III. Prospects for long-term productivity growth

By Ben Deboeck

Since the number of people at working age will begin shrinking in the coming years, demographic ageing will impose a permanent drag on economic growth in the euro area. As a result, growth will critically depend on labour productivity. Developments in total factor productivity (TFP) particularly matter, since they reflecthow technological progress allows for a more efficient use of labour and capital. However, TFP growth in the euro area has fallen back to the lowest levels in a very long period. The latest figures point to a sluggish medium-term outlook. Views on the long-term outlook for productivity growth differ. A more optimistic view considers that TFP growth will unavoidably rebound once new ground-breaking technologies mature, complementary investment and organisational changes are made and the necessary new skills acquired. However, technology diffusion has fallen because of the rising importance of intangible capital and higher market concentration, all of which deter innovation. Therefore, a return to historical TFP growth rates seems a tall order under current policies. A more downbeat view concludes that, aside from a transmission problem, innovation has become simply less transformative. As a result, productivity growth has reversed to its long-run trend and we should not expect a permanent return to a higher growth path. In addition, the cautious view points to rising structural headwinds, such as global fragmentation, climate change, demographic ageing and rising government debt, all of which might add to the downward trend in productivity growth.

Based on the standard neoclassical Cobb-Douglas production function, economic growth g_{GDP} can be expressed as a function of five parameters:

$$g_{GDP} = g_{TFP} + \alpha \times g_{K/L} + g_{WAP} + g_{ER} + g_{hours} \quad (1)$$

With capital inputs K (e.g. infrastructure, machinery, equipment or software); labour inputs L (the number of hours worked); α the income share of capital; K/L capital deepening or capital intensity, measuring the amount of capital per worker; *WAP* the size of the working-age population; *ER* their employment rate; and *hours* the average number of hours they work. TFP stand for total factor productivity, a non-observable variable that measures how efficient labour and capital inputs are used (73).

The last three terms in equation 1 determine the change in the total number of hours worked and the first two terms constitute hourly labour productivity growth (74). Graph III.1 provides the breakdown of economic growth in the euro area since the mid-1960s, on the basis of the above expression (75). It shows how economic growth in past decades has been mainly driven by labour productivity (capital intensity and TFP), with a much smaller effect from the labour supply.

- The size of the ***working-age population*** has expanded steadily, though at a slowing pace. It still rose slightly over the past decade but is about to enter a downward trajectory, reducing future economic growth. In most of the newer euro area countries, this is already the case.

  Rising ***employment rates*** have been contributing to growth. However, employment rates are already high in many countries, while for others lifting them would require a tightening in retirement conditions and reforms to labour markets.

- The average number of ***hours worked*** has been declining for many decades. This reflects shorter working weeks, a higher prevalence of part-time employment and a reduction of working time leading up to retirement.

  Since the mid-1990s, ***capital intensity*** contributed 0.4 pps to average annual growth, and more for newer euro area countries. The falling contribution over time highlights limits to the extent to which capital accumulation can produce growth, considering diminishing returns and a constant depreciation of the existing capital stock.

- ***TFP*** has been on a declining trend since the 1970s, a period when it was still growing by more than 2% annually. It has contributed just 0.4 pps to GDP growth since 2000 and even fell to zero in 2006-10. Recent TFP growth figures are more robust for newer euro area

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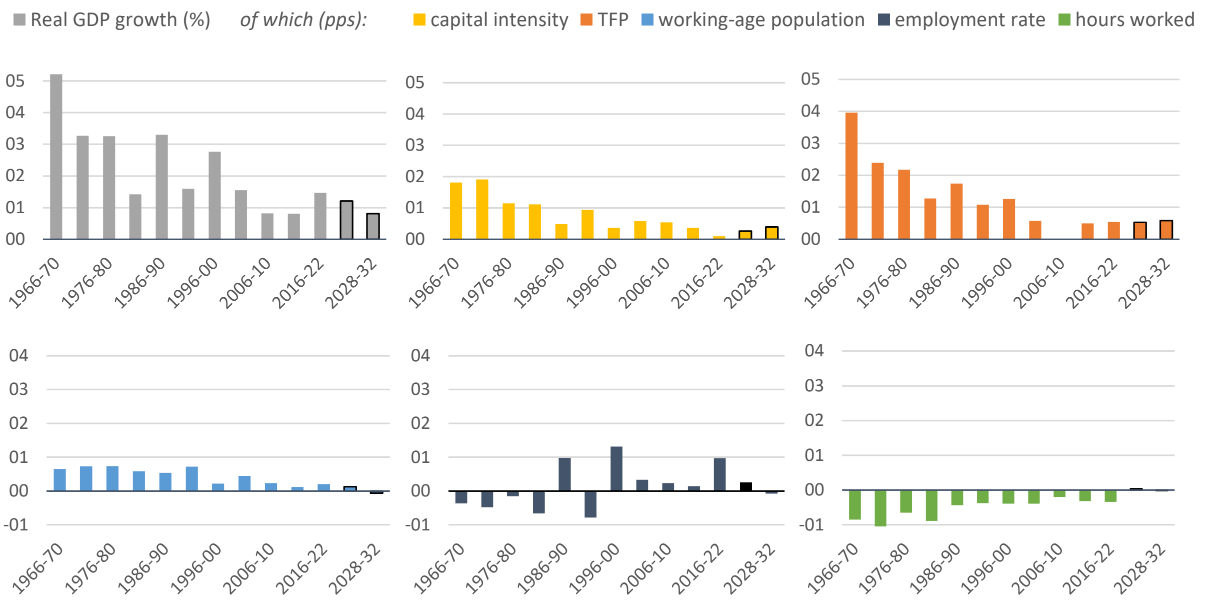
(73) In growth accounting terms, TFP is measured as the 'Solow residual': the variation in growth that cannot be explained by capital and labour inputs.

(74) Since total output is the product of the total number of hours worked in the economy (i.e. the last three terms in equation (1)) and the output per hour worked (hourly labour productivity).

(75) Summary country tables can be found in Annex 1.

Graph III.1: **Breakdown of economic growth in the euro area (1966-2032)**



EU20 as of 1995; EA14 (the 14 euro area countries) before (excluding EE, HR, LV, LT, SI & SK). Projections for 2022-32.
Source: AMECO; 2022 European Commission autumn forecast.

countries, which have nevertheless seen a slowdown compared to 1996-2005.

These trends show how labour productivity has been the main growth driver. Given population ageing, it will become even more key to future growth, in particular TFP growth. While capital deepening contributes to GDP growth when an economy is catching up with its peers, once nearing the technology frontier, TFP should become the predominant productivity driver (76). Yet TFP growth also slowed considerably, especially in the original euro area countries.

The ultimate drivers of TFP are manifold and often interrelated. While a detailed discussion of these determinants goes beyond the scope of this article, they can be summarised as:

innovation (the adoption of new technologies and ideas in production and organisation);

human capital (higher educational attainment and better health raise the potential for innovation and facilitates technology diffusion);

investment in tangible capital (e.g. plants, research facilities, machinery, equipment, hardware)

investment in intangible capital (e.g. R&D, design, advanced software, databases, business processes);

physical infrastructure (e.g. transport, energy and telecommunication networks);

market efficiency (achieving an optimal sectorial allocation of available resources, e.g. through competition policy and labour mobility);

financial development (access to finance);

trade openness (access to foreign capital and intermediary goods);

prices and availability of *commodities* needed for certain production technologies;

the socially embedded system of *formal rules*, e.g. (intellectual) property rights, tax system, rule of law, labour and product market regulations

informal constraints, e.g. political stability, bureaucratic efficiency, norms and conventions, culture.

The next sections discuss past developments in TFP, and the medium- and long-term outlook for TFP growth, based on a literature review.

