CHAPTER
3.1

PRODUCTIVITY PUZZLE AND INNOVATION DIFFUSION

KEY FIGURES

1.0 %
the rate of productivity growth in Europe between 2010 and 2018

65.7 %
the contribution of R&I to total productivity growth in a sample of EU countries

12 %
the gap in real labour productivity between the EU and the United States in 2018

0.5 %
the annual growth rate of Total Factor Productivity in the EU after the crisis

What can we learn?

- **R&I are at the core of the productivity and competitiveness** of our economy.
- **Productivity growth and sustainability can reinforce each other**. Productivity can help overcome the trade-off between environmental policy and long-term growth.
- Despite the rise in digital technologies in the past decade promising large productivity gains, **productivity growth has been sluggish**, holding back more robust economic growth in Europe and other advanced economies.
- **The gap in productivity performance** between highly productive economies and firms at the frontier and the rest points, among other factors, to a **lack of innovation diffusion** in Europe.

What does it mean for policy?

- **R&I policy that aims to enhance productivity** will reinforce companies' ability to be competitive at the global level, benefitting jobs and creating value.
- **R&I policy plays an important role for catching-up** of laggard companies and regions by improving the conditions to speed up knowledge creation and diffusion (investment, regulation, science-business links, framework conditions, and capacity and quality of national R&I systems).

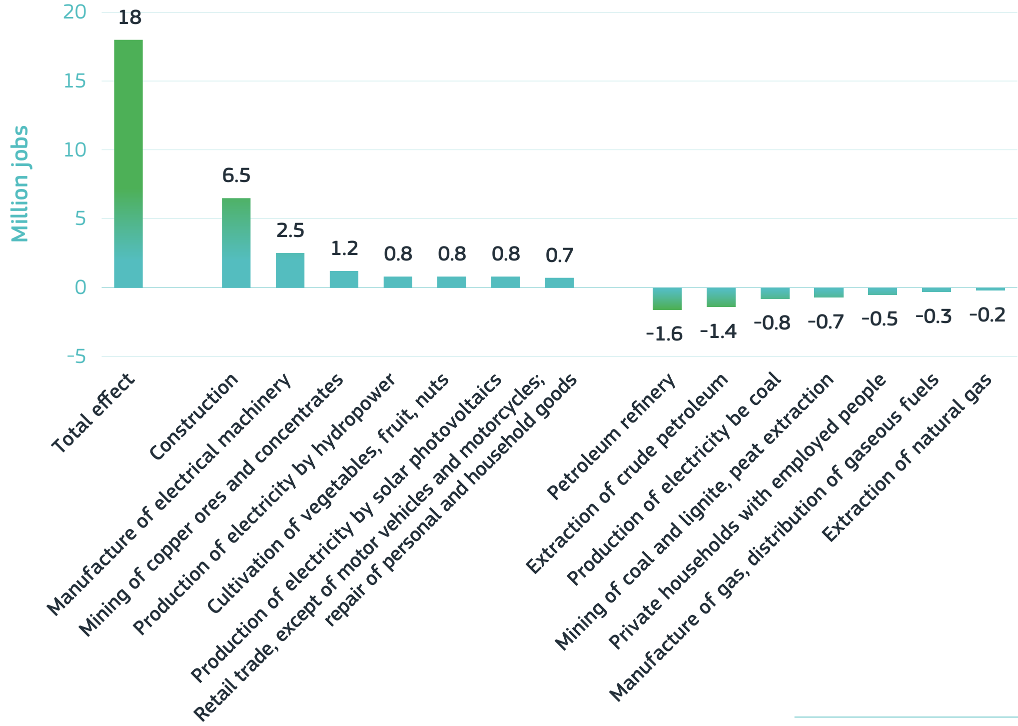
1. Productivity, competitiveness and innovation are closely related

Higher productivity means stronger competitiveness, which is crucial for EU companies in a globalised economy. This is even more true as the EU risks gradually losing its competitiveness, with slow innovation, adoption of technologies and productivity growth in a context where technology is changing fast and new global players are emerging rapidly (European Investment Bank, 2019). Higher productivity will also be essential in the future in the light of ageing societies to compensate for a declining share of the workforce in the population. In this context, productivity will be a key determinant of Europe's future prosperity.

Competitiveness, productivity and innovation are separate concepts but are very closely interrelated. In the global context, it would be a mistake to ignore the fact that innovation can drive the EU's competitiveness through productivity growth. Spurring innovation has a direct effect on what is produced, making goods better and cheaper whilst also ensuring that the production process is efficient. This improvement in the ratio of production output to input is referred to as productivity. Hence, it is a measure of efficiency. Enterprises are competitive when their productivity grows consistently and enables them to reduce the unit costs of their outputs. In turn, if this happens in traded sectors it can allow EU companies to compete on global markets without relying on government support.

Productivity growth and sustainability can reinforce each other. Productivity can also help overcome the trade-off between environmental policy and long-term growth when coupled with appropriate action, such as investment in pollution abatement (Basu and Jamasb, 2019). Boosting productivity growth needs refocusing the use of available resources and investments on more efficient production activities and systems, which must also be environmentally friendly in order to ensure a sustainable growth path (Kalff et al., 2019). Hence, increasing the efficiency of the production process can be compatible with sustainable production and support the sustainable transition. This raises the issue of ensuring a proper decoupling between economic activity and the negative externalities related to the production process. R&I can play a key role here. Productivity gains, and the related economic benefits in terms of value added and jobs, can also be directly generated by more competitive sustainable activities. For example, in Europe, the value added and employment of the environmental sector has increased rapidly compared to the rest of the economy, together with a steady increase in labour productivity (Box 3.1-1). The International Labour Organization (2018) shows an overall positive employment impact from the action taken in the energy transport and construction sectors to limit global warming to 2 °C. By 2030, the estimated job creation, driven by the high demand for labour from renewable energy sources, is around 18 million jobs globally. Under the same logic, it can be shown that the stringency of environmental policies is accompanied by higher levels of eco-innovation and economic competitiveness (European Environment Agency, 2020).

Figure 3.1-1 Sectors most affected by the transition to sustainability in the energy sector (in million jobs)



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Source: ILO (2018). World Employment and Social Outlook 2018 – Greening with jobs

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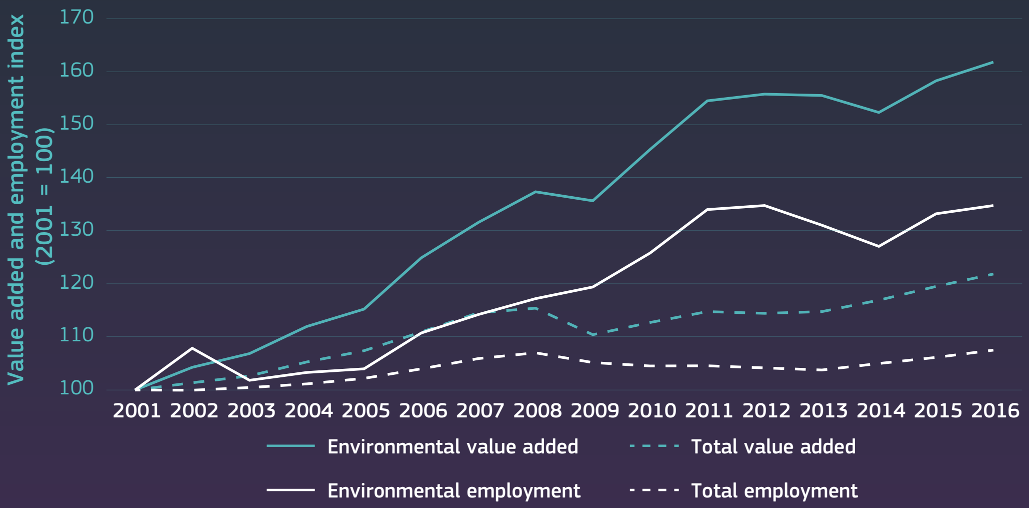
BOX 3.1-1 A sustainable transition

Europe has engaged in a transition towards a sustainable growth model, in line with the 2030 Agenda for Sustainable Development. Among the multifaceted dimensions of a sustainable development path, the creation of an economic and social model within the natural limits of our planet plays a key role, calling for a better use of resources and a transition towards a low-carbon and climate-nature Europe (European Commission, 2019).

Such a transition also requires a change in the way the production process takes place, including greater relevance and weight for those activities aimed at the prevention and maintenance of the stock of natural resources and a reduction in environmental degradation. Figure 3.1-2 presents the growth of employment and gross value added in activities devoted to environmental protection – the prevention, reduction and elimination of environmental degradation – and resource management – the preservation and maintenance of the natural resources stock. The trend reveals that **the EU has embarked on a sustainable development path, with a steady increase in the weight of the 'environmental sector' in terms of both employment and gross value added, as well as productivity**. Indeed, these activities are growing faster than the overall economy, with a steady and positive trend being in place since 2001.

Figure 3.1-2 Growth of the environmental sector in the EU28[1], 2001-2016



Science, research and innovation performance of the EU 2020

Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on Eurostat (online data code: env_ac_egss2 and env_ac_egss1)

Note: Data are normalised to 100 in 2001.

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Furthermore, productivity growth brings benefits to consumers through higher wages for workers. At the same time, businesses become more profitable, which also benefits investment and jobs. The question is to what extent these (technological/digital) productivity gains benefit society as a whole and what share is captured by a small number of dominant firms. This deserves further investigation, although the dominant market power of a few extremely productive large players could raise distributional questions (ILO, 2018).

R&I is crucial for the EU's productivity. For a long time, economic theory has highlighted the role of technical progress in productivity growth and the key role innovation systems play in this (Solow, 1957; Romer, 1986; Romer, 1990). Innovation has two roles in stimulating productivity (Hall, 2011). First, R&I can increase firms' efficiency through process innovation and improve the goods and services they produce. This raises their demand and reduces production costs. Second, firms that innovate are also likely to grow more, and new entrants with better products should displace existing inefficient firms. Overall, this contributes to increasing aggregate productivity: new ideas help to generate greater (or the same) output with the same (or less) input, for both companies and the whole economy. This, in turn, should positively affect wages and business profitability. Similarly, once a new technology is produced, its diffusion throughout the economy is a key productivity driver: higher adoption rates reduce the gap between leaders and laggard companies (and regions) and eventually positively affect aggregate performance (Andrews et al., 2016; Anzoategui et al., 2019).

BOX 3.1-2 Investments in intangible assets, innovation and productivity performance

Cincera, M. (ULB), Delanote, J. (EIB), Mohnen, P. (UNU-MERIT), Santos, A. (ULB) and Weiss, C. (EIB)

Investment in intangible assets has increased rapidly over the past few decades, mainly driven by changes in industrial market structure, with several important implications for how firms operate[1]. While the manufacturing sector is becoming more oriented towards services and customers, an increasing number of tasks in the services sector are automated thanks to artificial intelligence and robotisation. In this context, information and communications technologies (ICT) affect firms' organisational structure and commercial strategies by providing them with new ways of selling products and services (e.g. e-commerce) or giving fast and easy access to data (e.g., information about customers). Technological change is also affecting the structure of the labour market, creating a need for new jobs in the ICT sector and changes in the demand for workers' skills.

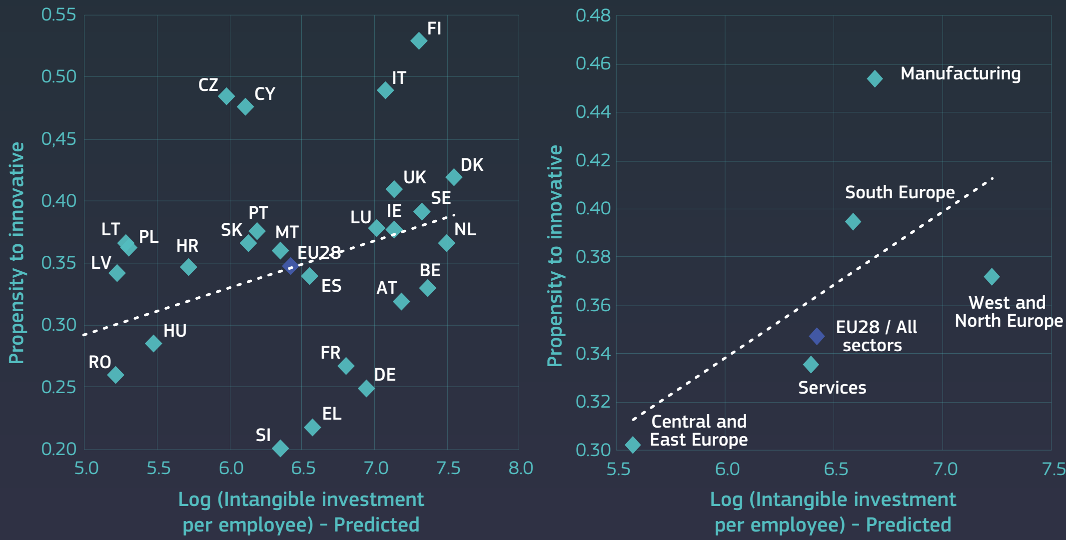
EU firms are facing new challenges. Digitalisation and globalisation are putting pressure on existing market positions competition. Investment in intangible assets – such as R&D, intellectual property rights (patents, trademarks, and design), software and data, and staff training – has gained relevance in overcoming these market pressures. Intangible investment has a positive effect on the propensity to innovate (Figure 3.1-3) and firm productivity (Figure 3.1-4).

Firms located in central and eastern Europe tend to invest less in intangible assets, have a lower propensity to innovate and are less productive. In contrast, firms in west and north Europe have higher levels of intangible investment and productivity.

Manufacturing firms have a higher propensity to innovate than services – for a similar level of intangible investment, they are more likely to introduce new products, processes or services. At the same time, firms in the manufacturing sector tend to be less productive, even though they display a higher average intangible investment intensity than those operating in the services sector.

1 Haskel, J. and Westlake, S. (2017), Capitalism without capital: The rise of the intangible economy, Princeton, NJ: Princeton University Press.

Figure 3.1-3 Intangible investment and innovation



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Source: EIB Investment Survey (EIBIS waves 2016 to 2018)

Note: The log of intangible investment per employee was estimated using an OLS regression, controlling for selection bias (decision to invest), obstacles to investment activities, competition index in the sector, firm production capacity utilisation and firm characteristics. Intangible investments include R&D expenditures (including the acquisition of intellectual property); software, data, IT networks, and website activities; acquisition of new skills through the training of employees; organisation and business process improvements (such as restructuring and streamlining).

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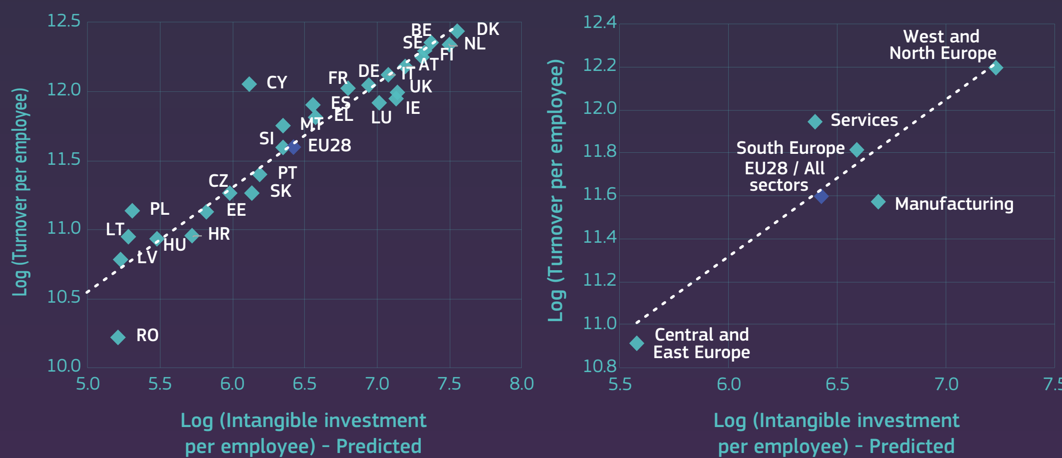
Figure 3.1-4 Intangible investment and productivity relationship



Science, research and innovation performance of the EU 2020

Source: Based on the EIB Investment Survey (EIBIS waves 2016 to 2018)

Note: The log of intangible investment per employee was estimated using an OLS regression, controlling for selection bias (decision to invest), obstacles to investment activities, competition index in the sector, firm production capacity utilisation and firm characteristics. Intangible investments include R&D expenditures (including the acquisition of intellectual property); software, data, IT networks, and website activities; acquisition of new skills through the training of employees; organisation and business process improvements (such as restructuring and streamlining).

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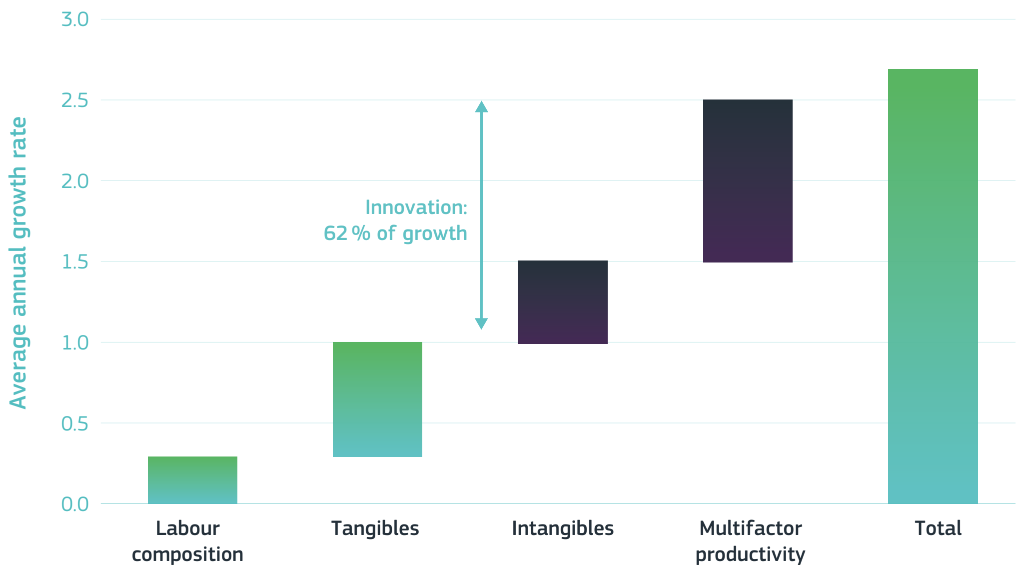
The positive relationship between R&I (and other intangible assets) and productivity has been observed and studied extensively in the literature (see Box 3.1-2 for a recent illustration). While the estimated impacts of R&I on productivity and economic growth vary depending on the methodology used and the period, countries and industries analysed, typical findings confirm the above economic rationale, revealing that R&I and intangible investments do explain a relevant share of productivity performance. Recent evidence also suggests that the decline in R&D and adoption investments contribute to explaining the productivity slowdown preceding the last economic crisis and in its aftermath, respectively (Anzoategui et al., 2019). To quantify the contribution of R&I and intangible investments to productivity and economic growth, the most notable findings suggest that[2]:

- **Before the crisis, almost two thirds of economic growth in Europe from 1995 to 2007 were derived from R&I**, broadly defined as TFP and intangible investments, including R&D, as reported in Figure 3.1-5 (Bravo-Biosca et al., 2013).

Figure 3.1-5 Contribution to European economic growth – percentage per annum (1995-2007)



Source: Bravo-Biosca et al. (2013)

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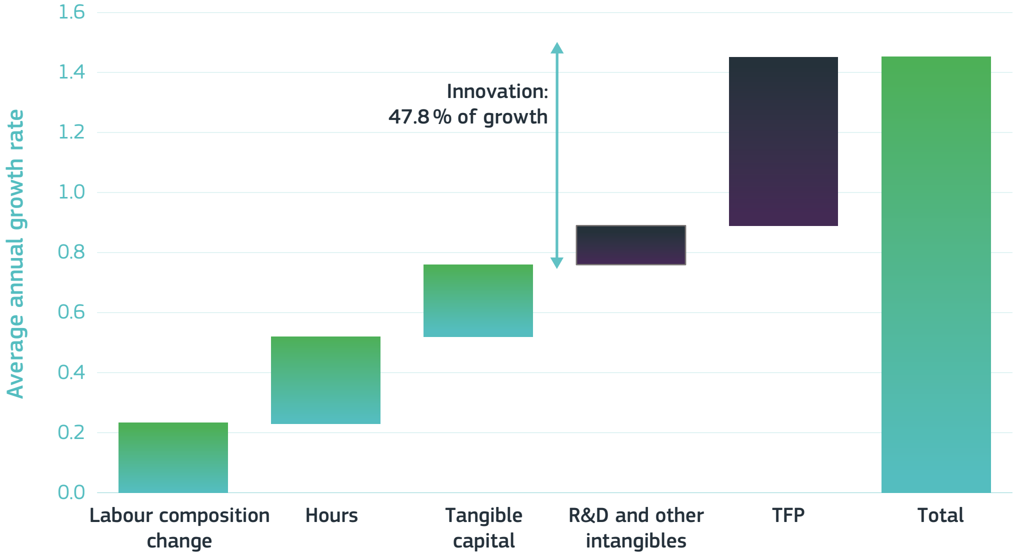
2 Growth accounting is a standard approach to estimating the contribution of capital, R&D and other intangible (and tangible) components to labour productivity growth, following the seminal work by Solow (1957). TFP is usually considered as the proxy of technological change, while different specifications of the estimation model allow the role of specific factors to be traced back, such as, for instance, ICT capital, R&D, economic competences, etc. The search for the contribution by intangibles has increased in recent years due to the increasing availability of reliable data.

- **After the crisis, from 2010 to 2016, almost half of the economic growth in Europe derived from R&I**, still defined as TFP and intangible investments, including R&D, obtained using the most recent EU KLEMS data 2019 (Figure 3.1-6). Unlike the precrisis estimates by Bravo-Biosca et al. (2013), the contribution of R&I declined slightly due to the significant increase in the role of hours worked, which had been rather minimal in the previous period.

Figure 3.1-6 Contribution to European economic growth (value added) – percentage per annum (2010-2016)



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Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on EU KLEMS 2019 (Analytical Database)

Note: Data covers 19 EU Member States: BE, CZ, DE, DK, EE, ES, FR, IT, LV, LT, LU, HU, NL, AT, RO, SI, SK, FI and SE.

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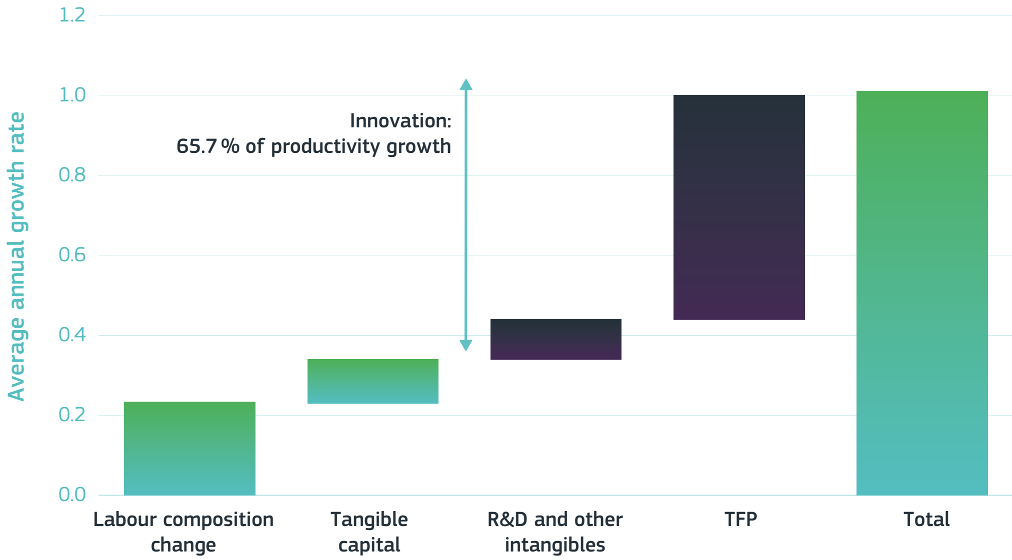
- **R&I contributed to nearly two thirds of labour productivity growth in Europe from 2010 to 2016**. If the focus is on labour productivity growth, then the contribution of R&I, as defined above, is equal to about 65.7 % of total productivity growth, signalling its key role as productive-enhancing investments even in the aftermath of the crisis. The results are shown in Figure 3.1-7, presenting the same growth-accounting exercise replacing value-added growth with labour productivity growth.

Figure 3.1-7 Contribution to European labour productivity growth – percentage per annum (2010-2016)



Science, research and innovation performance of the EU 2020

Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on EU KLEMS 2019 (Analytical Database)
Note: Data covers 19 EU Member States: BE, CZ, DE, DK, EE, ES, FR, IT, LV, LT, LU, HU, NL, AT, RO, SI, SK, FI and SE.
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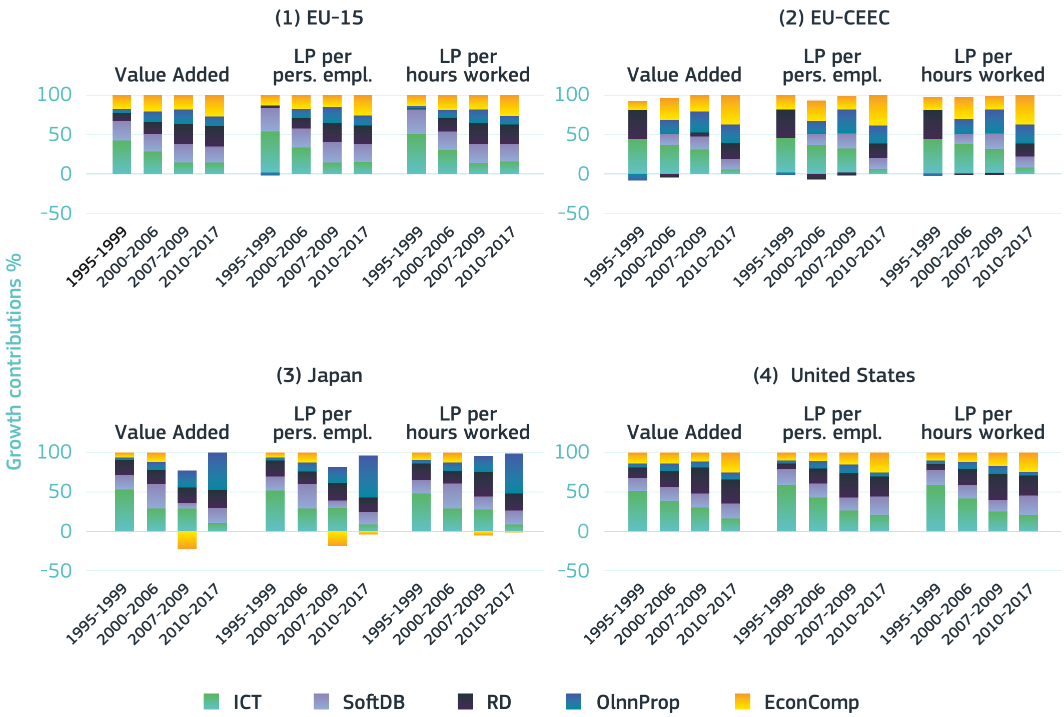
- **The significance of economic competences and intellectual property products has increased in the last two decades**, becoming key intangible assets together with R&D and software and database. While R&D has been and continues to be a relevant factor for economic and productivity growth, economic competences and intellectual property products (including design) have become key drivers of growth across the globe, including in the EU. It is worth noting the decline over time of the contribution of ICT capital (Figure 3.1-8).

- An increase in 10% in R&D investment is associated with gains in productivity between 1.1% and 1.4%, as shown in the meta-analysis by Donselaar and Koopmans (2016)[3].

3 It should be noted that a 10 % increase in R&D investment corresponds to a 0.2 % increase in GDP terms (i.e. R&D investment over GDP). This implies that, assuming no change in the number of hours worked, an increase in R&D investment of 0.2 % of GDP would result in an increase of 1.1 % of GDP, five times larger.

Figure 3.1-8 Contribution of ICT capital and intangible to value added and productivity growth



Source: EU KLEMS 2019

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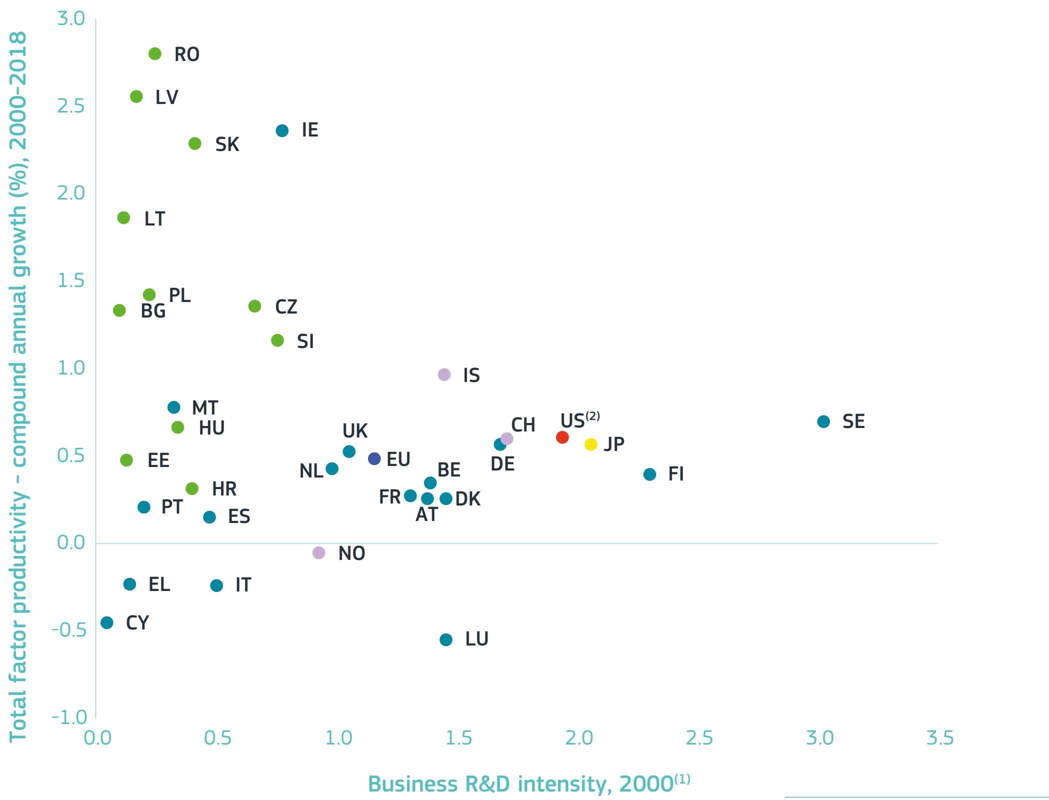
BOX 3.1-3 Total factor productivity and labour productivity

Labour productivity measures the amount of value added produced per work hour and is very often considered to be a good measure of the economy's overall efficiency. Increasing labour productivity can traditionally be associated with the ability to raise the returns to the production factors, notably capital, labour and technology.

Total factor productivity is a measure of the efficiency in the combination of production factors such as labour and capital to generate economic output.

Productivity growth is closely associated with the ability to foster innovation creation and diffusion in high-prosperity countries, but not in lower-performing countries (Figure 3.1-9). There are many factors explaining productivity growth, including well-functioning institutions, better infrastructure and high levels of education. However, and despite the intrinsic difficulties to map the contribution of all these factors, countries with high-income show a strong and positive correlation between TFP growth and business R&D (BERD), as their ability to innovate and technological advancement are main drivers for productivity growth. However, this is not true for lower- and middle-income EU countries where other factors can drive productivity growth, such as improvements in the business environment. In order to avoid a middle-income trap and ensure a long-term virtuous path, central, eastern and south-eastern (CESEE) countries in Europe need to move towards a more innovation-driven model (not just relying on foreign direct investment and technology uptake). The current situation in these countries does not favour the creation of high-skill jobs in the economy and reduces opportunities for high-skilled labour, which is reflected in low unemployment and high job-vacancy rates in the area (Correia et al., 2018).

Figure 3.1-9 **Total factor productivity – compound annual growth, 2000-2018 and business R&D intensity, 2000**



Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on Eurostat (online data code: rd_e_gerdtot) and European Commission - DG Economic and Financial Affairs

Notes: (1)SE, NO: 2001; HR, AT: 2002; MT: 2004. (2)US: Business expenditure on R&D (BERD) does not include most or all capital expenditure. (3)Countries in green correspond to CESEE countries.

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2. Productivity slowdown: a productivity paradox

Despite the rise in digital technologies over the last decade, promising large productivity gains, productivity growth has been sluggish, holding back more robust economic growth in Europe and other advanced economies. This is referred to as a **productivity paradox** which flags long-term risks for the competitiveness of European economies. The rise in digital technologies and their convergence with the physical world, in what some have called the Fourth Industrial Revolution, is transforming our economies and societies. Automation, big data, the Internet of Things and artificial intelligence are all digital technologies that are coming of age, promising new and more efficient business processes and products, which would bring significant gains in productivity growth in our economy. However, economic growth in Europe, and in other advanced economies, has been held back by very low levels of productivity growth that have remained almost flat for over a decade.

