CHAPTER 3.2

STRUCTURAL CHANGE

KEY FIGURES

50 %
share of knowledge-intensive sectors in EU employment

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

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

What can we learn?

- A higher weight of knowledge-intensive sectors **correlates with higher R&I investments and productivity performance**.
- **Knowledge-intensive services have a weight of more than 40%** and constitute the main bulk of employment shares in the EU.
- **Structural change is not favouring enough knowledge-intensive sectors in the EU**, reducing productivity growth patterns. This trend is particularly relevant in some Member States.
- **While a generalised transformation towards knowledge-intensive services has been observed, intra-EU differences persist**. In particular, some countries have been moving away from medium-high-tech and high-tech manufacturing while the catching up by others (most notably the central, eastern and south-eastern Europe - CESEE economies) is driven by greater specialisation in medium-high-tech manufacturing.
- **Differences in productivity performance also exist within sectors** and contribute to explain the productivity gap between the EU and the United States.

What does it mean for policy?

- **Mobilise national and European resources towards knowledge-intensive activities** as a lever to increase Europe's ability to invest in R&I and its productivity prospects.
- An **EU industrial strategy** is key to counter the deindustrialisation trends in the EU and to **increase long-term EU competitiveness while meeting the need for a transition towards a climate-neutral and sustainable economy**.

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

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

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

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

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

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

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

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

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

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

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

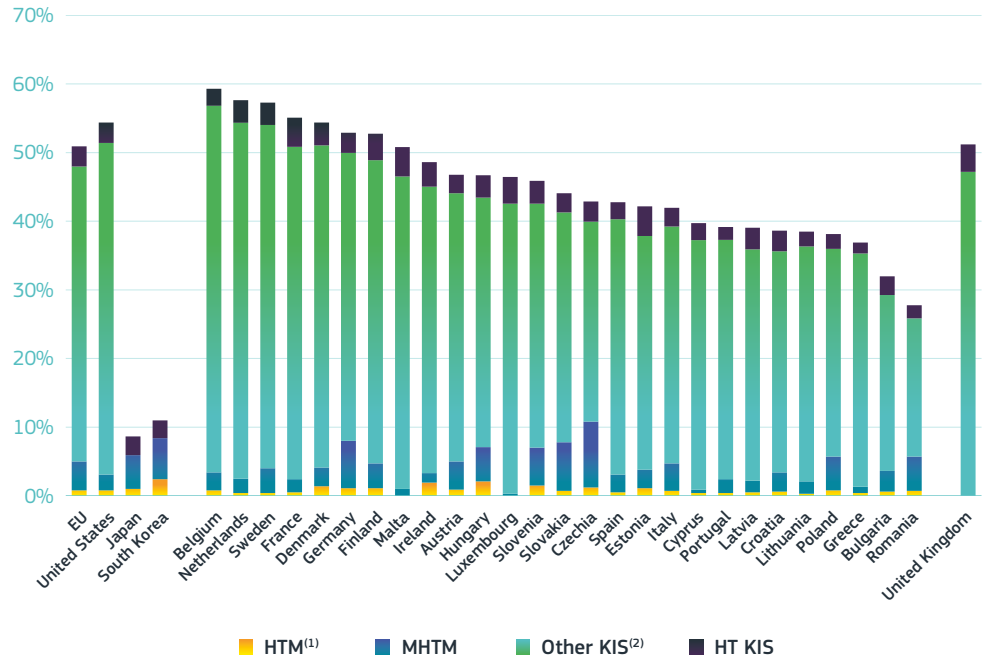
Other services include services not belonging to any of the above categories (including G, I, L, S, T and U).

