CHAPTER 4.1

INNOVATION, THE FUTURE OF WORK AND INEQUALITY

KEY FIGURES

11.1 %
adult participation in learning

73 %
of platform workers are men

1 in 5
jobs created in 2017 were part-time

133 million
new work roles may emerge worldwide until 2022

What can we learn?

- Digitalisation, automation, and robotisation risk creating **job displacement and further shrinking the labour share of income**, which could have consequences for inequality, particularly income inequality and inequality in opportunities.
- **Changing skills demand may lead to high job polarisation** in the labour market and is hollowing out the middle-skilled jobs.
- Even if technologies and business models may produce a sufficient number of new jobs to keep unemployment low, **they may contribute to a decline in overall job quality and employment standards**.
- While there is a lack of evidence on **massive disruption across sectors**, technological transformation will not be friction free and individuals or whole sectors need to **capitalise on the benefits** of new technologies in the workplace.
- The emergence of digital technologies **does not help to close the gender gap**, as observed by the lower participation of women in ICT-related fields and platform work.

What does it mean for policy?

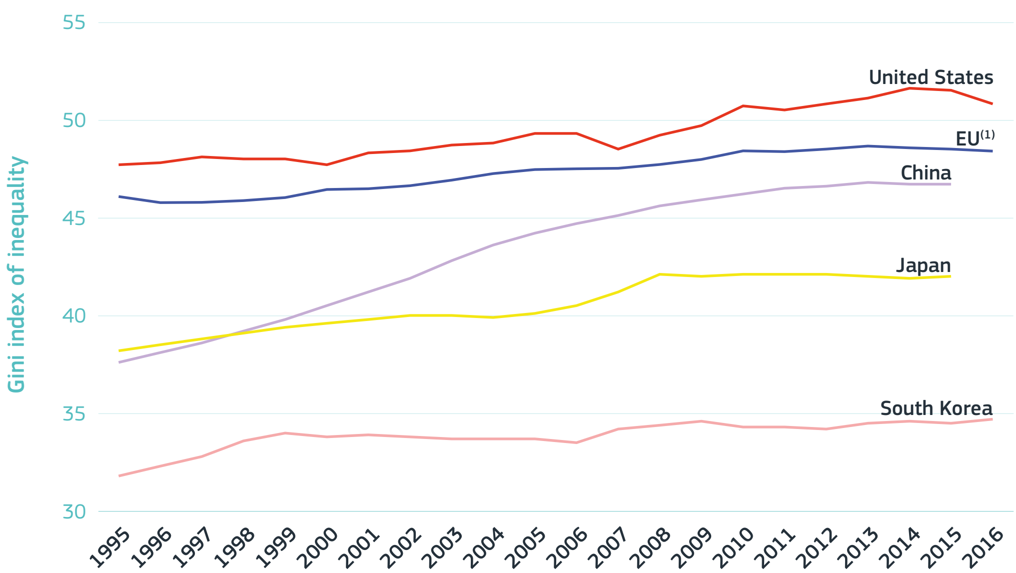
- With very limited growth in the share of adults participating in education and training, it is important to increase **adult participation in learning**, in particular for those in most need of access to learning.
- Improved **skills intelligence, labour-market relevant skills provision, transparency and recognition** of all types of skills remain a challenge. Increased synergies among programmes such as Horizon Europe, the European Social Fund (ESF) and Erasmus+ could address these challenges at different stages. Furthermore, policymakers need better **intelligence to act** (shorter forecasts, scenario planning and simulations in forecasting models) and **policy design that allows for a quick response**.
- Uptake of new technologies and industries has not helped reduce gender gaps; policies to **support the participation of women in specialised ICT-related positions** should be maintained and where possible reinforced to make further progress.

1. Rise in inequality and its perception related to technological developments

Inequality has been growing in most advanced economies in recent years, as indicated by the Gini coefficient of market income inequality (Figure 4.1-1). The index shows that inequality in market income has grown with the EU currently facing similar levels of market income inequality as in the United States. Nevertheless, Europe remains a more equal place to live compared to other countries because the national tax and welfare systems reduce the relatively high market income inequality. Although a substantial mitigation of a general rise in income inequality can be observed in Europe, there are certain age groups or places of residence that face increased income inequality (OECD, 2019). Furthermore, phenomena such as youth unemployment and inequality of opportunity can have long-lasting effects on young people in many European regions.

While fiscal policy has a direct impact on disposable income (i.e. after taxes and social benefits), **other policies enhancing productivity and real wages, or upgrading skills and providing equal opportunities can be equally important. Technological change ranks among the most important factors**[1] **affecting income distribution** as an increase in the demand for high-skilled employees leads to increases in their wage premiums and amplifies wage dispersion (EC, 2017).

Figure 4.1-1 Gini index of inequality - household market income (pre-tax, pre-transfer), 1995-2016



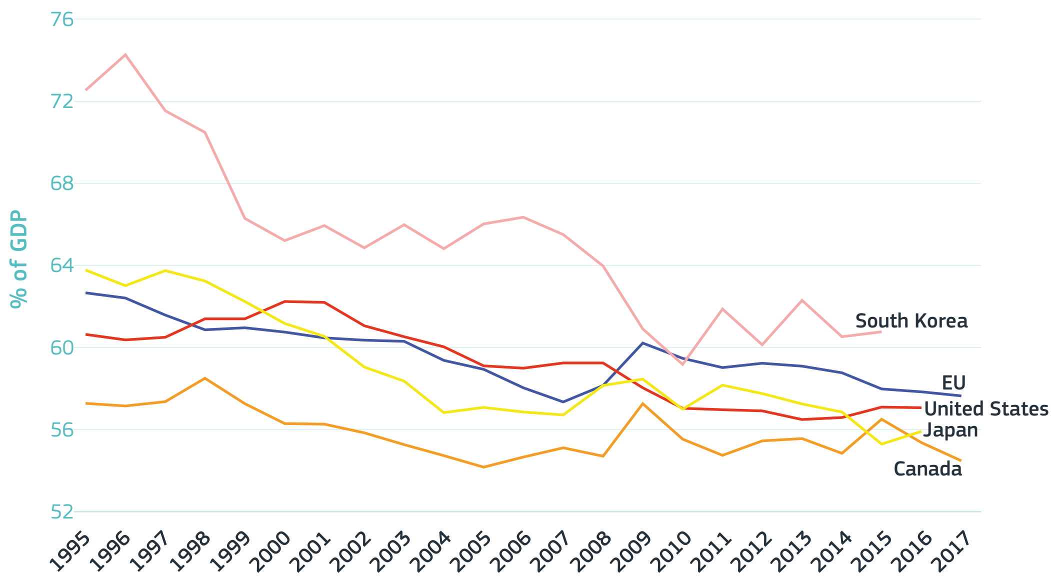
Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on Eurostat data
Note: (1)EU is the weighted average of the values for the EU Member States.
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter41/figure-41-1.xlsx

1 Globalisation, demographic developments and household composition rank among other factors.

This growing inequality is closely related to technological change that has affected the distribution of production factors towards higher shares of capital and technology (Figure 4.1-2). With the increasing ability of machines – potentially reinforced with contributions from artificial intelligence – to automate a greater number of job tasks performed by humans, the distributional implications increase inequality. As automation increases productivity and decreases the cost of production, it can lead to deeper automation – i.e. further improvements to existing machinery in tasks that have already been automated.

Although both effects further increase demand for labour, automation contributes to a higher increase in outputs per worker than their wages and therefore the labour share in national income could shrink. This would mean that the rise in real incomes[2] resulting from automation is skewed towards a narrow segment of the population with much lower marginal propensity to consume than those losing incomes and possibly their jobs (Acemoglu and Restrepo, 2018). Such a technologically accelerated substitution of labour with capital could introduce productivity gains while also reducing the labour share of income and contributing to future inequalities affecting mostly lower-skilled workers. Companies are

Figure 4.1-2 Evolution of labour income(1) share (as % of GDP), 1995-2017



Science, research and innovation performance of the EU 2020

Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on Eurostat, OECD and DG Economic and Financial Affairs (AMECO database)

Note: (1)Labour income is calculated by multiplying compensation of employees by hours worked by all those employed (total employment domestic concept) and divided by the hours worked by employees.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter41/figure-41-2.xlsx

2 Evolution of the labour income share in the EU28 reveals a declining trend from 72 % in 1995 to around 60 % in 2015.

increasingly relying on a variety of intangible assets such as, for example, goodwill or patents, and it is increasingly the low-skilled workers who suffer the negative consequences brought about by technological change and new types of capital assets. A closer look at the intangibles within the distribution of income is crucial to understand the decline in labour shares over past decades.

More unequal distributions of income and wealth have increased attention to tax shifts towards capital. As there is a gap between capital income and labour income taxation, higher labour taxation could dampen employment levels and contribute to higher capital accumulation. Therefore, the suggestion is that shifting taxes away from labour towards capital could increase the labour share and lead to stronger overall productivity growth (JRC, 2019a). Important policy questions relate to how and where to tax capital income and what might be the broader economic effects of such taxation (Mathé et. al., 2015).

2. Broad technological uptake would have repercussions for the quantity and quality of jobs

While employment rates are at record high numbers since the crisis in many European countries and in the United States[3], polarisation has appeared in the job market with a significant shrinking of medium-skilled routine jobs and an increase in high- and low-skilled jobs. With almost 236 million people in employment in 2017, EU employment is at an all-time high and means an increase of 19.5 million since 2002 (EC, 2018). This is mainly due to a strong increase in female employment as well as a higher employment rate among older workers. As labour market conditions have continued to improve, many countries have reached values above their pre-crisis level (Figure 4.1-3). The same applies to unemployment rates which have continued to fall across the EU. In April 2019, the unemployment rate had dropped to 6.8 % in the EU, which is the lowest level since 2008[4].

Available evidence concerning the impact of new technological development on the labour market is inconclusive[5]. A high level of uncertainty accompanies different estimates, as they are highly sensitive to the choice of data sources and the methods used to categorise tasks. Implications for the net displacement of jobs will depend on the new models of work organisation and management of workplaces, including platform work and new unconventional working arrangements. Figure 4.1-4 shows various assessments of automatable job shares, but also more balanced employment effects when job-creation effects are included (Wolter et al. 2015; Arntz et al. 2018).

While estimates identified a broad range of job shares with routine tasks, it seems that automation and digitalisation are less likely to destroy large numbers of jobs in the short term. A greater

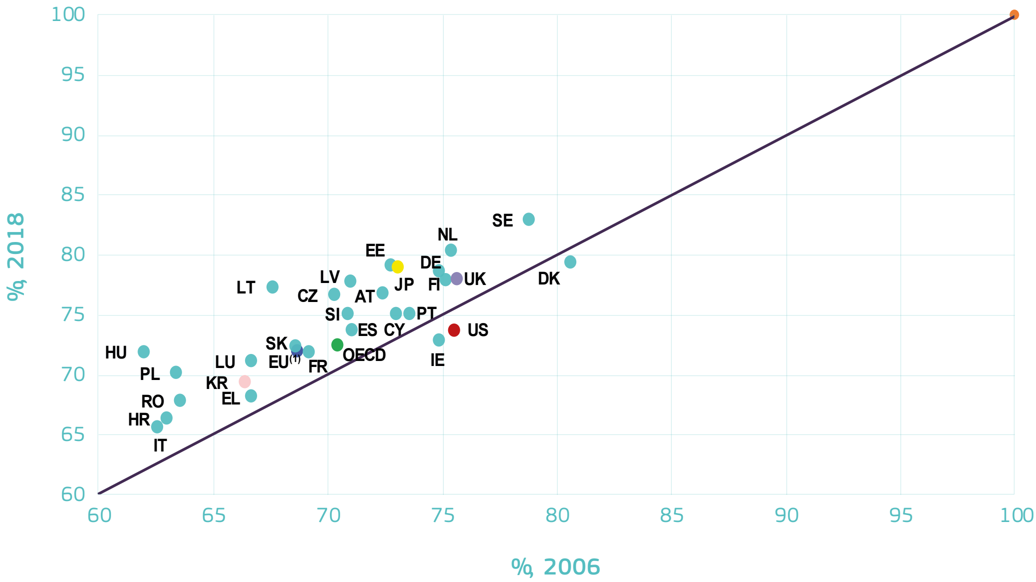
CHAPTER 4

3 Employment rate (age range 15-64) in OECD countries rose from 66 % in 2010 to 69.5 % in 2017; in the EU from 64.1 % to 67.7 % and the United States from 66.7 % to 70.1 %.

4 EU (from 2019) value; Eurostat. Unemployment – monthly average.

5 See European Commission (2018) Chapter 2, World Bank (2016), Frey and Osborne (2013; 2017), Nedelkoska and Quintini (2018).

Figure 4.1-3 Labour force participation rate, 15-64 year-olds, as % in same age group, 2006 and 2018



Science, research and innovation performance of the EU 2020

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

Note: Employment by activity - total active population as percentage of total population. The economically active population is the sum of employed and unemployed people. Inactive people are those who, during the reference week, were neither employed nor unemployed. (1)EU estimated by DG Research and Innovation.

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degree of automation and data exchange in manufacturing technologies will inevitably affect firms' strategic approaches and organisational models in their production and innovation systems. Low-qualified and low-skilled workers are likely to bear the burden of the adjustment costs as trends in the labour market seem to work against them. Therefore, the likely challenge for the future lies in coping with rising inequality and ensuring sufficient training, especially for low-qualified workers. To understand the magnitude of the challenge, various attempts have been made to assess the share of automatable jobs (Figure 4.1-4). A full understanding of broader impacts and reskilling needs demands factoring in issues such as adjustments in learning systems, individual motivation, and financing schemes, which represent additional layers of complexity.

While many of the current jobs will become obsolete through technology, many others will change the set of performed tasks and new jobs will be created. The changing task content of occupations introduced by technological innovations ranges from generally reducing the importance of physical tasks to higher safety standards and better-quality jobs (see Box 4.1-1).

Figure 4.1-4 Share of highly automatable jobs and net effects on employment

Source	Share of automatable jobs	Time horizon	Remarks
Frey and Osborne (2013)	47 %	10–20 years	USA, all sectors
Bowles (2014)	47 % to 60 %	10–20 years	EU Member States, following the approach of Frey and Osborne (2013)
Bonin et al. (2015)	12 %		DE, all sectors
Arntz et al. (2016)	9 %		21 OECD countries, following the approach of Bonin et al. 2015
World Bank (2016)	50 % to 60 %	coming decades	USA and Europe, real effects moderated by lower wages and slower technology adoption
Nedelkoska and Quintini (2018)	14 %	10–20 years	32 developed, mostly OECD countries, following the approach of Arntz et al. (2016)
Source	**Automatable jobs and job creation**	**Time horizon**	**Remarks**
Wolter et al. (2015)	- 1 %	25 years	DE, manufacturing, incl. economy-wide compensation effects
Arntz et al. (2018)	+1.8 %	5 years	DE, incl. job-creation effects, baseline

Science, research and innovation performance of the EU 2020

Source: DG Research and Innovation

Note: See the references for full citations. Conclusions simplifed for presentation purposes.

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BOX 4.1-1 Current jobs with new tasks

Innovations in **production techno-logies and work organisation** reduce **workplace risks** and increase the **overall quality of jobs**. In recent decades, automation technologies have helped to significantly improve health and safety across industries. The quality of jobs can be broadly understood as a measure of the richness of work and creative human activity. It is improved by more intellectual tasks which increase the variety and stimulation. a shift to more work in teams along assembly lines helps to boost social interaction in the workplace (Eurofound, 2019).

New jobs are not centred on the automation process with humans plainly assisting machines or algorithms in the production process. Although many new occupations will be enabled through technology, they will not be technology- or machine-specific. New jobs will respond to human needs and societal challenges, such as global warming or food production[6]. The downside of this is that educators are often tasked with tackling the problems of preparing people during education for jobs that do not yet exist, eventually using technologies that have not yet been invented and solving problems that we have yet to define clearly (Penaluna and Rae, 2018). Any forecasts about the number of newly created jobs or predictions on the net destruction of jobs must be taken with caution (Chapter 11 - The consequences of AI-based technologies for jobs). Replacing labour with technology is accompanied by countervailing mechanisms that are difficult to quantify. Dedicated studies, such as that by Bruegel on the impact of industrial robots on employment conclude with displacement effects, particularly significant for medium-skilled workers, for example[7]. A later study by Autor and Salomons (2018) shows that although automation leads to job displacement in industries, it facilitates indirect employment gains in customer industries and contributes increasing aggregate demand, ultimately leading to net employment growth. Given the human imagination and ingenuity, other estimations are oriented towards more qualitative approaches categorising new roles and jobs according to their technological proximity, time horizon or emerging sectors of the economy (Figure 4.1-5).

The effects of an increasingly digital economy, including many jobs created through the platform economy and new unconventional working arrangements, start to emerge for a growing number of workers. Permanent full-time employment constitutes the largest share of employment by far, although a growing incidence of less standard forms of employment may bring structural change. Contractual stability and employment quality still greatly depend on industrial relations and coverage by collective agreements. The evidence shows that one in ten adults have some experience of supplying goods or services on internet platforms (Figure 4.1-6). The majority of platform workers provide professional services (such as software development, translation services, or writing) which demand high skill levels (Gonzalez Vazquez et al., 2019).

