity growth. *Cette et al.* (2016) show that the productivity slow-down in the USA started already around the year 2005 and that TFP-levels in major continental European countries lost touch to the US-technology frontier mainly due to structural rigidities and the misallocation of capital during the low real interest rate period after the introduction of the Euro.

Human capital accumulation is an alternative source of productivity growth in endogenous growth models. The dynamics of human capital investment will slow down over the next years, because the process of replacing retired older cohorts by better educated younger ones nears its end. The decade-long catch-up process in which the share of young people with higher educational attainment rose from the comparatively low levels after World War II levels off (*Goldin – Katz*, 2008; *Gordon*, 2014). For example, *Bilek-Steindl et al.* (2016) show that higher educational attainment among young people can explain 0,2 percentage points or roughly one third of total factor productivity growth in Austria between 2004 and 2014. Figure 3.1 suggests that educational improvement among younger cohorts was still ongoing between 2010 and 2019, building on a continued shift from secondary to tertiary educational attainment. This process was, nevertheless, not reflected in higher productivity growth over this period.

While the previous arguments for low productivity growth focus on inputs and innovation, an alternative explanation for low growth is based on the long-term structural shift in developed economies from industrial production to service sectors with relatively low productivity growth. *Valentinyi et al.* (2019) develop the *Baumol* (1967) cost disease hypothesis further and estimate the potential size of the effect of structural change on productivity growth over the next 50 years. They define productivity as the value added per quality adjusted labour input and use a set-up with non-homothetic preferences, i. e. the model allows for permanent shifts in demand between services with above average productivity growth and services with below average productivity growth. *Valentinyi et al.* (2019) estimate, that over the period 1947 through 2016, one third of the productivity slow-down in the USA can be traced back to the structural change towards stagnant service sectors. Over the next 50 years they expect the negative effect from structural change to be only half as big as compared to the last half century, because in the future the substitution will be between the two types of service sectors rather than from goods towards services.

A similar explanation for low productivity growth is proposed by *Elstner et al.* (2018). They refer to the successful integration of several millions of low-skilled immigrants into the German labour market, conditional on the implementation of Agenda 2000 related labour market reforms at the beginning of the 2000's. This created high employment growth in the service sectors (trade, transportation, accommodation, healthcare, and administrative and support services), which are labour intensive and less productive compared to manufacturing. Furthermore, per capita productivity measures in Germany were dampened by a considerable increase in part-time work between 2005 and 2016. This transition reflects a more favourable labour market equilibrium, but at the same time permanently reduces productivity growth.

An alternative demand-oriented explanation, proposing a long period of low productivity growth, relies on the very low or even negative equilibrium real interest rates observed over the last decades. *Krugman et al.* (1998) concluded from the Japanese experience, that if the equilibrium real interest rate is negative, an economy could move towards a suboptimal low growth path with deflation arising. This transition would be the result of the zero-lower bound on nominal interest rates. If the equilibrium real interest rate is already low, central banks lose their ability to restore full employment, satisfactory growth, and financial market stability simultaneously by following a zero interest-rate policy over an extended period. Excess liquidity demand by firms and private households may result from a shrinking or ageing population, from deleveraging high levels of private debt accumulated before the financial market crisis in 2007/2008, or from central banks accumulating reserves in combination with conservative investment strategies. Consequently, the economy is more prone to a liquidity trap. *Summers* (2014) labelled this environment as the new secular stagnation hypothesis.

4.2 Arguments in favour of a temporary decline in productivity growth

Figure 4.4 presents the growth rate of labour productivity in Austria since the 1970's. When the financial market crisis happened, productivity growth dropped sharply and shows a subdued development since then. Only the year 2020, which is distorted by short-time work and other COVID-19 related government support measures, is an exception. Figure 4.4 also shows low labour productivity growth for the years covered by the WIFO medium-term forecast (until 2025). Although the period from 2008 through 2025 is long, the productivity slowdown may still turn out to be a temporary phenomenon in retrospective. There are essentially two lines of thought supporting the hypothesis of transitory low productivity growth, which we will present in this section.

Glaeser (2014) and *Mokyr et al.* (2015) reject the idea of permanently low technological progress and present historical evidence, that past technological innovations first produced anxiety about living standards and costs of restructuring, but subsequently, resulted in revived productivity growth. Additionally, they expect no lack of solutions for existing technical problems and observe that several new technologies – "new" meaning that they do not yet suffer from diminishing returns to research activity, as stressed in *Bloom et al.* (2020) – start to diffuse from science into business. Analysing the spread of mechanised cotton spinning machines in France during the industrial revolution, *Juhász et al.* (2021) show that the introduction of spinning machines started with a trial and error process with low initial average productivity. It took decades until productivity growth surged as new entrants adopted improved methods of operating the new mechanized technology. *Brynjolfsson et al*. (2021) also mention, that the implementation of artificial intelligence in a firm requires investments in complementary intangible capital which are poorly measured in the national accounts and this leads to an underestimation of productivity growth during the early years of technology diffusion. After the reorganisation of workflows and business models is concluded, measured productivity will be overestimated giving rise to a J-curve shape in productivity growth.