While the slowdown is also true in other major economies, over the last decade, productivity growth in the EU has been particularly poor compared to global competitors (Figure 3.1-10). From 2008-2018, TFP growth in the EU was less than half what it was over the period 1995-2007. While it was also low in other advanced economies, such as the United States and Japan, which only managed growth rates below 1 %, the slowdown in productivity growth was particularly acute in the EU. Labour productivity growth rates in the EU also tend to decline over time. While labour productivity per working hour in the EU increased on average by 2.1 % (1.9 % per worker) per year in the period 1995-2000, in the decade 2000-2010 this fell to 1.2 % (0.9 %) per year then decelerated further to 1.0 % (0.8 %) from 2010 to 2018[4]. Box 3.1-4 explores TFP dynamics at the sectoral level for a few Member States.

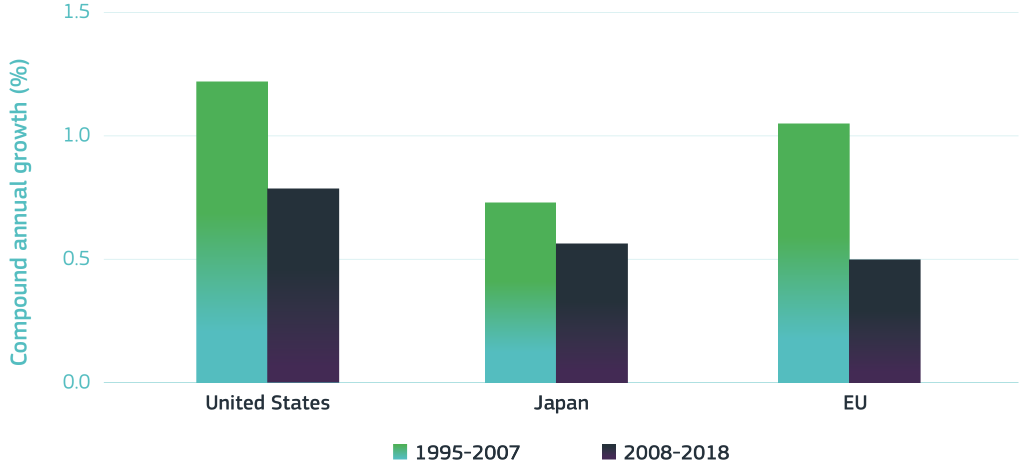
This productivity slowdown is also observed systematically at Member-State level[5] (Figure 3.1-11). Over the last decade, low EU growth was mainly driven by declines in Greece, Luxembourg and other Member States with values close to -1 %. On the other hand, Ireland, Slovakia, Latvia and Poland presented the highest TFP growth rates over the last decade.

Compared to the United States, almost all EU countries present lower labour productivity. Only Ireland, Luxembourg, Belgium and Denmark report similar or higher labour productivity. Central and eastern countries show the lowest performances in terms of labour productivity. Overall, the gap in labour productivity growth between the EU and the United States is about 12 % (see Figure 3.1-12).

4 Source: DG Regio.

5 Except for Ireland, although productivity growth levels in Ireland should be analysed with caution due to a statistical break following a revision in the calculation of GDP that led to a GDP growth rate of 26 % in 2015.

Figure 3.1-10 Total factor productivity – compound annual growth, 1995-2007 and 2008-2018



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Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit, based on Eurostat and European Commission - DG Economic and Financial Affairs

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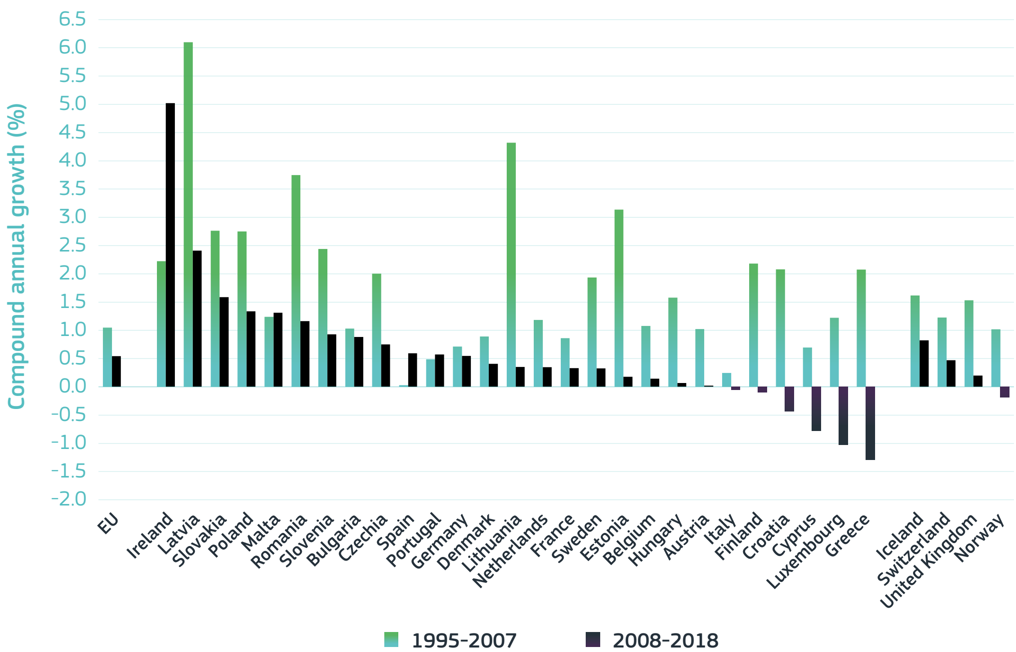
Figure 3.1-11 Total factor productivity – compound annual growth, 1995-2007 and 2008-2018



Science, research and innovation performance of the EU 2020

Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on Eurostat and European Commission - DG Economic and Financial Affairs

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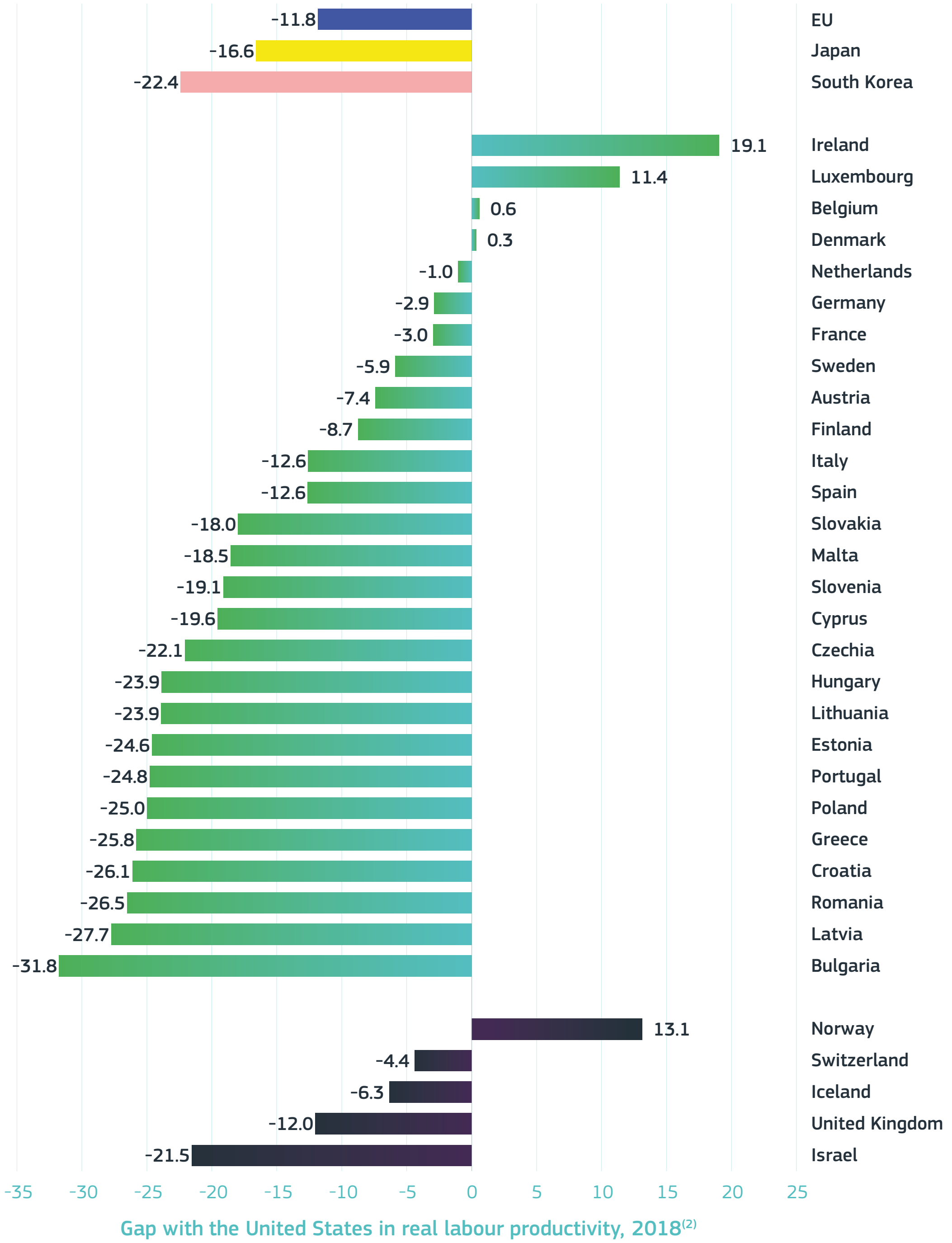
Figure 3.1-12 The gap in real labour productivity (GDP per hour worked[1]) between each country and the United States, 2018



Science, research and innovation performance of the EU 2020

Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on European Commission - DG Economic and Financial Affairs, OECD

Notes: [1]GDP per hour worked in PPS€ at 2010 prices and exchange rates. [2]IS, NO, CH, IL, JP, KR: 2017.

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BOX 3.1-4 TFP trends at the sectoral level

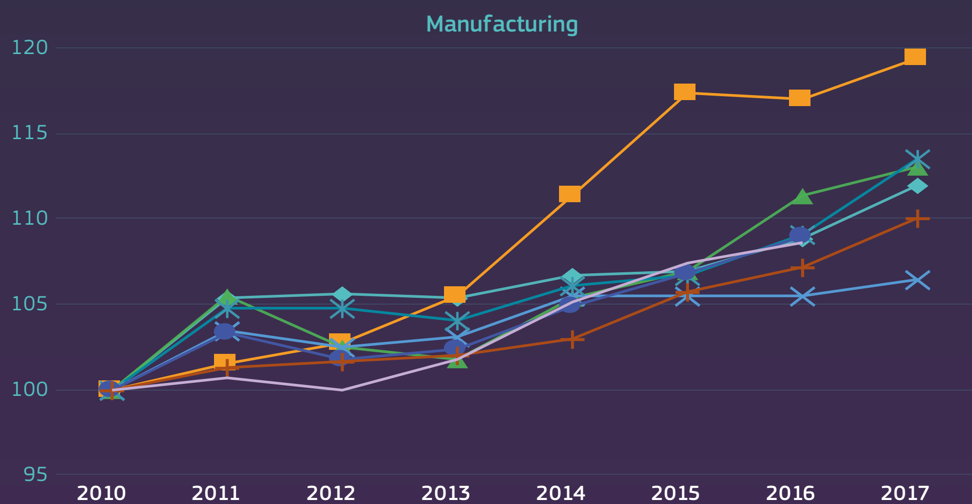
Jeoffrey Malek Mansour - Belgian Science Policy Office (Belspo)

Higher labour productivity can be achieved if more or better capital is used (capital deepening), or if the combined efficiency with which labour and capital are used (i.e. TFP) is improved. As such, TFP is thus a fundamental driver of global productivity and is linked to technological progress in an economy. Figure 3.1-13 shows the evolution of TFP over the post-crisis period (2010-2017) for the EU19[6] and a number of reference countries and across three aggregate sectors: manufacturing, market services[7] and non-market services[8].

It appears that, on average for EU19 countries, TFP has known divergent evolutions across these 3 macro-sectors: while it increased steadily in the manufacturing industries (+9 %), its progression was more moderate in market services (+4 %) and even declined slightly in non-market services (-1 %).

With respect to these averages, individual countries have evolved differently and a variety of trends can be observed. In the manufacturing sector, TFP growth has proved particularly vigorous in Belgium but rather sluggish in France and Italy. Germany, the Netherlands and Austria have remained close to the EU19 average. On the contrary, Germany and the Netherlands have performed particularly well in the market-services sector while France, Belgium and Italy have stagnated and have proved to be the worst-performing economies in our sample. Concerning the non-market-services sector, countries' performance is even more adverse, in particular for Italy and Austria (-2 %), Belgium (-3 %) and more spectacularly Spain (-7 %). Conversely, TFP in Germany, France and the Netherlands has increased by 1 to 1.5 % over the same period in non-market services.

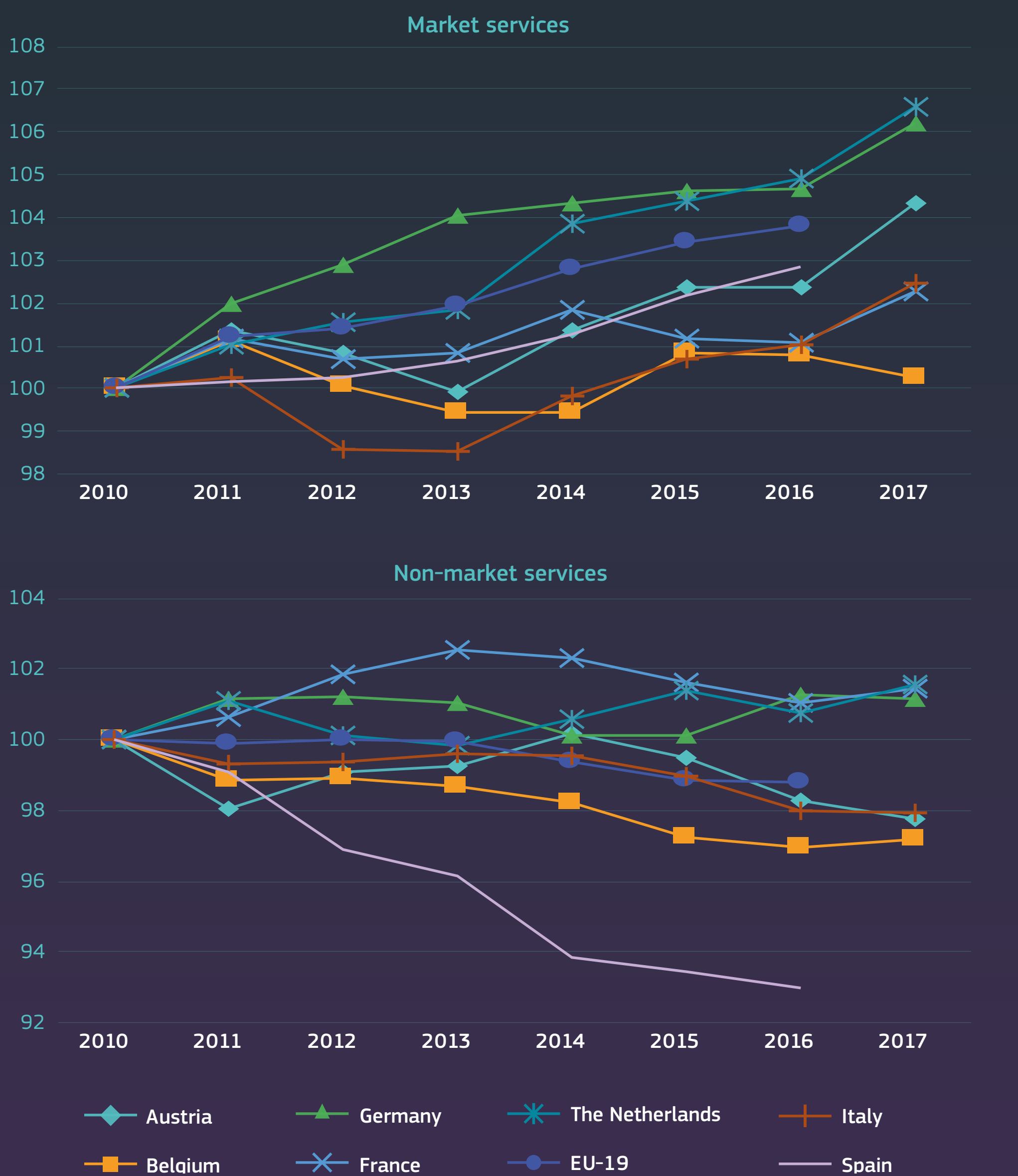
Figure 3.1-13 Total factor productivity by sector and selected EU countries, 2010-2017



6 AT, BE, CZ, DE, DK, EE, ES, FI, FR, HU, IT, LT, LU, LV, NL, RO, SE, SI, SK.

7 Market services are proxied by NACE sectors (sections) G to N: wholesale and retail trade; Transportation and storage; Accommodation and food service activities; Information and communication; Financial and insurance activities; Real estate activities; and Professional, scientific, technical, administrative and support service activities.

8 Non-market services are proxied by NACE sections (sections) O to Q, i.e. public administration, defence, education, human health and social work activities.



Science, research and innovation performance of the EU 2020

Source: Authors' own computations based on EUKLEMS, 2019 release

Note: TFP is set at 100 in 2010.

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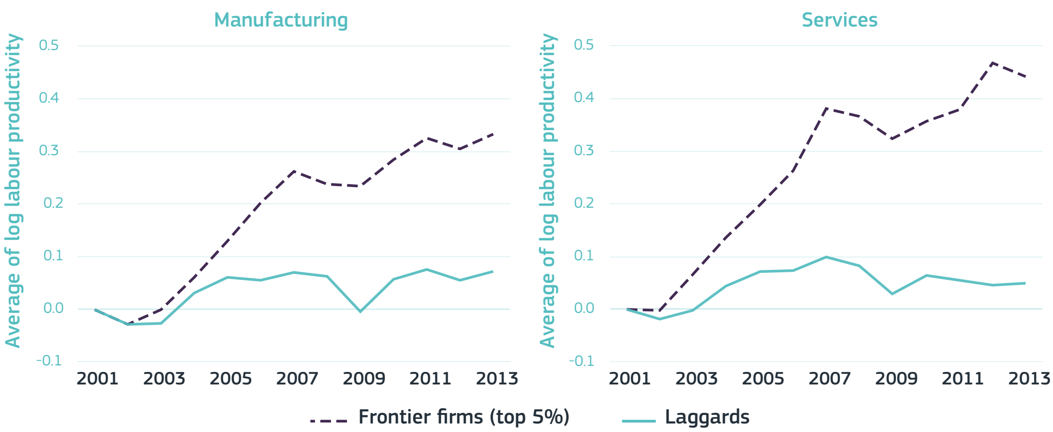
3. A growing productivity gap and a lack innovation diffusion

The productivity paradox points to deep changes in innovation dynamics. These changes relate to the rise of several breakthrough innovations led by **new global technological champions that are creating and shaping entirely new markets**. However, they are also linked to the **slowdown in innovation diffusion**, which is holding back a stronger uptake of innovations across companies, sectors and regions. The convergence of digital technologies with the physical world has enabled the rise of many important breakthrough innovations. At the same time, it has rendered the innovation process more complex as companies need to master different technologies and new business models. This, coupled with the rise in network effects, has led to a slowdown in innovation diffusion across firms, regions and sectors, preventing the benefits of innovation from being disseminated fully across the economy.

This slowdown in innovation diffusion has been observed since the beginning of the 2000s. A small number of leading firms (in particular, platform-economy companies, see Box 3.1-5) have championed strong productivity growth rates, while a 'fat tail' of laggard firms have depicted disappointing productivity growth rates that translate into low aggregate productivity growth. These differences are found across sectors, although there are some intra-sectoral differences, notably with lower overall growth rates in the business service sector. This widening of the productivity gap may explain why a rapid technological change and productivity slowdown can be observed at the same time. This has strong implications not only for productivity growth but also for rising inequality patterns. Wage inequality has increased both within and between firms, suggesting that increasing between-firm inequality does not simply reflect the flow of similar workers into similar firms but that the ones at the top of the wage distribution are seeing even higher rewards (OECD, 2019).

Figure 3.1-14 Labour productivity gap between global frontier firms and other firms, 2001-2013



Science, research and innovation performance of the EU 2020

Source: Andrews et al. (2016)

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter31/figure-31-14.xlsx

BOX 3.1-5 The rise of platform-economy companies

In the past two decades or so, digital technologies have enabled some of the most impressive breakthrough innovations in our economy, which have revolutionised entire industries and markets. The rise of the so-called platform-economy companies, such as Alphabet, Facebook, Amazon, Alibaba, Uber or Netflix, has deeply transformed how we search for things, communicate with each other, buy products, move within cities or consume entertainment. Many of these firms have been able to grow at an unprecedented pace to become global economic behemoths by market capitalisation, transforming entire industries and markets. At the same time, these companies do not seem to improve the quality of employment as they tend to offer less-stable contracts and fewer prospectives for career development (EPSC, 2019).

One sign of this lack of innovation diffusion is the increasing industry concentration (see also Chapter 2 - Changing innovation dynamics in the age of digital transformation). This is one development that indicates that technological change or globalisation is enabling the most productive firms to expand (Autor et al., 2017), although it has recently also raised questions about the lack of competition and the formation of quasi monopolies. Evidence shows that, between 2000 and 2014, three quarters of European industries saw a **concentration increase in market performance** in the order of 4 percentage points for the average European industry (Bajgar et al., 2019).

In parallel, as a result of persisting rigidities that affect the well-functioning of the markets, 'zombie' firms[9] continue to 'capture' capital and labour resources that could otherwise be redirected towards innovative, more productive activities, thereby hindering Europe's innovation performance (see also Chapter 3.3 - Business Dynamics and its contribution to structural change and productivity growth). The misallocation of resources, including credit, barriers to entry and inefficient product and labour markets ease the survival of less-productive firms which would otherwise have exited the market. Consequently, the economy is characterised by a wider distribution of productivity among firms, with a larger gap between the laggards and the most-productive companies. This also means that a more efficient allocation of resources across companies, allowing less productive firms to exit and productive firms to grow, would enable significant growth.

Inequalities between firms are also driven by sectoral dynamics, with the uptake of digital technologies over the past two decades varying significantly across different sectors of the economy. Some sectors have benefited more from the uptake of advanced digital technologies and have adapted their products, services and business models accordingly. On the other hand, other sectors seem to have lagged behind. These disparities could be broadened with the rising applications of artificial intelligence. Promising developments in artificial intelligence can go far beyond labour

9 Zombie firms are defined as those companies with a low ratio of operating income to interest expenses (less than one third for three consecutive years in McGowan et al., 2017), suggesting that they do not make enough profit to pay debt obligations on bank loans.

BOX 3.1-6 Chapter 10 – The bottom also matters: policies for productivity catch-up in the digital economy

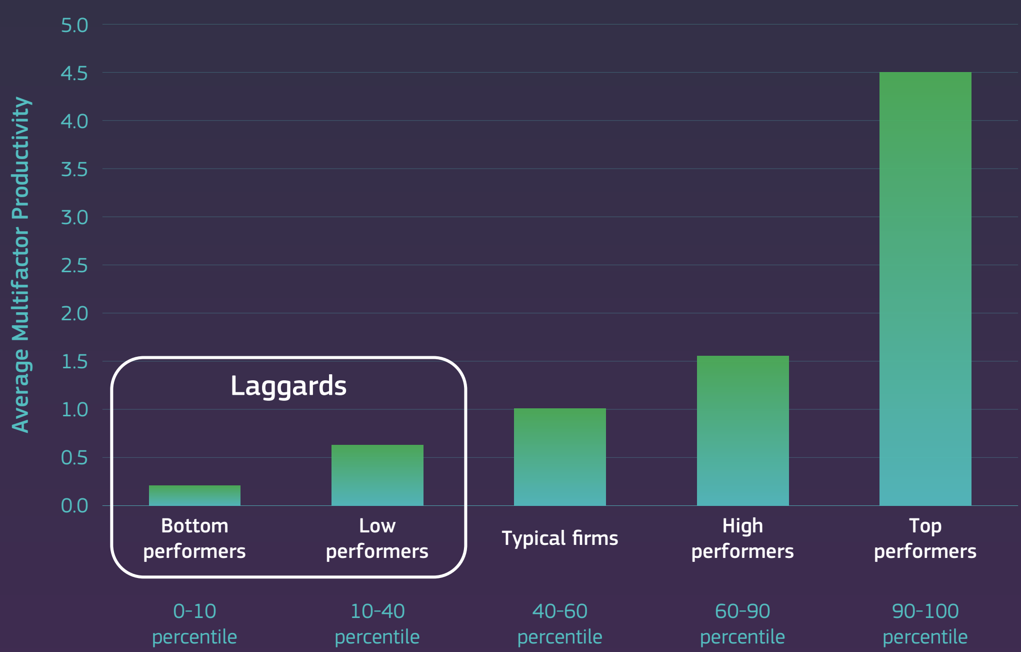
This chapter provides an overview of recent and ongoing analysis of these issues and discusses **policies that affect the catch-up of laggards in the context of digital transformation**.

First, the chapter introduces **productivity divergence** in the context of the global phenomenon linked to digital transformation and the knowledge economy. Then, it examines **trends in productivity divergence and business dynamism**, respectively, with a **focus on the bottom of the productivity distribution**. Beyond common trends, a few examples highlight **cross-country and cross-sector heterogeneity**. The descriptive sections conclude with company and sector characteristics and discussions about the possible explanations behind the documented trends at the bottom, including the role of openness.

The final analytical section provides a framework and summarises the main results of the analysis on the **role of policies on the speed of laggards catching up**.

Read more in Chapter 10.

Figure 3.1-15 Average productivity by performance group relative to the 'typical firms' group multifactor productivity



Source: Authors' own computations based on the EIB Investment Survey (EIBIS waves 2016 to 2018)
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter31/figure-31-15.xlsx

automation with impacts on business models and innovation activity. The differences observed between firms with strong digital capability and a well-designed AI adoption strategy could reinforce the differences in uptake, enabling these companies to raise profit margins or increase the efficiency of their R&D operations. Overcoming that gap requires, among others, policies to improve the conditions to speed up knowledge creation and diffusion via more investments in intangible assets and skills, and innovation-friendly regulation that supports transformative technological change across sectors.

Ensuring the EU's competitiveness and prosperity will require a boost in productivity. The gap in productivity performance between highly productive firms at the frontier and the rest points to a clear lack of innovation diffusion in Europe. As Member States approach higher levels of prosperity, the adoption of an innovation-based model is crucial to avoid the middle-income trap that this lack of diffusion can exacerbate, especially for Member States in the CESEE. Overcoming that gap requires policies to improve the conditions to speed up knowledge creation and diffusion via increased investments in intangible assets and skills, innovation-friendly regulation that supports transformative technological change across sectors, stronger science-business links, adequate conditions for the creation, scaleup and orderly exit of firms, access to risk capital, and efforts to raise the capacity and quality of national research and innovation systems.

4. Conclusions

R&I are key engines for Europe's productivity growth, driving long-term competitiveness and economic performance. Innovative investments make the production process more efficient and improve produced goods and services. Provided supportive framework conditions are in place, innovative companies can flourish and the process of creative destruction will make room for new entrants with better products, displacing existing inefficient and less-innovative companies.

After the last economic crisis, from 2010 to 2016, nearly two thirds of labour productivity growth in Europe derived from R&I, broadly defined. The contribution of different intangible investments has changed over time, reflecting the evolving innovation dynamics, including the increasing role of digitisation and AI and the rise of global technological champions creating and shaping entire markets. In particular, economic competences and intellectual property products have emerged as key intangible assets, together with R&D, software and databases.

In this context, the increasing concentration of R&I activities highlights the need to foster the diffusion of innovation creation and its uptake in order to spread the benefits across countries, regions and companies. This is particularly important for economies in the southern periphery of the EU, which have been unable to keep pace with the innovation leaders, and for the CESEE countries in order to ensure a continued (and sustainable) growth model in the long term. Innovation diffusion and knowledge absorption are also crucial to close the gap between a few leading top companies and the rest.

Productivity growth can and needs to drive the sustainability transition. As productivity growth entails more (equal) output with the same (fewer) resources, such an improvement in the efficiency of production systems is necessary to reduce the impact of production on the planetary boundaries. Similarly, innovation diffusion and its uptake can ensure that the benefits of productivity growth are widespread across companies, sectors and places, contributing to meeting the social dimension of the sustainability transition.

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CHAPTER 3.2

STRUCTURAL CHANGE

KEY FIGURES

50 %
share of knowledge-intensive sectors in EU employment

16 %
increase in the shares of knowledge-intensive services in the EU in the period 2000-2016

17 %
labour productivity growth driven by productivity gains within sectors in the EU in the period 2000-2016

What can we learn?

- A higher weight of knowledge-intensive sectors **correlates with higher R&I investments and productivity performance**.

- **Knowledge-intensive services have a weight of more than 40%** and constitute the main bulk of employment shares in the EU.

- **Structural change is not favouring enough knowledge-intensive sectors in the EU**, reducing productivity growth patterns. This trend is particularly relevant in some Member States.

- **While a generalised transformation towards knowledge-intensive services has been observed, intra-EU differences persist**. In particular, some countries have been moving away from medium-high-tech and high-tech manufacturing while the catching up by others (most notably the central, eastern and south-eastern Europe - CESEE economies) is driven by greater specialisation in medium-high-tech manufacturing.

- **Differences in productivity performance also exist within sectors** and contribute to explain the productivity gap between the EU and the United States.

What does it mean for policy?

- **Mobilise national and European resources towards knowledge-intensive activities** as a lever to increase Europe's ability to invest in R&I and its productivity prospects.

- An **EU industrial strategy** is key to counter the deindustrialisation trends in the EU and to **increase long-term EU competitiveness while meeting the need for a transition towards a climate-neutral and sustainable economy**.

While R&D is the engine of long-term productivity growth, the capacity of an economy to invest in R&D is shaped by its economic structure. Europe is slowly emerging from a period of sluggish economic growth since the aftermath of the last economic crisis. While high heterogeneity can be observed across Member States and their regions, low or null productivity growth has been identified as one of the key causes behind the weak economic performance, which is a challenge Europe must face in order to achieve greater and widespread prosperity. As acknowledged in the economic literature and described previously (see Chapter 3.1 - Productivity puzzle and innovation diffusion), investments in knowledge and innovation, measured most notably by R&D expenditure, are a fundamental lever to improve the competitiveness of an economy and its capacity to create value. However, while in general terms higher investments in R&D increase the innovation potential of economies and their productivity, several factors affect the production of knowledge and its diffusion. This chapter and Chapter 3.3 explore two of them, defined as structural as they determine – *ceteris paribus* – the overall capacity of an economic system to innovate and invest in R&D. These two elements are: i) the structural composition of an economy and its change; and ii) the dynamism of the business sector. As will be shown below, knowledge-intensive sectors are 'naturally' characterised by higher R&D intensity and they tend to innovate more. Therefore, economies specialising in knowledge-intensive activities experience the highest levels of productivity and the largest productivity growth. This will be the subject of this chapter. Furthermore, innovative companies are more likely to emerge in countries where the business environment is more dynamic, i.e. where there is a larger share of new companies entering the markets, as they contribute to boosting competition, introducing new business models and upgrading the economic structure. This topic will be analysed in Chapter 3.3.

1. Economic structure shapes economies' R&D intensity and labour productivity

Countries that have been able to change the structure of their economy by increasing their specialisation in knowledge-intensive sectors will become more productive, leading to greater prosperity in the long term. This section analyses the economic structure of the EU and its Member States and investigates its dynamics in recent years. The focus is on those sectors characterised by a higher intensity of research and innovation activities as they are the main drivers of productivity gains and are of fundamental importance for innovation and greater levels of prosperity.

To measure the degree of knowledge across different sectors, the analysis makes use of R&D intensity, i.e. the share of R&D investment in a sector's total value added. Being the most-used indicator, it is easily comparable across different countries and is a reasonable proxy for knowledge and innovation creation. Hence, the analysis below will use and compare four main knowledge-intensive macro-sectors: high-tech manufacturing, medium-high-tech manufacturing, high-tech knowledge-intensive services and (non-high-tech) knowledge-intensive services. Here, these four macro-sectors are referred to as knowledge-intensive activities or sectors.

BOX 3.2-1 Classification of manufacturing industries and knowledge-intensive services

The definition of manufacturing industries and knowledge-intensive services follows the aggregation by Eurostat according to technological intensity and based on NACE Rev.2[1]. Beyond the four knowledge-intensive macro-sectors, the remaining activities are used for the analysis later in this chapter and the corresponding classification is presented below.

High-tech manufacturing includes the manufacture of: basic pharmaceutical products and pharmaceutical preparations (C21) and of computer, electronic and optical products (C26).

Medium-high-tech manufacturing includes the manufacture of: chemicals and chemical products (C20), electrical equipment (C27), machinery and equipment (C28), motor vehicles, trailers and semi-trailers (C29), and the manufacture of other transport equipment (C30).

