5

REGIONAL INNOVATION AND THE DIGITAL TRANSITION

- Innovation shapes markets, transforms economies, stimulates changes in the quality of public services and is indispensable to achieving the overarching objectives of the twin green and digital transitions.
- Innovation is an important driver of long-run productivity growth and a key determinant of the competitiveness of firms, especially those in the EU competing in an increasingly competitive and fragmented geopolitical context.
- From a forward-looking perspective, the green and digital transitions have the potential to dramatically redefine production processes and value chains globally, with clear implications for economic geography and with more innovative firms finding it easier to adjust and take advantage of the opportunities that arise.
- There is potential for all EU regions to benefit from the digital transition, but the economic structure of more developed regions suggests that they are better equipped to do so.
- This is in line with the existing indicators of the geography of innovation – measured in terms of skills and education, R&D, patent activity, or composite indicators such as the Regional Innovation Scoreboard – which show a clustering around more developed, often metropolitan, areas and a persistent innovation divide.
- There is evidence pointing to substantial untapped potential for cross-border co-operation across all types of EU region in developing the value chains needed for the twin transitions.
- Place-based approaches can unlock the potential of all regions to innovate in line with their strengths and characteristics.
- Education – from early childhood to tertiary – plays a foundational role in fostering innovation. Investment in education is essential for creating the skilled, resilient and adaptable workforce required for sustained innovation and long-term economic development.
- Investment in R&D that fosters innovation in developed regions can have significant benefits for neighbouring ones, while for less developed regions, policies to improve the quality of institutions are equally important for stimulating innovation.
- The development of digital skills and access to a fast internet connection are key to ensuring that all regions can harness the potential of the digital transition. Over the past few years, there has been a significant improvement in broadband connectivity in many regions, but wide disparities across the EU remain as well as a persistent rural-urban gap in access to very-high-capacity networks.

Chapter 5

Regional innovation and the digital transition

1. Innovation and competitiveness of EU regions in a new complex global environment

Innovation plays a pivotal role in driving long-term productivity growth and competitiveness[1]. Innovation shapes markets, transforms economies, stimulates changes in the quality of public services and is essential for achieving the overarching objectives of the twin green and digital transitions. A substantial amount of the European Regional Development Fund (ERDF) (EUR 56 billion for the 2021–2027 period) goes to foster research and innovation (R&I) in the EU through place-based programmes co-managed at the local level ('smart specialisation' strategies, see Box 5.2). These programmes play a central role in strengthening regional innovation ecosystems so that they are better equipped to stimulate and sustain economic development[2].

More skilled and creative workers, increasingly efficient and powerful machines, new products and processes are key dimensions of innovation in an increasingly competitive global environment. Their importance has become evident over time, as EU firms have increasingly had to compete with those from emerging economies rapidly moving-up the value chain. These economies still have the advantage of cheaper labour, less stringent environmental regulations, and a rapid pace of technological advancement[3]. Moreover, in some areas, such as South-East Asia and China, they have reached the technological frontier in a number of sectors[4]. In advanced manufacturing and green technologies, the EU is a world leader in innovation. However, more effort is needed to maintain and further build a strong global position in digital technologies, an area where the US is a leader and emerging economies are becoming stronger[5].

Prospectively, the green and digital transitions have the potential to dramatically redefine production processes and value chains globally, with clear implications for economic geography. In this regard, the creation and diffusion of innovation – and its spatial dimension – are key not only to the competitiveness of the EU in the global economy, but also to its economic, social and territorial cohesion.