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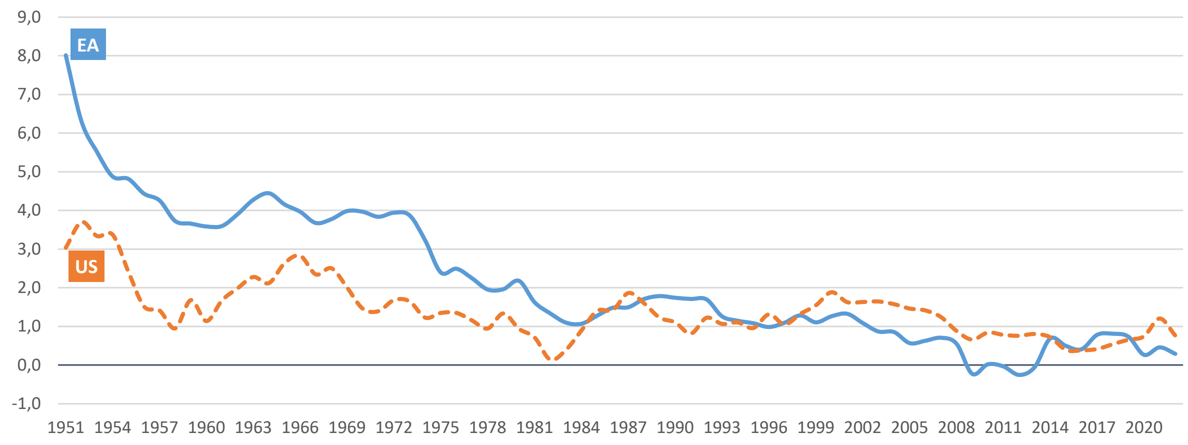
(76) Over 80% of the income differences between rich and poor countries can be explained by different rates of technology adoption, according to Comin D. & M. Mestieri (2018), *If Technology Has Arrived Everywhere, Why Has Income Diverged?*, American Economic Journal: Macroeconomics, Vol. 10 No. 3, pp 137-178.

Graph III.2: **TFP growth (%, 5y moving average)**



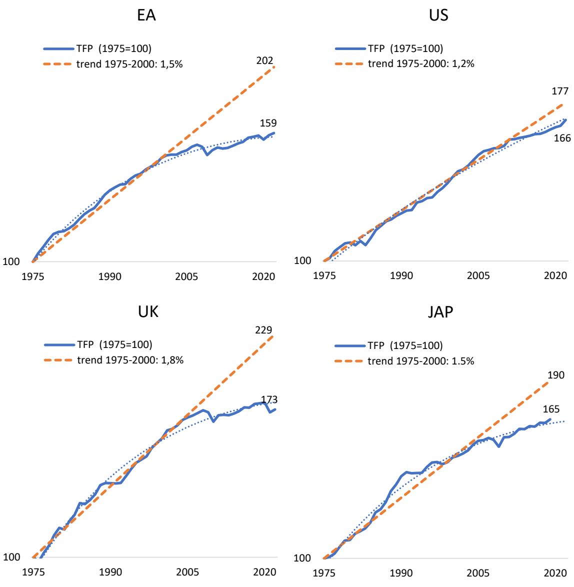
EA based on DE, FR, IT, ES, NL, BE, PT & FI for 1950-1965.
Source: European Commission; 1950-1965 based on www.longtermproductivity.com.

III.1. Past trends in TFP growth

In the decades following World War II, European countries grew at previously unseen rates. Between 1950 and the mid-1970s, annual GDP per capita growth averaged around 5% in the euro area, compared to a little under 3% in the US (77). For Europe, the post-war run of solid, broad-based growth represented a catching-up with the US, which saw the earlier mass adoption of two crucial 'general-purpose technologies': electrification and the internal combustion engine. Other major innovations concerned advances in chemistry and medicines. This led to a fast growth in TFP (see Graph III.2), which in itself put economic growth at about 4%. Worker' productivity was boosted also through a sharp rise in capital intensity because of the post-war reconstruction and the shift to more capital-intensive production, possibly also related to the increased productivity of capital.

The oil shocks of the 1970s ushered in a period of lower growth. The persistent growth slowdown was particularly driven by TFP growth, which fell back to about 1.5% on average in the euro area in 1975-2000. The oil shocks highlighted how western economies had, for more than a century, achieved rapid productivity growth by augmenting labour output with rising amounts of (cheap) energy and other resources (78). Aside from the surge in oil prices, also the nature of technology changed. The key innovations that fuelled the post-war stretch of high growth had been largely exploited.

Graph III.3: **Total factor productivity developments: actual and trend (log scale)**



EA14 before 1995 (excluding EE, HR, LV, LT, SI & SK).
Source: European Commission; Japan from www.longtermproductivity.com.

However, at the same time, the early 1970s heralded the emergence of a new general-purpose technology: microprocessors and, more in general, information technology. Computing power grew exponentially, and computers started to appear everywhere in the 1980s, similar to electricity and the internal combustion engine some decades earlier.

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(77) Based on data from www.longtermproductivity.com, euro area figure includes DE, FR, IT, ES, NL, BE, PT & FI.

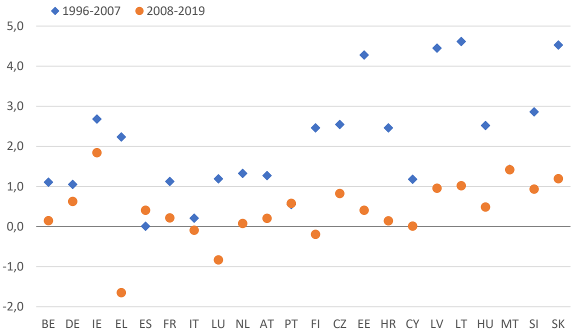
(78) DeLong B. (2022), *Slouching Towards Utopia*, Basic Books.

In hindsight, IT spread more slowly, affected fewer sectors and in less fundamental ways than electrification had done, so its impact on productivity was weaker and shorter. The temporary uptick in TFP growth for the US in 1995-2005 (see Graph III.2) can be attributed to IT-intensive sectors (79). The euro area generally did not experience a comparable acceleration.

Already before the onset of the global financial crisis in 2008, advanced economies had suffered a slowdown in TFP growth. Then, when the financial crisis hit, followed by the euro area debt crisis, productivity dropped further. The prolonged crisis seems to have amplified the already downward trend by the hysteresis it caused through tight credit conditions, a decline in aggregate demand, economic uncertainty, and lower investment. Trend TFP growth in the euro area has been at about 0.3% since 2008. Rather than a bug, weak productivity growth has become a feature of almost all euro area countries (see Graph III.4). However, this is not a uniquely European problem. In nearly all advanced economies, productivity has come down notably from the trend growth of 1975-2000 (see Graph III.3). This occurred despite the computer age being quickly followed by the emergence of internet and mobile technology, cloud computing, robotics, big data, etc. As a result, the view that new innovations fail to produce the tidal waves caused by past technologies has gained in prominence, as will be discussed in Section IV.3.

Productivity dynamics in the euro area were thus already sluggish going into the COVID-19 pandemic. On top of the uncertain outlook for productivity growth from the pandemic comes the energy shock that hit the European economies barely two years after the onset of the pandemic.

Graph III.4: **Average TFP growth since 1996**



Source: European Commission.

Following the oil shocks from the 1970s, oil prices remained elevated until 1985. Azam (2020) found that this prolonged oil shock inflicted sizable damage on potential TFP in France and Germany, who are resource-poor economies like most EU Member States. A similar fall in potential TFP is estimated to have taken place in 2003-15, another extended period of high oil prices (80). These findings highlight how the current energy crisis risks hampering further TFP growth.

III.2. Medium-term outlook

Based on its latest forecast, the European Commission prepares medium-term economic projections, including for TFP growth. The TFP figure derived from the forecast, which covers two years ahead, is broken down into a trend component and a cyclical component based on a Kalman filter methodology which exploits the link between the TFP cycle and capacity utilisation. This trend-cycle breakdown is used to project potential TFP growth ten years ahead (81).

Graph III.5 shows the medium-term TFP projections based on the Commission forecast from autumn 2019 (so prior to the pandemic and energy crisis) and the projections based on the 2023 Spring Commission forecast. At the end of 2019, TFP growth was expected to average 0.6% in 2016-22 and to rise to about 0.7% over the next decade. This compares to an average growth rate of 0.5% since 2000, so slightly above the recent average.