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

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

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

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



Science, research and innovation performance of the EU 2020

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

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

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

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

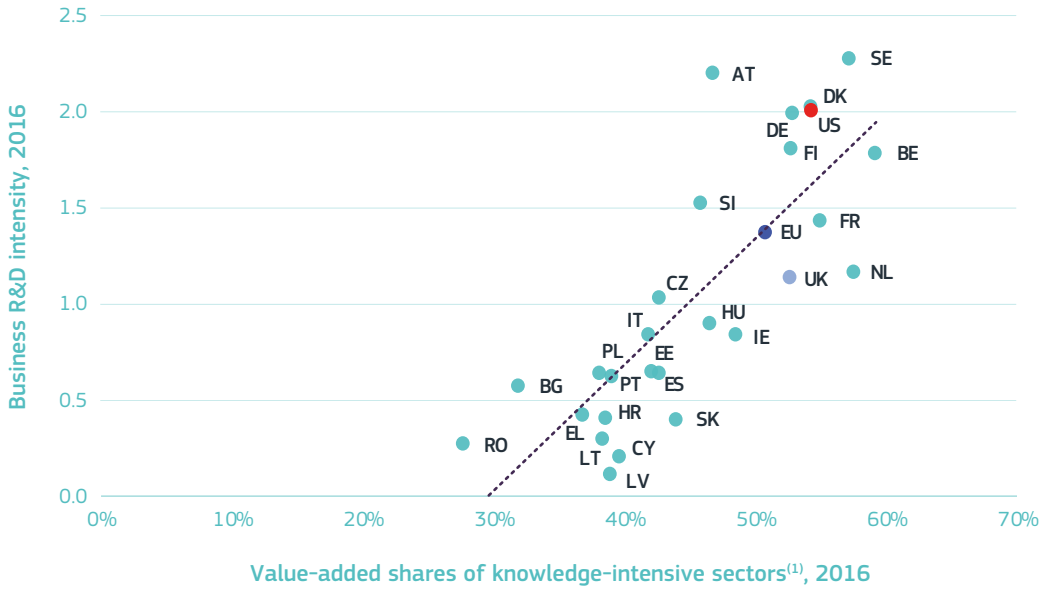
The European economic structure is similar to that observed in peer countries, adding up to more than half the total employment in knowledge-intensive sectors. Figure 3.2-1 shows that the EU, like any modern economy, is characterised by the predominance of services, representing more than 70% of total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

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

The larger the weight of knowledge-intensive sectors, the higher the capacity to invest in R&D and innovate. Given the above scenario, it is possible to investigate the relationship between R&D intensity and the weight of knowledge-intensive sectors which eventually determines how much an economy can invest in R&I. Figure 3.2-2 plots business R&D intensity and the sum of the employment shares of medium-high-tech and high-tech manufacturing and knowledge-intensive services. The private sector is the main performer in R&D investment, accounting for around 65% of total R&D investment in the EU and 72% in the United States. The figure reveals a clear positive relationship: countries with a larger total share of knowledge-intensive sectors are also those with larger R&D intensities. Empirical evidence suggests that differences in structural composition do explain most of the EU-United States business R&D gap, and that this is true

even when accounting for the role of company size and the share of young innovative firms in the two economies (Cincera and Veugelers, 2013). Among knowledge-intensive activities, high-tech and medium-high-tech manufacturing are key engines for R&D investments in the business sector, as a relevant share occurs in industry (European Commission, 2018; Coad and Vezzani, 2017). It is interesting to observe that, while there is a positive correlation between the share of knowledge-intensive manufacturing activities and business R&D intensity, there are a few exceptions (Figure 3.2-3). This is notably the case in some CESEE economies, which have the highest specialisation in knowledge-intensive manufacturing – especially in the medium-high-tech sectors – but relatively lower R&D intensity. As mentioned above, this is due to the delocalisation of production from abroad which does not come with the relocation of R&D activities (Correia et al., 2018).

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



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

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

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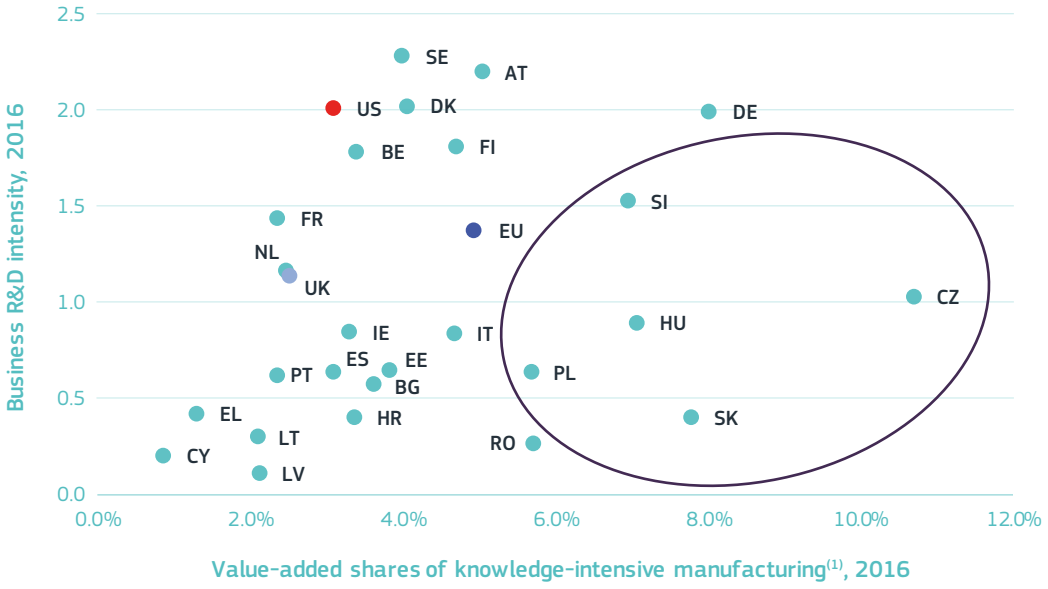
Figure 3.2-3 Business R&D intensity and employment shares in high-tech and medium-high-tech manufacturing, 2016[2][3]