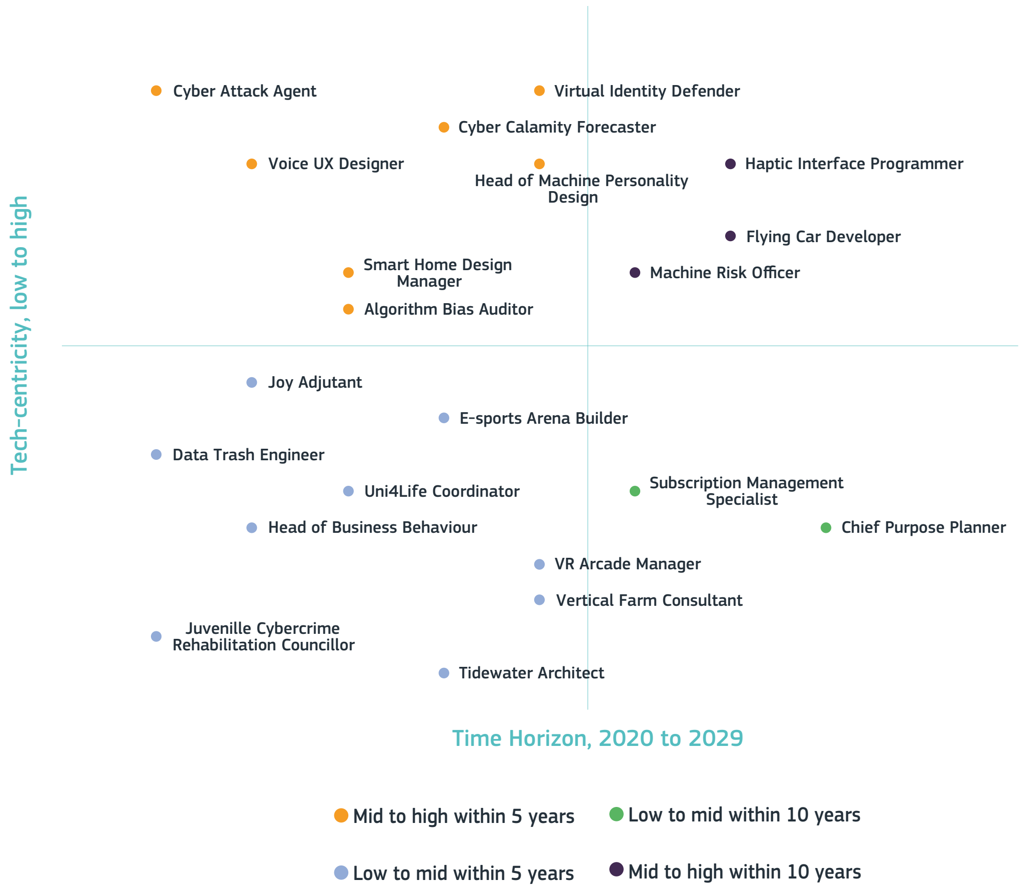
New technologies could provide workers with greater job satisfaction, but they can also demand more flexibility, creating new jobs that are less stable. New ways of working emerge on digital platforms and in the collaborative economy, with more part-time and freelance work and self-employment. The new features, such as higher degree of flexibility, a better work-life balance, and supplementary income inevitably bring the traditional employer-employee relationship into question. Online platforms acting as intermediaries between service users and providers revoke the temporary work agency model. Service providers working for the platforms are considered self-employed by the platform, even though the relationship between them often has features of an employment relationship based largely on subordination[8].

6 Experts list jobs such as 'vertical farm consultant' or 'tidewater architect'; Cognizant (2018). 42 Jobs: The Road to 2028-2029.

7 The study examined the impact of industrial robots on employment and wages in six EU countries that account for 85.5 % of the EU market for industrial robots. The assessment was that one additional robot per thousand workers would reduce the employment rate by 0.16-0.20 percentage points. The study also found a particularly strong displacement effect for medium-skilled workers and for young cohorts. Chiacchio, F., Petropoulos, G. and Pichler, D. (2018), The Impact of Industrial Robots on EU Employment and Wages: a Local Labour Market Approach, Bruegel Working Papers, Issue 2.

8 More details in the Commission report 'The Future of Work? Work of the Future!', a report by Michel Servoz.

Figure 4.1-5 Jobs of the future along expected time horizon and tech-centricity



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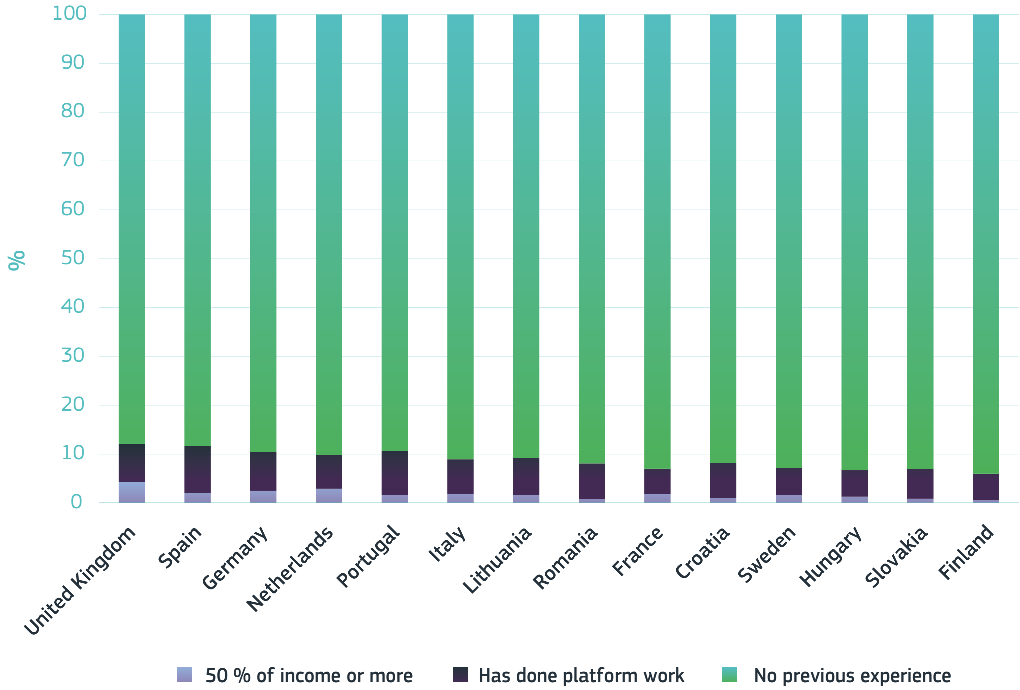
Source: Cognizant forecast based on the report 21 More Jobs of the Future (2018)

Note: Cognizant presented 21 jobs of the future in the order they expect them to appear. A more detailed description of each job is available in the report.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter41/figure-41-5.xlsx

While embracing the benefits of flexibility enabled by technologies, the future employee-employer relationship will have to deal with challenges such as rules on working time, equal access to training, and other benefits. Due to the slowly evolving nature of these challenges and a lack of robust evidence sometimes, many national governments are responding via policy experimentation. The Dutch government proposed to regulate self-employment with a minimum hourly rate for self-employed people, while French independent workers enjoy full rights to set up or participate in trade unions (JRC, 2019a; SZW, 2019).

Figure 4.1-6 Adult population involved in platform work (%), 2017



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Source: European Commision, DG Employment, Social Affairs & Inclusion calculations based on COLLEEM survey 2017

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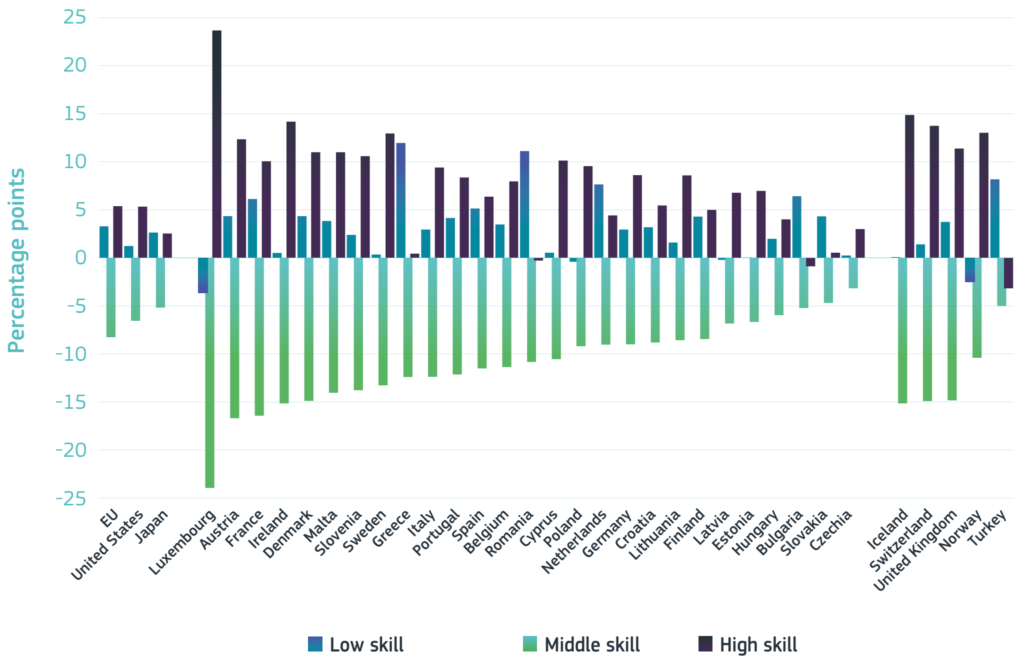
3. Changes in the labour market require new skills

Although we observe only mild symptoms of unemployment, further progress in ground-breaking digital transformation that has brought more efficient production and business processes can have a disruptive impact on workers. In particular, the rise of automation and digital technologies is already affecting labour markets, with **high rates of job polarisation and a hollowing of medium-routine tasks jobs**. This trend is expected to accelerate as digital technologies become more pervasive. At the same time, the quality of jobs done by the least skilled is likely to decline, as is their income share. This trend appears less pronounced in many of the new Member States where labour costs are relatively low and the incentives for automation are supposedly lower (OECD, 2017).

Figure 4.1-7 Percentage point change among shares of occupational groups[1], 1995-2018[2]



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: lfsa_egised) and OECD data

Note: [1]High-skilled occupations include jobs classified under the ISCO-88 major groups 1, 2, and 3. Middle-skilled occupations include jobs classified under the major groups 4, 7, 8, and low-skilled occupations include jobs classified under the groups 5 and 9. [2]US: 1995-2015; JP: 1995-2010; SI, NO, CH: 1996-2018; CZ, EE, HU, PL, RO, FI, SE: 1997-2018; LV, LT, SK: 1998-2018; CY: 1999-2018; BG, MT: 2000-2018; EU, HR: 2002-2018; TR: 2006-2018.

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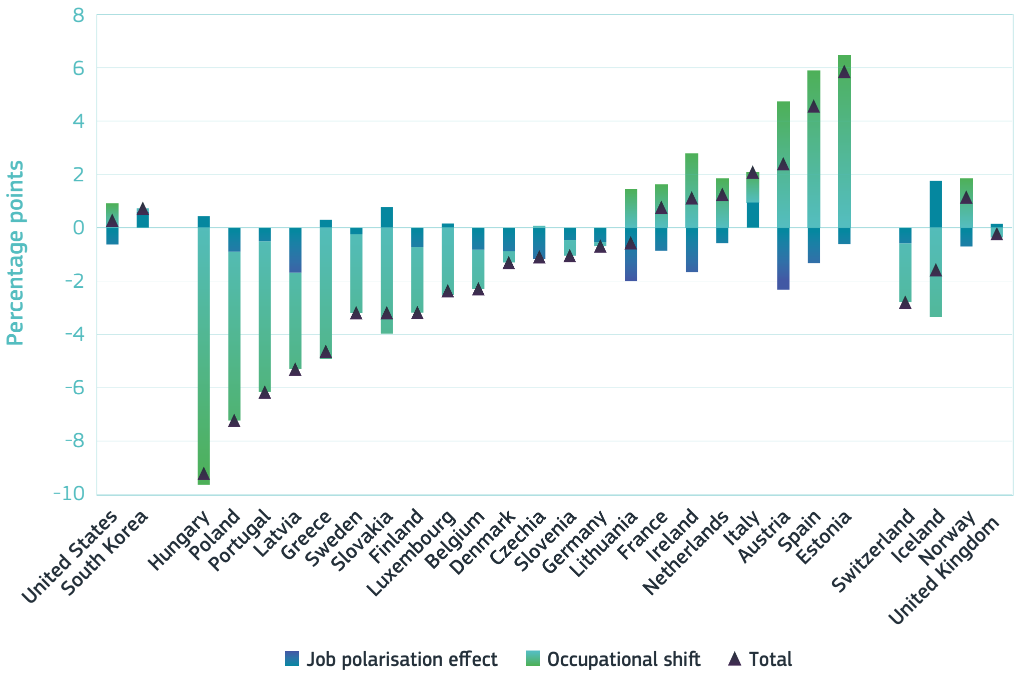
The borders between different skills and earning levels become fluid as some jobs demanding a high level of skills tend to no longer provide high incomes. This development seems to be primarily driven by very low wage growth among workers in high-skilled occupations in last decade or so (OECD, 2019). The overall effect on income distribution is still uncertain a priori since the emergence of new tasks and jobs may reward workers differently across the skills spectrum. Further evidence suggests that workers with less than tertiary education have shifted towards low-skill occupations, including mid-skilled workers, and face a higher risk of unemployment. The share of low-paid jobs is declining due to job polarisation and occupational shift. Job polarisation explains why the number of highly skilled occupations grew faster than other occupations, while the rest of the shift is explained by occupational shift whereby several occupations tend to pay lower wages. The overall trend in rising skill needs at lower levels creates further questions about changing mid-level occupations and future skills defining these occupations (Chatzichristou, 2018).

Figure 4.1-8 Percentage point changes in the share of low-paid[(1)] jobs by type of effect, 2006-2016[(2)]



Source: OECD Employment Outlook 2019

Notes: [(1)]Low-paid jobs are those paying less than two thirds of the median wage, while high-paid jobs are those paying more than 1.5 times the median wage. [(2)]Different time periods coverage for KR (2006-14), EL, LV, PT (2007-16), IT (2007-15), CH (2008-15), IE and LU (2006-15), and IS (2006-13).

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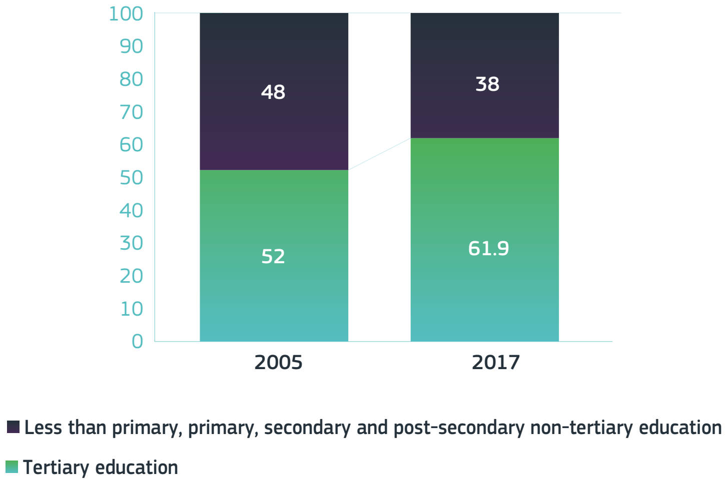
At the level of labour-market entrants, education is the solution to equip people with better skills which will increase both their employability outlook and earnings. Tertiary education is often associated with a considerable increase in the level of skills, especially in high-quality systems. Until recently, and despite massive expansion, in many countries the returns for university graduates remained high. Education belongs at the core of the inequality debate as differences in educational attainment and status are important markers of inequalities. In turn, unequal educational opportunities have repercussions on social cohesion and mobility (EC, 2017a).

While ICT skills seem to be slowly improving among the EU population, there is a growing need for highly skilled IT professionals. The best-known skills gap is perhaps the digital one where the lack of IT specialists is growing (according to IDC and Empirica, the shortage is expected to reach over 749 000 by 2020). Most jobs in the EU already require at least basic digital skills (Cedefop, 2018) and there is growing share of individuals with tertiary education working as ICT specialists in the EU labour market (Figure 4.1-9). On the other hand, 35 % within the overall EU labour force do not have at least basic digital skills (Eurostat, 2019).

Figure 4.1-9 Share of employed ICT specialists by educational attainment level (%), EU



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

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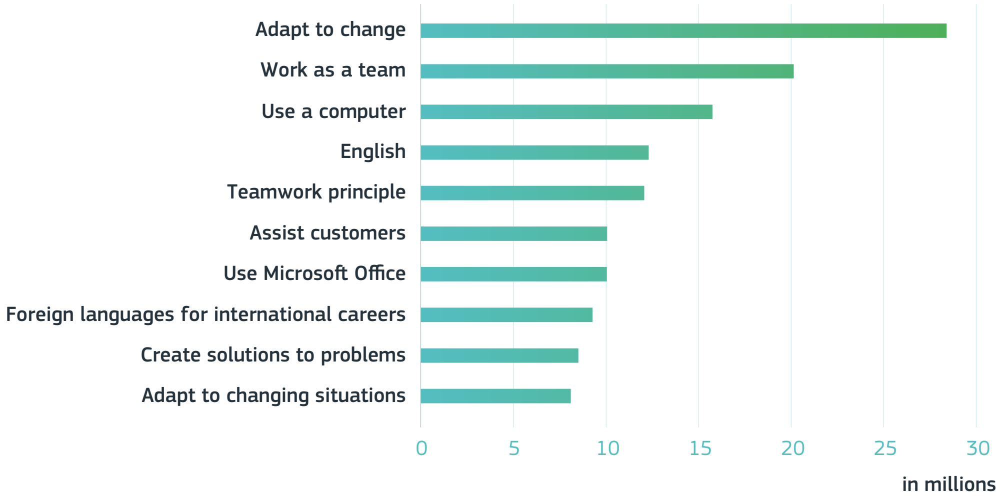
The changing content and nature of jobs require new knowledge, skills and mindsets. Soft skills[9] are increasingly important for all types of jobs, including those in the digital sector. While job- and sector-specific skills remain essential to support competitiveness and innovation, transversal skills[10], including digital skills, are increasingly determining our ability to adapt, progress and succeed in a fast-moving labour market. The latest evidence suggests a broader set of skills being demanded for the digital age, including not just digital skills but softer ones such as adaptability, entrepreneurship and multidisciplinarity (EPSC, 2019). This points to a solid base of social skills facilitating interaction and communication with others as a favourable complementary asset for employees in the future.

Moreover, the EU labour market is already demanding more soft and digital skills, and specifically a combination of both. The JRC report (Gonzalez Vazquez et al., 2019) showed that the vast majority of occupations which have expanded in recent years are in the groups of professionals or service and commercial managers who require a combination of ICT use and soft skills, e.g. to deal with customers and teams.

9 Personal skills not thought to be measured by IQ or achievement tests. Their attributes receive various labels in the literature, including non-cognitive, personality traits, non-cognitive abilities, etc.

10 In general, skills which have been learned in one context or to master a special situation/problem and can be transferred to another context are relevant to jobs and occupations other than those they currently have or have recently had (as broadly defined by Cedefop).