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(79) Aghion P., A. Bergeaud, T. Boppart, P.J. Klenow & H. Li (2019), *A Theory of Falling Growth and Rising Rents*, Working Paper Series 2019-11, Federal Reserve Bank of San Francisco. Gordon R. & H. Sayed (2020), *Transatlantic Technologies: The Role of ICT in the Evolution of U.S. and European Productivity Growth*, NBER Working Paper No. 27425.

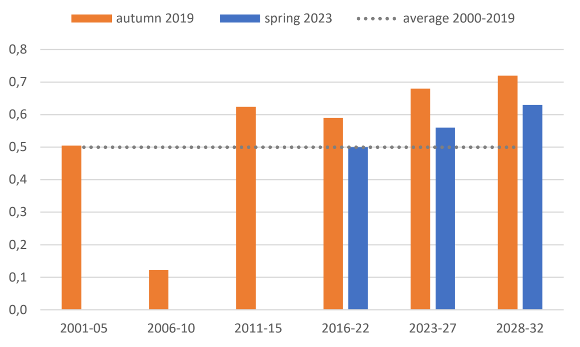
(80) Azam J-P. (2020), Oil shocks and Total Factor Productivity in resource-poor economies: The cases of France and Germany, TSE Working Paper, n° 20-1126.

(81) For more details about the methodology, see European Commission (2021), Output Gap Estimation Using the European Union's Commonly Agreed Methodology: Vade Mecum & Manual for the EUCAM Software, European Economy Discussion Paper 148.

Growth figures in the 2023 Spring Commission forecast have been revised downward compared to 2019. TFP growth eventually averaged just 0.5% in 2016-2022 and is projected to remain around these values before slightly increasing to 0.6% in 2028-2032. Lower medium-term estimates of TFP growth relative to Autumn 2019 are explained by the effects of the COVID-19 and energy shocks, which are still surrounded by considerable uncertainty. On the upside, capital accumulation and, subject to large uncertainty, technology fostered by the RRF are expected to give a significant boost to growth in the medium to long run.

TFP growth is, in other words, expected to only slightly improve upon the average of recent decades, which already compared bleakly with the longer-term average growth rate of 1.5% in 1975-2000. The tables in Annex 1 show a high dispersion in TFP growth among euro area countries. Most newer members have been achieving higher growth (see Graph III.4) and, despite downward revisions also for these countries, this difference is expected to persist over the next decade as they continue to catch up. Likewise, sluggish TFP growth would persist among the initial euro area countries.

Graph III.5: **TFP growth – euro area**



Source: European Commission.

III.3. Long-term outlook

Notwithstanding the fast pace of innovation in information technologies, productivity growth has been modest at best in the past two decades. Views on prospects for future productivity growth differ, depending on how this apparent paradox is assessed. Three broad views can be distinguished, which are discussed in this section:

1. According to the **mismeasurement hypothesis**, the observed slowdown in productivity is, at least partially, misleading since this apparent declining trend reflects how statistics do not appropriately account for digital productivity gains.

2. The **optimistic** view argues that time is needed for new technologies to mature and overcome barriers that hamper technology diffusion, stressing the role of structural policies.

3. The **pessimistic** view concludes that the decline in productivity growth is a structural phenomenon. It reflects how past transformative innovations are unlikely to be repeated in the future, with rising structural headwinds adding to the downward trend.

The mismeasurement hypothesis

Some economists point at mismeasurement by official productivity metrics to explain the modern productivity paradox. According to this view, traditional procedures for estimating GDP do not fully account for new and better products (82). However, studies that seek to correct for such omissions and biases generally conclude that mismeasurement alone can explain just a fraction of the slowdown. Syverson (2017) argues that the asserted mismeasurement in GDP data is inconsistent with estimations based on alternative sources for the US (83). Similarly, Byrne et al. (2016) argue that growth measurement errors for the ICT sector cannot explain the observed slowdown (84). They stress that the issue is not whether there is a bias but whether it is larger than it used to be. Aghion et al. (2018) estimate that at most one-sixth of the decline in the productivity growth rate between 1996-2005 and 2005-13 in the US could be attributed to mismeasurement since the rate did not increase much after 2005 (85).

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(82) See for example Hatzius J. & K. Dawsey (2015), *Doing the Sums on Productivity Paradox v2.0*, US Economics Analyst 15/30; Feldstein M. (2015), *The U.S. Underestimates Growth*, opinion contribution in the Wall Street Journal.

(83) Syverson C. (2017), *Challenges to Mismeasurement Explanations for the US Productivity Slowdown*, Journal of Economic Perspectives, Volume 31-2, pp 165-186.

(84) Byrne D., J. Fernald & M. Reinsdorf (2016), *Does the United States have a Productivity Slowdown or a Measurement Problem?*, Brookings Papers on Economic Activity.

(85) Aghion P., A. Bergeaud, T. Boppart, P. Klenow & H. Li (2018), *Missing Growth from Creative Destruction*.

The fact that the productivity slowdown is observed across all advanced economies, regardless of their ICT intensity, also suggests that it is driven by underlying macroeconomic factors, considering the varied sources and methods used across national statistical systems. Byrne et al. (2016) discuss how apparent innovations such as smartphones, Google searches, and social networks might create substantial consumer welfare, but this is essentially a non-market effect. Overall, the mismeasurement hypothesis does not satisfactorily explain the TFP growth slowdown. Brynjolfsson et al. (2017) nevertheless highlight how national statistics could fail to measure the full benefits of new technologies such as artificial intelligence (AI) in the future (86).

The optimistic view

The prolonged spell of sluggish TFP growth over the two last decades should be seen as a pause before a new acceleration arrives, argues a group of economists who are optimistic about long-term productivity prospects. In their view, a tidal wave of ground-breaking innovation is building, including: quantum computing, AI and machine learning, the Internet of Things, additive manufacturing, advanced robotics, blockchain, augmented reality, biochips, bionics and biological augmentation, human genome research and genetic engineering, synthetic biology, brain-machine interfacing, autonomous vehicles, revolutionary new materials such as graphene or nanotubes, and the innovation needed to meet the net zero carbon emission target by 2050. Spurred by global competition, these technologies should bring transformative change once they spread more widely across industries, accompanied by waves of complementary innovations (87).

Proponents of this view argue that many of the benefits of the digital and information revolutions are still to come as the technology needs to mature and spread in the economy and society. As the past showed, there can be a long lag between an innovation and the moment its applications start to have a significant impact. Van Ark (2016) considers that recent technology is often still in its 'installation phase' and productivity effects may occur only once it enters the 'deployment phase'. (88) The apparent paradox is, in other words, consistent with an economy in transition that is experiencing growing pains. Complementary investment, new skills and organisational changes are required to realise the benefits of new technologies, with productivity growth assumed to follow a J-curve (Brynjolfsson et al., 2020) (89). Frey (2019) reveals strong similarities with historical episodes, underscoring the disruptions and popular resistance that labour-replacing technologies brought about. As automation risks leaving many people worse off in the short term, the resulting social unrest might slow the pace of automation and productivity growth (90).

However, many authors believe that, while innovation might continue unabated, diffusion of new technology has become a problem, so the asserted potential might never come to fruition. This underscores the importance of structural policies. OECD firm-level analysis suggests that the aggregate productivity slowdown does not apply to the most productive firms. The overall slowdown then results from a diffusion problem from the best performers (typically larger, more profitable and younger firms, and more likely to be part of a multinational group) to the laggard firms (91). The highly uneven technological diffusion seems due to the nature of innovations at the current juncture. Intangible assets (e.g., digital platforms, design, computerised information, and organisational capital (92)) are characterised by high fixed costs and low marginal costs and are more difficult to replicate than machinery and hardware. As a result, intangible-intensive companies can scale up faster, becoming more productive and widening the gap with lagging companies (de Ridder, 2019) (93). Brynjolfsson et al. (2020) find that digital capital has disproportionately accumulated in a small

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(86) Brynjolfsson E., D. Rock & C. Syverson (2017), *Artificial Intelligence and the Modern Productivity Paradox: A Clash of Expectations and Statistics*, NBER Working Paper No. 24001.