Science, research and innovation performance of the EU 2020

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

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

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

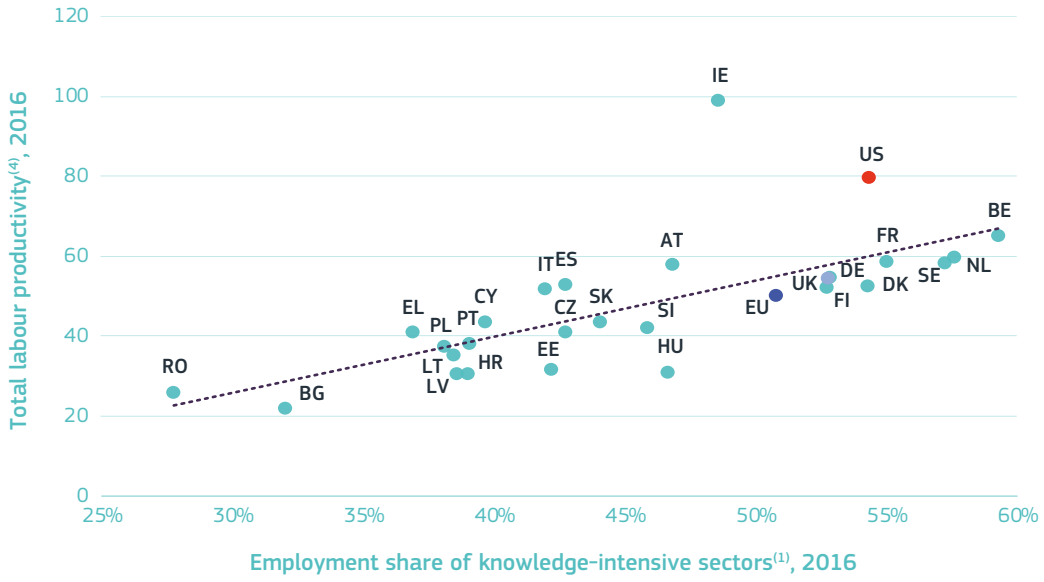
Higher shares of knowledge-intensive sectors are correlated with better economic performance, as investments in R&D and innovative activities are larger in those sectors. The high level of R&D intensity and the larger innovation propensity in knowledge-intensive sectors are fundamental drivers of labour productivity. New firms with innovative and more efficient business models or introducing breakthrough innovations to the market tend to develop more easily in these sectors. Similarly, they are more likely to adopt innovative products or processes due, for instance, to network effects and the technological proximity to those sectors where the original innovation was developed[3]. Therefore, it follows that there is significant correlation between economic performance and an economy's economic structure: higher shares of knowledge-intensive sectors in the economy bring higher productivity which, among others, is a driver of prosperity in the medium-long term.

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

3 See, for instance, Xiao et al. (2018) on the concept of related variety for industrial diversification in Europe.

4 In what follows, labour productivity is given by value added at constant prices (2010) over the number of workers.

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



Science, research and innovation performance of the EU 2020

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

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

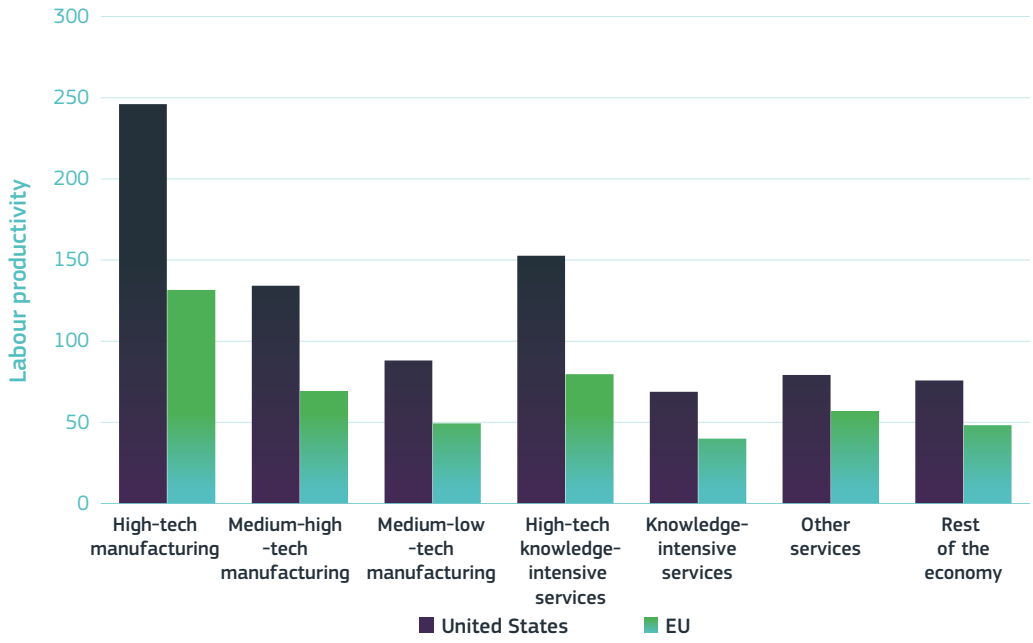
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter32/figure-32-4.xlsx

