CHAPTER
1.6

ENTREPRENEURSHIP AND STRUCTURAL CHANGE

Dynamic business environments that enable the birth and growth of innovative firms as well as the orderly exit of non-performing companies are crucial for innovation to flourish and be scaled up. Entrepreneurship, notably transformational entrepreneurship[1], allows innovations to be brought on to the market to transform our economies by making them more productive. Flourishing innovation systems should support profound changes in our economic structures towards more productive, knowledge-based activities, enabling the economic and social impacts that support higher levels of prosperity in society.

Against this backdrop, this chapter assesses Europe's ability to build innovation-led transformational entrepreneurship as well as to shift its economic structure towards more productive, knowledge-intense activities.

1 Transformational entrepreneurship relates to those new businesses which, from the outset, have the ambition to become big, which provide "disproportionally large contributions to net job creation" (Haltiwanger, 2014), and that invest proportionally more in R&D than older ones (Surowiecki, 2016).

CHAPTER I.6-A: TRANSFORMATIONAL ENTREPRENEURSHIP

Transformational entrepreneurship contributes to upgrading the economic structure and fosters economic and productivity growth, competitiveness and job creation.

Start-ups, especially technology-enabled ones, are based on new and innovative business models that introduce product and process innovations[2] and hence bring new ideas and products on to the market. Due to their innovation-led nature, these young firms tend to grow much faster than other companies and contribute disproportionately to net employment creation (Criscuolo et al., 2014). Moreover, they also stimulate economic dynamism by increasing competition in the markets where they operate by forcing their competitors to adapt or exit the market through an efficient resource-allocation process of labour and capital that has the potential to increase productivity growth in the overall economy ('creative destruction'[3]). However, the creation and scale-up of start-ups is very dependent on certain framework conditions, such as the regulatory and administrative framework, access to risk finance, the existence of networks and collaborative arrangements to access knowledge, the availability of highly skilled human capital, and a vibrant entrepreneurial culture underpinning the development of these activities (OECD, 2014).

In this section, we assess whether innovation-led entrepreneurship is flourishing in Europe and leading to structural change. a comparative analysis of business dynamism and high-growth, scale-up and the 'transformational' potential of European firms relative to other major economies is provided alongside an assessment of the main barriers hampering innovative entrepreneurship in Europe and the most suitable policy responses to overcome them[4].

Despite significant differences across Member States, Europe fares well in traditional measures of entrepreneurship, such as start-up rates.

Figure I.6-A.1 shows the start-up rates in 2009 and 2015 (or latest available year), i.e. the number of new and young companies (up to two years old) relative to the total number of employer enterprises in those given years. In addition, start-up rates in the overall economy are compared to those in high- and medium-high-tech sectors as well as in knowledge-intensive services (KIS) relative to the employer enterprises in those sectors.

In the latest available year, start-up rates associated with both the overall economy and knowledge-intensive services (KIS)[5] were higher in the EU than in the United States[6],

2 EC Communication (2016).

3 Schumpeter (1942).

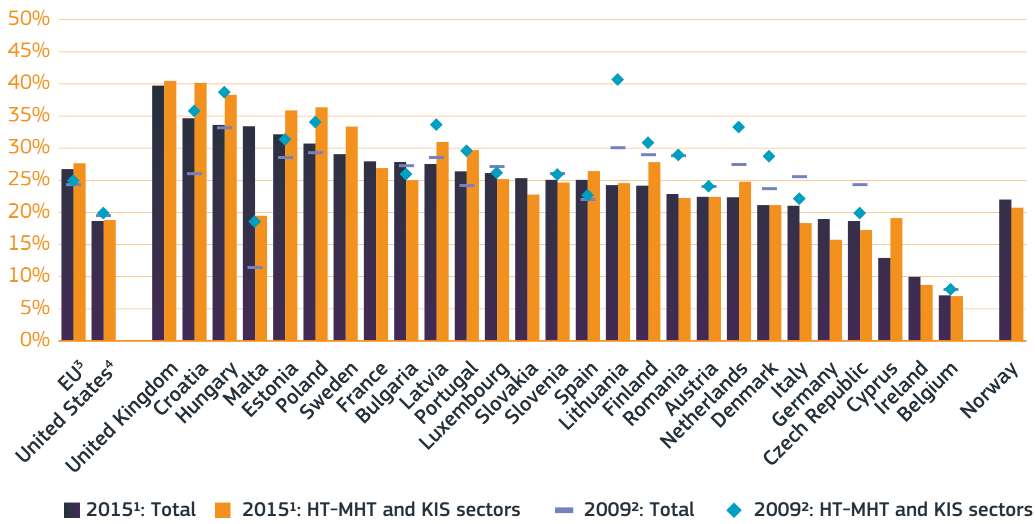
4 Some caveats in this analysis include the rapid pace of change, the impact of the crisis, availability of data for comparison purposes, and data issues related to the measurement of entrepreneurship, including in knowledge-intensive sectors.

5 Knowledge-intensive sectors include high-tech and medium-high-tech manufacturing and knowledge-intensive services in NACE Rev. 2 at the two-digits level. Please refer to the Annex for a more details.

6 For the EU Member States, either 2012, 2014 or 2015; for the United States, 2012. However, Kauffman Foundation's 'Index on Start-up activity' points to a recovery in enterprise creation in the United States since 2013 (see: http://www.kauffman.org/kauffman-index/profiles?loc=US&name=united-states&breakdowns=growth|overall,start-up-activity|overall,main-street|overall#indicator-panel-se-index).

while start-up rates in KIS were slightly above those in the overall EU economy (25.9 % vs. 23.6 %). This points to the dynamism of this sector in terms of enterprise creation and to its potential to foster structural change. However, there are different patterns in the evolution of start-up rates between 2009 and 2015 (or latest available year): some Member States, such as Croatia, Malta, Estonia, Poland, Portugal and Spain managed to increase their start-up rates between 2009 and 2015; in others, such as Hungary and Belgium, start-up rates remained relatively stable; and most EU Member States actually contracted their share of share of start-ups in knowledge-intensive sectors during this period. This was particularly the case in Lithuania, the Netherlands, Denmark and Romania.

Figure I.6-A.1 Start-ups (0 to 2 years old) as % of employer enterprises, 2009 and 2015



Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies
Data: Eurostat, OECD
Notes: [1]BG, CZ, DE, ES, FR, HR, IT, LV, HU, AT, PL, SK, SE, NO: 2014; BE, DK: 2013; CY, US: 2012. [2]BE, BG, HR, LU, MT, PL, FI: 2012; DK, HR, LU, MT, PL, FI: 2012. [3]EU was estimated by DG Research and Innovation. [4]US: OECD ISIC3 classification was used.
[5]Data refer to employer enterprises statistics.
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-a_figures/f_i_6-a_1.xlsx

However, the share of new companies in knowledge-intensive sectors has been declining in most EU Member States, with some notable exceptions.

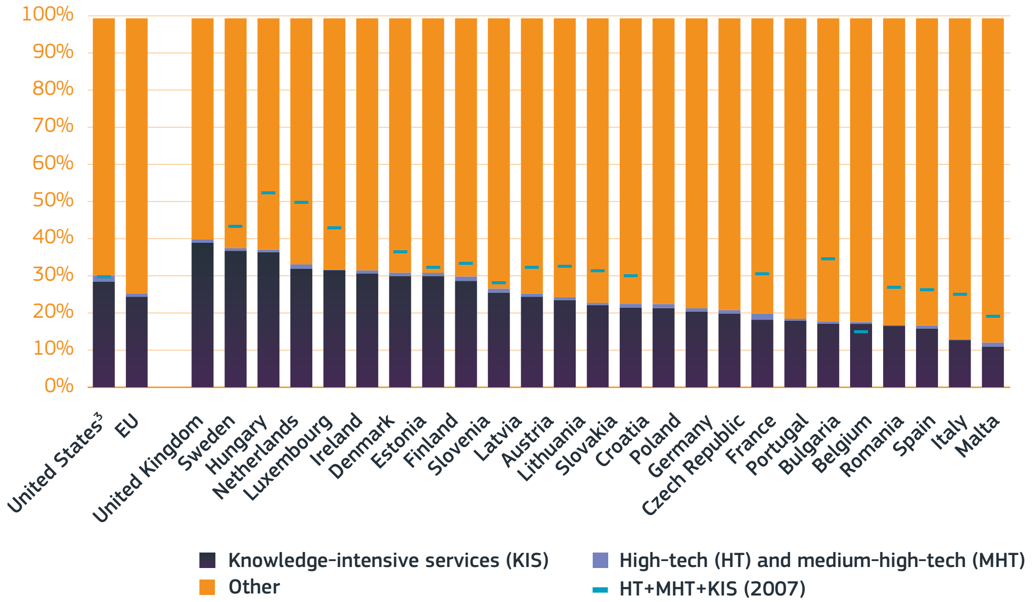
The crisis seems to have interrupted the path of structural change led by more innovative entrepreneurship, albeit with some signs of recovery more recently. As mentioned above, higher start-up rates in knowledge-intensive sectors compared to the overall economy could induce economic transformation in Europe. Nevertheless, Figure I.6-A.1 shows that these start-up rates have declined in most EU Member States, most probably due to the negative impact of the crisis. This is somehow corroborated by Figure I.6-A.2 where the share of enterprise births in knowledge-intensive sectors in total enterprise births is depicted before and after the onset of the economic and financial crisis[7].

With a few exceptions among EU Member States, the majority experienced a decline in the share of births in knowledge-intensive sectors after 2007, although most also seem to show some signs of recovery in 2015 with an increase in the proportion of births in knowledge-intensive sectors. Since the service sector is typically more dynamic than manufacturing, it is not surprising that the bulk of innovative births were markedly concentrated around knowledge-intensive services, since they are typically more dynamic and have less fixed costs than manufacturing. The Czech Republic and Finland had the highest birth shares in high-tech and medium-high-tech sectors in 2015. Overall, the United Kingdom, Sweden and Hungary stand out as EU Member States where the share of births in knowledge-intensive sectors was above 35% of total enterprise births in 2015. New firms in knowledge-intensive sectors seem to be flourishing more in the United States than in the EU, including in high-tech and medium-high-tech sectors[8].

7 Please note that in 2007 there was a break in series so this analysis needs to be done bearing that in mind.

8 Note that for the United States, employer enterprise statistics were used, while for EU Member States the data concern total active enterprises so the results should be assessed with caution when making comparisons.

Figure I.6-A.2 Employer enterprise births by type of enterprise as % of total employer enterprise births, 2015[1] (and for 2007[2] total HT+MHT+KIS)



Science, Research and Innovation performance of the EU 2018

Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies

Data: Eurostat, OECD

Notes: [1]US: 2012; BE, DK: 2013; BG, CZ, DE, ES, FR, HR, IT, LV, HU, AT, PL, SK, SE, EU: 2014. [2]US: 2008; BG, DK, MT: 2006. [3]US: OECD ISIC3 classification was used. [4]Elements of estimation were involved in the compilation of the data.

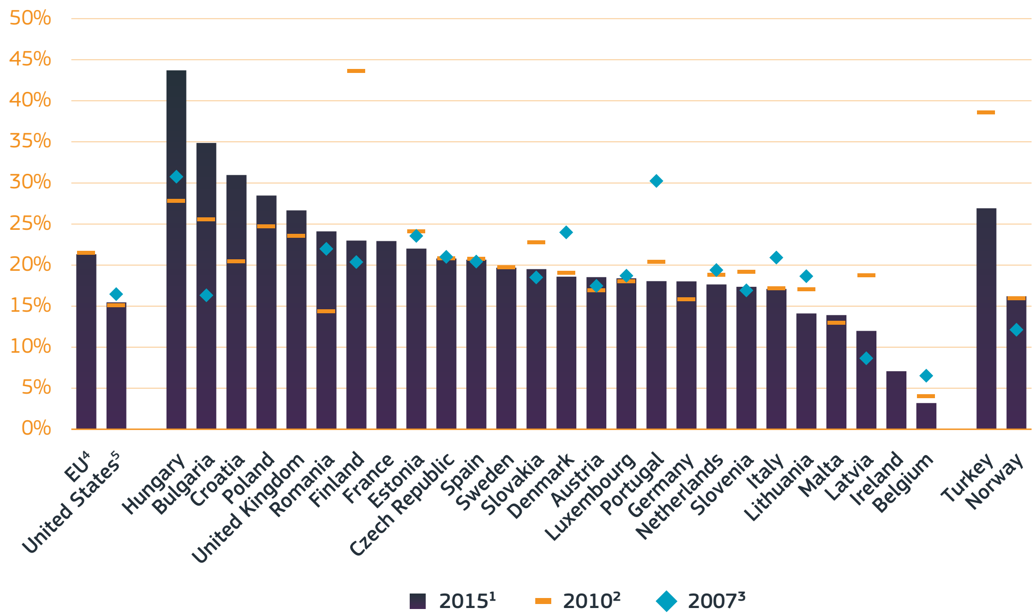
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-a_figures/f_i_6-a_2.xlsx

The EU also scores well in business dynamism, including in KIS.

Figure I.6-A.3 depicts the evolution of business churn in both the EU and the United States since 2007 related to employer enterprises. Churn rates correspond to the sum of company birth and death rates in a given country relative to the total number of employer enterprises. This measure of 'economic dynamism' shows how often new firms are created and existing enterprises closed, which can be associated with the so-called Schumpeterian process of 'creative destruction' whereby resources (i.e. capital and labour) are allocated to the most efficient firms which increases overall productivity growth.

On average, business dynamism in the EU remained relatively stable between 2010 and 2014 and above the United States in the latest year available (EU: 18.6 %; United States[9]: 15.5 %). However, the range of variation across EU Member States remains large, with Hungary (43.7 %), Bulgaria (34.9 %) and Croatia (31 %) registering the highest churn rates, and the lowest business churn being in Belgium (3.2 %), Ireland (7.1 %) and Latvia (12 %).

Figure I.6-A.3 Churn rates (birth rate plus death rate) of employer enterprises, 2007, 2010 and 2015



Science, Research and Innovation performance of the EU 2018

Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies

Data: Eurostat, OECD

Notes: [1]US: 2012; BE, DK, PL: 2013; BG, CZ, DE, ES, FR, HR, IT, LV, HU, MT, AT, SK, SE, NO, TR: 2014. [2]BE, BG, DK, DE, HR, MT, PL, SK, FI, SE, UK, NO, TR: 2012. [3]BG, DK, NO: 2005; EE, ES, LV, NL, SK, FI: 2006; US: 2008. [4]EU was estimated by DG Research and Innovation. [5]US: OECD ISIC3 classification was used.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-a_figures/f_i_6-a_3.xlsx

9 Due to data availability issues, data for the United States corresponds to 2012 so some caution is needed when assessing this result.

Figure I.6-A.4 highlights the fact that business churn also seems to be higher in Europe than in the United States when it comes to high-, medium-high-tech and knowledge-intensive services sectors.

Figure I.6-A.4 Employers' enterprise churn rates (birth rate plus death rate) - EU and the United States

Churn rates	EU[1]							
	2008	2009	2010	2011	2012	2013	2014	2015
Total economy	:	:	:	:	:	:	21.4	21.3
High-tech, medium-high-tech and knowledge instensive services	:	:	:	:	20.0	20.3	20.7	:

Churn rates	United States[1 2]							
	2008	2009	2010	2011	2012	2013	2014	2015
Total economy	16.5	14.9	15.1	15.5	15.5	:	:	:
High-tech, medium-high-tech and knowledge instensive services	15.9	14.4	14.6	15.1	15.3	:	:	:

Science, Research and Innovation performance of the EU 2018

Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies

Data: Eurostat, OECD

Notes: [1]Estimates were included in the compilation of the data. [2]US: OECD ISIC3 classification was used.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-a_figures/f_i_6-a_4.xlsx

Europe outperforms the United States in the share of high-growth firms.

Figure I.6-A.5 shows that, according to the most recent data available, European firms have managed to foster their high-growth potential more significantly relative to American firms when it comes to growth of 20% or more in employment. This share was 4.3% in the EU and 2.9% in the United States for the overall economy, and is estimated to be 7.2% in the EU and 4.5% in the United States specifically in knowledge-intensive sectors in the latest year available. Indeed, according to the Kauffman Foundation (2016)[10], high-growth entrepreneurship seems to have slowed down in the United States although some signs of recovery were reported in 2013[11].

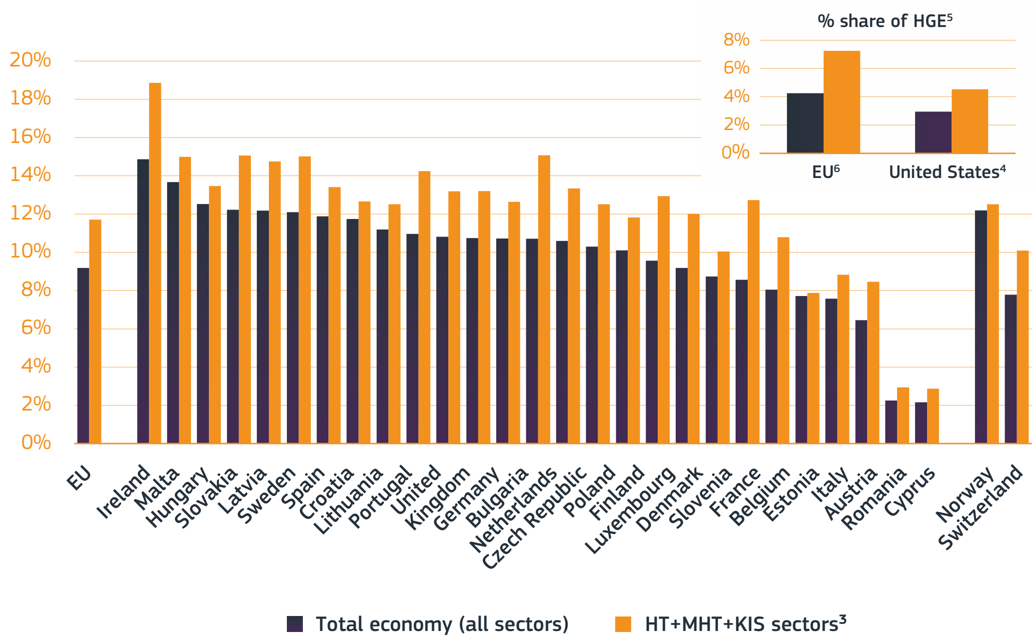
Almost 1 in 10 enterprises in the EU verified high-growth of 10% or more in employment in 2015.

While the EU's knowledge-intensive sectors seem to be producing a higher share of high-growth firms overall, there are substantial intra-EU differences. For instance, while high-growth firms in knowledge-intensive sectors seem to be quite well represented in Ireland, Slovakia, Malta, the Netherlands and Sweden, companies in these sectors in Romania and Cyprus (and also in the economy overall) seem to struggle to grow as fast as they do in other EU Member States.

10 Morelix et al. (2016).

11 Accordingly, the share of 'scale-ups' – defined as the number of companies that grow to employ at least 50 people in the first 10 years after creation as a percentage of all employer firms of 10 years and younger – rose in 2013.

Figure I.6-A.5 % share of high-growth enterprises (HGE)[1] in total active enterprises - total economy and total high-tech (HT) plus medium-high-tech (MHT) plus knowledge-intensive services (KIS) sectors, 2015[2]



Science, Research and Innovation performance of the EU 2018

Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies

Data: Eurostat, OECD

Notes: [1]Enterprises with at least 10 employees and with average annualised employment growth of 10% or more per annum over a three year period. [2]DK, CY, MT: 2014; US: 2012. [3]MT: 2013. [4]US: OECD ISIC3 classification was used. [5]The values for high-growth enterprises in the EU-US comparison refer to enterprises with at least 10 employees and with average annualised employment growth of 20% or more per annum over a three year period. [6]EU was estimated by DG Research and Innovation.