Empirical studies support the notion that innovation tends to concentrate in specific geographical areas, underlining the importance of understanding the spatial, social and economic dimensions of innovation. The link between innovation and spatial agglomeration effects has been extensively studied, and the close proximity of firms, suppliers, and related institutions in a cluster has been shown to foster innovation[6]. Agglomerations facilitate the sharing of tacit knowledge and collaboration,

1 European Commission (2022a).

2 In regions across the EU, the alignment of support from the ERDF with smart specialisation strategies is supporting place-based innovation and investment in line with regional business needs and opportunities. This has led to the creation of regional innovation hubs and industrial clusters based on the co-location of research infrastructures, universities, research and technology centres, and industry (e.g. Grenoble, Hamburg and Brno). Thematic smart specialisation platforms and partnerships have also become important means of connecting innovators with similar or complementary strengths in different parts of the EU, including in technology areas that are key to the twin green and digital transitions. Over the last six years, 37 inter-regional partnerships involving 180 regions in 33 EU and non-EU countries have provided such support in areas such as advanced battery materials, and hydrogen and fuel cell technology.

3 World Economic Forum (2019).

4 The EU has a strong overall innovation performance but lags behind China in investment in intangibles and patent activities relating to digitalisation (European Commission, 2022b). While the EU is strong in advanced manufacturing and advanced materials (in terms of both publications and patent applications), its production, design and capacity are less strong in other areas, including artificial intelligence (AI), big data, cloud computing, cybersecurity, robotics and micro-electronics (European Commission, 2021b, 2022b).

5 European Commission (2022b).

6 Porter (1998).

and attract a pool of skills that serve to increase innovation[7]. The formation of such a cluster is also influenced by the 'quality' of the location, by the amenities available and the business environment[8]. The positive externalities generated by innovation clusters tend to have multiplier effects on local employment and income, so reinforcing the benefits of attracting high-skilled jobs and the people to fill them[9]. In sum, the fact that innovation tends to agglomerate in specific areas highlights the importance of understanding its spatial, social and economic dimensions, with a view to developing a balanced policy mix that promotes economic cohesion as well as innovation.

Place-based approaches can tailor policies to foster the potential of regions to innovate in line with their strengths and characteristics. Investment in research and development (R&D) can stimulate innovation in more developed regions, with important benefits for neighbouring regions. On the other hand, for less developed regions, policies targeted at education, skills and training are needed to foster innovation[10]. The quality of institutions is also important for regions at all stages of development to successfully participate in competitive research programmes[11]. Creating collaborative networks between lagging regions and innovation hubs can facilitate knowledge transfer and provide opportunities for shared learning[12]. For regions struggling to keep pace with innovation hubs, it is important to identify economic sectors where they have a comparative advantage and introduce tailor-made policies that help to develop these[13]. Such an approach can involve support for the creation of clusters to unleash agglomeration forces and to focus on linked economic activities with appropriate degrees of complexity[14]. All this implies that a differentiated, place-based approach to fostering innovation is essential for promoting economic convergence across regions and reducing the innovation divide.

This chapter presents an overview of regional innovation and digital performance across Europe and the future potential. Section 2 sets out indicators of innovation, such as education, expenditure on R&D, patent applications and the Regional Innovation Scoreboard. Section 3 gives an overview of digital accessibility across regions. Section 4 indicates how cross-border co-patenting and specialisation in sectors where regions have potential strengths can help them to take advantage of the opportunities offered by the digital transition and reduce the risk of a digital and innovation divide. Section 5 assesses how foreign direct investment (FDI) and access to finance can foster innovation and integration into global value chains.

2. The geography of innovation in Europe: education, R&D, patent applications, and the Regional Innovation Scoreboard

Innovation can take many forms and assessing it requires a holistic approach that covers the main dimensions. Measuring innovation is a widely acknowledged challenge[15]. This is particularly true in respect of the regional context, which highlights the need for better territorial data on innovation. This section provides a snapshot of regional innovation in the EU by reviewing the main indicators: tertiary education, expenditure on R&D, patent applications, and the Regional Innovation Scoreboard, a composite indicator capturing several dimensions of innovation.