Finally, macroeconomic models with a build in financial accelerator suggest that a financial crisis – in particular a worldwide crisis as in 2008 – requires more time for the closure of an output gap than other shocks to the economy (*Bernanke et al.*, 1999). *Reinhart – Rogoff* (2014) show that after a financial crisis it takes on average 6.5 years for per-capita GDP to get back to its pre-crisis level and more than 40 percent of the countries experience a double-dip recession. This result implies that by now the depressing effect of the financial market crisis should have been completed, but the median duration of 6.5 years does not preclude longer episodes. In a similar vein, *Hamilton et al.* (2016) argue that the unusually severe business cycle downturn after the financial market crisis has been misinterpreted as a chronic long-term condition by proponents of the secular stagnation hypothesis.

Teuling – Baldwin (2014) did not come up with a conclusion whether we are at the beginning of a secular stagnation period, or just experience a transitory low-growth episode – e. g. due to the repair of balance sheets after the financial crisis (*Bernanke – Gertler*, 1989) – because at the time of publication in 2014 there was not enough conclusive evidence available. By now, another six years of low productivity growth have materialised, and the medium-term output forecast by *Baumgartner – Kaniovski* (2021) expects another five years of low productivity growth on top of this. Both, recently published data and the medium-term outlook support the reduction in long-term TFP-growth suggested in the base scenario. Furthermore, *Huber et al.* (2010) already expected a demographically induced decline in productivity growth by 2030 at the amount of 0.7 to 1.3 percentage points annually across Austrian states (Bundesländer). Furthermore, demographic trends are very similar across developed countries and consequently the link between demographic developments and productivity growth as implemented in the new A-LMM 2.0 model provides a common factor explaining decline in productivity growth visible throughout developed countries (*Kaniovski – Url*, 2019).

4.3 International comparison of long-term productivity forecasts

Between 2019 and 2030, the European Commission assumes an average growth in labour productivity of 0,9 percent for the euro area and Austria. The growth rate for the euro area improves to 1.5 percent for the decade 2031 to 2040 and converges towards 1.6 percent in the period 2061 through 2070. After 2030, Austria's labour productivity will grow 0.1 percentage points below the euro area average, cf. Table 4.2. The long-term increase in labour productivity across EU-members varies between 1.5 percent per year for the EU-15 countries and 1.7 percent for the accession countries from CESEE. This assumption ensures a convergence of per-capita income levels throughout member countries. Some of the recent long-term projections made by national institutions from other EU-members also take a more cautious view on productivity growth and deviate from the EC-projections, cf. Table 4.2.

The implied national projections of long-run labour productivity growth vary considerably across countries. Whereas the German and French forecasts appear cautious in comparison to the Commission's values, the projections by Italy and the United Kingdom correspond more closely to the *European Commission* (2017) proposals. Our new assumption for Austria of +1.3 percent per year is comparable to the main scenarios in France and Sweden, but Germany's lower and upper scenarios use smaller growth rates more in line with the low-growth scenario for Austria.

Table 4.2: International comparison of long-term labour productivity growth forecasts

	Scenario	ALPHA	TFP-growth rate	growth rate of labour productivity				
				National	EU (2009)	EU (2014)	EU (2017)	EU (2020)
				In percent				
Austria	Main	0.50	0.65	1.30	1.7	1.5	1.5	1.5
	Lower		0.50	1.00				
	Upper		0.75	1.50				
France	Main	-	-	1.30	1.7	1.5	1.5	1.5
	1	-	-	1.00				
	3	-	-	1.50				
	4	-	-	1.80				
Germany	T-	0.67	0.60	0.90	1.7	1.5	1.5	1.5
	T+	0.67	0.80	1.20				
Italy	Main	0.65	1.00	1.54	1.7	1.6	1.6	1.6
	Lower	0.65	0.75	1.15				
	Upper	0.65	1.25	1.92				
Sweden	Main			1.30	1.7	1.5	1.5	1.5
United Kingdom	Main	-	-	1.50	1.7	1.5	1.5	-

S: Latest national projections from COR (2020), Konjunkturinstitutet (2021), MEF (2020), Verikios (2020), Werding et al. (2020), and own computations for Austria. - EC forecasts for the latest decade from each Ageing Report in European Commission (2009, 2014, 2017, 2020). ALPHA represents the coefficient in the production function showing the factor shares.