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This is also the case for young high-growth firms (gazelles), where Europe, and notably some Central and Eastern European countries continue to outperform the United States.

Young, high-growth companies are typically R&D-intensive, tend to introduce disruptive innovations in the market, and even a small share contributes disproportionately to job creation. As a result, they play a major role in promoting innovation-driven economies and economic dynamism. Haltiwanger et al. (2016) analysed the pace of business dynamism and entrepreneurship in the United States over time and found that, since 2000, the decline in dynamism and entrepreneurship in the country has been accompanied in particular by a decline in high-growth young firms. This is substantiated in Figure I.6-A.6 which also shows that the share of European gazelles – young firms less than five years old with high-growth in employment of 20% or more – was significantly higher than the share of American gazelles in total high-growth enterprises in 2012. In addition, while there was a slight fall in this share in the United States between 2009 and 2012, in the EU the percentage of young high-growth firms has increased. In absolute terms, the EU[12] also outperformed the United States in 2012; in fact, France alone outnumbered the United States in gazelles. However, there are significant intra-EU disparities with some economies 'in transition', such as Romania, Bulgaria and Lithuania, registering the highest shares of gazelles in high-growth firms.

This apparent "reduction in the ability of (American) companies to scale in a meaningful and systematic way"[13] could be partly explained by the greater power of established incumbents[14] and hence the concentration of benefits around a few so-called 'superstar' companies which are successfully mastering information technology[15]. According to Hathaway and Litan (2014), this concentration has increased substantially in the United States over the last three decades, which may have reduced the overall chances of new firms in the marketplace to grow as fast as they might expect, including in more innovative sectors. This could explain why, as Haltiwanger et al. (2016) put it: "the likelihood of a young firm being a high-growth firm has declined" in the country.

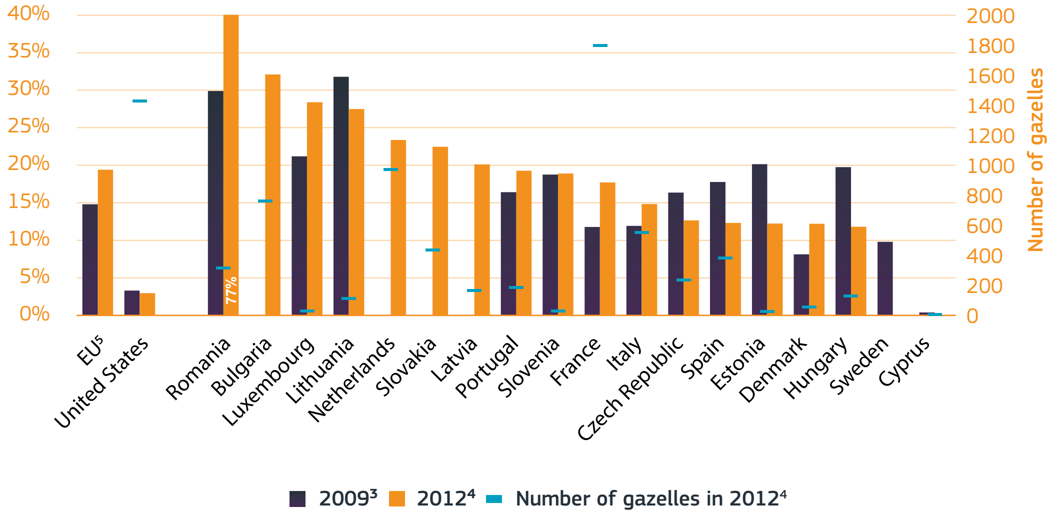
12 The EU absolute value is the sum of the number of gazelles for the EU Member States for which data are available which poses some limitations in the comparison with the United States.

13 Stern et al. (2016).

14 MIT Technology Review (2016).

15 Harvard Business Review (2017).

Figure I.6-A.6 % share of gazelles[1] in high-growth enterprises[2], 2009 and 2012



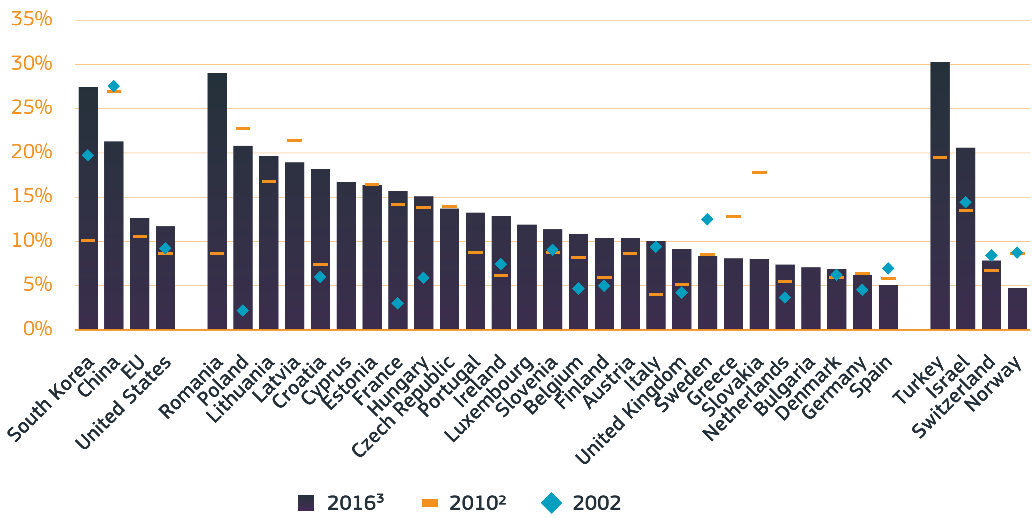
Science, Research and Innovation performance of the EU 2018

Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies
Data: Eurostat, OECD SDBS database
Notes: [1]Gazelles are enterprises up to 5 years old with at least 10 employees and with an average annualised employment growth greater than 20% per annum over a three year period. [2]High-growth enterprises: all enterprises with at least 10 employees and with average annualised employment growth greater than 20% per annum over a three year period. [3]SE: 2008; CY, LT: 2010. [4]DK, LT, LU, SI: 2011. [5]EU was estimated by DG Research and Innovation.
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-a_figures/f_i_6-a_6.xlsx

Moreover, entrepreneurial intention is on the rise in Europe.

According to the Global Entrepreneurship Monitor (GEM) which looks into ‘entrepreneurial behaviour and attitudes’, based on GEM’s adult population survey, entrepreneurial intention – the percentage of adults who intend to start a business within three years – rose in most EU countries between 2010 and 2016 (Figure I.6-A.7) with many reporting a greater intention to become entrepreneurs than in the United States, but all (except Romania) below China and South Korea in 2016. In 2016, the seven EU Member States where entrepreneurial intention was the highest are all from the most recent enlargement processes (2004, 2010 and 2013). In relative terms, these are at an economic ‘transition stage’, and with the enlargement process they gained access to a wider market with more opportunities for business expansion (including e.g. access to new financing/funding instruments) and with more knowledge and technological diffusion to these countries, which may have made entrepreneurship more ‘appealing’. In addition, self-employment may be seen as an interesting option when compared to the existing job opportunities (and job quality) there. These may be two possible explanations although there are certainly others, too.

Figure I.6-A.7 Entrepreneurial intention[1] by country, 2002, 2010 and 2016



Science, Research and Innovation performance of the EU 2018

Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies
Data: Global Entrepreneurship Monitor
Notes: [1]Percentage of population aged 18-64 (not including individuals involved in any stage of entrepreneurial activity) who are latent entrepreneurs and who intend to start a business within three years. [2]CZ, LT, PL, SK, NO: 2011, EE, AT: 2012. [3]DK, LT: 2014; BE, RO, NO: 2015.
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-a_figures/f_i_6-a_7.xlsx

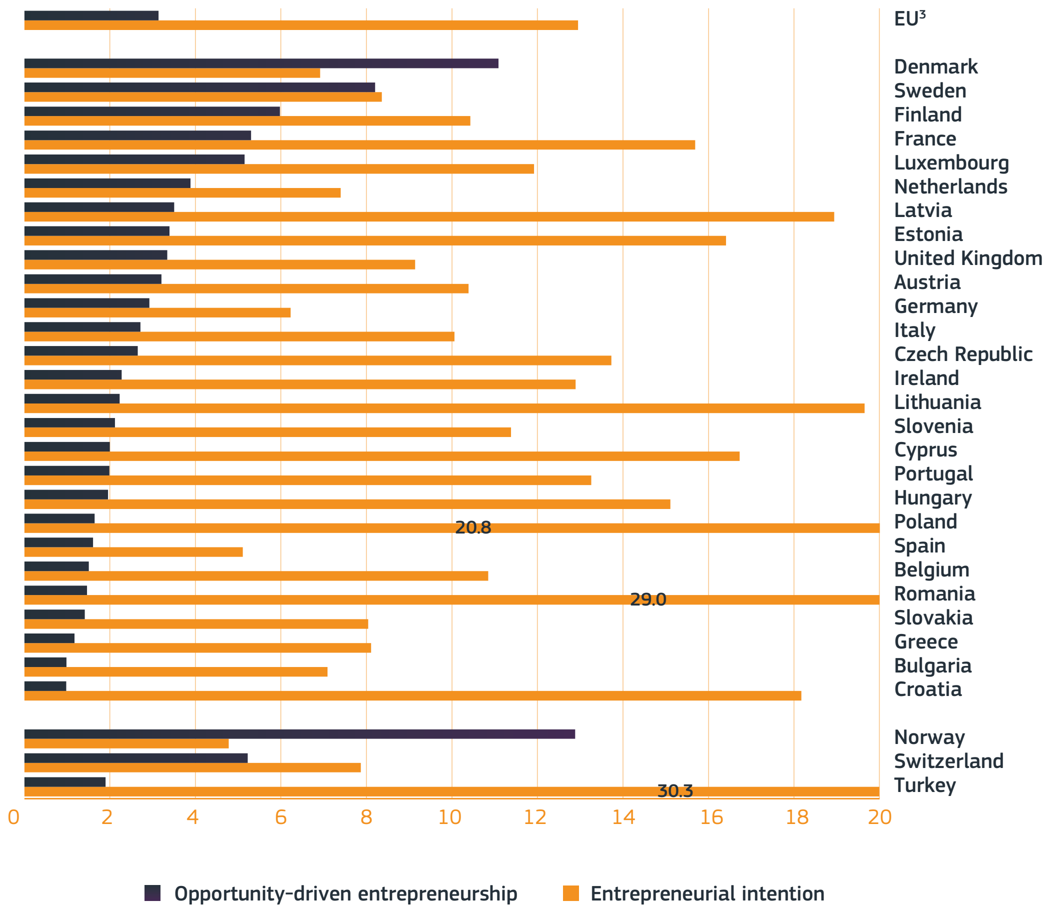
However, there seems to be different intra-EU motivations driving the interest to become an entrepreneur: from subsistence to transformational.

Entrepreneurial intention is depicted in Figure I.6-A.8 together with the opportunity-driven entrepreneurship indicator calculated as the ratio between the share of people involved in improvement-driven entrepreneurship and the share of those involved in necessity-driven entrepreneurship. Broadly speaking, this indicator can be seen as a motivational index in the sense that it attempts to capture whether the intention to become an entrepreneur in a given country is mainy driven by the existence of business opportunities in the market, or whether this intention is more necessity-driven because, for example, there are no better choices for work. Bhola et al. (2006) also found that necessity entrepreneurs are driven by push motivations and opportunity entrepreneurs mostly by pull motivations. In addition, they have concluded that for opportunity-driven entrepreneurs, administrative complexity and the unfavourable economic climate negatively influence their intention to become entrepreneurs, while this is not the case for necessity-driven entrepreneurs.

In line with the findings of the EIS (2017), Figure I.6-A.8 shows that countries with a high relative prevalence of improvement-driven opportunity entrepreneurship appear primarily to be more advanced[16], innovation-driven economies. In these countries, opportunities may be expected to be more abundant, and individuals may have more alternative ways to make a living. Therefore, while Member States such as Romania, Poland and Croatia verify in relative terms very high entrepreneurial intention, as mentioned before, in these countries the opportunity-driven entrepreneurship ratio is at the same time very low, which seems to indicate that in these countries the motivation to become an entrepreneur might be, in relative terms, mainly linked to unemployment situations or higher dissatisfaction with their jobs. Denmark, Sweden and Finland, the three EU 'innovation leaders' in the EIS 2017, have the highest opportunity-driven entrepreneurship ratios (only outperformed by Norway) even though overall their entrepreneurial intention is markedly below other EU Member States.

16 Wennekers et al. (2006) also found that the ratio of opportunity to necessity entrepreneurship seems to be higher in countries with higher per-capita income.

Figure I.6-A.8 Entrepreneurial intention[1] and opportunity-driven entrepreneurship[2] by country, 2016



Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies
Data: Global Entrepreneurship Monitor, European Innovation Scoreboard 2017
Notes: [1]Percentage of population aged 18-64 (not including individuals involved in any stage of entrepreneurial activity) who are latent entrepreneurs and who intend to start a business within three years. [2]The opportunity-driven entrepreneurship index is calculated as the ratio between the share of people involved in improvement-driven entrepreneurship and the share involved in necessity-driven entrepreneurship; three year averages were used (EIS2017). [3]EU does not include Malta.
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-a_figures/f_i_6-a_8.xlsx

However, in terms of the transformational impact of entrepreneurship, Europe trails behind the United States.

In 2013, Aileen Lee – an American seed investor – analysed the start-up and tech ecosystem[17] and spotted a rapidly expanding group of 39 start-ups valued at more than US$ 1 billion which she coined as 'unicorns' due to their "rarity". Four years later, this has become an 'increasingly crowded club' (CB Insights, 2017[18]) with an accumulated number of 261 unicorns as of July 2017, including exits through IPOs or acquisitions (Box 7). In addition, the boom in the evolution of the NASDAQ-100 Index[19], shown in the graph, illustrates one of the main reasons behind the "technological hype" and explosion in the number of unicorns mainly between 2009 and 2015 – the presence of "vibrant public markets fuelling optimism" in the tech sector. However, it seems that in the last two years, the number of new unicorns has slowed down, even though the NASDAQ-100 has risen.

Despite the growing number of unicorns since 2009, these companies remain part of an 'exclusive group' in relative terms – for example, Lee (2015) calculated that in 2015 only 0.14 % of software and internet companies funded in the past decade reached the unicorn status (2014: 0.07 %) although, accordingly, calculating unicorn probability with accuracy is difficult.

The general characteristics of unicorns are summarised in Box 7 based mainly on a study performed by the European Commission's Joint Research Centre (JRC) on a sample of exited unicorns[20].

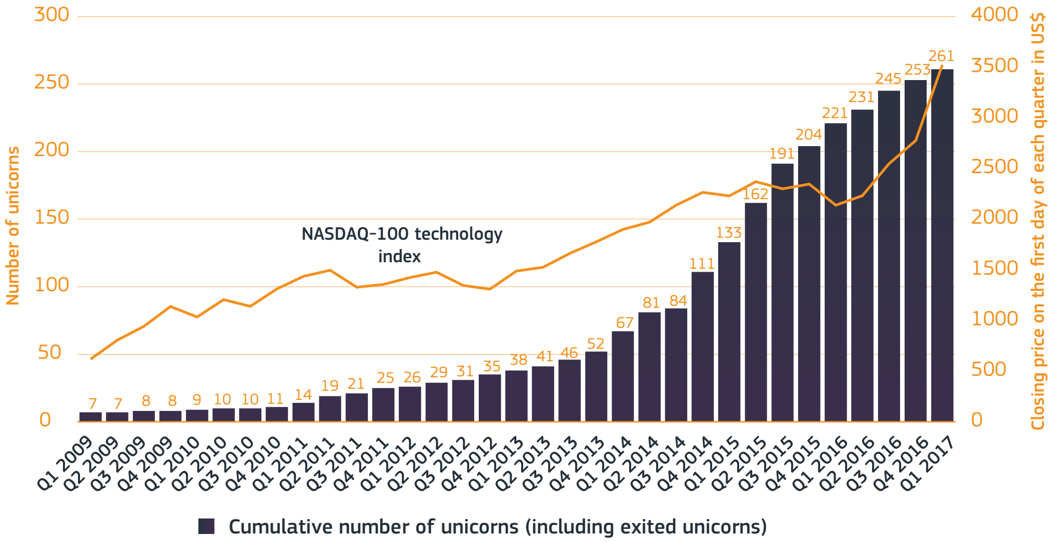
17 Aileen Lee (2013), 'Welcome to the Unicorn Club: Learning from Billion-dollar Start-ups', Contribution to TechCrunch.

18 https://www.cbinsights.com/research/increasingly-crowded-unicorn-club/

19 The NASDAQ-100 Index is an equal-weighted index based on the securities of the NASDAQ-100 Index that are classified as technology according to the Industry Classification Benchmark (ICB) classification system.

20 Jean Paul Simon (2016).

Figure I.6-A.9 Cumulative number of unicorns (including exited unicorns)[1] and the closing price of the NASDAQ-100 technology index, 2009-2017 (by quarter)



Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies

Data: Graph generated based on NASDAQ data - http://www.nasdaq.com/symbol/ndxt/interactive-chart; Crunchbase data on unicorns (as of July 2017).