(87) See for example Brynjolfsson E. & A. McAfee (2014), The Second Machine Age - Work, Progress, and Prosperity in a Time of Brilliant Technologies, WW Norton & Co; Mokyr J., C. Vickers & N. L. Ziebarth (2015), The History of Technological Anxiety and the Future of Economic Growth: Is this Time Different?, Journal of Economic Perspective, 29/3, pp 31-50.

(88) Van Ark (2016), *The Productivity Paradox of the New Digital Economy*, International Productivity Monitor 31, pp 3-18.

(89) Brynjolfsson E., D. Rock & C. Syverson (2020), *The Productivity J-Curve: How Intangibles Complement General Purpose Technologies*, NBER Working Paper No. 25148.

(90) Frey C.B. (2019), The technology trap. Capital, labor and power in the age of automation, Princeton University Press

(91) Andrews D., C. Criscuolo & P. N. Gal (2015), *Frontier Firms, Technology Diffusion and Public Policy: Micro Evidence from OECD Countries*, OECD Productivity Working Papers No. 2.

(92) Bloom, Sadun & Van Reenen (2017) find that differences in management practices account for about 30% of TFP differences both between countries and within countries across firms.

(93) De Ridder M. (2019), *Market Power and Innovation in the Intangible Economy*, Cambridge Working Papers in Economics 1931.

subset of 'superstar' firms and its concentration is much greater than that of other assets (94).

Aghion et al. (2019) conclude that the expansion of firms achieving high productivity levels leads to higher market concentration, thus deterring innovation by smaller and less productive firms. Notwithstanding an initial burst of growth, TFP would fall and undermine growth in the long term. Autor et al. (2020) see evidence of winner-take-all effects in high-tech sectors (95). Suedekum & Woessner (2019) find that industrial robots disproportionally lifted productivity in the European firms that were already the most productive, allowing them to increase markups (96). Akcigit and Ates (2019) see a sharp increase in the concentration of the number of patents applied for and bought by the top 1% innovating companies, with killer acquisitions by large companies, who buy patents to put them on the shelf rather than deploy the patented technology (97). Given that major leaps in technology tend to come from younger, smaller firms, the increasingly dominant position of such 'superstar' companies bodes ill for innovation.

These findings draw attention to the importance of the institutional environment and public policies such as competition policy, fundamental research, tax policy, network infrastructure, education and training, data proprietary rights and industrial policies. Philippon (2019) documents how 'superstar' firms have been lobbying successfully for anticompetitive regulations, a point stressed also in Aghion et al. (2021) (98).

As a result, even the more optimistic voices admit that a positive impact from artificial intelligence might take time to materialise and warn about excessive incentives for automation over labour-augmenting technologies. AI is considered the prime candidate to become the next general-purpose technology. It has the potential to spur a wave of complementary innovations and to automate non-routine cognitive tasks and services once thought out of reach, such as driving or medical evaluations (99). However, technology is not skill-neutral, nor is its outcome preordained: there are plenty and highly varying ways in which AI can be developed and applied. According to Acemoglu & Restrepo (2019) recent trends in AI have been biased towards automation of production ('human-replacing innovations'), resulting in 'so-so technologies': advances that disrupt employment and displace workers without generating much of a boost in productivity or quality of service (100). They argue that there has been insufficient focus on creating new activities for which labour can be employed more productively ('human-enhancing innovations'). Brynjolfsson (2022) similarly warns about an excessive focus on human-like artificial intelligence, which tries to imitate humans. Such an outcome would negatively affect inequality and welfare, feeding resentment and political instability (101). This corroborates with findings and warnings in Frey (2019). Presumable factors tilting the balance against new tasks include tax distortions between capital and labour, excessive enthusiasm about the benefits of fast automation based on not yet very effective frontier technology and skills mismatches. Hoffmann & Nurski (2021) conclude that skills, data and financing put constraints on artificial intelligence advancement in Europe (102). The prevailing business model and vision of large tech companies steering AI developments might also play a role, as well as the overall declining government role in innovation, with research paying less attention to future promises than on near-term automation possibilities. According to Acemoglu (2021) government regulation and policies, going beyond promoting competition, are needed to redirect AI research towards the most beneficial outcomes (103).

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(94) Brynjolfsson E., L. Hitt, D. Rock & P. Tambe (2020), *Digital Capital and Superstar Firms*, NBER Working Paper 28285.

(95) Autor D., D. Dorn, L.F. Katz, C. Patterson & J. Van Reenen (2020), *The Fall of the Labor Share and the Rise of Superstar Firms*, NBER Working Paper No. 23396.

(96) Suedekom J. & N. Woessner (2019), *Robots and the Rise of European Superstar Firms*, European Economy Discussion Paper No. 118.

(97) Akcigit U. & S.T. Ates (2019), *What Happened to US Business Dynamism?*, BFI Research Brief.

(98) Philippon T. (2019), *The Great Reversal: How America Gave Up on Free Markets*, Harvard University Press; Aghion P., C. Antonin & S. Bunel (2021), *The Power of Creative Destruction*, Belknap Press.

(99) See, for instance, Trajtenberg M. (2018), *AI as the next GPT: a Political-Economy Perspective*, NBER Working Paper No. 24245; Agrawal A., J. Gans & A. Goldfarb (2019), *The Economics of Artificial Intelligence: An Agenda*, University of Chicago Press.

(100) Acemoglu D. & P. Restrepo (2019), *The Wrong Kind of AI? Artificial Intelligence and the Future of Labor Demand*, NBER Working Paper No. 25682. As examples of 'so-so technologies', they point to self-checkout kiosks at grocery stores, self check-in at airports and automated customer service software.

(101) Brynjolfsson E. (2022), The Turing Trap: The Promise & Peril of Human-Like Artificial Intelligence, Stanford Digital Economy Lab Insights.

(102) Hoffmann M. & L. Nurski (2021), The triple constraint on artificial-intelligence advancement in Europe, Bruegel blog post 06/12/2021.

(103) Acemoglu (2021), *Harms of AI*, NBER Working Paper No. 29247.

The pessimistic view

According to other economists, even if barriers to productivity diffusion were to be overcome, future innovation will fail to lift productivity growth permanently above its sluggish trend. Gordon (2014, 2016) is probably the best-known proponent on this side of the debate. He argues that, similar to what has been ongoing for the past 50 years, contemporary breakthroughs in for example AI, robotics or nanotechnology fall short of the progress during 'the long century' of 1870-1970, which was exceptional in the number and scope of life-changing innovations. The 'big wave' of broad-based innovation seen during that exceptional period can simply not be repeated (104). The downward trend of past decades then justifies a cautious view about the ability of new technology to significantly lift future productivity growth.

Vollrath (2020) similarly highlights how the 20th century was exceptional. Lower growth is the outcome of a successful process of rising longevity and living standards, which shift demand towards services. Services can less easily achieve productivity gains, though, as they often require interaction and non-standard actions. The sharp price decrease for electronics and computing power might have accelerated the shift to services and ageing might do the same. According to Vollrath, policy makers should focus on issues such as environmental and distributional problems rather than trying to bring growth back to past rates (105).

Importantly, Gordon does not claim that technological progress has stopped but rather that it has reversed to its historical trend. The IT-driven acceleration that started in the mid-1990s is considered a temporary deviation from the long-term downward trend in productivity growth. Moreover, it was only a minor wave compared to the 'one big wave'. More such deviations might follow since new technologies could result in positive shocks, though no permanent return to a higher growth rate is to be expected. Gordon notes how progress since the 1970s has been concentrated in a relatively narrow part of the economy: entertainment, communication and information processing.