4.4 Low growth scenario

The low growth scenario for Austria also connects to the medium-term WIFO forecast ending in 2025, but forces TFP-growth in the long run to be 0,3 percentage points below the base scenario. This will bring down the steady state growth rate of total factor productivity to roughly 1 percent per year with small variations due to demographic fluctuations. The low growth scenario provides a picture which corresponds to the lower end of TFP scenarios as projected by national institutes, cf. Table 4.2. In ALMM 2.0 a lower productivity growth has no feedback on participation rates or to other variables related to the labour market. These are still based on the forecasts resulting from the cohort model and on the explanatory factors determining the long run value of the NAWRU. Also, the projected inflation rate does not respond a permanently lower expansion of productive capacities. The main results for the low growth scenario are summarised in Table 4.3.

Starting from the last year of the medium-term WIFO forecast in 2025, the low growth scenario quickly converges to the steady state. The average growth rate of real GDP from 2019 through 2075 amounts to 0.9 percent per year (Table 4.3) which is 0.7 percentage points below the average growth rate expected in *Kaniovski et al*. (2014) and 0.4 percentage points below the current EU-Ageing report, cf. *European Commission* (2020). By 2075 real GDP will be 68 percent above the value from the starting year 2019, as compared to a 96 percent increase in the base scenario.

Real per capita GDP grows in line with GDP at constant prices, but the significant ageing of the Austrian population dampens the average growth rate of real per capita GDP by an average of 0.2 percentage points per year (Table 4.3). In comparison to the base scenario, the loss in output will be 10,600 € per capita in 2075 (measured in prices as of the year 2015). The Cobb-Douglas production function with constant returns to scale has the property to generate a constant distribution of income between factors of production. Therefore, lower productivity growth is one-to-one reflected in lower hourly wages. On average, hourly wages increase by 0.9 percent per year which results in a loss of 5.6 € per hour in 2075 relative to the base scenario (at constant prices).

Neither participation rates nor the unemployment rate is linked to improvements in productivity. Therefore, rising participation rates still compensate the decline in the working age population and the long-run contribution of labour to GDP-growth is close to zero. Figure 4.4 shows that productivity growth is lower in the second scenario, but it still is the main source of long-term GDP growth.

4.5 High growth scenario

The high growth scenario also connects to the last year of the medium-term WIFO forecast. Starting in 2026 we force TFP-growth in the long run to be 0.2 percentage points above the base scenario. This will improve the steady state growth rate of total factor productivity growth to roughly 1.5 percent per year with small variations due to demographic fluctuations. The high growth scenario provides a picture which corresponds to European Commission projection for Austria, but some of the national institutes also use higher values in their upper scenarios, cf. Table 4.2. In ALMM 2.0 higher productivity growth has no feedback on participation rates or on other variables related to the labour market. These are still based on the forecasts resulting from the cohort model and on the explanatory factors determining the long run value of the NAWRU. Also, the projected inflation rate does not respond permanently to a higher growth path. The main results for the high growth scenario are summarised in Table 4.4.

Starting from the last year of the medium-term WIFO forecast in 2025, the high growth scenario converges to the long-term growth rate by the year 2035. The average growth rate of real GDP from 2019 through 2075 amounts to 1.4 percent per year (Table 4.4) which is 0.2 percentage points below the average growth rate expected in *Kaniovski et al*. (2014) and 0.1 percentage points above the current EU-Ageing report, cf. *European Commission* (2020). By 2075 real GDP will be 114 percent above the value from the starting year 2019, as compared to a 96 percent increase in the base scenario.

Real per capita GDP grows in line with GDP at constant prices, but the significant ageing of the Austrian population dampens the average growth rate of real per capita GDP by an average of 0.2 percentage points each year (Table 4.4). In comparison to the base scenario, GDP will be higher by 7,027 € per capita in 2075 (measured in prices as of the year 2015). The Cobb-Douglas production function with constant returns to scale has the property to generate a constant distribution of income between factors of production. Therefore, higher productivity growth is one-to-one reflected in higher hourly wages. On average, hourly wages increase by 1.3 percent per year between 2019 and 2075, which results in a gain of 3.7 € per hour in 2075 (at constant prices) relative to the base scenario.

Neither participation rates nor the unemployment rate is linked to improvements in productivity. Therefore, rising participation rates still compensate the decline in the working age population and the long-run contribution of labour to GDP-growth is close to zero. Figure4.4 shows that productivity growth is higher in the third scenario and still works as the main source of long-term GDP growth.

