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Quo vadis, productivity?

Andreas Breitenfellner, Robert Holzmann, Richard Sellner, Maria Silgoner and Thomas Zörner[1]

Abstract

Achieving high productivity growth is a central goal of policymaking, given that productivity (growth) impacts not only key macroeconomic variables, but also a country's living standards. Central banks have an intrinsic interest in promoting productivity growth because of its interaction with the natural rate of interest r, a key variable of monetary policy. The natural rate of interest is also crucial for the scope of monetary policy space – both in terms of conventional and unconventional policies. Summarizing recent empirical evidence, we present nine hypotheses about why productivity dynamics may have slowed down recently in industrial countries around the world: (1) lack of (investment) demand; (2) expansionary monetary policy; (3) firm size and age; (4) technological cycles, the nature of recent innovations and the time it takes to apply them productively; (5) weak technological diffusion; (6) subdued creative destruction; (7) financial market dynamics and valuation; (8) population aging; and (9) regulation and the compliance burden. The factors that will shape future productivity trends may differ from today's and past drivers. For this reason, we highlight three policy fields that may become even more critical over the next decades: population aging, digitalization and climate change. We conclude that weak productivity growth must be approached from various angles. Appropriate policy mixes may differ widely across global and European regions. Here, central banks can play a crucial role in helping governments find this appropriate policy mix.*

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1 Motivation and outline

Paul Krugman (1994): "Productivity isn't everything, but in the long run it is almost everything."

Achieving high productivity growth is a central goal of policymaking in most countries around the globe, given its key role for variables such as income per capita, supply of goods and services, wage growth and international competitiveness, potential output and the natural rate of interest. The lower productivity is, the more economic growth depends on resource use. Also, the productivity level of firms is positively correlated with job creation (Bauer et al., 2020).

In this paper, we aim at giving an overview about the various factors that have potentially contributed to the recent slowdown of productivity dynamics as well as to regional productivity gaps in industrial countries. Starting from this problem identification, we sketch policy options to promote productivity growth. As the factors that will shape future productivity trends may differ from current and past drivers, we highlight fields that will be particularly important over the next decades.

1.1 What is productivity?

OECD (2015): Productivity is about "working smarter," rather than "working harder."

Productivity in its basic form is a notion of efficiency of an economic activity as it compares output to input, specifically over time. Technically this is typically reflected in the estimated total factor productivity (TFP), which measures residual growth in total output once all quantifiable input factors have been considered.

In the economic policy discussion, however, productivity typically has a broader connotation, according to which high productivity growth is seen as instrumental for improving living standards. From such a broad angle of productivity, an increase in real incomes is not exclusively based on higher input of production factors such as labor and capital or environmental resources, but also hinges on their more efficient use. Key sources of productivity growth include innovation, entrepreneurship, education and health as well as creative destruction. The most promising ways forward are the subject of political debate. In its Annual Sustainability Growth Strategy 2020, the European Commission (2019) emphasized that productivity considerations should generally guide structural reforms, investment and fiscal policy decisions.

1.2 Why are central banks interested in productivity levels and trends?

There are four interrelated lines of arguments for central banks' particular interest in the level, trend and manageability of productivity.[2]

First, a key variable of monetary policy is considered to be **positively related with productivity**, namely the **natural (or neutral) rate of interest r***. The full specification of the relationship has not yet been worked out but both growth models and general equilibrium model frameworks provide valuable insights. Starting from the Euler equation, which describes the optimal intertemporal consumption choice, r* is endogenously determined and depends on factors that influence a household's consumption smoothing behavior. These factors, which depend on the particular model choice, are, e.g., productivity and labor force growth or consumer-specific characteristics such as the discount rate or the rate of intertemporal substitution.[3] A detailed theoretical treatment of these relationships can be found in Woodford (2003).

It is worth emphasizing that changes of long-run productivity growth may impact on r*, with potential feedback effects: Lower productivity (or potential output) growth is associated with smaller investment returns through lower interest rates. As a result, consumption-smoothing households tend to save more. The imbalance between saving and investment may be the result of increased macroeconomic risks, aging or the shift from tangible towards intangible capital for production. In addition, higher (macroeconomic) uncertainty, different entrepreneurial risk attitudes and the bank-centered financial system may explain the stronger pressure on EU interest rates compared to the USA (Demertzis and Viegi, 2021). In some countries it was the firm sector which increased savings and accumulated large stocks of assets not employed for investment. As Muller (2021) suggests, a green transition towards a low-carbon economy may also require a higher interest rate to incentivize intertemporal consumption shifts (see section 4.3 on climate issues below).

Second, given this positive relationship between productivity growth and the natural rate of interest, the level of **r* critically affects the room of maneuver of monetary policy**. If r* and inflation are sufficiently high, the lower bound in the central bank lending rate (traditionally 0) will not be reached and monetary policy can be confined to conventional instruments. r* cannot be observed directly and has to be estimated empirically or inferred from calibrated theoretical frameworks (like DSGE models) with

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[2] A detailed treatment of the current low interest environment, its link with productivity growth, and the resulting challenges for monetary policy can be found in Brand et al. (2018).

[3] A potential link based on the result of optimal consumption decision (Ramsey equation) suggests the following relationship that should broadly hold within an extended framework: $r^* = f(\pi, n, v)$, $f'(\pi) \geq 0$, $f'(n)$, with π a measure of TFP, n a measure of labor force growth, and v a set of further variables. Under some (mild) assumptions the relationship is linear (i.e., $r = \pi + n$).

high uncertainty. These estimates indicate a reduction of r* towards or even below zero in many developed economies around the world during the last three decades, specifically in Europe and the USA. In these circumstances, monetary policy needs to resort to unconventional instruments, including negative key interest rates, asset purchase programs or subsidized credit programs.

Third, central banks need to focus on productivity dynamics given the risk that long periods of very accommodative monetary policy may contribute to the creation and expansion of **zombie firms**, which would reduce firm dynamics and thus dampen productivity further. This in turn might give rise to an even more aggressive monetary stance leading to a downward spiral. Central banks need to consider this risk factor when taking monetary policy decisions. This topic will be discussed in more detail in section 3.2.

Fourth, the **endogeneity of r*** to policy interventions – above all measures aimed to raise productivity – has crucial **implications for the relationship between fiscal and monetary policy and for the economic perspectives of society**.[4] Broadly speaking, there are two different perspectives:

- Starting from a very low r* around zero, r* offers limited perspectives for policy design around the secular stagnation hypothesis by Rachel and Summers (2019). Fiscal policy needs to be expansive to create demand and this can be accommodated by monetary policy under low inflation. This approach allows keeping the current standard of living, but offers limited perspectives also for the developing world; it is under constant threat of fiscal dominance, as monetary tightening to address inflationary pressures risks being inconsistent with the high level of sovereign debt.
- Starting from a very low r* around zero, yet with the perspective that effective measures of productivity growth (or labor force growth) may increase r*, offers a much broader setting for fiscal and monetary policy. Fiscal policy may also need to be expansionary, but mostly to drive productivity-enhancing measures in support of infrastructure and structural changes. The latter can be oriented toward climate, digitalization, and activating an aging population. Starting from very low values, an increase of productivity by 1% and an increase in labor force by 1% – e.g., through women's higher labor force participation and a later retirement age for all – would create, *ceteris paribus*, breathing room for monetary policy to become conventional again. Positive real interest rates would create pressure on fiscal policy to be more selective but would also offer the perspective of rising living standards for all.

[4] Borio et al. (2019), for instance, found in their empirical and theoretical treatment of the question that monetary policy plays an important role for long-run economic outcomes. Moreover, the authors empirically challenge the question whether the natural rate of interest is exogenous to monetary policy.

It is worth stressing the link between uncertainty and productivity. Uncertainty is a complex concept that includes a state of incomplete knowledge or the degree of confidence and probabilities that decision-makers have about possible outcomes of specific decisions. Uncertainty's dampening effects weigh on aggregate demand, while the freeze in resource reallocation can hold back productivity and aggregate supply. In times of high uncertainty, companies prefer to "wait and see" and delay investment projects. Choi et al. (2017) show that an increase in aggregate uncertainty reduces productivity growth more in industries that depend heavily on external finance. Stylized facts suggest that global uncertainty has increased significantly since 2012 (Ahir et al., 2018). Climate change poses a particular challenge to decision-makers who need to decide whether and how to mitigate and adapt all systems and sectors. Since a shift from brown to green investment and an increase in overall investment by some 2 percentage points are needed over the next decades (Pisani-Ferry, 2021), policymakers, including central banks, have to consider how to address climate policy uncertainty, reflecting incoherent alignments with the global goal of net-zero emissions by 2050.

In conclusion, another very important reason why productivity should be closely monitored by central banks concerns **productivity shocks**. While the early real business cycle (RBC) frameworks, where business cycle dynamics are only driven by productivity shocks, may fail to explain some business cycle characteristics, they still offer insight into the role of technology for macroeconomic fluctuations. More recently, news shocks about productivity growth have been found to have substantial explanatory power in explaining business cycle fluctuations and should therefore be on central banks' agenda (Beaudry and Portier, 2014).

1.3 How the OeNB may promote productivity (measurement)

Given central banks' intrinsic interest in the level and trend of productivity, the OeNB may play a key role in promoting productivity and its measurement, either through action on its own or through encouraging structural policy changes. It goes without saying that the Eurosystem's focus on price and financial stability is an important contributor to productivity, not least as this helps to reduce pervasive uncertainty weighing on investment and consumption.

First, the **OeNB** may **facilitate analytical work.** As an independent think tank with substantial financial funds, e.g., via the OeNB's Jubilee Fund, the OeNB has the means to initiate a major research project on productivity and disseminate the resulting key policy messages. Such efforts need to embrace all important stakeholders with respect to data (OeNB, Statistics Austria) and research (OeNB, Austrian Institute of Economic Research – WIFO, Institute for Advanced Studies – IHS, academia) and may cover the following aspects:

- Fully exploit and link existing **data sources** to derive alternative measures of productivity;
- Initiate in-house **big data** projects to exploit the potential of existing data banks;
- Make use of existing firm-level databases and collect new **firm-level data** to gain insight into productivity dispersion;
- Identify the most **promising routes for reform** to promote productivity;
- Identify important **binding constraints**, using a multidimensional approach
- (microeconomic, structural, experimental, and institutional).

Second, the **OeNB** will soon **host Austria's National Productivity Board.** The European Commission (2016) recommends that National Productivity Boards be established in all countries[5]. Renda and Dougherty (2017) claim that well-designed pro-productivity institutions that concentrate knowledge and research on productivity in one independent, highly skilled and reputed body can help create the momentum to promote long-term productivity growth. While government bodies could allow experimental policymaking and a more adaptive, evidence-based policy process, institutions located outside the government have more leeway in promoting reforms that challenge vested interests and produce results over a time span that goes beyond the electoral cycle. Key requirements for successful productivity bodies are sufficient resources, skills, transparency, and procedural accountability. Further crucial factors are a sufficiently broad mission – tailored to both supply-side and demand-side considerations – and policy evaluation functions as well as the ability to reach out to the general public in various ways.

Third, the OeNB may play a key role in promoting **rigorous (input) monitoring and (outcome) evaluation (M&E)** of measures aimed at promoting productivity growth. Rigorous M&E is essentially unknown in the public sector and – with a few exceptions (e.g., medical drugs) – also largely unknown in the private sector. If well applied, M&E reduces unproductive inputs and steers intervention towards the most promising directions. The OeNB is currently building up such a capacity for monitoring and evaluating financial literacy interventions.

[5] Reservations against productivity councils concern overlaps with other existing bodies, potential trade-offs and democratic legitimation.

1.4 Structure of the paper

In **chapter 2**, we want to deepen our understanding of the concept of productivity. To this end we will briefly present the different measures of productivity and their main use. Next, we will describe productivity trends and regional differences at the global and European level. In **chapter 3**, we summarize nine key hypotheses why productivity growth has become so low in industrial countries:

1) lack of (investment) demand;
2) expansionary monetary policy;
3) firm size and age;
4) technological cycles, the nature of recent innovations and the time it takes to apply them productively;
5) weak technological diffusion;
6) subdued creative destruction;
7) financial market dynamics and valuation;
8) population aging;
9) regulation and the compliance burden.

For each of these hypotheses, we present the theoretical argument and empirical evidence and end with some policy suggestions about how to tackle this specific challenge. In **chapter 4**, we postulate three areas that are critical for boosting productivity in the future: addressing population aging through a labor market offensive, promoting digitalization, and addressing climate change. **Chapter 5** concludes.

2 Deepening our understanding of productivity

2.1 Concepts and measures of productivity: from macroeconomic to firm-level measurement

Commonly, productivity is defined as a **ratio of an output volume measure and an input volume measure**. The measures can be used to trace technical change, to assess the efficiency of the production process or to evaluate real cost savings in production. The choice of the measure depends on the purpose and on data availability. Since all measures have their flaws, the OECD (2001) recommends using various approaches to get a spectrum of estimates of productivity growth.

In its simplest definition, productivity is the efficiency at which firms convert inputs into outputs (see Syverson, 2011). While productivity measures that focus on a **single** class of an **input factor** – i.e., labor, capital, or materials – offer interesting insights for some research questions; the **total factor productivity (TFP)** or **multifactor productivity (MFP)**, which jointly relates all input factors to output, has received by far the most attention in economic research. By definition TFP captures all remaining variation in output that cannot be explained by the observable inputs used to calculate it. Therefore, TFP is often termed a residual or "measure of our own ignorance" (see Abramovitz, 1993). The determinants of TFP growth are manifold and subject to extensive research.

For many decades TFP was estimated at the macro and sector level, which was subject to severe measurement and definition issues regarding the input factors labor and, in particular, capital. For most emerging economies this is still the dominant approach. The contribution of capital to output is usually measured as the productive services from a share-weighted average of different types of capital stocks, while using their marginal products as weights (Sichel, 2019). Calculation is often done via a Törnqvist aggregate index over each type of capital (e.g., ICT, intellectual property, equipment, structures, and other capital), accounting for different utilization rates, price developments and service lives. Besides issues related to the estimation of productive services of the stocks and depreciation rates, accounting for quick price changes of high-tech capital goods (see e.g., Byrne et al., 2017) and the growing importance of intangible assets (see Corrado et al., 2009, or Jona-Lasinio et al., 2019) pose major measurement challenges.

With the increasing availability and accessibility of **firm-level data** in some advanced economies in the 1990s, the focus gradually shifted from macro and sector level analysis to the microeconomic level. It is now well documented that productivity differences among firms, even within narrowly defined industries, are huge and persistent (see Syverson, 2004). Improvements in data and empirical patterns thus derived were matched by modern theories focusing on firms being heterogeneous with respect to their productivity (see for instance Melitz, 2003). In these models, survival and growth (gaining market shares) crucially depend on the firm's productivity, and reallocation via entry, exit and the increasing market shares of incumbents are important channels of aggregate productivity growth.

Productivity at the firm level faces particular measurement issues. In a seminal contribution to the productivity literature, Syverson (2011) discusses several of these aspects. A first issue arises in output aggregation. Since firms often produce more than a single type of good or service, these need to be aggregated in a consistent way. Moreover, most firm-level data sources do not record physical quantities but revenues. Foster et al. (2008) showed for a narrowly defined industry with a homogeneous good (cement) that using a plant-level deflator corresponds to calculating the quantity-type TFP – a measure research is usually interested in – whereas using an industry-level deflator (as is usually done due to data limitations) corresponds to a revenue-type TFP measure. This latter measure is not only influenced by changes in efficiency but also by idiosyncratic demand shifts and variation in market power.

The second major issue relates to the measurement of inputs. Labor can be measured by the number of employees, hours worked or quality-adjusted measures like wages (considering human capital). Capital is typically measured by the firm's book value of its capital stock, while ideally, we would like to measure the productive flow of capital services. Even worse, some data sources only record investments that need to be converted to a capital stock via approaches such as the perpetual inventory method, which is very sensitive to short period coverages. The same issue arises for material input as for output. These choices will all be made knowing that any output not accounted for by inputs will end up in the TFP measurement.