the sum of the shares of knowledge-intensive services, high-tech and medium-high-tech manufacturing in total employment. The graph reveals a positive relationship: labour productivity increases with the weight of knowledge-intensive sectors in the economy. A group of leading EU economies with productivity and specialisation in knowledge-intensive activities higher than the EU average can be observed on the right of the graph. A large group of countries follow, with employment shares and productivity levels (with the exception of Italy, Austria and Spain) below the EU average. Most countries lie around the dashed line representing the average trend, while a few exceptions can be identified. First, Ireland, with the highest labour productivity across countries, is also significantly higher than might be expected, given the share of knowledge-intensive sectors. While the data used in this chapter do not allow any conclusions to be drawn, this could be because Ireland is the European hub of international companies with strong innovation performance and generating high value added. Second, the United States is the second most productive economy, having higher labour productivity than countries with a similar economic structure. The relevance of high-tech knowledge-intensive services and the large numbers of unicorns, startups and multinational giants at the innovation frontier – e.g. in the Internet of Things and the digital economy – contribute to explain the United States' good performance. It is also worth noting that the United States experiences higher labour productivity across all sectors in the economy (see Figure 3.2-5). Finally, mention should be made

of the group of CESEE economies previously highlighted. While their R&D intensity is relatively low compared to their economic structure, their labour productivity seems consistent with the observed trend, as suggested by the dashed line. While this corroborates that their growth model has paid off to date, previous analyses have suggested a shift towards more R&D and that intangible investment could be beneficial to sustain productivity growth and prosperity in the future (Correia et al., 2018).

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

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



Science, research and innovation performance of the EU 2020

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

Note: [(1)]Thousand PPS€ at constant 2005 prices and exchange rates per worker.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter32/figure-32-5.xlsx

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

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

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

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

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

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

However, this process is accompanied by a transformation in the opposite direction in relation to manufacturing: employment shares declined for both high-tech and medium-high-tech manufacturing activities. While the weight of the former decreased at a faster pace than the latter, the lower initial values contribute to the larger variations, due to the potential impact of single shocks on the overall economy. Increased specialisation in services, including those intensive in knowledge, is a common feature of modern economies. However, excessive deindustrialisation may have negative consequences because of the relevance of industry for innovation and productivity

prospects. This is particularly true for the deep transformation industry is currently undergoing, at the crossroads between the physical and digital world, which is radically changing the way production takes place and business models work and change. The need to boost the competitiveness of the EU and its industry, while meeting the requirements of social, environmental and economic sustainability, are among the key policy challenges facing Europe today[5].