7 Rosenthal and Strange (2003).

8 Chatterjee and Sampson (2015).

9 Moretti (2010).

10 Rodríguez-Pose and Crescenzi (2008).

11 Peiffer-Smadja et al. (2023).

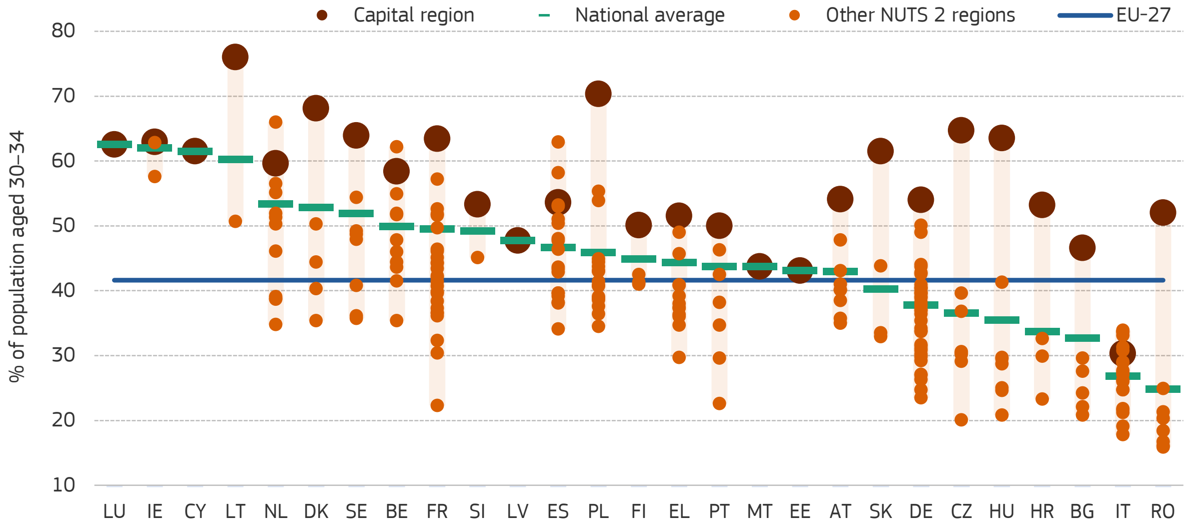
12 Foray (2009).

13 McCann and Ortega-Argilés (2015).

14 Delgado, Porter and Stern (2010); Boschma (2015).

15 OECD and Eurostat (2018).

Figure 5.1 Share of population aged 30–34 with tertiary education, in the EU-27 Member States, and NUTS 2 regions, 2021



Source: Eurostat.

2.1 Regional education systems and attainment

Education plays a pivotal role in fostering innovation. A well educated population is a prerequisite for sustained innovation and long-term economic development. Numerous studies underline the correlation between education, creativity, entrepreneurship and innovative capacity, emphasising the multi-faceted nature of the innovation process[16]. Investment in education is needed to ensure a skilled, resilient and adaptable workforce, and to nurture a culture of innovation conducive to economic development. Investment needs to cover all levels of education, starting from early childhood. The work of Nobel laureate James Heckman has highlighted the long-term impact of early education on cognitive abilities and has found that the economic and social returns of investing in early childhood and care vastly outweigh the cost[17]. A highly skilled and educated population, capable of critical thinking and problem-solving, creates an environment where creativity and innovation can thrive, so underpinning sustainable and inclusive long-term development[18].