A third issue involves the aggregation of multiple inputs, i.e., the individual inputs need to be weighted by the researcher to construct a single-dimensional input index. A common empirical approach is to econometrically estimate a Cobb-Douglas production function to derive output elasticities to use as weights. But this is just one of numerous methods available, each having advantages and disadvantages (see for instance Sickles and Zelenyuk, 2019). For instance, input choices may be correlated with productivity. In the end, as Syverson (2011) stated, "Certainly one cannot escape the fact that some assumptions must be made when estimating the production function."

In the context of creative destruction and globalization, further challenges emerge for productivity measurement. Innovation in software and ICT may result in mismeasurement of GDP if certain nonmarket goods (i.e., zero marginal cost products like free apps) are excluded. These omissions may bias GDP-based productivity measures (like TFP) downwards (Brynjolfsson et al. 2019). Additionally, globally dispersed value-added chains in complex innovative products (e.g., smartphone supply network) may complicate the measurement of nationally captured added value. Moreover, the statistical practice of extrapolation and imputation in the measurement of prices may underestimate productivity growth by neglecting the substitution of switching from old to new, qualitatively improved products. If the impacts of these creative destruction forces differ between input and output price deflators, constant prices productivity measure derived from them may be upward or downward biased. In the literature, these measurement issues are often conjectured to have partly contributed to the global productivity slowdown (Byrne et al., 2016, Aghion et al., 2021).

Finally, negative environmental externalities as well as costly climate change policies are rarely taken into account when measuring productivity. As undesirable output such as pollution (i.e., greenhouse gas emissions) arises as a by-product in the production process, a productivity index should, ideally, reward firms for reducing such bad output and increasing good output (Chung et al., 1997, Ananda and Hampf, 2018). Failing to account for negative externalities would overestimate the productivity of heavily polluting countries and firms, and underestimate the productivity in countries with stricter environmental regulation and firms that devote more resources towards preventing pollution. Such an adjusted measure should also reflect whether the productivity growth of an industry or firm is based on exploiting the environment or on technical efficiency improvements. For a number of OECD countries Brandt et al. (2014) found, given reasonable shadow prices for a range of emissions (CO_2, NO_X and SO_X), that the adjustment of the traditional TFP for bad output remains low overall. While this suggests that traditional productivity measures have so far been only marginally biased, the impact of bad output may increase in the future with rising marginal abatement costs of climate change.

Researchers, e.g., the Competitiveness Research Network (CompNet), recently attempted to establish a cross-country firm-level data set. In some countries data made available by central banks or statistical offices have a bias towards the largest firms and are hence not fully representative, which limits international comparison. Aside from this caveat, such international data cooperation initiatives offer valuable insights into a range of topics. For instance, the EU-wide research project MICROPROD uses firm-level data to study the microeconomic mechanisms behind globalization and digitalization as well as the resulting distributional effects (Claeys and Demertzis, 2021). The MULTIPROD project of the OECD also features Austrian firm-level data (Berlingieri et al., 2017). Recently, Peneder and Prettner (2021) analyzed the MULTIPROD micro-aggregated data for Austrian firms. The authors confirmed the large labor and multifactor productivity heterogeneities between individual companies and their systematic differences with respect to sector, size, age and ownership structure. Their analysis reveals the importance of reallocation towards high productivity firms for aggregate TFP growth, especially for firms in non-financial market services.

In a future step, if bank-level data on lending to individual firms could be linked to firm-level data on productivity measures, we may be able to estimate the impact of monetary policy on productivity development as well as key drivers and differences (such as investment in intangibles, human capital, management quality, growth, merger) in more detail.

2.2 Global productivity trends

Robert Solow (1987): "You can see the computer age everywhere but in the productivity statistics."

Past major advancements in production techniques (e.g., the industrial revolution) had tangible positive effects on productivity growth. Over recent decades, electronics and information technology were increasingly used to automate production. We would thus expect this again to be visible in productivity figures. However, as the above citation illustrates, this is not the case.

Instead, despite increasing digitalization, labor productivity growth has slowed down in all advanced economies since the 1970s and has been essentially stagnant since the mid-2000s, with the notable exception of the USA from 1995 to 2005, as illustrated by the chart below (Bergeaud et al., 2016). Labor productivity growth is at its lowest level in 150 years (apart from world war periods).

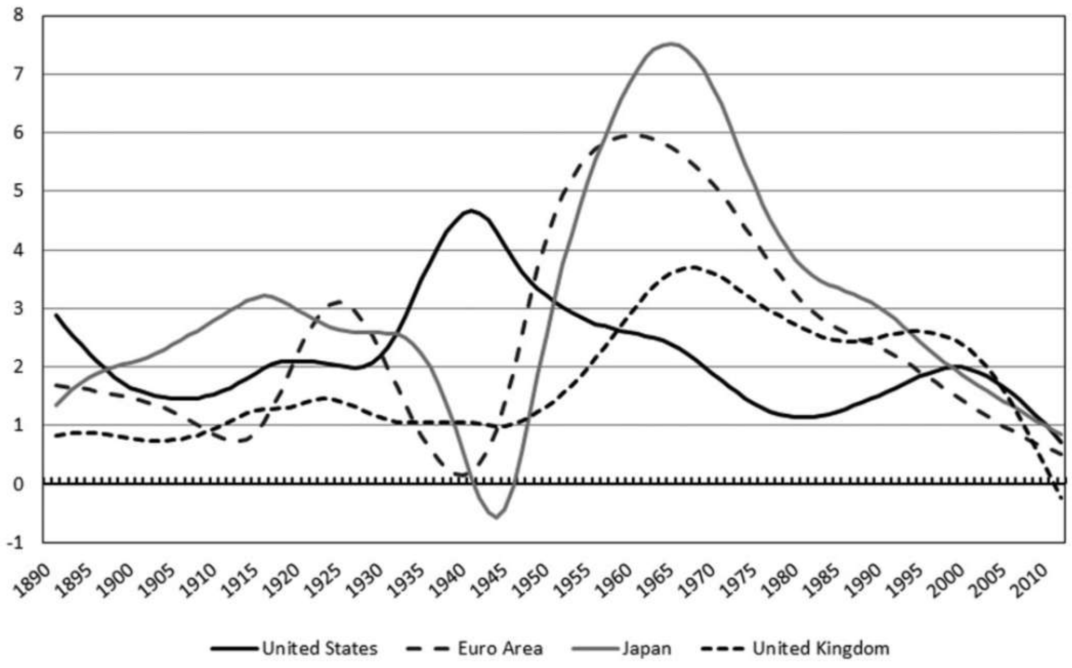


Figure 1. Smoothed (by Hodrick–Prescott Filtering[6]) Annual Growth of Labor Productivity per Hour (*LP*) in the United States, the Euro Area, Japan, and the United Kingdom, 1891 to 2012 (percent)

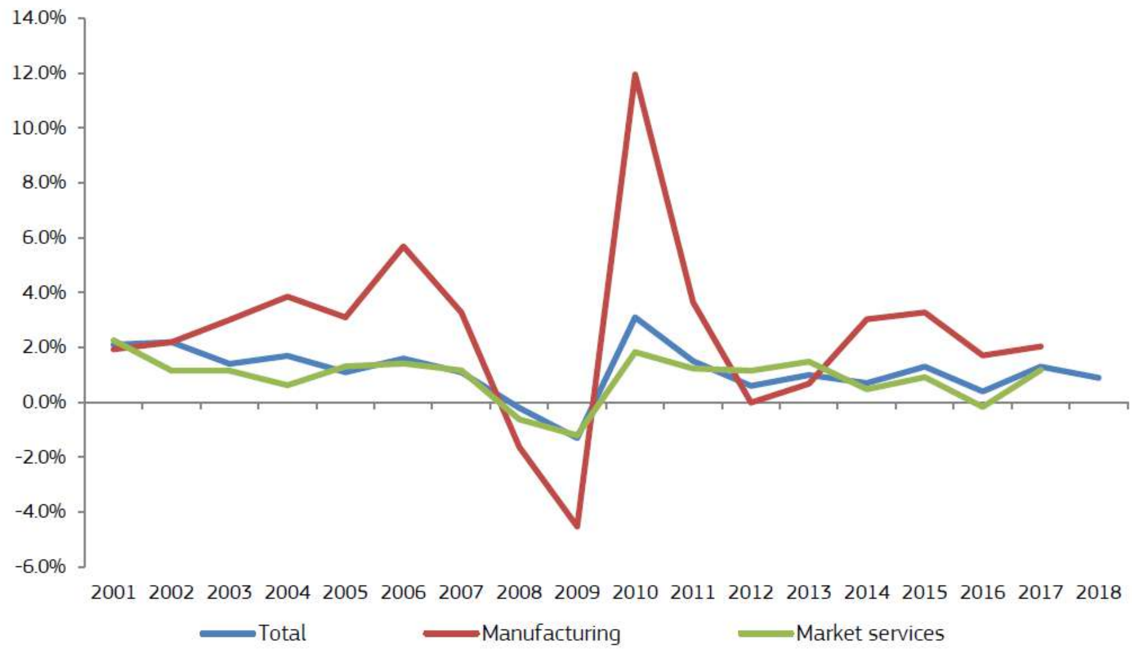
Source: Bergeaud et al. (2016), p.427.

In the **euro area**, annual growth in labor productivity per hour declined from an average of 5.4% (1950-75) to 2.7% (1975-95), was only 1.2% from 1995 to 2005 and hovered around 0.7% from 2005 onward (Bergeaud et al., 2016). In the mid-1990s, productivity growth in Europe started to fall short of that in the US, reversing the previously observed convergence trend, and **opening** up the **productivity gap to the USA**.

2.3 Sectoral shifts

Productivity growth in Europe seems to be much more reactive to business cycle fluctuations in **manufacturing** than in **services**, where productivity growth is generally lower (see chart below, Bauer et al., 2020). Because of this, the **secular shift** in the economic structure from manufacturing to services implies a decline in aggregate productivity growth. Weyerstrass et al. (2021) perform a shift-share analysis for EU countries, the USA and Japan and show that structural shifts still had a positive effect in Central and Eastern European economies (after 2009), while the effect was already negative in the other regions.

Figure 1. Growth rate of labour productivity (GDP per hour worked) in EU28 (%).



Source: EU KLEMS, 2019, for labour productivity in manufacturing and market services and Eurostat for the total economy.

Source: Bauer et al. (2020), p.6.

However, more recently, technology creation has been accelerating in services and slowing down in manufacturing. Bauer et al. (2020) show that TFP has recovered to pre-crisis growth rates in many services sectors, while still falling short of the rates recorded in manufacturing.

Within sectors, the use of new technology increases productivity. As a result, labor is shifting towards other sectors with higher wages, unlocking productivity capacities. New sectors emerge: the quaternary sector of information- and knowledge-based services, or the quinary sector of human services or hospitality. Technological change is thus a source for new sector definitions.

2.4 Regional differences in productivity growth

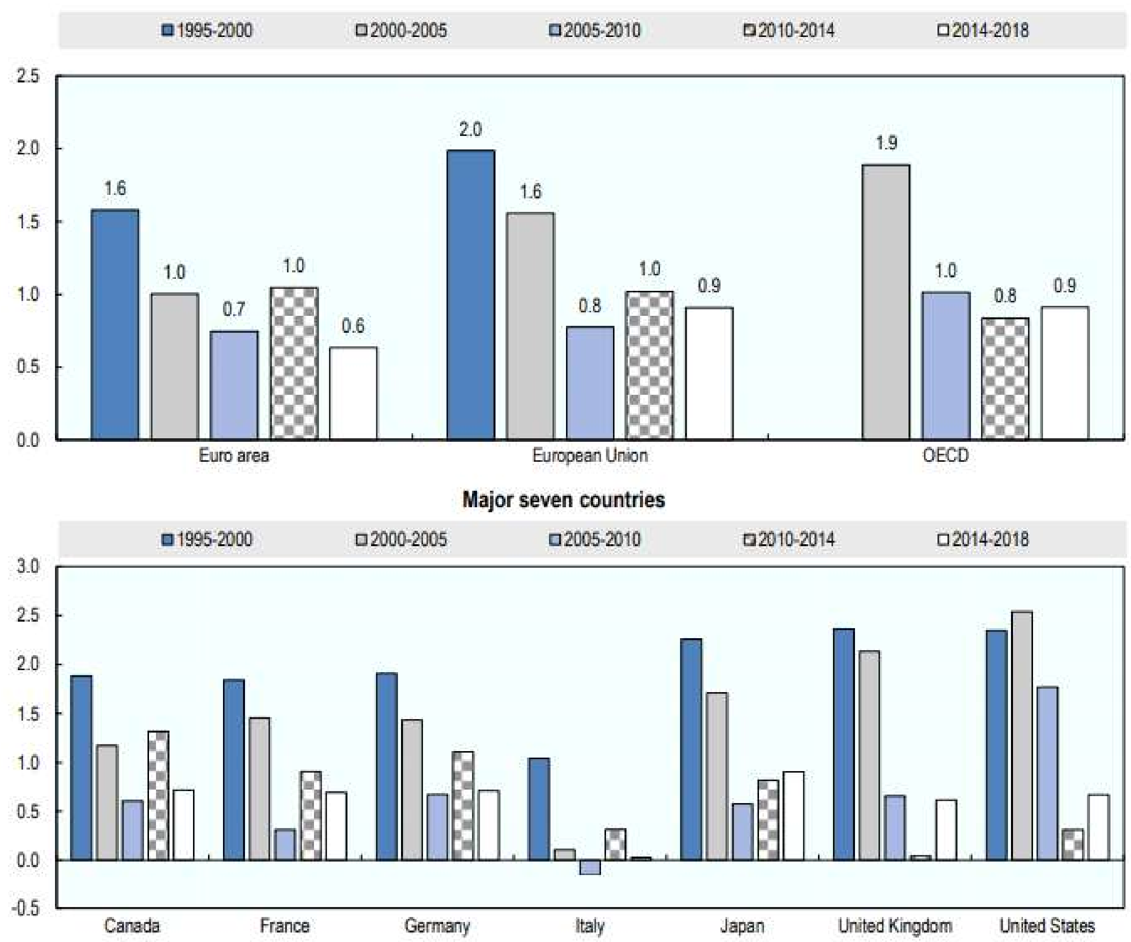
Bauer et al., 2020: "TFP growth remains the Achilles' heel of Europe's growth performance."

Cross-country comparison of productivity (growth) is limited by the fact that measurement of productivity depends on stringent assumptions (see subchapter 2.1 above). When we compare capital-related productivity (growth) across countries, we must assume that capital stock (and flows of investment) data come with symmetric measurement and valuation errors. Still, with these limitations in mind, it is useful to identify lasting regional differences in productivity patterns and to try to understand their origin.

The comparison chart (OECD, 2019a) shows **productivity trends** in major industrialized countries as well as in the euro area over time. The downward trend in labor productivity growth over the last decades is visible in all cases.

Figure 1.1. Labour productivity growth in the OECD

GDP per hour worked, percentage rate at annual rate



Source: OECD (2019a), p.18.

However, more recently dynamics differ, with the US and UK already beyond the productivity trough, whereas no trend reversal is visible in the euro area. The low productivity growth in the euro area from 2014-2018 – as compared to the OECD average – appears to be driven by individual countries such as Italy. Numerous reasons have been brought forward in the literature for these diverging productivity trend patterns. We are going to discuss these aspects in more detail in the following chapters. Here we just briefly list the key arguments why productivity growth in the US and UK outperforms that of, e.g., European economies:

- Investment in **ICT-related technologies** (van Ark et al., 2008) is higher and implementation of such technologies faster (Parry, 2020) in the US and the UK . In the period 1995-2004, the contribution of the knowledge economy (ICT, TFP) to overall labor productivity growth was only 1.1% in Europe, but 2.6% in the US (Anderton et al., 2020).
- **Firm dynamism** is higher in the US than in Europe, reflecting differences in business regulation and insolvency procedures. This may lead to faster productivity growth if young firms are more productive.
- **Demographic** differences between the US and Europe as well as differences in migration policies also contribute to differing productivity dynamics.
- **Financial market** disparities are reflected in the better availability of equity-based sources of finance in the US and UK, especially for SMEs and start-ups.
- Differences in **management** practice within companies, e.g., higher participation of employees in innovation processes and stronger within-company mobility, result in a higher degree of flexibility and decentralization in the US.