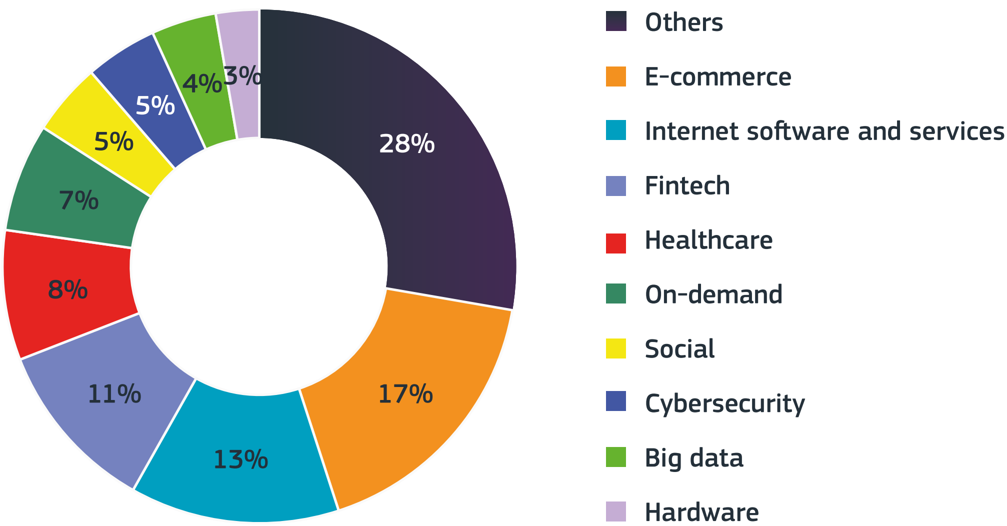
Note: [1]A unicorn is a private company with a post-money (i.e. "after funding") valuation at more than US$ 1 bn. Exited unicorns are no longer private unicorns due to acquisition or IPO.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-a_figures/f_i_6-a_9.xlsx

BOX 7: Main common characteristics of Unicorns

- IT-centred: E-commerce, internet software and services, and Fintech dominate (Figure I.6-A.10)
- Often young global companies that match unsatisfied demand with supply through the provision of innovative and usually affordable services and products with a high scaling-up potential
- Part of the mobile internet wave, relying on connectivity (high-speed networks, mobile and fixed)
- Rely on new devices (e.g. smartphones and tablets) and the opportunities they bring such as through apps. The launch of the iPhone (in 2007) and the Android (in 2008) have contributed to this trend
- Based on network effects, demand-side economies of scale and scope
- Highly dependent on a favourable business environment, and in particular on access to venture capital
- The competition for funding can generate impressive (i.e. inflated) valuations
- Can be disruptive for other sectors and firms

Figure I.6-A.10 Private unicorn companies[1] by sector - % shares, December, 2017



Science, Research and Innovation performance of the EU 2018

Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies

Data: CBinsights

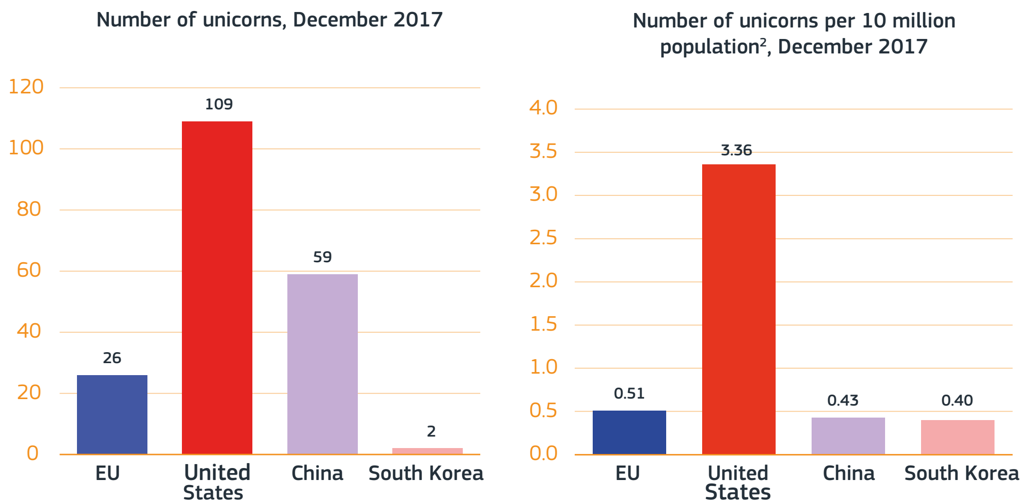
Note: [1]A unicorn is a private company with a post-money (i.e. "after funding") valuation of more than US$ 1 bn.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-a_figures/f_i_6-a_10.xlsx

The number of private unicorn companies is much lower in Europe than in the United States or China.

However, Figure I.6-A.11 shows that Europe is still lagging behind in terms of the number of companies reaching the unicorn status of more than US$ 1 billion in post-money valuation, while the United States is remarkably leading the production of private unicorns. In fact, at the end of 2017, there were 26 private unicorns in the EU compared to 109 in the United States and 59 in China which is quickly catching up. When controlled for the size of the population, the EU remains a weak player but compares similarly with China, while the United States maintains its pronounced leading position. Hence, despite the relatively lower overall high-growth performance of companies in the United States, as mentioned above, according to new research by Stern and Guzman (2016)[21] on entrepreneurial growth potential, it would appear that 'high-quality' and highly-ambitious American start-ups are still being set up and are shaping the United States economy with their high R&D investments and radical innovations.

Figure I.6-A.11 Private unicorns[1]



Science, Research and Innovation performance of the EU 2018

Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies

Data: CBinsights, OECD, Eurostat

Notes: [1]A unicorn is a private company with a post-money (i.e. "after funding") valuation of more than US$ 1 bn.

[2]Population data refer to 2016.

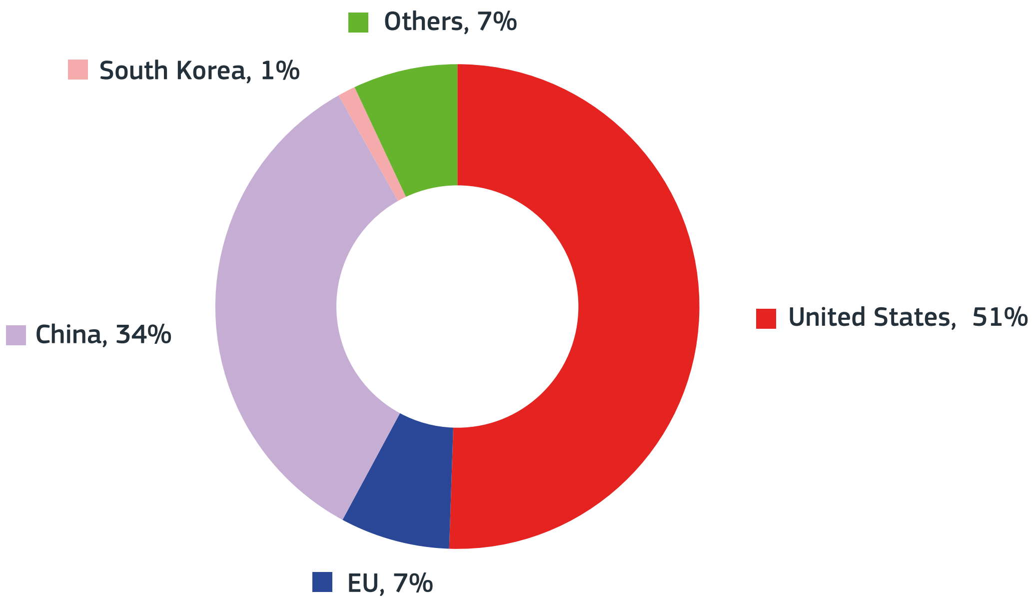
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-a_figures/f_i_6-a_11.xlsx

21 Stern and Guzman (2016).

The company valuation of private unicorn companies in Europe is also much lower than in the United States or China.

Figure I.6-A.12 enhances the United States' superiority in terms of 'excellence' in entrepreneurship, as measured by the share of each major economy in total private valuation of unicorns, with American companies aggregating more than half of this valuation while the EU's share is only 7 %. China has also managed to increase the quality of its entrepreneurial performance and currently has a share slightly above one-third of the total unicorn valuation.

Figure I.6-A.12 Total valuation of private unicorns[1] - geographical distribution (%), December, 2017



Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies
Data: CBInsights
Note: [1]A unicorn is a private company with a post-money (i.e. "after funding") valuation of more than US$ 1 bn. Exited unicorns, due to acquisition or IPO, are not included.
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-a_figures/f_i_6-a_12.xlsx

Likewise, unicorn companies' R&D investment is much lower in Europe than in the United States.

Some unicorns are also highly R&D-intensive, especially those in the software and computer services sector which have either exited through an IPO or were acquired. Out of the 186 unicorn exits[22], almost 25% were in the top 2500 global companies ranked by R&D according to the 2017 EU Industrial R&D Scoreboard[23]. Most companies in Figure I.6-A.13 are from the United States, with just two from the EU (out of the 20 European unicorns that have *exited* since 2009)[24]. Moreover, together these companies contribute significantly to job creation with Facebook having the largest number of employees. However, it is important to note that of the 40 companies represented in the table below, only 7 were profitable which raises questions on the sustainability of unicorns and whether their previous valuations may have been over-inflated.

22 According to CBInsights' 'Unicorn Exits Tracker', accessed on 4 December 2017. Exits include IPOs, acquisitions, corporate majority, mergers and reverse mergers.

23 This excludes companies that do not disclose information on R&D investments publicly. This concerns, for instance, Alibaba (China) which, however, is reputed to invest heavily in R&D. In fact, the company is expected to invest US$ 15 billion in R&D labs (see: https://www.ft.com/content/774080c4-1a34-3998-b787-87c029c3cf36).

24 This includes exited unicorns from Germany (Delivery Hero, Hello Fresh, Rocket Internet, Zalando, Ganymed Pharmaceuticals), Finland (Rovio Entertainment, Supercell), United Kingdom (Skyscanner, O3B Networks, Novocure, Adaptimmune, Markit, Just Eat, Betfair), the Netherlands (Takeaway.com, Acerta Pharma, Dezima Pharma), France (Criteo), Ireland (King Digital Entertainment) and Denmark (Sitecore) that have exited through an IPO, were acquired or went through a corporate majority.

Figure I.6-A.13 Exited unicorns[1] that went public after 2009 and are in the world top 2500 companies as ranked by total R&D investment

Rank	Company	Country	Sector	R&D intensity[2] (%)	Profitability (%)	Number of employees
19	FACEBOOK	United States	Software & Consumer Services	21.4	45.0	17,000
174	TWITTER	United States	Software & Computer Services	33.1	-14.5	3,600
175	TESLA	United States	Automobiles & Parts	11.9	-9.5	17,800
206	WORKDAY	United States	Software & Computer Services	43.4	-25.0	6,600
353	PALO ALTO NETWORKS	United States	Software & Computer Services	19.7	-10.2	4,600
366	GOPRO	United States	Leisure Goods	28.3	-31.5	1,600
376	FITBIT	United States	Healthcare Equipment & Services	15.0	-5.2	1,800
380	ZYNGA	United States	Software & Computer Services	43.2	-15.4	1,700
403	TABLEAU SOFTWARE	United States	Software & Computer Services	36.6	-16.9	3,200
410	SPLUNK	United States	Software & Computer Services	31.1	-36.2	2,700
427	FIREEYE	United States	Software & Computer Services	40.3	-58.4	2,900
431	SERVICENOW	United States	Software & Computer Services	20.5	-11.0	4,800
442	ARISTA NETWORKS	United States	Software & Computer Services	24.2	21.6	1,500
449	SQUARE	United States	Software & Computer Services	15.8	-7.0	1,900
458	JUNO THERAPEUTICS	United States	Pharmaceuticals & Biotechnology	333.0	-329.0	500
462	YANDEX	Russian Federation	Software & Computer Services	20.9	17.5	6,300
484	PURE STORAGE	United States	Technology Hardware & Equipment	33.8	-29.5	1,700
599	SNAP	United States	Software & Computer Services	45.4	-128.7	1,900
718	FIBROGEN	United States	Pharmaceuticals & Biotechnology	80.7	-29.9	400
736	IRONWOOD PHARMACEUTICALS	United States	Pharmaceuticals & Biotechnology	50.9	-18.8	700
761	LENDINGCLUB	United States	Financial Services	11.4	-12.6	1,500
868	CRITEO	France	Media	6.5	6.7	2,500
869	NUTANIX	United States	Software & Computer Services	15.2	-55.7	:
877	BOX	United States	Software & Computer Services	29.1	-37.8	1,500
949	CLOUDERA	United States	Software & Computer Services	39.2	-71.8	1,500
981	VEEVA SYSTEMS	United States	Software & Computer Services	17.9	19.8	1,800
1056	TWILIO	United States	Mobile & Telecommunications	32.1	-14.9	700
1170	SHOPIFY	Canada	Software & Computer Services	20.3	-9.5	1,900
1196	NANTHEALTH	United States	Software & Computer Services	75.9	-160.9	900
1269	UBIQUITI NETWORKS	United States	Technology Hardware & Equipment	8.0	33.5	700
1288	ETSY	United States	General Retailers	18.5	4.8	1,000
1309	CHEGG	United States	Software & Computer Services	26.1	-16.2	800
1329	NEW RELIC	United States	Software & Computer Services	24.7	-23.3	1.100
1570	QUOTIENT TECHNOLOGY	United States	Software & Computer Services	18.6	-9.5	700
1688	NOVOCURE	United Kingdom	Pharmaceuticals & Biotechnology	55.7	-131.4	500
1696	GOGO	United States	Fixed Line Communications	7.7	-4.5	1,200
1746	OKTA	United States	Software & Computer Services	27.5	-51.8	900
1873	CASTLIGHT HEALTH	United States	Software & Computer Services	39.8	-58.0	400
1958	ADURO BIOTECH	United States	Pharmaceuticals & Biotechnology	73.1	-141.8	200
2096	MEITU	China	Software & Computer Services	14.8	-39.4	1,300
2124	MULESOFT	United States	Software & Computer Services	17.5	-25.8	800

Science, Research and Innovation performance of the EU 2018

Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies

Data: EU Industrial R&D Investment Scoreboard 2017 and CBinsights (exited unicorns since 2009), accessed on 04 December 2017

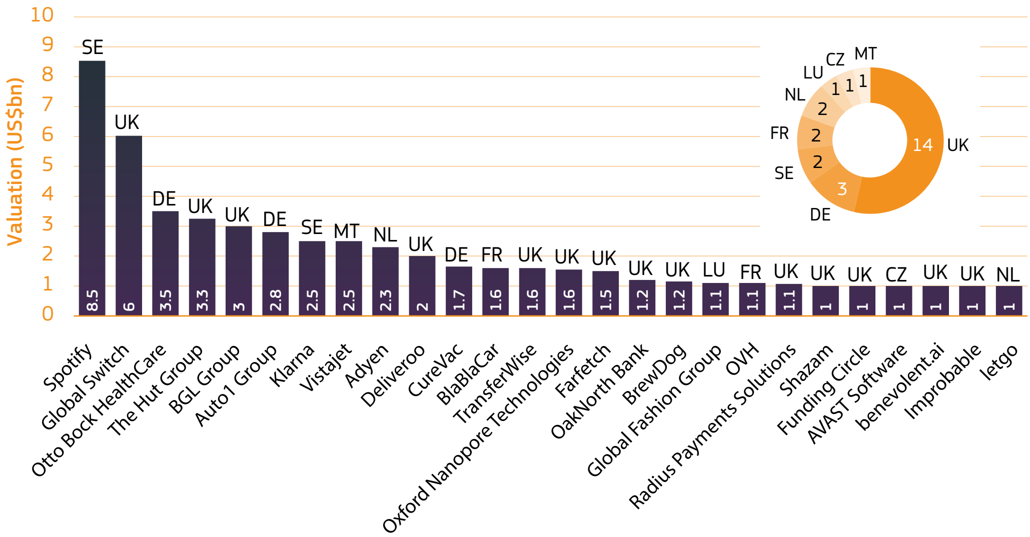
Notes: [1]A unicorn is a private company with a post-money (i.e. "after funding") valuation of more than US$ 1 bn. [2]The ratio between the company's R&D investment and net sales.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-a_figures/f_i_6-a_13.xlsx

Within Europe, there is a high concentration of unicorn firms in core countries, with only one in Southern Europe and another one in Central and Eastern Europe.

When looking into intra-EU performance, the number of unicorns is very concentrated in the UK which is 'home' to more than 50 % of the EU unicorns. Germany comes next with three unicorns, France, Sweden and the Netherlands with two each and Luxembourg, Malta and the Czech Republic with one unicorn each (Figure I.6-A.14). The significant gap in valuation between EU and American unicorns is also evident from the difference in valuation at the top – while the Union's most valuable unicorn, Spotify, reached US$ 8.5 billion, Uber's 2017 valuation of US$ 68 billion positions the company as the leading private unicorn in the United States.

Figure I.6-A.14 Private unicorns[1] in EU Member States with valuation in US$bn, December 2017



Science, Research and Innovation performance of the EU 2018

Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies

Data: CBInsights, as of 4 December 2017

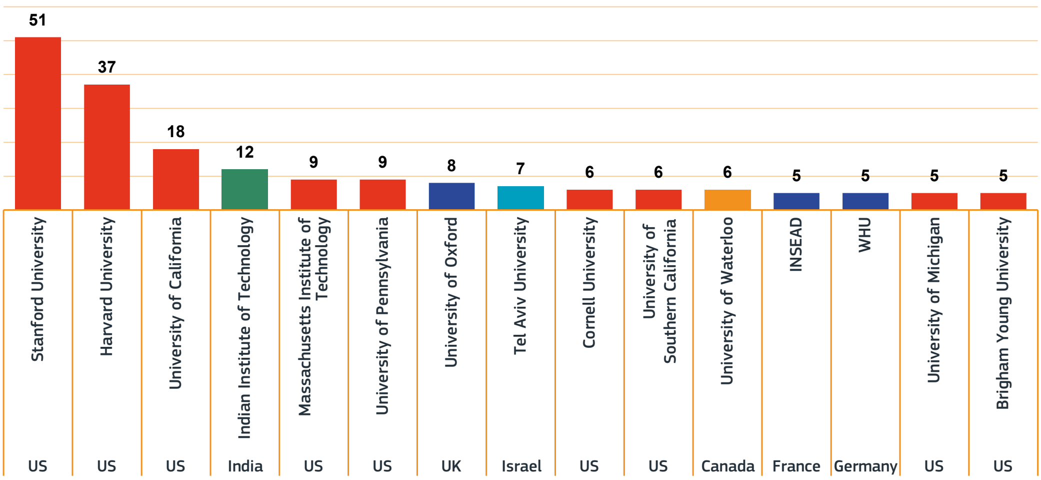
Note: [1]A unicorn is a private company with a post-money (i.e. "after funding") valuation at more than US$ 1 bn.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-a_figures/f_i_6-a_14.xlsx

A similar geographical pattern exists when analysing the higher education institutions from which unicorn founders graduated.

When looking into where "transformational entrepreneurs" (i.e. unicorn founders) went to college[25], American universities emerge as the most popular, with Stanford University, Harvard University and the University of California in the lead ('top 3'). In total, 146 unicorn founders were alumni in nine US universities. Eighteen unicorn founders graduated from three universities in the EU (as of January 2017), namely Oxford University (UK), INSEAD (France) and the WHU – Otto Beisheim School of Management (Germany) (Figure I.6-A.15).

Figure I.6-A.15 Universities producing the most unicorn[1] founders



Science, Research and Innovation performance of the EU 2018

Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies

Data: Sage

Notes: [1]A unicorn is a private company with a post-money (i.e. "after funding") valuation at more than US$ 1 bn. [2]All data are up to date as of January 2017.

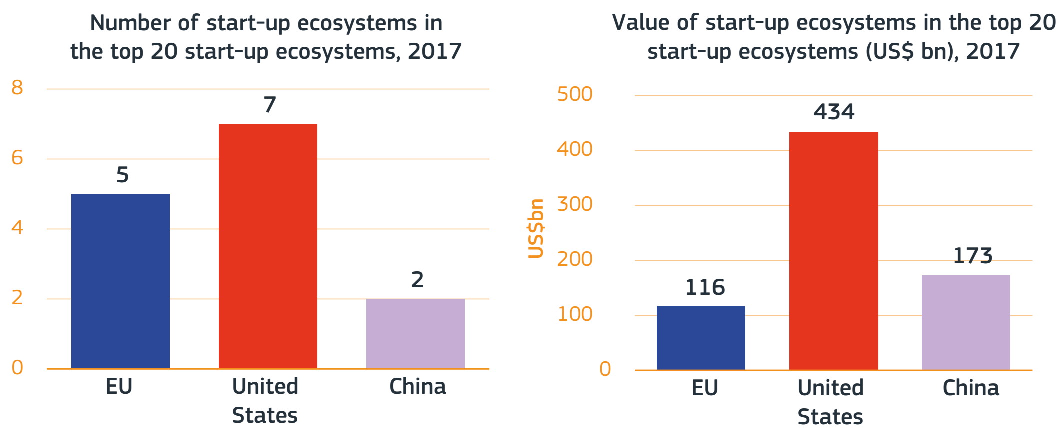
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-a_figures/f_i_6-a_15.xlsx

25 According to Sage research on the Unicorn League.

This seems to indicate that the EU lags behind in the creation of vibrant entrepreneurial ecosystems.