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

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

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

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

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

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

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

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

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

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

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

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

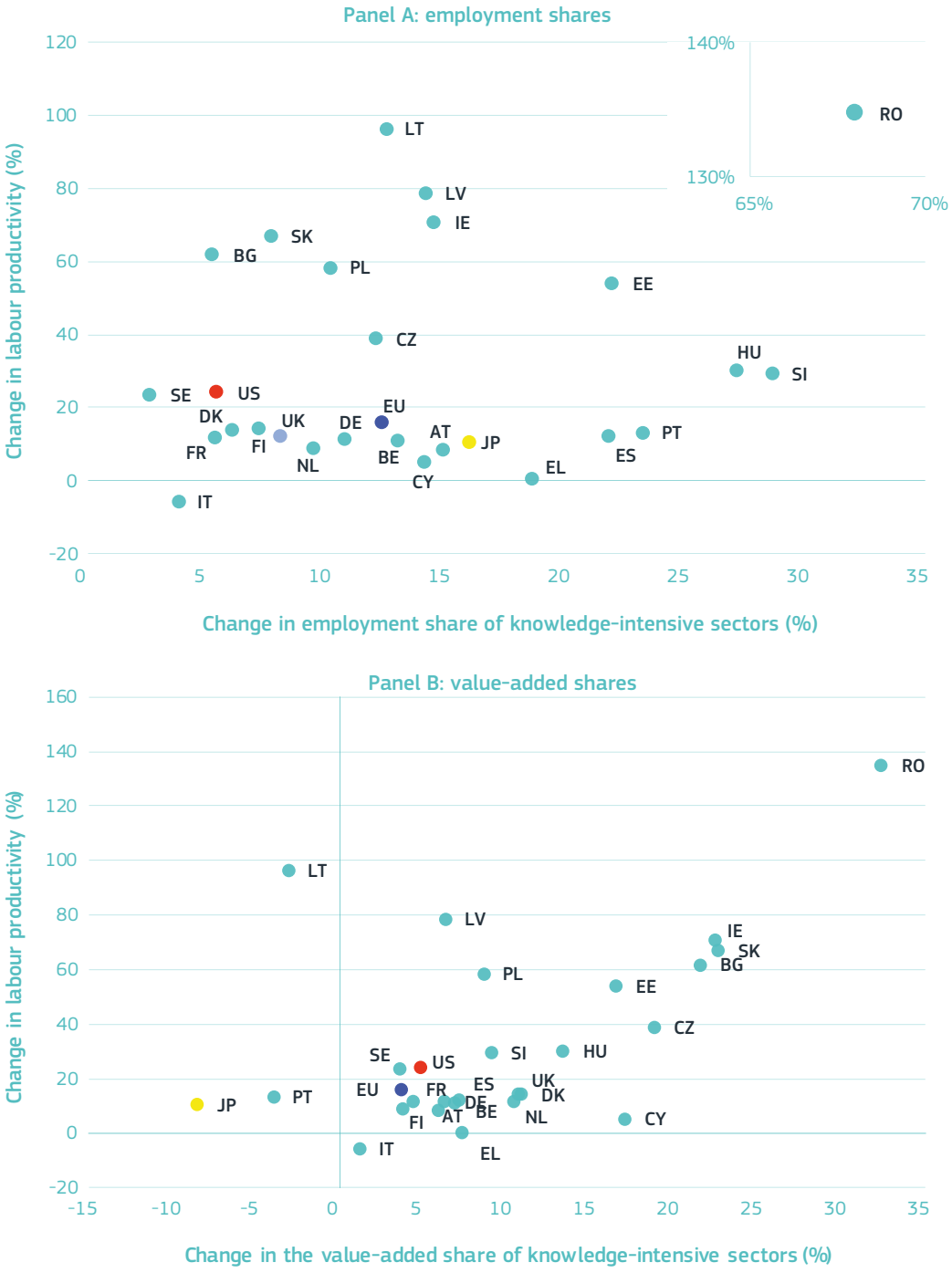
The rest of this chapter estimates the contribution of structural change to total labour productivity growth in the EU and peer economies, disentangling it from the role of productivity gains within sectors. In particular, labour productivity is broken down into:

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

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

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

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



Science, research and innovation performance of the EU 2020

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

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

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

BOX 3.2-2 Decomposition of labour productivity growth

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

Equation 1

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

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

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

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

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

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

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

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

While structural change has made a similar contribution to productivity growth in both the United States and the EU, productivity gains in knowledge-intensive activities in the former have been systematically larger. As in the European case, structural change contributes negatively to labour productivity growth (-3.2 %), as it does in knowledge-intensive manufacturing, flagging a more intense deindustrialisation trend such as in the EU. However, the productivity gains in high-tech and medium-high-tech manufacturing are higher at above 2 %, and they manage to counterbalance the loss in employment shares. The productivity performance in medium-high-tech manufacturing in the EU is higher due to a smaller decline in the employment shares, driven mostly by the CESEE economies. Knowledge-intensive services are the main drivers of productivity growth in both economies, because of positive productivity gains together with sustained increases in their employment shares. Even

in this case, it is worth noting the difference in performance: while labour productivity growth has grown by just around 2.4% in the EU, the United States has experienced an increase over 10%, which also includes the high-tech knowledge-intensive services, outperforming by far any other sector in their economy. It should also be noted that, in both economies, high-tech knowledge-intensive services have had a relatively low growth rate – negative in the case of the EU – despite having the second highest labour productivity level, as shown above.