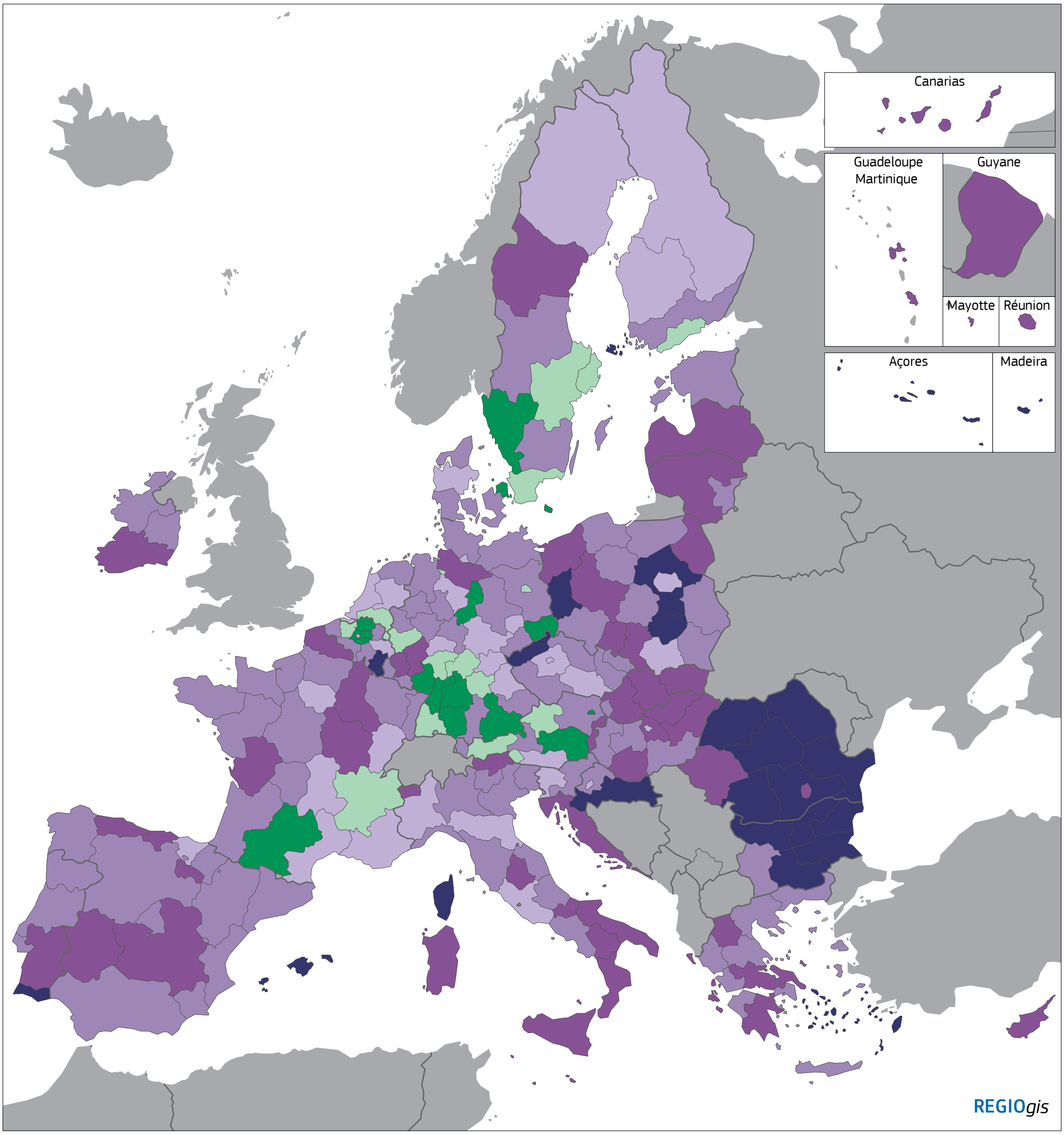
There are wide variations across EU regions in the share of people with tertiary education, reflecting a tendency for them to concentrate in more developed and metropolitan regions. Overall, around 37 % of the population aged 25–64 in more developed regions in the EU had tertiary education as against 25 % in less developed ones. The proportion increased in all regions over the 2011–2021 period, though regional differences have remained[19]. Taking those aged 30–34 only to reflect the most recent developments, in some regions around 70 % or more of people in this age group in 2021 had tertiary education (e.g. in the capital city regions of Denmark, Lithuania or Poland), whereas in other regions, the share was less than 20 % (e.g. Sud-Est in Romania or Sicilia in Italy; Figure 5.1).

16 See Biasi et al. (2021) and the discussion in Section 3 of Chapter 6 on education and the risk of falling into a talent development trap.

17 Garcia et al. (2020).

18 In a review of the literature, Biasi et al. (2021) find that improvements in the accessibility and quality of education have great potential to encourage entrepreneurship and innovation. This happens largely through two channels. First, education helps those who would have been innovators anyway (because of innate traits) to become more successful. Second, and more importantly, education enables individuals who would not have otherwise become innovators to fulfil their potential.