Table 4.3: Low growth scenario

	2019	2020	2025	2030	2040	2050	2060	2075	Avg. Change 2019/2075 (in %)	Cum. change 2019/2075 (in % points)
	1,000 persons									
Working Age Population (15-64)	5,915.8	5,928.5	5,881.2	5,757.7	5,645.3	5,631.0	5,573.1	5,629.0	-0.1	
Economically active population (Labour force)	4,581.6	4,606.5	4,752.5	4,775.1	4,797.1	4,767.6	4,724.1	4,764.0	0.1	
Economically active employees	3,720.0	3,643.9	3,876.4	3,916.2	3,935.6	3,909.0	3,871.7	3,904.4	0.1	
	In percent									
Participation rate, total	76.9	77.1	79.6	81.1	82.9	82.6	82.6	82.6	0.1	5.8
Women	71.2	71.4	74.5	76.8	79.5	79.2	79.2	79.2	0.2	8.0
Men	82.4	82.7	84.7	85.4	86.4	86.1	86.0	86.0	0.1	3.6
Unemployment rate	7.4	9.9	7.5	7.0	7.0	7.0	7.0	7.0	-0.1	-0.4
Old age dependency ratio	28.3	28.6	32.0	37.0	43.9	46.8	49.1	50.5	1.0	22.3
	Bill. €									
Gross domestic product at constant 2015 prices	374.1	349.4	390.9	409.7	454.3	495.6	538.3	628.0	0.9	
Gross domestic product at current prices	397.6	375.6	454.7	527.5	727.7	967.7	1,281.3	2,011.9	2.9	
	1,000 €									
GDP per capita at constant 2015 prices	42.2	39.2	43.1	44.5	48.2	51.7	55.7	63.8	0.7	
	2019 = 100									
Real wage per hour, (MPL)	100.0	106.2	102.0	106.7	118.0	129.6	142.2	164.6	0.9	
	Percentage change against previous year									
Gross domestic product at constant 2015 prices	1.4	-6.6	1.5	1.0	1.0	0.8	0.9	1.0	0.9	
Compensation to employees, at current prices	4.2	-1.8	2.9	3.3	3.1	2.8	3.0	3.1	2.9	
Real wage per hour	1.2	6.2	0.4	0.9	1.0	0.9	1.0	1.0	0.9	
Average hours worked	0.2	-7.1	-0.2	0.0	0.0	0.0	0.0	0.0	-0.1	
GDP deflator	1.7	1.1	1.7	2.2	2.0	2.0	2.0	2.0	2.0	
Consumer price index	1.5	1.4	1.7	2.2	2.0	2.0	2.0	2.0	2.0	
	Ratio									
Marginal product of capital	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.0	0.00
Capital-output-ratio	3.49	3.78	3.65	3.68	3.69	3.69	3.69	3.69	0.1	0.20

S: Statistics Austria, own calculations.

Table 4.4: High growth scenario

	2019	2020	2025	2030	2040	2050	2060	2075	Avg. Change 2019/2075 (in %)	Cum. change 2019/2075 (in % points)
	1,000 persons									
Working Age Population (15-64)	5,915.8	5,928.5	5,881.2	5,757.7	5,645.3	5,631.0	5,573.1	5,629.0	-0.1	
Economically active population (Labour force)	4,581.6	4,606.5	4,752.5	4,775.1	4,797.1	4,767.6	4,724.1	4,764.0	0.1	
Economically active employees	3,720.0	3,643.9	3,876.4	3,916.2	3,935.6	3,909.0	3,871.7	3,904.4	0.1	
	In percent									
Participation rate, total	76.9	77.1	79.6	81.1	82.9	82.6	82.6	82.6	0.1	5.8
Women	71.2	71.4	74.5	76.8	79.5	79.2	79.2	79.2	0.2	8.0
Men	82.4	82.7	84.7	85.4	86.4	86.1	86.0	86.0	0.1	3.6
Unemployment rate	7.4	9.9	7.5	7.0	7.0	7.0	7.0	7.0	-0.1	-0.4
Old age dependency ratio	28.3	28.6	32.0	37.0	43.9	46.8	49.1	50.5	1.0	22.3
	Bill. €									
Gross domestic product at constant 2015 prices	374.1	349.4	390.9	412.1	479.6	552.3	633.4	801.4	1.4	
Gross domestic product at current prices	397.6	375.6	454.7	530.5	768.7	1,079.1	1,508.5	2,568.7	3.4	
	1,000 €									
GDP per capita at constant 2015 prices	42.2	39.2	43.1	44.7	50.8	57.6	65.6	81.5	1.2	
	2019 = 100									
Real wage per hour, (MPL)	100.0	106.2	102.0	107.3	124.6	144.6	167.4	210.3	1.3	
	Percentage change against previous year									
Gross domestic product at constant 2015 prices	1.4	-6.6	1.5	1.3	1.6	1.3	1.5	1.6	1.4	
Compensation to employees, at current prices	4.2	-1.8	2.9	3.6	3.6	3.4	3.5	3.6	3.4	
Real wage per hour	1.2	6.2	0.4	1.2	1.6	1.5	1.5	1.5	1.3	
Average hours worked	0.2	-7.1	-0.2	0.0	0.0	0.0	0.0	0.0	-0.1	
GDP deflator	1.7	1.1	1.7	2.2	2.0	2.0	2.0	2.0	2.0	
Consumer price index	1.5	1.4	1.7	2.2	2.0	2.0	2.0	2.0	2.0	
	Ratio									
Marginal product of capital	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.0	0.00
Capital-output-ratio	3.49	3.78	3.65	3.68	3.69	3.69	3.69	3.69	0.1	0.20