Entrepreneurial ecosystems play a key role in the innovation cycle by acting as a platform for start-up ideas, developing products and services and making them grow in the market. In parallel, these powerful, well-connected 'technical hubs' contribute to economies of scale and agglomeration since they are the 'meeting point' between skilled entrepreneurs, suppliers, supportive services and infrastructure, and institutional structures such as financial intermediaries (Martin et al., 2001). For this reason, start-ups tend to emerge in hubs built around first-class universities that act as key players in developing a dynamic entrepreneurial environment because they are a source of talent which includes students and academics. This support to ecosystem building around top universities is the approach chosen by the European Institute of Innovation and Technology (EIT). The EIT model aims at bringing together actors in the knowledge triangle of education, research and business in vibrant innovation ecosystems operating across the entire value chain of innovation. In this context, the 'Global Startup Ecosystem Report 2017' by Startup Genome follows a multidimensional approach to analyse "in which ecosystems does an early-stage start-up have the best chance of building a global success". This approach comprises five main dimensions, namely performance, funding, market reach, talent and start-up experience of the ecosystems. Figure I.6-A.16 shows that, according to the above-mentioned report, the EU had five entrepreneurial ecosystems in the top 20 start-up ecosystems. This compares with seven ecosystems in the United States and two in China. Furthermore, the accumulated value of the top EU ecosystems – London, Berlin, Paris, Stockholm and Amsterdam – is accordingly significantly below that of both the United States and China (EU: US$ 116 billion, United States: US$ 434 billion, China: US$ 173 billion).

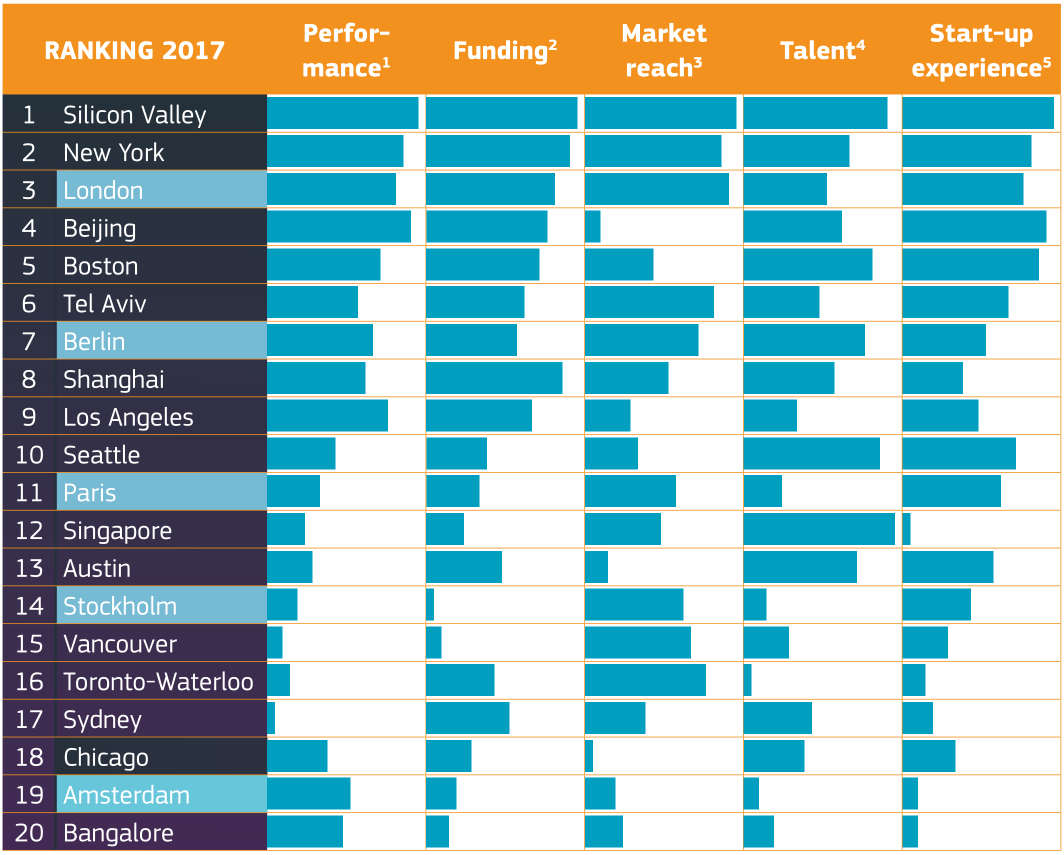
Figure I.6-A.16 Start-up ecosystems



Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies
Data: Global Startup Ecosystem Report, 2017
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-a_figures/f_i_6-a_16.xlsx

Figure I.6-A.17 indicates the relative strengths of the top-performing world entrepreneurial ecosystems. Silicon Valley appears as the clear leader, followed by New York and London, the latter being the EU's top start-up ecosystem. Berlin also stands out in particular as a hub capable of attracting highly talented entrepreneurs and for its global and local connectedness. Paris' top relative strength rests on the existence of strong and effective networks to access knowledge, while Stockholm performs relatively well in market reach, and Amsterdam in terms of overall ecosystem value.

Figure I.6-A.17 World top 20 start-up ecosystems, 2017



Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies
Data: Global Startup Ecosystem Report 2017, Startup Genome
Notes: [1]Performance includes start-up output, exits, valuations, early-stage success, growth-stage success, and overall ecosystem value. [2]Funding concerns growth in early-stage investments, and funding quality through the presence of experienced VC firms. [3]Market reach is linked to global connectedness and global and local reach, based on the start-ups' proportion of foreign customers and the national GDP. [4]Talent-access, cost, and quality of talent. [5]Start-up experience: team experience and ecosystem experience in terms of knowledge and networks available from which start-ups can develop.
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-a_figures/f_i_6-a_17.xlsx

Several factors may affect the lower rate of transformational entrepreneurship in Europe, including lower access to growth financing in Europe relative to the United States.

Access to finance has a key role to play in supporting the pre-launch, launch and early-stage development phases of a business[26]. Venture capital is especially relevant in the case of young innovative companies in deep-tech sectors that have high growth and a disruptive potential and may even contribute to creating new markets. However, due to both the high uncertainty and investments required, they have difficulty in accessing traditional finance since some sort of collateral is needed. For this reason, banking finance should be complemented by diverse and flexible funding sources with a focus on the development of the venture capital industry to support transformational entrepreneurship in Europe.

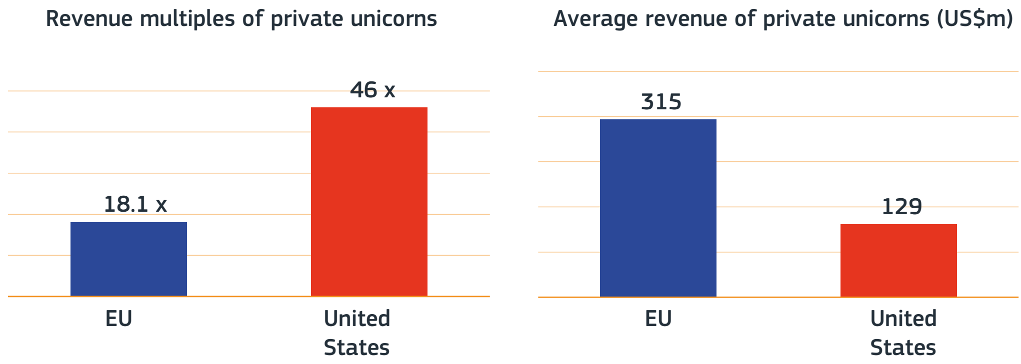
As mentioned in Chapter I.4[27], after the crisis, venture capital investments as a percentage of GDP contracted substantially in Europe and currently represent only a fraction of those in the United States. This is particularly true for accessing growth-stage funding. With less later-stage funding available to thrive and scale-up, European tech start-ups favour earlier revenue generation to the detriment of fast growth to be compete for capital from less risk-taking investors available in Europe (in comparison to the United States). GP Bullhound's research (2016) argues that, overall, European private tech unicorns are growing sustainably "on a base of profit and revenue". They compare valuations and actual revenue in a sample of European and American private unicorns in 2016. Figure I.6-A.18 shows that in the United States, on average, unicorn valuations are 46 times the revenues generated, while in the EU this number is much lower, at 18 times. However, when comparing the average revenue between EU and American private unicorns in the sample, they found that European unicorns have almost three times the average revenue obtained by the American unicorns in the sample. As a result, this research seems to indicate that "investors in the European Union request a "stronger track record of revenues and profits for billion-dollar valuations".

In line with these findings, Lee (2015) highlights in her analysis the growth of the so-called "paper unicorns" which are those with considerable low capital efficiency. While she admits that some of these new unicorns are due to "fantastic market fundamentals", she believes that this trend is linked mainly to the combination of a perception of "winner-takes-all markets" related to the importance of branding and the establishment of extensive networks, and private capital to fuel a company's growth which makes companies prioritise the idea of "getting big fast" instead of generating sufficient cash flow earlier. Recently, this conclusion has also been substantiated by Gornall and Strebulaev (2017) who show that, on average, these companies report values about 51 % above what they are actually worth – and what public markets would give them.

26 InvestEurope.

27 For further reference to access to risk capital, please see Chapter I.4 on 'Framework conditions'.

Figure I.6-A.18 Private unicorns[1] - revenues[2] in the EU and the United States



Science, Research and Innovation performance of the EU 2018

Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies

Data: GP Bullhound Research - European Unicorns 2016

Notes: [1]A unicorn is a private company with a post-money (i.e. "after funding") valuation of more than US$ 1 bn. [2]Sourced latest revenue and valuation data available, revenue data is one year older than valuation data. Sample set size: 12 EU unicorns and 20 US unicorns, as of April 2016.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-a_figures/f_i_6-a_18.xlsx

All in all, removing barriers for transformational, innovative start-ups to thrive and scale-up could boost technological dynamism and productivity growth in Europe.

As mentioned above, a lack of sufficient access to financing for innovation is a major barrier for innovative entrepreneurship to flourish in Europe since it limits the growth and scale-up potential of young, innovative and talented European firms. Despite recent progress in reversing the significant decline of venture capital investments in Europe as a result of the crisis[28], more needs to be done to further develop the venture capital industry in Europe. According to the European Investment Fund (EIF)[29], hostile regulations for equity investments persist, as well as some degree of market fragmentation and complexity, which hinders the creation of a critical mass of companies and venture capital investors. The Pan-European Venture Capital Fund-of-Funds intends to tackle these issues, together with exploring alternative sources of financing such as crowdfunding and business angels. Moreover, according to the European Commission's 'Start-up and Scale-up Initiative'[30], completing and deepening the Digital Single Market is extremely relevant for innovative start-ups which, by expanding to other EU Member States, typically face considerable regulatory and administrative barriers inherent in cross-border situations. In addition, other framework conditions, such as fostering faster insolvency procedures, simplifying tax procedures, and propelling an entrepreneurial culture that does not penalise failure and allows for a 'second chance', have also been identified as important elements to enable a more innovation-driven European economy. The European Innovation Council (EIC) pilot provides bottom-up support targeting market-creating innovations with the potential to scale-up globally and which are of a 'high risk-high gain' nature for investors. This includes, for instance, six 'EIC Horizon Prizes' under the Horizon 2020 Work Programme 2018-2020. Fostering high-quality technical hubs throughout Europe, combining access to knowledge, capital, talent and infrastructure in a synergetic fashion, would also contribute to promoting transformational entrepreneurship.

28 Source: InvestEurope (2017) 'The Acceleration point: Why now is the time for European venture capital'.

29 European Investment Fund – presentation at the SEP Investors Forum Workshop 2015 – 'European Venture Capital. The Facts', by Patric Gresko.

30 EC Communication (2016).

CHAPTER I.6-B: STRUCTURAL CHANGE

In the current context of slowing productivity worldwide, and especially in the EU, it becomes even more important to understand why some economies manage to be more productive than others. As will be shown in this chapter, knowledge-intensive activities enjoy the highest productivity levels, have the largest productivity growth, and lay the foundations for productivity-enhancing innovations to materialise.

This chapter analyses how the economic structure of the EU and its Member States has evolved in recent years and assesses whether there has been a structural economic shift towards more knowledge intensive sectors. While knowledge intensity is in itself difficult to measure, it is common practice to use R&D intensity as a reasonable proxy, i.e. the share of investment in R&D of a sector's total value added. Economies that manage to invest and expand in those sectors with the highest productivity become more productive. Labour productivity tends to be especially high in high-tech manufacturing and high-tech knowledge-intensive services, followed by medium-high-tech manufacturing. These three macro-sectors are referred to in this chapter as knowledge-intensive activities or sectors.

Economic structure in the EU and its Member States

In the context of a global productivity growth slowdown presented in Chapter 1 of this Report, the gap between the EU vis-á-vis its main competitors, in particular the United States, can be tracked down to two main factors: (i) lower specialisation in knowledge-intensive activities, and (ii) lower productivity within each of these sectors.

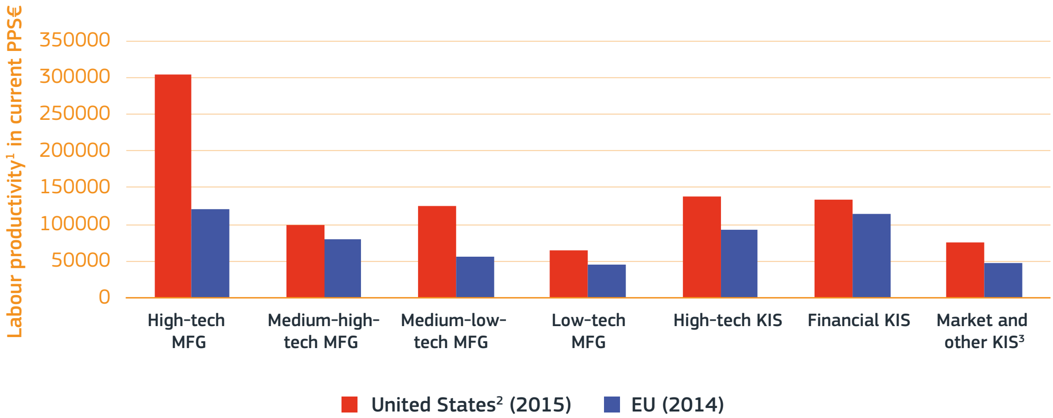
Figure I.6-B.1 compares labour productivity in the EU and the United States. While knowledge-intensive activities are the most productive sectors both in the EU and the United States, labour productivity in the EU is lower across all sectors. Such a gap is particularly significant in high-tech manufacturing, in medium-low-tech manufacturing and knowledge-intensive services (KIS), although most notably in high-tech sectors[31].

Economic specialisation across countries is linked to sectoral productivity levels that in turn define the competitiveness of the sectors in the global economic landscape. Economies where productivity in specific sectors is higher tend to enjoy higher value-added shares in those sectors, compared to other countries.

Figure I.6-B.2 plots labour productivity in knowledge-intensive services, high-tech and medium-high-tech manufacturing against the share of value added in the same sectors, revealing the existence of a positive relationship: countries tend to have higher specialisation in sectors where their productivity is higher in comparative terms. Labour productivity in knowledge-intensive activities in the United States is higher than in the EU, and the share of these activities in total value added is also larger.

31 The classification of manufacturing and services is based on NACE Rev. 2 at the two-digits level. In particular, HT manufacturing includes basic pharmaceutical products and preparations; computer, electronic and optical products. MHT manufacturing includes chemicals and chemical products; electrical equipment, machinery and equipment; motor vehicles, trailers and semi-trailers; and other transport equipment. KIS include a large range of activities, such as water and air transport; publishing activities; computer programming; telecommunications; and others (section J); financial and insurance activities; legal and accounting activities; market research; scientific research and development; and others (section M); security and investigation; public administration and defence, compulsory social security; education; human health and social work activities; arts, entertainment and recreation. See: http://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.PDF.

Figure I.6-B.1 Labour productivity[1] of manufacturing (MFG) and knowledge-intensive services (KIS) by type of sector - EU and the United States



Science, Research and Innovation performance of the EU 2018

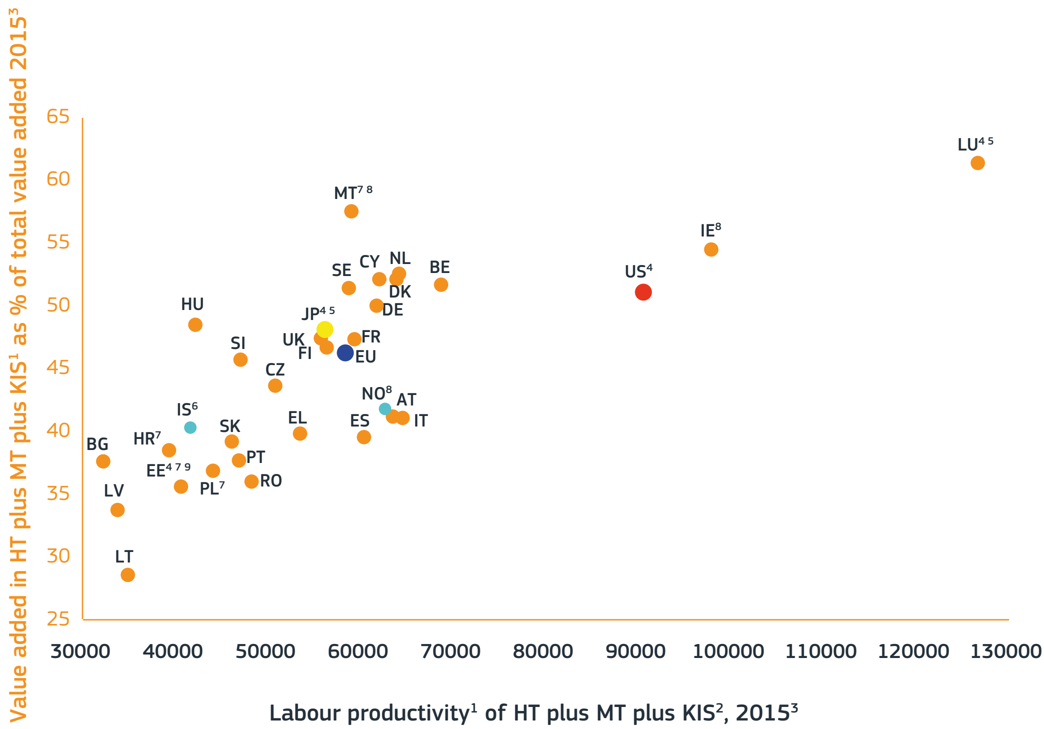
Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies

Data: Eurostat, OECD

Notes: [1]Value added per person employed in current PPS€. [2]US: (i) Medium-low-tech MFG does not include repair and installation of machinery and equipment; (ii) High-tech KIS does not include scientific research and development and telecommunications (iii) Market and other KIS does not include employment activities. [3]Market and other KIS does not include investigation activities due to unavailability of data.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-b_figures/f_i_6-b_1.xlsx

Figure I.6-B.2 Labour productivity[1] of high-tech manufacturing (HT) plus medium-high-tech manufacturing (MHT) plus knowledge-intensive services (KIS)[2] and % share of value added in HT plus MHT plus KIS, 2015



Science, Research and Innovation performance of the EU 2018

Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies

Data: Eurostat, OECD

Notes: [1]Value added per person employed in current PPS€. [2]KIS does not include security and investigation activities due to unavailability of data. [3]MT: 2013; BE, DE, IE, ES, FR, HR, IT, CY, LV, LT, PL, PT, RO, SE, EU, NO, JP: 2014. [4]EE, LU, US, JP: KIS does not include employment activities. [5]LU, JP: KIS does not include water transport and air transport. [6]IS: KIS does not include water transport. [7]EE, HR, MT, PL: KIS does not include air transport. [8]IE, MT, NO: Manufacture of coke and refined petroleum products is included in MHT. [9]EE: Manufacture of basic pharamaceutical products and pharmaceutical preparations is not included in HT. [10]Elements of estimation were involved in the compilation of the data.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-b_figures/f_i_6-b_2.xlsx

The EU landscape is heterogeneous in terms of both its structural composition and its sectoral productivity.