While productivity growth in Japan appears favorable over the last decades as compared to other industrial countries, several factors **restrain even higher productivity growth in Japan**:

- The rapid **aging** of Japan's population impedes the full exploitation of the productivity growth potential (IMF, 2020a). Indeed, a quarter of the population is aged 65+, and this share will increase to around 40% until 2050 (USA: 15% / 25%, respectively).
- **Labor market rigidities** also dampen productivity growth by hampering the pass-through of demand stimulus to real wages and prices (IMF, 2020a). For the case of Japan for instance dualities have been shown to suppress productivity growth and eventually impede the lift-off from the zero lower bound (IMF, 2013).

- **SMEs** play a substantial role because of their lower average productivity growth (Colacelli and Hong, 2019), with smaller and older SMEs showing particularly low productivity growth in Japan because of financing constraints, demographic factors and lack of intangible capital investment.
- The corporate sector in Japan is **hoarding cash** without putting it to productive use, e.g., investment or wage increases (OECD, 2019b).

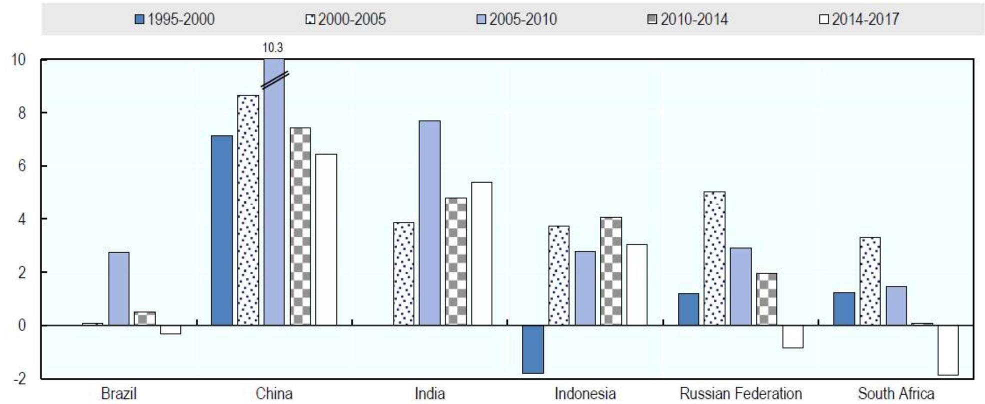
Within Europe we observe a clear **North-South gap** in productivity growth:

- **Investment in ICT capital** reached levels similar to the US in some European countries (e.g., in UK or Denmark), but fell considerably behind in the South.
- The quality of public **governance** (including the working of courts and contracts, the administrative burden, barriers to entry, red tape) and **management** practices all shape productivity patterns, to the disadvantage of countries in Southern Europe. Furthermore, the firm structure in these countries is more tilted towards **SMEs**, which tend to have lower productivity growth. Regulation, the tax system or financing constraints are claimed to be an obstacle for firm growth.
- Tight regulation in several Southern European countries may also be the source of **misallocation** of resources within/across regions and industries. The role of the **informal sector**, e.g., in Italy or Greece, may hamper productivity growth because of issues of property rights and lack of competition.
- North-South differences in factors related to the **labor market** (labor force participation, regulation, tax structure) and the **education system** (vocational and life-long training) also shape productivity patterns.
- The **secular shift** in the economic structure from manufacturing to services implies a decline in aggregate productivity growth. This effect differs in size across countries, with Italy and Spain being most affected within the EU (Bauer et al., 2020).
- The share of **zombie firms**, i.e., firms financially supported by banks which would be non-viable otherwise is also higher in Southern European economies (Bauer et al., 2020).

The chart on catching up economies (BRIICS) shows historically higher productivity dynamics compared to the industrialized countries, but recently even negative productivity growth in some countries (Brazil, Russia, South Africa), while still comparatively high rates in China, India and Indonesia.

Figure 1.2. Labour productivity growth in BRIICS

GDP per person employed, percentage change at annual rate



Source: OECD (2019a), p.19.

China is an especially interesting case:

- Productivity increased as part of the **transition process** and upgrading from lower-tech to high-tech. However, as China's transformation progresses and with the rising share of services, aggregate productivity growth will likely slow down.
- Restrictions on **trade and FDI**, or more generally accelerating de-globalization, may hamper technology diffusion and access to the international technology frontier and, hence, dampen productivity growth (IMF, 2021a).
- Almost unlimited support to **state-owned giants** in strategic sectors also contributed to the slowdown in productivity growth. IMF (2021b) finds a large and persistent gap in average productivity of state-owned versus privately owned firms. Recent refusals to bail-out state-owned firms may indicate a policy shift.
- While productivity growth remains comparatively high, as compared to the US, average productivity levels are still relatively low. **Unproductive infrastructure**, inefficient allocation of finance and investments as well as low incentives for state-owned enterprises are a threat to further productivity increases.

2.5 Productivity growth and the COVID-19 crisis

The recent health crisis can be expected to leave its marks in productivity figures. It is still too early to draw final conclusions because of volatile productivity figures reflecting the huge employment losses. However, early evidence (Altomonte et al., 2021) indicates potential cleansing effects, as it was the least productive firms that suffered most. By contrast, the more productive firms could benefit from the ample financial support.

The long-term effects of the crisis will largely depend on the benefits of technological upgrading, as well as on the lasting effects on work re-organization (see chapter 4.2).

3 Nine hypotheses why productivity growth has declined

Various arguments have been brought forward in the literature, trying to explain the recent productivity slowdown in industrial countries. Each tackles the productivity puzzle from a different angle. We attempt to structure these various approaches by summarizing them into nine broad categories.

The recent productivity slowdown or lasting regional productivity gaps may be the result of:

1. lack of (investment) demand;
2. expansionary monetary policy;
3. firm size and age;
4. technological cycles, the nature of recent innovations and the time it takes to apply them productively;
5. weak technological diffusion;
6. subdued creative destruction;
7. financial market dynamics and valuation;
8. population aging;
9. of regulation / compliance burden.

The order the arguments does not reflect their relevance, which may vary from country to country.

For each of these arguments we start with a description of the theoretical arguments underlying the hypothesis.

We then follow up with empirical evidence, also – if possible – highlighting the relevance for explaining regional differences.

We conclude with three key policy messages, indicating how productivity gaps may be tackled.

3.1 Lack of (investment) demand

Hypothesis:

* According to the **secular stagnation** hypothesis (Summers, 2014, Eichengreen, 2015) inadequate demand results in high unemployment and a general underutilization of resources and, hence, negatively affects investment. What follows is a prolonged period of low productivity and economic growth.

* Furthermore, rising **inequality** may dampen demand via its impact on the saving-investment imbalances, in particular after financial crises (Rajan, 2010, Koo 2008, Eichengreen, 2014).

* Others emphasize the connection between (minimum) wages and productivity growth based on variants of efficiency wage considerations (e.g., Storm and Naastepad 2017, Akerlof and Yellen 1986). According to this literature, wage increases may lead to increased training of the workforce, higher labor productivity and investment in capital – all factors alleviating or even offsetting negative employment effects.

Empirical evidence:

* **Aggregate demand**: Adler et al. (2017) find an adverse feedback loop between weak aggregate demand, investment and technological change, particularly after the financial crisis. Bughin et al. (2018) show that weak aggregate demand explains around half of the observed decline of productivity growth since the mid-1990s in several industrialized countries (the other half being a maturing ICT boom from the mid-1990s). In a calibrated Keynesian growth model with endogenous growth, Benigno and Fornaro (2018) show that under weak aggregate demand and with a pessimistic growth outlook a stagnation trap may occur – with dampening effects on productivity – as firms' innovations may be constrained by access to external finance. This and weak aggregate demand erode firms' internal funds further.

* **Secular stagnation**: Rawdonowicz et al. (2014) present evidence on secular stagnation signs in the euro area and Japan, but their evidence is less firm for the US and UK. Blanchard et al. (2015) confirm these findings analyzing 122 recessions in 23 countries over five decades.

* **Inequality**: Rachel and Summers (2019) and Ostry et al. (2014, 2019) corroborate the view that inequality dampens productivity growth. Rannenberg (2019) argues that lower natural rates of interest, higher household indebtedness and house price inflation are linked to increasing inequality. Using data on US patents and the income distribution between 1975 and 2010, Aghion et al. (2019) show that innovation and the process of creative destruction may temporarily increase inequality, especially at the top of the income distribution.

* **Labor markets and wages**: Ramskogler (2021) finds that increased labor market segregation leads to weaker wage dynamics. Generally speaking, reduced wage growth may lower incentives for firms to invest in labor-saving technologies, capital goods or human capital, all of which support productivity growth. Other studies for China (Mayneris et al., 2014, 2018), the US (Manning 2021) and the UK (Rizov et al., 2016, Riley and Bondibene, 2017) establish a positive link between minimum wages and productivity growth, e.g., because unproductive firms cannot compete in an environment of higher wages. For Germany, Dustmann et al. (2020) come to similar conclusions. Kong et al. (2020) find a positive effect of paying higher wages for rank-and-file employees on innovation and productivity growth in China. Kleinknecht (2020) identifies a negative impact of supply-side labor market reforms on productivity, as these reforms shift power relations between capital and labor. As a result, wage growth weakens, reducing incentives to invest in labor-saving technologies. This effect is especially strong in medium-high- to high-tech firms where firm-specific and tacit knowledge is important.

Key policy messages:

A. Strengthen domestic demand via **fiscal policy**, following a two-pronged approach: First, increase spending on those public goods that not only have short-term effects on employment but also long-term effects on economic and productivity growth, e.g., labor market policies, education, public infrastructure or spending on basic R&D. Second, ensure a sufficient degree of redistribution of income and wealth to avoid negative effects on aggregate demand ("secular stagnation") from rising inequality and ensure that future gains are shared as equally as possible. In addition, fiscal as well as monetary policy should ensure that increased corporate profitability does not lead to underinvestment via higher retained profits. To this end, reduce incentives to hoard large amounts of cash (as is visible in high net borrowing positions of the corporate sector, e.g., in Germany).

B. **Income policies**: increase minimum wages and workers' bargaining power and improve labor standards to incentivize entrepreneurs to upgrade their physical and human capital. Improve distributional outcomes via taxes.

C. Limit the **market dominance** of tech giants via enhanced competition policy and break-ups, address tax havens and support minimum income initiatives.

3.2 Expansionary monetary policy

Hypothesis:

While accommodating monetary policy may help to revive domestic demand (see section 3.1), very low or negative interest rates may have unintended side effects on productivity growth. Conceptually, loose monetary policy may increase or decrease productivity (growth), and both effects may co-exist:

* On the positive side, monetary policy increases demand and thus incentives to invest in productivity-improving technologies. Furthermore, expansionary monetary policy helps alleviate credit constraints and eases financing conditions. Therefore, the pace of technology diffusion and adoption is enhanced, supporting productivity growth. Furthermore, monetary policy accommodation may facilitate the entry of new and the recovery of existing firms. To the extent that new entrants are more productive, this will lift average productivity.

* On the **negative** side, very low or negative interest rates could, by easing financing constraints, reduce incentives for firms and banks to carry out necessary balance sheet repair and thus contribute to a misallocation of resources. Banks may be more tempted to evergreen loans. This may prolong the survival of distressed or less productive firms ("zombies"). Zombie firms, in turn reduce firm dynamics and thus dampen productivity further. The impact on productivity may be amplified if there were contagion effects to healthy firms as zombies lock resources (such as skilled labor) and crowd-out investment in more productive firms. As a result, monetary policy may need to become even more expansionary, starting a downward spiral.

Empirical evidence:

Given these opposing theoretical effects, the net effect is a priori ambiguous. Empirical studies tend to focus on partial aspects.

* **Positive demand effects:** Empirical evidence shows that accommodative monetary policy has a positive long-term effect on productivity in the US, while the effect in the euro area is not so clear-cut. For example, Anzoategui et al. (2019) show that negative productivity shocks in the US can be more permanent if monetary policy is constrained at the zero lower bound (ZLB) and hence cannot accommodate the shock to a full extent. By contrast, ECB staff (Schmöller and Spitzer, 2020) uses an estimated DSGE model and shows that if TFP is endogenously determined, business cycle persistence is much more pronounced. A monetary policy constrained through a binding ZLB increases the importance of liquidity demand shocks that depress consumption and favor safe asset holdings, in turn reducing investment. Hence the central bank's economic stabilization efforts remain ineffective, resulting into pronounced business cycle persistence and

hysteresis effects in productivity. However, without a binding ZLB these effects vanish, and expansive monetary policy remains beneficial for productivity growth.

* **Entry and exit**: Productivity growth is the result of (i) growth of existing firms, (ii) reallocation of resources from less to more productive firms, (iii) exit of old firms and (iv) entry of new ones. Lewrick et al. (2014) find that intra-industry reallocation (including exit and entry of firms) is the most important driver of productivity growth, allowing resources to move towards the most productive use. While unexpected expansionary monetary policy shocks tend to increase firm entry both in the euro area and the US, the effect on exit is less clear (Albrizio and González, 2020). In the US, there is evidence for prolonged survival – consistent with zombie hypothesis – followed by an increase in exit rates (overshooting) in the longer run. In the euro area, firm exit increases one year after monetary policy easing, but declines in the longer term after this first cleaning effect. Overall, the net effect remains unclear (Lopez-Garcia et al., 2021).

* **Misallocation of resources**: Decker et al. (2016) show that weak reallocation is responsible for most of the productivity slowdown. Gopinath et al. (2017) show evidence for Spain that credit flows more easily to less productive firms when interest rates fall. One reason may be that less productive firms are less financially constrained because of availability of collateral, e.g., in the construction sector. According to Acharya et al. (2019), the Outright Monetary Transactions (OMT) program announcement in the euro area in 2015 increased bank lending to weak firms relatively more than to creditworthy firms. According to Borio et al. (2016), employment shifts towards less productive sectors following credit booms. More generally, Vandeplas and Thum-Thysen (2019) show that around a quarter of workers report a **mismatch** between their **skills** and those required in their job. Within the EU, skill mismatch is most prevalent in Southern Europe.

* **Zombie firms**: Lopez-Garcia et al. (2021) show, based on firm level survey data (2009-19), that euro area firms generally benefited from improved lending terms and that financially weak firms benefited significantly less than others. However, this may mask some heterogeneity, as large and distressed firms reported an increased availability of bank loans when interest rates declined. This may support the zombie hypothesis. Moreover, a high share of zombies in one industry harms non-zombies in the same industry. McGovan et al. (2018) identify an increase in zombie firms over the period 2003-13 in OECD countries. Lopez-Garcia et al. (2021), using more recent data, come to a different conclusion, observing a decline in the share of zombie firms. The latter is generally highest in PT, IT and ES (Bauer et al., 2020). Banerjee and Hofmann (2018), analyze firms in 14 advanced economies since the late 1980s and find via regression analysis that an increase by 1% in the share of zombie firms lowers TFP growth in the economy by 0.3 percentage points. However, a higher risk appetite by banks following monetary easing may not only benefit "zombies" (low productivity and low repayment capacity) but also "gazelles" (high productive firms with short operating history). Furthermore, there is evidence that the zombie status is often only a temporary consequence of high investment. The share of "true"

zombies that actually exit the market following a period of financial distress is relatively low (less than 2% of all firms, Lopez-Garcia et al., 2021).