S: Statistics Austria, own calculations.

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6. Appendix 1: List of variables

	English	German
CPI	Consumer Price Index, 2015=100	Verbraucherpreisindex, 2015=100
EWPG	Expected average growth rate of working age population (10-years ahead)	Erwartete durchschnittliche Wachstumsrate der Bevölkerung im erwerbsfähigen Alter in den nächsten 10 Jahren
HOURST	Hours worked, in mill. hours	Arbeitsvolumen in Mill. Stunden
HOURST_AV	Average hours worked per year, in 1,000 hours	Durchschnittlich geleistete Arbeitsstunden pro Jahr, in 1.000 Stunden
ICT	ICT intensity (share of information and communication equipment in total capital stock), in percent	IKT-Intensität (Anteil der Informations- und Kommunikationsausrüstung am Kapitalbestand), in %
ICTHP	Trend ICT-intensity, in percent	Trend IKT-Intensität, in %
K	Net capital stock, at constant prices	Nettokapitalstock, real
LABORFORCE	Economically active population (Labour force) according to Baliweb data, in million persons	Erwerbspersonen laut Baliweb-Daten, Mio. Personen
LE	Employees (incl. LENA), in million persons	Unselbständig Beschäftigte (inkl. LENA), Mio. Personen
LEA	Persons in active dependent employment (excl. LENA), in million persons	Unselbständig aktiv Beschäftigte (exkl. LENA), Mio. Personen
LENA	Persons in valid employment contract receiving child care benefit or being in military service, in million persons	Personen in aufrechtem Dienstverhältnis, die Kinderbetreuungsgeld beziehen bzw. Präsenzdienst leisten, Mio. Personen
LF	Economically active population (Labour force) according to National Accounts definition, in million persons	Erwerbspersonen laut VGR, Mio. Personen
LF_F	Economically active population (Labour force) according to National Accounts definition, females, in million persons	Erwerbspersonen laut VGR, Frauen, Mio. Personen
LF_M	Economically active population (Labour force) according to National Accounts definition, males, in million persons	Erwerbspersonen laut VGR, Männer, Mio. Personen
LS	Dependent labour supply, in million persons	Angebot an unselbständigen Erwerbspersonen, Mio. Personen
LSS	Self-employed persons, in million persons	Selbständig Beschäftigte, Mio. Personen
LSSA	Self-employed persons in agriculture, in million persons	Selbständig Beschäftigte Landwirtschaft, Mio. Personen
LSSA_GR	Rate of change of self-employed persons in agriculture, in percent	Veränderungsrate der selbständig Beschäftigten in der Landwirtschaft, in %
LSSNA	Self-employed persons, non-agriculture, in million persons	Selbständig Beschäftigte Nicht-Landwirtschaft, Mio. Personen
LU	Unemployed, in million persons	Arbeitslose, Mio. Personen
PY	Deflator, GDP	Deflator, Bruttoinlandsprodukt
NAWRU	Natural Rate of Unemployment (national definition), in percent	Natürliche Rate der Arbeitslosigkeit (Nationale Definition), in %
NAWRU_ILO	Natural Rate of Unemployment (ILO definition), in percent	Natürliche Rate der Arbeitslosigkeit (ILO Definition), in %