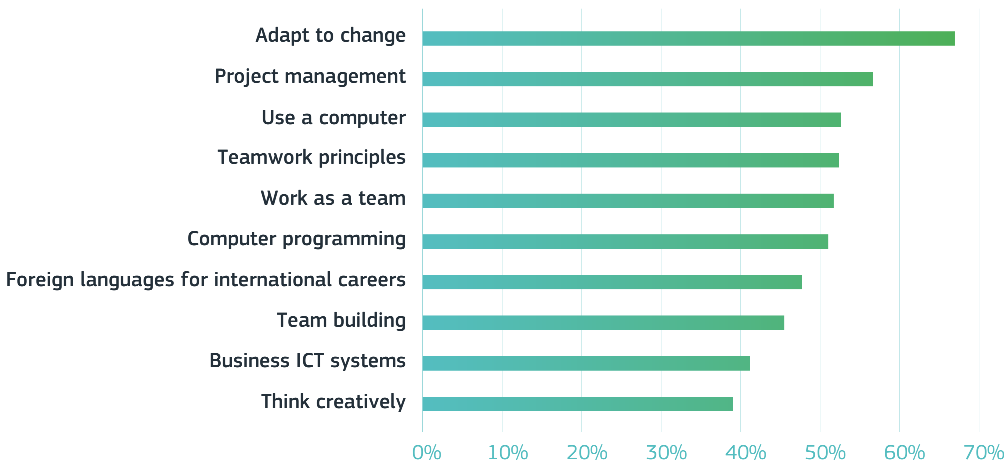
Figure 4.1-10 Most-sought-after skills 2018-2019



Science, research and innovation performance of the EU 2020

Source: Cedefop's Skills-OVATE 2019
Note: Based on analysis of online job-vacancy data in 18 EU Member States.
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter41/figure-41-10-11.xlsx

Figure 4.1-11 Share of most-sought-after skills, 2018-2019, for ICT professionals(1)



Science, research and innovation performance of the EU 2020

Source: Cedefop's Skills-OVATE 2019
Note: (1)Shares for skills when mentioned in vacancies at the 2 digit ISCO occupation for ICT professionals.
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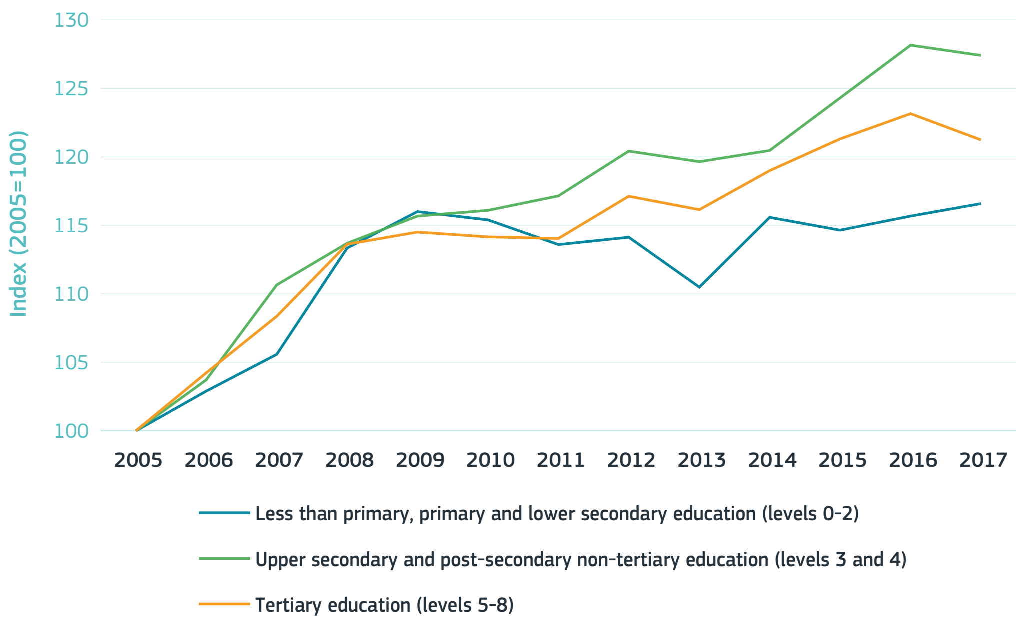
4. Skill-relevant policies need to be inclusive

Returns on investment in education have not always met expectations in countries that have expanded access to tertiary education without ensuring high quality since, in such cases, tertiary education does not lead to a substantial improvement in skills. Furthermore, the latest data suggests that tertiary wage premium is starting to decline, driven primarily by very low wage growth among workers in high-skilled occupations (Figure 4.1-12)[11]. If the expansion in the share of adults with high-level qualifications continues to exceed the speed of expansion in jobs requiring such qualifications, tertiary graduates' prospects may deteriorate. In some countries, it is already evident that tertiary graduates are more frequently undertaking jobs that do not require a high level of education, which also implies income and career prospects that fall below the expectations for someone holding a tertiary qualification and, on an aggregated level, leads to skill mismatch. In that context, the high numbers of highly educated people among platform workers (more than 50% of European platform workers have tertiary education) are remarkable given that the tasks performed by platform workers often do not require a high level of education (EC, 2018).

Figure 4.1-12 Evolution of median equivalised net income by educational attainment, EU[(1)(2)], 2005-2017



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: ilc_di08)

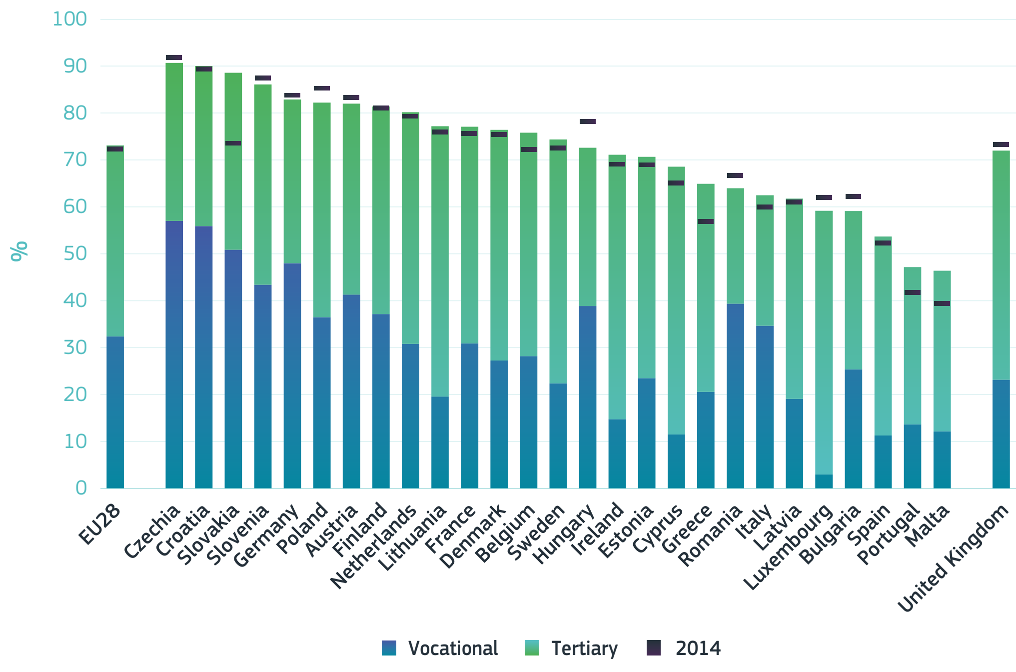
Notes: [(1)]The calculation is based on the EU 2007-2013 composition with the UK before accession of Croatia. [(2)]The calculation includes incomes of workers from 18 to 64 years.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter41/figure-41-12.xlsx

11 Additional evidence at: OECD (2019) The future of work. OECD Employment outlook 2019.

When properly designed, vocational education and training systems can offer high levels of employability and access to high-quality jobs, including in emerging sectors such as the digital economy. After compulsory education, around half the young people in Europe enrol in vocational education and training (VET) programmes. Traditionally, VET systems were concentrated in the initial education systems and targeted low-performing students to help them acquire the skills required to work in sectors with a predominance of manual or low-skilled tasks. Nowadays, to a large extent, economies do not rely on these sectors where a high proportion of the population could be employed with a lower level of skills. **Therefore, developing a high-quality vocational learning experience is necessary to equip young people with strong foundation skills and job-specific skills which are in high demand in the labour market**. This would provide access to jobs requiring middle and high levels of skills, as well as creating a sustainable base for lifelong learning. As shown in Figure 4.1-13, both types of educational path allow young adults to enter the labour market. The challenge is to preserve such a balance through a well-developed VET system that leads to high levels of employment and has the capacity to respond swiftly to changing trends in the demand for skills.

Figure 4.1-13 Share of young adults holding a vocational or tertiary education qualification[1] (%), 2014 and 2018



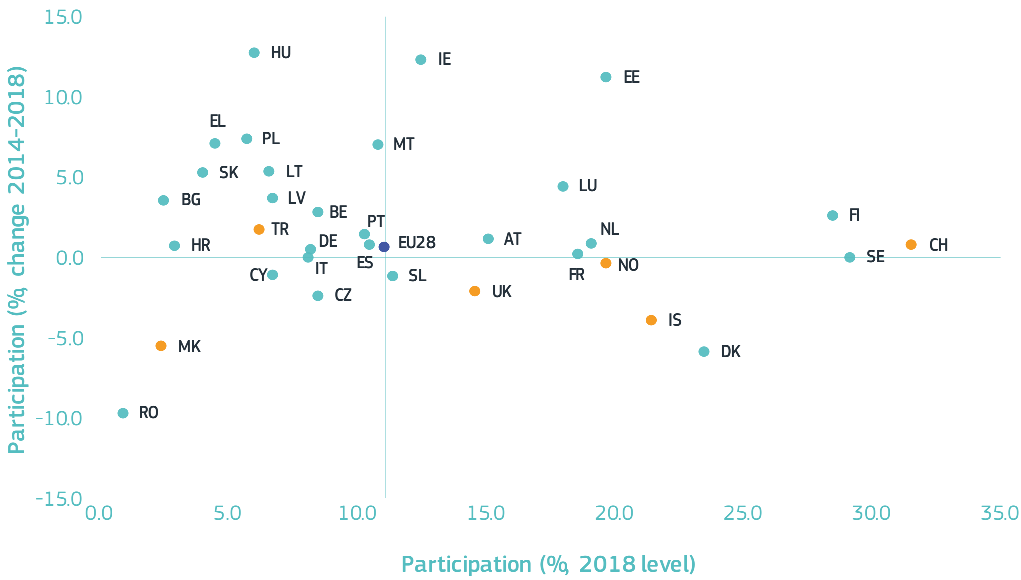
Source: Eurostat (online data code: edat_lfs_9914)

Note: [1]Shares of young adults aged 30-34. Vocational education attainment includes qualifications at ISCED levels 3-4 with a vocational orientation; tertiary educational attainment includes qualifications at ISCED levels 5-8.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter41/figure-41-13.xlsx

The importance of learning during adulthood is also increasing for all workers. A paradigm shift is taking place that requires the transformation of traditionally more front-loaded education systems delivering general and specialised skills at an early age into effective lifelong-learning models. Adult learning is perhaps the stage that requires the development of new models in most countries in order to learn and train workers during their lifetime, combining formal, non-formal and informal ways of gaining new knowledge. Broad participation in training remains a challenge for all EU Member States as currently only 10.9% of European adults are participating in training and the participation rates are not improving with time (Figure 4.1-14).

Figure 4.1-14 Participation rate in adult training (%)



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: trng_lfse_01)

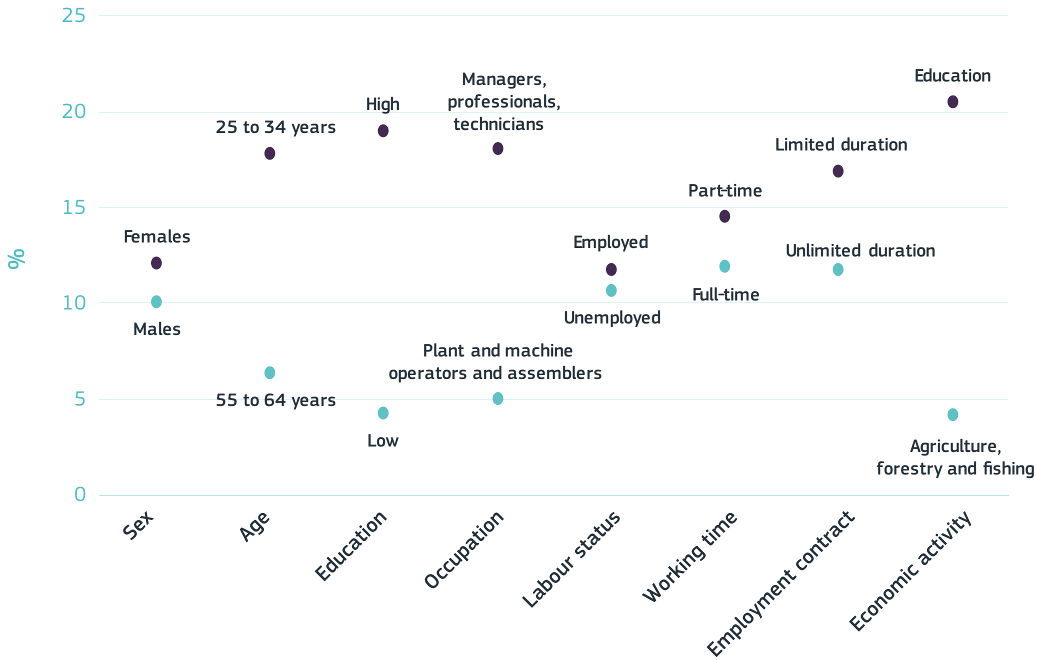
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter41/figure-41-14.xlsx

Those individuals likely to be the most affected by changes in the world of work are under-represented in training. There are large participation gaps between adults with low skills and their more-skilled peers, between those earning low wages compared to those on medium-high wages, and between different sectors of economy. Overall, there are broad opportunities for improving the general coverage of adult-learning systems to engage the adult population in learning (OECD, 2019a). The latest data reveal that 61 million adults aged 25-64, many of them in employment, are still low qualified[12]. Furthermore, the employment rates among the low qualified are already much lower than for medium and

12 Low-qualified people include lower secondary education at most. Among the 61 million low-qualified adults, aged 25 to 64, more than 34 million are in employment, over 21 million are inactive and less than 6 million are unemployed (EU, LFS, 2017).

higher qualified – around 55 % for low qualified compared to 75 % for medium qualified and 85 % for high-qualified people. **It is important that adult-learning systems are inclusive and aligned with skills needs in order to reach out to workers at most risk of job loss or displacement**. More can be done in this area as workers with jobs at significant risk of automation show lower participation rates in training (especially non-formal training) compared to workers at low risk of automation (Figure 4.1-15). These gaps in training participation and demands of the future labour market demand coordinated policy actions.

Figure 4.1-15 Highest and lowest shares of job-related adult learners by groups (%) in EU28, 2018



Science, research and innovation performance of the EU 2020

Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on Eurostat (data from Labour Force Survey)

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter41/figure-41-15.xlsx

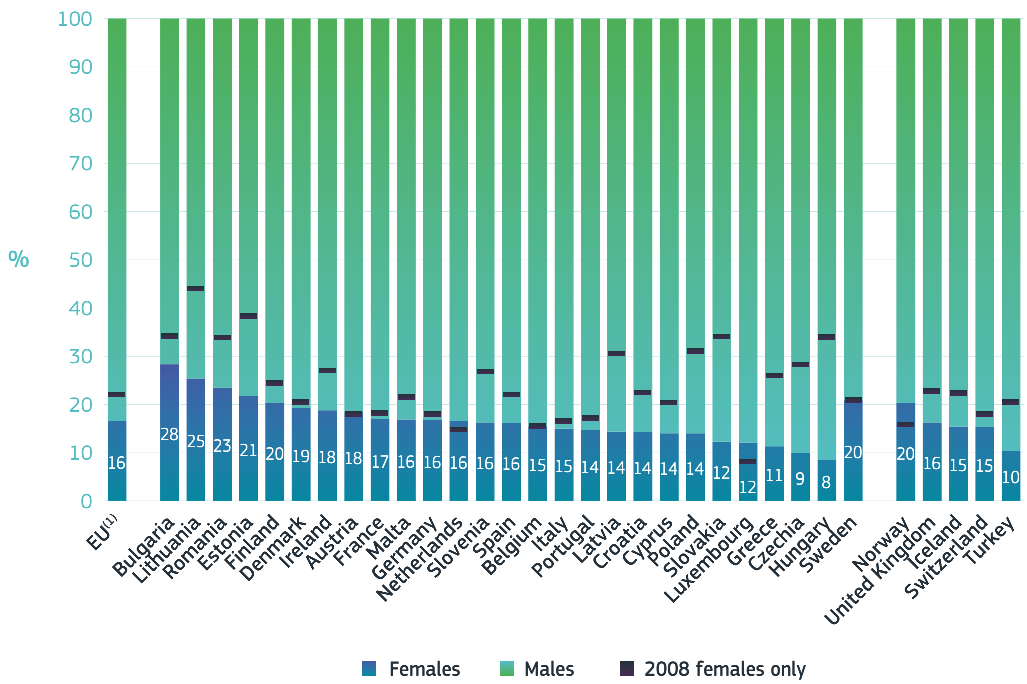
5. Gender gap in employment and entrepreneurship has new drivers

Although the EU has witnessed a significant increase in female employment over the last two decades, women's participation in the digital field is lagging behind in several areas, with varying participation rates across the Member States. Those Member States leading in digital competitiveness are also leaders in female participation in the digital sector. The gender gap is largest in the area of ICT specialist skills and employment:

82% for ICT specialists and 65% for science, technology, engineering, mathematics and ICT graduates (Figure 4.1-16).

Women account for 52% of the European population but only around 17% of women work in ICT-related jobs. Women's participation in the development and deployment of AI technology, such as machine-learning researchers, and in platform work is unbalanced. a review of participants attending AI academic conferences reveals an under-representation of women in academia (19% of conference authors) as well as industry researchers (16% of conference authors; Mantha and Kiser, 2019). OECD came to the same conclusion that software development is male dominated, especially in companies (OECD, 2018a). As regards platform work in Europe, these jobs are mainly dominated by men and the gender gap widens with the importance of platform work relative to total income (Figure 4.1-17). Irrespective of the concerns about job quality, more work flexibility can boost employment and help parents combine work with family life. The flexibility to choose where and when to work is one of the major advantages of digital platforms and offers women the possibility to better combine motherhood with pursuing a career (OECD, 2018a). These initially positive expectations of technological developments on female employment seem not to have materialised.