19 European Commission (2023a).



Map 5.1 Expenditure on R&D in NUTS 2 regions as a % of GDP, 2021

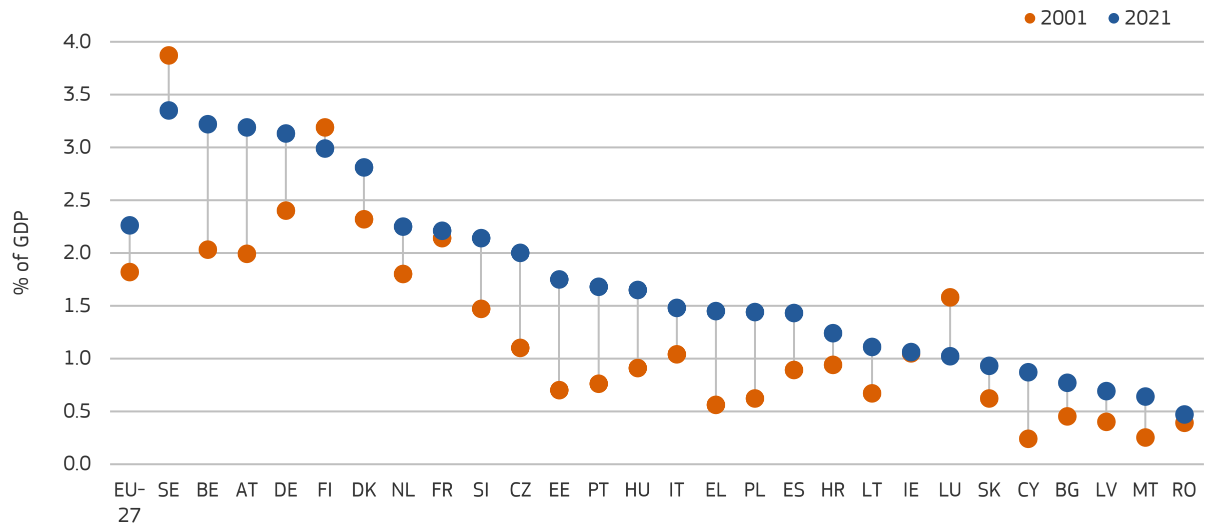
% of regional GDP

- < 0.5
- 0.5 – 1
- 1 – 2
- 2 – 3
- 3 – 4
- > = 4
- no data

EU-27 = 2.3
The EU-2020 target is 3 %.
DK: 2019.
Source: DG REGIO based on Eurostat data (rd_e_gerdreg).

0 500 km

Figure 5.2 Expenditure on R&D in EU Member States as a % of GDP, 2001 and 2021



Note: The 2001 figure for LU relates to 2000, for MT and HR to 2002.
Source: Eurostat [rd_e_gerdtot] and DG REGIO calculations.

2.2 Regional R&D expenditure

Spending on R&D in relation to GDP is also concentrated in more developed regions. Though this Is another widely used indicator of innovation capacity, it is really a measure of input into the innovation process, or the effort made, rather than of output. It is also likely to underestimate innovation activity, especially in sectors outside of manufacturing, where non-technological and non-research-based innovation is common and where expenditure on R&D is hard to define and identify (such as in respect of computer software programmes). In 2021, expenditure in the EU amounted to 2.3 % of GDP (Map 5.1) and increased by 0.5 pp over the preceding two decades (from 1.8 % of GDP in 2001). In most Member States, expenditure remained well below that in other developed economies, especially Japan or the US (where it was above 3 % of GDP, which has been set as a target for the EU).

There is also no evidence of convergence in spending within the EU over the past 20 years. Indeed, countries with the lowest R&D expenditure in 2001 recorded the smallest increase, resulting in a widening gap. Expenditure in the north-west of the EU (averaging 2.5 % of GDP in 2021) was almost twice as high as in the east (1.3 %), with the south having only a slightly higher level than the latter (1.5 %).