Medium-low-tech manufacturing includes both the medium-low and the low-technology manufacturing industries. These include the manufacture of: coke and refined petroleum products (C19), rubber and plastic products (C22), other non-metallic mineral products (C23), basic metals (C24), fabricated metal products, except machinery and equipment (C25), the repair and installation of machinery and equipment (C33), the manufacture of food products (C20, beverages (C11), tobacco products (C12), textiles (C13), wearing apparel (C14), leather and related products (C15), wood and wood and cork products except furniture, articles of straw and plaiting materials (C16), paper and paper products (C17), the printing and reproduction of recorder media (C18), the manufacture of furniture (C31) and other manufacturing (C32).

Knowledge-intensive services include water transport (H50), air transport (H51), information and communication (J), financial and insurance activities (K), professional, scientific and technical activities (M), employment activities (N78), public administration and defence, compulsory social security (O), education (P), human health and social work activities (Q), and arts, entertainment and recreation (R). They do not include services with high technological content which are classified separately as high-tech knowledge-intensive services.

High-tech knowledge-intensive services include motion picture, video and television programme production, sound recording and music publishing activities (59), programming and broadcasting activities (60), telecommunications (61), computer programming, consultancy and related activities (62), information service activities (63), and scientific research and development (72).

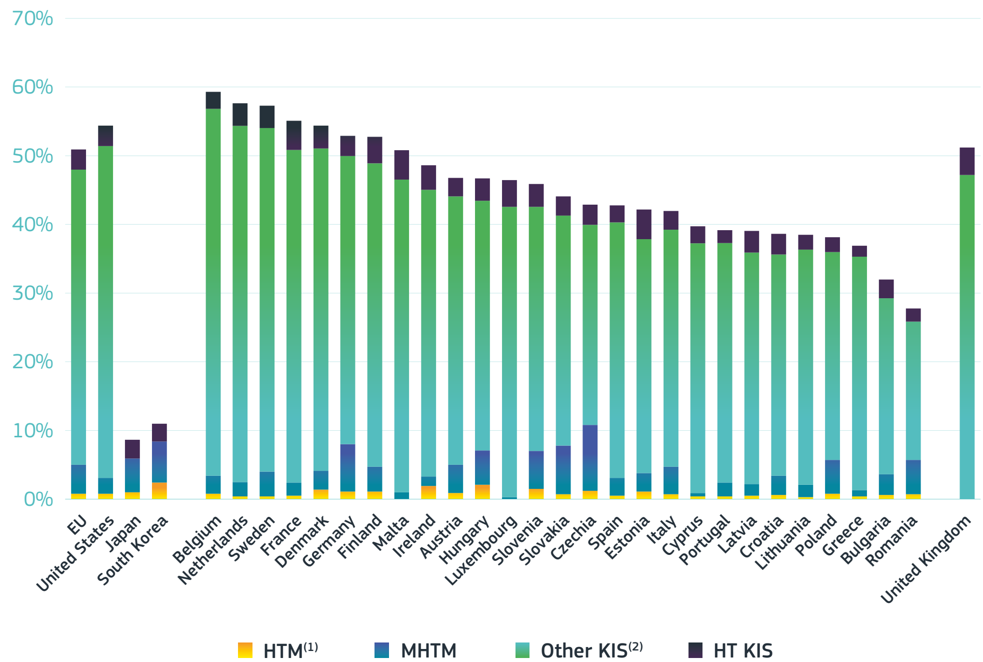
Other services include services not belonging to any of the above categories (including G, I, L, S, T and U).

Agriculture, hunting and forestry, mining and quarry (B) and construction (F) are classified as *Rest of the economy*.

1 See https://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.PDF

The structural composition of the EU's economies is a key factor in explaining why most Member States fall short in reaching high R&D intensity, with most of them remaining below 3%. The Lisbon Agenda sets the R&D intensity target for the EU at 3%. However, only a few Member States have met this target, while the EU as a whole is a long way off and will not be able to meet it by 2020 (see Chapter 5.1 - Investment in R&D). Countries more specialised in knowledge-intensive sectors tend to be characterised by higher R&D intensity, driven by larger shares of R&D over value added in the business sector (BERD). Indeed, activities belonging to high-tech and medium-high-tech manufacturing and high-tech and the other knowledge-intensive services are intrinsically more innovative and require more resources to be invested in intangible assets. Figure 3.2-1 presents the structural composition of European economies, measured by the share of employment per sector[2].

Figure 3.2-1 Employment shares in high tech manufacturing, medium-high tech manufacturing and knowledge intensive services, 2016[(3)]



Science, research and innovation performance of the EU 2020

Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on Eurostat (online data code: nama_10_a64_e) and OECD

Notes: (1)Data missing for MT and LU. (2)Data incomplete for JP and KR. (3)EU, KR: 2015.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter32/figure-32-1.xlsx

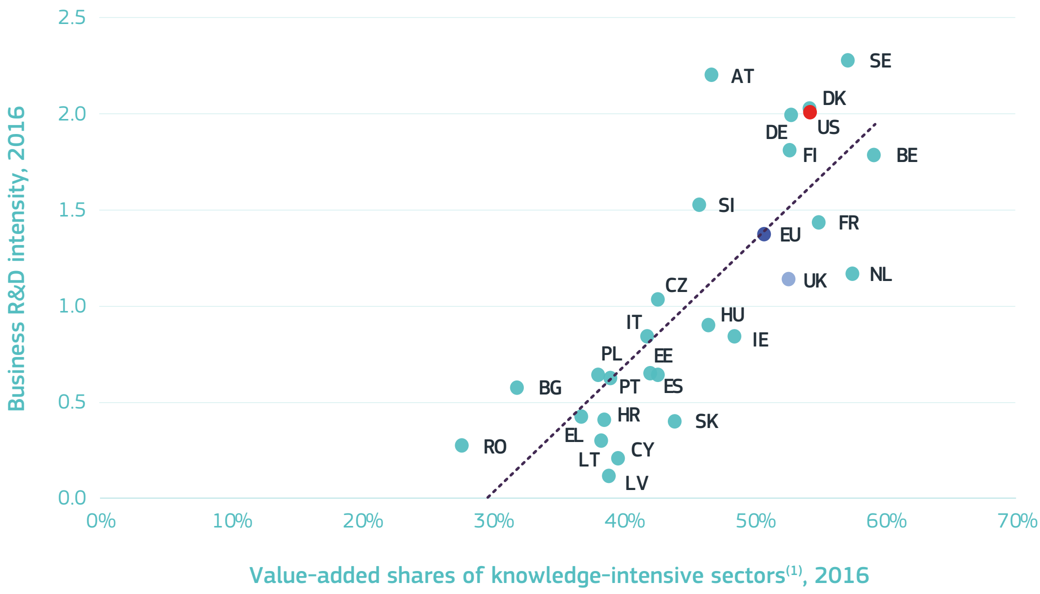
2 A similar graph can be produced using value-added shares. Employment shares are used to be consistent with the analysis in the rest of this chapter.

The European economic structure is similar to that observed in peer countries, adding up to more than half the total employment in knowledge-intensive sectors. Figure 3.2-1 shows that the EU, like any modern economy, is characterised by the predominance of services, representing more than 70% of total activities. In particular, knowledge-intensive services have a weight of more than 40% and constitute the main bulk of employment shares in the EU. When considering high-tech knowledge-intensive services only, their share is around 3% of total employment, even though, as for high-tech manufacturing, they are characterised by the highest productivity levels, as shown below. The economic structure of the EU is similar to that of the United States, which have a smaller share of medium-high-tech manufacturing and a higher specialisation in knowledge-intensive services. It is worth noting that South Korea stands out among the peer countries for high-tech and medium-high-tech manufacturing, with a significantly higher weight at 8.4%.

Within Europe, significant heterogeneity can be observed across the Member States. First, there are economies with a fairly high share of knowledge-intensive sectors, above 50%, and with the highest value (Belgium) falling slightly below 60%. On the other end of the distribution, there is a group of countries recording a total below 40%, mainly due to significantly lower shares of knowledge-intensive services. This group mainly includes eastern European economies and countries from southern Europe, following different paths over time. Indeed, the former are economies that are building their knowledge-based sectors, while the latter are countries facing difficulties to upgrade their economic structure, such as, for instance Italy, Greece and Portugal. Second, while Europe tends historically to be specialised in medium-high-tech manufacturing, there are a few countries with relatively higher shares. These are mainly central, eastern and south-eastern economies that have developed a large base in these sectors in recent decades, most notably in the automobile sector, driven by the location of production from other countries, such as, for example, from Germany. As will be shown below, this process has mainly involved production, while R&D intensity has not increased that much. It should be noted that Germany, Austria and Italy are three countries with a significant and long-standing specialisation in medium-high-tech manufacturing.

The larger the weight of knowledge-intensive sectors, the higher the capacity to invest in R&D and innovate. Given the above scenario, it is possible to investigate the relationship between R&D intensity and the weight of knowledge-intensive sectors which eventually determines how much an economy can invest in R&I. Figure 3.2-2 plots business R&D intensity and the sum of the employment shares of medium-high-tech and high-tech manufacturing and knowledge-intensive services. The private sector is the main performer in R&D investment, accounting for around 65% of total R&D investment in the EU and 72% in the United States. The figure reveals a clear positive relationship: countries with a larger total share of knowledge-intensive sectors are also those with larger R&D intensities. Empirical evidence suggests that differences in structural composition do explain most of the EU-United States business R&D gap, and that this is true even when accounting for the role of company size and the share of young innovative firms in the two economies (Cincera and Veugelers, 2013). Among knowledge-intensive activities, high-tech and medium-high-tech manufacturing are key engines for R&D investments in the business sector, as a relevant share occurs in industry (European Commission, 2018; Coad and Vezzani, 2017). It is interesting to observe that, while there is a positive correlation between the share of knowledge-intensive manufacturing activities and business R&D intensity, there are a few exceptions (Figure 3.2-3). This is notably the case in some CESEE economies, which have the highest specialisation in knowledge-intensive manufacturing – especially in the medium-high-tech sectors – but relatively lower R&D intensity. As mentioned above, this is due to the delocalisation of production from abroad which does not come with the relocation of R&D activities (Correia et al., 2018).

Figure 3.2-2 Business R&D intensity and sum of employment shares in knowledge intensive sectors, 2016(2)(3)



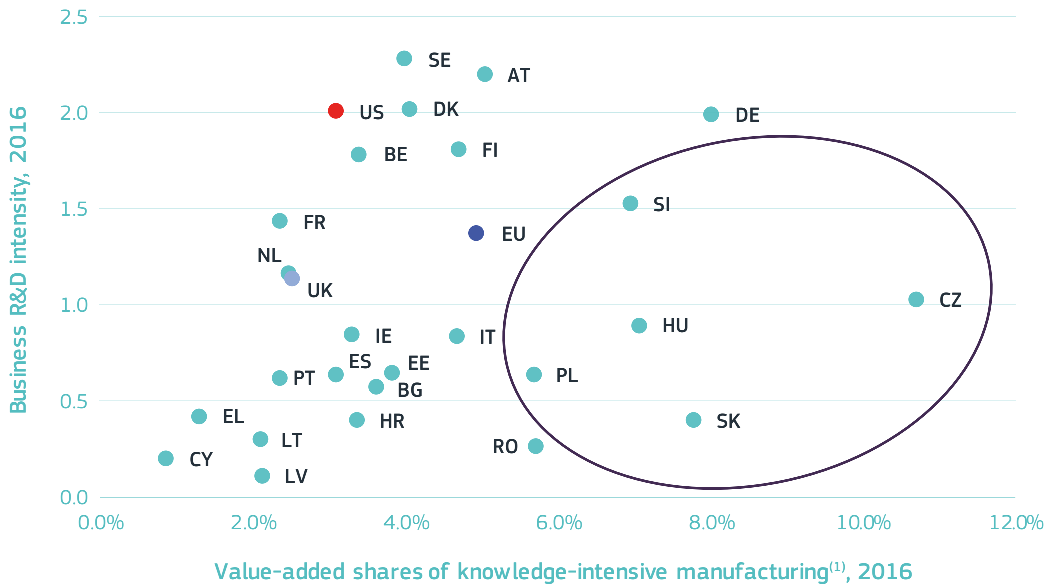
Science, research and innovation performance of the EU 2020

Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on Eurostat (online data code: nama_10_a64_e) and OECD

Notes: (1)Knowledge-intensive sectors include high-tech manufacturing, medium-high-tech manufacturing and knowledge-intensive services. (2)Data missing for MT and LU. (3)EU: 2015.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter32/figure-32-2.xlsx

Figure 3.2-3 Business R&D intensity and employment shares in high-tech and medium-high-tech manufacturing, 2016[2][3]



Science, research and innovation performance of the EU 2020

Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on Eurostat (online data code: nama_10_a64_e and rd_e_gerdtot), OECD

Notes: [1]Knowledge-intensive manufacturing includes high-tech manufacturing and medium-high-tech manufacturing. [2]Data missing for MT and LU. [3]EU: 2015.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter32/figure-32-3.xlsx

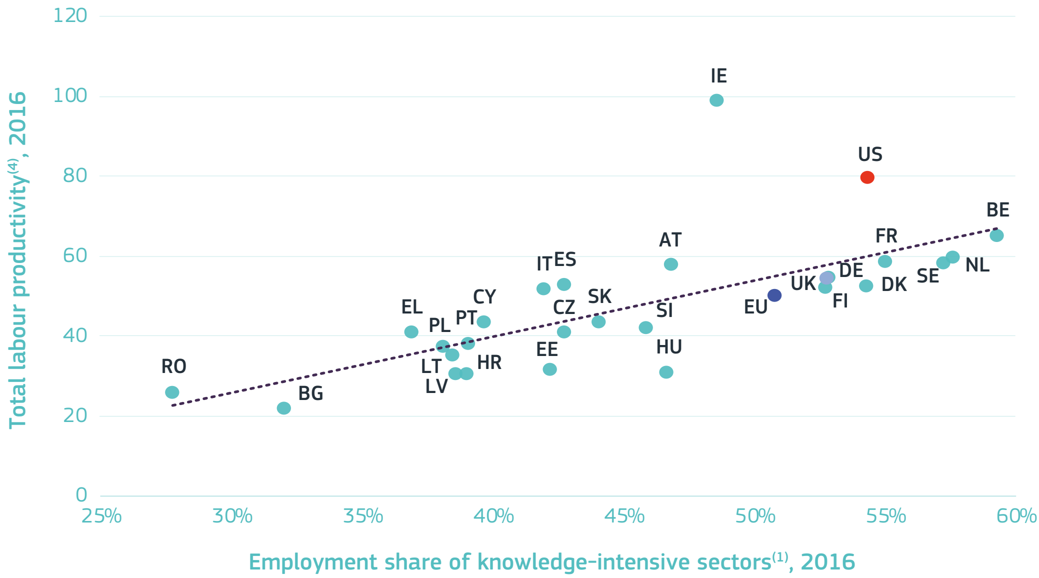
Higher shares of knowledge-intensive sectors are correlated with better economic performance, as investments in R&D and innovative activities are larger in those sectors. The high level of R&D intensity and the larger innovation propensity in knowledge-intensive sectors are fundamental drivers of labour productivity. New firms with innovative and more efficient business models or introducing breakthrough innovations to the market tend to develop more easily in these sectors. Similarly, they are more likely to adopt innovative products or processes due, for instance, to network effects and the technological proximity to those sectors where the original innovation was developed[3].

Therefore, it follows that there is significant correlation between economic performance and an economy's economic structure: higher shares of knowledge-intensive sectors in the economy bring higher productivity which, among others, is a driver of prosperity in the medium-long term.

The most productive EU economies tend to have a higher specialisation in knowledge-intensive sectors, while a significant gap between the EU and the United States persists, revealing an overall better performance. In Figure 3.2-4, total labour productivity[4] is used to measure countries' economic performance and is plotted against

3 See, for instance, Xiao et al. (2018) on the concept of related variety for industrial diversification in Europe.
4 In what follows, labour productivity is given by value added at constant prices (2010) over the number of workers.

Figure 3.2-4 Total labour productivity and the employment share of knowledge-intensive sectors, 2016[(2)(3)]



Science, research and innovation performance of the EU 2020

Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on Eurostat and OECD data

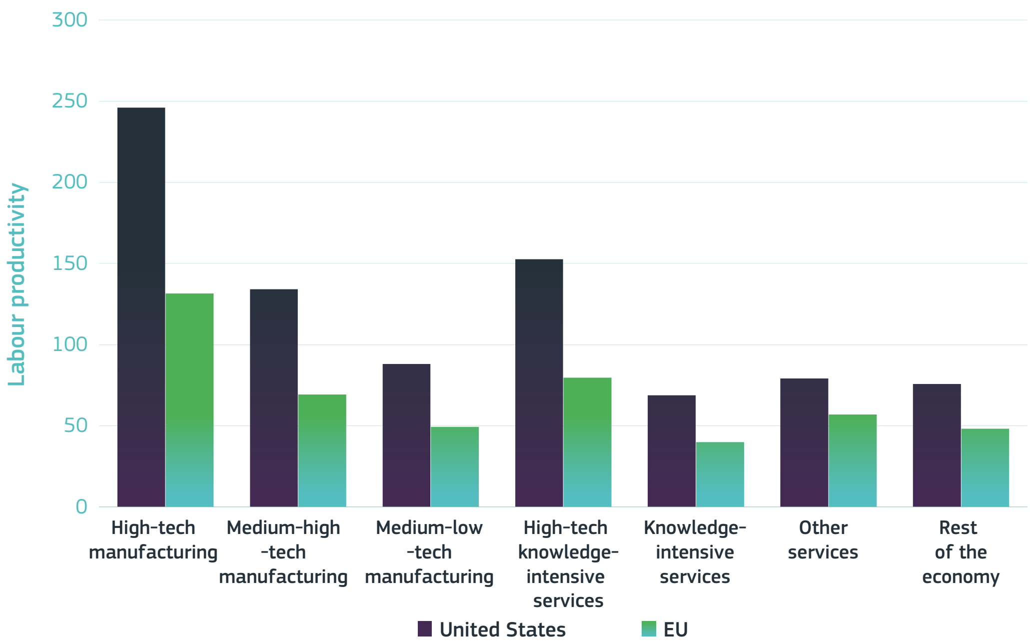
Notes: [(1)]Knowledge-intensive sectors include high-tech manufacturing, medium-high-tech manufacturing and knowledge-intensive services. [(2)]Data missing for MT and LU. [(3)]EU: 2015. [(4)]In thousand PPS€ at constant 2005 prices and exchange rates per worker.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter32/figure-32-4.xlsx

the sum of the shares of knowledge-intensive services, high-tech and medium-high-tech manufacturing in total employment. The graph reveals a positive relationship: labour productivity increases with the weight of knowledge-intensive sectors in the economy. A group of leading EU economies with productivity and specialisation in knowledge-intensive activities higher than the EU average can be observed on the right of the graph. A large group of countries follow, with employment shares and productivity levels (with the exception of Italy, Austria and Spain) below the EU average. Most countries lie around the dashed line representing the average trend, while a few exceptions can be identified. First, Ireland, with the highest labour productivity across countries, is also significantly higher than might be expected, given the share of knowledge-intensive sectors. While the data used in this chapter do not allow any conclusions to be drawn, this could be because Ireland is the European hub of international companies with strong innovation performance and generating high value added. Second, the United States is the second most productive economy, having higher labour productivity than countries with a similar economic structure. The relevance of high-tech knowledge-intensive services and the large numbers of unicorns, startups and multinational giants at the innovation frontier – e.g. in the Internet of Things and the digital economy – contribute to explain the United States' good performance. It is also worth noting that the United States experiences higher labour productivity across all sectors in the economy (see Figure 3.2-5). Finally, mention should be made of the group of CESEE economies previously highlighted. While their R&D intensity is relatively low compared to their economic structure, their labour productivity seems consistent with the observed trend, as suggested by the dashed line. While this corroborates that their growth model has paid off to date, previous analyses have suggested a shift towards more R&D and that intangible investment could be beneficial to sustain productivity growth and prosperity in the future (Correia et al., 2018).

Knowledge-intensive activities are the most productive sectors, although differences exist across countries. Knowledge-intensive sectors have the highest productivity levels in the economy. However, differences in performance do exist, with some sectors being more productive in some countries compared to others. These within sector differentials depend on countries' characteristics, specific activities within sectors and other factors, including policy, and contribute to shaping overall total productivity and the distribution of countries observed in Figure 3.2-4. Figure 3.2-5 compares labour productivity across sectors in the EU and the United States. High-tech manufacturing is the most productive sector, significantly ahead of the others. High-tech knowledge-intensive services and medium-high-tech manufacturing come next, the former showing productivity levels significantly higher than the other services, including knowledge-intensive ones. Most importantly, the figure highlights the productivity gap between the EU and the United States. Sectoral productivities

Figure 3.2-5 Labour productivity[(1)] by sector, EU (2015) vs. United States (2016)



Science, research and innovation performance of the EU 2020

Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on Eurostat and OECD data
Note: [(1)]Thousand PPS€ at constant 2005 prices and exchange rates per worker.
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter32/figure-32-5.xlsx

are higher in the latter in every sector, and the differential is particularly significant in high-tech, medium-high-tech manufacturing and high-tech knowledge-intensive services, where labour productivity is almost double the levels observed in the EU.

So far, this chapter has shown that European countries are heterogeneous in the composition of their economic structure and, as such, they do differ in their capability to invest in R&D and in their economic performance. Furthermore, differences in terms of labour productivity also exist within the same sectors, as shown by the comparison between the EU average and the United Sates.

Given the above scenario, it is interesting to see how countries evolve over time: first, how their sectoral specialisation has changed, i.e. whether they have been moving towards activities with higher knowledge intensity or the opposite trend has been taking place. This is usually defined as structural change. Second, it is interesting to note the impact of this transition on labour productivity dynamics. Has the change of economic structure had a positive impact on labour productivity growth, i.e. is the EU experiencing a growth-enhancing structural change? What has been the main driver of labour productivity growth in the EU since the 2000s? The analysis below focuses on these questions.

2. The contribution of structural change to productivity growth in the EU is limited

The economic structure of countries changes slowly over time. To observe the sectoral dynamics and their direction, this section takes a medium-term perspective by considering the period 2000-2016. Furthermore, a narrower time span is taken into account to identify the structural trend in the aftermath of the last economic crisis, focusing on the years after 2008. While movements are going to be smaller in such a shorter period, this allows for an analysis of how change has taken place in the post-crisis period, as well as seeing whether or not the trend has been affected by the recession. Figure 3.2-6 shows how structural change has affected knowledge-intensive sectors, reporting the cumulative growth rate in the period 2000-2016 for knowledge-intensive services (Panel A) and manufacturing (Panel B).

Overall, a clear trend towards knowledge-intensive services can be observed for all countries. The increase in their share averages 16 % for the EU, higher than in the United States (9 %) but around half the shift noted in the Japanese economy (32 %). The increase is higher for high-tech knowledge-intensive services, at 22 % for the EU and 23 % for Japan, while the growth rate is significantly lower (3.2 %) for the United States.

However, this process is accompanied by a transformation in the opposite direction in relation to manufacturing: employment shares declined for both high-tech and medium-high-tech manufacturing activities. While the weight of the former decreased at a faster pace than the latter, the lower initial values contribute to the larger variations, due to the potential impact of single shocks on the overall economy. Increased specialisation in services, including those intensive in knowledge, is a common feature of modern economies. However, excessive deindustrialisation may have negative consequences because of the relevance of industry for innovation and productivity prospects. This is particularly true for the deep transformation industry is currently undergoing, at the crossroads between the physical and digital world, which is radically changing the way production takes place and business models work and change. The need to boost the competitiveness of the EU and its industry, while meeting the requirements of social, environmental and economic sustainability, are among the key policy challenges facing Europe today[5].

Structural change is also heterogeneous across Member States. Whilst most countries have experienced a fall in their employment shares in high-tech manufacturing, a few have increased their specialisation. These include some CESEE countries (Poland, Romania, Czechia and Latvia), together with Cyprus, Greece and Denmark. A similar scenario holds for medium-high-tech manufacturing where a positive growth rate in employment shares can be observed mainly for the previously mentioned CESEE economies, including the high increase in specialisation in Estonia and Latvia. It is worth noting that the major EU economies have been shifting away from the sector, including those countries with an historical specialisation, such as Germany (-7.5 %), Belgium (-42 %), France (-36 %) and Italy (-12 %).

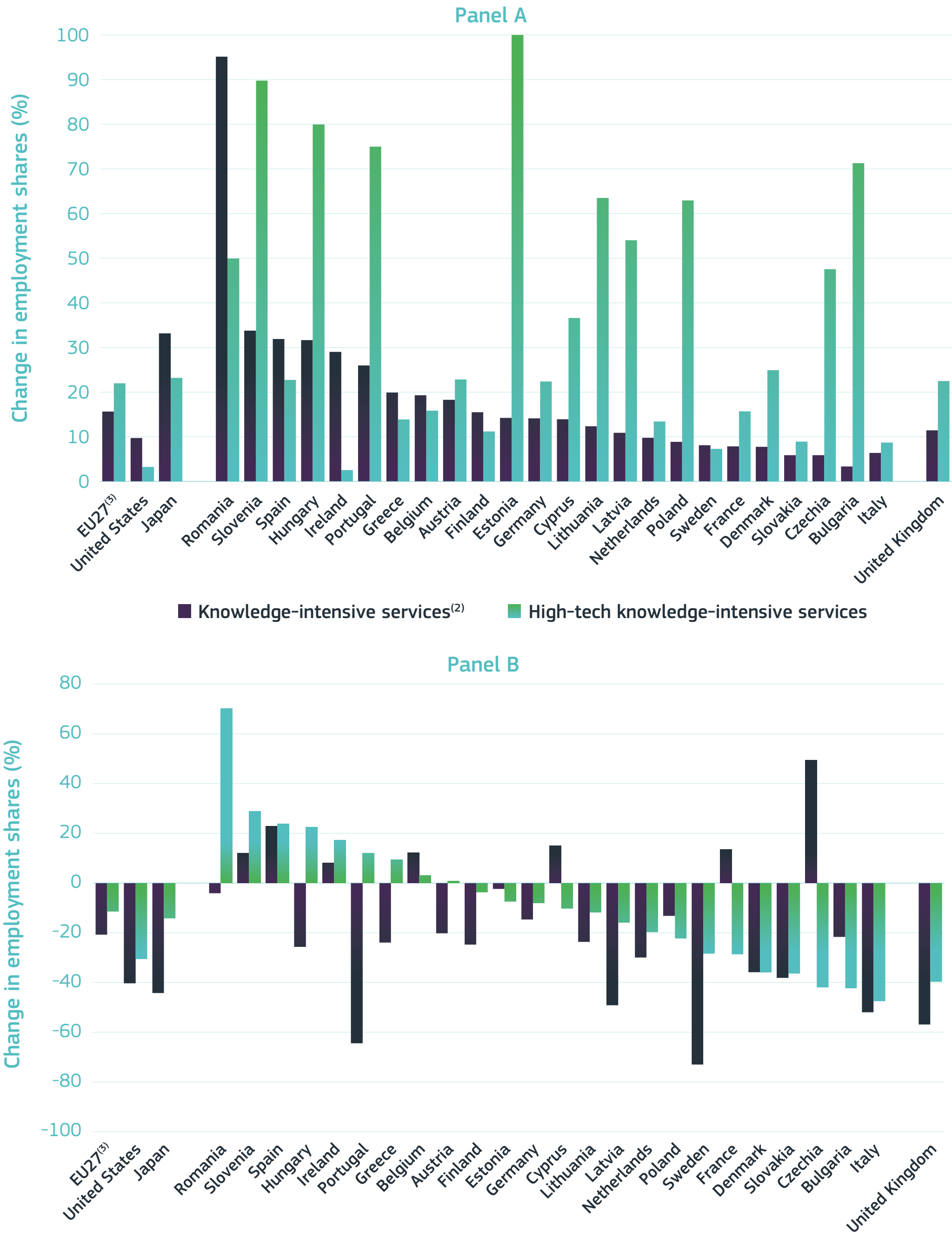
The main trends reported in Figure 3.2-6 are also confirmed for the period 2008-2016, although a few differences are worth mentioning. Romania experienced a negative shift away from high-tech manufacturing, which means that the positive shift towards the sector observed above took place in the period before the crisis. A similar trend occurred in Hungary in medium-high-tech manufacturing. Portugal has increased its specialisation in all knowledge-intensive activities, reversing the negative trends reported above. The positive shift in high-tech manufacturing (+7.1 %) is particularly noteworthy[6]. Similarly, Latvia has experienced increased specialisation in high-tech manufacturing (+29 %). Finally, the negative shift from knowledge-intensive manufacturing in Germany and Spain has been relatively contained compared to the overall trend observed since 2000, flagging an ongoing effort to reverse the deindustrialisation trend. This is particularly significant in the Spanish case, where the negative shift declined from -38.1 % to -0.6 % and from -36.5 % to -5 % in high-tech and medium-high-tech manufacturing, respectively. Finally, South Korea, unlike the EU, Japan and the United States, has been increasing its specialisation in medium-high-tech manufacturing since the crisis, which is the only such case among the major economies included in the analysis, highlighting the peculiarity of the South Korean economic process.

Countries that have increased their share in knowledge-intensive sectors have experienced better productivity performance. As shown in Figure 3.2-4, there is a positive correlation between knowledge-intensive sectors and economic performance. This is also true in dynamic terms: countries expanding the weight of knowledge activities tend to enjoy higher labour productivity growth. The relationship is shown in Figure 3.2-7. A process of structural change favouring knowledge-intensive sectors means that economic activity is displaced towards activities with higher productivity and innovation potential, consequently benefitting the total

5 See also https://ec.europa.eu/growth/industry/policy_en

6 It should be noted that some time may be needed for value-added shares to react to movements in employment from one sector to another. Therefore, considering value-added shares rather than employment shares may provide different figures as, for instance, in the case of Portugal and Italy whose changes in value-added shares have been negative and slightly positive, respectively. Since the scope of this section is to highlight structural trends, the focus is mainly on employment, while value added is used to build labour productivity figures

Figure 3.2-6 Percentage change in employment share in knowledge-intensive sectors(1), 2000-2016(3)



Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on Eurostat and OECD data

Notes: (1)Data missing for MT, LU and HR. (2)Data incomplete for JP. (3)EU: 2015.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter32/figure-32-6.xlsx

productivity of a country. Panel A shows the correlation between the cumulative increase in the employment share of knowledge-intensive sectors and productivity growth in the period 2000-2016. The figure reveals different groups of countries behaving differently, some where the positive relationship is steeper – i.e. Bulgaria, Slovakia, Poland, Ireland, Latvia and Lithuania together with Romania – and others where it is less straightforward, remaining rather flat. The positive correlation becomes clearer when using value-added shares rather than employment shares, as shown in Panel B, suggesting how the increase in production in those sectors plays a key role in driving productivity gains. The CESEE economies stand out as having the biggest shifts towards knowledge-intensive sectors and the largest increases in labour productivity, together with Ireland.

A key message to be drawn from the above figures is that structural change in the EU as a whole has not privileged knowledge-intensive activities, which have increased their share by just 5% since 2000. Furthermore, this average change has been driven mainly by a few countries, as shown in Figure 3.2-7.

The above analysis suggests that: 1) knowledge-intensive sectors tend to be more productive than traditional ones; therefore 2) knowledge-oriented economies have higher labour productivity levels; and 3) they enjoy higher growth rates if their economic structure changes to favour knowledge-intensive sectors.