Figure 4.1-16 **Share of ICT specialists by sex (%), 2008 and 2018**

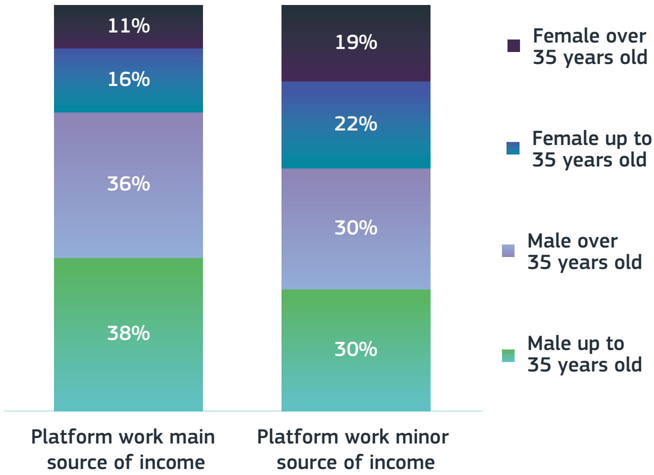


Source: Eurostat (online data code: isoc_sks_itsps)

Note: [1]EU average estimated by DG Research and Innovation.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter41/figure-41-16.xlsx

Figure 4.1-17 Share of platform workers by age and sex (%)



Science, research and innovation performance of the EU 2020

Source: European Commission, Joint Research Centre based on COLLEEM Survey 2017

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter41/figure-41-17.xlsx

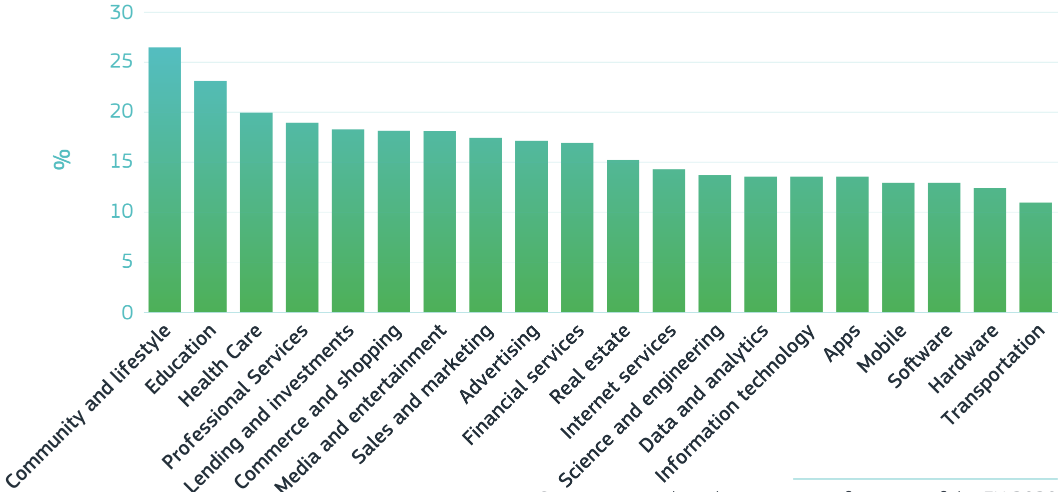
Female entrepreneurship and funding opportunities for high-potential startups are characterised by a significant gender gap. For example, in the EU, the proportion of women in self-employment is under 10 % compared to 17 % for men[13]. Recent studies of high-growth start-up activity find that only a marginal share of start-ups are founded by women while start-ups with at least one woman in the founding team are often less likely to receive funding than start-ups founded by men only[14]. (For more information, see Start-up gender gap section in Chapter 3.3 - Business Dynamics and its contribution to structural change and productivity growth and in Chapter 8 - Framework conditions). There seems to be a division between 'STEM-related' industries that are more dominated by male-founded companies and female-led start-ups, meaning that at least one founder is a woman (Figure 4.1-18). These tend to be in areas generally perceived as less high-tech, such as lifestyle, education, and fashion rather than ICT technologies. Given the preference of venture capital providers to invest in sectors which typically generate big returns on small initial investments, such as information and communications technology or life sciences, women's starting position could improve by expanding into these areas. **Thus, a substantial part of the gender gap can be attributed to the origins of gender gap in education and later career paths (e.g. gap in STEM education)**. Policies to close the participation gap of women would need to address upstream factors related to education and training. Policy interventions focused on education policy, women's participation in STEM entrepreneurship and various accompanying business supporting schemes could potentially reduce these divisions.

To find out more, see Chapter 11 - The consequences of AI-based technologies for jobs.

13 Eurostat. Employment and Self-employment by sex, 2018: 20.5 million self-employed men compared to 9.9 million self-employed women in the EU28.

14 Only 10-15 % of startups have been founded by women in the United States (Brush et al., 2014). Start-ups with at least one woman in the team of founders are 10 % less likely to receive funding compared to start-ups founded by men only. OECD (2019): Levelling the Playing Field: Dissecting the Gender Gap in the Funding of Innovative Start-Ups Using Crunchbase.

Figure 4.1-18 Female-founded startups across different sectors - share of companies with at least one female founder (%)



Science, research and innovation performance of the EU 2020

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

Note: Sample limited to firms created between 2000 and 2017, located in OECD, Colombia, and BRICS countries. Graph restricted to the top 20 technological fields in terms of number of firms in the sector.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter41/figure-41-18.xlsx

Summary of Peter Cappelli - The consequences of AI-based technologies for jobs

This contribution follows the recent public debate on the changes across industrial countries that stem from information technology, including notions of artificial intelligence and its implications for how work is performed. While acknowledging the size and pervasiveness of these discussions, **the article discusses the core argument related to the impact of information technology on the way businesses and organisations operate, how these changes could translate to the labour market**, and other potential outcomes such as lower wages or unemployment.

The argument begins with an introduction to the two ways in which people tend to anticipate future developments. This either happens through estimates based on prior experience (commonly known as forecasting) or through a belief in a real uncertainty of future developments and reliance on other kinds of evidence besides traditional forecasts. The article maps the projected impact of technological uptake on the labour markets and reviews the empirical evidence. It touches upon many of the above-discussed trends, such as skill-biased technological change or routine-biased technological change and their implications for skills demand. With an historic perspective, the article argues that predictions based on the past may be less relevant in the current context. Although new equipment and practices could eliminate certain jobs, on balance they do not necessarily destroy jobs because their overall effects on improving productivity and overall wealth create jobs elsewhere.

To understand why assumptions claiming that the future is like the past are not correct and extrapolations from prior experiences are unlikely to be accurate predictors of the future, read Chapter 11 - The consequences of AI-based technologies for jobs.

6. Conclusions

Technological developments accompanied by growing computing power and the greater availability of big data are shifting the boundaries of what can be automated by machines and could further reduce the costs of automation, in particular of so-called routine tasks. Although employment levels have not declined, other trends, such as the **polarisation of labour markets with a declining share of medium-skilled occupations**, have emerged across advanced economies. This suggests that the technological potential should not be equated with the actual impact on employment as this depends on specific circumstances. For example, a wider diffusion of technology is a necessary precondition for any broader occurrence of technology-driven employment effects. Furthermore, the evolving set of tasks within occupations can reshuffle the existing pool of jobs and the expected job-creation effects are currently difficult to quantify. In general, many of the developments in employment between occupations or whole industries introduced by cutting-edge technologies **are related to structural change within economies towards more productive and innovative activities**.

The various challenges in the field of education and training require actions from multiple stakeholders. **Better labour market intelligence that helps anticipate change and promotes innovation, new angles to lifelong learning and adult education that emphasise inclusiveness, or contributions by technologies to the training process** rank among the priorities. More focused training and qualification measures may help workers to target expanding occupations in a technology-rich environment and reduce the potential losses of those working in shrinking occupations, although this will depend on the accuracy and level (sectoral or company specific) of forecasts.

Exploring how to better align innovation and skills policy is increasingly relevant and some initial efforts have taken place, for example through the Skills Agenda, Sectoral Skills Alliances projects and, more recently, through the Vocational Excellence initiative. The **definition and diffusion of skills, along with new high-quality knowledge and technologies**, could support structural change and provide solutions to global challenges. However, this would require that policies supporting innovation and skills, both at the EU and national level, become increasingly more synergetic.

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CHAPTER 4.2

REGIONAL R&I IN EUROPE

KEY FIGURES

40 %
of jobs are in risk of automation in the West Slovakia region

10 out of 29
European unicorns are located outside of capital regions

27 out of 266
regions account for half of the EU's annual R&D spend on patent applications

3 %
in Hovedstaden (DK) is the highest share of researchers in the number of employed people

What can we learn?

- The **high concentration of R&D activities and agglomeration** effects imply that there are regions with more incentives for R&D investments.

- **Scientific production has become more dispersed** and higher investment in R&D has led to more scientific output from the central and eastern European countries and regions.

- Increasing concentration of economic and innovative activities in capitals and metropolitan areas, on the one hand, and declining industrial or peripheral areas on the other lead to **negative developments in regions with low capacity to exploit innovation**.

- **Upward convergence of economic growth at the regional level is stalling**. While many of the capital regions witnessed fast convergence, other regions have shown little progress and their labour productivity is slowing down. This suggests the **importance of R&I as a new growth engine for innovation-driven productivity growth in less-developed and transition regions**.

- Negative economic developments paired with the impact of globalisation and technological change on disadvantaged groups, i.e. the older and less educated, living in industrial or decaying areas, have led to a set of local economic conditions known as the **geography of discontent**.

What does it mean for policy?

- European innovation policy must place a **greater emphasis on promoting innovation in less-developed and transition regions to trigger economic dynamism** that would increase the competitiveness of the EU as a whole and close the innovation divide.

- Policymakers need to align policies targeted at improving R&I capacities and territorial inequalities with **greater coordination at all levels**. These include aligned R&I policies and Cohesion Policy, together with education and training.

- With substantial variation across EU regions in terms of institutional quality, **improvements in institutional quality and integration of smart specialisation strategies into regional development strategies** would improve the efficiency of R&I programmes, combat corruption and promote innovation.

1. Regional research and innovation systems show signs of convergence

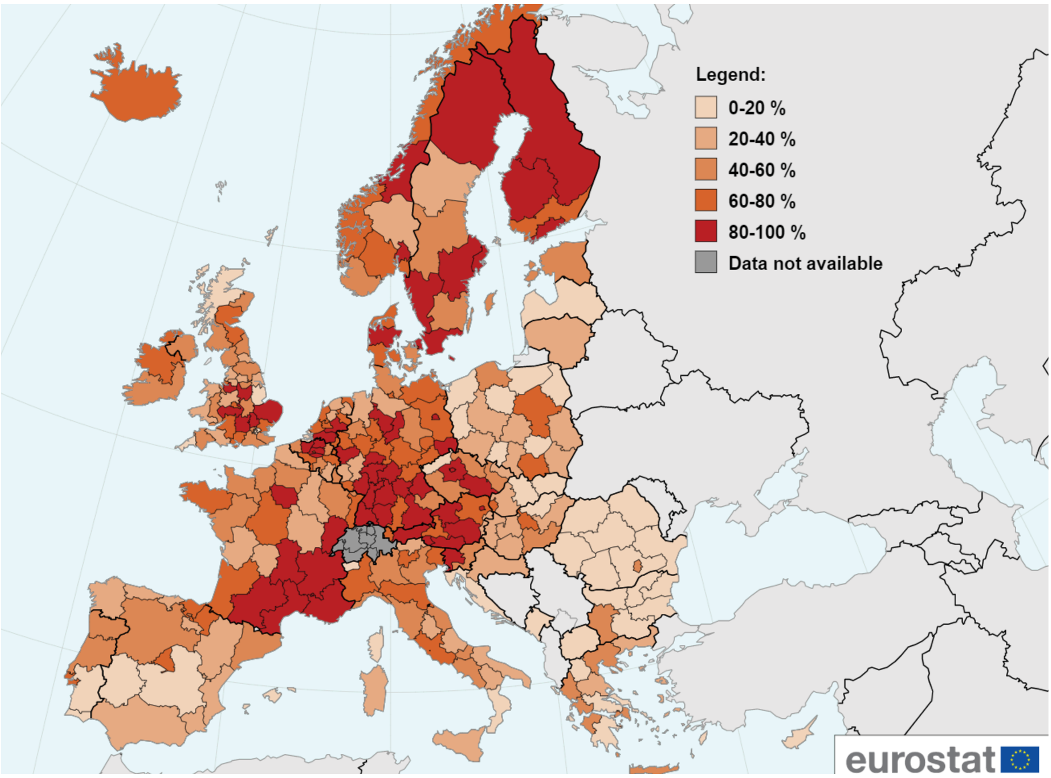
R&D-intensive regions

In general, R&D intensity is high in western and northern Europe with some well-performing regions in other parts of Europe, too. A closer look at the type of expenditure and the spending dynamism reveals specific patterns. As economies become more knowledge-based and dependent on intangible assets, economies and firms achieve large returns on R&D investments which also help to create new and better jobs. However, the latest literature concludes that R&D investment does not trigger the same returns everywhere. The reasons for this include the distance to the technological frontier and the related creation and distribution of new knowledge. The following maps show to what degree the core R&D-performing areas attract and concentrate resources.

R&D investment shows a high concentration of spending in regions with high R&D intensity. Within countries, there is strong concentration (in absolute terms) of R&D expenditure in a few regions, typically capital regions or those with large urban agglomerations. The R&D-to-GDP ratio provides an insight into contributions from public budgets[1] and private actors during the economic cycle. While business R&D trends traditionally depend on business expectations, public R&D is expected to be more counter-cyclical, buffering the effects of economic downturns (OECD, 2014). Currently, the intensity of R&D spending across EU regions varies considerably with highly intensive regions in the west and north of Europe, often as a result of being endowed with headquarters of large tech companies (Figure 4.2-1). As these indicators are related to GDP, eastern European countries showed strong economic growth and many regions also experienced growth in R&D intensity. The absolute amount of R&D expenditure (as well as the number of patents in the region) in eastern Europe as a whole and in many of its regions has clearly increased (Figure 4.2-2). On the other hand, some of the regions with high R&D intensity have continued to expand their R&D expenditure which means the distance to the top-performing regions has not decreased significantly. There are some noticeable exceptions of regions with high absolute amounts of R&D and lower R&D intensity, representing relatively large regions, including, for example Catalunya (ES51), Lazio (ITI4), Lombardia (ITC4), or mid-sized regions with a high GDP per capita (e.g. Southern and Eastern Ireland (IE02). On the other hand, there are (smaller) regions with small absolute amounts of R&D expenditure that are actually very R&D intensive, e.g. Övre Norrland (SE33) and Kärnten (AT21).

1 Data on sectoral R&D expenditure based on sector of performance, hence business spending also includes money coming from public budgets and vice versa.

Figure 4.2-1 R&D intensity (2017 or latest available)[2]



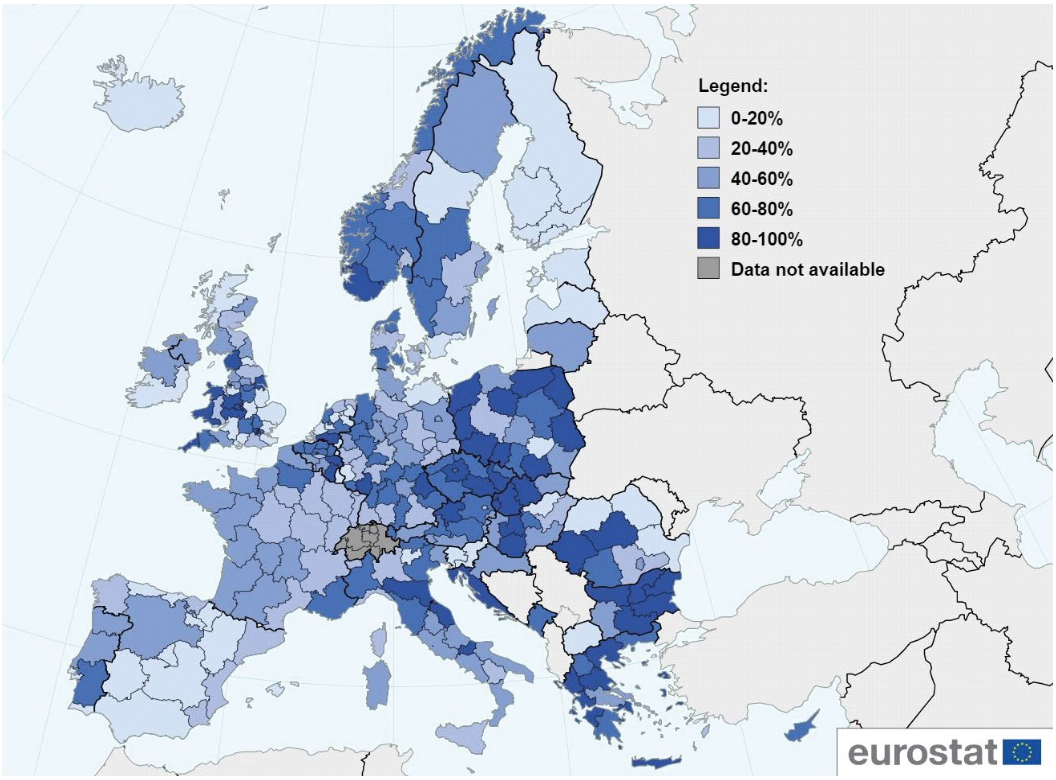
Source: Eurostat (online data code: rd_e_gerdreg)

Note: R&D intensity of UK, IS, NO:2016; BE, IE, LT: 2015; FR: 2013. The maps use NUTS2013 and, where necessary, regional data were matched with NUTS2016 (HU, LT, PL).

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter42/figure-42-1.xlsx

2 The maps across this chapter divide regional values of selected indicator into five quintiles according to their performance (0-20% the lowest quintile).

Figure 4.2-2 R&D growth (2010-2017 or latest available)



Science, research and innovation performance of the EU 2020

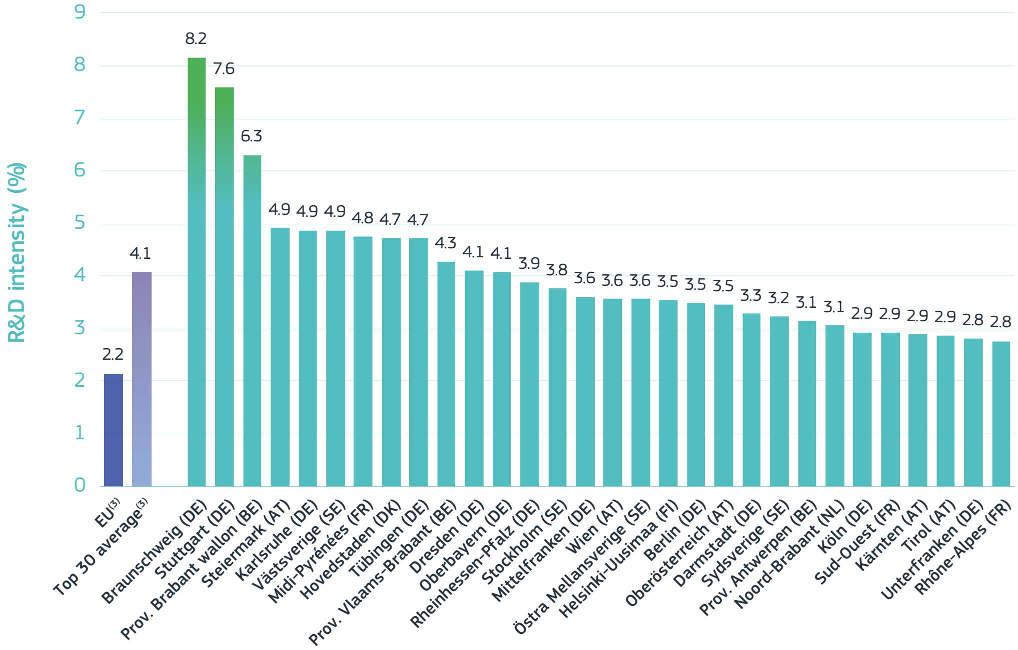
Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on Eurostat (online data code: rd_e_gerdreg)

Note: Compound annual growth rates calculated NL: 2015-2017; DE, EL, AT, ME: 2011-2017; BE, IE: 2010-2015; UK, NO: 2010-2016; FR:2010-2013; MK: 2015-2017. The maps use NUTS2013 and, where necessary, regional data were matched with NUTS2016 (HU, LT, PL).