	English	German
NR	Natural Rate of Interest, in percent	Natürlicher Zinssatz, in %
OMR	Ratio of old to middle-aged persons, in percent	Verhältnis von älteren zu mittelalten Personen, in %
OPEN	Degree of economic openness, in percent	Grad der wirtschaftlichen Offenheit, in %
OPENHP	Trend degree of trade openness, in percent	Trend Grad der Handelsoffenheit, in %
OPR	Share of persons aged 65 and more in total population, in percent	Anteil der Personen im Alter von 65 und mehr an der Gesamtbevölkerung, in %
OWR	Share of persons aged 55 to 64 in working age population, in percent	Anteil der Personen im Alter von 55-64 an der Bevölkerung im erwerbsfähigen Alter, in %
PARTS	Participation rate, total, in percent	Erwerbsquote insg., in Prozent
PARTS_1564	Participation rate, total in working age population, in percent	Erwerbsquote, insg. relativ zur Bevölkerung im erwerbsfähigen Alter, in %
PARTS_F_1524	Participation rate, females, age group 15 to 24, in percent	Erwerbsquote, Frauen, im Alter von 15 bis 24, in %
PARTS_F_1564	Participation rate, females, age group 15 to 64, in percent	Erwerbsquote, Frauen, im Alter von 15 bis 64, in %
PARTS_F_2554	Participation rate, females, age group 25 to 54, in percent	Erwerbsquote, Frauen, im Alter von 25 bis 54, in %
PARTS_F_5564	Participation rate, females, age group 55 to 64, in percent	Erwerbsquote, Frauen, im Alter von 55 bis 64, in %
PARTS_F_1519	Participation rate, females, age group 15 to 19, in percent	Erwerbsquote, Frauen, im Alter von 15 bis 19, in %
PARTS_F_2024	Participation rate, females, age group 20 to 24, in percent	Erwerbsquote, Frauen, im Alter von 20 bis 24, in %
…	…	…
PARTS_F_5559	Participation rate, females, age group 55 to 59, in percent	Erwerbsquote, Frauen, im Alter von 55 bis 59, in %
PARTS_F_6064	Participation rate, females, age group 60 to 64, in percent	Erwerbsquote, Frauen, im Alter von 60 bis 64, in %
PARTS_F_65UM	Participation rate, females, age group 65 and more, in percent	Erwerbsquote, Frauen, im Alter von 65 und mehr, in %
PARTS_M_1524	Participation rate, males, age group 15 to 24, in percent	Erwerbsquote, Männer, im Alter von 15 bis 24, in %
PARTS_M_1564	Participation rate, males, age group 15 to 64, in percent	Erwerbsquote, Männer, im Alter von 15 bis 64, in %
PARTS_M_2554	Participation rate, males, age group 25 to 54, in percent	Erwerbsquote, Männer, im Alter von 25 bis 54, in %
PARTS_M_5564	Participation rate, males, age group 55 to 64, in percent	Erwerbsquote, Männer, im Alter von 55 bis 64, in %
PARTS_M_1519	Participation rate, males, age group 15 to 19, in percent	Erwerbsquote, Männer, im Alter von 15 bis 19, in %
PARTS_M_2024	Participation rate, males, age group 20 to 24, in percent	Erwerbsquote, Männer, im Alter von 20 bis 24, in %
…	…	…
PARTS_M_5559	Participation rate, males, age group 55 to 59, in percent	Erwerbsquote, Männer, im Alter von 55 bis 59, in %
PARTS_M_6064	Participation rate, males, age group 60 to 64, in percent	Erwerbsquote, Männer, im Alter von 60 bis 64, in %
PARTS_M_65UM	Participation rate, males, age group 65 and more, in percent	Erwerbsquote, Männer, im Alter von 65 und mehr, in %
PENR	Retirement income replacement rate	Einkommensersatzquote durch die Pensionsleistung