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

Panel A: EU

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

Panel B: United States

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

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

Note: EU data is until 2015.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter32/figure-32-8.xlsx

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

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

EU

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

Japan

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

United States

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

South Korea

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

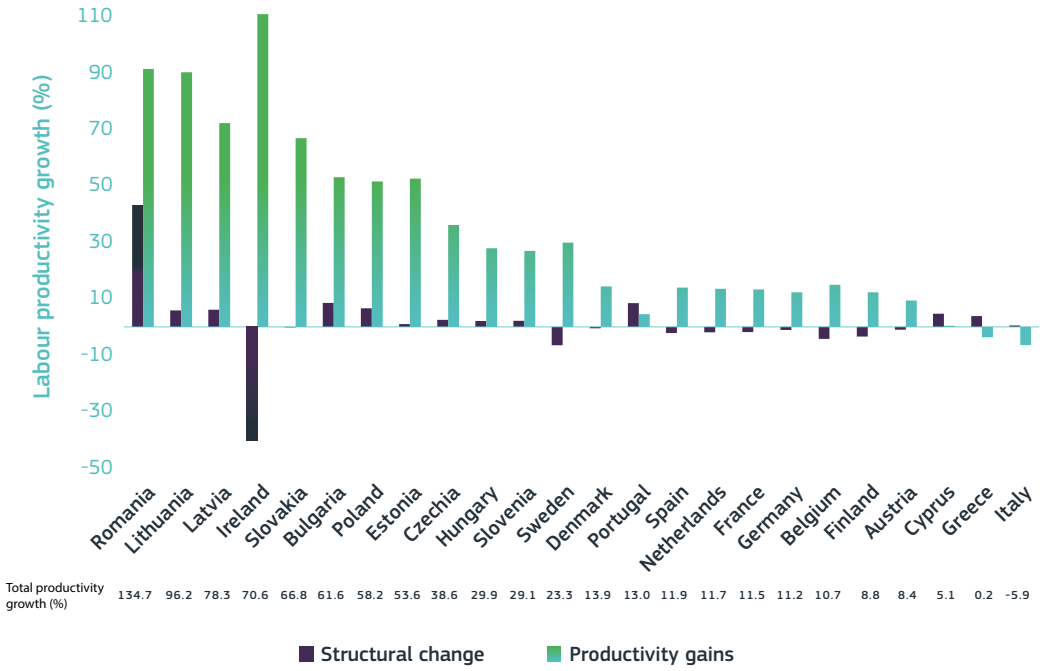
Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on Eurostat and OECD data

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

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

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

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



Science, research and innovation performance of the EU 2020

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

Note: (1)Data missing for HR, MT and LU.

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

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

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

Methodology

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

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

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

The decomposition is as follows[10]:

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

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

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

where:

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

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

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

9 The EU aggregate not including the UK.

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

Cross-country comparison

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

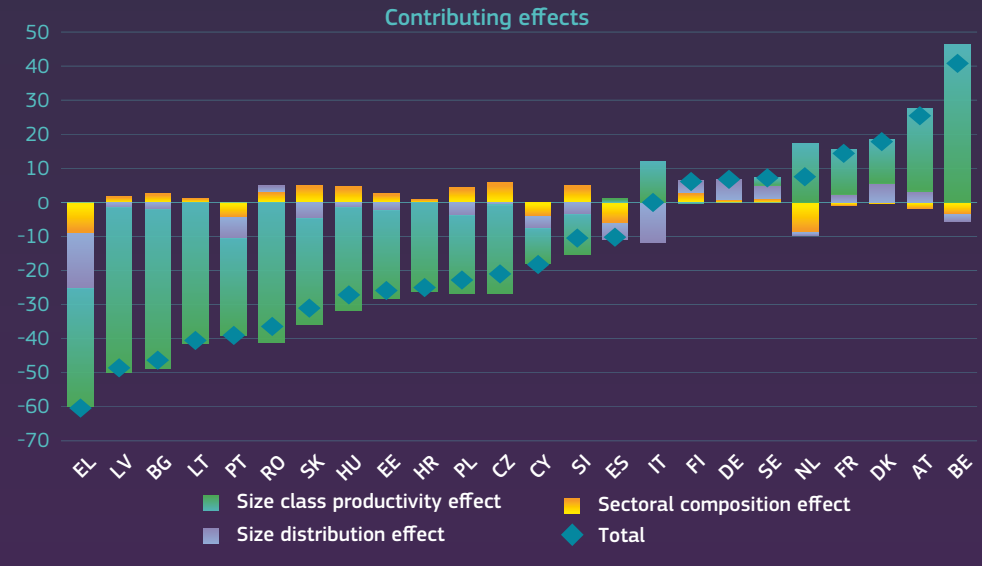
However, for a few countries, having a firm distribution tilted towards smaller firms would seem to be significantly detrimental for productivity performance. This is particularly the case for Greece, where it accounts for a quarter of the productivity difference with respect to the EU benchmark, and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