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter42/figure-42-2.xlsx

The EU's most R&D-intensive regions are all located in western and northern Europe and the degree of concentration confirms the described trends. The average intensity of the top 30 EU regions is more than twice the average intensity of the EU as a whole (Figure 4.2-3). In some cases, the regional R&D intensity is heavily influenced by presence of a single large tech company. An example is Braunschweig, the EU NUTS2 region with the highest R&D intensity, where the biggest European R&D spender Volkswagen has its headquarters.

Figure 4.2-3 The 30 most-R&D-intensive regions[1] in the EU - R&D intensity, 2017[2]



Source: Eurostat (online data code: rd_e_gerdreg)

Notes: [1]NUTS Level 2 regions. [2]BE: 2015; FR: 2013. [3]EU and top 30 regions' average calculated by DG Research and Innovation.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter42/figure-42-3.xlsx

Business and public R&D spending

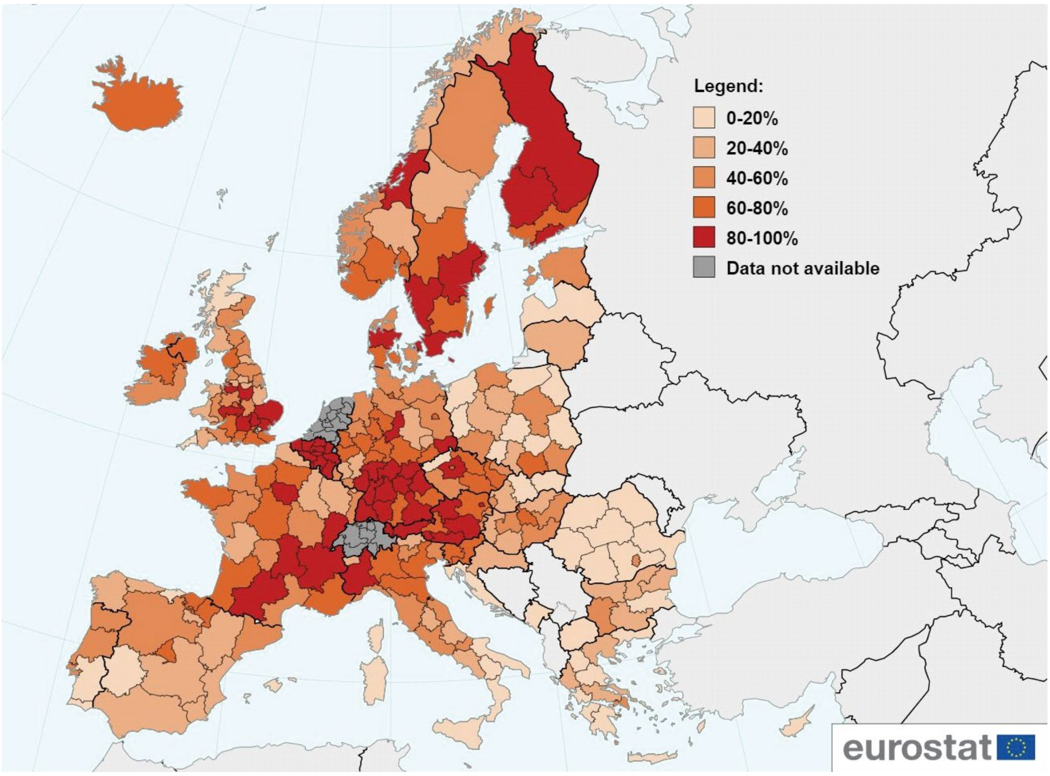
While business R&D expenditure contributes to an increase in R&D intensity in some less-developed and transition regions, overall business R&D expenditure remains heavily concentrated. Business-driven R&D expenditure is expected to play an important role in higher EU competitiveness and job creation (EC, 2014) and to reduce the EU's innovation gap (EC, 2017). Furthermore, the ultimate objective is to accompany the transition of those regions and workers most affected by globalisation and industrial developments and to facilitate their transition to a low-carbon and circular economy (JRC, 2018). Despite certain convergence trends in regions' business R&D intensity, the latest data **suggest a persisting concentration of R&D expenditure in more-developed central locations**. Business R&D expenditure is even more concentrated in more-developed regions with a strong concentration in relatively few internationally active technology companies. Germany, the UK and France contribute to two thirds of total EU business R&D with a strong contribution from the automotive sector in Germany, pharmaceuticals in the UK, whilst France has a relatively balanced sector composition (JRC, 2018)[3]. Currently, more-developed regions represent about 85% of R&D expenditure in the EU, transition regions about 10% and less-developed regions about 5%. One example is Baden-Württemberg, which has about 2% of the EU population but an 8% concentration of the EU's business R&D[4].

3 Among the sample of 1 000 EU top spenders, 899 companies are based in the top 10 Member States, accounting for 97.1% of total R&D. Moreover, the overall performance of the EU 1 000 group is largely driven by the results of companies based in Germany, France and the UK, accounting for 61% of companies, 68% of the total R&D, and 68% of total net sales.

4 The main NUTS2 reference region is Stuttgart DE11 (share of the EU, 2017).

Some upward convergence in R&D expenditure can be observed in many regions in central, eastern and south-eastern European countries (CESEE). Notably, regions such in Czechia, Hungary and Slovakia show an increase in business R&D intensity which seems to be driven by business R&D spending in the automotive and ICT sectors[5] (Figure 4.2-4.). Business R&D intensity in several regions in Greece – where recovery from the severe crisis has set in – is also increasing. In many regions of eastern and southern Europe, R&D expenditure has risen steadily in recent years, linked to a structural shift to more knowledge-intensive activities and expected returns on R&D investment. Although many less-developed regions began to grow from (and were facilitated by) low starting levels, high growth rates brought several regions closer to the performance of frontier regions. Střední Čechy (CZ02), Budapest (HU11) and Warszawski stoleczny (PL91), ranked in the top 20% of business R&D-intensive regions in 2017.

Figure 4.2-4 Business R&D intensity in 2017 or latest available



Source: Eurostat (online data code: rd_e_gerdreg)

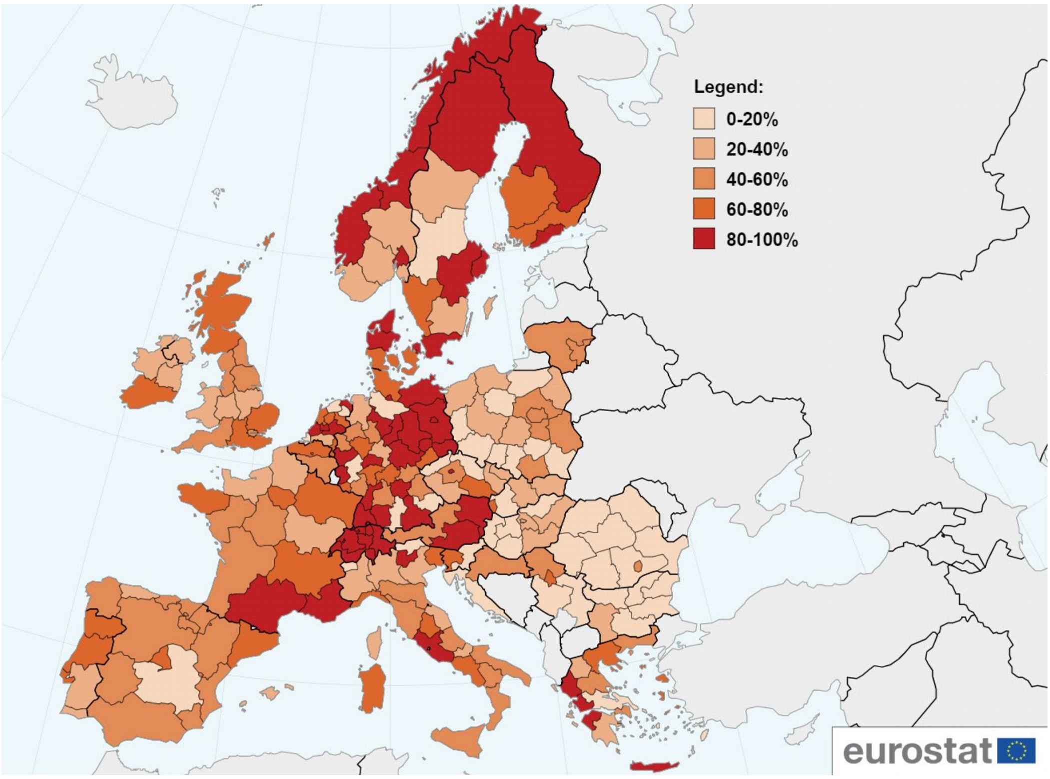
Note: Business R&D intensity of UK, NO: 2016; BE, IE, LT: 2015; FR: 2013. The maps use NUTS2013 level 2 and, where necessary, regional data were matched with NUTS2016 (HU, LT, PL). BE on NUTS1 level, NL data confidential.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter42/figure-42-4.xlsx

5 Expenditure in the areas of manufacturing motor vehicles and information technologies represents 36 % of overall business R&D expenditure in Czechia and 33 % in Slovakia.

Public R&D expenditure show similar levels of concentration, with higher rates in regions of Nordic countries. This pattern of innovation-lagging regions that invest less in R&D and of innovation-leaders forging ahead with public R&D spending resembles the earlier observed patterns at the national level (Veugelers, 2014). In particular, Sweden, Germany and Denmark increased their public expenditure on R&D during the financial crisis by a higher degree than in the case of other public expenditures, and this trend seems to persist since then (Figure 4.2-5). In regions that are seemingly too far from the technological frontier and that may have a weak industrial fabric, increasing the R&D effort alone does not always yield greater economic growth. An earlier work identified regions, which failed to achieve economic growth that would be at all proportional to the regions' increases in public R&D investment (Rodríguez-Pose, 2014).

Figure 4.2-5 Public R&D intensity in 2016 or latest available

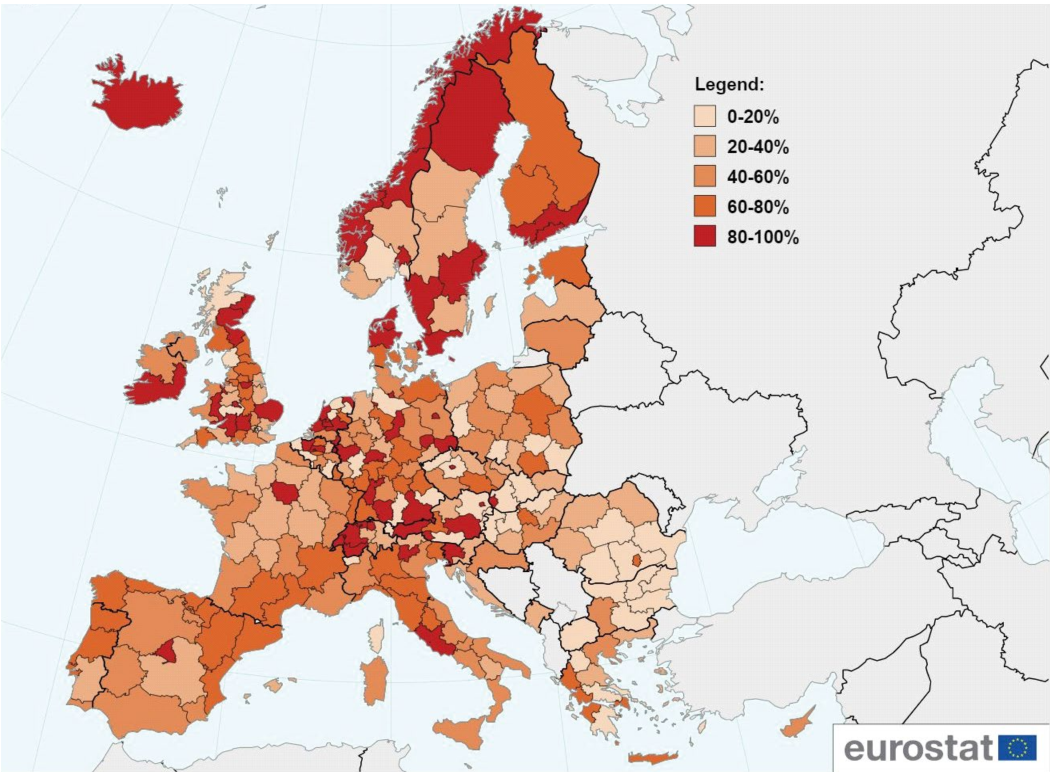


Science, research and innovation performance of the EU 2020
Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on Regional Innovation Scoreboard 2019
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter42/figure-42-5.xlsx

Scientific publications

Many of the lagging regions, mostly in eastern and southern Europe, have observed an improvement of their performance in scientific output, which indicates improved returns on R&D investment. The map of regional performance in scientific publications per capita shows a relatively dispersed pattern of scientific production across the EU (Figure 4.2-6). However, the picture becomes more concentrated when looking at the regional distribution of 10% top-cited publications per 1 000 inhabitants. This indicator shows poor performance particularly in regions in eastern Europe[6]. The quality indicator will potentially catch up in the future, as observed in the overall numbers of scientific publications, but the catching-up process may take longer. Currently, the production of high-quality publications is still very concentrated in western Europe with high shares of British and Dutch regions.

Figure 4.2-6 Share of scientific publications per 1 000 inhabitants



Science, research and innovation performance of the EU 2020

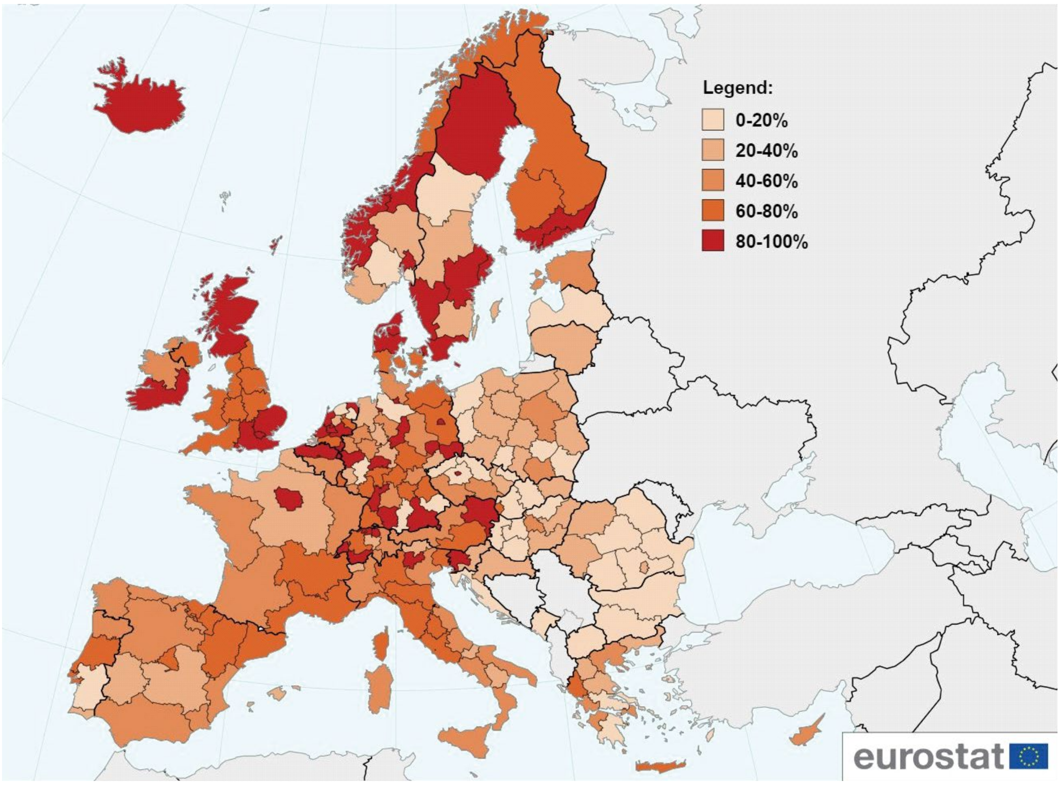
Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on CWTS using data from Web of Science database and Eurostat data

Note: Based on articles and reviews published in the period 2013-2017, covered by the Web of Science.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter42/figure-42-6.xlsx

6 Without adjustment per 1 000 inhabitants, the projected concentration of top-10% publications would increase further.

Figure 4.2-7 Share of top-10% most cited publications per 1 000 inhabitants[(1)(2)]



Science, research and innovation performance of the EU 2020

Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on CWTS using data from Web of Science database and Eurostat data

Notes: (1)Based on articles and reviews published in 2015, covered by the Web of Science. (2)BE, FR, AT at NUTS1 level.