Two main groups of countries can be identified in Figure I.6-B.2. On the bottom left, the Eastern European economies are characterised by low specialisation in knowledge intensive sectors and relatively low labour productivity levels within these sectors, while on the upper right, Western and Northern European countries dominate. Southern European countries score in-between, with average levels of productivity and knowledge-intensive shares. Luxembourg, Ireland and Malta stand out as exceptions. Luxembourg and Malta's high shares of value added in knowledge intensive sectors are driven almost completely by their specialisation in KIS: 59.9 % out of 61.2 % and 53.7 % out of 57.6 % respectively, while little of the contribution is due to manufacturing activities. In Luxembourg, this pattern is mirrored by labour productivity levels which are higher than in the United States. Finally, Ireland is placed in the top right of Figure I.6-B.2, mainly due to very high labour productivity and value added share in KIS and, unique in the EU, in high-tech manufacturing. The relevance of knowledge-intensive sectors is shown in Figure I.6-B.3 below, where labour productivity in knowledge-intensive sectors is plotted against the value-added share of the sector. The sector accounts for a relevant part of the economic structure of EU countries, ranging from 24.6 % in Lithuania to around 60 % in Luxembourg, with an EU average of 39 %. The chart also highlights the peculiarity of Luxembourg in terms of structural specialisation and labour productivity, as well as the labour productivity gap between the United States and EU economies, with the exception of Ireland[32].

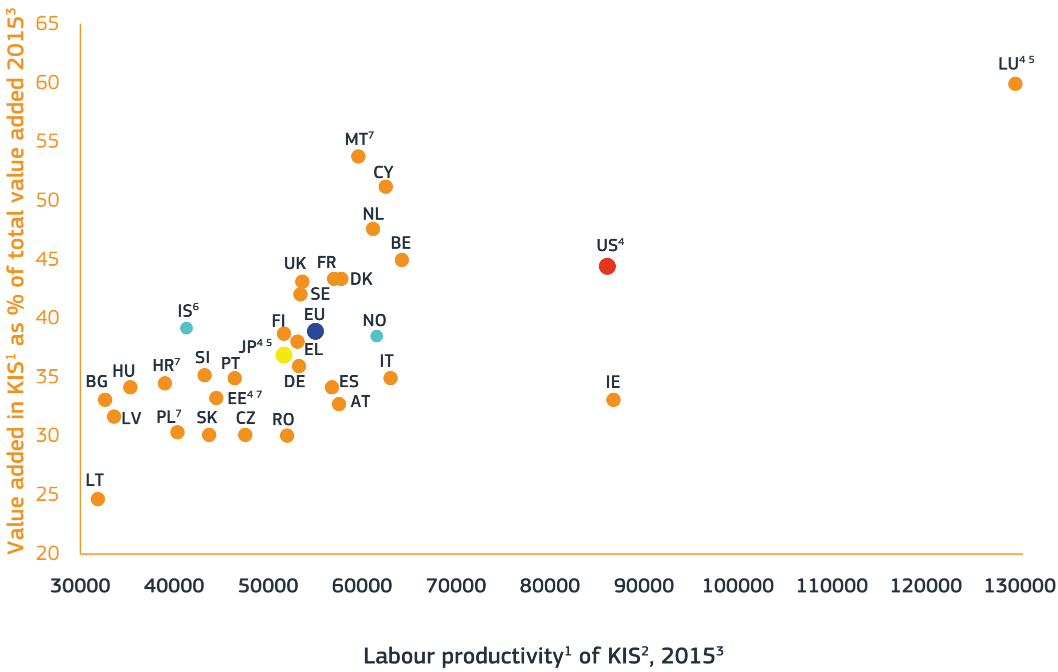
Countries' productivity levels, technological change and the presence of more or less favourable framework conditions for businesses and innovative investments[33] are all very closely linked to the evolution of an economy's economic structure. Furthermore, differences in R&D investments are key in explaining the divergences observed between Member States and between the EU and the United States. Figures I.6-B.4 and I.6-B.5 clearly show a positive relationship between the intensity of R&D investments and both value added and labour productivity in high-tech and medium-high-tech manufacturing sectors[34] in these countries.

32 See Figures I.6-B.9 and I.6-B.15 below. Overall, in what follows, Ireland and Luxembourg stand as consistent outliers. This is due to sectoral specialisations in high-tech manufacturing and KIS, as described in this paragraph.

33 For further details, see Chapter I.5 on Framework conditions for innovation.

34 R&D intensity in KIS will not be considered in the analysis due to the insufficient availability of data for most services activities. Therefore, only manufacturing sectors will be analysed for consistency.

Figure I.6-B.3 Labour productivity[1] of knowledge-intensive services (KIS)[2] and % share of value added in KIS, 2015



Science, Research and Innovation performance of the EU 2018

Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies
Data: Eurostat, OECD
Notes: [1]Value added in KIS per person employed in KIS, current PPS€. [2]KIS does not include security and investigation activities due to unavailability of data. [3]MT: 2013; BE, DE, ES, FR, HR, IT, CY, LV, LT, PL, PT, RO, SE, EU, NO: 2014. [4]EE, LU, US, JP: KIS does not include employment activities. [5]LU, JP: KIS does not include water transport and air transport. [6]IS: KIS does not include water transport. [7]EE, HR, MT, PL: KIS does not include air transport. [8]Elements of estimation were involved in the compilation of the data.
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-b_figures/f_i_6-b_3.xlsx

Overall, the EU has a slightly higher value added in medium-high and high-tech manufacturing sectors, but much lower R&D intensity than the United States. Within the EU, countries with low value added in high-tech and medium-high-tech sectors, namely the Southern and Eastern European Member States, also invest less in R&D in these sectors.

Figure I.6-B.4 shows that the EU has slightly higher value added in high-tech and medium-high-tech manufacturing than the United States, despite the lower R&D intensity. This can be explained by two main factors. First, investment in R&I takes time to translate into the production of new goods, and might therefore only show a significant effect on shares of value added with a time lag. Secondly, it can be explained by the structural composition of the EU versus that of the United States. As will be shown in Figures I.6-B.9 and I.6-B.10, the EU has a higher share of value added in medium-high-tech manufacturing sectors, which are traditionally more established sectors like automotive and chemicals, while the United States has a higher share in high-tech manufacturing, which includes frontier sectors such as pharmaceuticals and ICT. Since high-tech manufacturing is usually characterised by larger R&D investments than medium-high-tech manufacturing, the United States has a higher R&D intensity for both sectors combined.

The difference in R&D intensity, and consequently the sectoral composition of the EU and the United States, contributes explain why the EU reports considerably lower productivity levels in knowledge intensive sectors.

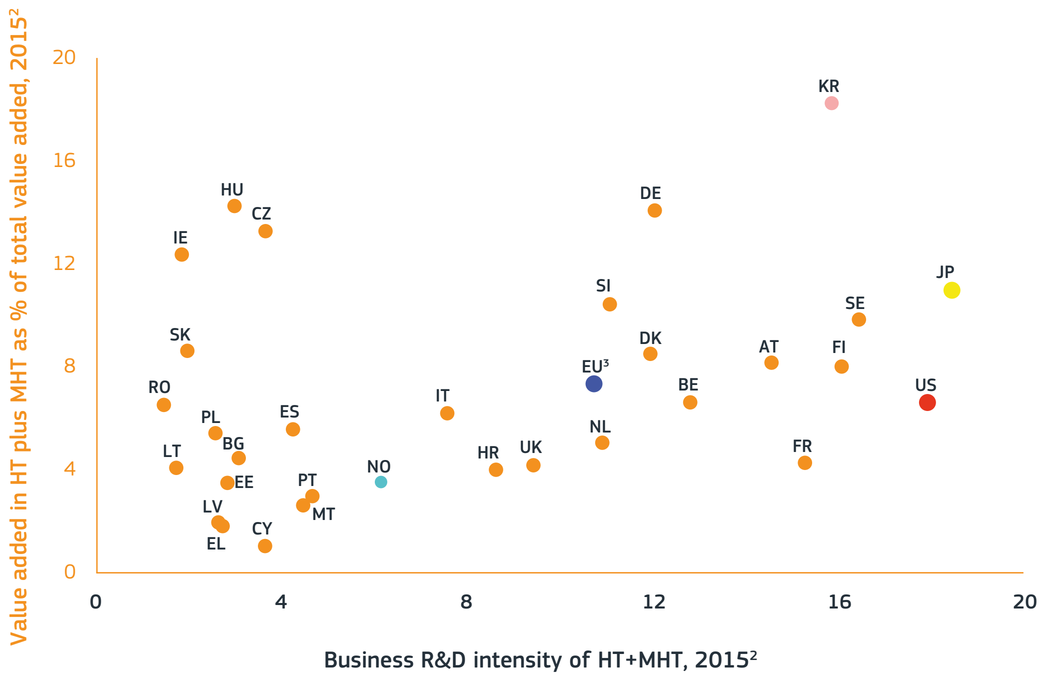
Figure I.6-B.5 shows clearly not only an even stronger positive relationship between investment and labour productivity (than for investment and value added), but also that the United States far outperforms the EU, as can also be seen in Figure I.6-B.1. Again, an intra-EU divide can be seen, with the Eastern and Southern European countries reporting low productivity levels paired with low R&D intensity in medium-high and high-tech manufacturing sectors. The positive correlation between R&D intensity and labour productivity levels is higher than with value added but, as outlined above, given that economies tend to specialise in their most productive sectors, it is to be expected that the value-added shares in the United States will increase in the future[35].

R&I policies are fundamental levers to drive R&D investment trends and to shape the transformation of a country's economic structure and, eventually, its productivity performance.

The following sections will analyse the dynamics of the structural composition of the EU and its Member States. First, the upward shifts in the importance of knowledge-intensive activities in the added value of an economy will be analysed. Then, labour productivity trends within these sectors will be explored. Finally, the evolution of business R&D intensity will be explored.

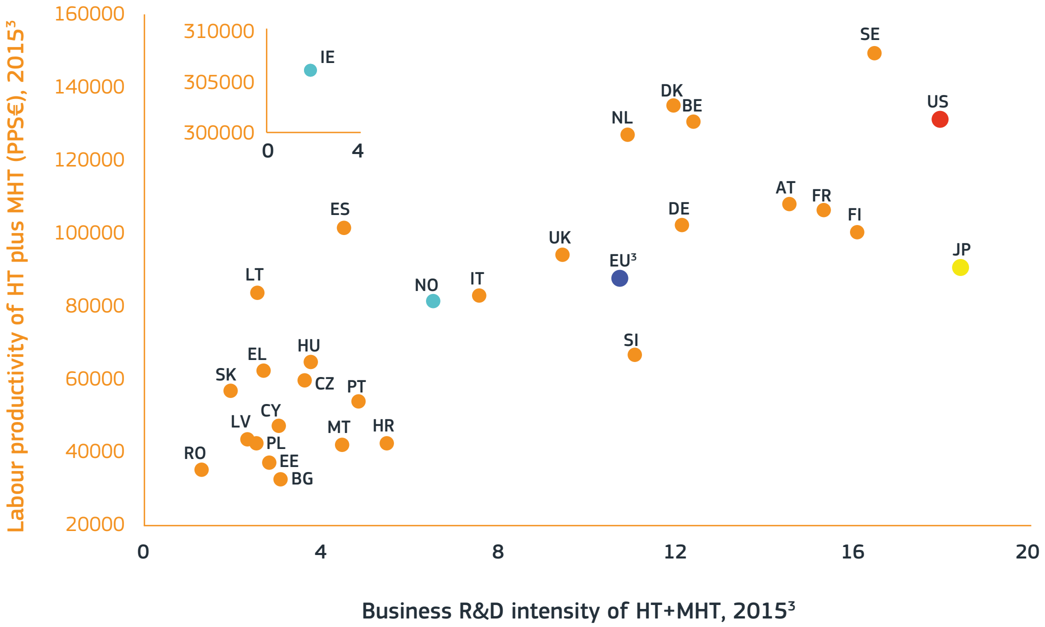
35 This may also explain why the productivity slowdown seems to affect the EU more than the United States, the former investing and therefore specialising less in high-tech manufacturing sectors.

Figure I.6-B.4 Business R&D intensity[1] and % share of value added in high-tech manufacturing (HT) plus medium-high-tech manufacturing (MHT), 2015



Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies
Data: Eurostat, OECD
Notes: [1]Business enterprise expenditure on R&D (BERD) as % of value added in HT+MHT sectors. [2]IE, FR, SE: 2013; PL, EU, JP: 2014. [3]EU was estimated by DG Research and Innovation and does not include Luxembourg. [4]Elements of estimation were involved in the compilation of the data.
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-b_figures/f_i_6-b_4.xlsx

Figure I.6-B.5 Business R&D intensity[1] and labour productivity[2] of high-tech manufacturing (HT) plus medium-high-tech manufacturing (MHT), 2015



Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies
Data: Eurostat, OECD
Notes: [1]Business enterprise expenditure on R&D (BERD) as % of value added in HT+MHT sectors. [2]Value added per person employed in current PPS€. [3]IE, FR, SE: 2013; BE, DE, ES, HR, CY, LT, HU, PL, PT, RO, EU, NO, JP: 2014. [4]EU was estimated by DG Research and Innovation and does not include Luxembourg. [5]Elements of estimation were involved in the compilation of the data.
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-b_figures/f_i_6-b_5.xlsx

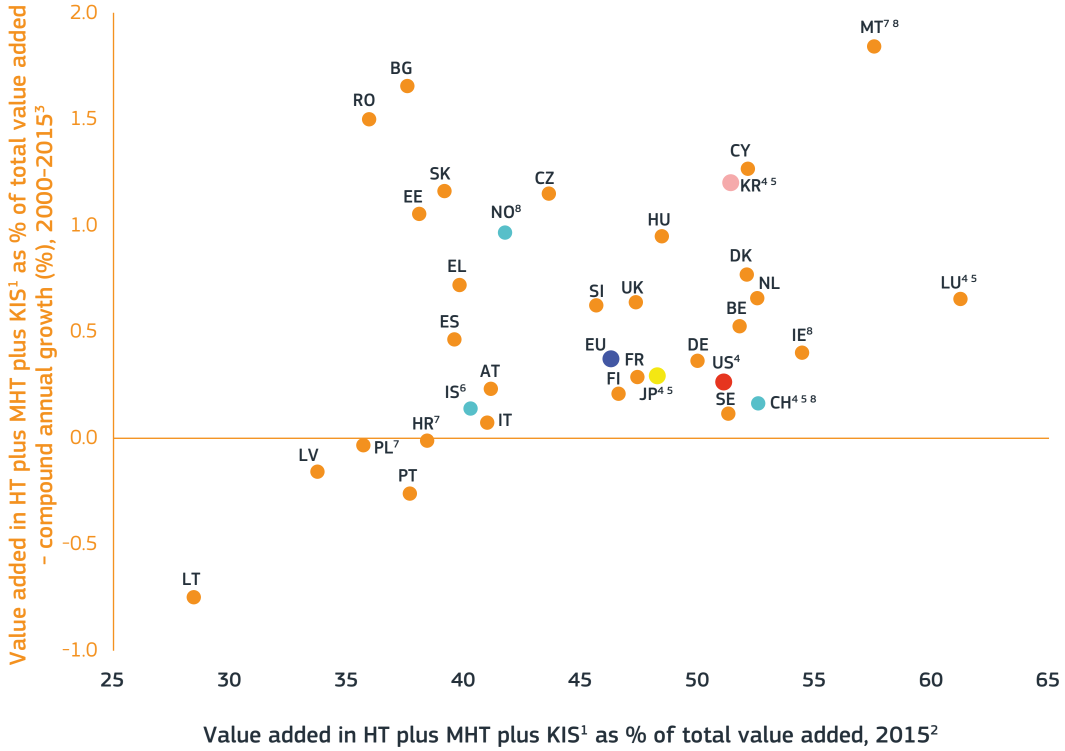
Shifts in the economic structure of the EU and its Member States

Structural change is defined as the long-term evolution of the economy's composition, measured as the variation in production and/or employment shares. Such a transformation is growth enhancing if employment and production are progressively reallocated towards more knowledge-intensive and productive sectors. In addition, increased R&D investment within sectors also contributes to the growth of sectoral and eventually aggregate productivity, as the variables are closely interrelated. Analysing the growth rates of value-added shares in knowledge-intensive services, high-tech and medium-high-tech manufacturing informs on the direction of the shifts within the economic structure.

Overall, the EU has experienced a process of structural change towards more knowledge intensive sectors. The growth rate of value-added shares in these sectors is higher in the EU than in the United States, Japan or Switzerland. However, this positive trend is not enough to close the gap with those countries and a more rapid shift is needed. South Korea was the most knowledge-intensive economy in 2015, also enjoying the fastest growth-enhancing structural change worldwide.

The EU trend is driven by high heterogeneity among Member States. Figure I.6-B.6 below plots the share of value added of the aggregate of the three sectors in 2015 against its compound annual growth rate in the period 2000-2015. At the top of the graph are the countries which have been increasingly shifting the composition of their economies towards more knowledge-intensive activities, by growing at rates between 1 % and 2 % per year. Bulgaria, Romania, Slovakia, Estonia and the Czech Republic have still an aggregate lower share than the EU average, but they managed to reduce or close the gap with countries like Austria, Italy, Portugal and Croatia whose structure has remained relatively unchanged over the 15 years observed. Malta and Cyprus have been shifting their structure at a high speed and are among the most knowledge-intensive countries in the EU at the end of the period. Denmark, the Netherlands, Belgium and Ireland have been increasing the value-added share of knowledge-intensive activities more slowly but are still far above the EU average. Conversely, Latvia, Portugal, Poland and Lithuania have experienced a decline in value-added shares, moving towards less-knowledge intensive sectors. The rest of the Member States stand in an intermediate position, with growth rates around or below the EU average, with the exception of Greece and Spain which still lagged behind in 2015.

Figure I.6-B.6 Share of value added in high-tech manufacturing (HT) plus medium-high-tech manufacturing (MHT) plus knowledge-intensive services (KIS)[1], 2015 and compound annual growth, 2000-2015



Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies
Data: Eurostat, OECD
Notes: [1]KIS does not include security and investigation activities due to unavailability of data. [2]MT, KR: 2013; BE, DE, IE, ES, FR, HR, IT, CY, LV, LT, PL, PT, SE, EU, NO, CH: 2014. [3]MT, KR: 2000-2013; BE, DE, IE, ES, FR, HR, IT, CY, LV, LT, PT, SE, EU, NO, CH: 2000-2014; PL: 2003-2014. [4]LU, CH, US, JP, KR: KIS does not include employment activities. [5]LU, CH, JP, KR: KIS does not include water transport and air transport. [6]IS: KIS does not include water transport. [7]HR, MT, PL: KIS does not include air transport. [8]IE, MT, NO, CH: Manufacture of coke and refined petroeum products is included in MHT. [9]Elements of estimation were involved in the compilation of the data.
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-b_figures/f_i_6-b_6.xlsx

The crisis has not hampered the process of structural change in the EU or the United States. On the contrary, a slight increase can be seen in the speed of change.

In both cases, the annual growth rate in the aggregate shares of value added in knowledge intensive sectors increased by 0.3% per year in the period 2008-2015 with respect to 2000-2007 (Figures I.6-B.7 and I.6-B.8 below). This is in contrast to the slowdown in South Korea (from 1.7% to 0.4% per year), in Japan (from 0.9% to -0.1% per year) and, to a lesser extent, in Switzerland.