	English	German
POP_0000	Population, in million persons	Bevölkerung, Mio. Personen
POP_0004	Population, age group 0 to 4, in million persons	Bevölkerung im Alter von 0 bis 4, Mio. Personen
POP_0014	Population, age group 0 to 14, in million persons	Bevölkerung im Alter von 0 bis 14, Mio. Personen
POP_1524	Population, age group 15 to 24, in million persons	Bevölkerung im Alter von 15 bis 24, Mio. Personen
POP_1564	Population, age group 15 to 64, in million persons	Bevölkerung im Alter von 15 bis 64, Mio. Personen
POP_1574	Population, age group 15 to 74, in million persons	Bevölkerung im Alter von 15 bis 74, Mio. Personen
POP_2554	Population, age group 25 to 54, in million persons	Bevölkerung im Alter von 25 bis 54, Mio. Personen
POP_5564	Population, age group 55 to 64, in million persons	Bevölkerung im Alter von 55 bis 64, Mio. Personen
POP_6574	Population, age group 65 to 74, in million persons	Bevölkerung im Alter von 65 bis 74, Mio. Personen
POP_75UM	Population, age group 75 and more, in million persons	Bevölkerung im Alter von 75 und mehr, Mio. Personen
POP_F_0004	Population, females, age group 0 to 4, in million persons	Bevölkerung, Frauen, im Alter von 0 bis 4, Mio. Personen
POP_F_0014	Population, females, age group 0 to 14, in million persons	Bevölkerung, Frauen, im Alter von 0 bis 14, Mio. Personen
POP_F_1519	Population, females, age group 15 to 19, in million persons	Bevölkerung, Frauen, im Alter von 15 bis 19, Mio. Personen
POP_F_1524	Population, females, age group 15 to 24, in million persons	Bevölkerung, Frauen, im Alter von 15 bis 24, Mio. Personen
POP_F_1564	Population, females, age group 15 to 64, in million persons	Bevölkerung, Frauen, im Alter von 15 bis 64, Mio. Personen
POP_F_2024	Population, females, age group 20 to 24, in million persons	Bevölkerung, Frauen, im Alter von 20 bis 24, Mio. Personen
POP_F_2529	Population, females, age group 25 to 29, in million persons	Bevölkerung, Frauen, im Alter von 25 bis 29, Mio. Personen
POP_F_2554	Population, females, age group 25 to 54, in million persons	Bevölkerung, Frauen, im Alter von 25 bis 54, Mio. Personen
POP_F_3034	Population, females, age group 30 to 34, in million persons	Bevölkerung, Frauen, im Alter von 30 bis 34, Mio. Personen
POP_F_3539	Population, females, age group 35 to 39, in million persons	Bevölkerung, Frauen, im Alter von 35 bis 39, Mio. Personen
POP_F_4044	Population, females, age group 40 to 44, in million persons	Bevölkerung, Frauen, im Alter von 40 bis 44, Mio. Personen
POP_F_4549	Population, females, age group 45 to 49, in million persons	Bevölkerung, Frauen, im Alter von 45 bis 49, Mio. Personen
POP_F_5054	Population, females, age group 50 to 54, in million persons	Bevölkerung, Frauen, im Alter von 50 bis 54, Mio. Personen
POP_F_5559	Population, females, age group 55 to 59, in million persons	Bevölkerung, Frauen, im Alter von 55 bis 59, Mio. Personen
POP_F_5564	Population, females, age group 55 to 64, in million persons	Bevölkerung, Frauen, im Alter von 55 bis 64, Mio. Personen
POP_F_6064	Population, females, age group 60 to 64, in million persons	Bevölkerung, Frauen, im Alter von 60 bis 64, Mio. Personen
POP_F_6574	Population, females, age group 65 to 74, in million persons	Bevölkerung, Frauen, im Alter von 65 bis 74, Mio. Personen
POP_F_00	Population, females, age group 0, in million persons	Bevölkerung, Frauen, im Alter von 0, Mio. Personen