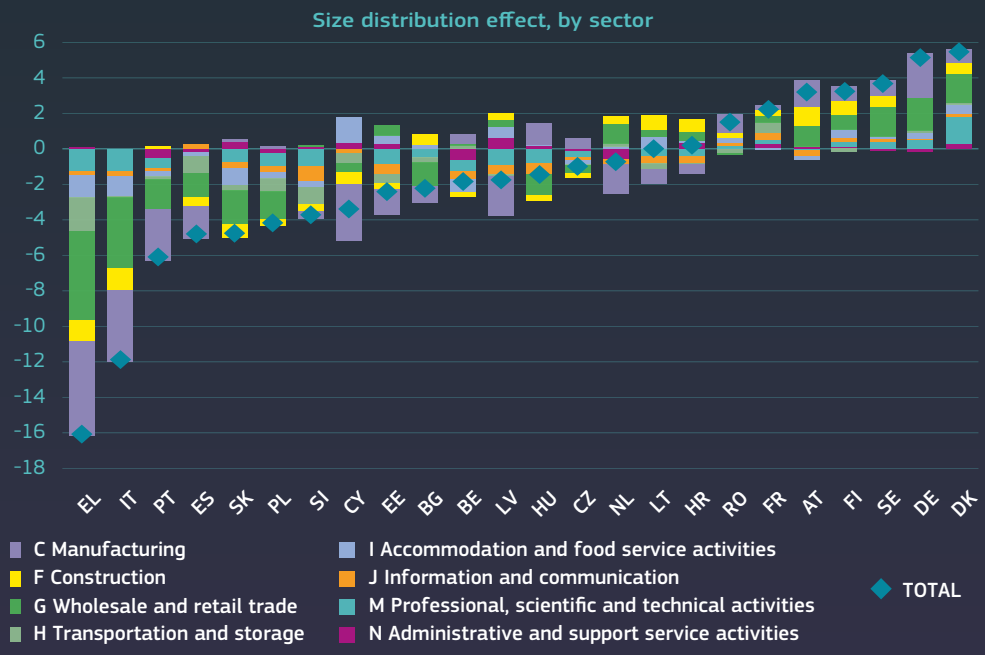
Figure 3.2-11B decomposes the size distribution effect in Figure 3.2-11A by sector. Contributions to size distribution effects are on average higher than their employment share for manufacturing (C), ICT services (J) and professional activities (M), suggesting a more important role for firm size shaping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

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

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

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





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

Recent dynamics

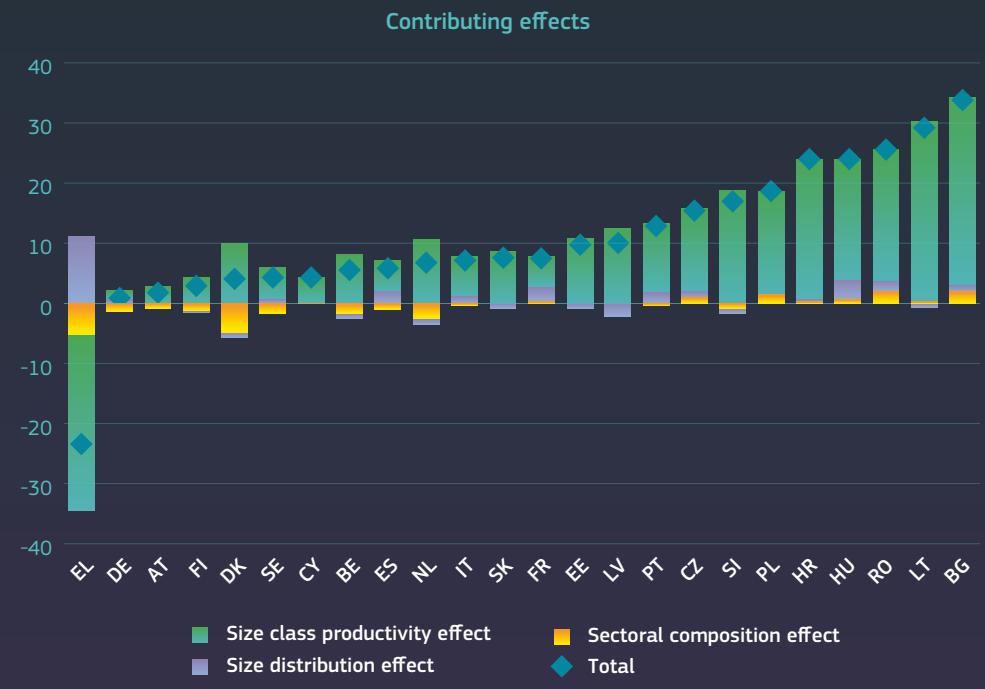
Labour productivity increased in recent years (2012-2016/17) across all countries, most notably in those Member States with lower levels compared to the EU benchmark (Figure 3.2-12A), Greece being the only exception. These developments supported a convergence process driven mainly by an increase in productivity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