However, the process has not been homogeneous among countries and different trends can be observed within the EU itself.

Starting in 2008, Greece and Portugal have inverted the shift towards knowledge-intensive activities, while Bulgaria, Romania, Slovakia and Cyprus have doubled or more than doubled the speed of change, also suggesting a possible positive effect generated by their accession to the EU. Denmark, Belgium and the Netherlands have accelerated the structural upgrade process, while the UK has slowed it down to a growth rate close to zero.

Figure I.6-B.7 Share of value added in high-tech manufacturing (HT) plus medium-high-tech manufacturing (MHT) plus knowledge-intensive services (KIS)[1], 2007 and compound annual growth, 2000-2007

Science, Research and Innovation performance of the EU 2018

Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies

Data: Eurostat, OECD

Notes: [1]KIS does not include security and investigation activities due to the unavailability of data. [2]PL: 2003-2007. [3]LU, CH, US, JP, KR: KIS does not include employment activities. [4]LU, CH, JP, KR: KIS does not include water transport and air transport. [5]IS: KIS does not include water transport. [6]HR, MT, PL: KIS does not include air transport. [7]IE, MT, NO, CH: Manufacture of coke and refined petroeum products is included in MHT. [8]Elements of estimation were involved in the compilation of the data.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-b_figures/f_i_6-b_7.xlsx

Figure I.6-B.8 Share of value added in high-tech manufacturing (HT) plus medium-high-tech manufacturing (MHT) plus knowledge-intensive services (KIS)[1], 2015 and compound annual growth, 2008-2015

Science, Research and Innovation performance of the EU 2018

Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies

Data: Eurostat, OECD

Notes: [1]KIS does not include security and investigation activities due to unavailability of data. [2]MT, KR: 2013; BE, DE, IE, ES, FR, HR, IT, CY, LV, LT, PL, PT, SE, EU, NO, CH: 2014. [3]MT, KR: 2008-2013; BE, DE, IE, ES, FR, HR, IT, CY, LV, LT, PL, PT, SE, EU, NO, CH: 2000-2014. [4]LU, CH, US, JP, KR: KIS does not include employment activities. [5]LU, CH, JP, KR: KIS does not include water transport and air transport. [6]IS: KIS does not include water transport. [7]HR, MT, PL: KIS does not include air transport. [8]IE, MT, NO, CH: Manufacture of coke and refined petroeum products is included in MHT. [9]Elements of estimation were involved in the compilation of the data.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-b_figures/f_i_6-b_8.xlsx

The above trends are the result of the aggregation of diverse trajectories in the different sectors. Hence, what follows is an analysis of the growth rates in value-added shares of KIS, high-tech and medium-high-tech manufacturing separately, providing a deeper perspective on the drivers of structural change. This is relevant given the technology content of the diverse economic activities in the three groups, as can been seen from each Member State's different specialisation and productivity figures in Figure I.6-B.2.

The EU as a whole is not as specialised in high-tech manufacturing activities as the United States, Japan, South Korea and Switzerland. Most of the EU countries have less than 2% of value added in the sector. This share has been decreasing overtime, suggesting that the gap between the EU as a whole and the other leading economies has been widening.

While such a shift away from high-tech manufacturing is also observed in the United States and Japan, the gap with the EU is growing in a sector which is crucial for innovation and productivity growth (Figure I.6-B.9). Ireland is a notable exception with around 9% of value added in high-tech manufacturing, despite a negative growth rate. Only a handful of countries have been increasing their specialisation in the sector, most notably Cyprus, Denmark, Latvia and the Czech Republic. Switzerland and South Korea are the countries most specialised in high-tech manufacturing outside of the EU, by far, and are increasing their specialisation over time. More interestingly, Finland and Malta have experienced a significant shift away from the sector, at a growth rate of -6.1% and -7.7% respectively, with spikes of -11% and -10.2% after 2008.

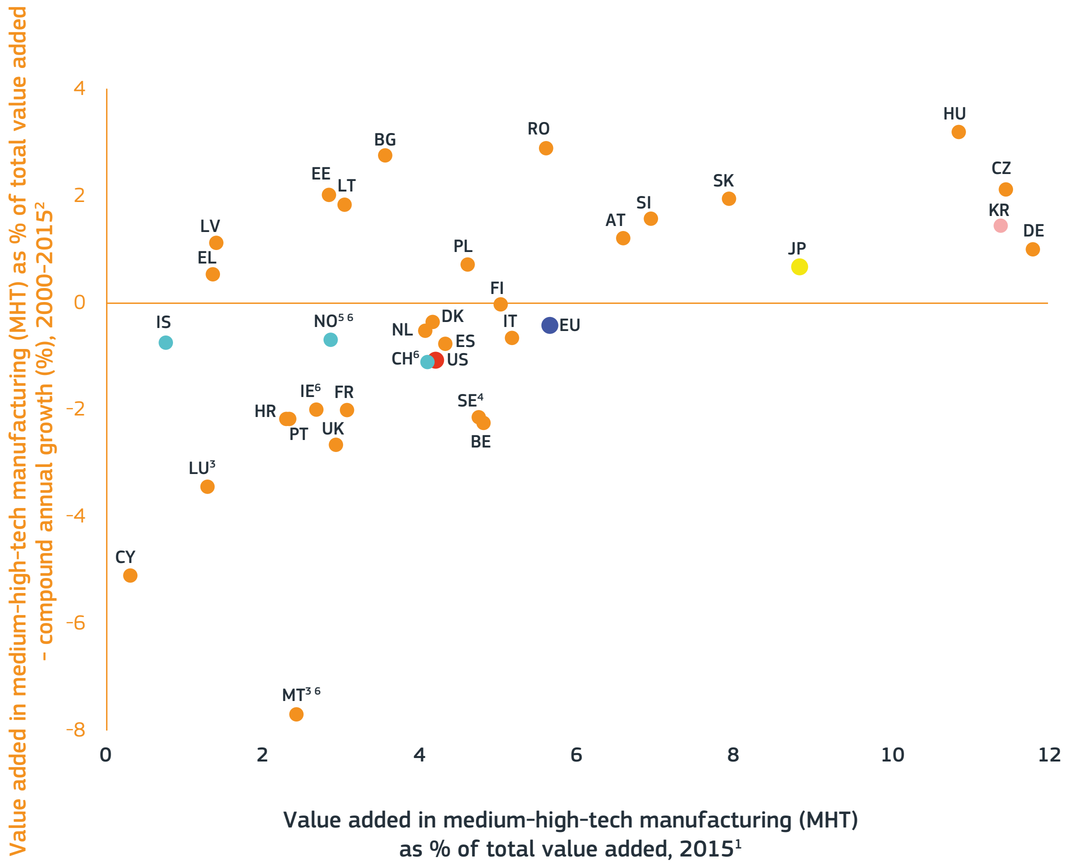
Figure I.6-B.9 Share of value added in high-tech manufacturing (HT), 2015 and compound annual growth, 2000-2015

Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies
Data: Eurostat, OECD
Notes: [1]KR: 2013; DE, IE, ES, HR, CY, LV, LT, PL, PT, SE, EU, NO, CH: 2014; MT: 2016. [2]KR: 2008-2013; DE, IE, ES, HR, CY, LV, LT, PL, PT, SE, EU, NO, CH: 2008-2014; MT: 2008-2016; TR: 2010-2015. [3]LU, MT: MHT is included in HT. [4]MT: Manufacture of coke and refined petroleum products is included in MHT. [5]SE: Manufacture of chemicals and chemical products is included in HT. [6]NO: Manufacture of basic pharmaceutical products and preparations is not included in HT. [7]Elements of estimation were involved in the compilation of the data.
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-b_figures/f_i_6-b_9.xlsx

The EU is more specialised in medium-high-tech manufacturing, which has been on a slightly declining trend since 2000 (-0.4% per year), although this decline is happening at a slower pace than in the United States (-1.1%). Overall, the gap with South Korea and Japan has been increasing during the period.

In 2015, the medium-high-tech manufacturing sectors accounted for 5.7% of total value added, compared to 4.2% in the United States and 4.1% in Switzerland. Germany is the Member State with the largest share (11.8%), higher than South Korea (11.4%) and Japan (8.8%), followed by the Czech Republic (11.5%) and Hungary (10.9%). Overall, high heterogeneity in value added shares can be observed throughout the EU. Between 2000 and 2015, a structural change towards medium-high-tech manufacturing activities took place mainly in eastern economies, together with Greece, Austria and Germany. All the other countries experienced negative growth rates, in particular Malta and Cyprus. This negative trend has been partially reversed since 2008, due to a positive shift for countries like Spain, Portugal, Ireland and the UK and stable and positive growth rates in Germany, Hungary and the Czech Republic.

Figure I.6-B.10 Share of value added in medium-high-tech (MHT) manufacturing, 2015 and compound annual growth, 2000-2015



Science, Research and Innovation performance of the EU 2018

Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies

Data: Eurostat, OECD

Notes: [1]KR: 2013; DE, IE, ES, HR, CY, LV, LT, PL, PT, SE, EU, NO, CH: 2014; MT: 2016. [2]KR: 2000-2013; DE, IE, ES, HR, CY, LV, LT, PT, SE, EU, NO, CH: 2000-2014; MT: 2000-2016; PL: 2003-2014. [3]LU, MT: HT is included in MHT. [4]SE: Manufacture of chemicals and chemical products is not included in MHT. [5]NO: Manufacture of basic pharmaceutical products and pharmaceutical preparations is included in MHT. [6]IE, MT, NO, CH: Manufacture of coke and petroleum products is included in MHT. [7]Elements of estimation were involved in the compilation of the data.

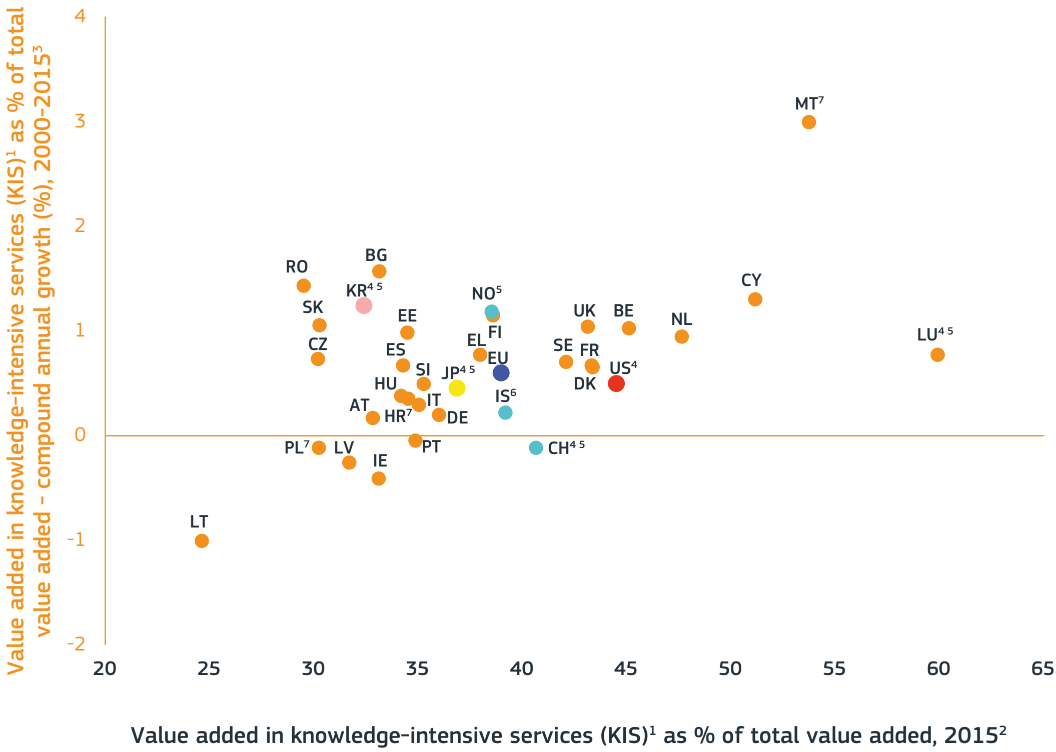
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-b_figures/f_i_6-b_10.xlsx

Moreover, over the last two decades, the EU has been transforming its economic structure, shifting more and more towards knowledge-intensive services, with an average growth rate of 0.6% per year. Positive growth in the sector has been driving the positive shift towards knowledge-intensive activities for the EU as a whole.

With a share of value added at 39% in 2015, the EU's degree of specialisation in KIS is higher than in Japan and South Korea, but lower than in the United States. Only a few countries have experienced a shift away from KIS, namely Poland, Latvia, Lithuania, Portugal and Ireland, the latter at an accelerated pace following the crisis in 2008. The structural composition of Malta is the fastest growing towards the sector. The years 2008-2015 show no change in the overall pattern. However, a reversion of the trend can be observed for some Member States, in particular Greece and Hungary, while an acceleration of the already negative growth rates occurred in Portugal, Latvia and Lithuania. Conversely, Slovakia and Cyprus increased the pace of shift towards the sector in the same period.

Given the above structural shifts and the differences in productivity presented in Figure I.6-B.1, this chapter also investigates labour productivity dynamics in the knowledge intensive sectors in the period 2000-2015 to shed further light on the performance of the EU and its Member States from a global perspective. Furthermore, understanding trends in productivity will complement the static figures presented in Figures I.6-B.2 and I.6-B.3.

Figure I.6-B.11 Share of value added in knowledge-intensive services (KIS)[1], 2015 and compound annual growth, 2000-2015



Science, Research and Innovation performance of the EU 2018

Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies

Data: Eurostat, OECD

Notes: [1]KIS does not include security and investigation activities due to the unavailability of data. [2]MT, KR: 2013; BE, DE, ES, FR, HR, IT, CY, LV, LT, PL, PT, SE, EU, NO, CH: 2014. [3]MT, KR: 2000-2013; BE, DE, ES, FR, HR, IT, CY, LV, LT, PT, SE, EU, NO, CH: 2000-2014; PL: 2003-2014. [4]LU, CH, US, JP, KR: KIS does not include employment activities. [5]LU, CH, JP, KR: KIS does not include water transport and air transport. [6]IS: KIS does not include water transport. [7]HR, MT, PL: KIS does not include air transport.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-b_figures/f_i_6-b_11.xlsx

On average, labour productivity in knowledge intensive sectors activities in the EU has been growing at 0.6 % per year, with most Member States experiencing growth rates around or below zero, lagging behind the United States.

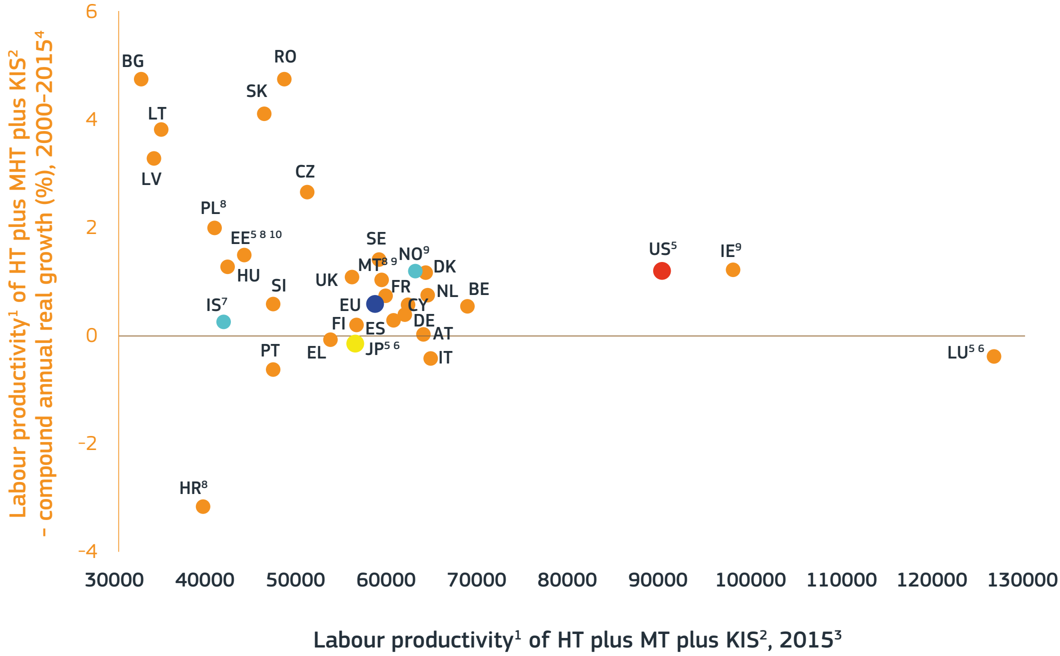
The global scenario over the period has been characterised by low or negative growth worldwide, with the United States growing at 1.2 % per year and Japan at -0.1 %.

Within the EU, a typical convergence pattern[36] can be observed for the eastern economies growing at a rate of up to five times the EU average, while most advanced economies have experienced close to zero (e.g. Germany, Austria, Spain) or negative growth (e.g. Italy, Luxembourg, Portugal).

However, this convergence process does not involve southern economies, such as Italy, Greece, Spain and Portugal. Indeed, the growth rate of labour productivity in the south of Europe has been consistently lower (and mainly negative) than in other Member States, such as Germany, France, the Netherlands or most of the Scandinavian countries, a trend which has worsened since the crisis. As a result, such countries still lag behind the EU average and more advanced Member States in terms of labour productivity levels. The only exception is Italy which, despite a negative performance over the period, has higher labour productivity in medium-high-tech, high-tech manufacturing sectors and knowledge-intensive services than Germany, Austria, Denmark and the Netherlands, only lagging behind Belgium, Ireland and Luxembourg. Overall, in 2015, EU labour productivity in knowledge intensive sectors is still only around two-thirds of the United States and this gap has been increasing over time (Figure I.6-B.12).

36 Economies are said to converge in absolute terms if those with a lower initial level of labour productivity grow faster than the most advanced ones. See, for instance, Barro, R.J. and Sala-i-Martin, X. (1992). Convergence. *Journal of Political Economy* 100(2): 223-251. Figure I.6-B.12 shows the last year (2015) on the horizontal axis rather than the initial year (2000), although the results would remain unchanged using the latter.