Claims that technological progress has reached a saturation point are not new. Already in 1988 Olson argued that a slowdown in productivity growth was unavoidable. He observed that within a couple of decades after World War II, the previously neglected innovations had largely been exploited, gains from reallocating resources had largely disappeared, high-tech production had dispersed globally because of technology adoption, and gains from institutional reforms had reached their limits (106). Similar observations were made at the end of the 19th century, as the drivers of the first Industrial Revolution had run their course and the benefits of electrification were not yet felt. Towards the end of the Great Depression, Alvin Hansen (1938) saw the emergence of a 'secular stagnation', due to a lack of investment because of faltering innovation and slowing population growth (107). Refuted by the post-war economic boom, the secular stagnation thesis was revived in the past decade. It blames weak economic growth on an imbalance between declining investment and higher savings so that negative real interest rates are needed to achieve full employment (108). A supply-side approach to the secular stagnation theory boils down to the arguments advanced by Gordon and others.

Bloom et al. (2017) find that ideas are getting ever harder to find: research inputs have been rising substantially but research output is declining sharply across industries. They estimate that just to maintain the same overall rate of economic growth, the US would need to double its research efforts every 13 years. It now takes, for instance, more than 18 times the number of researchers to achieve Moore's law — doubling chip density/power about every two years — than in the early 1970s. So, while the world is not running out of ideas, they are getting more expensive to find, for example because researchers need to master an ever-larger body of knowledge and they increasingly work in

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(104) Gordon R.J. (2014), The Demise of U.S. Economic Growth: Restatement, Rebuttal, and Reflections, NBER Working Paper No. 19895; Gordon R.J. (2016), The Rise and Fall of American Growth: The U.S. Standard of Living since the Civil War, Princeton University Press.

(105) Vollrath D. (2020), Fully Grown: Why a Stagnant Economy Is a Sign of Success, University of Chicago Press.

(106) Olson M. (1988), *The Productivity Slowdown, The Oil Shocks, and the Real Cycle*, Journal of Economic Perspectives, Volume 2, No. 4, pp 43-69.

(107) Hansen A. (1938), *Economic progress and declining population growth*, Presidential address delivered at the 51th Annual Meeting of the American Economic Association.

(108) Teulings C. & R. Baldwin (ed.) (2014), *Secular stagnation: Facts, causes, and cures*, CEPR Press.

larger teams of specialised members (109). In other words, innovation has run into diminishing returns, inexorably slowing TFP growth. Nordhaus (2021) concludes that, Contrary what is suggested by writers such as Brynjolfsson & McAfee (2014) (110), a 'growth singularity' is not near.

A growth singularity in this case refers to a rapid growth in computation and artificial intelligence, toa point after which economic growth will accelerate sharply, causing an ever-accelerating pace of improvements to cascade through the economy.

Even leaving aside the dearth of economy-altering innovation, the pessimistic viewpoint considers that the emergence of several structural headwinds raises the likelihood of a growth slowdown. To offset the impact of these structural changes, lots of additional innovation would be needed. There is, for example, a natural limit to the long-run pattern of rising educational attainment, both in duration of schooling and how many people are affected. Bergeaud et al. (2017) conclude that few gains remain to be obtained from this for the euro area, though there are considerable disparities among countries, and Bell et al. (2019) highlight how the 'inventor pool' includes few women, minorities and children from low-income families, resulting in 'lost Einsteins and Marie Curies' (111). Other factors that darken the productivity outlook include demographic ageing, deglobalisation, climate change and high public debt (limiting the potential to boost public investment).

Adler et al. (2017) estimate that shifts in the age structure may have played a role in lower TFP growth, reducing it by as much as 0.2-0.5 pps per year on average across advanced economies (112). Aiyar et al. (2016) find that an ageing workforce would reduce TFP growth by 0.2 pps per year in the euro area in the period up to 2035. They calculate that around 45% of the EU workforce is concentrated in occupations where productivity decreases with age and only 25% in occupations where productivity increases with age (113). However, micro-level studies argue that the link between age structure and firm productivity is more nuanced. Rather than being a function of age, the productivity divide appears to be based on skills levels. Acemoglu & Restrepo (2017) even find a positive relationship between ageing and economic growth and suggest that this might be related to a more rapid adoption of automation technologies such as industrial robots in countries undergoing rapid population ageing (114). Basso & Jimeno (2021) add an important qualification in that, because of a trade-off between investment in automation and innovation, population ageing eventually leads to lower growth in GDP per capita. Automation increases productivity by substituting labour in production but cannot sustain growth in the long run because automation is a subsidiary activity of innovation, which yields new products (115).

A decades-long drive toward global integration has halted and risks going into reversal. The post-war paradigm (that welfare increases when economies engage in international trade and integrate into global value chains) is challenged by the rising prevalence of protectionist policies and mounting geopolitical tensions. In addition, the COVID-19 pandemic exposed how tightly integrated global production systems are vulnerable to disruptions, which might lead to a retrenchment of global value chains. Together with the rise in trade barriers this might cause a partial reversal of globalisation. Such global fragmentation into trading blocs might negatively impact productivity growth through reduced technology transfers, a deterioration in input access and quality, and fewer possibilities for productive firms to grow internationally.

Climate change might lead to considerable losses in productivity, particularly via lost hours worked, damage to capital stocks, and resource diversion from investment in productive capital and innovation to climate change adaptation and

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(109) Bloom N., C.I. Jones, J. Van Reenen, M. Webb (2017), *Are Ideas Getting Harder to Find?*, NBER Working Paper No. 23782.

(110) Nordhaus D. (2021), *Are We Approaching an Economic Singularity? Information Technology and the Future of Economic Growth*, American Economic Journal: Macroeconomics, 13(1), pp 299–332.

(111) Bell A., R. Chetty, X. Jaravel, N. Petkova & J. Van Reenen (2019), *Who Becomes an Inventor in America? The Importance of Exposure to Innovation*, The Quarterly Journal of Economics, Volume 134/2, pp 647-713.

(112) Adler G., R. Duval, D. Furceri, S. Kiliç Çelik, K. Koloskova & M. Poplawski Ribeiro (2017), *Gone with the Headwinds: Global Productivity*, IMF Staff Discussion Notes No. 2017/004.

(113) Aiyar S., C. Ebeke & X. Shao (2016), *The impact of workforce ageing on Euro area productivity*, IMF Working Papers 16/238.

(114) Acemoglu D., Restrepo P. (2017), Secular Stagnation? The Effect of Aging on Economic Growth in the Age of Automation, NBER Working Paper No. 23077.

(115) Basso H.S. & J.F. Jimeno (2021), From Secular Stagnation to Robocalypse? Implications of Demographic and Technological Changes, Journal of Monetary Economics, Vol. 117, pp 833-847.

reconstruction efforts (116). These effects are expected to be further exacerbated by more frequent and intense extreme weather events. Estimates indicate that TFP in advanced economies hit by natural disasters declines by 0.3% in the first year, with climate disasters being particularly detrimental for productivity. Estimates for advanced economies indicate that climate disasters reduce labour productivity by about 0.5% and have persistent effects (117). At the same time, mitigating climate change by drastically cutting CO2 emissions and reaching net zero by 2050 is such an all-encompassing challenge that it would require a massive boost in innovation. This could push the technological frontier significantly outwards.

Gordon (2012) considers that efforts to cope with global warming partly represent a payback for past growth (118). To a considerable extent, current welfare levels mirror efficiency gains from technologies that rely on hydrocarbon burning, the negative externalities of which were ignored for much of the past century (119). The urgent need to decarbonise implies a large supply shock, with an overhaul of the economic fabric, abandoning certain technologies and investing massively in alternatives. The absolute priority of climate mitigation and adaptation measures over other considerations might crowd out more productive investment, thus restraining productivity growth in the medium term (120). However, the OECD (2021) finds that in recent decades the negative effect on aggregate productivity growth of (less far-reaching) environmental policies was temporary. At the same time, the productivity gap widened: the most technologically advanced companies and sectors saw a small increase in productivity, possibly as they were in the best position to adapt, while productivity fell further for the least productive firms (121).

III.4. Conclusion

Total factor productivity is the dominant determinant of growth in the long term, since it captures how technological progress allows for a more efficient use of labour and capital inputs. However, a declining trend in TFP growth has been ongoing for many decades.