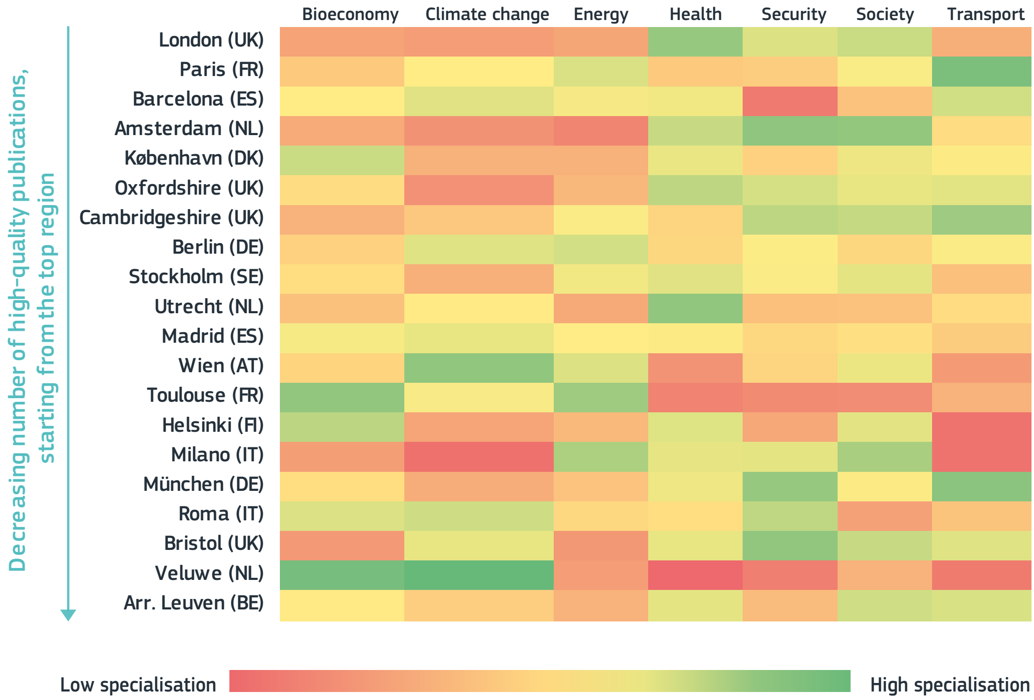
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter42/figure-42-7.xlsx

The increasing level of knowledge complexity[7] **suggests that even the metropolitan areas and well-connected regions concentrate specific knowledge**. Figure 4.2-8 is a matrix table of specialisation showing how the regions concentrate specific knowledge relative to other regions and depicts relative patterns of specialisation. The listed regions are ranked by the overall number of their high-quality publications. The matrix columns assess shares of top scientific publications among these regions in the fields of societal challenges compared to the overall European shares[8]. Very few regions, such as Berlin or Madrid, do not show a specific pattern of scientific specialisation. Other regions have their specific focus, such as, for example, Vienna and the Dutch region of Veluwe which perform well on topics related to climate change and environment.

7 Refers to assets for innovation activities in the knowledge economy. See Chapter 2 - Changing innovation dynamics in the age of digital transformation, or earlier publications, such as Westlund, 2006.

8 Societal challenges as defined in the Horizon 2020 Framework Programme.

Figure 4.2-8 Relative specialisation of top regions by societal challenges[(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 CWTS using data from Web of Science database and Knowmak project

Notes: (1)Green indicates high specialisation and red indicates low specialisation (share of publications related to the challenge among the publications of the region divided by the share of publications related to the challenge among European publications). (2)Data refers to number of publications that are in the most-cited 10% of publications in 2016. (3)The selected regions present the 20 regions with the highest numbers of scientific publications in the top 10% cited. The regions are ranked by the number of publications (top-down). (4)The ontology for Societal Grand Challenges publications and definitions were developed by the Knowmak project (Horizon 2020 project number 726992).

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter42/figure-42-8.xlsx

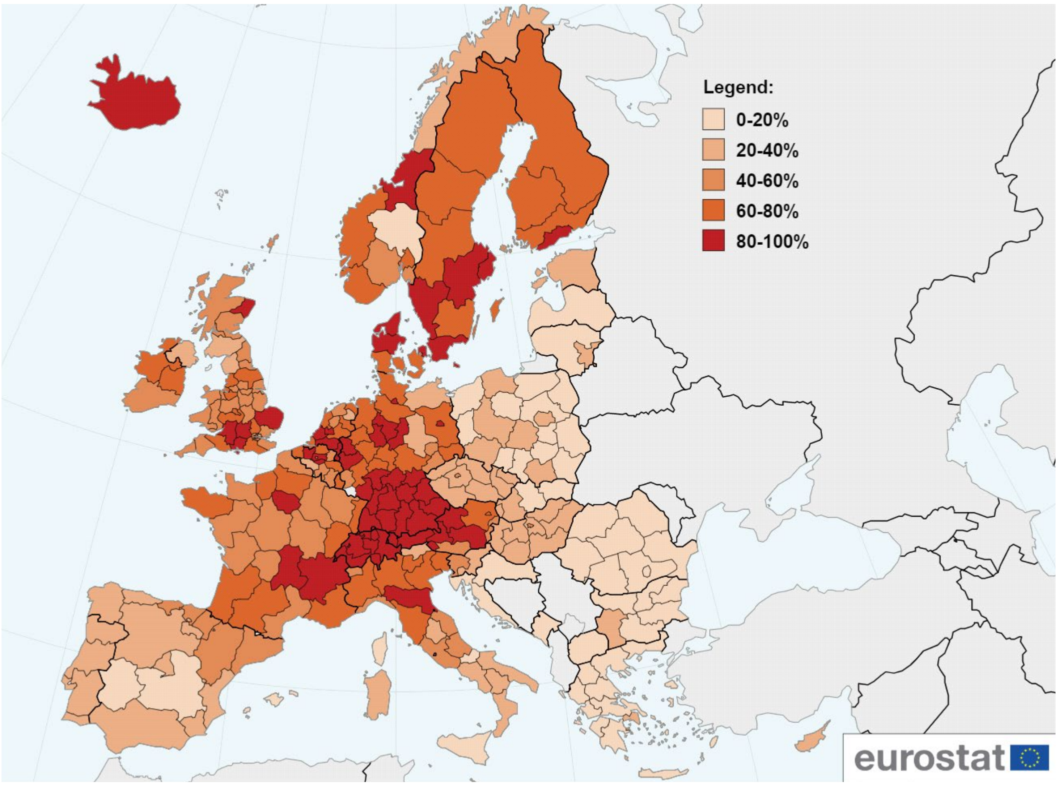
Technological production

The technological output, as measured by patents, is concentrated in regions with a high share of manufacturing and with tech companies' headquarters, such as southern Germany, Austria, Denmark and the Rhône-Alpes region. Furthermore, patenting is concentrated in capital cities (Figure 4.2-9). A high patent output per capita is observed in the Dutch NUTS2 Noord-Brabant (NL41) and Austrian Vorarlberg (AT34).

A look at trends in patent applications across European regions reveals a convergence pattern in the eastern European regions and growth in some southern European regions, too (Figure 4.2-10). Notably, growth in the south concerns regions that belong to the group of laggards. These findings do not confirm an increasing patenting divide but show a dynamic patenting activity instead. Another trend already observed at the national level is the concentration of innovation activities among large companies.

Innovation activity at the regional level, as measured by patent applications, is highly correlated to business expenditure on R&D and shows a similar spatial pattern. Large international technology companies have shifted manufacturing to eastern Europe, which is supposedly also boosting R&D expenditure and IP production in the corresponding regions. Therefore, innovation activities linked to technological production show a broad convergence trend (see more on the patenting divide in Chapter 12 - The research and innovation divide in the EU and its economic consequences).

Figure 4.2-9 Share of PCT patent applications per 1 000 inhabitants, 2016



Science, research and innovation performance of the EU 2020

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

Note: Data produced by Science-Metrix using data from the REGPAT database.

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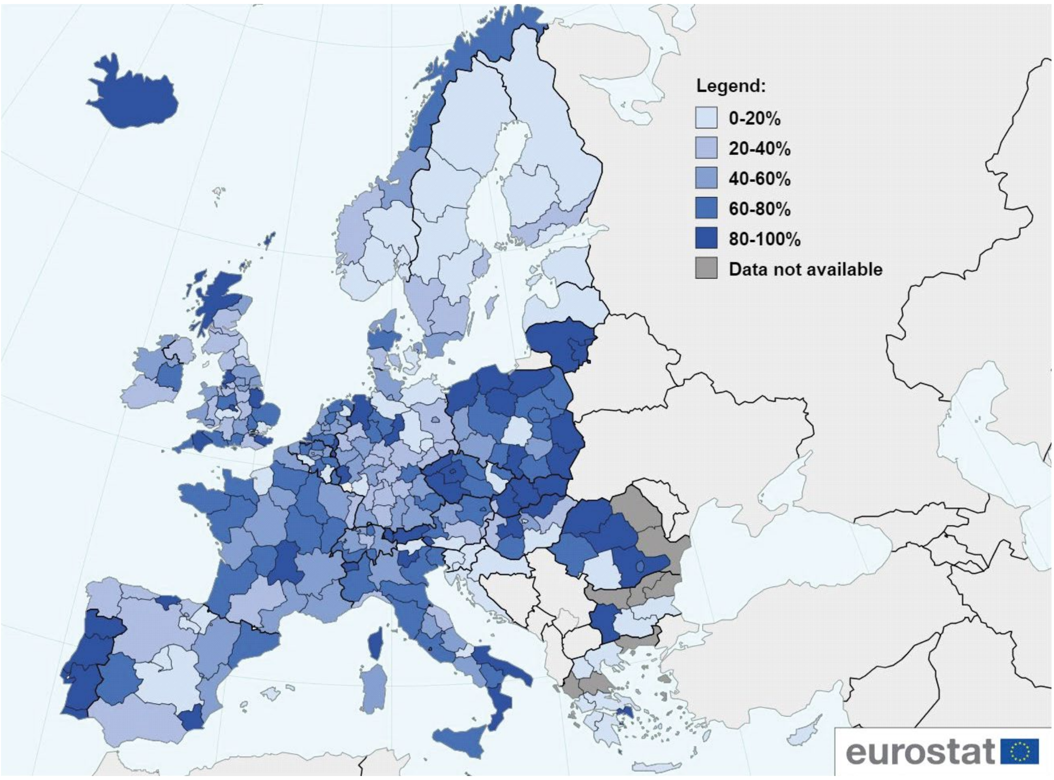
Figure 4.2-10 Growth in PCT patent applications between 2010 and 2016



Science, research and innovation performance of the EU 2020

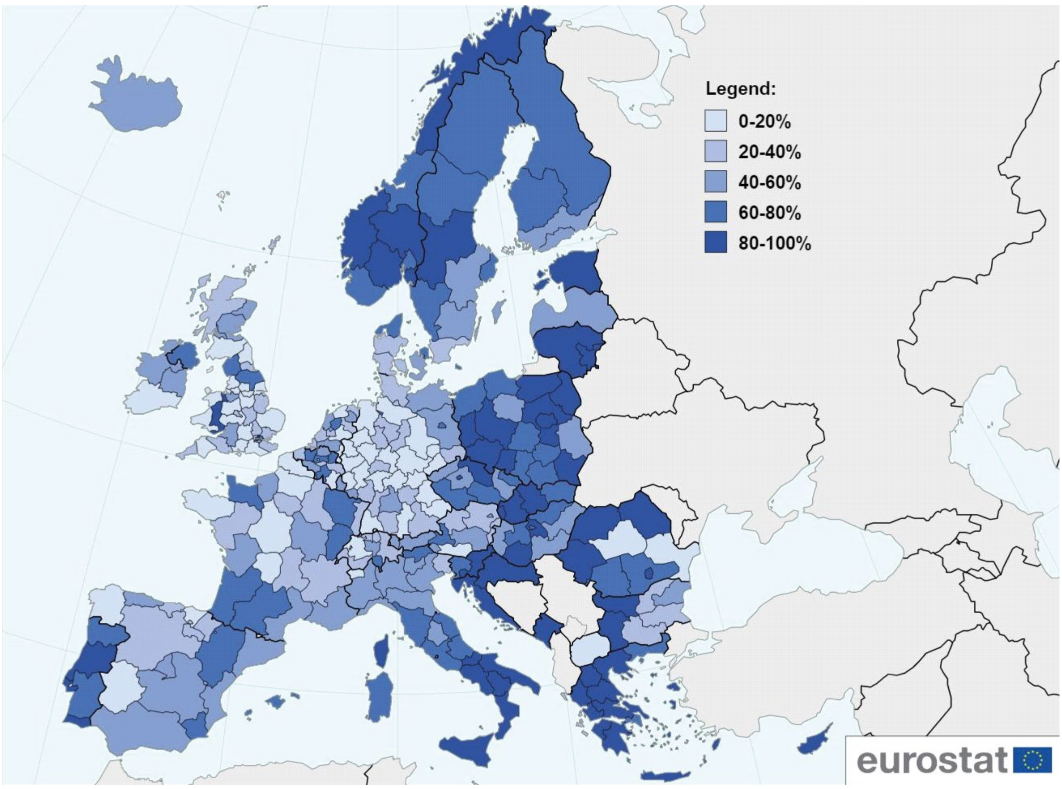
Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit.

Note: Data produced by Science-Metrix using data from the REGPAT database. The highest quintile shows regions with the highest increase from 2010 to 2016.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter42/figure-42-10.xlsx

Greater activity in design and trademark applications across Europe reveal emerging convergence trends and examples of local specialisation. A broader perspective on innovation output protected as intellectual property confirms that there is a high concentration and an overlap in the use of patents, designs and trademarks in some regions, but there are also more specialised regions. The emergence of specialisation in less technologically intensive fields covered by designs and trademarks could point to growth in service innovation or design-based innovation in lagging regions. Better performance in designs can be found, for example, in the Polish regions of Małopolskie (PL21) and Wielkopolskie (PL41), while trademarks play a prominent role in Andalucia (ES61) and in many Bulgarian regions (Figures 4.2-11 and 4.2-12). Bulgaria already outperforms the EU average as regards trademarks and design applications per unit of GDP. The changes in design and trademark applications over time show high growth rates in many regions of eastern and southern Europe and imply a catching-up process by some regions.

Figure 4.2-11 Growth in trademark applications between 2010 and 2018



Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit
Note: Data produced by Science-Metrix using data from the EUIPO database. The highest quintile shows regions with the highest increase from 2010 to 2018.
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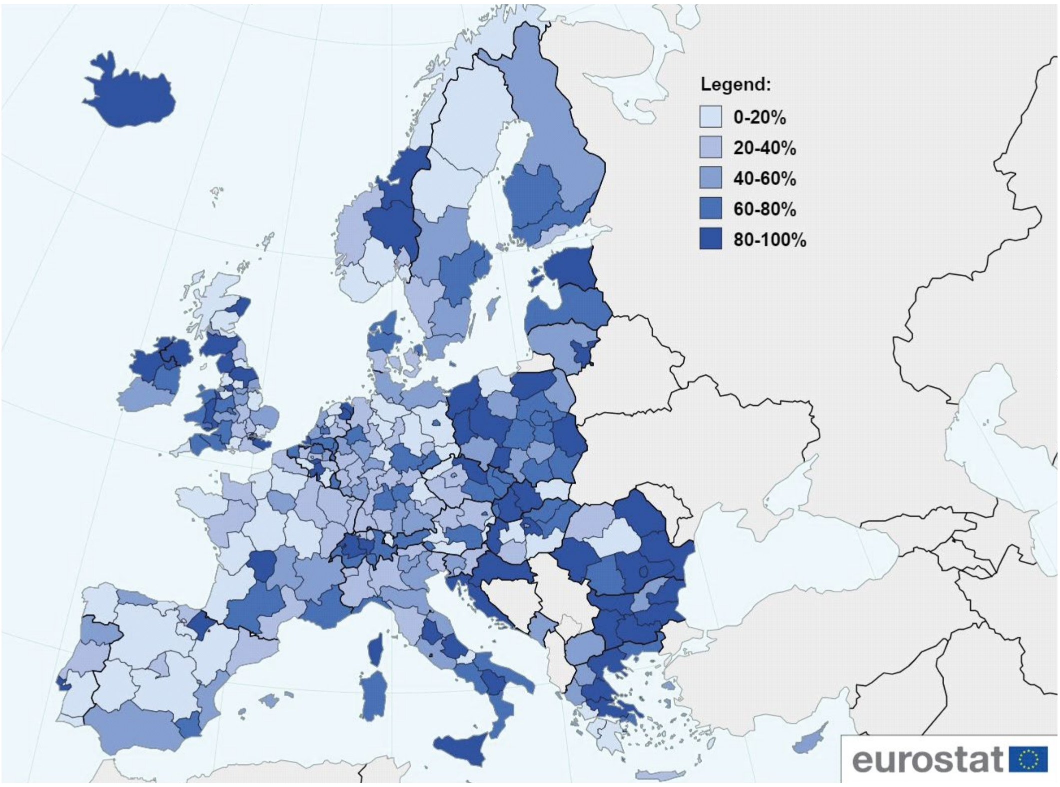
Figure 4.2-12 Growth in design applications between 2010 and 2018



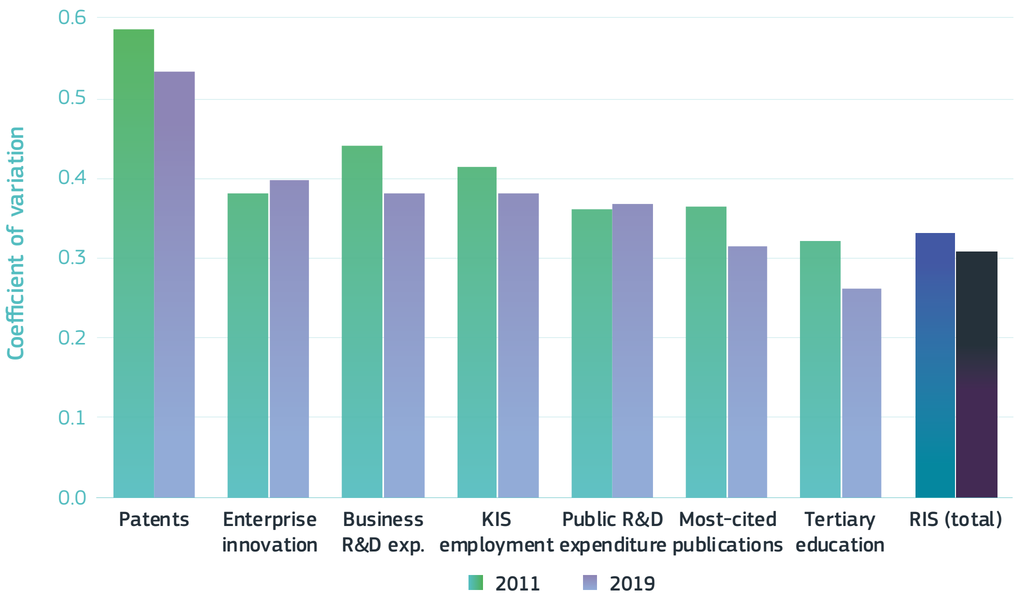
Science, research and innovation performance of the EU 2020
Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit
Note: Data produced by Science-Metrix using data from the EUIPO database. The highest quintile shows regions with the highest increase from 2010 to 2018.
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter42/figure-42-12.xlsx

2. Technological output remains concentrated

The Regional Innovation Scoreboard (RIS) results show a convergence in R&I performance across the EU for the period 2011-2019. Nevertheless, a group of low-performing regions has barely improved and has slowed down the convergence process. The dispersion of regions in terms of innovation performance declined between 2011 and 2019[9]. Performance increased in two thirds of the regions (159 out of 238) but decreased in one third (79 regions). The share of regions that improved was 55 % in the innovation-leader category, 64 % in the strong-innovator category and 80 %, the highest share, in the moderate-innovator category. However, only 45 % of regions within the modest-innovator category improved and several regions in this category showed significant negative growth rates.