At the NUTS 2 level, spending was above 3 % of GDP only in more developed regions and above 4 % only in a handful of regions, many of them located in the south of Germany, a centre for advanced manufacturing (Figure 5.2). The highest level of R&D expenditure within countries is in many cases in capital city regions, Belgium, Germany and Italy being notable exceptions.

2.3 Regional patent applications

Patent applications are one of the few tangible means of comparing performance in innovation between regions, though they give only a very rough estimate of actual innovation activity. Innovations registered with the European Patent Office, the most common indicator, relate predominantly to those arising within manufacturing. However, many innovations arising in services, which account for around 75 % of EU gross value added, remain unpatented as they are intangible or non-codifiable (e.g. work organisation or computer programming).

Nevertheless, despite their limitations, as noted above, patents provide one of the only tangible means of comparing technological innovation across regions. Over the period 2018–2019, 124 patent applications per million inhabitants were registered at the European Patent Office (Map 5.2).

Box 5.1 Synergies between Horizon 2020 and Cohesion Policy

Synergies among different EU funds to support innovation are important to foster regional development. As indicated in Chapter 9, a substantial amount of EU Cohesion Policy funding goes to supporting R&I through place-based programmes co-managed at the regional level. A large part goes to less developed regions. By contrast, funding from Horizon 2020, the EU programme for supporting R&D, is highly concentrated in the more developed regions[1]. This reflects the nature of the selection process, which is highly competitive and is aimed at rewarding excellence[2].

Using econometric methods, Peiffer-Smadja et al. (2023) analyse the factors affecting success in respect of Horizon 2020. The results show that critical mass in terms of R&D expenditure, human resources, and research outputs is needed for a region to succeed in obtaining funding. The study finds that regions with low R&D spending could increase their success rate by improving institutional quality, though regions with higher levels could also benefit[3]. The findings highlight the importance of considering a holistic approach that takes account of several factors at the same time (especially, economic development, human capabilities and quality of institutions). In the light of the findings, the authors suggest that success rates of less developed regions could be improved by supporting and facilitating collaboration with more advanced regions, in line with their strengths and areas of specialisation, as reflected in their smart specialisation strategies (see Box 5.2).

Recently, significant efforts have been set in place to build stronger synergies between Horizon Europe and the ERDF. Acknowledging some of the legal and practical difficulties of building synergies between Horizon 2020 and the ERDF, the Commission services in the current multiannual financial framework have resolved some of the legal provisions that hindered the creation of synergies in practice and published practical guidance to implement synergies. In addition, an expert group has been set up that provides analysis and advice on how to overcome persistent difficulties in the implementation of these synergies.

1 Peiffer-Smadja et al. (2023); European Commission (2017); Balland et al. (2019); Protogerou et al. (2010); Enger (2018). Peiffer-Smadja et al. (2023) examined the success of regions in participating in Horizon 2020, measured as the number of successful proposals in relation to the total number submitted. The highest success rates (over 18 % of proposals submitted) are in western and northern regions in France, the Netherlands, Austria and Sweden. Interestingly, German regions, with high R&I performance in terms of R&D expenditure and patent applications, have lower (moderate to high) success rates. The lowest success rates (below 10 % of proposals submitted) are in regions in southern and eastern Member States, in Italy, Poland, Hungary, Slovakia and Bulgaria.

2 Horizon 2020 provided financing of EUR 80 billion for R&I in the EU over the 2014–2020 period, most being allocated following an open, competitive process. This resulted in funding being concentrated on a relatively small pool of beneficiaries: see European Commission (2017); Balland et al. (2019); Protogerou et al. (2010); Enger (2018).