The oil shocks of the 1970s ended a decades-long period of fast economic growth. The slowdown mainly affected TFP growth, which entered a lower growth trajectory as of the 1970s, despite notable technological progress. Around the turn of the century, TFP growth decelerated further in nearly all initial euro area countries, while newer members in turn caught up. However, when the global financial crisis hit, productivity dropped across the board and came to a standstill. In the 2010s, few countries showed signs of a substantial recovery in TFP growth, with the prolonged financial crisis seemingly having hurt the productivity potential. The succession of frequent supply shocks in recent years, with the COVID-19 pandemic, the war in Ukraine and the energy crisis, might further erode the already weak trend in TFP growth.

The apparent discrepancy between relentless innovation and the productivity slowdown in advanced economies has been attributed to several factors. The more optimistic view considers that TFP growth will unavoidably rebound once (i) new ground-breaking technologies such as artificial intelligence have had more time to mature, (ii) complementary investment and organisational changes are made, and (iii) the necessary new skills have been acquired. Less optimistic studies conclude that technology diffusion has fallen because of the rising importance of intangible capital and higher market concentration, deterring innovation. Or because innovation is simply not as transformative as in the past.

However, the extent to which innovation eventually translates into productivity is not predetermined since certain factors can inhibit the growth potential of new technology, e.g. a shortage of skilled workers, access to financing or competition policies that favour incumbents.

There are also signs that research has an insufficient focus on creating new activities for which labour can be employed more productively. As a result, even the more optimistic voices admit that a positive impact from breakthrough

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(116) Batten S. (2018), *Climate change and the macro-economy: a critical review*, BoE Staff Working Paper No. 76.

(117) Dieppe A. (ed.) (2021), Global Productivity – Trends, Drivers and Policies, World Bank Group.

(118) Gordon R.J. (2012), Is US economic growth over? Faltering innovation confronts the six headwinds, NBER Working Paper No. 18315.

(119) Similarly, productivity growth can be overestimated where economic growth relies on heavily polluting technologies or on natural capital depletion.

(120) Pisani-Ferry J. (2021), Climate Policy is Macroeconomic Policy, and the Implications Will Be Significant, PIIE Policy Brief 21-20.

(121) OECD (2021), Assessing the Economic Impacts of Environmental Policies: Evidence from a Decade of OECD Research, OECD Publishing.

technologies such as artificial intelligence might take time to materialise.

An even more cautious view has gained in prominence because of the observed developments. It concludes that, aside from a transmission problem, innovation is simply not as transformative as in the past. A dearth of economy-altering innovation has pushed productivity growth back to its long-run historical trend and one should not expect a permanent return to a higher growth rate, even though new technologies might temporarily lift it (as was the case with the IT-driven acceleration at the end of the 20th century).

In addition to a lack of transformative inventions, the cautious view points to rising structural headwinds that might add to the downward trend in productivity growth, such as global fragmentation, climate change, demographic ageing, and rising government debt.

In conclusion, in the medium-term, the outlook for productivity growth is negatively affected by the effects of the COVID-19 pandemic and the energy shocks, which are still surrounded by considerable uncertainty, partly compensated by capital accumulation and technological developments fostered by the RRF. In the longer term, curbing the slowing trend in productivity growth depends on fully exploiting the potential of breakthrough innovation. This underlines the importance of policies that enable innovation to be translated into technology. These policies include fundamental research, taxation, network infrastructure, competition policy, access to finance, education and training, data proprietary rights, and industrial policy.

EU programmes such as NextGenerationEU and Horizon Europe, as well as the effectiveness of national research frameworks, should facilitate the diffusion of existing innovation and the creation of new innovation in the context of the twin green and digital transitions.

Annex 1: Country tables

Table III.1: **Average growth and contributions**

BE	K/L	TFP	WAP	ER	hours	total
1966-70	1,4	3,6	0,4	0,1	-0,8	4,7
1971-75	1,5	2,8	0,6	-0,3	-1,1	3,5
1976-80	1,5	2,5	0,5	-0,5	-0,9	3,1
1981-85	0,7	1,0	0,2	-1,0	0,0	0,9
1986-90	0,6	1,7	0,3	0,9	-0,5	3,0
1991-95	1,2	1,4	0,5	-0,3	-1,2	1,6
1996-00	0,3	1,2	0,0	1,2	0,1	2,8
2001-05	0,3	0,9	0,4	0,4	-0,1	1,9
2006-10	0,2	0,3	0,7	0,3	0,0	1,5
2011-15	0,3	0,5	0,5	0,0	0,0	1,3
2016-22	0,2	0,1	0,5	0,9	-0,2	1,5
2023-27	0,2	0,3	0,4	0,3	0,2	1,4
2028-32	0,3	0,4	0,2	0,0	0,0	0,9

DE	K/L	TFP	WAP	ER	hours	total
1966-70	1,8	3,4	0,4	-0,5	-1,1	4,0
1971-75	1,9	2,4	0,4	-0,7	-1,7	2,4
1976-80	0,8	2,2	0,5	0,4	-0,6	3,3
1981-85	0,9	1,2	0,3	-0,1	-0,9	1,4
1986-90	0,4	2,1	0,3	1,6	-1,1	3,2
1991-95	1,0	1,4	0,7	-0,6	-0,5	2,0
1996-00	0,6	1,1	0,1	0,9	-0,9	1,9
2001-05	0,6	0,7	0,2	-0,5	-0,5	0,5
2006-10	0,0	0,4	-0,4	1,3	-0,1	1,2
2011-15	0,0	1,0	-0,2	1,2	-0,4	1,7
2016-22	0,2	0,7	0,1	0,7	-0,6	1,1
2023-27	0,2	0,6	-0,1	0,3	-0,2	1,0
2028-32	0,5	0,8	-0,2	-0,3	0,0	0,7

EE	K/L	TFP	WAP	ER	hours	total
1966-70	-	-	1,1	-	-	-
1971-75	-	-	1,0	-	-	-
1976-80	-	-	0,6	-	-	-
1981-85	-	-	0,5	-	-	-
1986-90	-	-	0,5	-	-	-
1991-95	-	-	-1,3	-4,2	-0,2	-
1996-00	1,9	4,9	0,1	-1,6	0,8	6,1
2001-05	2,1	3,8	-0,3	1,2	0,3	7,1
2006-10	3,4	-0,2	-0,6	-1,6	-1,4	-0,4
2011-15	0,6	0,4	-0,8	3,4	-0,2	3,3
2016-22	1,1	1,0	0,3	0,7	0,1	3,1
2023-27	0,9	1,0	0,2	-0,2	0,0	1,9
2028-32	0,8	1,0	-0,3	0,0	0,0	1,4

IE	K/L	TFP	WAP	ER	hours	total
1966-70	1,7	3,0	0,6	-0,9	0,1	4,6
1971-75	2,0	3,2	1,7	-1,3	-0,8	4,8
1976-80	1,7	2,3	1,5	0,0	-1,1	4,4
1981-85	1,8	2,0	1,1	-2,6	0,1	2,5
1986-90	0,4	3,0	0,2	0,8	-0,1	4,5
1991-95	0,4	3,3	1,3	0,4	-0,9	4,6
1996-00	-0,2	4,3	1,7	4,1	-0,9	9,0
2001-05	1,3	2,0	2,1	0,7	-0,9	5,2
2006-10	2,3	0,7	1,7	-2,8	-1,5	0,4
2011-15	2,9	2,0	0,4	0,9	0,2	6,4
2016-22	0,1	4,8	1,3	1,7	-0,2	7,7
2023-27	0,2	3,1	1,2	-0,1	0,3	4,6
2028-32	0,8	1,8	0,7	-0,2	0,0	3,1

EL	K/L	TFP	WAP	ER	hours	total
1966-70	3,1	6,0	0,7	-1,4	-0,7	7,7
1971-75	2,3	2,2	0,6	-0,2	0,1	4,9
1976-80	1,3	1,7	1,4	-0,4	0,1	4,1
1981-85	0,6	-1,3	0,9	0,5	-0,5	0,1
1986-90	0,6	0,3	0,9	-0,2	-0,4	1,2
1991-95	0,3	0,0	1,4	-0,8	0,3	1,2
1996-00	0,5	2,4	0,8	-0,1	0,0	3,6
2001-05	0,2	1,8	-0,1	1,6	0,3	3,8
2006-10	0,9	-0,6	0,0	0,3	-1,0	-0,3
2011-15	0,1	-2,5	-0,9	-0,8	0,0	-4,1
2016-22	-0,9	0,4	-0,5	2,5	-0,4	1,2
2023-27	-0,1	0,7	-0,5	1,3	0,0	1,4
2028-32	0,4	0,8	-0,8	0,3	0,0	0,7