	English	German
POP_F_01	Population, females, age group 1, in million persons	Bevölkerung, Frauen, im Alter von 1, Mio. Personen
…	…	…
POP_F_73	Population, females, age group 73, in million persons	Bevölkerung, Frauen, im Alter von 73, Mio. Personen
POP_F_74	Population, females, age group 74, in million persons	Bevölkerung, Frauen, im Alter von 74, Mio. Personen
POP_F_75UM	Population, females, age group 75 and more, in million persons	Bevölkerung, Frauen, im Alter von 75 und mehr, Mio. Personen
POP_M_0004	Population, males, age group 0 to 4, in million persons	Bevölkerung, Männer, im Alter von 0 bis 4, Mio. Personen
POP_M_0014	Population, males, age group 0 to 14, in million persons	Bevölkerung, Männer, im Alter von 0 bis 14, Mio. Personen
POP_M_1519	Population, males, age group 15 to 19, in million persons	Bevölkerung, Männer, im Alter von 15 bis 19, Mio. Personen
POP_M_1524	Population, males, age group 15 to 24, in million persons	Bevölkerung, Männer, im Alter von 15 bis 24, Mio. Personen
POP_M_1564	Population, males, age group 15 to 64, in million persons	Bevölkerung, Männer, im Alter von 15 bis 64, Mio. Personen
POP_M_2024	Population, males, age group 20 to 24, in million persons	Bevölkerung, Männer, im Alter von 20 bis 24, Mio. Personen
POP_M_2529	Population, males, age group 25 to 29, in million persons	Bevölkerung, Männer, im Alter von 25 bis 29, Mio. Personen
POP_M_2554	Population, males, age group 25 to 54, in million persons	Bevölkerung, Männer, im Alter von 25 bis 54, Mio. Personen
POP_M_3034	Population, males, age group 30 to 34, in million persons	Bevölkerung, Männer, im Alter von 30 bis 34, Mio. Personen
POP_M_3539	Population, males, age group 35 to 39, in million persons	Bevölkerung, Männer, im Alter von 35 bis 39, Mio. Personen
POP_M_4044	Population, males, age group 40 to 44, in million persons	Bevölkerung, Männer, im Alter von 40 bis 44, Mio. Personen
POP_M_4549	Population, males, age group 45 to 49, in million persons	Bevölkerung, Männer, im Alter von 45 bis 49, Mio. Personen
POP_M_5054	Population, males, age group 50 to 54, in million persons	Bevölkerung, Männer, im Alter von 50 bis 54, Mio. Personen
POP_M_5559	Population, males, age group 55 to 59, in million persons	Bevölkerung, Männer, im Alter von 55 bis 59, Mio. Personen
POP_M_5564	Population, males, age group 55 to 64, in million persons	Bevölkerung, Männer, im Alter von 55 bis 64, Mio. Personen
POP_M_6064	Population, males, age group 60 to 64, in million persons	Bevölkerung, Männer, im Alter von 60 bis 64, Mio. Personen
POP_M_6574	Population, males, age group 65 to 74, in million persons	Bevölkerung, Männer, im Alter von 65 bis 74, Mio., Personen
POP_M_00	Population, males, age group 0, in million persons	Bevölkerung, Männer, im Alter von 0, Mio. Personen
POP_M_01	Population, males, age group 1, in million persons	Bevölkerung, Männer, im Alter von 1, Mio. Personen
…	…	…
POP_M_73	Population, males, age group 73, in million persons	Bevölkerung, Männer, im Alter von 73, Mio. Personen
POP_M_74	Population, males, age group 74, in million persons	Bevölkerung, Männer, im Alter von 74, Mio. Personen
POP_M_75UM	Population, males, age group 75 and more, in million persons	Bevölkerung, Männer, im Alter von 75 und mehr, Mio. Personen
PR_ADJ	Participations rate, adjustment factor	Erwerbsquote, Anpassungsfaktor
PR_F_15	Participation rate, females, age group 15 and younger	Erwerbsquote, Frauen, im Alter von 15 und jünger
PR_F_16	Participation rate, females, age group 16	Erwerbsquote, Frauen, im Alter von 16
…	…	…

	English	German
PR_F_74	Participation rate, females, age group 74	Erwerbsquote, Frauen, im Alter von 74
PR_F_75	Participation rate, females, age group 75 and older	Erwerbsquote, Frauen, im Alter von 75 und älter
PR_M_15	Participation rate, males, age group 15 and younger	Erwerbsquote, Männer, im Alter von 15 und jünger
PR_M_16	Participation rate, males, age group 16	Erwerbsquote, Männer, im Alter von 16
…	…	…
PR_M_74	Participation rate, males, age group 74	Erwerbsquote, Männer, im Alter von 74
PR_M_75	Participation rate, males, age group 75 and older	Erwerbsquote, Männer, im Alter von 75 und älter
PY	Deflator, GDP	Deflator, Bruttoinlandsprodukt
RLF_F	Share of females in total labourforce, in percent	Anteil der Frauen an den Erwerbspersonen, in %
RR	Real long-term interest rate	Realer Zinssatz, Sekundärmarktrendite Bund
SR	Total economy saving rate, in percent	Gesamtwirtschaftliche Sparquote, in %
TFP	Total factor productivity	Gesamte Faktorproduktivität
U	Unemployment rate (national definition), in percent	Arbeitslosenquote (Nationale Definition), in %
U_ILO	Unemployment rate (ILO definition), in percent	Arbeitslosenquote (ILO Definition), in %
USPICT	US-deflator of ICT capital	Deflator, USA IKT-Kapital
W	Real wages and salaries per hour worked	Löhne und Gehälter je geleistete Arbeitsstunde, real
Y	Trend gross domestic product, volume	Trend Bruttoinlandsprodukt, real
YGAP	Output gap, as a percentage of trend output	Output-Lücke, in % des Trendoutputs
YL	Compensation to employees, value	Arbeitnehmerentgelte, nominell
YN	Gross domestic product, value	Bruttoinlandsprodukt, nominell
YPR	Share of persons aged 15 to 24 in total population, in percent	Anteil der Personen im Alter von 15-24 an der Gesamtbevölkerung, in %
YR	Gross domestic product, volume	Bruttoinlandsprodukt, real
YWR	Share of persons aged 15 to 24 in working age population, in percent	Anteil der Personen im Alter von 15-24 an der Bevölkerung im erwerbsfähigen Alter, in %
YWS	Wages and salaries	Lohn- und Gehaltssumme