Key policy messages:

Aim at achieving a policy path that allows to combine the positive effects of accommodating monetary policy (revived domestic demand, improved resource allocation by loosening financial constraints of more productive firms) while at the same time containing their negative effects (misallocation of resources, e.g., by locking resources in zombie firms):

A. Zombie firms tend to be associated with weak banks. **Strengthened banking supervision** needs to set strict rules to curtail bank forbearance and insufficient balance sheet consolidation. Gropp et al. (2020) show that restructuring distressed banks can have positive long-term effects on productivity even if it takes place during the crisis itself. Regions with less supervisory forbearance are shown to have higher productivity growth. **Financial support** for firms in temporary difficulties should be focused on grants instead of loans and expectation of government bailout needs to be contained.

B. Add to this **reforming and streamlining insolvency regimes**, e.g., by reducing barriers to corporate restructuring or exit of weak firms. The latter should be coupled with policies to contain the social costs of firm restructuring, including active labor market policies.

C. To disentangle the tight links between weak banks and fragile firms, the corporate financing base needs to be broadened by providing more **market-based financing** instruments as well as venture capital. This also requires removing the debt bias in the corporate tax system.

Overall, the right mix of **micro- and macroprudential tools** should help avoid the buildup of financial risks that would lead to prolonged periods of low productivity and growth.

3.3 Firm size and age

Hypothesis:

* **Micro and small firms** tend to be less open towards foreign trade, less innovative, less digitalized, have limited access to finance, production is more labor intensive, and the labor force is less skilled. These factors are interrelated and result in lower productivity growth in small firms. Countries with a high share of SMEs thus show lower productivity growth.

* On the other hand, also the market dominance of **multinationals** may decrease productivity growth: Monopolistic or oligopolistic market structures reduce competition and, hence, incentives for research and innovation.

Empirical evidence:

* **Lower productivity of SMEs:** In Europe there is evidence of lower productivity growth of micro and small firms, e.g., for Italy (see, e.g., Bugamelli et al., 2018) or Spain (Diaz and Sanchez, 2008). Similar results are available for Japan (Colacelli and Hong, 2019). Bauer et al. (2020) find that the fact that the firm distribution is skewed towards SMEs helps explain low productivity in Southern European countries. Evidence is more mixed for the US: Dhawan (2001) shows that small firms in the USA are significantly more productive but also more risky than larger firms. Based on US and French firm-level data Akcigit and Kerr (2018) show that SMEs are strong innovators with more significant and disruptive innovations compared to large firms. OECD (2019a) generally finds smaller firm size effects in the services sector.

* **Firm age**: Firm size is related to firm age. The latter may actually be more relevant for employment growth, innovation and productivity, as shown by Coad and Karlsson (2022) for Sweden: the majority of high-growth firms are small, but also relatively young. Andrews et al. (2015) find a positive link between the share of young firms and productivity growth at the industry level across 23 countries. Accordingly, the higher dynamism in the firm sector in the US may explain the diverging results concerning firm size. Yang and Chen (2019), by contrast, show that the productivity of new firms is smaller than previously suggested. Lopez-Garcia et al. (2021) find low productivity of new firms, but selection is strong and young surviving firms grow faster than incumbents.

* **R&D and innovation** seem to play a crucial role in this respect: Baumann and Kritikos (2016) show for Germany, that micro firms have a smaller probability of engaging in innovative activities, but if they do, their profitability benefits in a comparable way from innovation as in larger firms. Friesenbichler and Peneder (2016) show based on joint estimations for catching-up economies that both competition and innovation have a simultaneous positive effect on labor productivity.

* **Market power** may reduce productivity growth. Gutiérrez and Philippon (2019) and Demertzis and Viegi (2021) show that market power increased globally as result of digitalization and globalization, low interest rates and the rising importance of intangible capital, and more so in the US than in the EU. Rising markups go hand in hand with reduced productivity growth in the corporate sector and are highly concentrated among (very) large firms. "Killer acquisitions" in technology intensive industries often target on innovative start-ups (Cunningham et al, 2021). This suggests a non-linear relationship between firm-size and productivity growth. Higher markups also weigh on the labor share of income, potentially reinforcing the effects of inequality on productivity growth via the demand channel described above (IMF 2019). Recent research thoroughly documents the link between market power/concentration and investment/productivity, with rising importance since the 1980s (see, e.g., Akcigit et al., 2021, Philippon, 2019, or Ganglmair et al., 2020). According to Haskel and Westlake (2017), market concentration is largely due to the increasing use of intangible capital. This complex form of capital also affects the measurement of productivity (see section 2.1), and complicates the valuation of firms (Crouzet and Eberly, 2021).

Key policy messages:

The challenge here is to promote sustainable growth of productive firms, e.g., by providing sufficient finance, capital and skilled workers, without fostering an accumulation of market power and business wealth by monopolies/oligopolies or winner-take-all markets. The latter could lead to excessive rents in the corporate sector and increase wealth inequality, which in turn can hamper productivity growth. This implies striking a delicate balance between growth policies and regulation to hinder market-power accumulation by (fast) growing firms.

A. Remove (legal and financial) **barriers to firm growth**, with a special focus on public administration efficiency (Friesenbichler et al., 2014). Ensure market-based sources of finance for SMEs, in particular equity capital, which will require new forms of supply (such as the British Growth Fund) and better financial education on the demand side. **Efficient insolvency laws** and procedures are needed to avoid resources to be locked-in with incumbents to the detriment of newcomers. Increase the **efficiency of tax collection** where possible to ensure sufficient public funding for new entrants. Reduce tax avoidance and the extent of the informal economy.

B. Invest in **human capital** with a special focus on **technical knowledge** to ensure an efficient use and combination of input factors – a key factor for firm growth. Investment in tertiary education and life-long training should be complemented with measures to lift the quality of early childhood education (Heckman, 2011) and after-school childcare.

C. **Increase market dynamism** through structural policies. For instance, labor mobility is important to maintain a sufficient degree of dynamism. Increase spending on and efficiency of active and passive labor market policies to avoid hysteresis effects via long-term unemployment. Enhance the skills of the workforce, also by fostering continuous re-skilling and an efficient labor market matching process. Cammeraat et al. (2021) find evidence that informal training may be even more effective than formal training. This suggests encouraging firms to evolve into learning organizations, based on teamwork, job autonomy and room for reflections.

3.4 Technological cycles, the nature of recent innovations and the time it takes to apply them productively

Hypothesis:

* Technological progress is a dynamic phenomenon, evolving in time. Hence, significant **time lags** may exist between the implementation of new technologies and the full realization of their productivity gains. Together with the nature of recent innovation, the process of productivity growth may be subject to **cycles**. High productivity growth periods result in longer periods with rather slow productivity growth until the next disruptive technological shock appears. Based on that – and compared to the invention of information processing systems (computers) – the current technological innovations, resting mainly on ICT advances (and therefore generating path dependencies), fail to produce a comparable impact and are thus less disruptive.

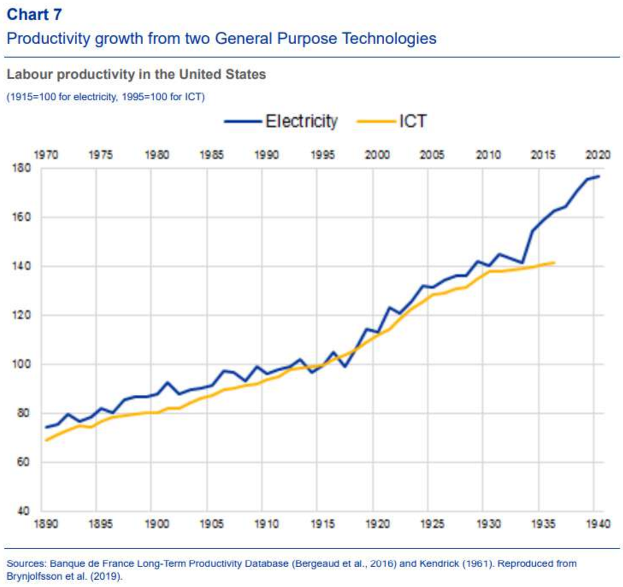
* In addition, it is necessary to rethink and **rework production**/business **processes** to implement new technologies in an efficient manner. This in turn needs knowledge and financial capacity. Moreover, the ICT infrastructure (slow expansion of the fiber cable and 5G networks) may play a limiting factor in productivity increases. The current productivity slowdown may be attributed to the need to combine existing technologies to push the frontier in an interdisciplinary fashion. Hence, the ongoing productivity weakness may be caused by the time span needed to extract the full technological potential of new, mainly ICT-based, innovations.

* Sectoral shifts and the rising dominance of (vertically and horizontally) integrated firms that use a variety of technologies (machines, controlling devices, distribution systems) and inputs (physical and human capital) to produce and promote their products complicate the measurement of productivity (see section 2.1). In the course of the digital transition of almost all sectors and the disappearance of 'traditional' sectors, productivity measures may be biased and productivity itself subdued, as it takes time to optimize these new sectoral organizations.

Empirical evidence:

* One line of argument sees the recent slowdown as a **permanent phenomenon**, mainly attributable to path dependency: Innovations of the first half of the 20th century (e.g., electrification) are far more significant than anything that has taken place since then (e.g., ICTs). Gordon (2018) emphasizes the maturity of the IT revolution: today's innovations are merely further developments of past REAL innovations (internet + telephone = smartphone). Hence productivity growth is expected to be lower (Gordon, 2017). However, another position argues that the underlying rate of technological progress has not slowed, and that the IT revolution will dramatically transform frontier economies (Brynjolfsson and McAfee, 2014).

* Cette et al. (2020) take this argument and push the idea that digitalization may affect productivity only with a lag, similarly to what was observed after the emergence of electricity. Thus, over time, cyclical productivity growth patterns may emerge due to the following factors: Electricity and ICT are both **General Purpose Technologies** with a time lag between their installation and their full deployment. New technologies require reorganization within firms and a high stock of specialized physical, human and managerial capital, initially slowing down productivity. The fact that the productivity slowdown is most pronounced in sectors that intensively use ICT supports the hypothesis of implementation lags (van Ark, 2016). As the high-technology sector of **health/medical services** revealed this pattern, it may serve as an example: Building on simple diagnostic imaging (X-ray), the current available technologies like MRT or CT scans are only possible because of the massive advances in software development for image processing. While the productivity increases in this sector currently appear rather muted, the development of complex automated diagnostic tools may increase productivity substantially in the near future. However, the measurement of these kinds of productivity increases might not well captured in the statistics.



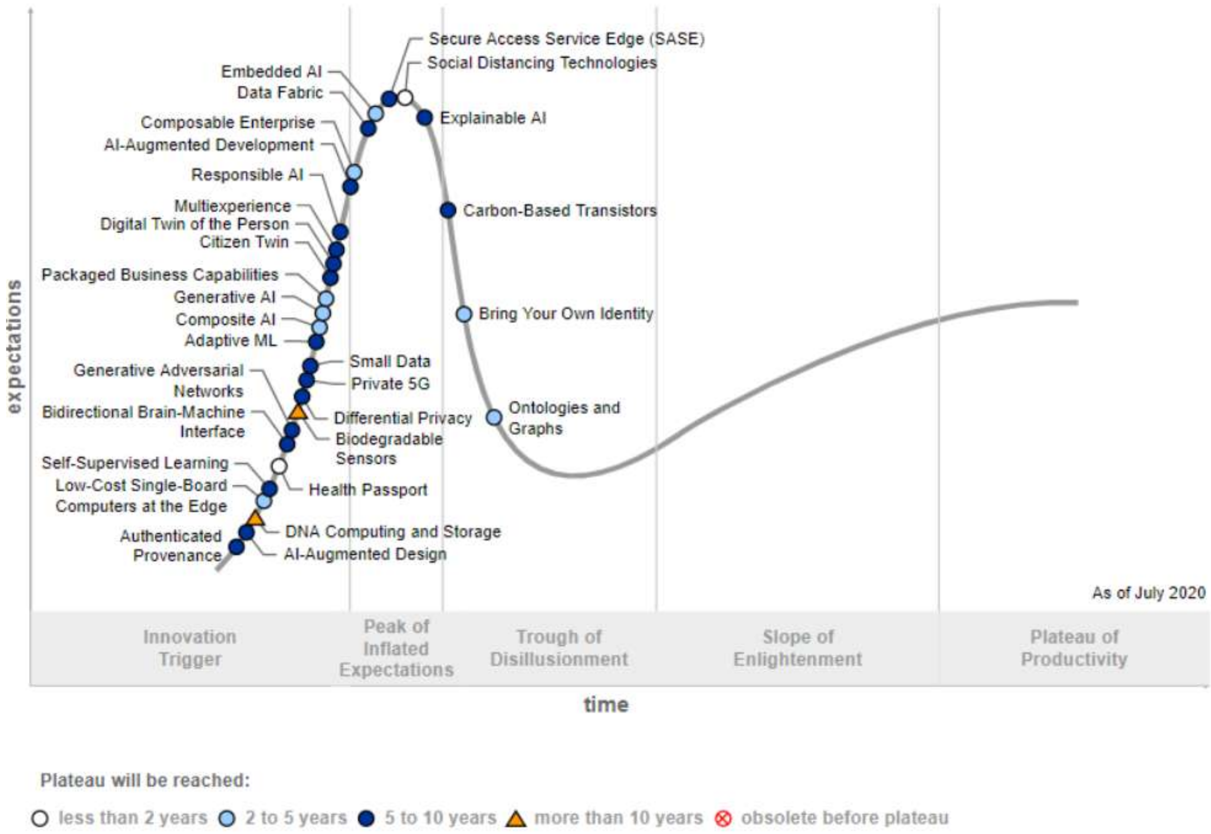
Source: Anderton et al. (2020), p.40.

* According to Bhattacharjya (1996), technological cycles are well observed in **patent** time series of the US and may be linked to the Schumpeterian (1939) description of innovation cycles. Hence, we may currently be in an innovation trough. However, empirical studies are scarce for the recent past, especially at the firm level.

* Bloom et al. (2020) claim in their study about the US economy that over time research needs more inputs (money, time, effort) to reach the same improvement in outputs than before (**decreasing returns to scale**). As a result, we cannot expect R&D to produce enormous productivity effects. Increasing time efforts until a suitable progress has been achieved may produce a cyclical pattern, where productivity growth spikes and longer periods with rather muted growth alternate.

* Gartner (2020), analyzed about 1700 new ICT based technologies (grouped into 30 categories) and assessed their expected impact potential on productivity across time. Differentiating technologies not only by their expected future impact but also by the time span until the highest impact on productivity is reached shows that the **nature of ICT-based technologies** and **the time to implement them productively matter**: Some of the innovations become obsolete before they are even able to exert a positive impact on

productivity. It may take between two to more than ten years before the productivity plateau is eventually reached.



Source: Garner (2020).

Key policy messages:

A. Future innovations are most likely to lie at **the intersection of ICT and other sectors**, which is why an interdisciplinary stance in R&D is of utmost importance. Hence, policy measures should actively promote and **fund interdisciplinary** workstreams to identify future research objectives as well as to smooth research output cycles by leapfrogging dynamics. A potential avenue could be creating and funding **research centers** with different groups of researchers to identify and pursue productivity-enhancing research. This would shorten the time until the next wave of productivity growth emerges. Also, do not underestimate the role of investment in **basic research**. After all, past breakthrough innovations such as the internet, aerospace or key medications had their origins in **public research** (OECD, 2015), financed with public sources (Mazzucato and Semieniuk, 2017). Moreover, R&D produces – as a "**by-product**" – a highly skilled local labor force with the right know-how, as well as institutions and firms equipped to apply cutting-edge technologies developed elsewhere and to adjust them to the local needs. China is an example of steeply increasing R&D spending, with high original innovative output, but also an enormous absorptive capacity concerning foreign innovation. Finally, promoting collaboration between highly specialized sectors may break the path dependency within certain industries, with potentially beneficial effects for overall productivity, as demonstrated in Reinstaller and Reschenhofer (2019) for European countries.