The RIS convergence trends confirm that R&I output linked to business shows significant gaps (e.g. patents) or lack of convergence (e.g. enterprise innovation). Figure 4.2-13 depicts in nutshell some of the trends described earlier. Tertiary attainment and top scientific publications are at the frontier of the convergence process, although some other indicators show persistent differences. a more detailed look at Regional Innovation Scoreboards would enable a better understanding of these indicators and regional developments.

Figure 4.2-13 Regional convergence of key R&I components in the EU (coefficient of variation), 2011 and 2019



Science, research and innovation performance of the EU 2020

Source: DG Regional and Urban Policy based on Regional Innovation Scoreboard

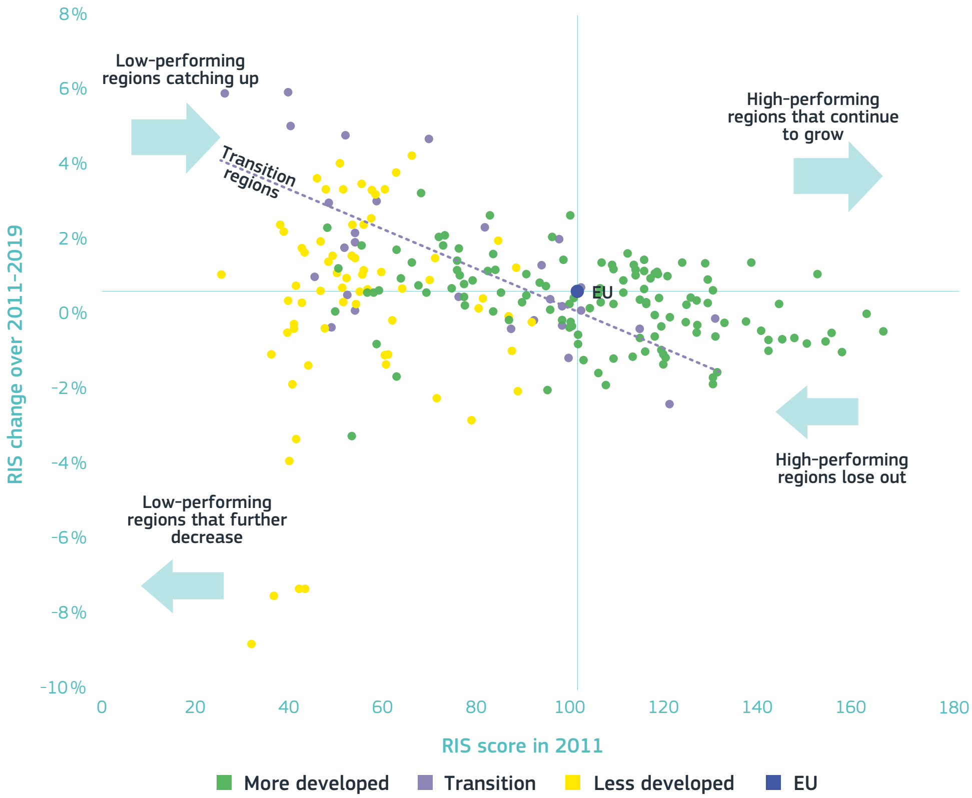
Note: The coefficient of variation (CV) is the ratio of the standard deviation to the mean, which shows the extent of variability of data in a sample in relation to the average value. The higher the coefficient of variation, the greater the level of dispersion around the mean.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter42/figure-42-13.xlsx

9 The coefficient of variation of the regional scores was 0.314 in 2011 and 0.300 in 2019.

The overall R&I performance and convergence pattern differ according to the level of economic development, with a stronger convergence pattern in transition regions. The so-called transition regions, reaching 75-90% of the EU's average GDP, showed a convergence trend with a higher catch-up of low performers in this group and a declining rate of growth with higher levels of R&I performance. The performance of less-developed regions is influenced by a group of low-performing regions where performance has deteriorated significantly over the last decade (Figure 4.2-14). The majority of low-developed regions are in the CESEE countries and are considered to be moderate or modest innovators. Their poor digital capacities together with certain other bottlenecks, such as low R&D investment, could hinder higher absorption of current and future innovations. This issue, coupled with some skills gaps and underdeveloped innovation systems, could perpetuate their poor ability to transform R&D investment into scientific and technological capacity and might further restrict the region's potential to boost its economic growth from an improved innovation performance.

Figure 4.2-14 Regional convergence as measured by the European Regional Innovation Scoreboard, regions by level of economic development



Science, research and innovation performance of the EU 2020

Source: DG Research and Innovation, Chief Economist - R&I Strategy & Foresight Unit based on Regional Innovation Scoreboard 2019 and 2011

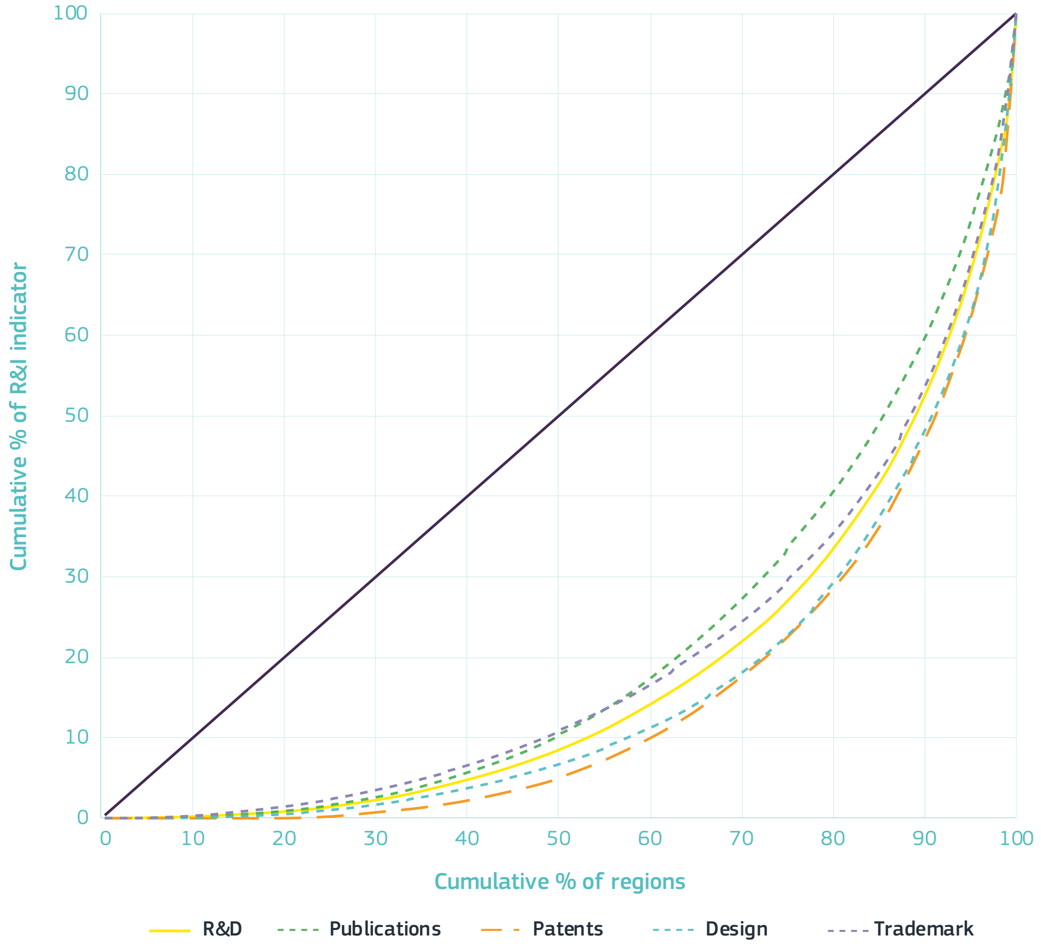
Note: The level of regional development refers to the GDP per capita of each region, measured in purchasing power parities (PPS) and calculated on the basis of EU figures for the period 2007-2009, and relates to the average GDP of the EU for the same reference period.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter42/figure-42-14.xlsx

Regional performance is affected by the capacity of regions to ride the undergoing innovation wave by producing, diffusing and adopting technologies which change the way we produce and compete globally. The high concentration of R&I activities and agglomeration effects imply that regions where these investments are located have an initial advantage, while those regions at the periphery need to rethink their economic growth model in order to position themselves better in global value chains. As long as these developments prevail over the benefits of knowledge spillovers, tailored R&I policy is needed to promote territorial cohesion and inclusive growth (see more on policy design in Chapter 12 – The research and innovation divide in the EU and its economic consequences), as well to manage the related social, economic and political consequences of widespread discontent (Dijkstra et al., 2018).

Despite overall convergence trends among European regional R&I systems, there is still a strong concentration in technological output. Patenting activity together with design applications show higher regional concentration than the numbers of scientific publications and less technologically demanding trademarks (Figure 4.2-15). The graph below shows that 70 % of regions hold a share of around 28 % of publications compared to only 18 % of patent applications. An increase in scientific output has narrowed the gap in scientific publications relative to the scientific leaders in Europe. In order to boost the overall performance of the R&I system, European regions have to increase the production of knowledge at the frontier while their business partners must reach high adoption rates. a weak technological innovation characterised by a focus on innovation in the service sector, along with an innovation activity in the low-tech and medium-tech manufacturing sector would not equip countries and regions well for the digital transformation. It is the complexity of technological developments and the novelty of business models that often restrict firms from becoming more innovative and thus hinder their competitiveness. The increasingly digital economy, characterised by 'winner-takes-all' dynamics, hampers the stronger uptake of innovations across companies, sectors and regions.

Figure 4.2-15 Regional concentration of R&I components[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, Science-Metrix based on EIPO database, Patstat, Web of Science

Notes: [1]Cumulative percentage shares within European NUTS2 regions. [2]Data refers to R&D investment in 2015, scientific publications in period 2013-2017, patent applications in 2014 and design and trademark applications in 2018.

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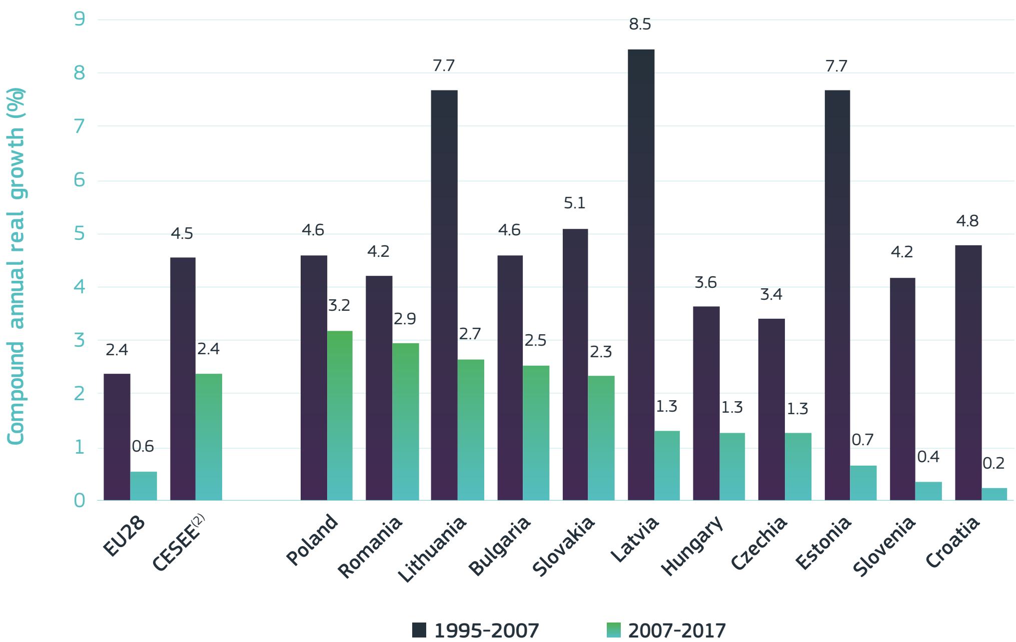
3. Stronger innovation could boost regional productivity and economic growth

Over the last two decades, the EU has shown convergence in economic output with many poorer countries catching up. However, the trajectory of economic convergence is changing as central and eastern European countries continue to converge more slowly and southern countries are falling behind. New Member States with a lower initial GDP per capita (in relative terms) have exhibited a higher speed of convergence towards the EU average. In the post-crisis decade, economic growth in CESEE countries slowed down and was mainly associated with slower TFP growth (Alcidi et al., 2018). On the contrary, the position of some southern Member States with an initially higher GDP per capita has deteriorated in relation to the EU. Four countries that were below the EU average in 2000 (Greece, Cyprus, Spain and Portugal) did not manage to keep pace with it and their relative position deteriorated (Figure 4.2-16).

Figure 4.2-16 GDP per capita[1] - compound annual real growth (%), 1995-2007 and 2007-2017



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 DG Economic and Financial Affairs data

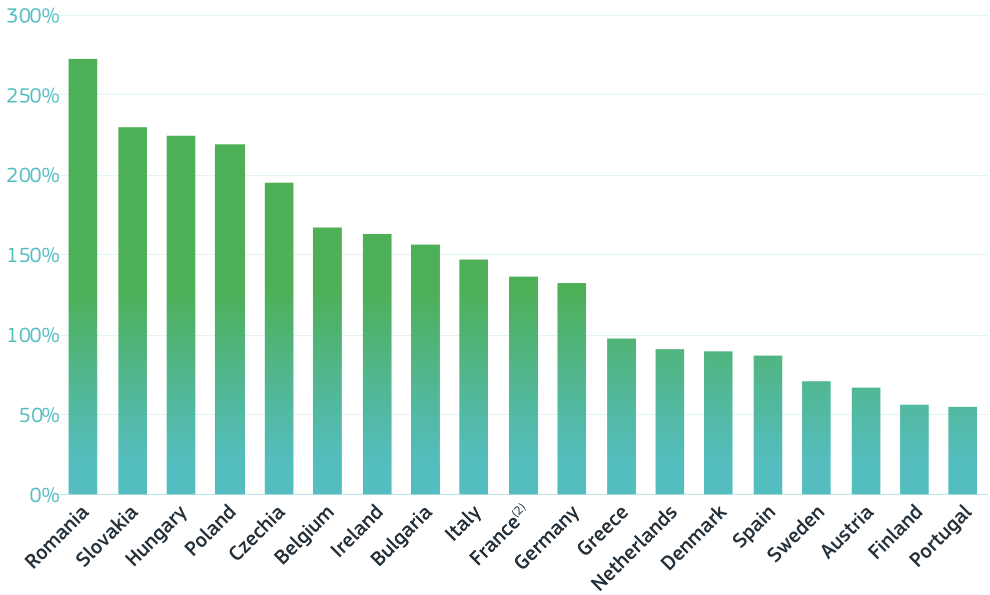
Notes: [1]GDP per head of population in PPS€ at 2005 prices and exchange rates. [2]CESEE: BG+CZ+EE+HR+LV+LT+HU+PL+RO+SI+SK.

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter42/figure-42-16.xlsx

While trends at the national and regional level suggests that poorer Member States and regions have been converging towards a higher level of GDP per capita since 2000, there has been an increasing divergence within many countries. In terms of the growth rate of GDP per capita, convergence at the regional level has been particularly strong in Bucharest and Bratislava, enabling them to surpass the national growth rates. At the same time, these strong growth rates also contribute to inequalities within countries at the regional level (Figure 4.2-17).

These exceptionally high regional growth rates reveal that country aggregates contain different patterns at regional level. This is the case in many central and eastern European countries, where capitals are accelerating the convergence process while the rest of the country lags behind. On the other hand, some regions have performed below their national average. Such regions are also among Greek, Italian and Spanish regions which suggests that that some of these underperforming regions either remained poor or became even poorer relative to the EU.

Figure 4.2-17 GDP per head of population[(1)] – the difference between the highest and the lowest NUTS2 regional values as % of the lowest value in 2017[(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 data

Notes: [(1)]GDP per head of population in current PPS€. [(2)]French NUTS2 regions Guadeloupe, Martinique, Guyane, La Réunion and Mayotte not included in the calculation. [(3)]HR, CY, LV, LT, LU, MT, SI excluded due to low number of NUTS2 regions.

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Labour productivity growth has been stronger in those regions that have traditionally lagged behind. Nevertheless, slower productivity growth over the last 10 years, notably in some less-developed and transition regions, explains the slowdown in the convergence process (Figure 4.2-18). Within the less-developed regions, there is a tendency for stronger growth rates in regions that started from lower levels, reflecting the convergence process. Nevertheless, despite their strong growth rates, all less-developed regions show levels of labour productivity that remain below the EU average (except Basilicata region in Italy)[10]. Over the last two decades, labour productivity growth rate has been higher in the low-developed regions (mainly CESEE) than in the EU. However, since the onset of the global financial and economic crises, several countries in the region have experienced low levels of labour productivity growth – in some cases, such as Slovenia and Hungary, labour productivity growth was even lower than the EU average. Regional productivity went through the same development and, after a convergence period, notably in the period 2000-2009, progress came to a halt after the crisis and there has only been a slight increase in divergence since 2013.

There is a mixed evidence on productivity growth in the European metropolitan and capital regions[11,12]. Capital regions in the east of the EU show the fastest productivity growth, while productivity has been shrinking in capital cities across the centre and south of the EU. Productivity growth in capital regions was notably slow in southern Europe (EL, PT, IT, ES) and in centrally located EU countries (AT, DE), where it fell between 2010 and 2017.