ES	K/L	TFP	WAP	ER	hours	total
1966-70	1,4	3,4	0,9	-0,2	0,4	6,1
1971-75	1,8	3,0	1,2	-0,8	0,0	5,2
1976-80	2,2	2,0	1,2	-2,8	-0,8	1,8
1981-85	1,8	2,5	1,0	-2,4	-1,5	1,4
1986-90	0,2	1,0	0,9	2,6	-0,3	4,4
1991-95	1,3	0,6	1,2	-1,5	-0,1	1,5
1996-00	-0,1	0,2	0,7	3,1	0,2	4,0
2001-05	0,5	-0,3	1,3	2,0	-0,3	3,2
2006-10	1,4	0,0	1,0	-1,2	-0,2	1,0
2011-15	0,7	0,5	-0,3	-0,8	-0,1	0,0
2016-22	0,0	0,2	0,4	1,0	-0,4	1,3
2023-27	-0,1	0,2	0,6	0,6	0,3	1,6
2028-32	0,4	0,4	0,1	-0,2	0,0	0,8

FR	K/L	TFP	WAP	ER	hours	total
1966-70	2,1	4,2	1,0	-0,3	-1,6	5,4
1971-75	2,0	2,6	0,9	-0,4	-1,3	3,8
1976-80	1,2	2,1	0,7	0,0	-0,6	3,3
1981-85	1,5	2,0	0,7	-0,8	-1,8	1,6
1986-90	0,6	1,9	0,7	0,3	-0,1	3,3
1991-95	0,9	1,0	0,7	-0,7	-0,5	1,3
1996-00	0,3	1,6	0,3	1,2	-0,5	2,9
2001-05	0,6	0,8	0,6	-0,1	-0,3	1,7
2006-10	0,5	-0,2	0,4	0,0	0,1	0,8
2011-15	0,4	0,5	0,5	0,0	-0,3	1,0
2016-22	0,1	-0,1	0,4	0,8	0,0	1,1
2023-27	0,4	0,2	0,1	0,1	0,0	0,8
2028-32	0,2	0,1	0,0	0,1	0,0	0,4

HR	K/L	TFP	WAP	ER	hours	total
1966-70	-	-	-	-	-	-
1971-75	-	-	-	-	-	-
1976-80	-	-	-	-	-	-
1981-85	-	-	-	-	-	-
1986-90	-	-	-	-	-	-
1991-95	-	-	-	-	-	-
1996-00	0,8	2,6	-	-	0,0	3,2
2001-05	0,8	2,8	-	-	0,0	4,5
2006-10	1,2	-1,4	-0,3	1,0	0,2	0,6
2011-15	1,3	1,1	-0,5	-0,8	-1,2	-0,2
2016-22	0,1	1,6	-1,1	2,6	0,1	3,2
2023-27	0,6	0,7	-0,7	1,1	0,0	1,8
2028-32	1,0	1,1	-1,0	0,2	0,0	1,3

IT	K/L	TFP	WAP	ER	hours	total
1966-70	1,7	4,9	0,5	-0,5	0,0	6,6
1971-75	2,0	1,6	0,6	0,0	-1,4	2,8
1976-80	1,1	2,6	0,8	0,1	-0,6	4,0
1981-85	0,9	0,3	0,6	-0,3	0,0	1,4
1986-90	0,6	1,5	0,5	0,4	0,0	3,0
1991-95	0,9	1,1	0,5	-1,2	-0,1	1,2
1996-00	0,3	0,8	-0,2	1,2	-0,1	2,0
2001-05	0,4	-0,3	0,1	1,1	-0,4	0,9
2006-10	0,5	-0,7	0,2	0,0	-0,4	-0,3
2011-15	0,3	-0,1	0,3	-0,5	-0,7	-0,7
2016-22	-0,1	0,4	-0,4	1,0	-0,2	0,8
2023-27	0,3	0,4	-0,1	0,0	0,1	0,7
2028-32	0,3	0,4	-0,1	0,0	0,0	0,5

CY	K/L	TFP	WAP	ER	hours	total
1966-70	-	-	-	-	-	-
1971-75	-	-	-	-	-	-
1976-80	-	-	-	-	-	-
1981-85	-	-	-	-	-	-
1986-90	-	-	-	-	-	-
1991-95	-	-	-	-	-	5,2
1996-00	0,9	1,6	1,9	-0,7	0,3	4,1
2001-05	0,7	1,0	1,9	1,1	-0,8	4,0
2006-10	1,3	-0,7	2,9	-0,9	0,0	2,7
2011-15	1,0	-0,5	0,4	-2,3	-0,2	-1,7
2016-22	0,0	1,3	1,0	2,1	-0,1	4,3
2023-27	0,8	0,3	0,6	-0,2	0,4	1,9
2028-32	1,0	0,7	0,0	0,0	0,0	1,7

LV	K/L	TFP	WAP	ER	hours	total
1966-70	-	-	-	-	-	-
1971-75	-	-	0,9	-	-	-
1976-80	-	-	0,5	-	-	-
1981-85	-	-	0,3	-	-	-
1986-90	-	-	0,5	-	-	-
1991-95	-	-	-1,0	-6,5	-0,2	-12,6
1996-00	1,3	4,0	-0,3	0,2	0,0	5,1
2001-05	2,3	4,8	-0,7	1,7	-0,2	7,8
2006-10	4,0	0,0	-1,4	-1,3	-1,7	-0,5
2011-15	0,7	2,0	-1,8	2,9	-0,3	3,4
2016-22	1,0	1,9	-1,1	0,9	-0,2	2,4
2023-27	1,0	1,3	-1,0	0,5	0,0	1,9
2028-32	1,3	1,7	-1,1	-0,5	-0,1	1,4

LT	K/L	TFP	WAP	ER	hours	total
1966-70	-	-	-	-	-	-
1971-75	-	-	1,4	-	-	-
1976-80	-	-	1,0	-	-	-
1981-85	-	-	0,8	-	-	-
1986-90	-	-	1,0	-	-	-
1991-95	-	-	0,0	-2,4	-2,2	-10,9
1996-00	0,8	3,5	-0,4	-0,7	1,3	4,5
2001-05	1,4	5,3	-0,6	0,9	0,4	7,3
2006-10	2,8	0,8	-1,3	-1,3	0,1	1,2
2011-15	0,6	2,0	-1,5	3,0	-0,3	3,7
2016-22	1,3	1,2	-0,5	1,7	-0,4	3,3
2023-27	1,4	1,2	-0,4	0,0	0,2	2,5
2028-32	1,4	1,5	-0,9	-0,5	0,0	1,5

LU	K/L	TFP	WAP	ER	hours	total
1966-70	0,5	3,0	0,6	-0,1	-0,6	3,3
1971-75	0,5	1,2	1,5	0,8	-1,2	2,9
1976-80	1,1	1,7	0,4	-0,4	-0,7	2,2
1981-85	0,7	2,1	0,4	-0,1	-0,6	2,5
1986-90	0,1	4,0	0,7	2,4	0,0	7,2
1991-95	0,6	1,1	1,2	1,5	-0,5	3,9
1996-00	0,1	1,7	1,1	2,8	-0,1	5,5
2001-05	0,4	0,1	1,2	1,8	-0,5	3,1
2006-10	0,4	-0,1	1,9	1,2	-0,6	2,7
2011-15	0,3	-0,6	2,6	-0,2	0,0	2,1
2016-22	-0,1	-0,3	2,1	0,9	-0,4	2,2
2023-27	-0,3	-0,1	1,8	0,7	0,4	2,5
2028-32	0,3	0,1	1,2	0,0	0,0	1,7