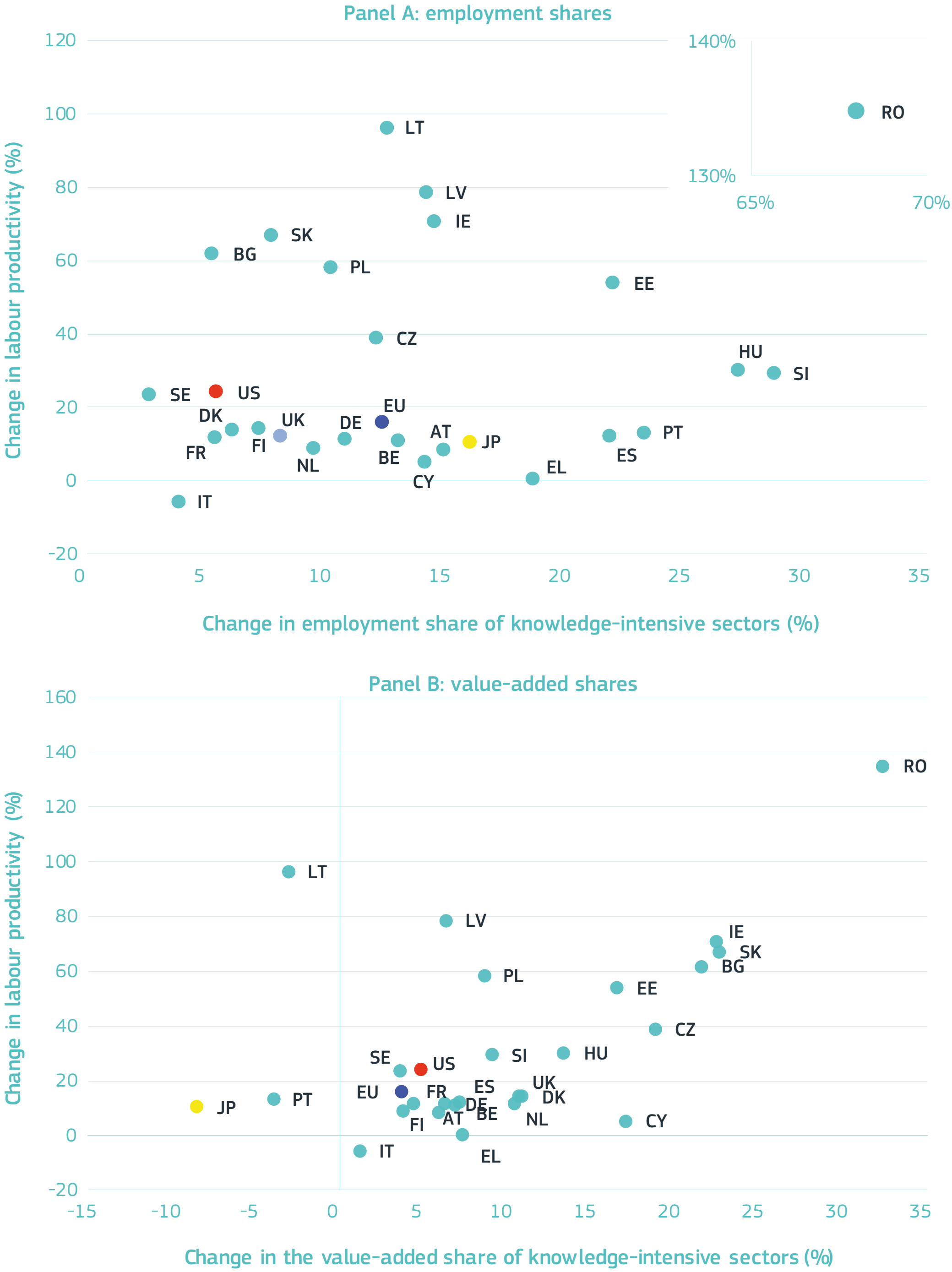
The rest of this chapter estimates the contribution of structural change to total labour productivity growth in the EU and peer economies, disentangling it from the role of productivity gains within sectors. In particular, labour productivity is broken down into:

- increases (decreases) due to the shift in employment shares from sectors where productivity growth is lower (higher) to sectors where it is higher (lower);
- increases (decreases) due to productivity gains (losses) within the same sector driven by efficiency gains, such as, for instance, following productivity-enhancing innovations.

The methodology is explained in more detail in Box 3.2-2[7].

7 There are different ways to break down labour productivity growth into its sources. This chapter follows the approach as in Cimoli et al. (2011) and Martino (2015), among others.

Figure 3.2-7 Change in the share of knowledge intensive sectors and labour productivity growth, 2000-2016[(1)(2)(3)(4)]



Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on Eurostat and OECD data

Notes: [(1)]Knowledge Intensive sectors includes High-Tech Manufacturing, Medium-High-Tech Manufacturing and Knowledge-Intensive Services. [(2)]Data missing for KR, MT and LU. [(3)]Data on knowledge-intensive services for JP are not complete for some subsectors, hence changes are reported for the available subsectors. [(4)]EU: 2015.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter32/figure-32-7.xlsx

BOX 3.2-2 Decomposition of labour productivity growth

In this chapter, the analysis of the sources of labour productivity growth follows a standard approach in the economic literature, based on the algebraic decomposition of the growth rate into three components. While different approaches do exist, the analysis is based on Equation (1):

Equation 1

$$\Delta y/y_0 = \sum_i [\underbrace{(\Delta y_i L_0)/y_0}_{PrG} + \underbrace{(\Delta L_i y_0)/y_0}_{ShEff} + \underbrace{(\Delta y_i \Delta L_i)/y_0}_{DynEff}]$$

where *L* and y are employment shares and labour productivity for each sector *i* respectively, the subscript $_0$ indicates the first year, while Δ measures the change in a variable from the first to the last year. Note that the computed labour productivity growth rates are cumulative for the period – they are not yearly growth figures.

Total labour productivity growth is the sum of the three components for every sector in the economy.

The first term of Equation (1) defines productivity gains (*PrG*) in each sector, given by increases (reductions) in productivity keeping employment constant, and are given by increased (reduced) efficiency, such as, for instance, due to technical progress within the sector in case of positive growth. The second and third terms make up the structural change component of labour productivity growth, being the sum of changes in employment shares – the pure share effect (*ShEff*) – and interaction between changes in both employment shares and labour productivity – the dynamic effect (*DynEff*). The *ShEff* term provides information on the direction of structural change, i.e. informs on which sectors employment has been flowing to. The *DynEff* term refers to the interaction between structural change and productivity dynamics. Indeed, this term is positive, i.e. structural change is positively contributing to total productivity growth, if employment shares are either shifting towards sectors with rising labour productivity or moving away from sectors where productivity is declining. The sum of the last two components indicates whether the structure of the economy is shifting towards activities with higher productivity growth. Note that, by construction, this term is also positive in cases where employment shares in a knowledge-intensive sector are declining if labour productivity growth in that sector is negative. Therefore, the *PrG* component provides fundamental information to complement the contribution of structural change. This is the case in Italy, for instance, where the contribution of structural change in medium-high-tech manufacturing is slightly positive, driven by negative productivity gains and the loss of employment shares. Of course, the key elements here are rather the declining productivity and reduced employment share in a knowledge-intensive sector, which are both detrimental to the competitiveness of the Italian economy.

For simplicity, the total economy is divided into seven macro-sectors, three of which are knowledge-intensive: i.e. 1) knowledge-intensive services; 2) high-tech knowledge-intensive services; 3) high-tech manufacturing; and 4) medium-high-tech manufacturing. The remaining are the more traditional ones: i.e. 5) medium-low-tech manufacturing; 6) other market services; and 7) the rest of the economy. While simple, such a classification allows the contribution of each sector to be traced to total productivity growth to see whether structural change has been contributing to it positively or negatively.

As from the 2000s, structural change towards knowledge-intensive sectors has not been the main driver of labour productivity growth in the EU, while the performance of knowledge-intensive sectors is low – although positive – compared to the United States. South Korea is the only economy where structural change has favoured medium-high-tech manufacturing. Figure 3.2-8 summarises the breakdown of total labour productivity growth into its structural change and productivity gains components, by sector, for the period 2000-2016. This enables the total contribution of each sector (last column) and of structural change and productivity gains, respectively (last row), to be highlighted.

While labour productivity has grown by 15.67 % in the EU since 2000, the growth rate would have been higher if structural change had favoured more the sectors with higher productivity gains. As shown in Panel A, this is particularly true for the industrial sectors with high knowledge intensity, i.e. high-tech and medium-high tech manufacturing. However, a closer look at the figure reveals that the most negative components of structural changes are in non-knowledge-intensive sectors, most notably medium-low-tech manufacturing and the rest of the economy. This is linked to the high productivity gains in those sectors during the reference period, suggesting that the loss of employment shares has reduced the total labour productivity growth and added to the negative contribution of structural change (-1.19 %).

A key challenge faced by the EU is that knowledge-intensive sectors have the lowest productivity gains, despite the higher labour productivity levels, as presented in the second column of Figure 3.2-8. Conversely, the other market services and the rest of the economy are by far the main sectors in which labour productivity has been growing the most while the loss of employment shares in the latter is actually reducing the overall growth figures. Since these sectors are less knowledge-intensive, these positive productivity gains suggest an increase in efficiency, hinting at the application of productivity-enhancing technologies to traditional activities.

While structural change has made a similar contribution to productivity growth in both the United States and the EU, productivity gains in knowledge-intensive activities in the former have been systematically larger. As in the European case, structural change contributes negatively to labour productivity growth (-3.2 %), as it does in knowledge-intensive manufacturing, flagging a more intense deindustrialisation trend such as in the EU. However, the productivity gains in high-tech and medium-high-tech manufacturing are higher at above 2 %, and they manage to counterbalance the loss in employment shares. The productivity performance in medium-high-tech manufacturing in the EU is higher due to a smaller decline in the employment shares, driven mostly by the CESEE economies. Knowledge-intensive services are the main drivers of productivity growth in both economies, because of positive productivity gains together with sustained increases in their employment shares. Even in this case, it is worth noting the difference in performance: while labour productivity growth has grown by just around 2.4% in the EU, the United States has experienced an increase over 10%, which also includes the high-tech knowledge-intensive services, outperforming by far any other sector in their economy. It should also be noted that, in both economies, high-tech knowledge-intensive services have had a relatively low growth rate – negative in the case of the EU – despite having the second highest labour productivity level, as shown above.

Figure 3.2-8 Labour productivity growth decomposition: structural change and productivity gains, 2000-2016

Panel A: EU

	Structural change	Productivity gains	Total
High-tech manufacturing	-0.62%	0.95%	0.33%
Medium-high-tech manufacturing	-0.87%	1.75%	0.88%
Medium-low-tech manufacturing	-3.01%	2.55%	-0.45%
Knowledge-intensive services	5.37%	2.53%	7.90%
HT-knowledge-intensive services	0.97%	-0.12%	0.86%
Other market services	2.48%	4.16%	6.64%
Rest of the economy	-5.40%	4.92%	-0.48%
Total	**-1.19%**	**16.87%**	**15.67%**

Panel B: United States

	Structural change	Productivity gains	Total
High-tech manufacturing	-2.18%	2.31%	0.13%
Medium-high-tech manufacturing	-2.11%	2.10%	-0.01%
Medium-low-tech manufacturing	-3.36%	2.53%	-0.83%
Knowledge-intensive services	4.61%	8.78%	13.39%
HT-knowledge-intensive services	0.22%	1.68%	1.90%
Other market services	0.32%	7.34%	7.65%
Rest of the economy	-0.73%	2.29%	1.56%
Total	**-3.23%**	**26.82%**	**23.80%**

Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on Eurostat and OECD data
Note: EU data is until 2015.
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter32/figure-32-8.xlsx

The post-crisis period reveals higher productivity growth in knowledge-manufacturing activities in both the EU and United States, although well below the figures for South Korea. The low performance of the EU's knowledge-intensive services is confirmed. Figure 3.2-9 reports the decomposition of labour productivity growth for the post-crisis period, including data which are also available for Japan and South Korea. Figures for the EU and United States confirm the trend observed for the whole period, but with two main differences. First, productivity growth in the industrial sectors in the United States is higher, due to a slowdown in the pace of structural change away from those sectors. Second, productivity gains in the EU's knowledge-intensive services have been very low (+0.21 %) and negative in the high-tech ones (-0.23 %). Growth in the sector has been entirely driven by the increase in employment shares (+2.69 % in knowledge-intensive services and +0.49 % in the high-tech ones) which, in turn, explains 70 % of total productivity growth (3.18 % out of 4.54 %). On a more positive note, productivity gains in high-tech manufacturing, while relatively low, appear to have been mainly concentrated in the post-crisis period (+0.64 % between 2008-2016 compared to +0.95 % for 2000-2016). As regards Japan and South Korea, while data availability does not allow the complete picture to be drawn, it is worth noting the loss of productivity in knowledge-intensive services in both countries, despite increased specialisation within the sector, which has not favoured the high-tech services. As already mentioned above, South Korea stands out for being the only economy with positive figures in knowledge-intensive industries, showing productivity gains significantly higher than in peer countries. It is also the only country where structural change contributes significantly to productivity growth in medium-high-tech manufacturing (1.2 % out of 2.47 % growth in the sector) and its contribution in high-tech manufacturing is almost non-negative (-0.2 %). Finally, South Korean total labour productivity growth (+14 %) is almost double that in the United States (+8 %) and more than three times higher than in the EU (+4.5 %).

Figure 3.2-9 Labour productivity growth decomposition: structural change and productivity gains, 2008-2016

EU

	Structural change	Productivity gains	Total
High-tech-manufacturing	-0.28%	0.64%	0.35%
Medium-high-tech manufacturing	-0.20%	1.11%	0.91%
Medium-low-tech manufacturing	-1.35%	1.00%	-0.35%
Knowledge-intensive services	2.69%	0.21%	2.90%
HT-knowledge-intensive services	0.49%	-0.23%	0.26%
Other market services	0.58%	1.18%	1.76%
Rest of the economy	-2.47%	1.20%	-1.28%
Total	**-0.55%**	**5.09%**	**4.54%**

Japan

	Structural change	Productivity gains	Total
High-tech manufacturing	-0.95%	-0.45%	-1.40%
Medium-high-tech manufacturing	-1.52%	1.05%	-0.46%
Medium-low-tech manufacturing	-0.48%	2.80%	2.32%
Knowledge-intensive services	2.93%	-4.48%	-1.54%
HT-knowledge-intensive services	0.09%	0.00%	0.08%
Other market services	-0.03%	-6.23%	-6.26%
Rest of the economy	NA	NA	10.59%
Total	**NA**	**NA**	**3.33%**

United States

	Structural change	Productivity gains	Total
High-tech manufacturing	-0.57%	0.81%	0.24%
Medium-high-tech manufacturing	-0.39%	0.80%	0.42%
Medium-low-tech manufacturing	-0.84%	0.49%	-0.35%
Knowledge-intensive services	1.51%	3.24%	4.75%
HT-knowledge-intensive services	0.34%	0.41%	0.75%
Other market services	0.06%	3.32%	3.38%
Rest of the economy	-0.77%	-0.24%	-1.02%
Total	**-0.66%**	**8.89%**	**8.17%**

South Korea

	Structural change	Productivity gains	Total
High-tech manufacturing	-0.20%	1.53%	1.33%
Medium-high-tech manufacturing	1.20%	1.27%	2.47%
Medium-low-tech manufacturing	-0.01%	1.55%	1.54%
Knowledge-intensive services	6.59%	-2.86%	3.73%
HT-knowledge-intensive services	0.76%	-0.62%	0.14%
Other market services	-1.68%	5.47%	3.79%
Rest of the economy	NA	NA	1.04%
Total	**NA**	**NA**	**14.05%**

Science, research and innovation performance of the EU 2020

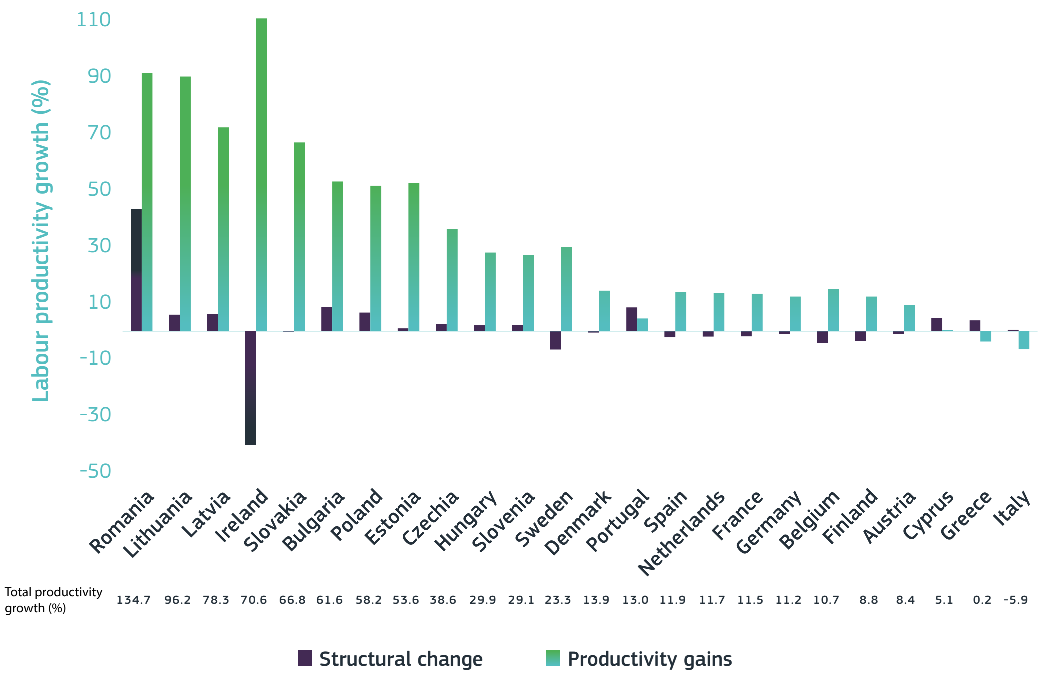
Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on Eurostat and OECD data

Note: Data for Japan and South Korea is not complete for some subsectors, hence changes are reported only for the available subsectors. EU data is until 2015.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter32/figure-32-9.xlsx

Figure 3.2-10 shows the contribution of structural change and productivity increases within sectors to total productivity growth for EU Member States in the period 2000-2016. Values represent the total sum of the two dimensions across sectors, while countries are ordered by total productivity growth. Most of growth has been driven by productivity gains, which is true for all economies. Structural change is a positive but still minor source of growth, mainly for the CESEE economies, together with Portugal, Cyprus and Greece. For the remaining countries, its contribution is negative, and almost null for Italy. Romania and Ireland are two notable outliers since structural change contributes to around half of labour productivity growth in the former while reducing it by around one third in the Irish case.

Figure 3.2-10 Contribution of structural change and productivity gains to total labour productivity growth in EU Member States, 2000-2016[1]



Science, research and innovation performance of the EU 2020

Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on Eurostat data

Note: [1]Data missing for HR, MT and LU.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter32/figure-32-10.xlsx

BOX 3.2-3 Firm size distribution and sectoral labour productivity[8]

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Differences in productivity between countries might also arise in the face of heterogeneous productivity across production units. In this box, we exploit the observation that, despite sectoral differences, there is an overall positive relation between firm size and labour productivity and hence different firm-size distributions could have an impact on aggregate productivity. We develop a decomposition analysis that splits the sectoral productivity in Member States relative to the EU[9] aggregate into differences in both the firm-size distribution and in the productivity level within each firm-size class.

Methodology

The analysis relies on data from Structural Business Statistics (SBS) for five firm-size classes (less than 10 people employed, 10-19, 20-49, 50-249 and 250 or more) within eight NACE sections: C (manufacturing), F (construction), G (trade), H (transportation and storage), I (accommodation and food services), J (information and communication), M (professional activities) and N (administrative and support activities).

For instance, if employment in a country was more concentrated in larger firms compared to the EU aggregate, given that larger firms are associated on average with higher productivity, the *size distribution effect* would be positive. However, at the same time, if average productivity for larger firms in this country was lower than peers in the EU aggregate, the *size class* productivity effect would be negative.

Finally, to provide an overall picture, we aggregate results at the country level. A third component is then added to account for differences in the weight of sectors and the fact that productivity is higher in certain sectors than others (e.g. manufacturing compared to trade activities). We refer to this component as the sectoral composition effect.

The decomposition is as follows[10]:

$$LP_{c,j} - LP_{EU,j} = \sum_i a_{c,j,i} \times LP_{c,j,i} - \sum_i a_{EU,j,i} \times LP_{EU,j,i} =$$

$$\sum_i (a_{c,j,i} - a_{EU,j,i}) \times \left(\frac{LP_{c,j,i} + LP_{EU,j,i}}{2}\right) \text{ [size distribution effect] } +$$

$$\sum_i (LP_{c,j,i} - LP_{EU,j,i}) \times \left(\frac{a_{c,j,i} + a_{EU,j,i}}{2}\right) \text{ [size class productivity effect]}$$

where:

$a_{c,j,i}$ = employment share of firm size class i in sector j of country c

$LP_{c,j,i}$ = labour productivity of firm size class i in sector j of country c

8 Based on the homonymous chapter included in Bauer et al. (2020).

9 The EU aggregate not including the UK.

10 Labour productivity is calculated by the ratio of value added and the number of people employed. Value added is measured in purchasing power parity-adjusted euros using GDP-based price levels.

Cross-country comparison

In general terms, country differences in productivity levels within each firm-size class play the most important role by large and mainly explain the divergence across Member States (Figure 3.2-11A), whereas both the sectoral composition effect – i.e. differences in sectoral employment shares – and the firm-size distribution effect play a more limited role.

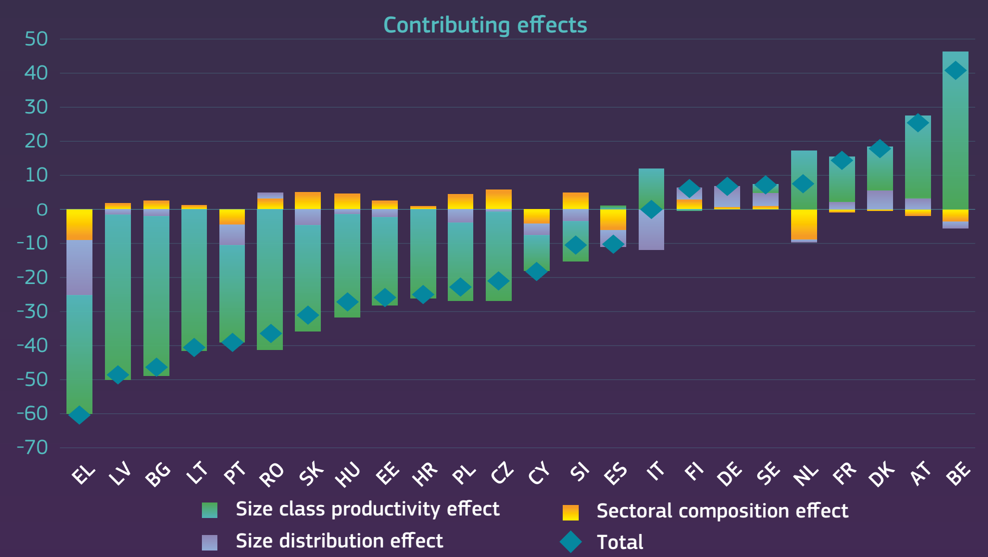
However, for a few countries, having a firm distribution tilted towards smaller firms would seem to be significantly detrimental for productivity performance. This is particularly the case for Greece, where it accounts for a quarter of the productivity difference with respect to the EU benchmark, and Italy, where it fully offsets the positive contribution from the 'pure' productivity effects. It is also worth highlighting the case of Spain, in which the size distribution effects and the sectoral composition effects explain 50-50 the productivity gap.

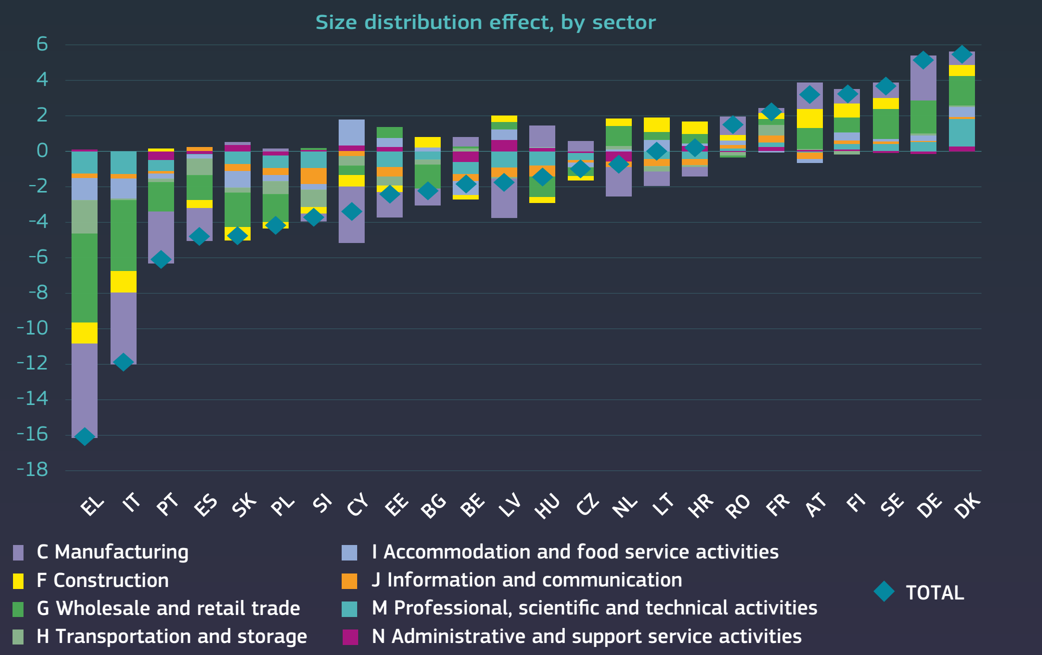
Figure 3.2-11B decomposes the size distribution effect in Figure 3.2-11A by sector. Contributions to size distribution effects are on average higher than their employment share for manufacturing (C), ICT services (J) and professional activities (M), suggesting a more important role for firm size shaping productivity relative to other economic activities.

Sectoral contributions seem to move in the same direction within most countries, particularly for those where the size effect is larger. Nevertheless, there are some noticeable exceptions: e.g. Czechia and Hungary which are largely involved in central European value chains, show positive size distribution effects in the manufacturing sector but negative in some service activities, while the opposite happens in the Baltic countries.

To summarise, while the dispersion of firm-size distributions across Member States plays a limited role overall in explaining productivity gaps within the EU, there are some specific cases in which this effect is significant and might deserve policy action. In particular, the related literature points to the importance of the institutional framework in shaping firm-size distributions, judicial and government efficiency being a supportive factor for increasing firm size.

Figure 3.2-11 Percentage difference in labour productivity relative to the EU28, 2016





Science, research and innovation performance of the EU 2020

Source: Authors' own computations based on SBS data
Note: Malta and Luxembourg are not included due to lack of data.
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter32/figure-32-11.xlsx

Recent dynamics

Labour productivity increased in recent years (2012-2016/17) across all countries, most notably in those Member States with lower levels compared to the EU benchmark (Figure 3.2-12A), Greece being the only exception. These developments supported a convergence process driven mainly by an increase in productivity levels across all firm-size classes, supported in some cases and to a much lesser extent by a sectoral shift towards economic activities with higher productivity levels (e.g. in Bulgaria, Romania and Poland).

Overall, changes in firm-size distribution played a limited role in shaping productivity growth but made a significantly positive contribution in those countries where size distribution had previously been identified as having a detrimental effect, namely Greece, Spain, Portugal and Italy. In policy terms, it might be worth investigating whether such a declining share of employment in smaller firms is associated with the aftermath of the crisis (i.e. being less resilient than bigger firms) or/and the result of structural reforms supporting larger enterprises.

Figure 3.2-12B decomposes the size distribution effect in Figure 3.2-12A by sector. On average, this factor made a positive contribution to productivity growth in manufacturing (C), retail trade (G) and accommodation and food services (I), while proving negative for construction (F) and ICT services (J), showing different sectoral patterns following the crisis.

On a country basis, within those recording a significant shift in employment towards larger firms, developments were driven in particular by accommodation and food services in Greece, while in other countries, manufacturing (e.g. in Hungary) and trade (e.g. in Portugal and Spain) played a relatively more important role.

Figure 3.2-12 Percentage change in labour productivity, 2012-2016/2017

Source: Authors' own computations based on SBS data

Note: Malta and Luxembourg are not included due to lack of data.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter32/figure-32-12.xlsx

3. Conclusions

The structure of an economy shapes its capacity to invest in R&D and to innovate. The EU and peer modern economies are characterised by the predominance of knowledge-intensive services, accounting for more than 40% of total employment and being the backbone of economic activity. The weight of knowledge-intensive manufacturing activities is smaller and heterogeneous across the Member States, with some of them being relatively more specialised, most notably in central and eastern Europe.

In recent decades, Europe has gone through a generalised transformation towards knowledge-intensive services, while most Member States have been moving away from medium-high and high-tech manufacturing, with the exception of the CESEE countries. This trend has had a subduing effect on economic dynamics, despite productivity gains within knowledge-intensive manufacturing sectors positively contributing to productivity growth. Overall, structural change is not the main driver of growth, either in the EU or in peer countries, with the exception of South Korea, which suggests that productivity improvements within sectors are the key driving factor.

In a broader context in which a productivity gap between the EU and the United States persists across sectors, the observed structural dynamics contribute to making the case for an **EU industrial strategy to counter the deindustrialisation trends in the EU and to increase its long-term competitiveness while meeting the need for a transition towards a climate-neutral and sustainable economy**.

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CHAPTER 3.3

BUSINESS DYNAMICS AND ITS CONTRIBUTION TO STRUCTURAL CHANGE AND PRODUCTIVITY GROWTH

KEY FIGURES

20%
EU business churn rate

1 in 10
active enterprises in the EU are high-growth enterprises

12%
of EU high-growth enterprises in HT, MHT manufacturing and HT knowledge-intensive services

7%
of ‘today’s unicorns’ are based in the EU

2%
of EU unicorn founders are women

7/30
top global startup ecosystems are in the EU

What can we learn?

- **The decline of business dynamism may hamper productivity growth**.
- **Most jobs created by new firms emerged in less-productive sectors** of the economy albeit some progress over time.
- **Slightly more than 1 in 10 enterprises in the EU are high-growth enterprises;** only a small share is 'high-tech'.
- **EU's scaling-up performance lags behind the United States and China**, including in the presence of tech scaleups and unicorn companies.
- **Unicorns are very geographically concentrated**: in the EU in Germany, in the US in California, in China in Beijing. Looking into **'hidden' radical innovators** broadens the understanding of the state of innovation across the EU and its regions.
- **'EU DNA' unicorns** with headquarters in the United States and the United Kingdom and their (co-)founders tend to keep strong connections 'back home' with benefits also to the country of origin.
- There are considerable **intra-EU differences in entrepreneurial quality and motivation**.
- **The EU has seven ecosystems in the world's 'top 30' startup ecosystems** compared to 12 in the United States and only 3 in China.
- Despite some progress, a **gender gap remains among founders of innovative startups**.
- The **presence of zombie firms** is still problematic in some EU Member States.

What does it mean for policy?

- **Improve overall framework conditions for innovation**, including access to risk finance and deepening the Single Market to ensure the scaling-up of 'made in EU' disruptive ideas, and their permanence in the EU, while maintaining a global outreach.
- **Tackle the startup gender gap**, beyond the classical market failures.
- **Boost the resilience and integration of startup ecosystems to reach greater critical mass**, with a strategic vision that builds upon the EU's industrial strengths and tackles societal challenges linked to the ambitions of the EU Green Deal.
- A **'tech-with-a-purpose' approach** would leverage R&I to create the solutions that match the urgency of the environmental and social challenges of our time.

1. Declining business dynamism may hamper productivity growth

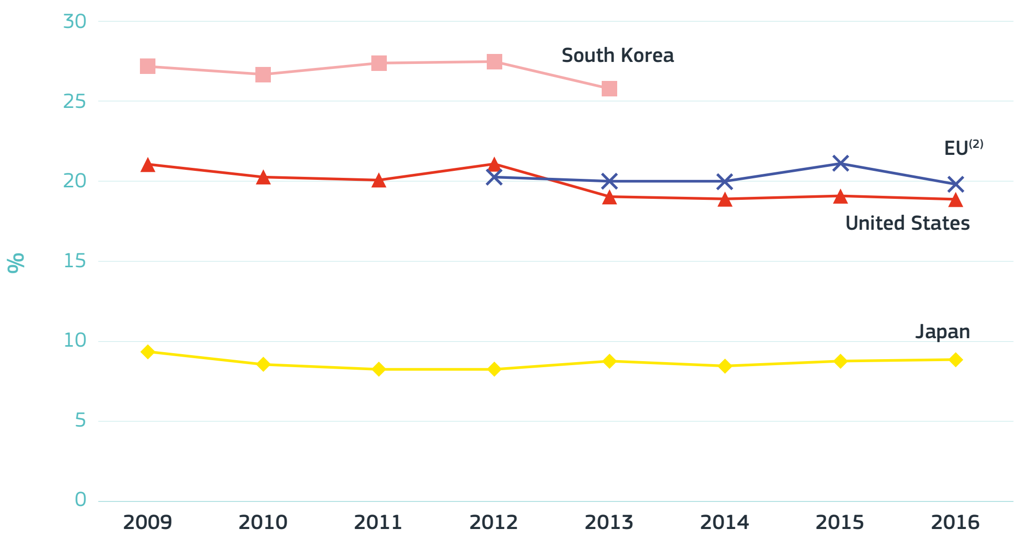
Business dynamism, via the process of creative destruction, can contribute to productivity growth and a more robust economy. An economy's business dynamism can be examined through a set of different measures, such as firm entry and exit rates, churn, and job reallocation rates (i.e. the simultaneous creation and destruction of jobs (Calvino et al., forthcoming)). Economic theory shows that an economy that exhibits higher firm dynamics will in principle be more innovative and productive.

Joseph Schumpeter coined the term 'creative destruction' in 1942. Acemoglu (2008) also refers to the importance of creative destruction for growth. The thesis is that an economy where resources move from less-productive to more-productive businesses within industries will show higher productivity growth (Decker et al., 2016) via a more efficient allocation of resources in the economy. Put differently, it assumes that new businesses will introduce new products and services and challenge older businesses to adapt and compete and will eventually replace them. Bauer (2020) found that higher entry rates improve productivity growth and that net entry contribution is an important driver of productivity. Moreover, Criscuolo et al. (2014) highlight the role of startups in job creation by demonstrating that young firms contribute disproportionately to net employment creation.

In this chapter, we look into recent and longer-term trends across different measures of business dynamism in Europe, benchmarking with other major economies, and we discuss the implications these developments may have for innovation, productivity and growth prospects. In addition, we analyse the state of play of innovative entrepreneurship on the continent as well as some enabling conditions for the success of European entrepreneurs.