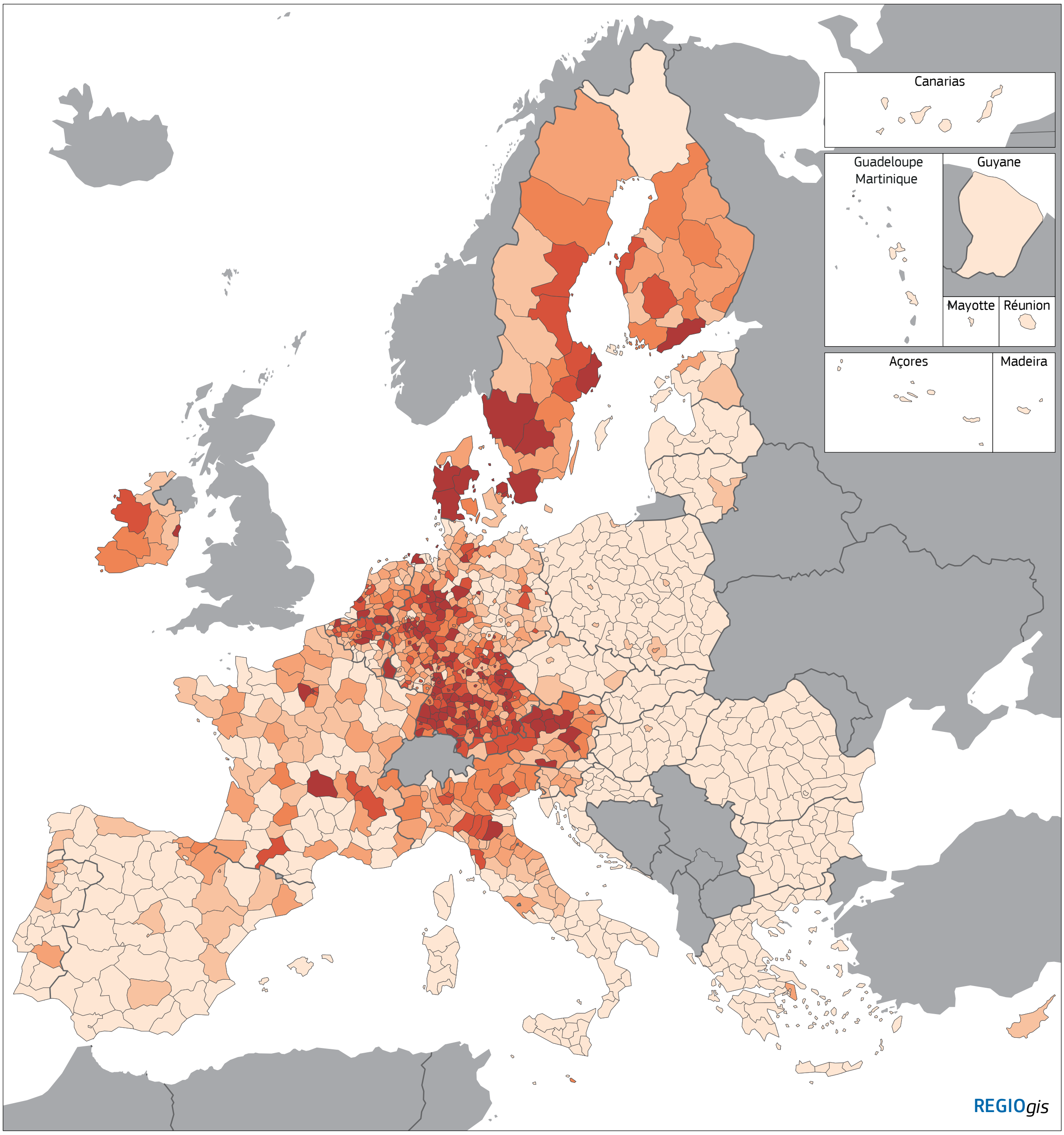
3 For all regions, a focus on the quality of research outputs, such as scientific publications and patents, rather than on the quantity, appears to be important to be recognised as a partner in international R&I projects, particularly those aimed at tackling societal challenges. For more advanced regions, investing in R&D and in science and technology specialists also seems to increase the chances of participating in Horizon projects.