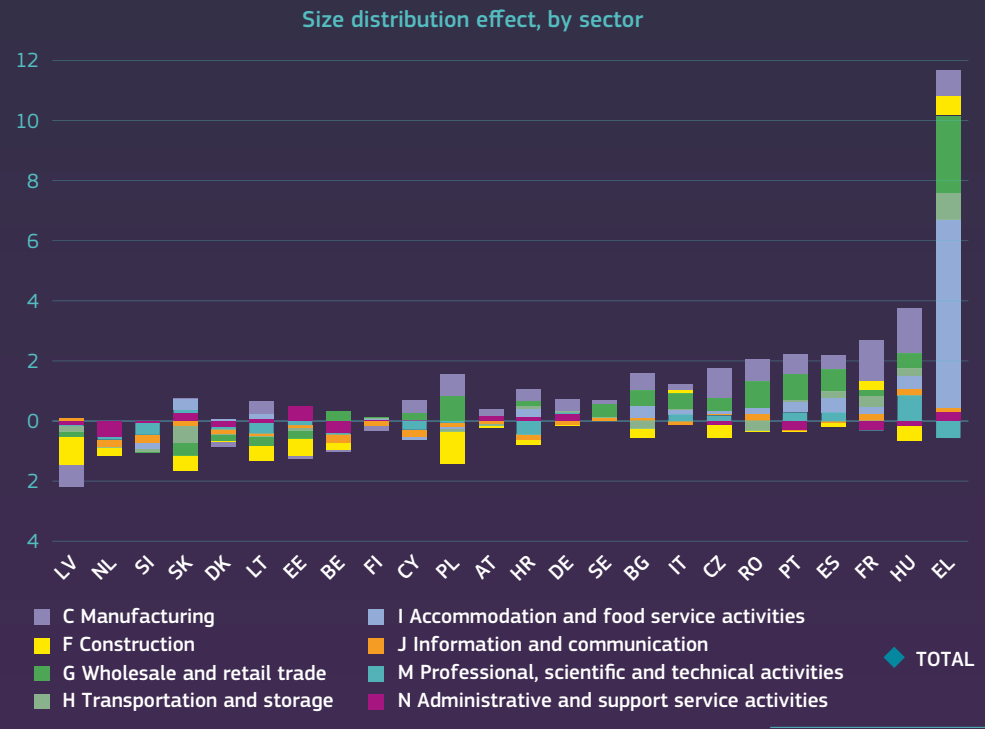
Overall, changes in firm-size distribution played a limited role in shaping productivity growth but made a significantly positive contribution in those countries where size distribution had previously been identified as having a detrimental effect, namely Greece, Spain, Portugal and Italy. In policy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

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

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

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





Source: Authors' own computations based on SBS data

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

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

3. Conclusions

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

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

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

4. References

Bauer, P., Fedotenkov, I., Genty, A., Hallak, I., Harasztosi, P., Martinez Turegano, D., Nguyen D., Preziosi, N., Rincon-Aznar, A. and Sanchez Martinez, M. (2020), *Productivity in Europe – Trends and drivers in a service-based economy*, JRC Technical Report, European Commission, Brussels.

Cimoli, M., Pereira, W., Porcile, G. and Scatolin, F. (2011), Structural change, technology, and economic growth: Brazil and the CIBS in a comparative perspective, *Economic Change and Restructuring*, 44(1-2), 25-47.

Cincera, M. and Veugelers, R. (2013), Young leading innovators and the EU's R&D intensity gap, *Economics of Innovation and New Technology*, 22(2), 177-198.

Coad, A. and Vezzani, A. (2017), Manufacturing the future: is the manufacturing sector a driver of R&D, exports and productivity growth? (No. 2017-06), Joint Research Centre (Seville site).

Correia, A., Bilbao-Osorio, B., Kollar, M., Gereben, A. and Weiss C. (2018), Innovation investment in Central, Eastern and South-Eastern Europe: Building future prosperity and setting the ground for sustainable upward convergence, *EIB regional studies*.

European Commission (2018), The 2018 EU Industrial R&D investment scoreboard.

European Commission (2019), Reflection paper. Towards a sustainable Europe by 2030.

Martino, R. (2015), Convergence and growth. Labour productivity dynamics in the European Union, *Journal of Macroeconomics*, 46, 186-200.

Xiao, J., Boschma, R. and Andersson, M. (2018), Industrial diversification in Europe: The differentiated role of relatedness, *Economic Geography*, 94(5), 514-549.