Figure I.6-B.12 Labour productivity[1] of high-tech manufacturing (HT) plus medium-high-tech manufacturing (MHT) plus knowledge-intensive services (KIS)[2], 2015 and compound annual real growth, 2000-2015

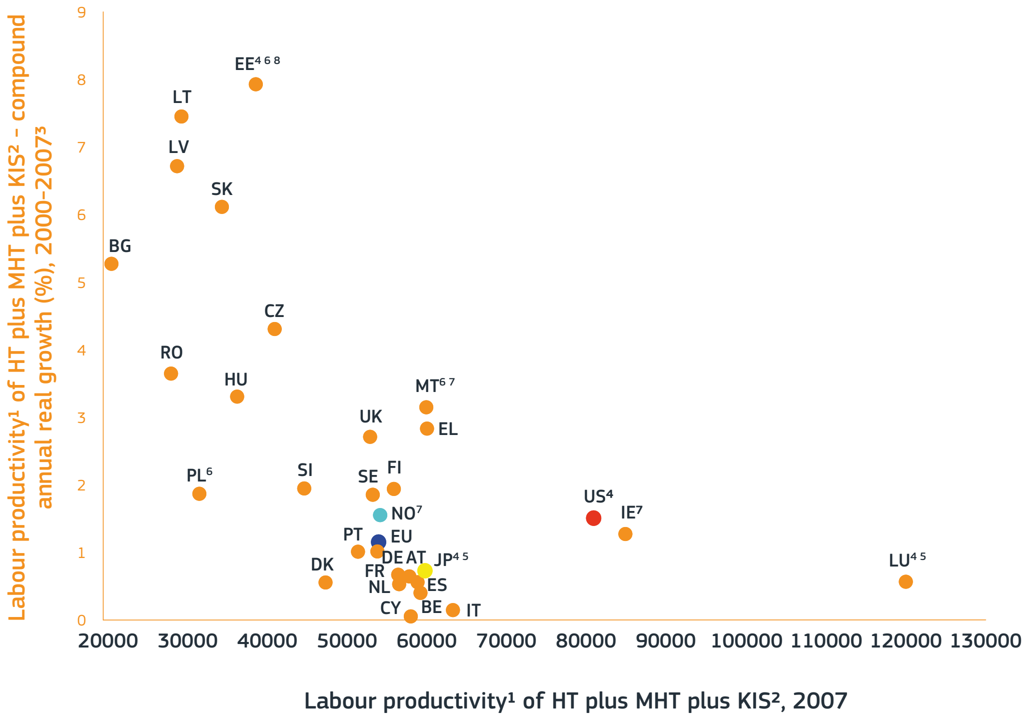


Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies
Data: Eurostat, OECD
Notes: [1]Value added per person employed in current PPS€. Compound annual real growth was calculated from values at 2010 prices. [2]KIS does not include security and investigation activities due to unavailability of data. [3]MT: 2013; BE, DE, IE, ES, FR, HR, IT, CY, LV, LT, PL, PT, RO, SE, EU, NO, JP: 2014. [4]MT: 2000-2013; PL: 2003-2014; EE: 2004-2015; HR: 2008-2014; IS: 2008-2015; BE, DE, IE, ES, FR, IT, CY, LV, LT, PT, RO, SE, NO, JP: 2000-2014. [5]EE, LU, US, JP: KIS does not include employment activities. [6]LU, JP: KIS does not include water transport and air transport. [7]IS: KIS does not include water transport. [8]EE, HR, MT, PL: KIS does not include air transport. [9]IE, MT, NO: Manufacture of coke and refined petroleum products is included in MHT. [10]EE: Manufacture of basic pharmaceutical products and pharmaceutical preparations is not included in HT. [11]IE, CY, RO: Breaks in series occur between 2000 and 2015; when there is a break in series the growth calculation takes into account annual growth before the break in series and annual growth after the the break in series. [12]Elements of estimation were involved in the compilation of the data.
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-b_figures/f_i_6-b_12.xlsx

The general productivity slowdown seems to have accentuated since the Great Recession, hitting the EU as a whole, Japan and, to a lesser extent, the United States, the latter showing some resilience and reducing its annual growth rate by only 0.2 % after 2007.

Figures I.6-B.13 and I.6-B.14 show some stylised facts concerning labour productivity dynamics before and after the surge of the crisis. First, the convergence dynamics characterising the periods 2000 and 2015 were already in place between 2000 and 2007. During this period, labour productivity growth was up to eight times higher in eastern economies than the EU average, while staying between 0 % and 2 % per year in most advanced Member States, the majority of them experiencing yearly growth rates below 1 %. Second, despite huge heterogeneity, the growth rates in knowledge intensive sectors were positive in every EU Member State before the crisis hit, leading to an EU average growth rate of 1.2 %. Third, after 2007, the crisis sharply impacted the performance of most countries, reducing labour productivity growth rates, which became negative in southern European economies, Austria, Malta, Finland and some of the eastern economies. The impact was significantly negative in Greece, Croatia and Portugal, while Denmark, Cyprus and the Netherlands are the only countries which have continued to enjoy growing rates of productivity since 2007. Fourth, Romania, Bulgaria, Poland, Slovakia and Czech Republic have continued their convergence trend, even though it is at a slower pace than before the crisis. Conversely, the process came to a halt for Estonia, Latvia, Lithuania, Slovenia and Hungary whose growth rates turned negative and fell below the EU average. Fifth, the economies more resilient to the crisis were those with the largest R&D intensities in knowledge intensive sectors (Figure I.6-B.5), suggesting that investing in R&I improves competitiveness over the long term. Finally, the gap between the EU and the United States increased in 2015 compared to 2007, while Japan fell behind due to a worse and negative performance over the period.

Figure I.6-B.13 Labour productivity[1] of high-tech manufacturing (HT) plus medium-high-tech manufacturing (MHT) plus knowledge-intensive services (KIS)[2], 2007 and compound annual real growth, 2000-2007



Science, Research and Innovation performance of the EU 2018

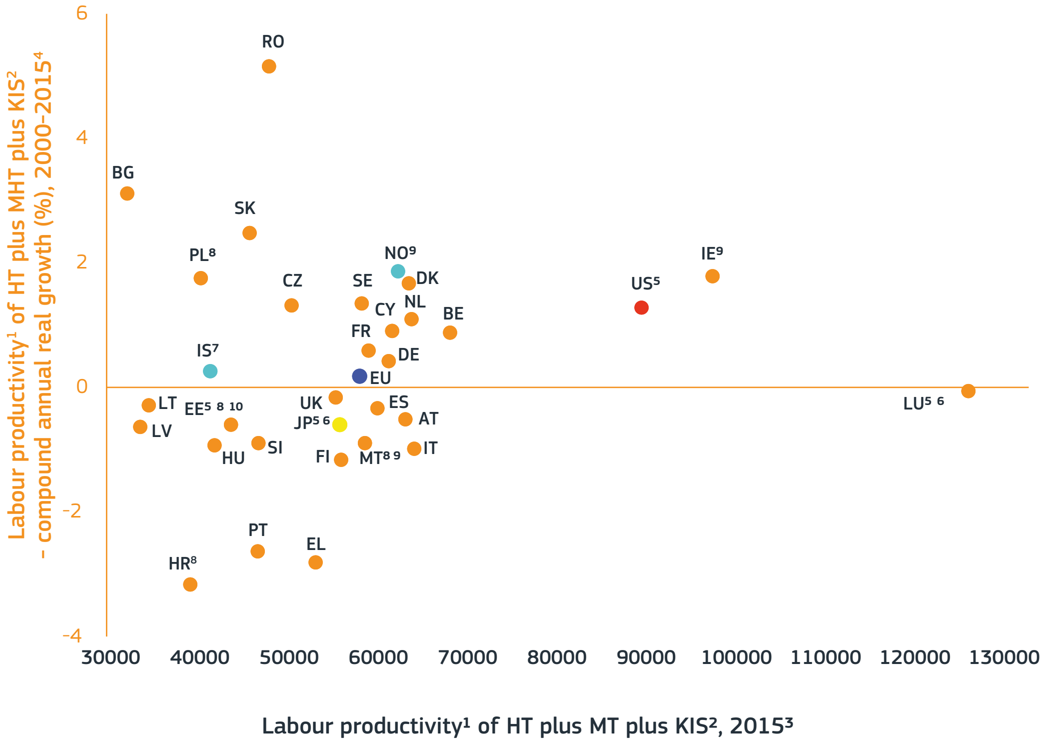
Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies

Data: Eurostat, OECD

Notes: [1]Value added per person employed in current PPS€. Compound annual real growth was calculated from values at 2010 prices. [2]KIS does not include security and investigation activities due to the unavailability of data. [3]PL: 2003-2007; IE, ES, FR, HR, IT, CY, LV, LT, PL, PT, RO, SE, EU, NO, JP: 2014. [4]MT: 2000-2013; PL: 2003-2014; EE: 2004-2015; HR: 2008-2014; IS: 2008-2015; BE, DE, IE, ES, FR, IT, CY, LV, LT, PT, RO, SE, NO, JP: 2000-2014. [5]EE, LU, US, JP: KIS EE: 2004-2007. [4]EE, LU, US, JP: KIS does not include employment activities. [5]LU, JP: KIS does not include water transport and air transport. [6]EE, MT, PL: KIS does not include air transport. [7]IE, MT, NO: Manufacture of coke and refined petroleum products is included in MHT. [8]EE: Manufacture of basic pharmaceutical products and pharmaceutical preparations is not included in HT. [9]Elements of estimation were involved in the compilation of the data.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-b_figures/f_i_6-b_13.xlsx

Figure I.6-B.14 Labour productivity[1] of high-tech manufacturing (HT) plus medium-high-tech manufacturing (MHT) plus knowledge-intensive services (KIS)[2], 2015 and compound annual real growth, 2008-2015



Science, Research and Innovation performance of the EU 2018

Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies

Data: Eurostat, OECD

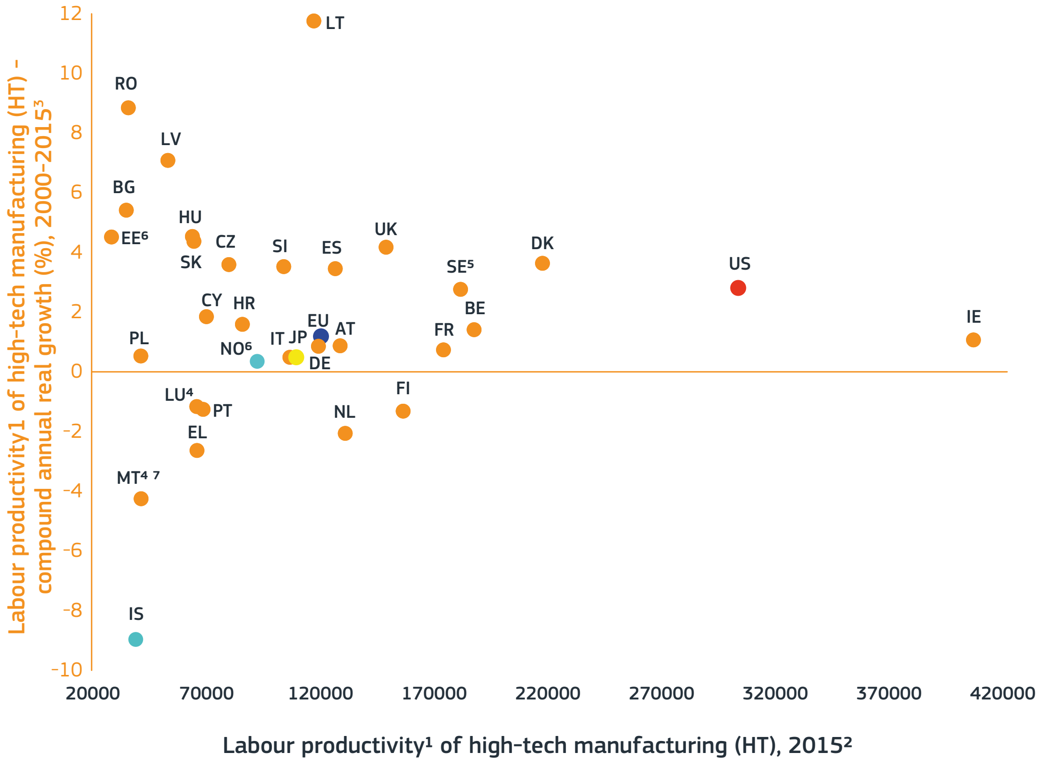
Notes: [1]Value added per person employed in current PPS€. Compound annual real growth was calculated from values at 2010 prices. [2]KIS does not include security and investigation activities due to unavailability of data. [3]MT: 2013; BE, DE, IE, ES, FR, HR, IT, CY, LV, LT, PL, PT, RO, SE, EU, NO, JP: 2014. [4]MT: 2008-2013; BE, DE, IE, ES, FR, HR, IT, CY, LV, LT, PL, PT, RO, SE, EU, NO, JP: 2008-2014. [5]EE, LU, US, JP: KIS does not include employment activities. [6]LU, JP: KIS does not include water transport and air transport. [7]IS: KIS does not include water transport. [8]EE, HR, MT, PL: KIS does not include air transport. [9]IE, MT, NO: Manufacture of coke and refined petroleum products is included in MHT. [10]EE: Manufacture of basic pharmaceutical products and pharmaceutical preparations is not included in HT. [11]IE, CY, RO: Breaks in series occur between 2008 and 2015; when there is a break in series the growth calculation takes into account annual growth before the break in series and annual growth after the break in series. [12]Elements of estimation were involved in the compilation of the data.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-b_figures/f_i_6-b_14.xlsx

Labour productivity in high-tech manufacturing in the EU has been growing at a faster pace than the aggregate of all the knowledge-intensive activities (1.2% against 0.6% per year). The United States still (2.8%) outperforms the EU, implying an increase in the gap between the two economies, while Japan's performance has been stuck at 0.5% growth per year.

Within the EU, southern economies, with the exclusion of Spain, have experienced weak or negative growth over the period, together with the Netherlands, Finland, Luxembourg and Malta. Productivity has been rising in all the other countries, with the highest growth rates in Lithuania, Romania, Latvia and Bulgaria. Overall, the United States had by far the highest productivity level in high-tech manufacturing in 2015, exceeding by a large margin even the EU countries performing well, such as Denmark, Sweden, Belgium and France. Ireland stands apart because of its exceptional labour productivity level, more than three times higher than the EU average, and also outperforming United States values despite slower growth rates (Figure I.6-B.15). The crisis had a slightly negative impact on labour productivity dynamics in high-tech manufacturing in the EU, slowing down the aggregate growth rate from 1.5% to 1.2% per year in the period 2008-2015 but not significantly affecting the overall trend.

Figure I.6-B.15 Labour productivity[1] of high-tech manufacturing (HT), 2015 and compound annual real growth, 2000-2015



Science, Research and Innovation performance of the EU 2018

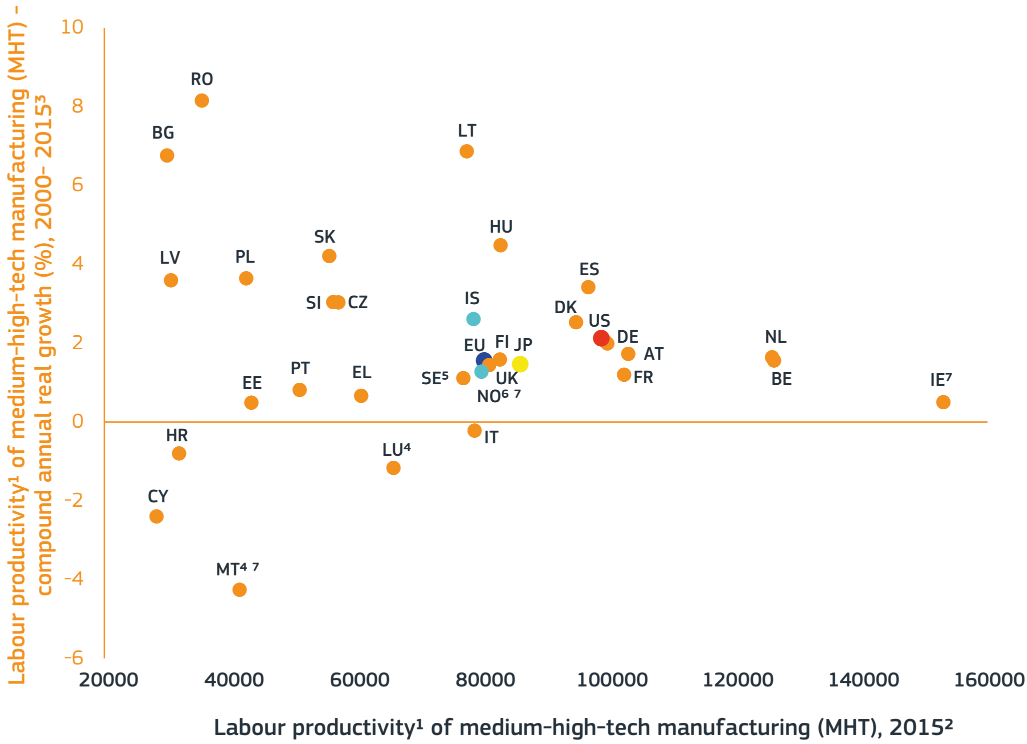
Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies
Data: Eurostat, OECD
Notes: [1]Value added per person employed in current PPS€. Compound annual real growth was calculated from values at 2010 prices. [2]DE, IE, ES, HR, CY, LV, LT, PL, PT, RO, SE, EU, NO, JP: 2014; MT: 2016. [3]DE, IE, ES, CY, LV, LT, PT, RO, SE, EU, NO, JP: 2000-2014; MT: 2000-2016; PL: 2003-2014; HR: 2008-2014; IS: 2008-2015. [4]LU, MT: MHT is included in HT. [5]SE: Manufacture of chemicals and chemical products is included in HT. [6]EE, NO: Manufacture of basic pharmaceutical products and pharmaceutical preparations is not included in HT. [7]MT: Manufacture of coke and refined petroleum products is included in MHT. [8]IE, CY, RO: Breaks in series occur between 2000 and 2015; when there is a break in series the growth calculation takes into account annual growth before the break in series and annual growth after the the break in series. [9]Elements of estimation were involved in the compilation of the data..
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-b_figures/f_i_6-b_15.xlsx

Medium-high-tech manufacturing is the sector among knowledge-intensive activities where labour productivity has been growing at the fastest pace in the EU, experiencing an average compound growth rate of 1.6% per year in the period 2000-2015, faster than Japan (1.5%) but still slower than the United States (2.1%). Most Member States have increased their productivity levels, with only five countries (Italy, Croatia, Luxembourg, Cyprus and Malta) experiencing negative growth rates.

Romania, Bulgaria and Lithuania[37] are the economies where productivity in the sector has grown the most, while the remaining countries have experienced growth rates between around 0% and 4% per year (Figure I.6-B.16). Labour productivity in Germany, the EU country with the highest specialisation in medium-high-tech manufacturing (see Figure I.6-B.10), has been growing at the same rate as the United States and their levels in 2015 were equal. Ireland is the Member State with the highest labour productivity, followed by the Netherlands, Belgium, Austria and France. The crisis had a heterogeneous effect across countries, depressing the performance of some economies (such as Austria, Malta and the Netherlands), while others have either shown resiliency or higher growth rates (such as, for instance, Denmark, Poland and Hungary).