In recent years, business dynamism has stagnated and even declined in the EU and/or its international competitors. This may limit its contribution to productivity growth. Figure 3.3-1 depicts the evolution of business churn in the EU and in other major economies between 2009 and 2016, depending on data availability. Business dynamism is highest in South Korea and lowest in Japan. Over time, churn rates seem to have stagnated in Japan and the EU, while in the United States and South Korea a slight decline is more evident after 2012.

Figure 3.3-1 Business churn of employer enterprises (%)(1) by region, 2009-2016



Science, research and innovation performance of the EU 2020

Source: Eurostat (online data code: bd_9fh_sz_cl_r2), DG Joint Research Centre, OECD

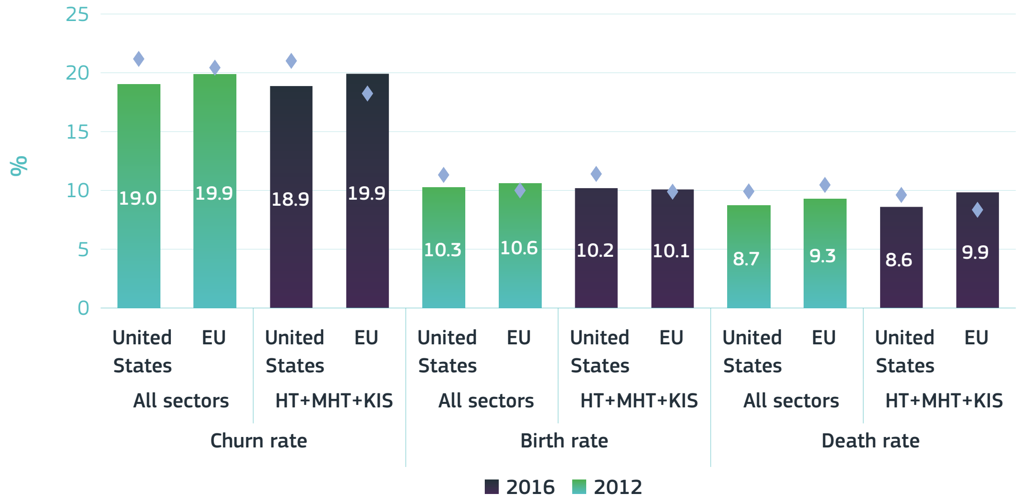
Notes: (1)Business churn is the sum of birth and death rates of employer enterprises i.e. enterprises, with at least 1 employee. (2)EU was estimated by DG Research and Innovation.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter33/figure-33-1.xlsx

The EU exhibits slightly higher business dynamism than the United States. The combined dynamics in high- and medium-high-tech manufacturing and knowledge-intensive services are similar to those of the overall economy. In 2016, the EU's economy was somewhat more 'dynamic' than the United States, both in all sectors and in high- and medium-high-tech manufacturing (HT, MHT) and knowledge-intensive services (KIS) sectors (Figure 3.3-2). This was mainly due to slightly higher company death rates in the EU. Between 2012 and 2016, there appears to have been a stagnation in EU business dynamism, and a small increase in the HT, MHT and KIS sectors derived from higher death rates in these sectors. The United States experienced a decline in business churn activity between 2012 and 2016 due to a slight contraction in both birth and death rates.

Some EU Member States have seen a decline in business churn activity over recent years, while overall increases were more visible in EU-13 countries. Figure 3.3-3 depicts the evolution of churn rates between 2010 and 2017. Business churn declined in some Member States during this period. Hungary, Poland, Bulgaria, Estonia and Croatia had the highest churn in 2017, while Belgium, Ireland, Greece and Malta showed the lowest business dynamism and have not made any progress compared to 2010. The largest increases were in Hungary (mainly due to much higher company death rates), Poland and Romania. Denmark stands out as a country with high birth rates and relatively low death rates. The United Kingdom and Norway registered increases in business churn, while Turkey experienced the largest decline in the group of associated countries represented in the graph.

Figure 3.3-2 EU-US comparison of churn, birth and death rates, all sectors and in high- and medium-high-tech manufacturing, and knowledge-intensive sectors, 2012 and 2016



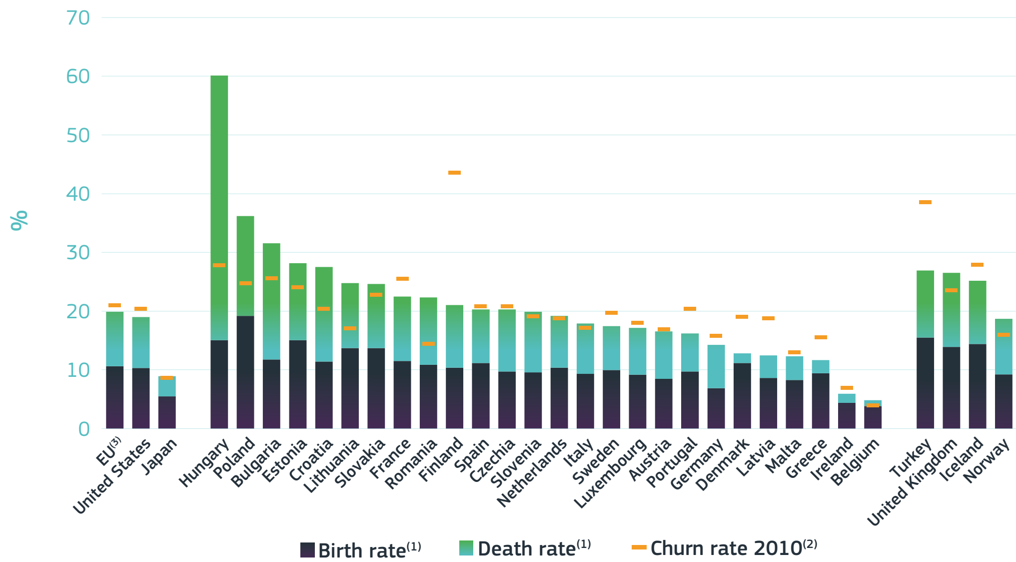
Science, research and innovation performance of the EU 2020

Source: Eurostat (online data code: bd_9fh_sz_cl_r2), DG Joint Research Centre

Note: [1]EU was estimated by DG Research and Innovation and excludes Cyprus.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter33/figure-33-2.xlsx

Figure 3.3-3 Churn rate (birth rate plus death rate) of employer enterprises, 2017 and total churn rate 2010[1]



Science, research and innovation performance of the EU 2020

Source: Eurostat (online data code: bd_9fh_sz_cl_r2), DG Joint Research Centre, OECD

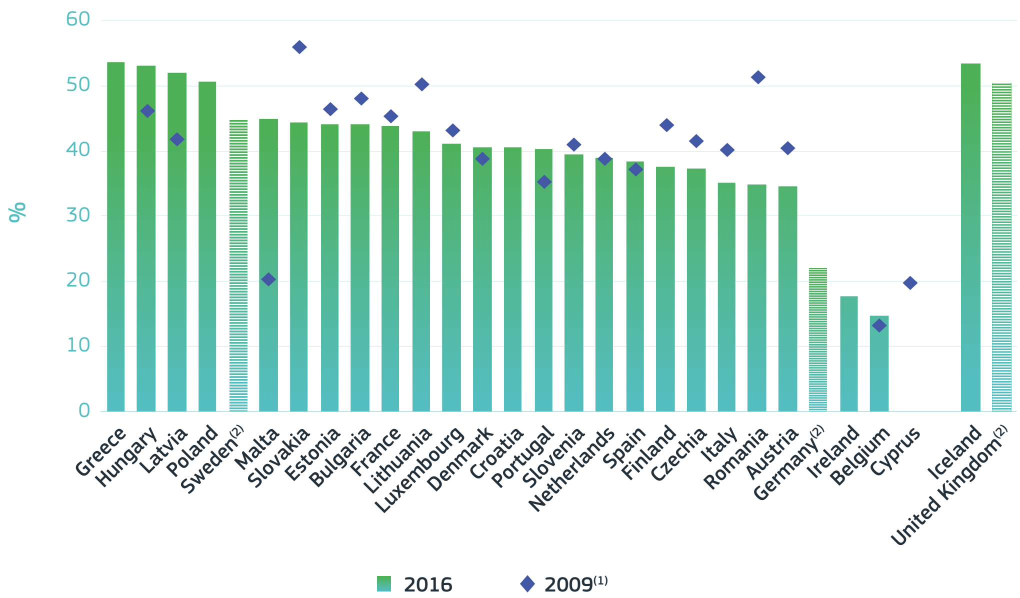
Notes: [1] EU, CZ, IE, FR, HU, MT, PL, RO, SK, TR, US, JP: 2016. [2]EU, BE, BG, DK, DE, HR, MT, PL, SK, FI, SE, UK, NO, TR: 2012. IE: 2014 EL: 2015. [3]EU was estimated by DG Research and Innovation and excludes Cyprus.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter33/figure-33-3.xlsx

The presence of young companies in EU Member States ranges from more than half in Greece to only slightly over 10 % of employer enterprises in Belgium. Startups (defined here as young companies up to five years old) constitute more than half of employer enterprises in Greece, Hungary and Latvia, and less than one fifth in Ireland, Belgium and Cyprus (Figure 3.3-4). In Iceland and the United Kingdom, startups comprise more than 50 % of enterprises. In most EU Member States (for which either 2009 or the earliest year is available) the share of startups in the economy contracted. The biggest declines were registered between 2009 and 2016 in Romania, Slovakia and Lithuania, while increases were more pronounced in Malta, Latvia and Hungary. Chapter 8 - Framework conditions provides an overview of the framework and market conditions that may partly explain these cross-country differences.

The evolution of enterprise birth rates across the EU reveals a mixed pattern. As expected, the evolution of job creation by new firms correlates positively with birth rates. There are considerable cross-country differences in terms of job creation rates. Employer enterprise birth rates have not yet reached pre-crisis rates in some EU Member States such as France, Luxembourg, Latvia, Romania and Slovenia. On the other hand, in Spain, Lithuania, Estonia, Slovakia and Hungary, birth rates have surpassed those before the crisis. In a few Member States, like Austria, Belgium, Germany, Portugal and Sweden, birth rates seem to be relatively stable. In 2017 (or latest year available), enterprise birth rates ranged from 19 % in Poland to only around 4 % in Belgium and Ireland (Figure 3.3-4). In the United States, following a rise in 2012, birth rates appear to have slightly declined again.

Figure 3.3-4 Share of startups (up to 5 years old) in total employer enterprises, 2009 and 2016



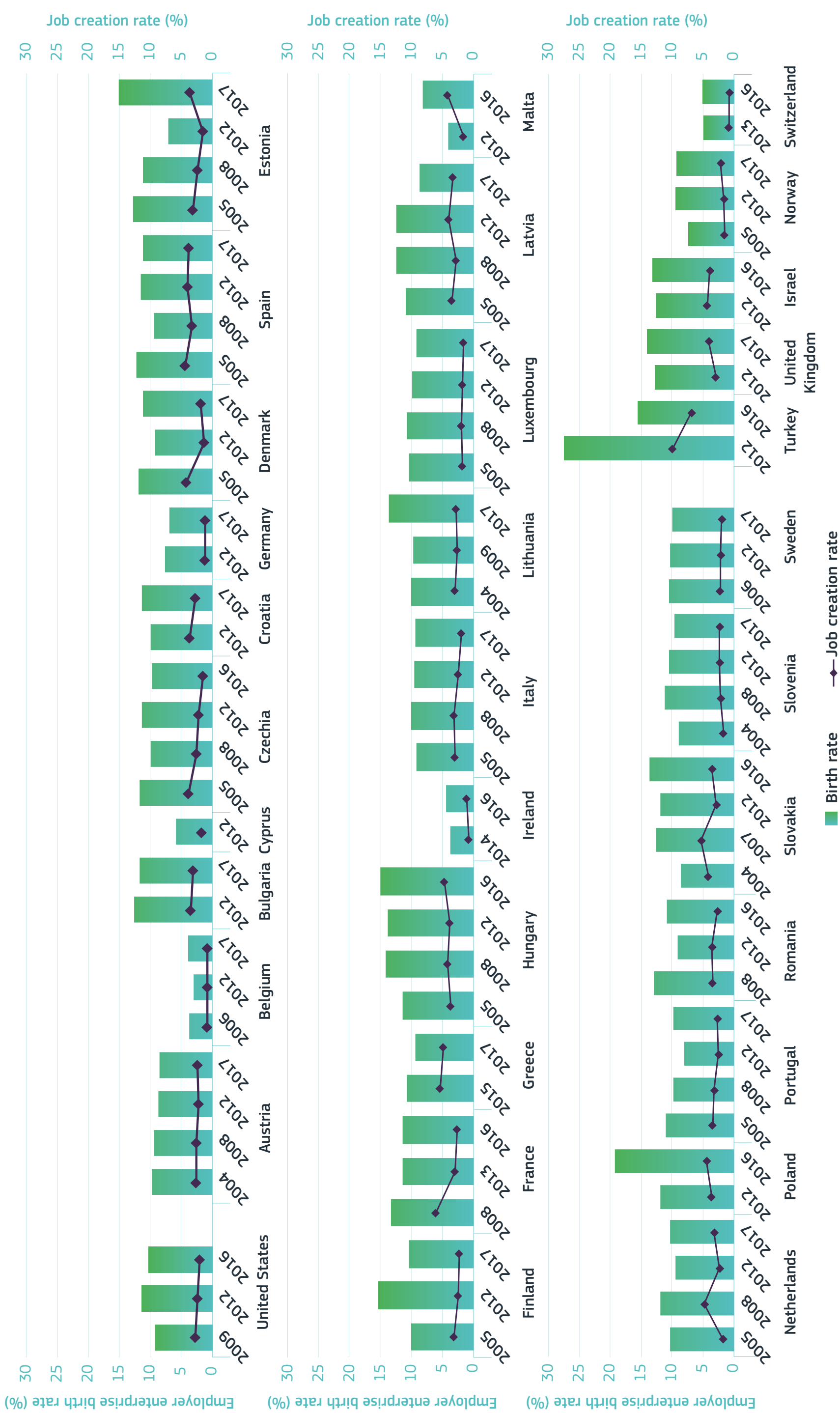
Source: Eurostat (online data code: bd_9fh_sz_cl_r2)

Notes: [1]BE, BG, DK, CY, MT, NL, FI: 2012. FR, SK: 2013. [2]SE, DE and UK do not include the share of employer enterprises that are 5 years old due to data unavailability.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter33/figure-33-4.xlsx

As expected, the evolution of job-creation rates among new employer enterprise births has more or less followed the evolution of enterprise birth rates. Job creation rates are the highest (above 4%) in Hungary, Greece, Spain, Poland and Slovakia, compared to job-creation rates by the newly created enterprises covered of just 1% or less in Belgium, Germany and Ireland. In the United States, job creation by new firms seems to be declining slightly.

Figure 3.3-5 Employer enterprise birth rates and job creation rates[1] (%), by country



Source: Eurostat (online data code: bd_9fh_sz_cl_r2), OECD (SME and Entrepreneurship Outlook 2019), DG Joint Research Centre

Note: [1] Job creation rate is the ratio of jobs created by employer enterprise births over the number of jobs in employer enterprises.

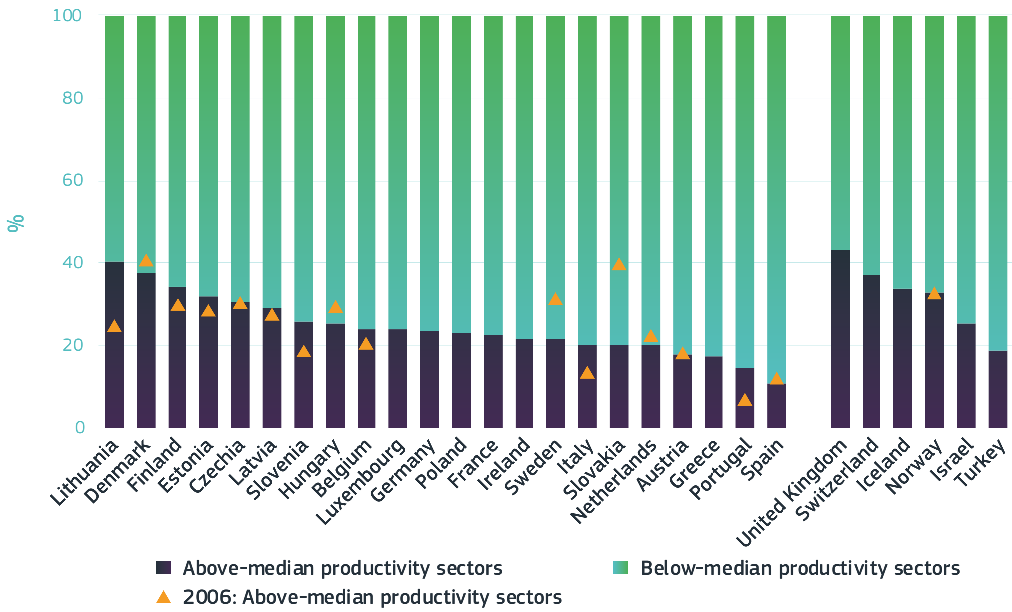
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter33/figure-33-5.xlsx

Most jobs created by new firms emerged in less-productive sectors of the economy. However, in some countries, there has been progress towards job creation in more-productive sectors. Figure 3.3-6 depicts the share of jobs created by new firms in above- and below-median productivity sectors in 2016 and compares it with 10 years ago (whenever country-level data is available). Lithuania, Denmark, Finland, Estonia and Czechia registered the highest percentages of new jobs created by new firms in above-median productivity sectors, with 30-40% of new jobs being created in sectors with higher productivity. A similar picture applies to the United Kingdom, Switzerland, Iceland and Norway. On the other hand, over 80% of jobs created by firm births in Spain, Portugal, Greece, Austria and the Netherlands were in lower-productivity sectors.

Nonetheless, since 2006, there has been an increase in the shares of jobs being created by new firms in more productive sectors in some countries. This is the case in Lithuania, Finland, Estonia, Czechia, Latvia, Belgium, Italy, Austria, Portugal and Spain. In the case of Lithuania, this increase almost doubled in percentage points. In other countries, such as Denmark, Hungary, Sweden, Slovakia, and the Netherlands, the contribution to new job creation from more productive sectors appears to have declined.

Overall, considering the link between productivity and wage-setting, it seems that most jobs created by new firms were in lower-productivity sectors and hence, in principle, were lower-paid jobs. As mentioned in OECD (2019), this may provide an explanation for

Figure 3.3-6 **Percentage of jobs created by firm births in above- and below-median productivity sectors[1], 2016[2] and comparison with 2006 share for above-median productivity sectors**



Science, research and innovation performance of the EU 2020

Source: OECD SME and Entrepreneurship Outlook 2019

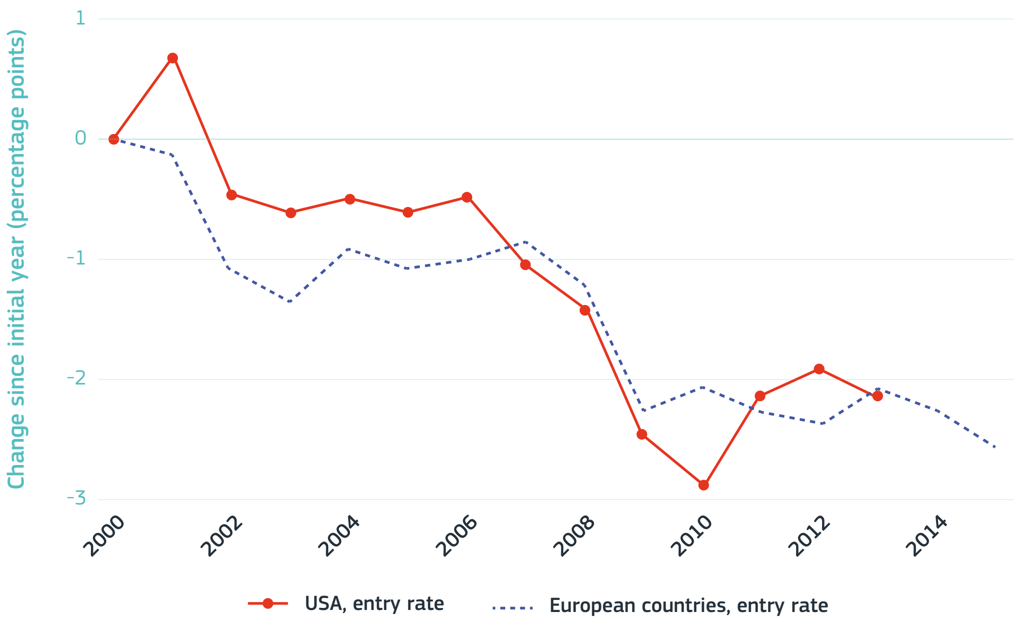
Notes: [1]Median productivity (as measured by valued added per person employed) is calculated at the sectoral level (ISIC Rev4) for each country and year. [2]2016 or latest year available.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter33/figure-33-6.xlsx

wage stagnation in many countries, despite the improvement in economic indicators, such as GDP growth and employment rates, since the crisis.

Longer-term analyses based on firm-level data are needed to better understand the evolution and impact of changes in business dynamism in the economy. Research points towards a decline of business dynamism in both Europe and the United States. As mentioned above, according to economic theory, stronger business dynamism can lead to a higher productivity-enhancing reallocation of resources in an economy and consequently can be a source of growth. Decker et al. (2016) showed the decline of business dynamism in the United States as well as a *reduction in high-growth entrepreneurship in the United States in the post-2000 period*. Calvino et al. (forthcoming) use microdata for a set of European countries and the United States to compute firm-level business dynamics within industries. Figure 3.3-7 confirms that since 2000 there has also been a decline in business dynamism, as measured by entry rates, in Europe. Bijnens and Konings (2018) found similar results for Belgium using 30 years of firm-level data.

Figure 3.3-7 Average cumulative changes in entry rates, selected European countries and comparison with the United States, 2000-2015



Source: Calvino et al (forthcoming)
Note: This figure reports within-country-industry trends of entry rates, based on the year coefficients of regressions within country-sector, for the period 2000-2015, conditional on data availability. European countries include BE, ES, IT, NL, AT, PT, SE, FI, UK, NO. Each point represents cumulative change in percentage points since 2000.
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter33/figure-33-7.xlsx

However, understanding the direct causes and impact of declining business dynamism since 2000 is a complex exercise. Disentangling the impact of the slowing pace of job reallocation and entry rates on innovation and productivity, with certainty, can be a challenging task. For example, Decker et al. (2018) argue that to get the full picture about the slowing business dynamism it is important to consider the hypothesis that *changes in the business model within sectors may imply less need for a high pace of business formation and reallocation dynamics to achieve productivity growth*. Hence, existing firms may continue to be productive because of process, organisational and business model innovation. In fact, Aghion et al. (2016) showed that *innovation by existing firms contributed more to productivity growth than did innovation by entering firms*. Akcigit and Ates (2019) found that the explanation for declining business dynamism in the United States may lie in a decline in knowledge diffusion.

Business dynamics in digital sectors have received closer scrutiny in the literature due to concerns over market concentration in the digital sectors (Andrews et al., 2018). Calvino et al. (forthcoming) found that the higher the digital intensity of the sector, the larger the decline in entry and job reallocation rates (see Chapter 2 - Changing dynamics of innovation in the age of digital transformation). On finding a similar picture, Decker et al. (2016) concluded that there has been a decline in the contribution from reallocation to productivity growth since 2000, which has been particularly true in the high-tech sector.

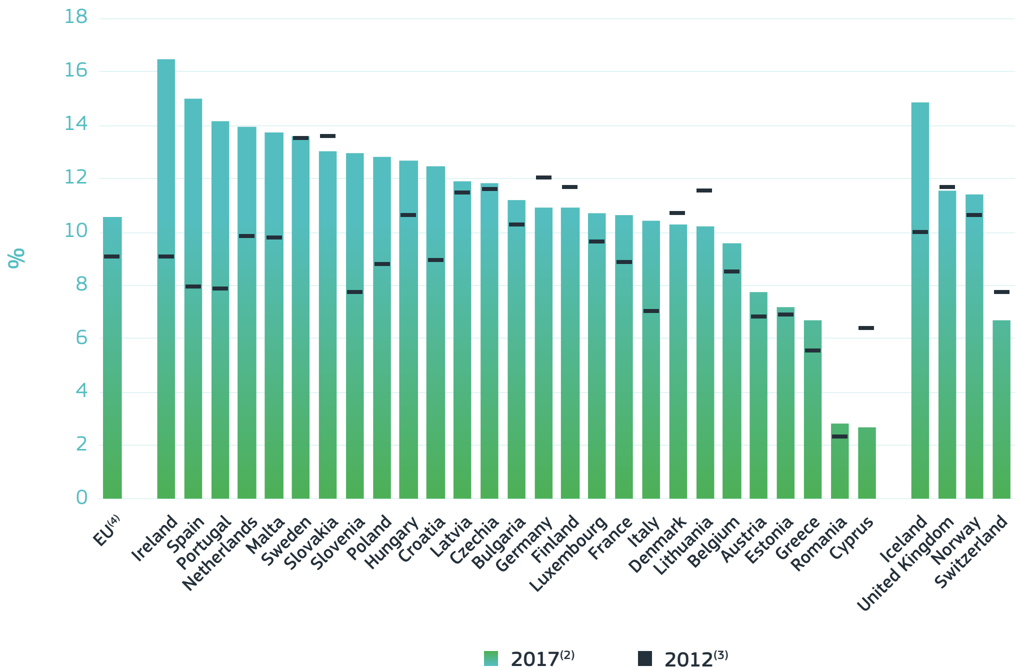
Calvino et al. (forthcoming) shed more light on the impact of changes in the competitive environment on business dynamism measured by entry rates and job reallocation rates. On the impact of the business cycle, they find that it *plays an important role but the observed declines in dynamism do not seem to be a cyclical phenomenon only*. Furthermore, greater efficiency in contract enforcement and business regulations was found to be associated with stronger business dynamism. The authors also identified a negative association between the administrative burden on startups and entry rates. These aspects are further explored in Chapter 8 - Framework conditions.

2. Europe's scaling-up performance needs revamping

Slightly more than 1 in 10 enterprises in the EU are high-growth companies. In many EU Member States, the representation of high-growth firms in the economy has increased. High-growth enterprises can be measured either in terms of employment or turnover growth. Since data are more commonly available for employment, this is the criteria we have applied – a high-growth enterprise has at least 10 employees and an average annualised employment growth of 10% or more per annum over a three-year period – which also follows the definition of Eurostat and the OECD. Grover Goswami et al. (2019) from the World Bank found that *high-growth firms are not only powerful engines of job and output growth but also create positive spillovers for other businesses along the value chain*. Daunfeldt et al. (2014) show that high-growth firms contribute disproportionately to new job creation. In the European Innovation Scoreboard, the European Commission (2019) also includes an indicator for employment in fast-growing innovative enterprises, following the rationale that the spread of these high-growth enterprises in the most innovative sectors can potentially lead to structural change (see Chapter 6.3 – Innovation output and knowledge exploitation and valorisation).

Overall, the share of high-growth enterprises in Europe has increased between 2012 and 2017 (Figure 3.3-8). In 2017, in the EU, 10.6 % of the companies were recognised as high-growth enterprises. The share of high-growth firms ranged from nearly 17 % in Ireland to slightly less than 3 % in Cyprus. Between 2012 and 2017 (or 2016 depending on data availability), the largest increases occurred in Ireland, Spain and Portugal[1], while absolute declines were most pronounced in Cyprus, Lithuania and Germany[2].

Figure 3.3-8 Share of high-growth enterprises[(1)] in total active enterprises with at least 10 employees, 2012 and 2017



Science, research and innovation performance of the EU 2020

Source: Eurostat (online data code: bd_9pm_r2)

Notes: (1)Enterprises with at least 10 employees at the beginning of their growth and having an average annualised growth in number of employees greater than 10 % per annum, over a three-year period. (2)EU, CY, CH: 2016. (3)FI: 2013. EL, CH: 2014. (4)EU was estimated by DG Research and Innovation.

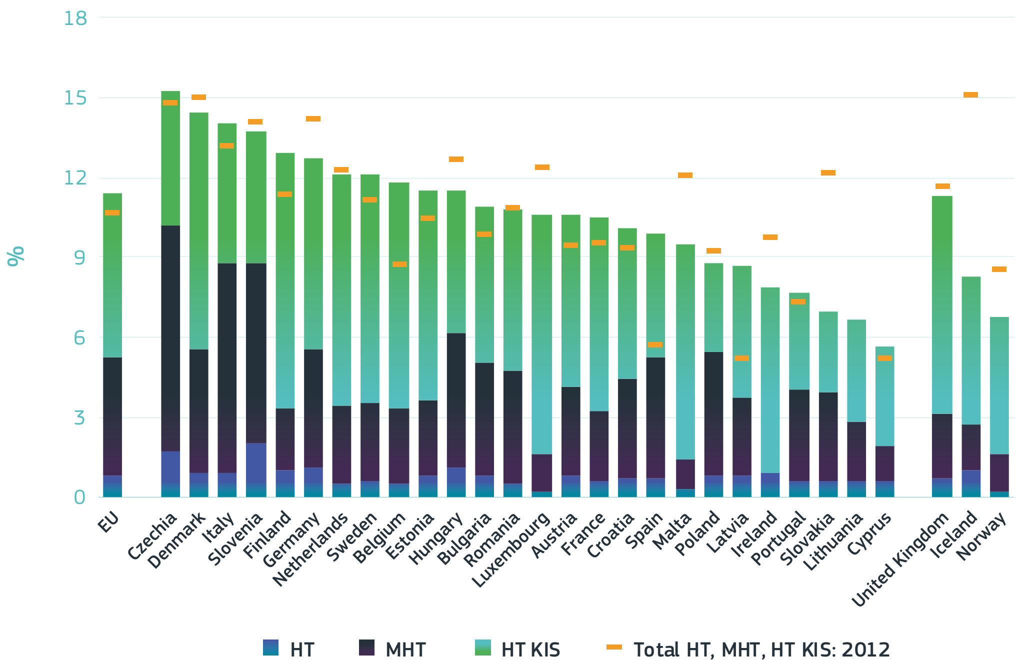
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter33/figure-33-8.xlsx

1 This may reflect business cycle fluctuations.

2 For more on high-growth firms see as well https://publications.jrc.ec.europa.eu/repository/handle/JRC119788

Less than 12 % of all high-growth enterprises in the EU are in high-tech, medium-high-tech manufacturing and high-tech knowledge-intensive services, although there has been an increase in recent years. Figure 3.3-9 shows that most high-growth enterprises do not occur in high-tech, medium-high-tech manufacturing and high-tech knowledge-intensive services (KIS). In fact, their share ranges from around 15 % in Czechia to 6 % in Cyprus. There are also intra-EU differences in terms of the representation of high-tech KIS and high-tech and medium-high-tech manufacturing, which also reflects countries' economic structure. For example, in central, eastern and south-eastern European countries, such as Czechia, Slovenia, Hungary, Slovakia and Poland, medium-high-tech manufacturing accounts for almost half of the shares. On the other hand, in Ireland, Luxembourg, the Netherlands, Belgium, Sweden and France, high-tech KIS make the greatest contribution, of at least 70 %. High-tech KIS also play an important role in the United Kingdom, Iceland and Norway. High-tech manufacturing has the lowest share in all countries.

Figure 3.3-9 Share of high-growth enterprises[1] in high-tech (HT) and medium-high-tech (MHT) manufacturing, and high-tech knowledge-intensive services (HT KIS) in total high-growth enterprises, 2017 and 2012 without breakdown



Science, research and innovation performance of the EU 2020

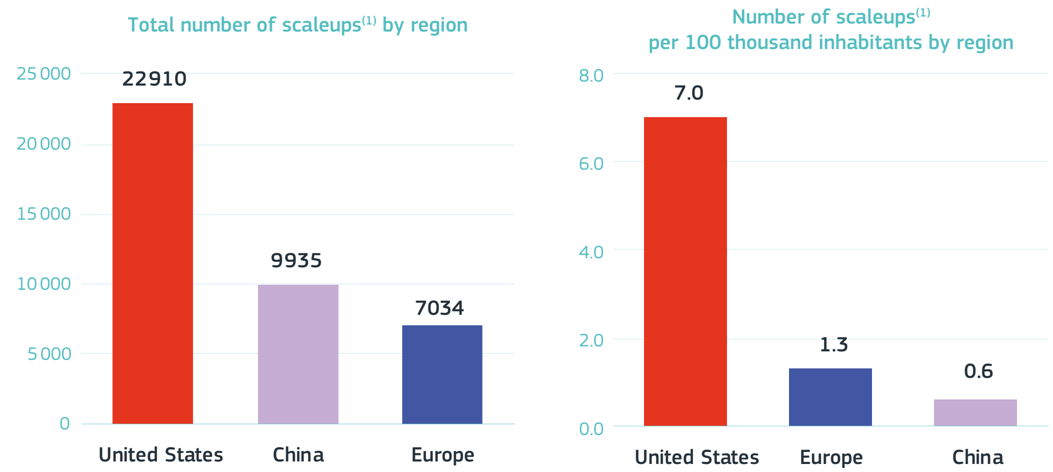
Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit, based on Eurostat (online data code: bd_9pm_r2)

Note: [1]Enterprises with at least 10 employees at the beginning of their growth and having an average annualised growth in number of employees greater than 10 % per annum, over a three-year period.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter33/figure-33-9.xlsx

An alternative way to look into high growth concerns the amount of funding raised. Europe lags considerably behind the United States as regards the presence of tech scaleups. A scaleup is defined by Mind the Bridge (2019) as a tech company that has raised more than EUR 1 million in funding. Figure 3.3-10 compares the absolute and relative presence of these companies in Europe, the United States and China. Europe has a lower number of tech scaleups than the United States and China and, when standardised by population, it still lags behind the United States. As of 2018, there were 1.3 scaleups per 100 000 inhabitants in Europe compared to seven scaleups in the United States.