B. To identify sectors with technological research capacity underutilization, critically assess the comparative advantages of each sector across potential competitor countries. To prepare for forthcoming productivity shifts, set out the necessary conditions now by enhancing **sustained investments in basic sciences and ICT** as well as the necessary **infrastructure**. Hence, to enable the **flow of investments in high-tech sectors**, incentives like tax credits or tax exemptions could ease the constraints emerging from lack of finance. Longer-term availability of financial funds may mitigate research slowdowns.

C. With the **banking service sector** undergoing a persistent technological shift (for B2B and B2C activities), not only opportunities but also new risks to financial stability may emerge. Here, regulatory institutions like central banks will have to take on new tasks. Technological advances may, in turn, also benefit the monitoring of financial stability with a view to implementing automated screening procedures and producing timely reports. This may enable regulators to react swiftly to situations where financial stability may be under threat.

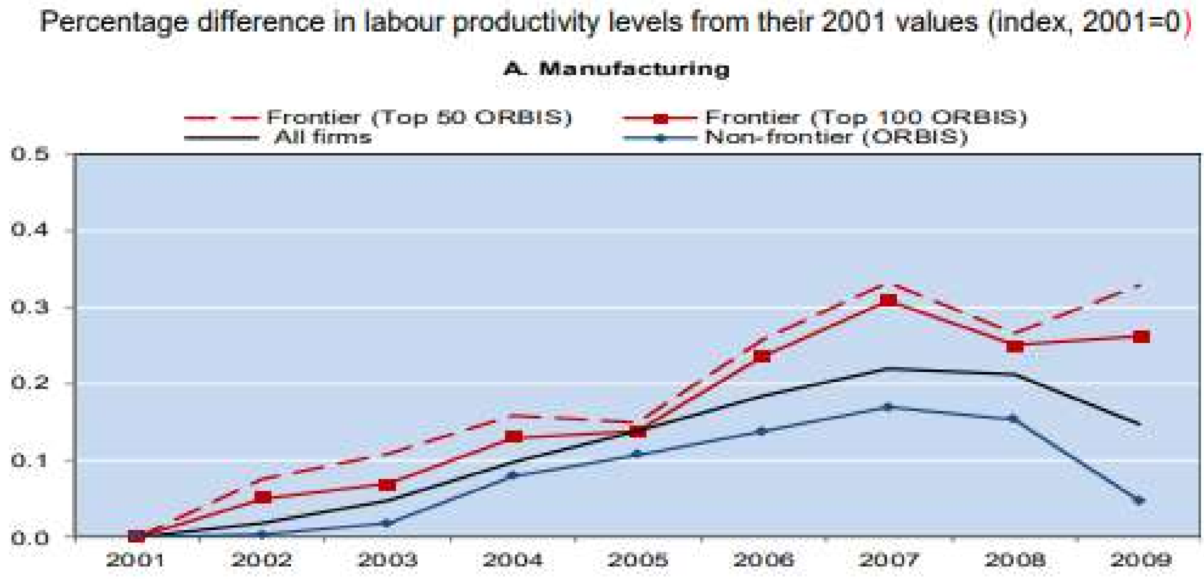
3.5 Weak technological diffusion

Hypothesis:

* The recent productivity slowdown is not so much the result of slowing of innovation by the most advanced firms, but rather a declining pace of technological diffusion i.e., the pace at which innovation spreads to lagging firms. This may relate to "winner takes it all" dynamics or the rising importance of tacit knowledge, i.e., the ability to combine computerized information, innovative property and economic competencies in the production process (OECD, 2015). This requires especially specialized labor and high managerial capital to steer new production processes. The lagged technological diffusion is thus reinforced – or partly explained – by a lagging diffusion of management practices or societal processes, particularly in middle income countries or transition economies.

Empirical evidence:

* **Knowledge diffusion from leading companies** to smaller ones has been found to be a key determinant for business dynamism and for productivity growth (Akcigit and Ates, 2020). Andrews et al. (2015) show that during the 2000s average labor productivity growth of frontier firms (the 50 / 100 globally most productive firms in each 2-digit sector) grew much faster than that of all other firms. After 2007, productivity growth of frontier firms remained robust, while the gap to the other firms widened. This may suggest that the capacity of non-frontier firms to learn from the frontier may have diminished. Italy is highlighted as one example where productivity could be around 20% higher if national frontier firms were as productive as the global frontier benchmark.



Source: Andrews et al. (2015), p.12.

* **Trade:** The positive effects of trade on productivity go well beyond the technology diffusion effects (OECD, 2015): First, trade and FDI enhance **knowledge flows** from global customers and suppliers (Crespi et al., 2008; Duguet and MacGarvie, 2005) and from the activities of multinational firms. Enhanced knowledge exchange will take place within the multinational firm itself (Criscuolo et al., 2010), both from the headquarters to their affiliates and vice versa, via reverse technology transfer (Griffith et al., 2006), and from the multinationals to local economic agents and vice versa (Puga and Trefler, 2010). Moreover, domestic firms that trade get in touch with the most efficient foreign and domestic producers that are able to compete on international markets and thus get them closer to the global frontier (Alvarez et al., 2013). Second, trade openness leads to **tougher product market competition**, which in turn promotes productivity-enhancing reallocation via the expansion of the most productive firms into foreign markets and exit of low productivity firms (Melitz, 2003; Melitz and Ottaviano, 2008; Melitz and Trefler, 2012). Third, trade openness increases the effective market size, which magnifies the expected profits arising from the successful adoption of foreign technologies (Schmookler, 1966; Acemoglu and Linn, 2004).

* **Management skills** are a key factor determining the ability of firms to implement new innovation and benefit from their potential impact on productivity. Bloom et al. (2012) show that UK firms owned by US firms are more productive and explain it by their different organizational structures (degree of flexibility and decentralization) that helps them to exploit ICT-related productivity. Schivardi and Schmitz (2019) emphasize the role of management practices for productivity gaps in Southern Europe.

* For the past 10-15 years, investment shifted from **tangible assets** (machines) to **intangible assets** (software). Rent-seeking behavior of firms may prevent the full (optimal for the economy/society) usage of intangible assets and thus weigh on productivity via blocking the technological diffusion process (Orhangazi, 2019).

Key policy messages:

A. At the national level, create **innovation hubs** to support technological diffusion, especially among SMEs. Assure that FDIs use increasingly local inputs and share technological and managerial knowledge (Chinese approach).

B. At the global level, the pace at which innovation spreads to lagging firms may be accelerated by **economic integration** via trade, FDI and mobility of skilled labor. Foster the emergence of border-crossing research opportunities.

C. The **diffusion** of new technologies is especially relevant in the services sector, which plays an increasingly important role for GVCs (logistics, finance, communication).

3.6 Subdued creative destruction

Hypothesis:

An important dimension of innovation – and thus productivity – concerns the **process of creative destruction**, where new innovations replace older ones and therefore push the research frontier forward. Originally proposed by Schumpeter (1950), it was formalized in a growth model setup by Aghion et al. (1992). While this process may be subsumed by arguments related to technological cycles (see section 3.4), the very nature of the phenomenon stands for itself. Thus, in their recent book, Aghion et al. (2021) scrutinize this phenomenon and analyze a variety of **aspects that may hamper creative destruction to unfold** its potential for productivity increases in the longer run. Innovators who block new innovation to seek to extract the accruing rents as long as possible, reinforced by weak technological diffusion (see section 3.5) or a high regulatory burden (see section 3.9), pose a threat to the positive effects of creative destruction. In a recent survey paper, Griffith and Van Reenen (2021) build on the original growth model with creative destruction and provide an analysis of the relationship between innovation, product market competition and creative destruction.

Empirical evidence:

* Empirical evidence for the US supports the notion that strongly innovative states (measured by filed patents) also excel in terms of growth (Akcigit et al. 2017). In addition, an **"up or out" pattern** has been detected: While younger firms show higher job growth compared to older firms, they also exhibit a much higher exit rate (Haltiwanger et al. 2013). However, survivors of this process may produce exorbitant growth.

* Consequently, a **lack of competition** may prevent creative destruction to unfold. This linkage is pictured by Aghion et al. (2005) as an inverted-U relationship between competition and growth and thus exhibits a complementarity between competition and protection of intellectual property (IP) rights. Hence, there is a trade-off between rewarding innovation and muting competition that hinders creative destruction. In an empirical study on the European manufacturing sector, Aghion et al. (2015) confirm this nonlinear relationship between competition and patents and the effect on innovation. They report that the competition-friendly European Single Market has had a stronger stimulating effect on innovations in states with stronger IP protection.

* **Optimal policy support**: Peters and Zilibotti (2021) employ the idea of creative destruction in a growth context and augment it with endogenous firm dynamics. An empirical estimation with firm data from India and the US shows that policy support for more productive firms is helpful in comparatively poorer countries as there is little creative destruction. However, in rich countries these selective industrial policies may be harmful for economic growth.

Key policy messages:

A. Without a proper **policy mix**, the potential of creative destruction cannot be harnessed in an optimal way and would ultimately lead to subdued productivity growth.

B. Not only growth policies but also **industrial policy may harness the beneficial effects of Schumpeterian creative destruction.** Especially the potential to unlock resources may help to avoid a misallocation of (physical and human) research capital in the economy. In the sense of creative destruction as a Darwinian process, some firms and thus jobs will be destroyed. However, they will be replaced by new entrants (firms) that will create new opportunities (jobs) for laid-off workers.

C. To **enable a friendly business environment** where failure is part of the process, bankruptcy laws and labor protection laws need to provide an environment that allows for innovation and experimentation as well as failure and market exit.

3.7 Financial market dynamics and valuation

Hypothesis:

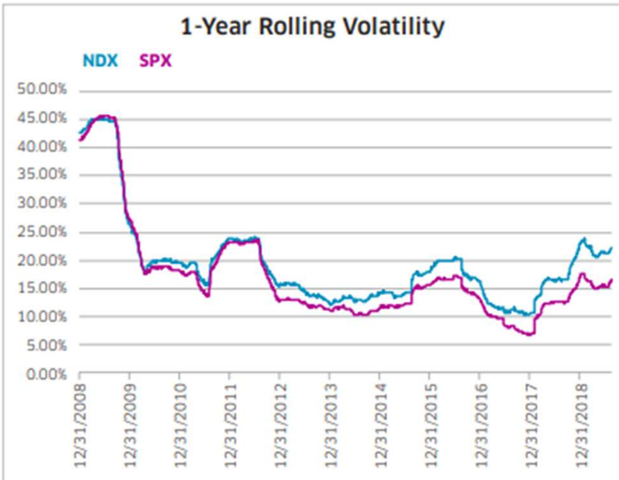
* Financial markets are an important transmission channel of **uncertainty** associated with technological innovation, which needs ample financial and human capital. The future return of an investment into a new technology may be uncertain and crucially depends on factors like the diffusion, adoption, costs, and the actual efficiency gain of the new technology (Schumacher and Zochowski, 2017). Higher uncertainty about the future return on investment is reflected in higher risk premia. As a result, innovative firms' equity premia rise.

* **Capital market finance** benefits innovative firms (high risk, low collateral); bank-based finance tends to be associated with lower productivity. The firm's current financial situation (capital or **debt overhang**) also affects investment decisions.

* **Credit booms** divert resources to less productive sectors (e.g., real estate or construction) and hence weigh on productivity (Gorton, G. and Ordoñez 2020).

Empirical evidence:

* Sizeable technological invention may have **negative first round effects**, transmitted via financial markets (Laitner and Stolyarov, 2019). As the first-round effects may increase the volatility of financial markets (see, e.g., the increasing volatility gap between NASDAQ and S&P500 in the chart), important productivity enhancing innovations may be postponed to reduce uncertainty for shareholders.



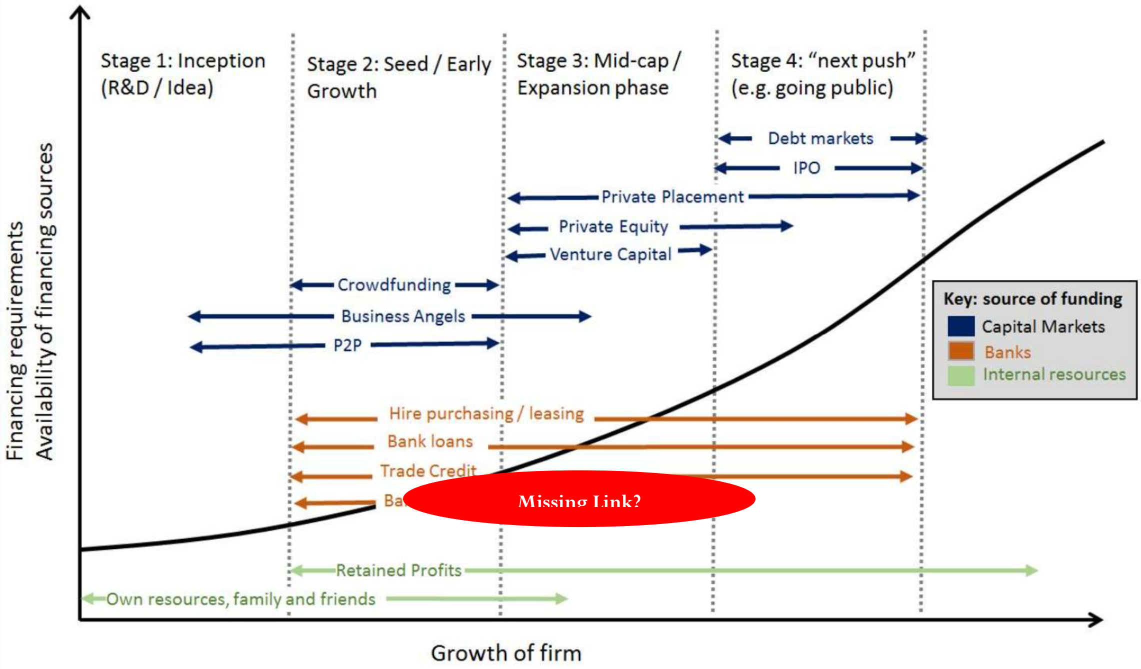
Source: Nasdaq.

* Studies based on US manufacturing data confirm that the **financial structure** matters for productivity, indicating that the latter is positively affected by equity and bond financing compared to bank loans (Bernstein and Nadiri, 1993 and Uras, 2014). This helps explain why firms in the digital economy are mainly based in countries like the US with solid non-bank financing. The more risk-friendly business environment in the US fosters the emergence of new technologies. Bank-based finance is ill-suited for firms mainly operating with intangible capital because of lack of collateral (Hsu et al., 2014).

* While larger firms have more absorptive capacity to implement new innovations, small firms may lack the human and physical capital to benefit from new technologies. Moreover, depending on the size of the firm, productivity shocks can be at least partly offset by changes in the investment behavior. Thus, through different investment elasticities, firms react more or less pronounced to productivity shocks. Risk premia may therefore decline with

increases of the **capital-to-productivity ratio** as larger firms are more resilient against productivity shocks and therefore need to provide less compensation for risks (Balvers and Huang, 2007).

* The **life cycle of business activity** moves along different development stages with different contributions to overall productivity. As the different episodes are associated with different business and market risks, each particular stage may require different financial sources (European Commission, 2020). Particularly, the expansion period should be ideally characterized by an already stable financial situation but needs access to secured finance opportunities in the future. The *funding escalator* depicts the relationship between the growth stage of a firm and the financing requirements.



Source: European Commission (2020).

For providing a financial environment that enables prosperous firm growth, the required financing facilities need to be accessible along the associated stages. Especially the European financial system lacks a broader access to alternative sources of capital market finance, like private equity or crowdfunding; as a consequence, financial bottlenecks may hinder firms' expansion along their life cycle and consequently deprives productivity growth.