37 A positive impact of their accession to the EU may be contributing to their overall performance.

Figure I.6-B.16 Labour productivity[1] of medium-high-tech manufacturing (MHT), 2015 and compound annual real growth, 2000-2015



Science, Research and Innovation performance of the EU 2018

Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies

Data: Eurostat, OECD

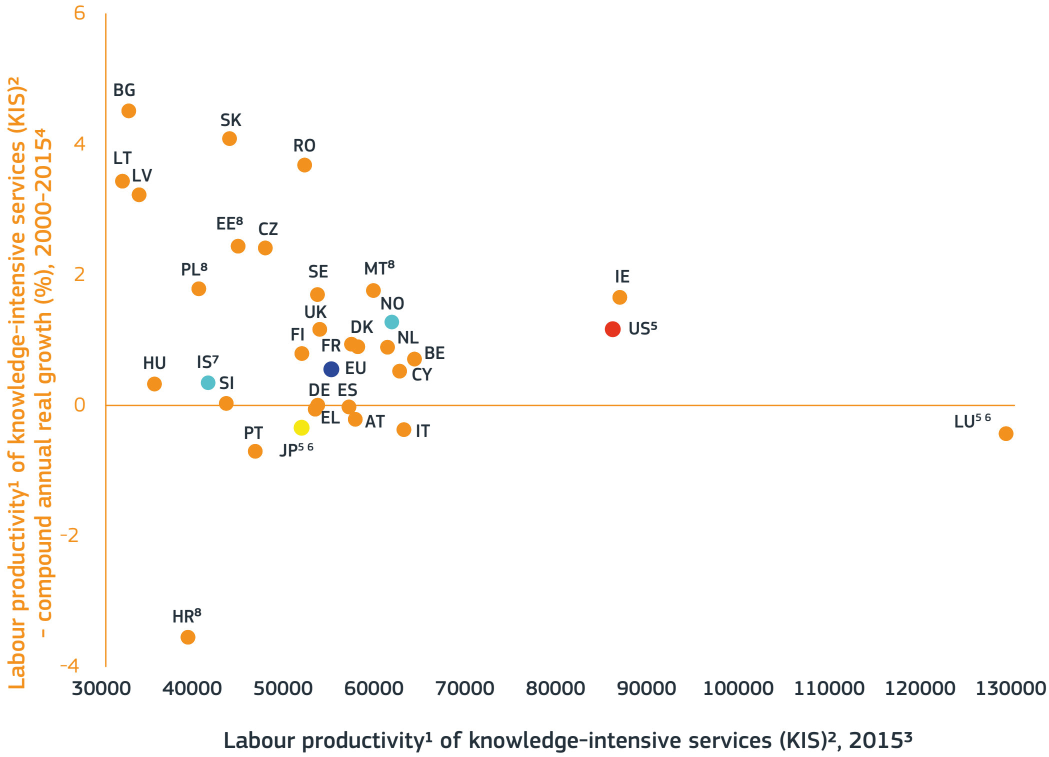
Notes: [1]Value added per person employed in current PPS€. Compound annual real growth was calculated from values at 2010 prices. [2]DE, IE, ES, HR, CY, LV, LT, PL, PT, RO, SE, EU, NO, JP: 2014; MT: 2016. [3]DE, IE, ES, CY, LV, LT, PT, RO, SE, EU, NO, JP: 2000-2014; PL: 2003-2014; EE: 2004-2015; HR: 2008-2014; IS: 2008-2015; MT: 2008-2016. [4]LU, MT: HT is included in MHT. [5]SE: Manufacture of chemicals and chemical products is not included in MHT. [6]NO: Manufacture of basic pharmaceutical products and pharmaceutical preparations is included in MHT. [7]IE, MT, NO: Manufacture of coke and refined petroleum products is included in MHT. [8]IE, CY, RO: Breaks in series occur between 2000 and 2015; when there is a break in series the growth calculation takes into account annual growth before the break in series and annual growth after the break in series. [9]Elements of estimation were involved in the compilation of the data.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-b_figures/f_i_6-b_16.xlsx

EU labour productivity dynamics in knowledge-intensive services have slightly improved over the past 15 years despite having been negatively affected during the crisis. Growth performance in the sector, which was already the lowest among knowledge-intensive activities at 1.2% per year from 2000-2007, collapsed to 0% from 2008 to 2015, resulting in overall weak performance during the whole period.

As a result, in 2015, EU labour productivity was higher than in Japan but lagged behind the United States, with a bigger gap as compared to 2000. This is worrying given the weight of KIS in total economic activity in modern economies. In addition, while there was a positive trend in the first half of the 2000s, the period following the last recession is characterised by declining labour productivity growth across all Member States, which turns negative for the southern economies, the UK and some Eastern European countries. This negative trend also applies to Japan and the United States, the latter nevertheless being able to maintain positive growth over time.

Figure I.6-B.17 Labour productivity[1] of knowledge-intensive services (KIS)[2], 2015 and compound annual real growth, 2000-2015



Science, Research and Innovation performance of the EU 2018

Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies

Data: Eurostat, OECD

Notes: [1]Value added per person employed in current PPS€. Compound annual real growth was calculated from values at 2010 prices. [2]KIS does not include security and investigation activities due to the unavailability of data. [3]MT: 2013; BE, DE, ES, FR, HR, IT, CY, LV, LT, PL, PT, RO, SE, EU, NO: 2014. [4]MT: 2000-2013; BE, DE, ES, FR, IT, CY, LV, LT, PT, RO, SE, EU, NO: 2000-2014; PL: 2003-2014; HR: 2008-2014; IS: 2008-2015. [5]EE, LU, US, JP: KIS does not include employment activities. [6]LU, JP: KIS does not include water transport and air transport. [7]IS: KIS does not include water transport. [8]EE, HR, MT, PL: KIS does not include air transport. [9]IE, CY, RO: Breaks in series occur between 2000 and 2015; when there is a break in series the growth calculation takes into account annual growth before the break in series and annual growth after the break in series. [10]Elements of estimation were involved in the compilation of the data.

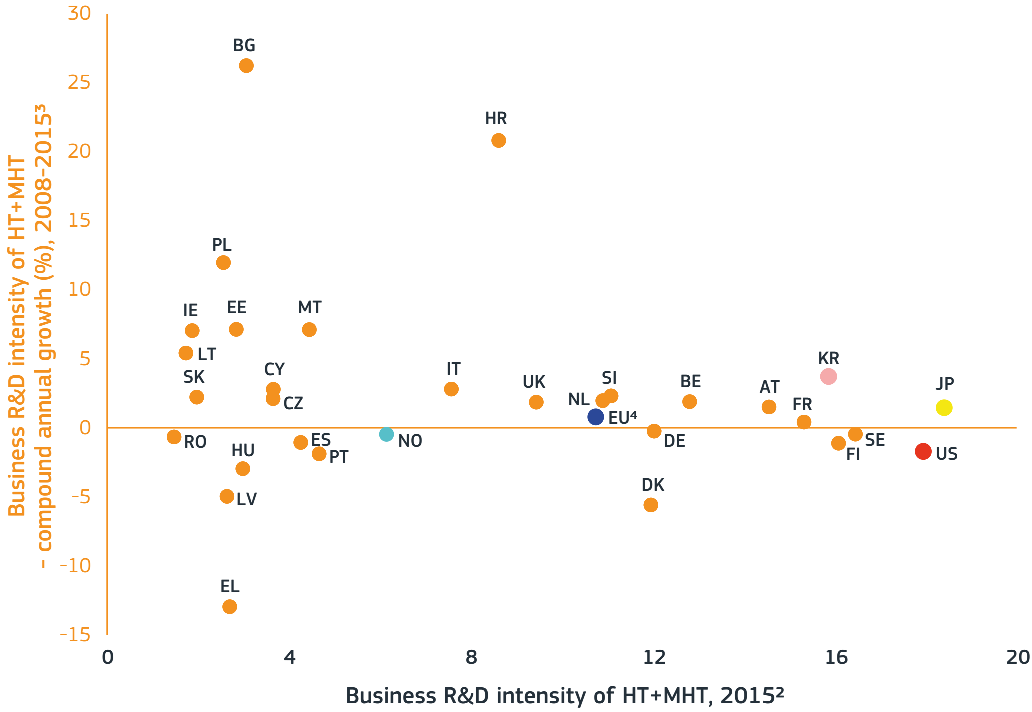
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-b_figures/f_i_6-b_17.xlsx

In conclusion, over the last two decades, the EU has been unable to bridge the productivity gap with the United States. Furthermore, such a divide has been widening since the last economic crisis due to zero or negative growth rates in the EU. This overall scenario can be partially explained by relatively lower R&D investment in these sectors compared to the United States and international competitors. Business R&D intensity in the EU is considerably lower than in the United States, South Korea and Japan and the trend in the years after the crisis has not led to a significant narrowing of the gap.

While business R&D intensity in medium-high and high-tech manufacturing has increased slightly in the EU since 2008, the low growth rate (0.8 % per year) has not been enough to bridge the gap with Japan, the United States and South Korea (Figure I.6-B.18). The latter has increased its R&D investment at a much higher pace (3.7 %) than the United States (-1.7 %) and Japan (1.5 %). Within the EU, some eastern economies have experienced positive growth in R&D intensity, while a negative performance has been observed in particular for Greece[38]. In 2015, nine Member States had business R&D intensities above the EU average, and only Finland, Sweden, France and Austria are close to the rates of the main international competitors.

38 It should be noted that for some smaller economies, a relatively small variation in R&D investment at the sectoral level can have a large effect on both the growth rate and the intensity.

Figure I.6-B.18 Business R&D intensity of high-tech manufacturing (HT) plus medium-high-tech manufacturing (MHT)[1], 2015 and compound annual growth, 2008-2015



Science, Research and Innovation performance of the EU 2018

Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies

Data: Eurostat, OECD

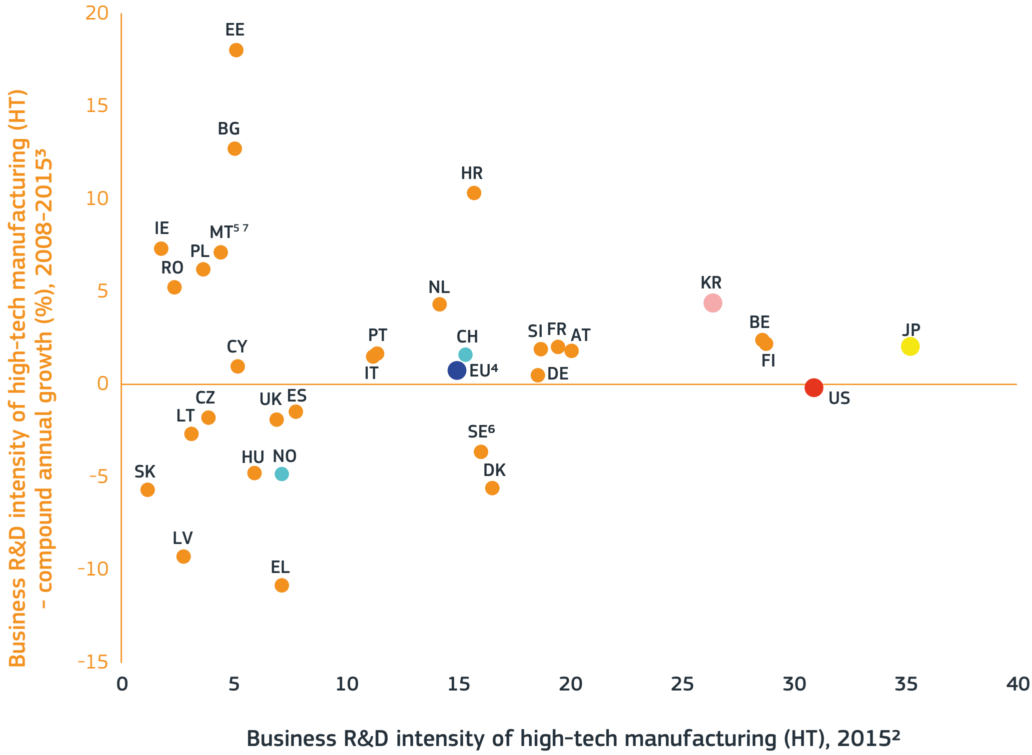
Notes: [1]Business enterprise expenditure on R&D (BERD) as % of value added, in HT+MHT sectors. [2]IE, FR, SE: 2013; PL, EU, JP: 2014. [3]FR, SE: 2008-2013; PL, EU, JP: 2008-2014; BG, DK, HR: 2009-2015; EE, MT: 2010-2015; IE: 2011-2013; EL: 2011-2015; LV: 2012-2015. [4]EU was estimated by DG Research and Innovation and does not include LU. [5]NL, RO, SI: Breaks in series occur between 2008 and 2015; when there is a break in series the growth calculation takes into account annual growth before the break in series and annual growth after the break in series. [6]Elements of estimation were involved in the compilation of the data.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-b_figures/f_i_6-b_18.xlsx

Business R&D intensity in high-tech manufacturing has been growing slightly faster in the EU (0.8 % per year) compared to the United States (-0.2 %) but slower than in Japan (2.0 %), while South Korea has been the largest investor over the period (4.4 %). Nevertheless, the EU still invests considerably less in R&D than its international competitors.

With an average BERD of 15 %, the EU invests less than half of what can be observed in the United States (30.9 %) or Japan (35.3 %), and significantly less than South Korea (26.4 %). Overall, there is no trend towards significantly higher R&D investment in high-tech manufacturing in the EU since the last economic crisis (Figure I.6-B.19). The EU landscape is quite diverse, with R&D intensities ranging from values close to zero – e.g. Slovakia, Ireland and Romania – to levels comparable to those observed in the United States – e.g. Belgium and Finland. In fact, Belgium and Finland are contributing significantly to driving the EU average up, since the majority of Member States have a remarkably lower BERD intensity. The BERD intensity has also been increasing at significant rates in some Eastern European economies and a positive performance can also be observed for Austria, France and the Netherlands among others. Conversely, some countries have been reducing the R&D investment in the sector, with Greece experiencing the lowest growth rate in the EU (-10.9 % per year). Growth dynamics have also been particularly negative for Slovakia, Sweden, Latvia and Denmark.

Figure I.6-B.19 Business R&D intensity of high-tech manufacturing (HT)[1], 2015 and compound annual growth, 2008-2015



Science, Research and Innovation performance of the EU 2018

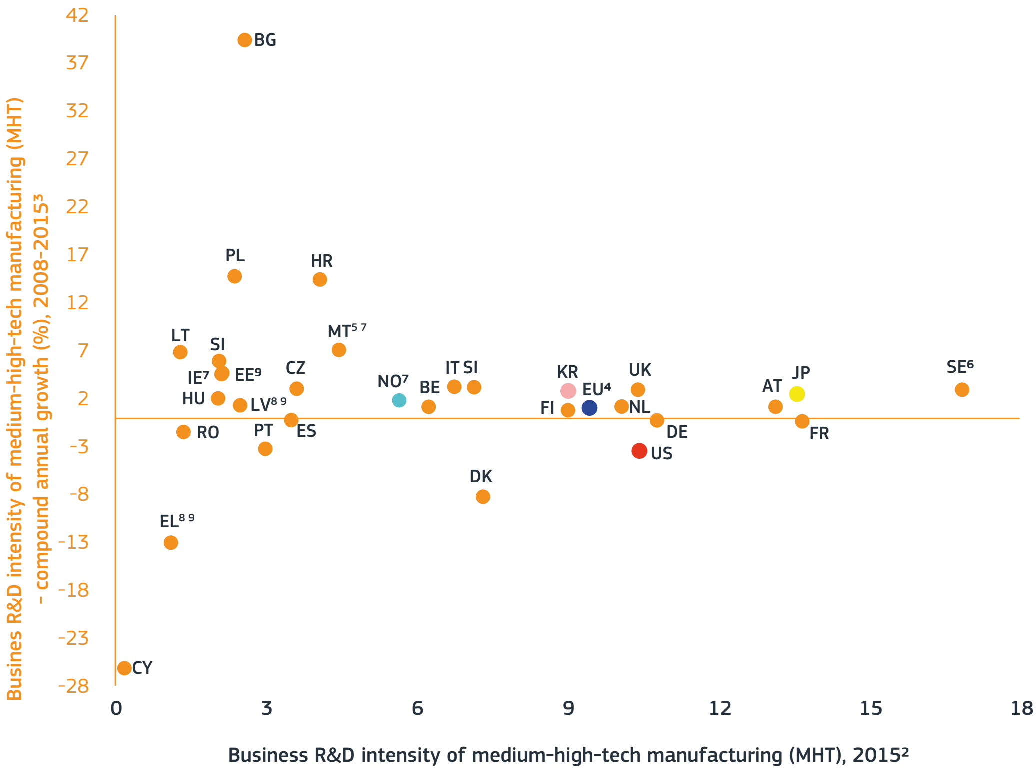
Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies
Data: Eurostat, OECD
Notes: [1]Business enterprise expenditure on R&D (BERD) as % of value added in HT sectors. [2]FR, IE, SE: 2013; PL, EU, JP: 2014. [3]FR, SE: 2008-2013; PL, JP, EU: 2008-2014; BG, DK: 2009-2015; EE, MT, SK: 2010-2015; IE: 2011-2013; EL: 2011-2015. [4]EU was estimated by DG Research and Innovation and does not include LU and MT. [5]MT: MHT is included in HT. [6]SE: Manufacture of chemicals and chemical products and manufacture of coke and refined petroleum products are included in HT. [7]MT: Manufacture of coke and refined petroleum products is included in MHT. [8]IE, NL, RO, SI: Breaks in series occur between 2008 and 2015; when there is a break in series the growth calculation takes into account annual growth before the break in series and annual growth after the break in series. [9]Elements of estimation were involved in the compilation of the data.
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-b_figures/f_i_6-b_19.xlsx

Medium-high-tech manufacturing industries in the EU are characterised by R&D investments (BERD intensity equal to 9.5%) comparable to those in the United States (10.4%) and South Korea (9%). The investment trend has been stable since 2008, with a growth rate of 1.1% per year over the period 2008-2015, slower than in South Korea (2.9%) and Japan (2.5%), but much faster than the United States (-3.4%), implying a narrowing of the gap with the latter.

Most Member States have been experiencing positive growth rates between 0% and 5% per year, suggesting an effort has been made to increase knowledge intensity in the sector over time (Figure I.6-B.20). Some countries, e.g. Latvia, Slovenia, Malta, Poland and Croatia, have been growing faster at rates up to 15%. Conversely, Cyprus and Greece have been going through a drastic collapse in R&D investment, with an annual negative growth rate of 26.6% and 13%, respectively. In the case of Cyprus, this trend is coupled with a shift in economic activity away from the sector and a growing specialisation in high-tech manufacturing, suggesting an upgrade in the economy's knowledge structure. Bulgaria stands as an outlier, with an exceptional annual growth rate of BERD intensity in the sector of 39.8% since 2008. As of 2015, Sweden has the highest investment in R&D in the industry, larger (16.8%) than Japan (13.6%), followed by France (13.7%) and Austria (13.1%).

This chapter has analysed structural change in the EU and among its main competitors and has linked these trends to labour productivity dynamics. Economies with higher productivity in a sector are more competitive and, in the long term, tend to have larger shares in that sector than other countries, and are also more resilient to external shocks, such as the last economic crisis. Furthermore, R&D investments are a key factor behind labour productivity, shaping sectors' competitiveness and acting as an important lever to drive changes in economic specialisation. The EU has been slightly increasing both its specialisation in knowledge intensive sectors and business R&D intensity in those sectors. However, these trends are not sufficient to bridge the gap with the most advanced economies, most notably the United States, South Korea and Japan. Therefore, both a faster pace of structural transformation and greater R&D investments would be needed to increase labour productivity growth and EU competitiveness on the global scale.

Figure I.6-B.20 Business R&D intensity of medium-high-tech manufacturing (MHT)[1], 2015 and compound annual growth, 2008-2015



Science, Research and Innovation performance of the EU 2018

Source: DG Research and Innovation - Unit for the Analysis and Monitoring of National Research and Innovation Policies
Data: Eurostat, OECD
Notes: [1]Business enterprise expenditure on R&D (BERD) as % of value added in MHT sectors. [2]IE, FR, SE: 2013. PL, EU, JP: 2014. [3]FR, SE: 2008-2013; PL, EU, JP: 2008-2014; BG, DK, HR, SK: 2009-2015; MT: 2010-2015; IE: 2011-2013; EL: 2011-2015. [4]EU was estimated by DG Research and Innovation and does not include LU and MT. [5]MT: HT is included in MHT. [6]SE: Manufacture of chemicals and chemical products is not included in MHT. [7]IE, MT, NO: Manufacture of coke and refined petroleum products is included in MHT. [8]EL, LV: Manufacture of motor vehicles, trailers and semi-trailers is not included in MHT. [9]EE, EL, LV: Manufacture of other transport equipment is not included in MHT. [10]NL, RO, SI: Breaks in series occur between 2008 and 2015; when there is a break in series the growth calculation takes into account annual growth before the break in series and annual growth after the break in series. [11]Elements of estimation were involved in the compilation of the data.
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/parti/i_6-b_figures/f_i_6-b_20.xlsx

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