MT	K/L	TFP	WAP	ER	hours	total
1966-70	-	-	-	-	-	-
1971-75	-	-	-	-	-	-
1976-80	-	-	-	-	-	-
1981-85	-	-	1,0	-	-	-
1986-90	-	-	1,2	-	-	-
1991-95	-	-	1,4	0,2	-1,2	-
1996-00	0,6	2,2	1,0	-0,8	1,4	4,4
2001-05	1,0	0,8	1,5	-0,8	-0,7	1,8
2006-10	0,8	0,9	0,9	0,7	-0,3	3,0
2011-15	0,4	2,9	1,4	2,5	-2,0	5,3
2016-22	0,2	0,2	2,6	2,4	-0,4	5,0
2023-27	0,9	1,2	1,8	0,4	-0,2	4,1
2028-32	0,7	1,2	1,5	0,3	-0,1	3,6

NL	K/L	TFP	WAP	ER	hours	total
1966-70	1,4	3,0	1,4	0,2	-0,7	5,3
1971-75	1,9	2,8	1,4	-0,9	-1,9	3,3
1976-80	0,9	1,5	1,4	-0,1	-1,1	2,6
1981-85	0,8	1,0	1,1	-1,1	-0,7	1,1
1986-90	0,1	1,5	0,8	1,5	-0,7	3,3
1991-95	0,1	0,8	0,6	0,7	0,1	2,3
1996-00	0,1	2,0	0,4	2,0	-0,2	4,3
2001-05	0,7	0,7	0,5	-0,1	-0,4	1,3
2006-10	0,4	0,1	0,4	0,6	-0,2	1,4
2011-15	0,3	0,3	0,4	-0,4	0,1	0,7
2016-22	-0,2	0,2	0,6	1,4	0,0	2,1
2023-27	0,3	0,2	0,4	0,3	0,1	1,2
2028-32	0,4	0,4	0,0	0,0	0,0	0,7

AT	K/L	TFP	WAP	ER	hours	total
1966-70	2,0	5,0	0,2	-0,9	-1,1	5,2
1971-75	1,4	1,5	0,5	0,3	0,1	3,9
1976-80	1,3	1,6	0,5	0,2	-0,3	3,2
1981-85	1,3	1,2	0,5	-0,9	-0,6	1,5
1986-90	0,7	1,4	0,4	0,5	0,0	3,0
1991-95	1,2	1,4	0,8	-0,7	-0,6	2,2
1996-00	0,6	1,2	0,1	0,8	0,3	2,9
2001-05	0,7	0,9	0,6	0,0	-0,5	1,8
2006-10	0,6	0,6	0,5	0,6	-1,0	1,3
2011-15	0,4	0,5	0,6	0,3	-0,7	1,1
2016-22	0,3	0,5	0,5	0,8	-0,5	1,5
2023-27	0,3	0,2	0,1	0,5	0,1	1,2
2028-32	0,4	0,6	0,1	0,1	0,0	1,2

PT	K/L	TFP	WAP	ER	hours	total
1966-70	1,1	4,4	-0,7	0,8	-0,8	4,8
1971-75	1,3	1,4	1,2	-1,2	1,7	4,5
1976-80	1,4	3,3	1,7	-1,7	0,4	5,1
1981-85	1,4	-0,5	0,9	-1,7	1,0	1,2
1986-90	0,7	3,2	0,6	0,5	1,0	6,0
1991-95	1,5	0,8	0,6	-1,2	0,1	1,9
1996-00	0,7	1,0	0,7	1,5	0,2	4,0
2001-05	1,2	-0,1	0,3	-0,3	-0,2	0,9
2006-10	0,9	0,4	0,0	-0,7	0,0	0,6
2011-15	0,3	0,3	-0,5	-0,8	-0,2	-0,8
2016-22	-0,3	1,5	-0,1	1,5	-0,6	2,0
2023-27	0,1	0,9	-0,2	0,3	0,4	1,4
2028-32	0,5	0,9	-0,6	-0,2	0,1	0,7

SI	K/L	TFP	WAP	ER	hours	total
1966-70	-	-	1,0	-	-	-
1971-75	-	-	0,8	-	-	-
1976-80	-	-	1,0	-	-	-
1981-85	-	-	0,7	-	-	-
1986-90	-	-	0,9	-	-	-
1991-95	-	-	0,7	-	-	-0,6
1996-00	1,5	3,2	0,4	-0,5	-0,5	4,0
2001-05	1,2	2,1	0,2	0,1	-0,2	3,5
2006-10	1,2	0,2	0,2	0,5	-0,2	1,9
2011-15	-0,1	0,9	-0,3	-0,1	0,1	0,4
2016-22	-0,4	2,5	0,2	1,7	-0,6	3,5
2023-27	0,8	1,2	0,1	-0,2	0,0	1,9
2028-32	0,7	1,6	-0,3	0,1	0,0	2,1

SK	K/L	TFP	WAP	ER	hours	total
1966-70	-	-	1,5	-	-	-
1971-75	-	-	1,1	-	-	-
1976-80	-	-	0,8	-	-	-
1981-85	-	-	0,5	-	-	-
1986-90	-	-	0,8	-	-	-
1991-95	-	-	1,1	-	-	-
1996-00	0,8	3,8	0,7	-1,5	-0,4	3,4
2001-05	0,3	4,4	0,5	0,1	-0,5	4,9
2006-10	0,8	3,0	0,3	0,4	0,4	5,0
2011-15	0,9	1,2	0,1	0,8	-0,6	2,5
2016-22	0,9	1,3	-0,1	1,1	-1,1	2,0
2023-27	1,0	1,2	-0,3	0,0	-0,1	1,8
2028-32	1,0	1,5	-0,6	-0,4	-0,1	1,5

FI	K/L	TFP	WAP	ER	hours	total
1966-70	1,9	3,5	0,8	-0,7	-0,9	4,6
1971-75	2,2	3,5	1,0	-0,6	-1,5	4,6
1976-80	1,5	2,6	0,5	-0,2	-1,2	3,2
1981-85	1,1	1,6	0,5	0,1	-0,4	2,8
1986-90	1,2	2,2	0,2	0,2	-0,3	3,4
1991-95	1,4	1,8	0,5	-4,1	0,1	-0,4
1996-00	-0,1	3,2	0,3	1,9	-0,3	5,0
2001-05	0,4	1,6	0,2	0,8	-0,4	2,6
2006-10	0,5	0,1	0,5	0,1	-0,4	0,9
2011-15	0,4	-0,2	0,3	-0,1	-0,4	0,1
2016-22	0,3	0,5	0,2	1,1	-0,5	1,6
2023-27	0,5	0,5	0,0	0,2	-0,1	1,2
2028-32	0,6	0,7	-0,2	0,1	0,0	1,1

EA	K/L	TFP	WAP	ER	hours	total
1966-70	1,8	4,0	0,7	-0,4	-0,8	5,2
1971-75	1,9	2,4	0,7	-0,5	-1,3	3,3
1976-80	1,1	2,2	0,7	-0,2	-0,6	3,3
1981-85	1,1	1,3	0,6	-0,7	-0,9	1,4
1986-90	0,5	1,7	0,5	1,0	-0,4	3,3
1991-95	0,9	1,1	0,7	-0,8	-0,4	1,6
1996-00	0,3	1,3	0,2	1,3	-0,3	2,8
2001-05	0,5	0,5	0,4	0,3	-0,3	1,6
2006-10	0,6	0,1	0,2	0,2	-0,3	0,8
2011-15	0,4	0,6	0,0	0,1	-0,4	0,8
2016-22	0,1	0,6	0,1	1,0	-0,3	1,5
2023-27	0,2	0,5	0,1	0,3	0,1	1,2
2028-32	0,4	0,6	-0,1	-0,1	0,0	0,8

The columns show the contribution to the total growth of the different factors: K/L: capital intensity; TFP: total factor productivity; WAP: working-age population (people aged 15-74y); ER: employment rate (15-74y); hours: average number of hours worked by workers aged 15-74. Note that growth projections follow the methodology explained in The Production Function Methodology for Calculating Potential Growth Rates & Output Gaps (europa.eu).

Source: European Commission