* Also, the development stage of a country and the respective importance of frontier innovations have implications for the necessary financial environment fostering innovation-led growth. Diallo and Koch (2018) provide an empirical analysis based on a Schumpeterian growth setup to show the effects of bank concentration on economic growth. Their main finding reveals that the necessity of reliable access to capital-based financing becomes more important with the country's proximity to the world technology frontier.

Key policy messages:

The European policy answers to the weaknesses and gaps in the financial market may not be overcome by selective changes in taxation or the repeated but irresolute launch of the capital markets union. They require deep reforms and innovations for the financial escalator. Three steps stand out:

A. A capital markets union requires a broad basis of domestic and international investors as well as the government. In most EU countries individuals do not **participate in capital markets** through pensions funds and individual savings accounts. This reduces the base for enhanced equity financing and productivity-enhancing investments.

B. An efficient **funding escalator** in a region that is characterized by SMEs and limited financial markets requires new institutions that pre-identify potential gazelle companies, offer equity capital below a majority share as well as managerial support during the difficult period of stage three, and exit when the job is done but not when the return is maximized. The British Growth Fund created in 2011 offers such a missing link. For Austria, Hölzl et al. (2016) propose an SME stock exchange (Small-Cap Markets) to offer firms broader access to private equity and other financing options.

C. To enhance the importance of equity capital, it will also be necessary to revisit the **taxation** of equity capital and apply the same tax treatment as with debt financing. Moreover, incentives for private equity investors and potential tax deductions for losses may motivate wealthy individuals to finance risky start-ups.

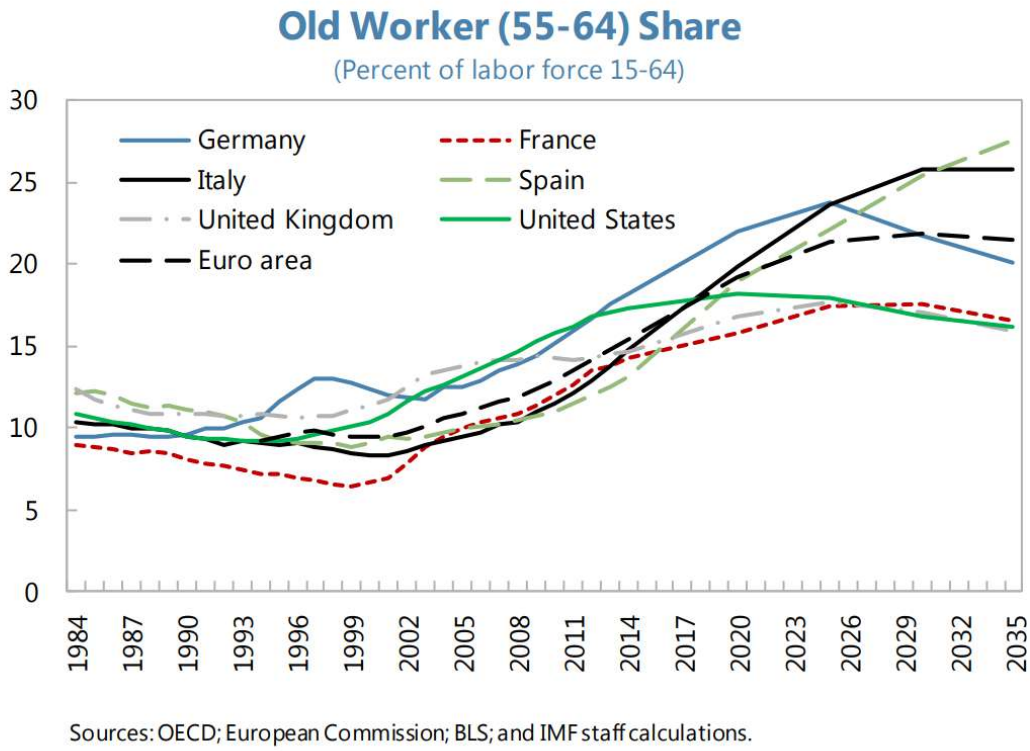
3.8 Demographic developments

Hypothesis:

Demography plays a key role in explaining productivity differentials between the US and Europe. The lower growth rate of the population and the labor force in Europe reflects lower fertility rates and a less efficient labor immigration; together with higher life expectancy in Europe it leads to a more pronounced aging population structure. Changes in the population structure affect productivity through human capital changes across the life cycle (Disney 1996, Dixon, 2003) and the incentives and capacity to adjust to modern information technology.

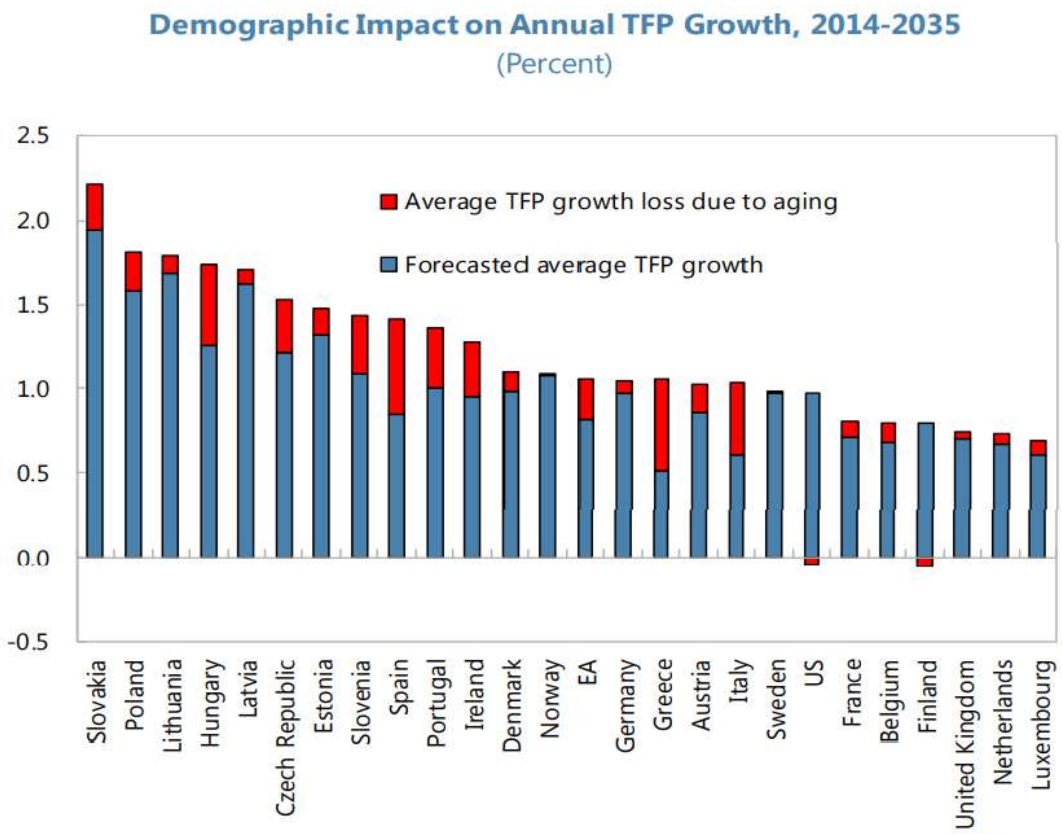
Empirical evidence:

* Aiyar et al. (2016) explore the increase of the **share of older workers (55-64) within the labor force** and the effect on productivity While the surge appears to continue until around 2025 in some countries before levelling off, it continues particularly in Italy or Spain for another 5-10 years, reaching more than 25%. In the US, the peak appears to have been reached already.



Source: Aiyar et al. (2016), p.4.

The cross-country analysis suggests that an increase of the ratio of workers aged 55+ to the total workforce significantly reduces productivity growth. The authors conclude that aging has lowered euro area TFP growth by about 0.1 percentage points each year over the past two decades and could lower TFP growth by about 0.2 percentage points each year in the years until 2035 (see chart below). This is substantial, given that according to European Commission forecasts, TFP growth in most euro area countries is expected to fall short of 1% per year.



Source: Aiyar et al. (2016), p.14.

* In another **cross-country evidence**, Feyrer (2007) and Feyrer (2008) find an inverted U-shaped relationship between worker age and productivity, peaking in their 40s. This has been disputed (National Research Council, 2012). It may be argued that while physical productivity declines with age, this is not necessarily the case for **cognitive productivity** (van Ours and Stoeldraijer, 2010). This argument could become stronger with the declining share of manufacturing over time. Furthermore, aging may slow down digital uptake, but technologies may support productivity of the elderly. Overall, the effects of aging on aggregate productivity are hard to pin down (skills-shifting, cognitive skills, aspects of education, longer high-quality life expectancy), but may be relatively small.

* Age effects may generally differ across sectors or **occupations**, e.g., productivity may be even increasing with age for lawyers, managers, medical doctors, or professors.

* Aggregate effects may be larger than **sector or firm-level effects**, as suggested by a study on large car manufacturers in Germany, indicating that productivity of workers declines around age 60 (Börsch-Supan and Weiss, 2016). Firm-level policies, e.g.,

providing age-specific equipment or supporting work in age-diverse teams can crucially dampen or even equalize the individual productivity decline.

* A **cohort perspective** can offer a different viewpoint, as highlighted by Holzmann (2013) or Ayuso et al. (2020): While productivity may decline for each individual over the live cycle, productivity at a specific age increases from one cohort to the next. Over the last decades, life expectancy and the health status at standard retirement age have improved dramatically, and also the cognitive skills of the elderly have improved.

* Holzmann et al. (2020) emphasize the importance of **adapting labor markets** to increase incentives (or reduce disincentives) for delayed retirement and continued labor force participation. This requires interventions to keep the elderly skilled, healthy and motivated. And it requires also reforms of the pension schemes to create incentives for delayed retirement/longer labor market participation. If successful, this promises to not only eliminate any negative aging effect on productivity, but it may even increase productivity.

* Additionally, the nexus between climate and population changes deserves more attention than is currently given. For instance, Schneider-Mayerson and Leong (2020) provide empirical evidence that young people in many countries are increasingly factoring climate change into their reproductive choices. Viewed from a long-term perspective, findings of Zhang et al. (2007) suggest that long-term climate change has driven worldwide population cycles synchronized with war-peace patterns in recent centuries.

Key policy messages:

A. **Population aging does not necessarily have to lower productivity growth.** Younger cohorts have a higher life expectancy and hence a longer planning horizon, they are typically better educated and, at each age, in better shape than the cohorts before. Increasing the capacity for each younger cohort at each – even advanced – age may compensate for a life-cycle effect of declining age-related capacity which reduces productivity growth in an aging population.

B. To enhance the capacity for a given age across cohorts requires, inter alia, choosing the **right incentives**. They are influenced by a person's planning horizon and the expected year of retirement, which in turn needs to change in line with rising life expectancy. This calls for new policies to actually live up to expectations about life-long learning and deliver an older work force that is healthy, skilled and motivated. It requires also main reforms in the labor market and social policies to create the right incentives.

C. While some good practices exist in a few countries, the conceptual and empirical knowledge to **guide national (or Europe-wide) policies** in a relevant manner is extremely limited.

3.9 Regulatory or compliance burden

Hypothesis:

* **Compliance costs** can have direct effects on productivity by requiring more resources – labor and capital – than otherwise, thus reducing income gains for the total population. They may create barriers to entry of new firms, lowering competition (Arnold et al. 2008).

* **Regulation** can impact the cost of capital and thus affect competitiveness. Other regulatory policies, e.g., excessive micro- and macro-prudential measures require more staff and reduce labor productivity created elsewhere in the financial sector (Dixon, 2003). However, a too low level of regulation may create negative externalities where the costs would be borne by the many instead of the few. Examples include environmental pollution, tax avoidance and financial instability.

Empirical evidence:

* **Costs of regulation**: Regulation of business activities, however well-intended they are, can increase costs for the firm sector and hamper trust in regulatory authorities (OECD 2018). Scarpetta et al. (2002) emphasize the role of product and labor market regulation for industry productivity performance. Ranasinghe (2017) finds that small differences in the regulatory burden may have significant aggregate effects on productivity because of the associated **disincentive to innovate**. The rather strict data protection laws in the EU compared to the US may be the source of frictions. However, a study by Hölzl et al. (2019) argues for the case of Austria, that data protection is not itself a bottleneck, but rather the first implementation of new standards in combination with low levels of digitalization. Through the implementation of the European data protection standards, especially SMEs and micro firms experienced a (albeit one-time) push in digitalization. Parker and Kirkpatrick (2012) provide a useful survey on the general topic, while warning that the focus in most studies is on costs to the economy while failing to take into account potential benefits of regulation.

* **Benefits of deregulation**: Lanau and Topalova (2016) find significant positive effects of product market reforms on productivity in Italy. These effects are even larger when coupled with more efficient public administrations. Bouis et al. (2020) quantify the effects of product market deregulation on five key indicators, among which productivity growth, in 26 advanced economies, although the positive effects materialize only with a lag of several years. Kouamé and Tapsoba (2018) broadly confirm these findings for developing countries.

* **Spill-overs**: There is also some evidence that regulation in non-manufacturing sectors has indirect effects on the productivity of other sectors (Bourlès et al. 2013), suggesting negative spill-overs from tight regulation. However, the size of this impact has not yet been well quantified. Regulatory burden also negatively affects international trade of goods and

services (OECD, 2017a), hence international competitiveness and productivity. But there may also be potential positive externalities from stringent regulations, e.g., more R&D to adhere to regulations (Hamamoto, 2006).

* **Potential trade-offs**: While increased costs due to stricter supervision or risk-management rules may reduce investment, sales or profits of banks, they enhance financial stability and reduce the risks of (severe) financial crises (Ayyagari, 2018). Too much deregulation in the financial sector may increase the probability of financial crises (Schularick and Taylor, 2012). Borio et al. (2016) analyze 21 advanced economies and confirm that credit booms undermine productivity by reallocating labor towards less productive sectors, which is amplified if a crisis follows a credit boom. Kleinknecht (2020) suggests that the effects of supply-side structural reforms are far from being only beneficial. In many cases, they are even detrimental to productivity growth. Vergeer and Kleinknecht (2014) find that labor productivity growth in the US, UK, Canada, Australia and New Zealand was significantly lower than in Europe, despite a series of supply-side reforms during the 1970s and 1980s.

* **Binding constraints of reforms:** Banerji and Holzmann (2009) emphasize the role of binding constraints: Labor regulation often constrains growth and productivity. At the same time, institutions, the jurisdiction and the political setting crucially determine what kind of reforms are feasible within a country, because they determine the absorptive capacities of the involved bodies and the uncertainty about the ability to enforce contracts. It is therefore essential to identify the most binding constraints across sectors to avoid reforms which are difficult to implement in practice.

Key policy messages:

A. For the time being it is unclear whether compliance and/or regulation have reached the level where the impact on productivity has become negative, on balance. What seems clear is that both interventions have potentially large **side effects** and **need to be carefully monitored**. The framework for that seems missing and good analytical work to this end is scarce.

B. A starting point for the review could be an **analysis of compliance requirements in the banking sector** and their effects on staffing and costs and also outcomes such as fraud and money laundering. A microcosmic approach may help to focus our mind.

C. As regards regulation, in particular of the financial sector, the challenges of analytical penetration and proposals for improvement are even higher. How best to proceed to **attain the positive while limiting the negative effects** has yet to be explored. Moreover, the much stricter data protection regulation within the EU (and therefore the EU's competitive disadvantage compared to the US) raises the question whether societal goals restrict the business potential, especially in the ICT sector.

4 Three critical areas for boosting productivity

> Bill Gates (2016): "50 years from now we won't need as much human labor to do what manual workers do, so we should be able to take that extra productivity and put it to better use."

In chapter 3, we summarized the main strands of literature, trying to explain the past productivity slowdown in major economies from various angles. While all these factors may have contributed to the productivity puzzle in the past, there are good arguments that the productivity slowdown was only a temporary phenomenon and may come to an end (Kaniovski et al., 2021). One claim is that major past technological innovations will finally start pushing productivity growth with a time lag (sections 3.4 and 3.5), while new technologies start to diffuse subsequently. Another argument is that we may still feel the aftermath of the 2008/09 financial crisis, a factor that is about to fade.