Figure 3.3-10 Total number of scaleups(1) and number of scaleups per 100 000 inhabitants, as of 2018



Science, research and innovation performance of the EU 2020

Source: Mind the Bridge - Tech Scaleup Europe 2019 Report

Note: (1)A scaleup is a tech company (i.e. a company - operating in Tech & Digital industries, founded in the New Millennium, with at least one funding event since 2010.Biotech, Life Sciences and Pharma, Semiconductors are currently not included in the scope of research) which has raised more than EUR 1 million in funding, as defined by Mind the Bridge (2019). (2) Europe includes EU Member States, and 18 other European countries (LI, NO, CH, RS, ME, BA, MD, XK, AL, IS, UA, BY, MK, UK, SM, MC, AD, VA). Removing the Top 5 non-EU Member States reduces the number of scaleups in the European aggregate substantially, to 4295.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter33/figure-33-10.xlsx

France, Germany and Sweden represent half of all tech scaleups in the EU. Figure 3.3-11 examines the distribution of tech scaleups within the EU. Just five EU Member States – France, Germany, Sweden, Spain and the Netherlands – account for nearly two thirds of all scaleups identified in the EU[3]. Furthermore, the number of UK and Israeli tech scaleups is higher than any EU Member State.

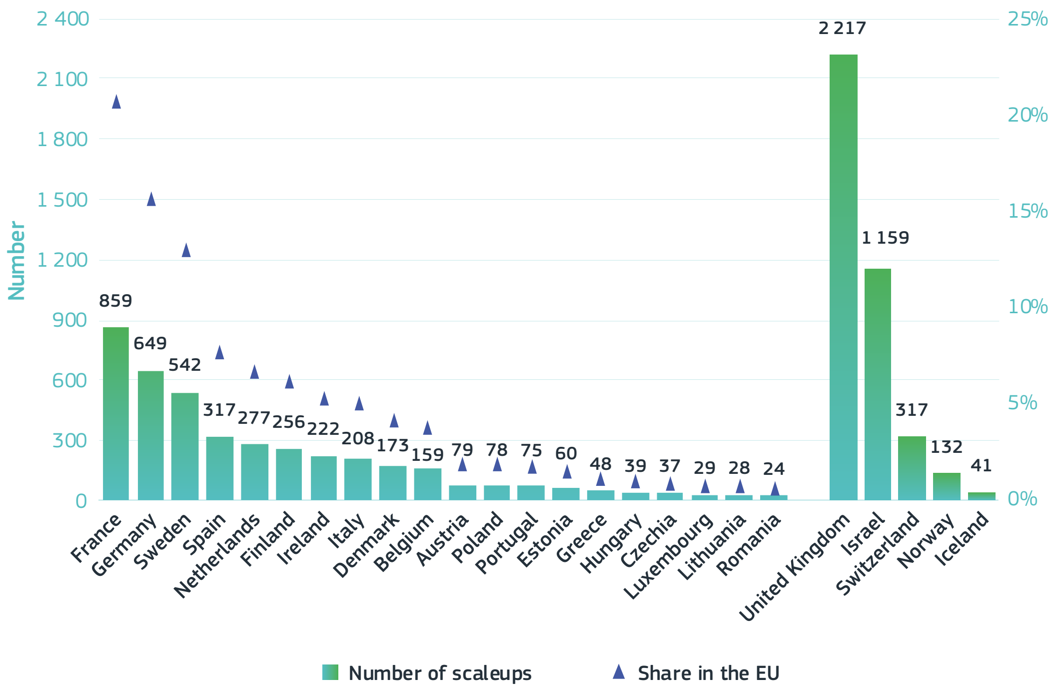
When it comes to transformational entrepreneurship with a global outreach, the EU trails behind the United States and China. For example, for each private

3 These are mostly the largest Member States in terms of population, firms and GDP, so it would be expected that they also account for more tech scaleups as well (size effect).

unicorn in the EU, there are seven in the United States and four in China. As mentioned by the European Commission (2018), the term 'unicorn' was first coined by Aileen Lee in 2013[4] following the emergence of a 'rare' group of companies that was experiencing spectacular growth and had reached a post-money valuation of more than USD 1 billion.

As of January 2020, there are 439 companies worldwide with private unicorn status. Of those, nearly half (or 215) are based in the United States, around a quarter in China (or 101), and 7 % (or 29) are in the EU (Figure 3.3-12). This gap is also evident when looking into the geographical distribution of the total valuation of private unicorns: US unicorns account for 49 %, Chinese unicorns for 29 %, and EU unicorns are only 4 % of the total. When standardising the number of unicorns per million population, the gap relative to both the United States and China remains although the EU's performance comes very close to China[5].

Figure 3.3-11 Total number of scaleups[(1)] and share in the EU (%), as of 2018



Source: Mind the Bridge - Tech Scaleup Europe 2019 Report

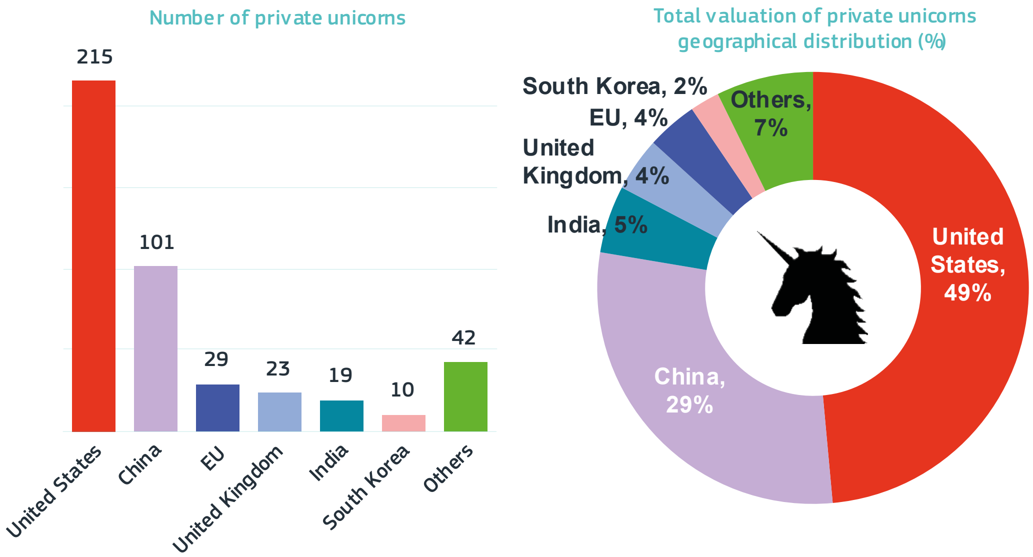
Notes: [(1)]A scaleup is a tech company which has raised more than EUR 1 mn in funding. [(2)]EU average was calculated with the available countries.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter33/figure-33-11.xlsx

4 https://techcrunch.com/2013/11/02/welcome-to-the-unicorn-club/

5 Using population data for 2018 from the World Development Indicators, we find the following results for unicorns per million population: United States (0.7), China (0.07) and EU (0.06).

Figure 3.3-12 Private unicorns[1], January 2020



Science, research and innovation performance of the EU 2020

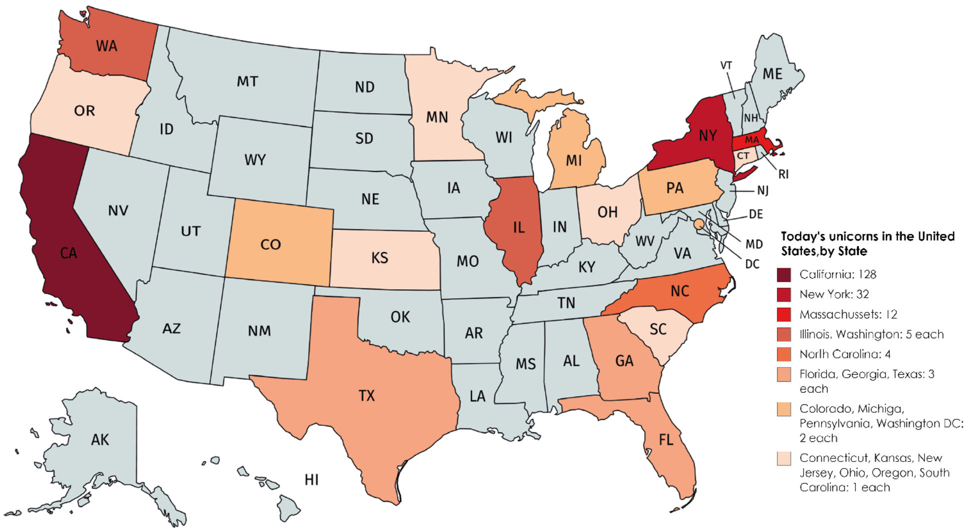
Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit, based on CB Insights-Unicorn tracker, accessed on 24 January 2020

Note: [1]A private unicorn is a private company with a post-money valuation (i.e. 'after funding') valuation of more than USD 1 billion. Even though Kaseya and Collibra are not counted as private unicorns in CB Insights database, after checking Crunchbase and Linkedin company data a decision was made to include them as they are based in the EU. Image © martialred, #125077712; 2019. Source: stock.adobe.com

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter33/figure-33-12.xlsx

'It's all about California'. The United States is home to most unicorns worldwide but they are highly concentrated in just three states – California, New York and Massachusetts. Together, these three states account for 82% of the country's current unicorns, with California alone being home to 60% of all US private unicorns (Figure 3.3-13). New York comes next with 31, followed by Massachusetts with 12 private unicorns. Of the 50 states, 20 (less than half) have at least one private unicorn. In California, San Francisco stands out thanks to the city's strong tech ecosystem which includes, for example, an experienced network of venture capital investors, a vibrant tech community and a pool of tech talent.

Figure 3.3-13 Today's 'unicorn land' in the United States



Science, research and innovation performance of the EU 2020

Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit, based on CB Insights-Unicorn Tracker, accessed on 6 January 2020. Created with mapchart.net©

Note: Today's unicorns are private unicorns at the date of extraction of the data. A private unicorn is a private company with a post-money valuation (i.e. 'after funding') of more than USD 1 billion.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter33/figure-33-13.xlsx

'Unicorns: a tale of concentration'. The spatial concentration of unicorns is not only visible in the United States but also in the EU and China. Unicorns are usually 'born' in well-connected hubs where risk finance and talent are also more widely available. Unicorn companies are very capital-intensive and usually connected to global markets from the start (i.e. 'born-global' companies). For this reason, they tend to emerge in the top entrepreneurial cities where the network of investors, partners and academia is well established. Figure 3.3-14 shows the attractiveness of Germany, France and Sweden (in particular, Berlin, Paris and Stockholm) in the EU as together they account for 66 % of the EU's current unicorns. Moreover, as mentioned above, California (and notably San Francisco) is home to more than half of all US private unicorns and, together with the states of New York and Massachusetts, they represent 82 % of the US unicorn landscape. The high spatial concentration of unicorns in top urban centres also holds for China, with the municipality of Beijing currently home to almost half of all Chinese unicorns. Cumulatively, 82 % of Chinese private unicorns are based in Beijing, Shanghai and the province of Guangdong.

Unicorns are mostly present in fintech, internet software and services, e-commerce and, more recently, in artificial intelligence. Figure 3.3-15 displays the top 15 sectors where private unicorns can be found. Slightly more than half are in the top five sectors, i.e. fintech, internet software and services, e-commerce, artificial intelligence and health.

Figure 3.3-14 Top hubs of ‘today’s unicorns’ by region, and share in the region (%)

Region	Top unicorn hubs	Share (% of in region)
	**Top Member State: Germany**	**41 %**
	Top 3 Member States: Germany, France, Sweden/Spain	72 %
	**Top state: California**	**60 %**
	Top 3 states: California, New York, Massachusetts	82 %
	**Top province/municipality: Beijing municipality**	**46 %**
	Top 3 provinces/municipalities: Beijing, Shanghai, Guangdong	81 %

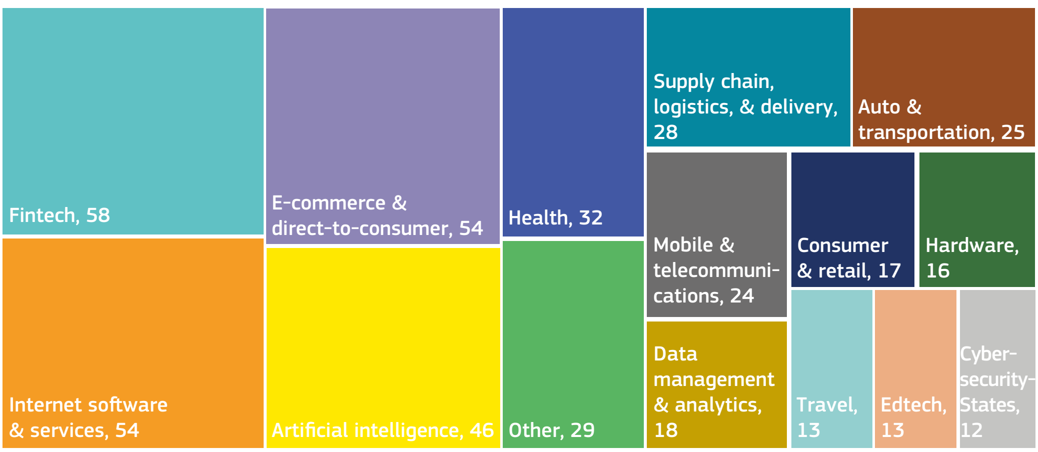
Science, research and innovation performance of the EU 2020

Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit, based on CB Insights-Unicorn Tracker, accessed on 6 January 2020

Note: Today’s unicorns are private unicorns at the date of extraction of the data. A private unicorn is a private company with a post-money valuation (i.e. 'after funding') of more than USD 1 billion.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter33/figure-33-14.xlsx

Figure 3.3-15 Top 15 sectors[1] of private unicorns[2], January 2020



Science, research and innovation performance of the EU 2020

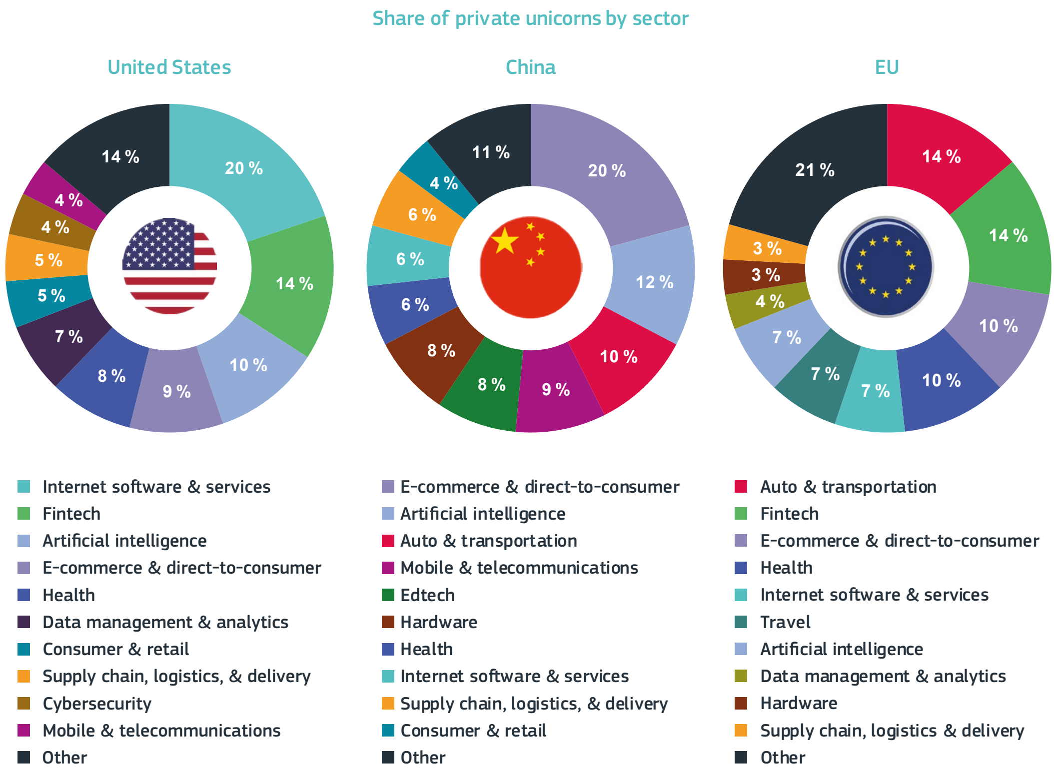
Source: Calculations based on CB Insights-Unicorn tracker, accessed on 21 January 2019

Notes: [1]Sectors were defined according to CB Insights classification. [2]A private unicorn is a private company with a post-money valuation (i.e. 'after funding') of more than USD 1 billion.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter33/figure-33-15.xlsx

Figure 3.3-16 looks at the **sectoral distribution of private unicorns in the EU, United States and China**, with the same colours identifying the different sectors. The 29 EU private unicorns seem to be mainly present in auto and transportation (14%), fintech (14%), e-commerce (10%), health (10%), internet software and services (7%), and travel (7% each). In the United States, internet software and services (20%), fintech (14%), AI (10%), e-commerce (9%) and health (8%) are the 'top five' sectors accounting for slightly more than 60% of the country's current unicorns. The sectoral representation is somewhat different in China, where e-commerce (20%), AI (12%), auto and transportation (10%), mobile and telecomm (9%), educational technology, and hardware (8% each) have the largest weights, representing close to 70% of the current Chinese unicorn landscape.

Figure 3.3-16 Top 10 sectors of private unicorns (%) by region, January 2020



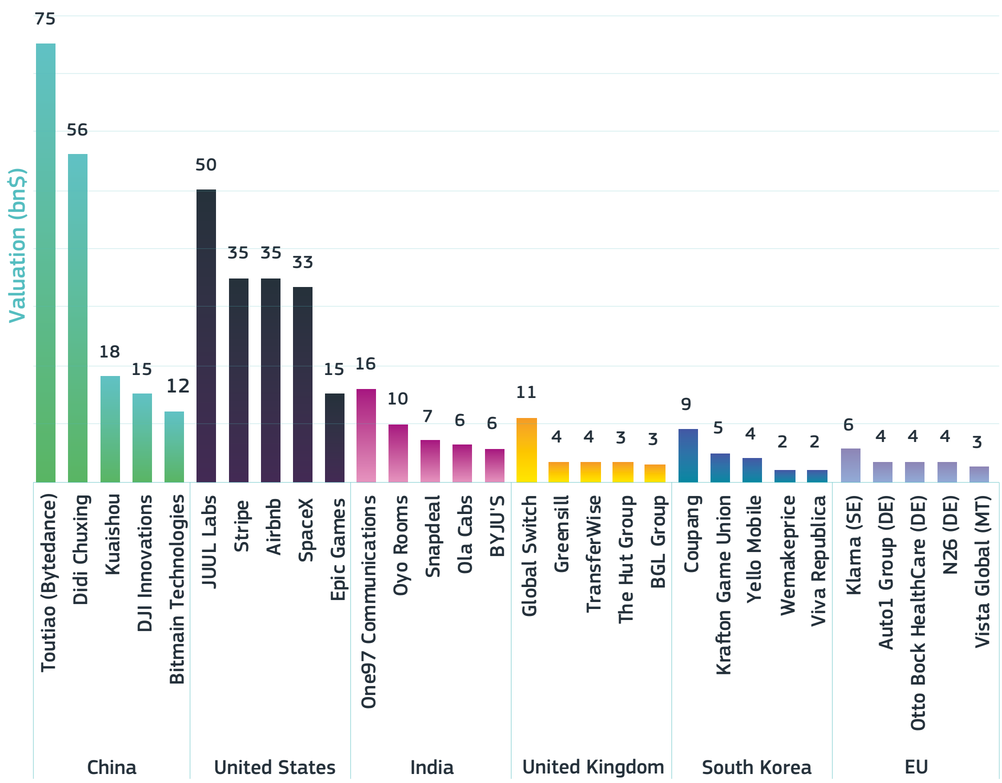
Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit, based on CB Insights-Unicorn tracker, accessed on 21 January 2020

Note: A private unicorn is a private company with a post-money valuation (i.e. 'after funding') of more than USD 1 billion.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter33/figure-33-16.xlsx

The gap between the EU and the United States and China becomes even more evident in the top most-valuable unicorns. The 'top five' private unicorns ranked by valuation in USD billion by region are presented in Figure 3.3-17. It can be seen that the most valuable private unicorns in the EU have significantly lower valuations when compared to other major economies such as the United States, China and India.

Figure 3.3-17 Top 5 private unicorns[1] in terms of valuation (USD bn) by region, January 2020



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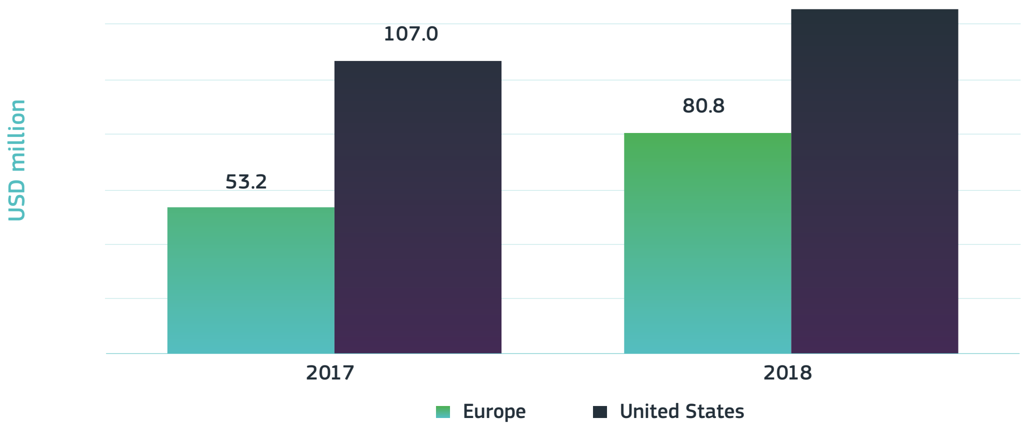
Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit, based on CB Insights-Unicorn tracker, accessed on 21 January 2020

Note: [1]A private unicorn is a private company with a post-money valuation (i.e. 'after funding') of more than USD 1 billion.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter33/figure-33-17.xlsx

Despite the gap in unicorns compared to the United States, European companies seem to have a 'greater efficiency at scaling' prior to reaching unicorn status at USD 1 billion. Figure 3.3-18 indicates that, prior to reaching unicorn status, European companies seem to be more capital efficient, i.e. they manage to reach the USD 1 billion valuation with less available capital. In other words, US unicorns seem to 'burn more cash' when developing their businesses before joining the unicorn club.

Figure 3.3-18 Median funding (in USD million) required prior to reaching private unicorn[1] status



Science, research and innovation performance of the EU 2020

Source: TechCrunch article 16/04/2019 'Unicorns a tale of two continents' based on Pitchbook

Note: The median funding secured prior to (not including) the round in which tech companies in the US and Europe achieved a USD 1 billion valuation during 2017/18.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter33/figure-33-18.xlsx

When adding exited unicorns to the current number of private unicorns, the ratio relative to the United States increases slightly to 1:8 and improves relative to China. The previous figures only considered private unicorns. However, since 2009, there have been other unicorns that were either acquired or are no longer private because they went through an initial public offering (IPO).

In Figure 3.3-19, we assess whether the gap relative to the United States and China would be smaller if the definition of a unicorn was expanded to include those that went public or were acquired by other companies. Thus, the ratio of EU unicorns to the United States slightly increases to 1:8, while relative to China it improves to 1:3.

In the EU, Germany is home to nearly 40% (or 17) of all unicorns. France and the Netherlands come next with six and five unicorns, respectively. Taking into consideration both private and exited unicorns, Figure 3.3-20 indicates that not all EU Member States have generated at least one unicorn; in fact, that has only happened in half of them. Nevertheless, as is highlighted later in this chapter, there is a group of 'EU DNA' unicorns which, even though they currently have their main headquarters in the United States or the United Kingdom, the (co)-founders have EU nationality and, in some cases, even started the company in a EU Member State.

Germany leads in the creation of unicorns with 5 exited unicorns (HelloFresh, Delivery Hero, Ganymed Pharmaceuticals, Rocket Internet and Zalando) and 12 private unicorns (Auto1 Group, Otto Bock Healthcare, CureVac, N26, NuCom Group, Celonis, About You, Omio, FlixBus, GetYourGuide, Deposit Solutions and wefox Group). France follows with six unicorns – BlaBlaCar, Deezer, Doctolib, OVH, Meero and Criteo – and the Netherlands with five – Adyen, Takeaway.com, Acerta Pharma, Dezima Pharma and Bitfury. The four Swedish unicorns are Spotify, iZettle, Klarna and Northvolt. The most well-known Finnish unicorns are Rovio

Entertainment and Supercell. Cabify and Glovo are the two Spanish unicorns. Ireland is represented by King Digital Entertainment and Kaseya[6]. Nine other EU Member States have produced (or are the headquarters of) one unicorn each: Avast Software (CZ), Sitecore (DK), Bolt (also known as Taxify) (EE), OCSiAl (LU), VistaJet (MT), OutSystems (PT) and Vinted (Lithuania), and Collibra (BE).

Figure 3.3-19 Exited[(1)] and private unicorns[(2)] by region, January 2020

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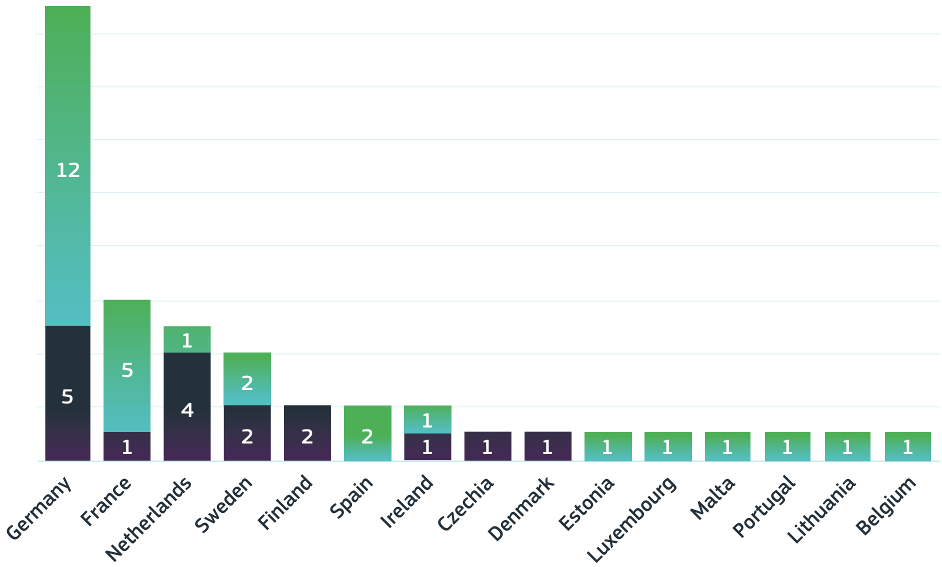
Source: CB Insights-Unicorn Tracker & The Unicorn Exits Tracker, accessed on 21 January 2020

Notes: [(1)]Exited unicorns since 2009 include private unicorns with one of the following exit strategies: IPO, Acquisition, Corporate majority, Merger, and Reverse Merger. CB Insights tracker includes first exits only. [(2)]A private unicorn is a private company with a post-money valuation (i.e. 'after funding') of more than USD 1 billion.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter33/figure-33-19.xlsx

6 Kaseya was founded in the United States but is now Dublin-based.

Figure 3.3-20 Total unicorns - exited[(1)] and private[(2)] - in EU Member States, January 2020



Science, research and innovation performance of the EU 2020

Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit, based on CB Insights-Unicorn Tracker & The Unicorn Exits Tracker, accessed on 21 January 2020

Notes: [(1)]Exited unicorns since 2009 include private unicorns with one of the following exit strategies: IPO, Acquisition, Corporate majority, Merger, and Reverse Merger. CB Insights tracker includes first exits only. [(2)]A private unicorn is a private company with a post-money valuation (i.e. 'after funding') of more than USD 1 billion.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter33/figure-33-20.xlsx

From north to south, east to west, there are examples of 'EU DNA' unicorns whose founders have established or moved their headquarters to the United Kingdom or the United States because of access to capital, market size or the intense network of investors and entrepreneurs. Some unicorn founders studied at top US universities and decided to start their companies in the United States. As mentioned before, the criteria typically used to attribute a country to each unicorn is the (current) location of the headquarters[7]. We have compiled a list of unicorns that are global successes and have EU-DNA – i.e. founders with EU nationality and/or who decided to start, or establish, or move their headquarters to the United Kingdom or the United States (Figure 3.3-21). However, this list may not be exhaustive.

For example, Farfetch´s Portuguese founder, Jose Neves, started the online luxury fashion platform in Portugal, with its headquarters currently in the United Kingdom. TransferWise, a fintech business, was created in Estonia by the Estonians Kristo Kaarmann and Taavet Hinrikus before being relocated to the United Kingdom even though their largest office

7 According to CB Insights and Crunchbase. Other sources attribute other criteria such as the place where the company reached unicorn status.

with over 800 people is in Estonia[8]. Unity technologies, a game development platform, was founded in Copenhagen in 2005 by David Helgason, Nicholas Francis and Joachim Ante, and is currently San-Francisco-based. The Irish brothers John and Patrick Collision founded Stripe in the United States after studying at Harvard University and the Massachusetts Institute of Technology (MIT). Stripe is currently one of the highest valued private unicorns which builds economic infrastructure for the internet.

One of Udacity's co-founders is an immigrant from Germany that started Udacity, an online education company based in the United States. Even though UiPath's headquarters are now in New York, the company keeps a very strong presence in Bucharest, where two Romanian entrepreneurs founded it. The founders of these unicorns typically hold diplomas from top US and European universities, and many of them had previous entrepreneurial activities and experiences.

Figure 3.3-21 Unicorns with 'EU DNA' in the United States and the United Kingdom

Unicorn	Type of EU DNA	Short company description	HQ	Valuation (USD bn)[(1)]	Founded in	Number of employees
1. Shazam	Co-founder (BE) Company born in the UK	App to identify any music playing around you	UK	1**	2000	n.a
2. Just Eat	Founders (DK) Company HQ relocated from DK to the UK	Access to delivery restaurants and online food orders	UK	6.6*	2001	1 970
3. Tradeshift	Founders (DK) Company relocated HQ from DK to the US	Cloud-based business network connecting buyers and suppliers	US	1.1	2009	976
4. Unity Technologies	Co-founder (DK) Founded in CPH, moved HQ to US	Game development platform	US	3	2004	2 605
5. TransferWise	Founders (EE) Company HQ relocated from EE to the UK	Money transfer service without hidden charges	UK	1.6	2011	1 400
6. Eventbrite	Co-founder (FR) Co-founder studied at Cornell Univ. Company born in the US	Self-service ticketing platform for events	US	1.5*	2006	1 075
7. Symphony Communica-tion Services	Founder (FR) Company born in the US	Integrated messaging platform	US	1	2014	346

8 https://transferwise.com/community/nextgeneration

Unicorn	Type of EU DNA	Short company description	HQ	Valuation (USD bn)(1)	Founded in	Number of employees
8. Tango	Co-founder Co-founder studied at Stanford Univ. Company born in the US	Mobile messaging service	US	1.1	2009	128
9. Oscar Health Insurance	Co-founder Co-founder studied at Harvard (MBA) Company born in the US	Health insurance	US	3.2	2012	973
10. Palantir Technologies	Co-founder Co-founder studied at Stanford Univ. Company born in the US	Software to connect 'data, technologies, people and environments'	US	11	2004	2 510
11. Udacity	Co-founder Company born in the US	Online education company	US	1.1	2011	2 112
13. Ginkgo Bioworks	Co-founder Co-founder studied at the MIT Company born in the US	Design custom microbes for customers across multiple markets	US	1	2009	264
14. Intercom	Founders Company born in the US	Develop and publish communications technology to monitor user behaviour	US	1.3	2011	882
15. Stripe	Founders Founders studied in Harvard and the MIT Company born in the US	Build economic infrastructure for the internet	US	35	2010	2 134
16. Compass	Co-founder Company born in the US	Technology-driven real estate platform	US	4.4	2012	n.d.
17. OfferUp	Co-founder Co-founder studied at the Univ. of Washington Company born in the US	Online classifieds	US	1.2	2011	326

Unicorn	Type of EU DNA	Short company description	HQ	Valuation (USD bn)[1]	Founded in	Number of employees
18. AppNexus	Co-founder Company born in the US	Cloud-based software for online advertising	US	2**	2007	n.a
19. Farfetch	Founder Company started in PT, HQ in the UK	Online luxury fashion retail platform	UK	2.9*	2007	3 232
20. Talkdesk	Founders Company born in the US	Enterprise Contact Center Platform	US	1	2011	704
21. UiPath	Founders Company relocated HQ from RO to the US	Design and develop robotic process automation software	US	3	2005	+3 000
22. Letgo	Founders Company relocated HQ from ES to the US	Second-hand shopping app to help users buy and sell locally	US	1	2015	321
23. Warby Parker	Co-founder Co-founder born in Sweden, raised in San Diego Co-founder studied at UC Berkeley, Wharthon School Company born in the US	Online prescription glasses and sunglasses	US	1.2	2010	1 322

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Source: DG Research and Innovation, Unit for the Chief Economist - R&I Strategy & Foresight, based on multiple sources: Craft (access in December 2019), CB Insights, Crunchbase, LinkedIn profiles, companies' websites, the National Foundation for American Policy (2018), online news and media articles

Note: [1]All unicorns listed in the figure are private and hence the values correspond to post-money valuations. Exceptions are indicated with * concerning exited unicorns via an IPO (valuation corresponds to market capitalisation), and ** concerning exited unicorns that were acquired (valuation corresponds to the exit valuation before the acquisition took place). Information displayed in the figure is not exhaustive, so if corrections are needed please contact the authors. Figure displays unicorns ordered by country alphabetic order.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter33/figure-33-21.xlsx

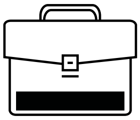
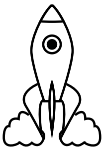
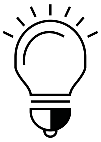
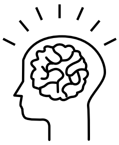
Nevertheless, in general EU DNA unicorn companies and (co-)founders tend to keep strong connections 'back home', which also benefits the country of origin. More generally, the European Commission (2017) investigated the growing phenomenon of dual companies (Onetti and Pisoni, 2016), i.e. high-tech startup companies founded in European countries before relocating their headquarters to outside of the EU, notably the United States. However, they typically maintain a presence (such as R&D labs) in their home country which benefits from positive externalities such as new job creation. The study concluded that 13% of European scaleups follow this 'dual model', and that for 83% of them the United States (in particular Silicon Valley) is the destination, a trend already mentioned in this chapter. For those that relocate within Europe, the United Kingdom is the top choice.