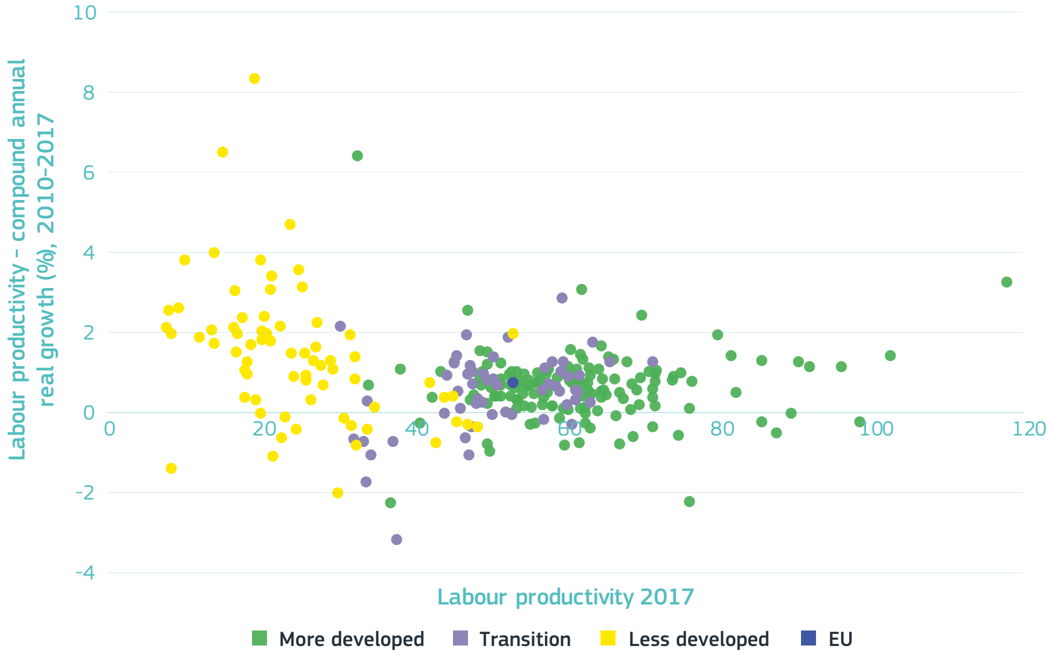
The potential of leading (superstar) cities and regions that benefit from agglomeration economies and have access to the intangible assets and human capital required by the increasing complexity of innovation is likely to gain in importance. The overall productivity growth in the United States has slowed considerably, accompanied by a stark gap between the high productivity of the relatively few metropolitan areas with very high shares of innovation industries and those without them (Atkinson et al., 2019). The European mapping of most specialised areas in innovation industries and the presence of large local innovation sectors that spur metro-wide productivity requires closer examination. From the initial observations, low and declining productivity growth in the service sector and a shift from industry to services contribute mainly to dampening down productivity growth in capital regions and other regions with large cities.

10 The region of Basilicata has 0.57 million inhabitants but is home to a plant in Melfi where Fiat invested EUR 1 billion to boost production. This plant, with 8 000 employees, plays a big part in Basilicata's economy and is responsible for the recent boost in the region's economic output.

11 Labour productivity calculations based on output-weighted average Eurostat data for capital regions and other regions with cities with over 0.5 million inhabitants, for the period 2010-2017.

12 Metropolitan regions are NUTS3 regions or a combination of NUTS3 regions which represent all agglomerations of at least 250 000 inhabitants.

Figure 4.2-18 Labour productivity (GVA per person worked), 2017 and compound annual growth 2010-2017(1)(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 DG for Regional and Urban Policy data

Notes: (1)EL+PL regions labour productivity value 2016 and growth 2010-2016. (2)French NUTS2 regions divided by level of development according to Eurostat 2017 calculations, not including Régions ultrapériphériques. (3)Data includes regions from United Kingdom.

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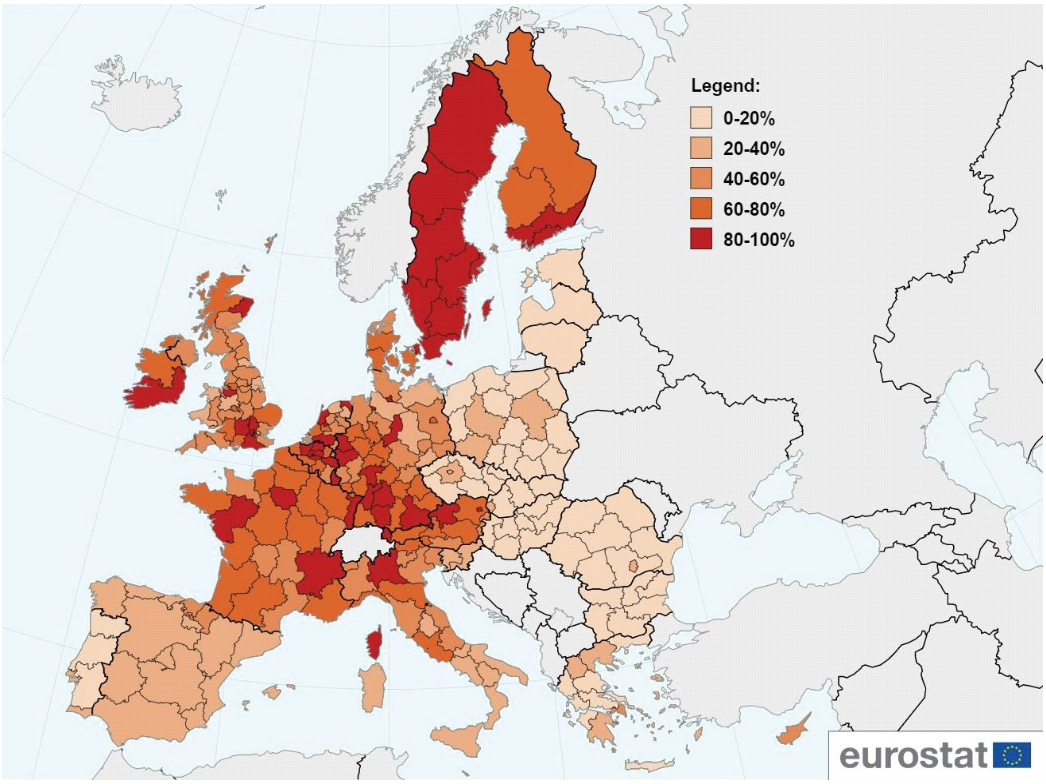
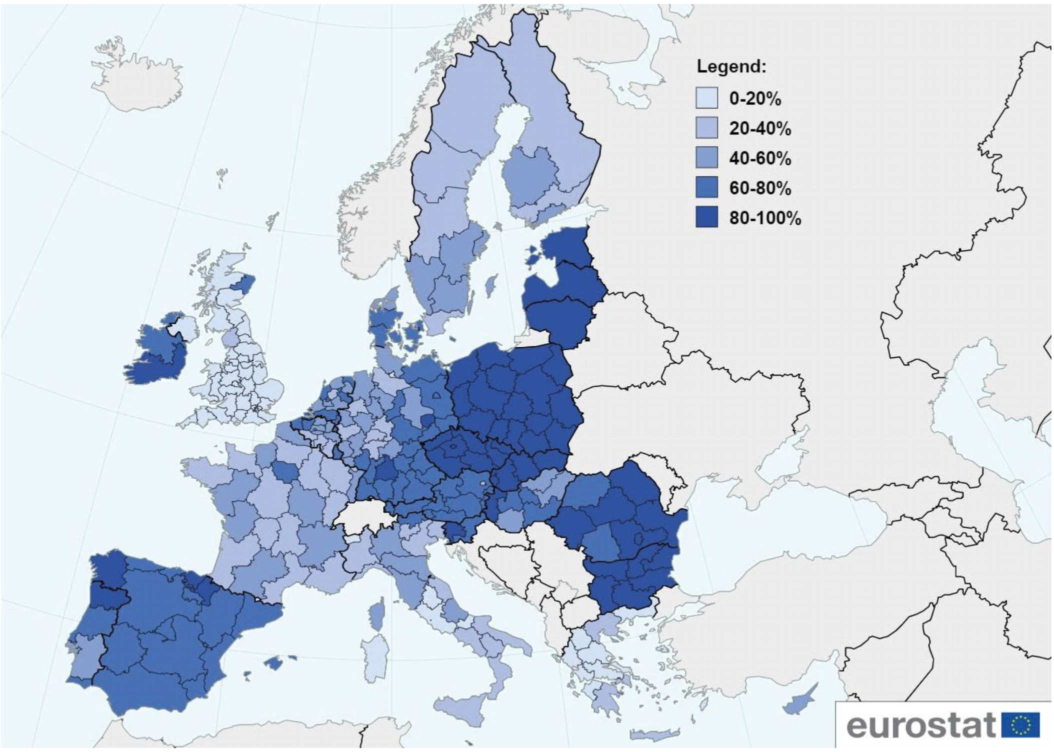
Lower labour productivity growth rates reflect the stagnation, or even the decline, in TFP growth over the last decade. Economic growth and social prosperity rely on the ability of an economy to mobilise all available resources while boosting productivity growth. TFP is arguably the best predictor for long-term economic growth and reflects an economy's overall efficiency and ability to work more smartly and produce higher value-added products and services. There is a clear divide in total factor productivity among regions in the eastern and southern part of the EU and the rest (Figure 4.2-19). Most of the regions in the eastern part of Europe have shown high growth rates during the last two decades. However, at the same time, many regions in the south of Europe, notably in southern Italy and Greece, have been falling behind in total factor productivity growth.

Figure 4.2-19 Total factor productivity in the EU28, 2015



Source: European Commission, DG Employment, Social Affairs and Inclusion
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter42/figure-42-19.xlsx

Figure 4.2-20 Total Factor productivity growth in the EU28 between 2005 and 2015



Science, research and innovation performance of the EU 2020

Source: European Commission, DG Employment, Social Affairs and Inclusion

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter42/figure-42-20.xlsx

For more developed economies, boosting TFP growth is closely associated with the ability to foster innovation creation and diffusion. Although there are many factors explaining TFP growth, ranging from how institutions function and the rule of law (see more on institutional quality in Chapter 8 - Framework Conditions) to better infrastructure or high levels of education, TFP growth in high-income countries and regions is typically supported by a high level of technological advancement and innovation. Business enterprise R&D (BERD), as a proxy for innovation capacity, is highly correlated with TFP for high-income regions, whose prosperity rely on the ability to innovate (Figure 4.2-21).

More focus on R&I-driven growth and innovation diffusion would support productivity growth. As many less-developed (located predominantly in central and eastern European countries)[13] and transition regions approach higher levels of prosperity, avoiding a 'middle-

13 According to Regulation 1303/2013, the classification of regions into three categories shall be determined on the basis of how the GDP per capita of each region, measured in purchasing power parities (PPS) and calculated on the basis of EU figures for the period 2007-2009, relates to the average GDP of the EU for the same reference period.

income trap' will require a new growth model based on innovation. This growth model will need to be based on new innovation activities that move beyond the traditional drivers of economic growth in the regions. The emigration of skilled labour and insufficient home-produced innovation create risks for the sustainability of the convergence process in less-developed regions, making the case for building up innovation capacity. Without counteraction, the underdeveloped regional innovation systems, skills gap and poor institutional quality will undermine the growth potential of these lagging regions (EC, 2017b).

The group of some less-developed and mainly transition regions is immediately associated with the risk of falling into a 'middle-income trap'. With higher productivity and wages, they become less attractive for labour-intensive or low-skilled activities. These regions show the lowest GDP growth, mainly because they are neither very low cost nor particularly innovative or productive. This implies that the transition regions[14] are not innovative enough to compete with the most-productive and developed regions of Europe and the world, while their cost levels are too high to compete with low-cost, less-developed regions (EC, 2017a).

Figure 4.2-21 **Total factor productivity - compound annual growth, 2004-2014 business R&D intensity, 2005**(1)(2)

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

Notes: (1)Based on data for 243 European NUTS2 regions. (2)Data for Croatia not available.

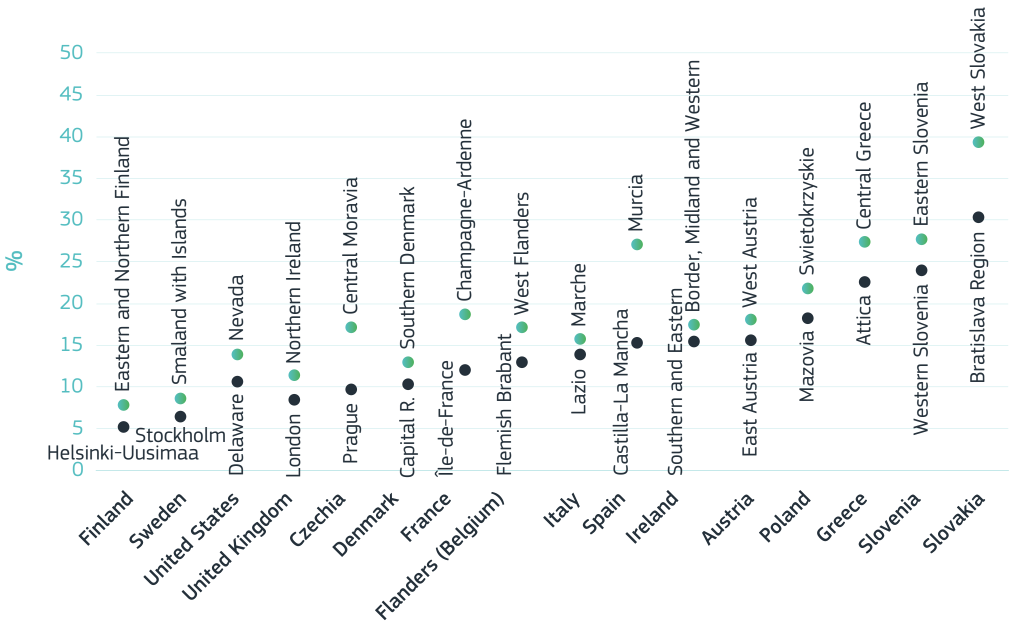
Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter42/figure-42-21.xlsx

14 As the classification of regional income groups differs, the 'Seventh report on economic, social and territorial cohesion' refers to the medium-income group of regions with a GDP per head of 75-120 % of the EU average.

Economic activity and innovation have become more concentrated in core cities and regions, which could potentially lead to a less economically and socially cohesive Europe. These internal divergences are most apparent in the growing gap between capitals and metropolitan areas where most economic and innovative activities are concentrated, on the one hand, and the declining industrial and peripheral areas, on the other hand, experiencing skilled emigration and less resilience to change. If left unmanaged, technological change is likely to widen these divergences, as shown by the most recent evidence (European Commission, 2017a; Iammarino et al., 2018).

As has been happening over the last decade, a 'geography of discontent' is emerging, with increasing distrust being shown towards political and democratic institutions. This is mainly driven by the dissatisfaction of those who are most affected by the negative impact of technological change, i.e. the older and less educated, living in industrial or decaying areas (Iammarino et al., 2018). The perceived risks are of concern as technological developments can contribute to the displacement of some current jobs, while many of the emerging and future jobs require a special set of conditions, as described above.

Figure 4.2-22 Share of jobs at high risk of automation across regions, 2016



Source: OECD - Job Creation and Local Economic Development 2018, based on Nedelkoska and Quintini (2018) and national Labour Force Surveys (2016)

Stat. link: https://ec.europa.eu/info/sites/info/files/srip/2020/parti/chapter42/figure-42-22.xlsx

Jobs are increasingly becoming concentrated in a smaller number of capital or metropolitan regions. The large regional differences and concentration of new jobs in capital regions favour imbalances in employment developments. In Finland, Denmark and Ireland, more than 80% of net job creation between 2006 and 2016 took place in the capital region (OECD, 2018). Many of the new jobs were created in new industries, e.g. the number of jobs in the ICT sector for the period 2010-2017 increased by 72% in Bucharest, 31% in Berlin and 27% in Stockholm[15]. Although the 6% share of ICT employment across EU capital regions remains small compared to approximately 25% in retail and services[16], there are structural changes that will require targeted efforts to create an attractive environment for highly skilled jobs and growing industries across the regions. The transfer of skills and knowledge from mature industries often enables the emergence of new industries, but in cases of more radical technological change, the new industries draw directly from R&D (Storper et al., 2015).

To find out more, see Chapter 12 - The research and innovation divide in the EU and its economic consequences.

Summary of Andrés Rodríguez-Pose's Chapter 12 - The research and innovation divide in the EU and its economic consequences

This contribution looks at **the economic consequences of the R&I divide across EU regions** and highlights the policy challenge they represent. It reviews the theoretical factors behind current levels of territorial polarisation, maps the current state of this divide and presents an econometric approach to identifying the effects.

The core of the argument is that **R&D investment alone does not trigger the same returns on investment everywhere because of several factors**. These are linked to the cost of technology accessibility in different places, the distance to the technological frontier, positive externalities from larger and denser regions, the quality of local institutions, and hampered knowledge sharing.

Many of these factors disadvantage the less-developed regions in their efforts to broaden their innovation capacities with the aim of unleashing greater economic activity and growth. Nevertheless, most of the R&D growth in less-developed regions has been in the higher education sector, which has led to a substantial improvement in scientific output. The chapter discusses how to improve the efficiency of investment in R&I systems and strengthen innovation-driven economic growth.

In its conclusions, the chapter not only diagnoses the situation but also suggests elements of innovation policy for less-developed regions. These aim at **closing the innovation divide between more- and less-developed areas in the EU and increasing the EU's competitiveness** through a stronger role for innovation as a trigger of economic dynamism.

15 Employment by economic activity in NUTS2 regions. Estonia and Malta show even higher increases in ICT jobs.

16 Wholesale and retail trade, transport, accommodation and food service activities.

4. Conclusions

Economic dynamism and productivity growth often depend on the implementation of structural policies, which do not take regional conditions into account. This implies an important role for further **place-based policies to boost underutilised regional potential and strengthen regional innovation systems**. To deliver on this ambitious innovation agenda, policymakers must align policies targeted at improving R&I capacities and territorial inequalities with **greater coordination at all levels**. These include R&I policies and Cohesion Policy, together with education and training implemented through a broad range of instruments.

European policies must put **greater emphasis on promoting innovation combined with more focus on the local context** to trigger economic dynamism in less-developed regions. An ambitious innovation agenda at the regional level should not focus solely on comparing performance with more-advanced regions but must embed local issues. Place-based approach in promoting innovation, especially the diffusion and commercialisation of existing innovation in lagging regions, is essential and should be supported in line with the specificities of each region and its current or possible comparative advantages as mapped in 'smart specialisation strategies'. Effective public support for innovation must understand the specificities of both the national and regional innovation systems and build on these. Furthermore, the substantial variation across EU regions in terms of institutional performance calls for **improvements in institutional quality**. The local authorities play a major role in well-tailored innovation strategies as well as in the efficiency of R&I programmes, combating corruption and tackling market failures such as the weak take-up of technology.

Policy in lagging regions can contribute to **improving economic competences**, especially managerial competences in firms, including internal processes and organisational structure, and **building technological capacities**, for example, by supporting technology transfer. The **reinforcement of local R&D capacities** and **pursuit of radical innovation** can be targeted by a mix of initiatives, such as **public procurement for innovation** on the demand side or dedicated supply-side measures.

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