Having said that, however, new factors may come into play and shape future productivity trends. Some of them may bring another setback to productivity dynamics. One example is the partial reversal of past globalization trends: Over the last decades, massive outsourcing and offshoring allowed for a concentration of business activities on core competencies and, hence, facilitated productivity gains. This trend is not going to extend into the future. The slowdown in globalization already observed ("de-globalization") is the natural result of the unsustainable increase in globalization over the last four decades (Antràs, 2021). The vulnerabilities and risks associated with global value chain (GVC) integration laid bare in the course of the COVID-19 pandemic may speed up the trend of re-shoring, nearshoring and shortening of GVCs (Silgoner, 2022).

To the extent that the sources of a future drag on productivity growth may differ from past ones, also the appropriate policy reaction may differ. In this chapter we highlight three policy areas that we consider critical for major and sustainable progress in productivity in Europe (and Austria). These areas will gain further relevance over the next years and decades:

1. Addressing population aging through the labor market
2. Promoting digitalization
3. Addressing climate change

While we may conjecture about the importance of these areas, the policy playbook how to achieve sustained productivity gains in these fields is much less certain.

4.1 Addressing population aging through the labor market

As briefly highlighted in the opening, population aging is likely to impact negatively on the hypothetical equilibrium interest rate r*: (1) directly through lower growth of the population, i.e., labor force, and (2) through an aging population's conjectured increased demand for a safe (retirement) asset, which dampens the equilibrium interest rate; and (3) indirectly through reduced aggregate productivity effects of an aging labor force (e.g., Papetti, 2019).

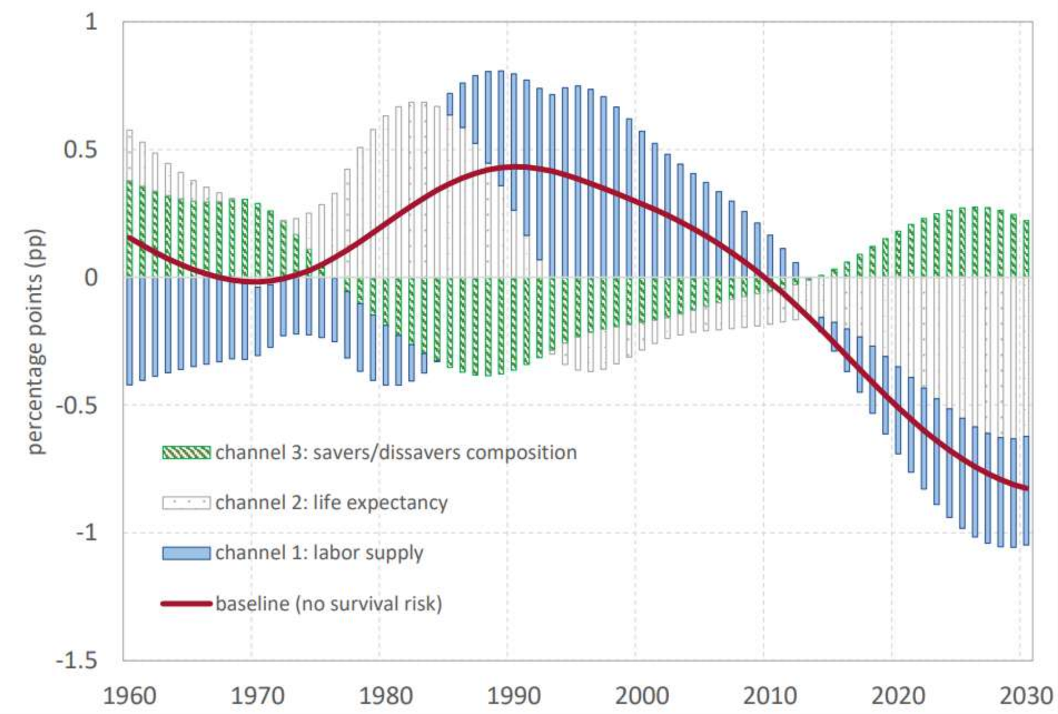


Figure 8: Real interest rate in EA12, demeaned: drivers [cf. Section 3.3]

Source: Papetti (2019), p.39.

In all three cases, making the labor market for older adults more accessible and attractive promises to address productivity concerns but also to directly impact the equilibrium interest rate in a positive manner. This implies that people will stay longer in the labor market and retire later. Demographically, socially and economically this is possible as life expectancy at standard retirement age of 65 years has considerably increased over recent decades, the health status of older people has markedly improved, their cognitive skills have increased over time, and a labor market for older people works very well, when developed and nurtured (Holzmann 2013, Holzmann et al., 2020).

The most difficult part of increasing the effective retirement age amid rising life expectancy is how to bring about the necessary cultural change. This includes moving from a retrospective aging view – i.e., looking how much time we have already spent on earth – to a prospective aging view of how much time we can still expect to spend (Scherbov and Sanderson, 2007). Adjusting the traditional onset of retirement at, say, 65 (with a remaining life expectancy of some 15-20 years) with the rising life expectancy gives you a prospective version of the old-age dependency ratio. The result is a broadly flat perspective compared to a rising traditional old-age dependency ratio (Scherbov and Sanderson, 2020).

Accepting that demographics as such are not an obstacle to addressing the challenges of population aging, we can explore which economic problems need to be solved and in what way, and which requirements need to be worked on.

Key examples of **what and how**:

- Increasing the (effective) retirement age in line with higher life expectancy (preferably estimated with cohort, not period data, see Holzmann et al., 2020) offers labor force growth of around 0.5% p.a. even if total population growth is around zero. This may translate into productivity growth of a similar size. Further significant labor force gains of a similar magnitude can be reached through an increase in women's labor force participation, particularly in Southern Europe.
- To achieve a financially sustainable pension scheme for an aging population conceptually requires two steps: Increasing the effective retirement age to a level that avoids deficits, and thereafter indexing this deficit-free effective retirement age with the changes in cohort life expectancy of this age. Technically this could be broadly done for conventional defined benefit schemes but would be complex; it would be easier to achieve this result under a (non-financial) defined contribution scheme (Holzmann et al., 2020). Achieving both reform steps would also substantially reduce the implicit pension debt that competes with financial debt under the intertemporal government budget constraint. This would also offer more room for productivity-oriented expenditures or tax reforms.
- A later effective retirement age would also reduce the retirement saving volumes by sizable proportions with potentially major implications for the issues at stake: If people stay longer in the labor market, this increases their incentives to invest in their human capital and thus to remain more productive. Less retirement saving reduces the savings overhang an aging population is confronted with. Last but not least, if older people save less, their demand for safe assets also declines.

Key example of **requirements**:

- Having individuals stay longer in the labor market requires both the right incentives as well as job opportunities. As regards the **incentives**, there is strong cross-country evidence that incentives do indeed matter: If the pension system does not honor extended labor market participation, individuals will retire as early as possible (Gruber and Wise, 1998, Hofer and Koman, 2006). In principle, those incentives can be established under both defined benefit and defined contribution-based schemes, but conceptually and empirically the latter are more effective. Hence, a critical requirement is likely to be the move toward a defined contribution based scheme, best integrated into a balanced multi-pillar structure (Holzmann et al., 2020).

- The **opportunities** for staying in the labor market include on the one hand employers' interest in hiring older adults and providing job offers. On the other hand, they also imply that older individuals have adequate qualifications. Research and case studies are scarce but strongly suggest that employers need to make some additional investment to make jobs fit for older people, even in the case of manual jobs. However, we know very little about how to ensure that older workers stay healthy, skilled, and motivated. What weighs even stronger is that we do not have public and enterprise policies in place to make that happen.
- A successful strategy to include older adults in the labor market would require close cooperation between policymakers across different areas of government, including education, labor, social production, public finance and economics, as well as the central bank. In reality such cooperation hardly ever happens in a sustained way, however, and even less so on the topic of aging.

Key policy messages:

A. To make the labor market more accessible and attractive for older adults, set incentives for companies to **make jobs old-age-fit**. This requires keeping older people healthy, fit, and motivated. We have yet to find policies to achieve this goal.

B. **Increase** the effective **retirement age** with rising cohort (not period) life expectancy. Policy considerations need to shift from a retrospective to a prospective aging view.

C. A critical requirement is likely to be the move away from defined benefit plans towards a (non-financial) defined **contribution-based scheme**, best integrated into a balanced multi-pillar structure.

4.2 Promoting digitalization

> World Economic Forum (2016): "We stand on the brink of a technological revolution that will fundamentally alter the way we live, work, and relate to one another. [...] The First Industrial Revolution used water and steam power to mechanize production. The Second used electric power to create mass production. The Third used electronics and information technology to automate production. Now a Fourth Industrial Revolution is building on the Third, the digital revolution that has been occurring since the middle of the last century. It is characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres."

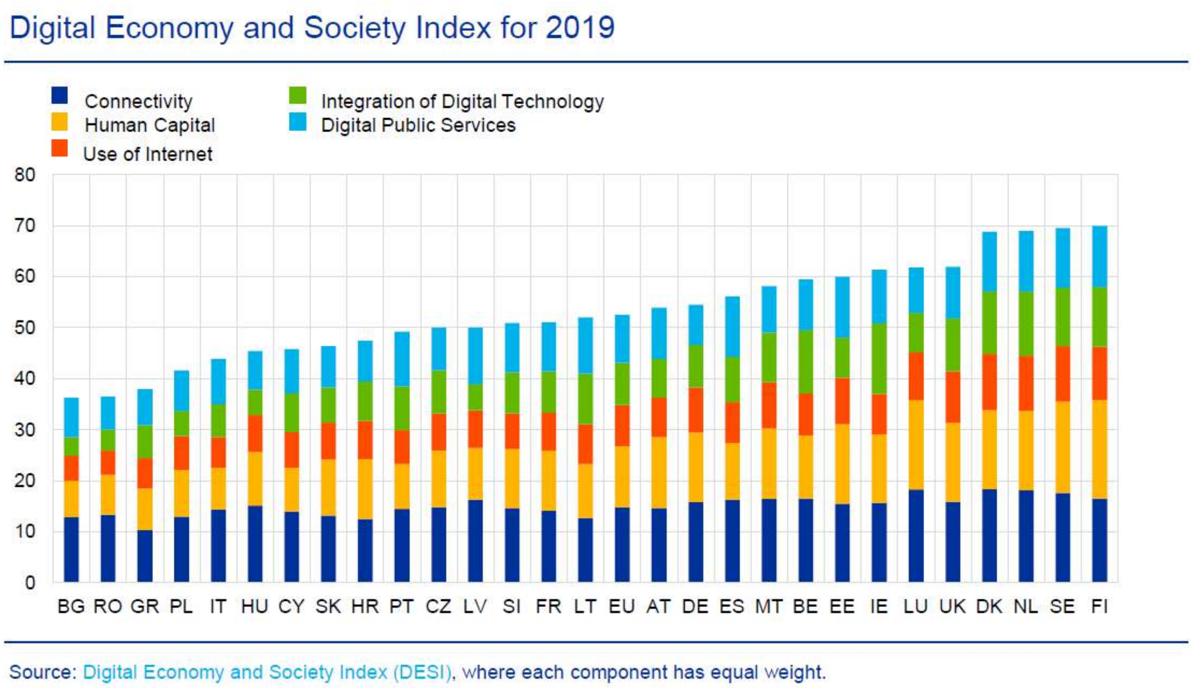
The above analysis of recent trends and regional differences in productivity growth has – from several angles – highlighted the crucial role of digitalization. Weyerstrass (2018), for example, shows for the EU that a high share of IT in the total capital stock is conducive to TFP growth. While increasing digitalization is so far not fully reflected in productivity figures, some of this effect may become visible only with a delay as it takes time until the benefits of digitalization are fully exploited in production processes. It may require continuous digital innovation to reach a longer-term effect on productivity growth, not just a shift in the level of productivity. Policy can play a key role in helping firms to exploit the gains from digitalization.

This requires not only investment in digital infrastructure and subsidies for digital equipment, but also setting incentives to improve managerial and organizational skills at the firm level. After all, the OECD (2019c) shows that firms with better technical, managerial and organizational skills tend to be more productive in the first place, but then also benefit more from digitalization, which helps them increase their lead in terms of productivity. Anderton et al. (2020) emphasize the role of good institutions and governance for digitalization.

Digitalization – in turn – affects the **measurement of inflation**, particularly with respect to the prices of digital services. This in turn affects the measurement of productivity and may partly explain the recent productivity slowdown. Efforts to improve price measurement for digital services are thus key.

The recent coronavirus pandemic episode has pushed the dissemination and adoption of digital technologies to unprecedented levels. Potentially, this may have delivered the structural change necessary to reap the productivity gains from digitalization. While this is a welcome development, there is still scope for improvement at the EU level, as many countries are not even near the frontier. The chart below shows the DESI, the **Digital**

Economy and Society Index, in cross-country comparison as well as reflecting the time dimension. In recent years, the DESI increased markedly in all countries, but large cross-country differences remain, with Nordic countries in the lead (Anderton et al., 2020). A comparison to the US (not visible in the chart) shows a lag of the EU, helping to explain higher US productivity growth in recent decades, but potentially also the faster recovery from the corona pandemic.



Source: Anderton et al. (2020), p.16.

Several aspects of digitalization may be of relevance for future productivity growth but require further deepening:

- Digitalization offers new opportunities to exploit the information content available at the firm level (“**big data**”). At the same time, it also opens new questions of **secure data transfer** within enterprise groups.
- The increasing use of **online transactions and platforms** – which accelerated further in the course of the coronavirus pandemic – may promote productivity growth: According to Costa et al. (2021), online trade accelerates the productivity growth of traditional businesses, and these gains are attributable to expanding value added rather than reduction in employment. These gains are larger for SMEs and for firms in the middle of the productivity distribution, potentially helping to close the gap with the most productive firms.
- Another factor that has gained importance in the course of the COVID-19 pandemic is the use of **telework**. According to Milasi et al. (2020), on EU average close to

40% of employees are in teleworkable occupations. However, only about one-quarter of this potential was actually used before the health crisis. Generally, remote working is more prevalent in certain sectors (ICT, education, financial activities, public administration), in highly paid jobs and in Nordic countries, and we find that the EU lags behind the US. In the course of the pandemic, more than one-third of workers in Europe started to work from home, most of them with previous telework experience.

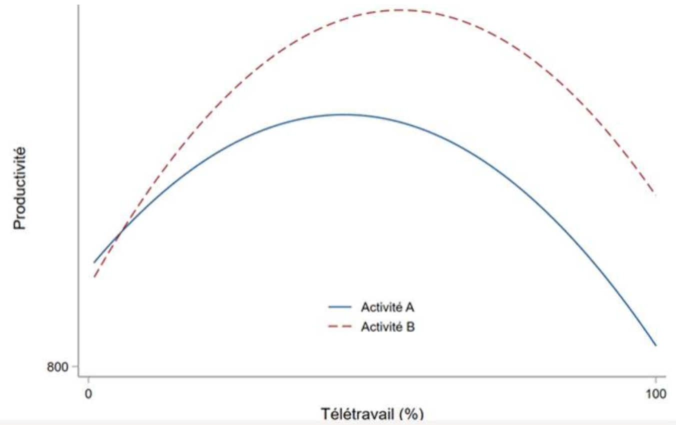


Figure 1: Relation en U inversée entre intensité du télétravail (en proportion de la durée travaillée) et productivité pour deux activités différentes Inspirée de OCDE (2020)

Source: Bergeaud and Cette (2021).

During crisis times, obligatory telework may temporarily reduce productivity. In turn, voluntary telework schemes during normal times and under adequate circumstances may have sizable benefits, such as raising the attractiveness of the workplace and thus attracting higher-quality labor (Bloom et al., 2020). Bergeaud and Cette (2021) also suggest that working from home may push productivity (see chart).