Although there are different reasons for relocating headquarters to the United States or United Kingdom, the most commonly identified are closer proximity to capital markets, an intense and experienced network of investors, and a larger market (see Chapter 8 - Framework conditions). Moreover, the authors' findings suggest that the more mature startup ecosystems (such as Germany, France, Sweden and the UK) show below-average numbers of dual companies (in the 11% to 13% range).

In this context, there are positive externalities to the 'home country' even when headquarters are relocated. This hypothesis holds true in the cases listed below (Figure 3.3-22). Benefits to the country of origin can include employing highly skilled professionals, as in the Tradeshift Frontiers Innovation Lab in Copenhagen or Stripe's new engineering hub in Dublin, participating as angels or seed investors in new startups, such as the founders of Talkdesk and TransferWise, or sponsoring digital education in less-developed regions, like UiPath in Romania, etc.

Some unicorns are highly R&D-intensive and have made it to the top global R&D investors, some despite their young age. Their presence is mainly in software and computer services and on average they have higher market capitalisation than the other top R&D-intensive companies in the sector. They are also less labour-intensive. Only 6 out of the 65 unicorns in the world ranking are from the EU.

Figure 3.3-22 Benefits and positive externalities to the EU country of origin

Type of benefit/positive externality to the home country		Examples from EU DNA unicorns with HQ in the USA and UK
	**Job creation**	**Offices and subsidiary(ies) in the home country[9]:** ▸ Farfetch: 1 500+ employees in Portugal ▸ Transferwise: 700+ employees in Estonia ▸ Letgo: 100+ employees in Spanish subsidiary ▸ Stripe: 100+ employees in Ireland ▸ UiPath: 700+ employees in Romania
	**Support of the startup ecosystem**	**Advice and mentoring from founders:** ▸ OfferUp: Co-founder is a startup advisor in the Netherlands **Seed and early-stage capital:** ▸ Talkdesk: Co-founder is an early-stage investor in Portugal ▸ Transferwise: Participation in seed capital funding for innovations including in secondary education in Estonia
	**R&D and innovation hubs**	**Launch of tech hubs in the home country:** ▸ Tradeshift: Tradeshift Frontiers Innovation Lab in Denmark ▸ Farfetch: Plans for a technology and operations campus in Porto ▸ Stripe: Engineering hub in Dublin ▸ UiPath: Immersion lab in Bucharest ▸ Intercom: large R&D team based at its Dublin office
	**Education and research**	**Education and cutting-edge research:** ▸ Tradeshift: Sponsors a PhD programme in machine learning in a Danish university ▸ UiPath: Foundation supports digital education in Romania ▸ Transferwise: Supports NGO Eesti 2.0 and practical mentoring to its students from Transferwise co-founder and others.

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Source: DG Research and Innovation, Unit of the Chief Economist - R&I Strategy & Foresight, based on ORBIS database as of September 2019, companies' websites, online news and media articles

Note: Information on employment was gathered from ORBIS database, accessed on 29-08-2019; Employment data for Farfetch (31/12/2018), Letgo (31/122017), Stripe (31/12/2017), UiPath (31/12/2017). The information displayed in the table is not exhaustive and might be outdated at the time of publication of the report. Should you identify any mistakes in the data please do not hesitate to contact the authors. Images © M.Style, _#125948076; 2019. Source: stock.adobe.com

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter33/figure-33-22.xlsx

9 According to CB Insights and Crunchbase. Other sources attribute other criteria such as the place where the company reached unicorn status.

BOX 3.3-1 Zooming in on the top R&D-intensive unicorns

The criteria for being 'highly-R&D intensive' is based on a company's presence in the European Commission R&D Industrial Scoreboard which collects data on the world top 2500 R&D investors. We start by looking at the spectrum of all unicorns (private and exited) since 2009 which are part of the top global R&D investors. This gives a total of 64 unicorns, up from 40 in the 2018 edition of this report (Figure 3.3-23). Figure 3.3-24 shows that a large majority (80%) of these very R&D-intensive unicorns can be found in the United States, while only 5 (or 8%) are in the EU, namely Spotify (Sweden), Yandex[10] (Netherlands), Zalando (Germany), Criteo (France), and AVAST Software (Czechia). As mentioned before, there is a considerable gap between the United States and the EU in terms of the creation of unicorn companies, which is also reflected in this analysis.

Figure 3.3-23 Number of unicorns in the world top R&D investors, SRIP 2018 vs. SRIP 2020

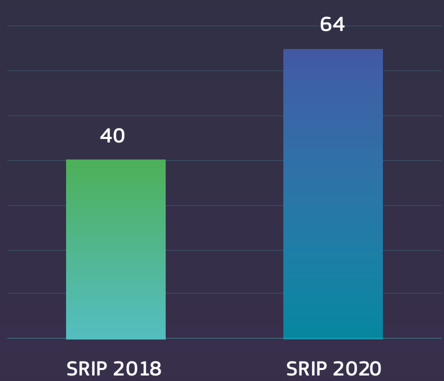
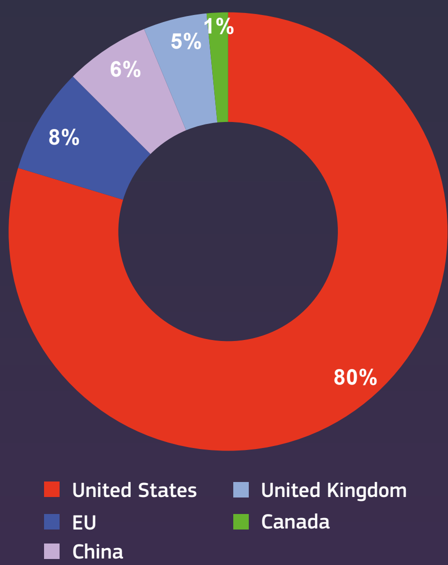


Figure 3.3-24 Geographical distribution of the 65 unicorns in the world top R&D investors



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Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit, based on CB Insights - Unicorn and Unicorn Exit Trackers; European Commission (2019), R&D Industrial Scoreboard 2018

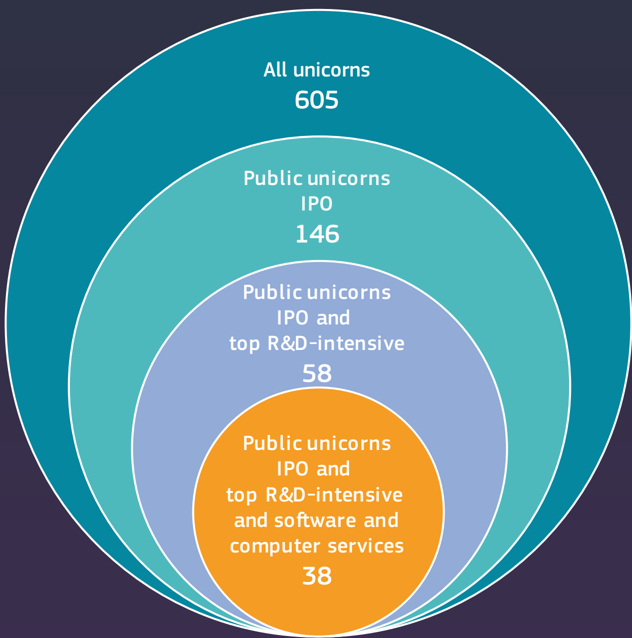
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter33/figure-33-23-24.xlsx

10 There may be methodological differences in country attribution. For instance, the R&D Scoreboard associates Yandex with the Netherlands, while Crunchbase with Russia

Guzman and Stern (2016) developed a new approach for estimating entrepreneurial quality by linking the probability of a growth outcome (e.g. achieving an IPO or a significant acquisition) as a startup characteristic observable at or near the time of the initial registration of the business. Hence, we focus on unicorn companies that are public and highly R&D-intensive (since acquired companies will not appear in the Scoreboard).

In the next stage, we focus on the software and computer services sector (since this is the sector where we found most unicorns in the R&D Scoreboard). This gives a total of 38 unicorns (Figure 3.3-25) which we then compare with the 268 companies in the R&D Scoreboard in the same sector (although there are definitely some caveats with this analysis).

Figure 3.3-25 **Zooming in on the top R&D-intensive unicorns**



Science, research and innovation performance of the EU 2020
Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit, based on R&D Industrial Scoreboard 2018, and CB Insights Unicorn Tracker (exits)
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter33/figure-33-25.xlsx

Figure 3.3-26 shows the results of this exercise. It seems that, on average, the 'top R&D unicorn investors' are more R&D-intensive, have around four times fewer employees, a negative profitability, and 1.5 times higher market capitalisation than others in the same sector.

Figure 3.3-26 Comparison of the top R&D-intensive unicorns with the top R&D-intensive companies in software and computer services

Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit, based on R&D Industrial Scoreboard 2018, and CB Insights Unicorn Tracker (exits)

Note: Higher standard deviations in R&D intensity and number of employees found for non-unicorns, but higher standard deviations in profitability and market capitalisation found for unicorns. Image © martialred, #125077712; 2019. Source: stock.adobe.com

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter33/figure-33-26.xlsx

Global Innovation Champions are radical innovators that have introduced a 'world-first' product innovation. They broaden our understanding of the state of innovation.

BOX 3.3-2 Beyond unicorns: evidence on European Global Innovation Champions

In search of European Global Innovation Champions', chapter 6 in Vértesy and Damioli (2020).

This pilot work by the Joint Research Centre provides new evidence on radical European innovator companies, in particular on the relatively small share of exporters that introduced a 'world-first' product innovation – referred to here as 'Global Innovation Champions' (GICs). Radical innovators are typically seen as important for shaping the direction of technological change and for job creation (Pianta, 2003; Lucchese and Pianta, 2012). While there is a rich body of literature on the innovative and economic performance of large corporations that account for the bulk of business R&D expenditure (Montresor and Vezzani, 2015; Bogliacino, 2014; Ortega-Argilés et al., 2009), evidence on small- or medium-sized radical innovator enterprises in Europe remains limited.

Yet, analysing European Innovation Survey data shows that about half of the European GICs are small- or medium-sized enterprises (SMEs) that are not part of a corporate group. This suggests a similarity with 'hidden champions', a term introduced by Simon (1996) to describe highly specialised SME world leaders in a niche market, which have been the subject of substantial research (e.g. Audretsch et al., 2018; Witt and Carr, 2013; Simon, 2009; Fryges, 2006). In particular, analogously to hidden champions, GICs might have specific strategies and behaviour that may easily fall under the radar in spite of their relevance for policy.

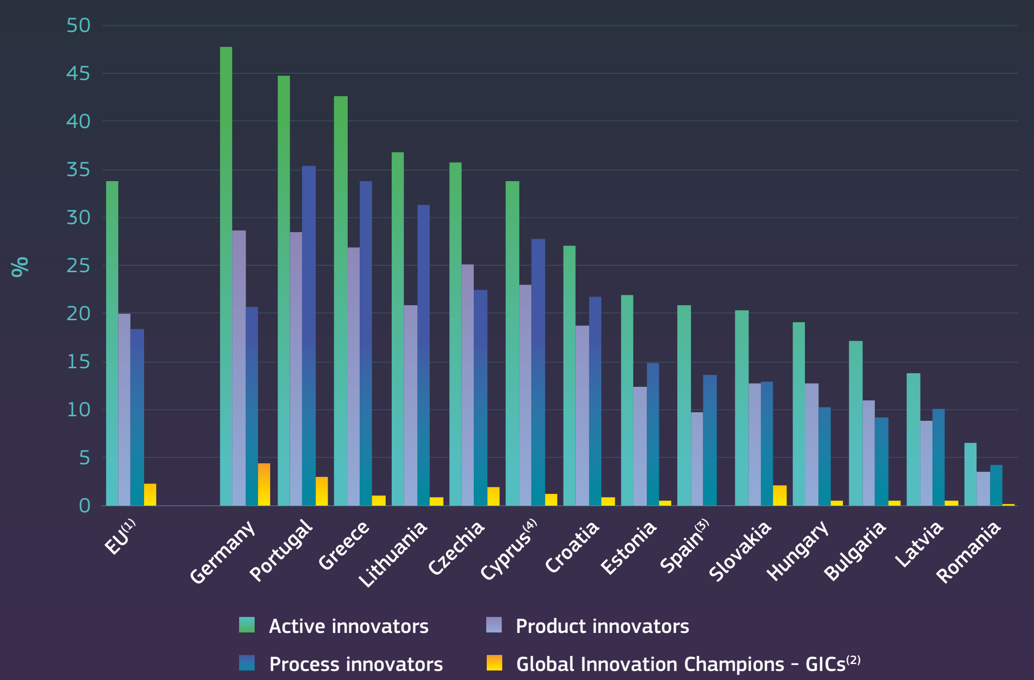
Based on Community Innovation Survey (CIS 2014) data, 1 710 companies were identified as GICs across 12 EU Member States and Norway. This implies that, on average, GICs constitute 3 % of all enterprises, 8 % of active innovators (companies that have introduced or have an ongoing product and/or process innovation) and 13 % of product innovators.

Figure 3.3-27 shows that the share of GICs is particularly high in Germany (4.4 %), and generally quite limited in eastern and Baltic Member States.

Other findings of the analysis:

- **GICs have stronger export performance than other types of innovators**: analogously to the high correlation with product innovations, this is due to the definition of GICs which requires a company to export, besides having introduced a world-first product innovation.
- Although the share of GICs over the population of general and innovative companies is larger for large ones than for SMEs, **the majority (55 %) of GICs are SMEs**.
- **GICs outperform active innovators in most IPR-related activities and MSs**, supporting the idea that the GICs definition identifies technologically intensive radical innovators.

Figure 3.3-27 Share of innovators by type (%), 2014



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Source: Figure 14 in Vértesy and Damioli (2020)

Notes: [1]EU was estimated by DG JRC based on data availability for EU Member States. [2]Global Innovation Champions are product innovators that are 'world first' and exporters, and typically leaders in niche markets. [3]CIS questionnaire does not cover 'world first' product innovation in Spain. [4]Breakdown by size not available for Cyprus.

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3. Cross-country variation in entrepreneurial attitudes in the EU: a startup gender gap remains

Four EU Member States are in the 'top 10' in the Global Entrepreneurship Index. However, the intra-EU dispersion of scores is quite significant, especially between the top and the lowest performers. The Global Entrepreneurship Index aims to assess and benchmark the 'health' of entrepreneurial ecosystems across 137 countries. It not only reflects attitudes and propensity towards entrepreneurship, but also the enabling socio-economic conditions underpinning the development of the startup ecosystem. Figure 3.3-28 shows that the top 3 enabling entrepreneurial ecosystems can be found in the United States, Switzerland and Canada. Denmark, Ireland, Sweden and France are in the top 10, while Bulgaria, Croatia and Hungary have the lowest scores at the EU level, quite a long way from the top scores. Overall, there seems to be room in most EU Member States for improving the health of their entrepreneurial ecosystems.

Figure 3.3-28 Global Entrepreneurship Index[(1)] – top 10 and positioning of EU Member States, 2018

Rank	Country	GEI
1	United States	83.6
2	Switzerland	80.4
3	Canada	79.2
4	United Kingdom	77.8
5	Australia	75.5
6	**Denmark**	74.3
7	Iceland	74.2
8	**Ireland**	73.7
9	**Sweden**	73.1
10	**France**	68.5
11	**Netherlands**	68.1
12	**Finland**	67.9
14	**Austria**	66.0
15	**Germany**	65.9
17	**Belgium**	63.7
20	**Luxembourg**	58.2
(...)Rank	Country	GEI
23	**Estonia**	54.8
25	**Slovenia**	53.8
29	**Lithuania**	51.1
30	**Poland**	50.4
31	**Portugal**	48.8
32	**Cyprus**	48.0
34	**Spain**	45.3
36	**Slovakia**	44.9
38	**Czechia**	43.4
42	**Italy**	41.4
44	**Latvia**	40.5
46	**Romania**	38.2
48	**Greece**	37.1
50	**Hungary**	36.4
54	**Croatia**	34.0
69	**Bulgaria**	27.8

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Source: Global Entrepreneurship Development Institute - Global Entrepreneurship Development Institute- 2018 Global Entrepreneurship Index

Note: [(1)]The Global Entrepreneurship Index is an annual index that measures the 'health of the entrepreneurship ecosystems' in each of 137 countries. It then ranks the performance of these against each other. The GEDI methodology collects data on the entrepreneurial attitudes, abilities and aspirations of the local population and then weights these against the prevailing social and economic 'infrastructure' – this includes aspects such as broadband connectivity and the transport links to external markets. This process creates 14 'pillars' which GEDI uses to measure the health of the regional ecosystem.

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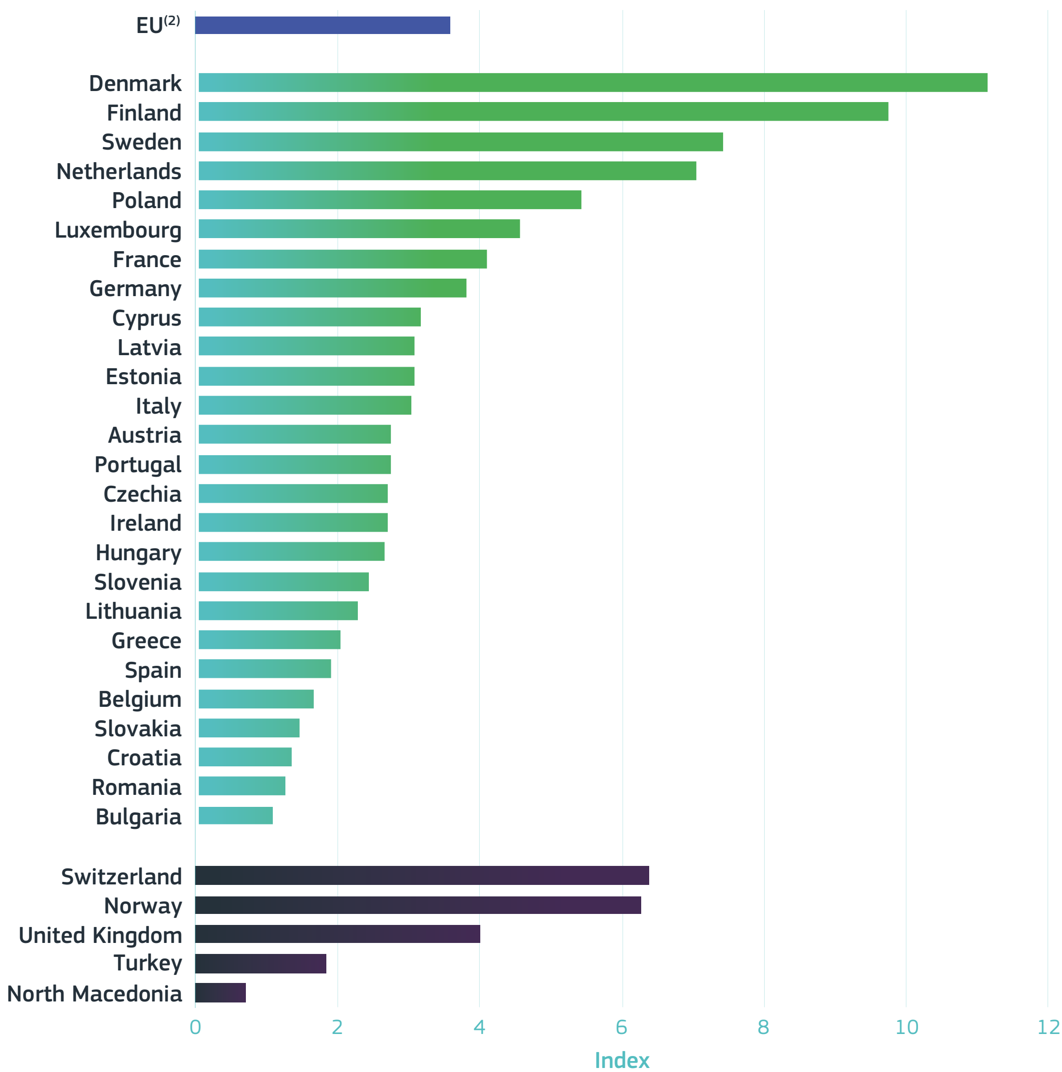
In the EU, 'innovation leader' entrepreneurs are more attracted by an opportunity in the market, while in southern and eastern European countries necessity remains an important factor driving the decision to become an entrepreneur. The Global Entrepreneurship Monitor distinguishes between entrepreneurs who *are pulled to entrepreneurship by opportunity and because they desire independence or to increase their income*, and those who are pushed to entrepreneurship out of necessity or those who sought only to maintain their income. The results are depicted in Figure 3.3-29. Building a tolerant and learning culture from 'failure', which is widespread in the EU, is also paramount when it comes to innovation.

Overall, innovation leader countries (Denmark, Finland, Sweden) exhibit a higher prevalence of opportunity-driven entrepreneurship due, in principle, to more opportunities and choices provided by the market to make a living. On the other hand, where the ratios are lowest (in countries such as Bulgaria, Romania and Croatia), it seems that necessity is still an important driver to become an entrepreneur.

Figure 3.3-29 Opportunity-driven entrepreneurship[1] by country, 2018



Source: European Innovation Scoreboard 2019

Notes: [1]The opportunity-driven entrepreneurship index is calculated as the ratio between the share of people involved in improvement-driven entrepreneurship and the share of people involved in necessity-driven entrepreneurship; three-year averages were used (EIS2019). [2]EU is the average value of Member States and does not include Malta.

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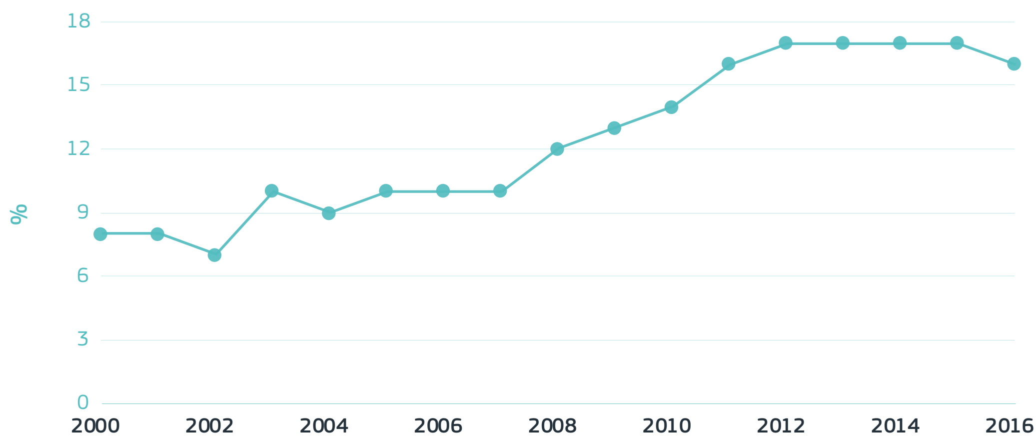
Despite some progress, a pronounced gender gap remains in the creation of innovative startups. There are also cross-country differences. Overall, female startup founders remain under-represented in the creation of startups despite having doubled their representation from 8% in 2000 to 16% in 2016 (Figure 3.3-30). Lassébie et al. (2019) show that *the gender gap in innovative high-potential startups is thus much larger than the gender gap in entrepreneurship in general*.

Moreover, a study by the Global Entrepreneurship Monitor indicated that Europe has the lowest female involvement, only 6 %, in the early stages of entrepreneurial activities. Rossetti et al. (2018) also found a gender imbalance in the Startup Europe initiative, where 90 % of digital startups supported by the Startup Europe Initiative had a male founder. This figure was found to increase with the age and the development stage of the firms.

Figure 3.3-30 **Evolution of the share of innovative startups with at least one female founder, 2000-2016**



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Source: Adapted from OECD estimates on Lassébie et al. (2019) and computed from Crunchbase data

Note: The sample is restricted to companies located in OECD, Colombia, and BRICS countries, founded between 2000 and 2017, and for which the gender of at least one founder can be identified.

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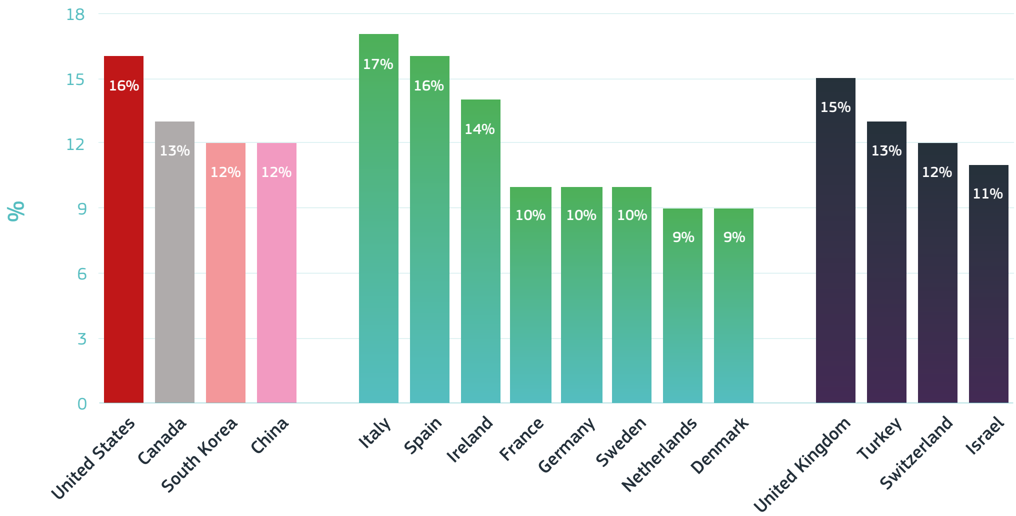
Figure 3.3-31 shows the **gender gap in startup creation across countries**. Taking into account the countries with available data, the share of innovative startups with at least one female founder is highest in the United States, Italy, Spain and the United Kingdom, and lowest in Ireland, France, Germany, Sweden, the Netherlands and Denmark.

Figure 3.3-31 Share of innovative startups founded between 2000 and 2017 with at least one female founder per country



Science, research and innovation performance of the EU 2020

Source: OECD estimates based on Lassébie et al. (2019), computed from Crunchbase data

Note: The sample is restricted to companies located in OECD, Colombia, and BRICS countries, founded between 2000 and 2017, and for which the gender of at least one founder can be identified. Figures reported only for the top 20 countries in terms of number of startups.

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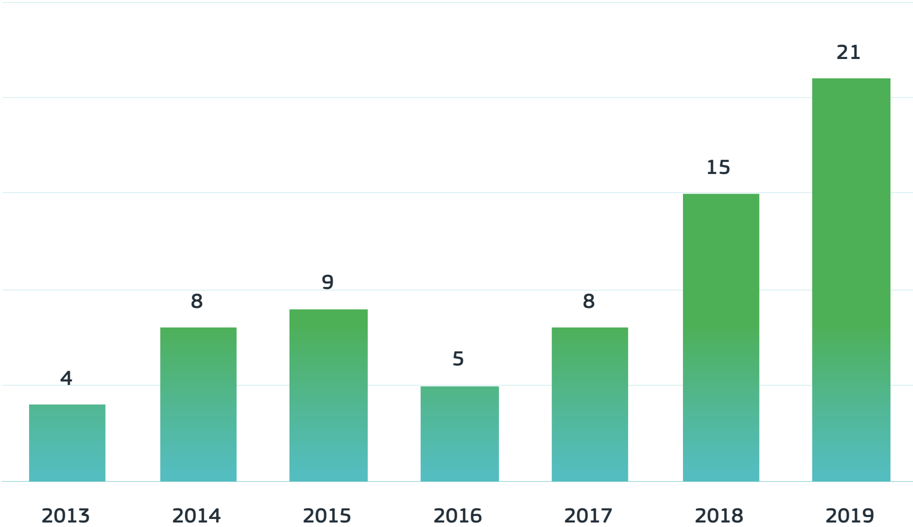
Female-founded unicorns are still rare, despite recent improvements. Figure 3.3-32 depicts the evolution of private unicorns with at least one female founder between 2013 and 2019 (until May) based on Crunchbase. It shows that the rate of new female-founded unicorns has increased at a greater speed in recent years although this remains a relatively rare phenomenon. In fact, in 2018, of the 127 new unicorns that joined the ‘unicorn leaderboard’[11], only around 9% (12) had at least one female founder.

When considering the economic and social benefits of gender balance in economic activities, understanding the reasons for the gap in female-founded startups is an issue that deserves policymakers’ attention. Verheul and Thurik (2006) showed that higher female engagement in entrepreneurial activities can improve the quality of entrepreneurship as it increases firms’ creativity and ultimately their innovation activities. Moreover, it also offers the potential for greater diversity in consumer insights, leading to the introduction of new products and processes.

The economic and social benefits being clear, Lassebie et al. (2019) summarise some of the potential explanations for the gender gap in innovative entrepreneurship in the literature. Gender differences in STEM education may explain why male founders have been more present in STEM-related (and also more tech fields) than women (see Chapter 4.1 –

11 According to CB Insights, accessed on 2 December 2019.

Figure 3.3-32 Number of unicorns[(1)] with at least one female founder, by year of first round of equity raised, 2013-2019



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Source: Crunchbase News - More Female-Founded Unicorns Were Born In 2019 Than Before, Data Shows, 18 December 2019

Note: [(1)]A private unicorn is a private company with a post-money (i.e. 'after funding') valuation of more than USD 1 billion.

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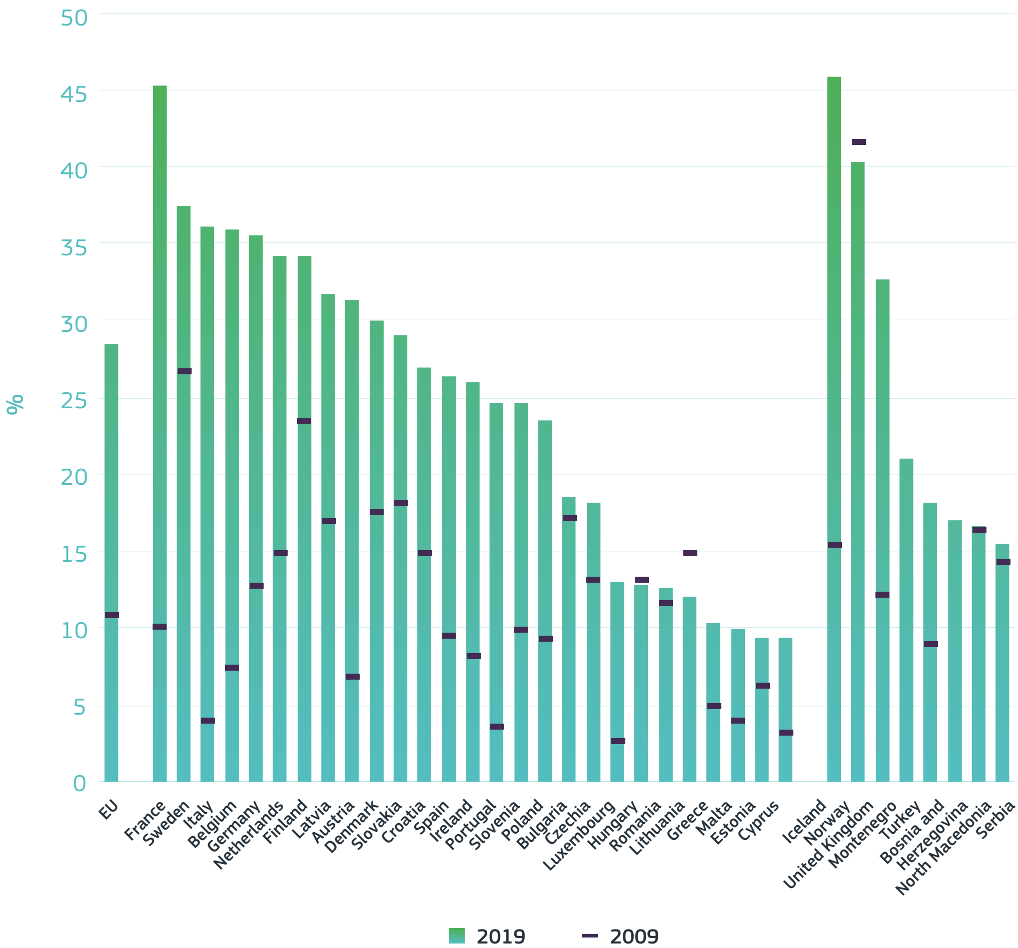
Innovation, the future of work and inequality). Furthermore, since venture capital tends to be more associated with STEM areas, this could also hint at the existing gender funding gap of innovative startups (see Chapter 8 - Framework conditions). Also, there may be factors of a sociological nature. For instance, some studies have documented differences in the personality traits ascribed to women and those attributed to the entrepreneur. This refers to, for instance, risk-taking behaviour and confidence in a negotiation. Increasing the number of female role models and mentors can raise the interest of women in the entrepreneurial path from an early age, and also balance out differences in aspirations.

A gender gap in management positions also remains in the EU and is even more evident at the top management level. However, there has been some progress over time, although substantial differences across the EU persist. According to the European Institute for Gender Equality (EIGE) and Eurostat, women accounted for 37 % of management positions in 2019, which compares with lower shares of 18 % for women as senior executives and 28.4% as board members in the largest publicly-listed companies. To note, however, that there has been progress over time. For instance, the share of women sitting on the board of the largest publicly listed companies in the EU has more than doubled in over a decade, from 10.9% in 2009 to 28.4% in 2019 (Figure 3.3-33). Nevertheless, progress at the EU aggregate level ´hides´ some differences across EU Member States. The share of women as board members is highest in France (45.2%), Sweden (37.5%) and Italy (36.1%), and lowest in Cyprus (9.4%), Estonia (9.4%) and Malta (10%).

Figure 3.3-33 Share of female board members in the largest publicly listed companies



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Source: Eurostat (sdg_05_60), based on European Institute for Gender Equality (EIGE)

Note: The indicator measures the share of female board members in the largest publicly listed companies. Publicly listed means that the shares of the company are traded on the stock exchange. The largest companies are taken to be the members (max. 50) of the primary blue-chip index, which is an index maintained by the stock exchange and covers the largest companies by market capitalisation and/or market trades. Only companies which are registered in the country concerned are counted. Board members cover all members of the highest decision-making body in each company (i.e. chairperson, non-executive directors, senior executives and employee representatives, where present). The highest decision-making body is usually termed the supervisory board (in case of a two-tier governance system) or the board of directors (in a unitary system).

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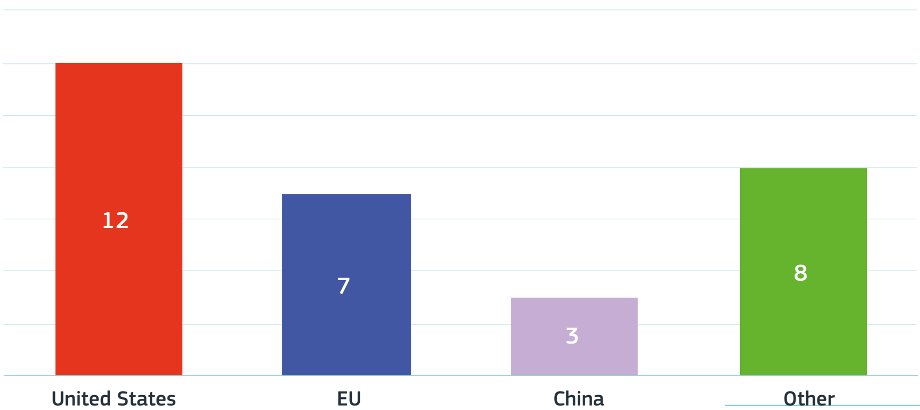
4. In the global technological race, Europe could benefit from developing its startup ecosystems further to reach a greater critical mass

The EU has seven ecosystems in the world top 30 startup ecosystems, compared to 12 in the United States and only three in China. Startup Genome (2019) uses data from over 1 million companies across 150 cities to rank startup ecosystems in terms of performance, funding, market reach, talent and startup experience[12]. Figure 3.3-34 shows that the United States leads in the number of quality startup ecosystems, with 12 in the top 30 world startup ecosystems. The EU comes next, with seven ecosystems, then China with three.

The EU's top ecosystems are Paris, Berlin, Stockholm, Amsterdam-StartupDelta, Barcelona, Dublin and Munich (Figure 3.3-35). Paris ranks high in terms of access to funding and quality, global connectedness, quality of the tech talent, and access to talent in life sciences. Berlin's relative strengths seem to be in global reach and in the quality of its tech talent. Stockholm also stands out for its global connectedness and quality of its talent. The quality of the tech talent and access to life sciences talent are key strengths found in Amsterdam-StartupDelta.

In the top 3 global startup ecosystems are two US ecosystems – Silicon Valley and New York – and London. As mentioned above, the high quality of these ecosystems across most dimensions assessed below justifies the move or relocation of unicorns originating in the EU to the United States and the United Kingdom for a greater market reach, access to funding and often to tech and life sciences talent.

Figure 3.3-34 Number of startup ecosystems in the top 30 by region, 2019

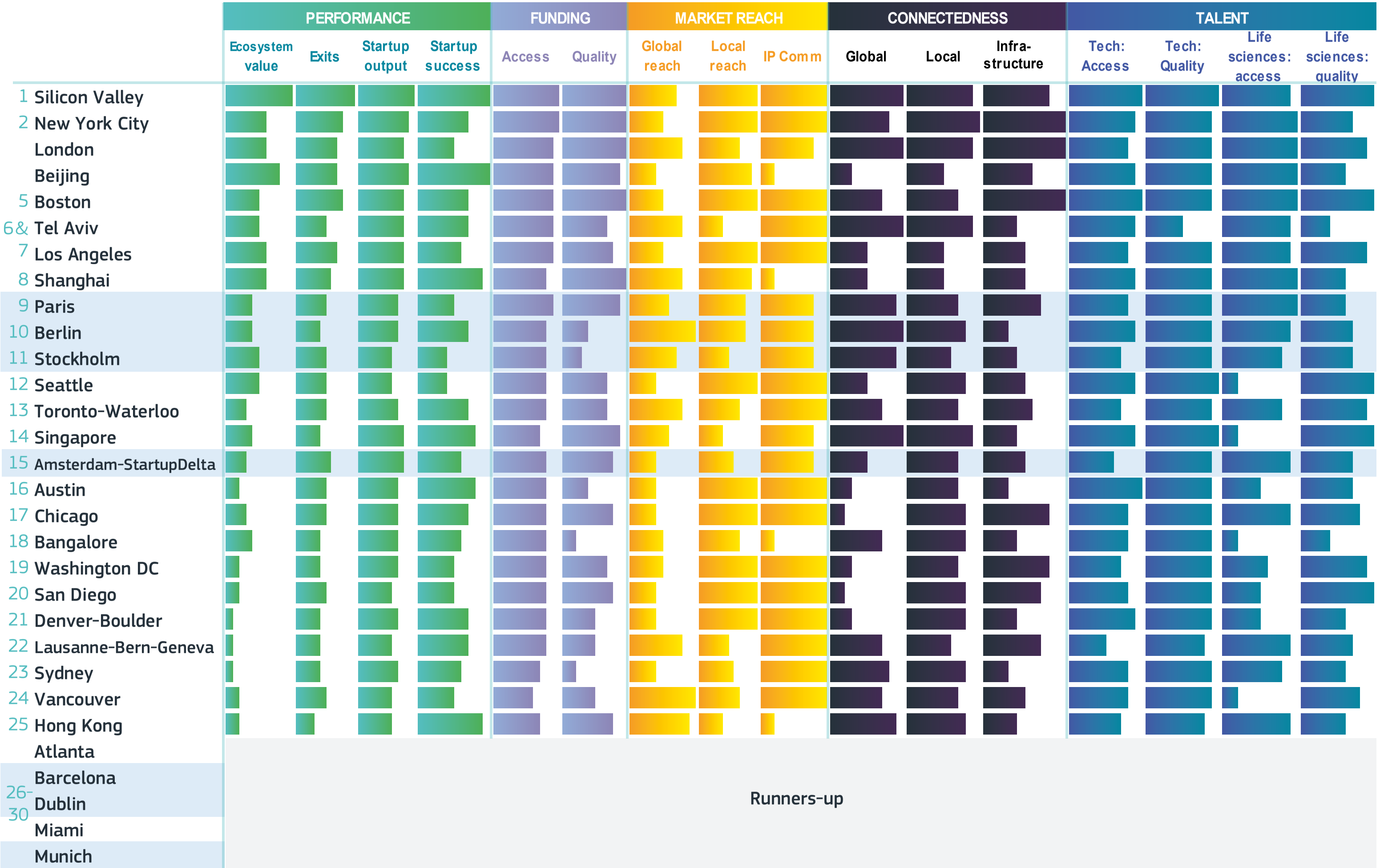


Source: STARTUP GENOME (2019), Global Startup Ecosystem Report 2019

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter33/figure-33-34.xlsx

12 Performance includes startup output, exits, valuations, early-stage success, growth-stage success, and overall ecosystem value. Funding concerns growth in early-stage investments and funding quality through the presence of experienced venture capital firms. Market reach is linked to global connectedness and global and local reach, based on the startups' proportion of foreign customers and the national GDP. Talent refers to the access, cost and quality of talent. Finally, startup experience refers to the team and ecosystem experience in terms of knowledge and networks available from which startups can develop.

Figure 3.3-35 2019 Global Startup Ecosystem Ranking, by category



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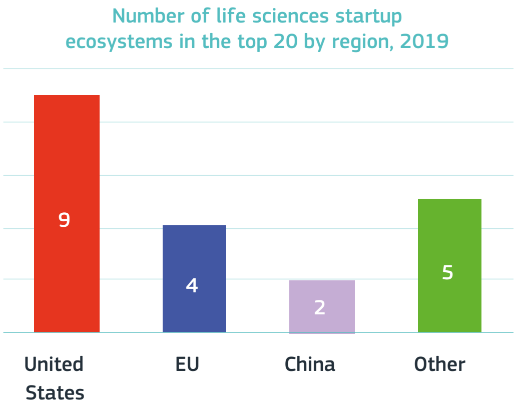
Four of the 20 most developed startup life sciences ecosystems can be found in the EU. The United States leads with nine ecosystems in the top 20. Figure 3.3-36 shows the ranking of the top life sciences ecosystems. The United States leads with nine ecosystems. The four EU ecosystems in the top 20 are Munich, Amsterdam-Startup Delta, Paris and Stockholm. China has only two ecosystems in the list.

Figure 3.3-36 Top 20 Life Sciences Ecosystems 2019, ranking and regional distribution

Ranking	Life sciences startup ecosystem
1	Silicon Valley
2	Boston
3	San Diego
4	New York City
5	London
6	Los Angeles
7	Lausanne-Bern-Geneva
8	Jerusalem-Tel Aviv
9	Shanghai
10	Washington DC
11	Beijing
12	Chicago
13	Seattle
14	Munich
15	Amsterdam-StartupDelta
16	Paris
17	Toronto-Waterloo
18	Stockholm
19	Singapore
20	Austin



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Source: STARTUP GENOME (2019), Global Startup Ecosystem Report 2019

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Even though the EU trails behind the United States in some aspects related to the quality of startup ecosystems, the EU is a leader in terms of fast-growing ecosystems across different maturity phases. Figure 3.3-37 depicts the top high-growth ecosystems in the world by phase of the ecosystem life cycle, namely activation, globalisation and attraction[13]. The EU leads with one fast-growing ecosystem – Western Denmark – in the activation phase, three in the globalisation phase – Paris, Antwerp and Copenhagen – and two in the attraction phase – Amsterdam-StartupDelta and Stockholm. The six EU high-growth ecosystems compare with none in the United States and three in Asia.

Figure 3.3-37 Fastest-growing ecosystems[(1)] by maturity phase of the ecosystem life cycle[(2)]

	Fastest-growing ecosystems by phase
Activation	1 Western Denmark
	2 Belgrade and Novi Sad
	3 Taipei City
	4 Atlantic Canada
	5 Manila
Globalisation	1 Paris
	2 Montreal
	3 Antwerp
	4 Sydney
	5 Copenhagen
Attraction	1 Amsterdam-StartupDelta
	2 Bangalore
	3 Stockholm

Source: STARTUP GENOME (2019), Global Startup Ecosystem Report 2019

Notes: [(1)]Based on growth in funding, exits and number of startups. [(2)]The Global Startup Ecosystem report defines four main phases in the life cycle of a startup ecosystem: activation, globalisation, attraction, integration.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter33/figure-33-37.xlsx

The top 'ecosystems to watch' in the EU are notably present in fintech, cleantech, agritech and advanced manufacturing and robotics. The EU lags behind in blockchain and artificial intelligence. Figure 3.3-38 displays the top 'ecosystems to watch' by technology field, according to Startup Genome. The EU stands out in fintech with seven ecosystems to watch – Berlin, Copenhagen, Estonia, Frankfurt, Lithuania,

13 According to Startup Genome, the activation phase is characterised by limited startup experience, low startup output of around 1 000 or fewer startups. The globalisation phase means that increased startup experience led to the production of a series of regionally impressive 'triggers', usually over USD 100 million, and with an output of 800 to 1 200 startups. Finally, in the attraction phase, there are usually more than 2 000 startups (depending on population), a series of globally impressive triggers that could be unicorns, and exits above USD 1 billion which generate global resource attraction. At this stage, very few success factor gaps remain.

Madrid and Paris. This compares with only three in the United States. As regards cleantech, the Amsterdam-StartupDelta and Stockholm stand out. In agritech and new food, the Amsterdam-StartupDelta also stands out, as does the Mid-East region of Ireland. Furthermore, three EU ecosystems – Paris, Rhineland and Western Denmark – emerge in the field of advanced manufacturing and robotics.

However, where the EU seems to lag behind is in the fields of blockchain and artificial intelligence (see Chapter 7 - R&I enabling artificial intelligence). In the case of AI, only Berlin and Greater Helsinki are mentioned.

Figure 3.3-38 Top 'ecosystems to watch'[(1)] in selected technology fields, by region

Technology field	Region	'Ecosystems to watch'
Fintech	European Union	Berlin
		Copenhagen
		Estonia
		Frankfurt
		Lithuania
		Madrid
		Paris
	United States	Chicago
		New York City
		Silicon Valley
	Other	São Paulo
		Bahrain
		Tel Aviv
		London
		Nur-Sultan
		Bengaluru
		Beijing
		Jakarta
		Manila
		Singapore
		Sydney
		Tokyo
Cleantech	European Union	Amsterdam-StartupDelta
		Stockholm
	United States	Houston
		New York City
		Silicon Valley
		Austin
	Canada	Calgary
		Vancouver

Technology field	Region	'Ecosystems to watch'
Agritech & new food	**European Union**	Amsterdam-StartupDelta
		Mid-East Region, Ireland
	United States	Denver-Boulder
		New York City
		Silicon Valley
	Other	London
		New Zealand
Advanced manufacturing & robotics	**European Union**	Paris
		Rhineland
		Western Denmark
	United States	Boston
		New York City
		San Bernardino County
		Silicon Valley
	Other	Montreal
		Tel Aviv
		Shenzen
		Taipei City
		Tokyo
Blockchain	**United States**	Silicon Valley
		New York City
	Canada	Toronto-Waterloo
		Vancouver
	Other	London
		Belgrade and Novi Sad
		Singapore
Artificial Intelligence	**European Union**	Greater Helsinki
		Berlin
	United States	Silicon Valley
		Boston
		Chicago
		Houston
		New York City
		Seattle
	Other	Edmonton
		Montreal
		Québec City
		London
		Tel Aviv
		Jerusalem
		Beijing
		Taipei City

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Source: STARTUP GENOME (2019), Global Startup Ecosystem Report 2019

Note: [1]According to STARTUP GENOME criteria based on startup output, exits, and funding.

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5. Presence of zombie firms is still problematic in some Member States, while others have undertaken a de-leveraging process

Rigidities in the market limiting their well-functioning may lead to capital and resources locked in so-called 'zombie firms'. This means that these resources could have improved economic performance had they been redirected towards higher-productivity firms. Overall, the shares of zombie firms have increased in the aftermath of the crisis and while there has been progress in some countries in recent years via, for example, a more effective deleveraging process, in others zombie firms continue to rise, especially in the services sector. Zombie firms are companies that survive in the market without being profitable in the long run because of external support that 'keeps them artificially alive' (European Commission, 2018). The consequence is the use of resources by non-productive firms that might otherwise have been used by more-productive companies, ultimately leading to productivity growth.

Figure 3.3-39 shows the **evolution of the average shares of zombie firms during three different periods, both in manufacturing and services**[14]. Right in the aftermath of the crisis (i.e. 2008-2010) the shares of zombies in the manufacturing sector were highest in Portugal, Italy and Spain, and zombie firms were mostly prevalent in the services sector in Portugal, Sweden and Spain. Looking at their evolution over time, overall shares have continued to rise, particularly in the services sector; exceptions include Portugal, for example. Even though the incidence of zombie firms is typically higher in manufacturing, the gap with services is limited apart from Finland.

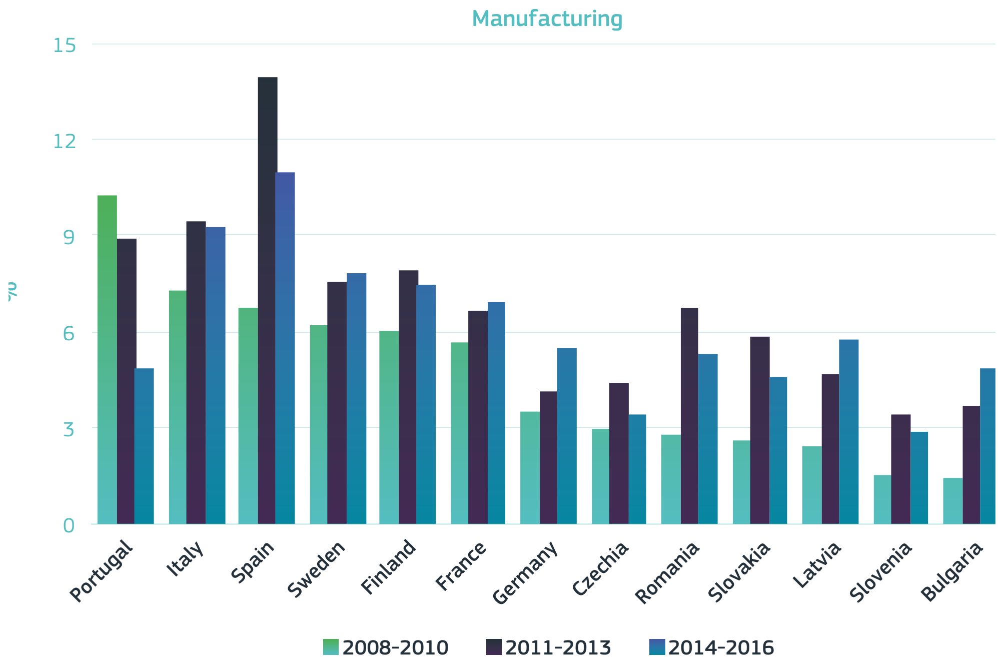
The EU Member States with the highest incidence of zombie firms in the period 2011-2013, namely Spain, Italy and Portugal, have more recently experienced a decline in their share across sectors, the largest drop being reported by Portugal. This phenomenon was accompanied by an increase in the firms' profitability as well as the de-leveraging of zombie firms[15]. Since 2013, the weight of zombie firms has been on the decline in Spain, Italy and Portugal, for all the sectors covered by Figure 3.3-39. These EU Member States had the highest shares in 2008-2010.

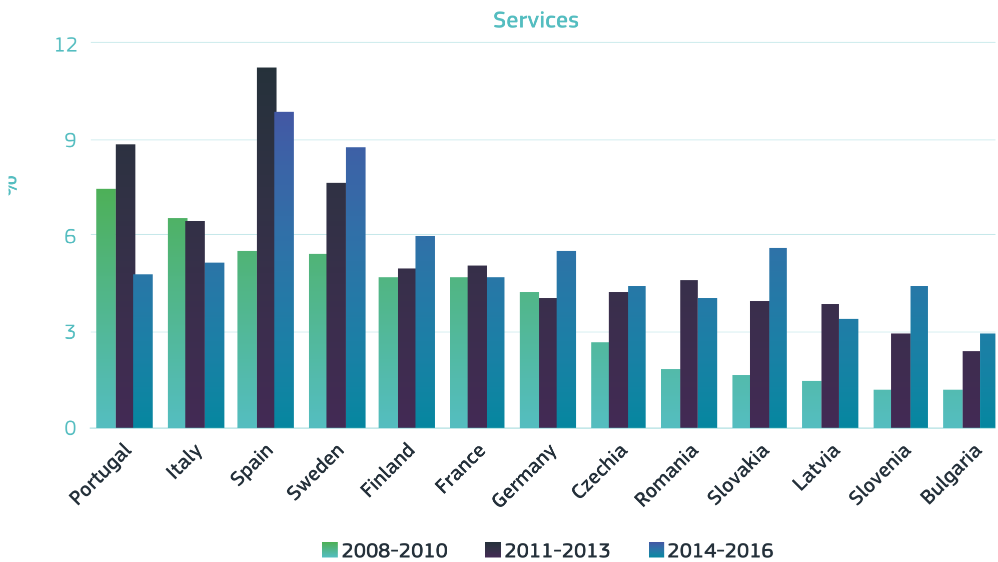
Zombie firms were found mainly in the construction – real estate sector but were less common in the information and communication sector. Portugal, in particular, saw the largest drop in zombie firms after 2013.

14 See Bauer et al. (2020).

15 Source: Hallak et al. (2018).

Figure 3.3-39 Evolution over time of the share of zombie firms[1] in total firms in the manufacturing and services sectors[2], 2008-2016





Source: JRC estimations based on Orbis data

Notes: [1]A zombie firm is a firm that is at least 10 years old and has an interest coverage ratio below 1. This latter term suggests that the firm does not make enough profit to pay debt obligations on bank loans. This is the OECD definition. [2]The figure reports the time variation of the share of zombies in each country in our sample. We report three-year averages in manufacturing and services in the periods: 2008-2010 (left), 2011-2013 (middle), 2014-2016 (right). Countries are sorted by the zombie shares in the figure according to the last period 2014-2016.

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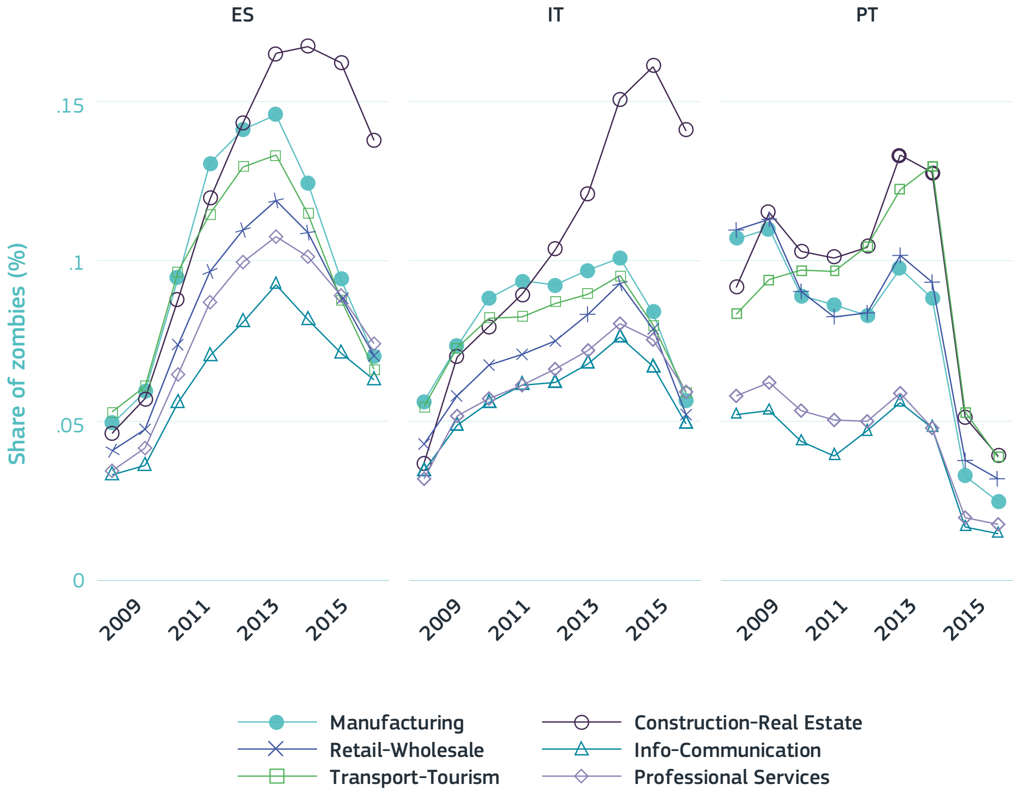
Figure 3.3-40 Evolution over time of the share of zombie firms(1) in Spain, Italy and Portugal(2) by sector, 2008-2016



Source: JRC estimations based on Orbis data

Notes: (1)A zombie firm is a firm that is at least 10 years old and has an interest coverage ratio below 1. This latter term suggests that the firm does not make enough profit to pay debt obligations on bank loans. This is the OECD definition. (2)The figure reports the yearly share of zombies in Spain, Italy, and Portugal in the period 2008-2016, in six broad sectors. Italy, Spain and Portugal report the top three zombie shares in the sample in the period 2011-2013.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter33/figure-33-40.xlsx

6. A 'tech-for-good' approach to match the urgent challenges of our time

Technological progress is behind many scientific and technological breakthroughs that have, for instance, significantly increased life expectancy worldwide from just 34 years in 1913 to 60 in 1973 and 71 in 2019. Incomes have risen and technology has also 'freed' workers from certain routine and/or dangerous tasks, thereby providing more leisure time[16]. But living longer also means that there is a greater concern about living healthier lives and improved well-being. Economic growth has also benefitted strongly from technologies that have boosted resource efficiency and productivity across all sectors (see Chapter 3.1 - Productivity puzzle and innovation diffusion).

While innovation has resulted in greater choice from the growth in products and services, there is an ongoing debate as to whether all innovation has created value (and proven its relevance) for society. Kalff and Renda (2020) revised academic literature on the role of innovation and noted that 'not all innovation is equally relevant for society', arguing that entrepreneurship and innovation should be the means to address the most pressing challenges of our time (see Chapter 1 - Megatrends and sustainability).

Moreover, tech with a social purpose can also drive profit as consumers are now demanding a shift in the mission of businesses towards social good[17]. As highlighted in Chapter 2 - Changing innovation dynamics in the age of digital transformation, consumers increasingly want social impact to be integrated into companies' missions so as to achieve 'economic value that is inclusive and sustainable'[18]. Putting the emphasis on responsible and ethical tech does not mean that products and services will not be scalable. On the contrary, it provides a business model in which consumers will have more trust. As a result, it also creates new opportunities for profit that can maximise social value, too.

Activating a global mindset which directs innovation activities towards solutions that effectively address societal challenges is challenging but certainly necessary and collectively achievable. The World Economic Forum (2020) refers to a set of enablers which include: responsible technology governance, leadership to mobilise commitment and standards, partnerships for collaboration and collective action, public policy and regulation for the Fourth Industrial Revolution, finance mechanisms to stimulate market solutions, breakthrough innovation, including collaborative R&D agendas, managing data and tools, and capacity development and skills. The EU is well-positioned to lead in this 'tech-with-a-purpose' approach thanks to its new growth strategy – the EU Green Deal – the prominence of the partnership approach in its Framework Programmes, the support of market-creating innovation with the European Innovation Council (EIC), etc.

16 https://www.mckinsey.com/featured-insights/future-of-work/tech-for-good-using-technology-to-smooth-disruption-and-improve-well-being

17 https://technation.io/insights/tech-for-social-good/

18 https://www.weforum.org/agenda/2020/01/davos-2020-heres-what-you-need-to-know-about-tech-for-good/

7. Conclusions

Business dynamism plays an important role in promoting creative destruction in the economy, which may ultimately raise productivity growth. For this reason, **the decline of business dynamism (notably in terms of entry rates) in Europe and other parts of the globe may hamper current and future productivity growth**, although the reasons for such a decline can be multiple. Moreover, **most jobs created by new firms emerged in less-productive sectors of the economy and hence were, in principle, lower-paid jobs**. However, in some countries there has been progress towards new job creation in more-productive sectors.

Europe´s scaling-up performance needs to be revamped. While the share of high-growth enterprises has increased over time in most EU Member States, there is only a small share in high-tech, medium-high-tech manufacturing and high-tech knowledge-intensive services, although this has increased in recent years. Furthermore, our analysis shows that **when it comes to tech scaleups and unicorn companies, a pronounced scaling-up gap remains when compared to the United States and (sometimes) China**. In particular, 1.3 scaleups per 100 000 inhabitants in the EU compares with 7 scaleups in the United States. Moreover, for each private unicorn in the EU, there are seven in the United States and four in China. In other words, the EU only accounts for around 7 % of all private unicorns worldwide. The EIC in Horizon 2020 and Horizon Europe, the VentureEU programme, and the different financial instruments available via the European Investment Bank aim to tackle the scaling-up needs in terms of capital among EU startups. Europe should capitalise on its strong science and richness of ideas for innovation to play a role on the global scene **reflecting the EU's values and ambitions to lead in the fight against climate change, healthy societies, and in the digital age**, to name but a few. Indeed, **a tech-with-a-purpose approach could integrate social and environmental concerns in businesses' missions to ensure that new products and services bring** both economic and societal value.

The **New Industrial Strategy for Europe**[19] stresses that 'relevant players should work together to create lead markets in clean technologies and ensure our industry is a global frontrunner'. This includes regulation, public procurement, rules for fair competition and involving SMEs, too. In addition, the Strategy also encourages place-based innovation and experimentation so that regions can develop and test new solutions with the involvement of both SMEs and consumers, capitalising on their local strengths and specificities.

Our research also identifies a group of 'EU DNA' unicorns that have started or moved their operations to the United States and the United Kingdom because of the greater availability of capital, the intense network, market size and other benefits. However, EU DNA unicorns tend to keep strong connections 'back home'. Although this could be seen as a normal consequence of globalisation and the new phenomenon of 'dual companies', at the same time it reflects the lower availability of risk capital in the EU and barriers to scaling up related to the yet to be fully completed Single Market. In addition, in the digital age, digital infrastructure, notably 5G, will also be a determinant in shaping innovation and its speed in the future. Research and other physical infrastructure also play an important role.

19 https://ec.europa.eu/commission/presscorner/detail/en/ip_20_416

Although there are resilient, high-quality and interconnected ecosystems in the EU, the United States still appears to lead globally. The EU has fewer startup ecosystems in the top world ecosystems, including in the life sciences. However, Europe appears to score well in fintech, cleantech, agritech and advanced manufacturing and robotics. By incentivising science-business collaboration, creating and attracting talent, pooling public and private resources, promoting strategic public-private partnerships, etc. the EU can reach greater critical mass and lead the way.

There is substantial cross-country variation in entrepreneurial attitudes in the EU. This calls for a culture of more tolerance towards startup failure, widespread entrepreneurship education, and improving the business environment in aspects including the ease of starting a business, availability of capital, innovation-friendly regulations, etc. The European Institute of Technology and the different Knowledge and Innovation Communities have also played an important role in this respect.

A pronounced startup gender gap remains in the creation of innovative enterprises worldwide, including in Europe. The share of female (co)-founders is still low, despite some progress over time. This calls for policies promoting the wider involvement of women in entrepreneurial activities, starting at an early age at school, the promotion of 'female role-models', a better work-life balance, greater female participation in STEM activities, and tackling the documented gender bias in the attribution of private funding, among other aspects.

Zombie firms remain prevalent in some Member States, especially in services. Although there has been a delivering process in some countries since the crisis, in others the presence of zombies has been aggravated. This requires careful consideration of the economic and financial conditions in each country.

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