How lasting will the changes be that we have observed in the course of the COVID-19 pandemic? Early evidence suggests that around one-third of the additional digital use may prove permanent. Barrero et al. (2021) survey 30,000 US Americans and conclude that 20% of workdays will be supplied from home after the pandemic ends, compared with 5% before. The reasons for this include better experience and less stigma with working from home, investment in physical and human capital and technological innovation and continued concern about contracting COVID-19. While the authors expect a 5% productivity boost due to re-optimized working arrangements, only one-fifth of it will be reflected in productivity measures, since the latter do not capture savings in commuting time.

The NextGenerationEU recovery plan with its explicit goal of making post-COVID-19 Europe more digital may help reduce the digital divide across European countries if countries lagging behind invest heavily in digital technologies. However, they may not be able to close the gap to the US. As a consequence, measures to foster the digital uptake and infrastructure remain high on the policy agenda.

A recent Austrian study (Friesenbichler et al, 2021) shows that, in international comparison, Austria shows weaknesses, e.g., in the availability of qualified IT staff and in ICT processes such as the integration of suppliers. As a result, use and diffusion of process-oriented ICT services lag behind, while ICT investment is comparable to international averages. This helps explain the small contribution to growth of ICT capital. A higher concentration and streamlining of digitalization policies could help define policy priorities. Lithuania's innovation hub "Digital Lithuania", a platform for cyber-security, E-business and E-government is a best practice example in this respect. ICT investment needs to be accompanied by higher diffusion of broadband net and process innovation. Especially SMEs lack behind in ICT processes and management capacity. Awareness programs and support in process adjustment within businesses may help increase technological diffusion. And (life-long) training offers should contribute to the increased availability of qualified IT staff.

Key policy messages:

A. Set **incentives** to invest in digital skills and equipment via tax incentives, supported by public investment in digital infrastructure to reduce digital exclusion. In addition, set incentives to improve managerial and organizational skills at the firm level to increase technological diffusion.

B. Promote (voluntary) **telework** schemes, as these may have sizable benefits, such as raising the attractiveness of the workplace and thus attracting higher-quality labor, which would ultimately push productivity. Foster telework, especially also for less skilled people to increase virtual labor flows that may help alleviate labor market bottlenecks in fast growing European regions.

C. Improve **price measurement** for digital services in order to achieve unbiased and robust measures of inflation, and – hence – of productivity.

4.3 Addressing climate change

Research suggests that climate change could not only dampen output levels but also output growth through impacts of **persistent damages** on factors of production and total factor productivity (Kikstra et al., 2021). Climate-related natural disasters may damage the capital stock, and higher temperatures have a negative impact on the health and productivity of workers (Burke et al., 2015). Economic policy could reduce these negative effects through instruments such as carbon taxes. But even if the 1.5°C goal will be achieved, climate change is likely to remain a possible cause of lower productivity growth in the future, including in advanced economies with relatively moderate climatic conditions, "unless populations engage in new forms of adaptation" (Deryugina and Hsiang, 2014).

The transition to a **low-carbon economy** is a, if not the, major undertaking for the next three decades. The need for huge green investments at the global level implies enormous costs in the short run (Pisany-Ferry, 2021). Only part of that is additional, since investments in infrastructure and energy must be done anyway. Hence, it makes sense to apply clean technologies to avoid lock-in effects and costly reversals. Anyhow, the long-run costs of inaction are likely to be much greater than the costs of action. Early and decisive action could even herald a win-win situation for the economy and the environment (Bhattacharya et al., 2021). While green investment and innovation might drive "the growth story of the 21st century" (Bhattacharya et al., 2021), the net effect of transition policies on productivity is uncertain as under-investment (in non-green activities) and rising stranded (non-green) assets could offset efficiency gains of technological innovation (NGFS, 2020).

Historically, energy productivity (output/energy ratio) has grown at close to the same rate as labor productivity. Empirically, the relation between environmental degradation and (productivity) growth is described by the (hump-shaped) **environmental Kuznets curve**. According to this, economic growth and environmental damage are positively correlated in early stages of development, while in advanced economies the two processes become increasingly decoupled (Grossman and Krueger, 1994). Regarding greenhouse gas (GHG) emissions, some relative decoupling can already be observed on a global scale. In advanced economies such decoupling is already taking place in absolute terms (see the charts below). Yet, there is no empirical evidence of economic growth decouplingfrom carbon emissions at a rate rapid enough in absolute terms to realize the transition to net-zero GHG emissions by 2050, as implied by the Paris Agreement (Hickel and Kallis, 2020). Appalled by the sheer scale of emission cuts needed, Jackson (2017) calls decoupling a myth. Conversely, the pandemic provided a natural experiment, putting de-growth strategies into question.[6]

Figure 3.2. World CO_2 emissions have decoupled from GDP only in relative terms, and not from energy consumption

World GDP, final energy consumption and CO2 emissions

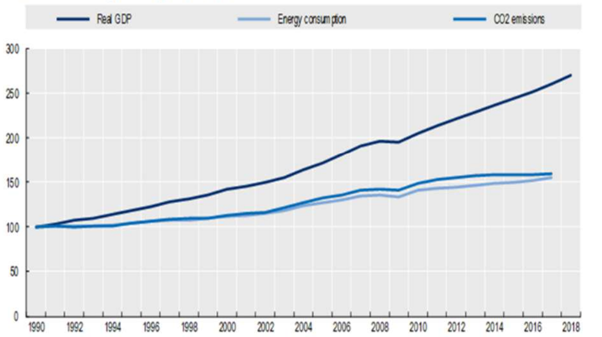
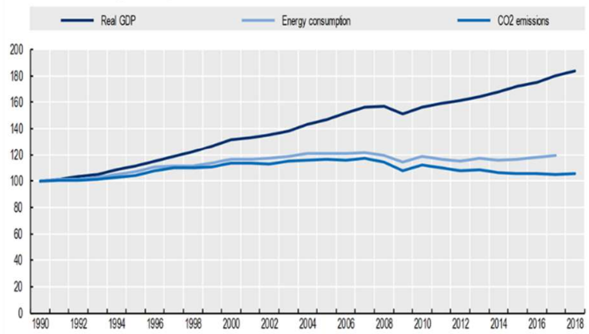


Figure 3.3. OECD CO_2 emissions may have decoupled from GDP and energy consumption in absolute terms

OECD GDP, final energy consumption and CO2 emissions



Source: OECD (2021), p.71.

Theoretically, the possibility of green growth has been highlighted by the **Porter hypothesis** (Porter and van der Linde, 1995). It stipulates that stringent but efficient environmental regulations can boost efficiency and innovations, reconciling social welfare with private benefits. An ECB (2020) analysis confirms the Porter hypothesis linking **environmental regulation** with productivity: EU countries with stricter environmental standards facilitate the reallocation of resources into green sectors and turn the latter into engines of growth during recoveries.

Environmental policies can increase (productivity) growth through various channels (based on Hallegatte et al., 2012):

- The **input channel** works by investing in the quantity of natural, human, and physical capital, scaling up clean economic production at decreasing costs.
- The **efficiency channel** spurs productivity by correcting market failures to price in social costs of GHG emissions and enhancing the efficiency of resource use through carbon pricing, command-and-control regulation (e.g. emission standards) as well as transparency (preventing greenwashing).
- The **stimulus channel** can occur during an economic slack when (transition) uncertainty is high and capacity utilization is low, increasing the likelihood that private investment gets crowded-in.
- The **innovation channel** can shift the production frontier (increasing the potential output) by accelerating the development and dissemination of innovation, creating knowledge spillovers.

[6] According to UNEP (2019) keeping the 1.5°C goal in reach would require global emission cuts by 7.6% every year in the decade until 2030, while the global economy should continue to grow by 3% per year. In 2020 emissions fell by a comparable magnituted (5.8%), when global economic activity declined by roughly 3% (IEA, 2021).

- A **competition channel** provides a dynamic business environment, where new firms applying sustainable innovation replace incumbents sticking to traditional production methods. Their supply meets increasing consumer demand for more environment-friendly products (Aghion et al., 2020).

Muller (2021) introduces the concept of a **green interest rate** that complements r* with an environmental component. The green interest rate (rg) depends on temporal changes in the pollution intensity of output and reallocates consumption from periods when output is pollution-intensive to periods when output is cleaner. In economies with pollution-intensive growth r* exceeds rg; on a cleaning-up path this difference gets reversed. This approach suggests that a central bank might set a policy rate that includes managing risks from GHG emissions.

The opportunities and risks of the green transition to productivity have yet to be analyzed in depth. Such analysis should include the following aspects:

- The most efficient – because technologically neutral – policy is the **pricing of carbon**, reflecting its social costs and hence directly tackling the underlying market failure. Indeed, evidence suggests that energy taxes tend to accelerate TFP, increase investment and the returns to capital (Tol and Lyons, 2011). While carbon taxes could dampen growth in the short run, output would be higher in the long run, since firms adjust. Low-carbon technologies get scaled up and negative TFP shocks from climate change are less frequent and severe.

- Innovation, and in particular **digitalization,** can contribute to climate mitigation and adaptation. Positive efficiency effects, however, are reduced by negative rebound and obsolescence effects. Thus, the net effects depend on the concrete policy design (Briglauer and Köppl-Turyna, 2021). Moreover, Acemoglu et al. (2012) show that environmentally and economically optimal policy involves both carbon taxes and research subsidies. Indeed, even if carbon is priced adequately, green innovations are underproduced by the market because of inventor-borne fix costs, knowledge spillovers, and uncertainty (Bryan and Williams, 2021). Since innovation and its diffusion are path dependent, incentivizing R&D expenditure on emission-saving technologies would yield a double dividend. Mazzucato and McPherson (2018) propose mission-oriented industrial policies to redirect the production-possibility frontier toward carbon-neutral technologies and to overcome paralyzing uncertainty. State investment banks and development banks would play an important role in providing "patient" long-term strategic finance to derive innovation. Initially higher public expenditures – crowding in private capital – could significantly reduce the overall economic costs of decarbonization in the longer term. Besley and Persson (2020) point to non-linear dynamics of rapid technical, behavioral and systemic change exhibiting increasing returns to scale.

- Furthermore, early **adoption** of energy-efficient technologies could improve **competitiveness** as the green economy becomes an important export sector.
- Given its great potential for the deployment of **solar and wind-based electricity** capacity, Europe has a chance to turn the weakness arising from the scarcity of fossil fuel resources into a strength. Thanks to its policy-induced scaling-up, European wind and solar energy is already cost competitive with fossil fuels. However, weather-dependent energy sources are unstable over the course of the year; they require storage and transformation capacities as well as long-distance interconnections.
- Doubts over Europe's **comparative advantage** in all types of renewable energy provision are reasonable but should be balanced against energy security considerations. Given huge demand for clean energy, European production could be complemented by imports of solar-produced electricity and hydrogen from the Middle East and Northern Africa (and Patagonia for wind-based hydrogen). While production is probably more efficient there, one must take transport and transformation losses into account, which might partly offset storage costs of Europe-based production.
- The green transition offers a huge opportunity for global investment programs and the **international division of labor**.
- **Transportation changes** could contribute to GDP growth, through reduced oil imports, less CO_2 production, better health of workers and – perhaps most importantly – through fast travel times for both cargo and people. A coordinated leap to integrating Europe's fragmented **railway** system could, e.g., reduce the travel time of cargo containers from Finland to Portugal to less than 24 hours and confine hydrogen trucks and buses to 50 km around the container or passenger hub.
- Green infrastructure will increase **productivity in low-carbon sectors**, thereby incentivizing the private sector to reallocate resources in those activities (IMF, 2020b).
- **Structural reforms** can boost both productivity and the transition to low-emission economies, through easier resource reallocation, faster technology development and diffusion, more dynamic labor markets and easier firm entry and exit (OECD, 2017b).
- Improving growth in **agricultural TFP** through innovation has the potential to meet rising food demand while using fewer environmental resources.
- Finally, greening the economy may also increase the **resilience** of the economy against climate-related risks, such as rising sea levels, depending on the geographical exposure.

To be sure, productivity growth is not the main target of the low-carbon transition. It remains unclear to what extent policies and preferences will lead to more **technological or behavioral** change. Technological optimism about an ecological modernization should at least be compared to the political and technological necessities in the sense of a "reality check". Important instruments or indicators of a green growth policy, such as environmental taxes or green patents, unfortunately give little cause for optimism (Veugelers, 2016). The effect of COVID-19 lockdowns on the economy and on GHG emissions exemplified that degrowth cannot be a viable decarbonization strategy. Nevertheless, preferences shifting toward anti-consumerism, a simple lifestyle and more artisan production could weigh on (labor) productivity growth. New growth theory, however, suggests that positive productivity effects will prevail. Yet, the manifestation of green or intangible growth requires significantly more stringent measures than is currently the case.

Key policy messages:

A. The recovery from the COVID-19 crisis offers an opportunity to lower the transitional costs of climate mitigation by **building "sustainably"** now, rather than having to rebuild infrastructure later. In uncertain times, interest rates are lower and fiscal multipliers of public investment are higher than usual since private investment gets crowded-in and employment can be easily absorbed. Initial investment support accompanied with steadily rising carbon prices would scale-up investment in low-carbon technologies.

B. **Carbon pricing** incentivizes the technological and behavioral change needed and corrects market failure through the polluter-pays principle. Command-and-control regulation, including "green finance" regulation, is often a second-best result of political economy processes. Ideally, it should only complement – not substitute – carbon pricing on grounds of additional market failures such as asymmetric information.

C. **Structural reforms** that stiffen competition alongside Schumpeter's "creative destruction" can play an important role in the diffusion of climate-neutral innovation, forcing market incumbents to either adjust or to exit.

5 Conclusions

Achieving high productivity growth is a central goal of policymaking in most countries, given its key role for potential output, incomes, international competitiveness, and a country's living standards. In view of recent challenges like climate change and the subdued growth perspectives in industrial countries, promoting productivity is even more important as such growth reduces the inputs necessary to achieve economic growth. Especially central banks are concerned about the topic because of the interaction of productivity growth and the business cycle. In particular, it is important to understand the relationship between the natural rate of interest r* and productivity, given that r* may restrict the room for maneuver of monetary policy. For example, a lower level of r* may call for long periods of very accommodative monetary policy, which may affect both financial stability and policies associated with productivity in light of the fiscal dominance threat.

Surveying key contributions in the theoretical and empirical literature has provided us with various explanations about why productivity growth has slowed down recently in developed countries around the world. We have identified nine hypotheses that offer unique reasons for the disappointing productivity performance. These explanations cover aspects of low demand, expansionary monetary policy, specific firm characteristics, technological cycles, weak technological diffusion, subdued creative destruction, financial market dynamics, demographics, and the burden of regulation. For each dimension we arrive at key messages for how economic policy may contribute to promoting productivity growth, also taking into account regional differences.

We identify three challenges on the policy agenda, whose importance is set to increase over the next decades: addressing population aging through the labor market, promoting digitalization, and addressing climate change. We highlight how dedicated action and judicious policy measures in these fields may contribute to achieving higher productivity.

"One-size-fits-all" policies are deemed suboptimal to combat weak productivity growth. The relative weight of appropriate measures depends on the current stage of a country's development as well as its history and the prevailing business environment. Hence, policies may differ widely not only across the world but also across European regions. Or as Jona-Lasinio et al. (2019) put it, "The imperfect knowledge about the key drivers of productivity and, above all, of the lags with which the economic system responds to policy shock calls for an experimental and tailor-made approach that addresses the most pressing bottlenecks affecting countries and sectors while refraining from a one-size-fits-all attitude."

Central banks can play a crucial role in supporting governments by contributing to an appropriate policy mix: (1) by giving well-founded advice to policymakers and by promoting rigorous monitoring and evaluation of productivity enhancing measures; (2) by helping to advance research in the areas addressed in this paper; and (3) by initiating and funding projects to better exploit existing data sources and collect new data.

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