Most applications came from regions in the north-western Member States and in northern Italy. At the NUTS 3 level, the top-performing regions are, in many cases, those hosting large corporations[20]. The spatial distribution suggests an innovation divide between regions in the most developed Member States and others.

Metropolitan areas tend to offer an environment that is particularly conducive to the development of new ideas, products and processes. Applications for patents are accordingly much higher there than elsewhere (Figure 5.3). A vast literature explains the reasons for this – the presence of a creative and skilled workforce and specialised clusters of economic activity, universities and research centres[21].

20 For instance, the three top-performing regions in the EU are Erlangen in Germany (1 209 patents per inhabitant), home to a major Siemens site, Zuidoost-Noord-Brabant in the Netherlands (973), home to Philips, and Ludwigshafen in Germany, home to BASF (961).

21 European Commission and UN-HABITAT (2016).



Map 5.2 Patent applications to the European Patent Office, average 2018–2019

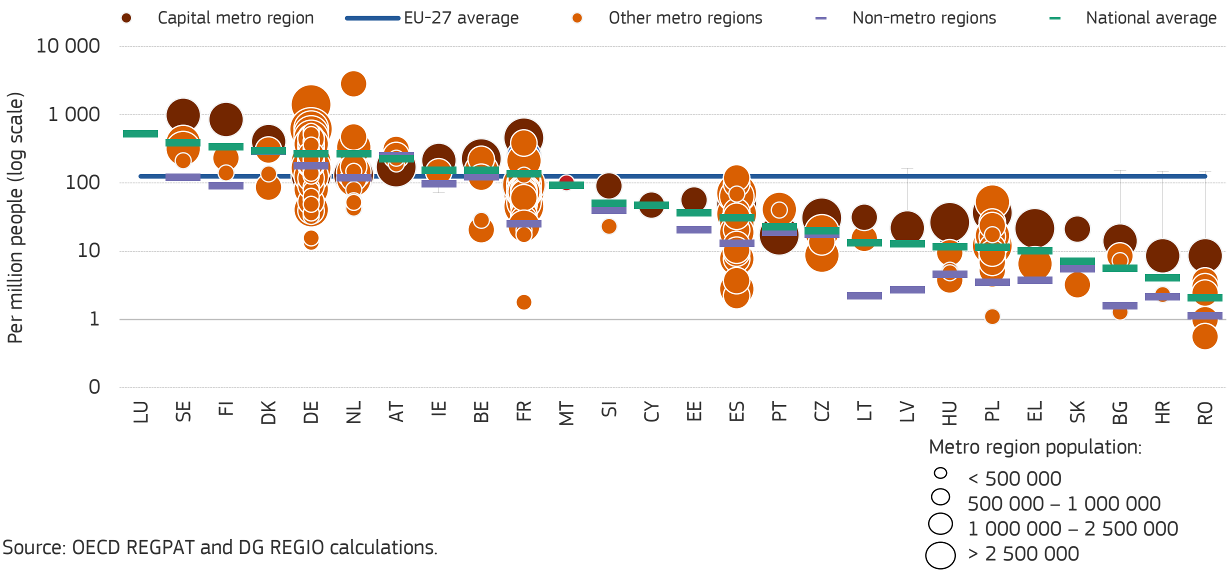
Applications per million inhabitants

- < 25
- 25 – 50
- 50 – 100
- 100 – 150
- 150 – 250
- >=250

EU-27 = 125.6
Sources: DG REGIO based on OECD REGPAT database August 2023 and Eurostat population data (nama_10r_3popgdp).

0 500 km

Figure 5.3 Patent applications to the European Patent Office by type of region, 2017–2018



Source: OECD REGPAT and DG REGIO calculations.

Capital metropolitan regions, in most cases, have the highest rates of applications in nearly all Member States. The only exceptions are Vienna and Lisbon. Only in a very few cases are applications in metropolitan regions below those in others in the same country. It should be noted as well that a larger number of skilled immigrants also tends to increase patents filed, and return migration of those concerned might boost patenting, and innovation, in the country of origin[22].

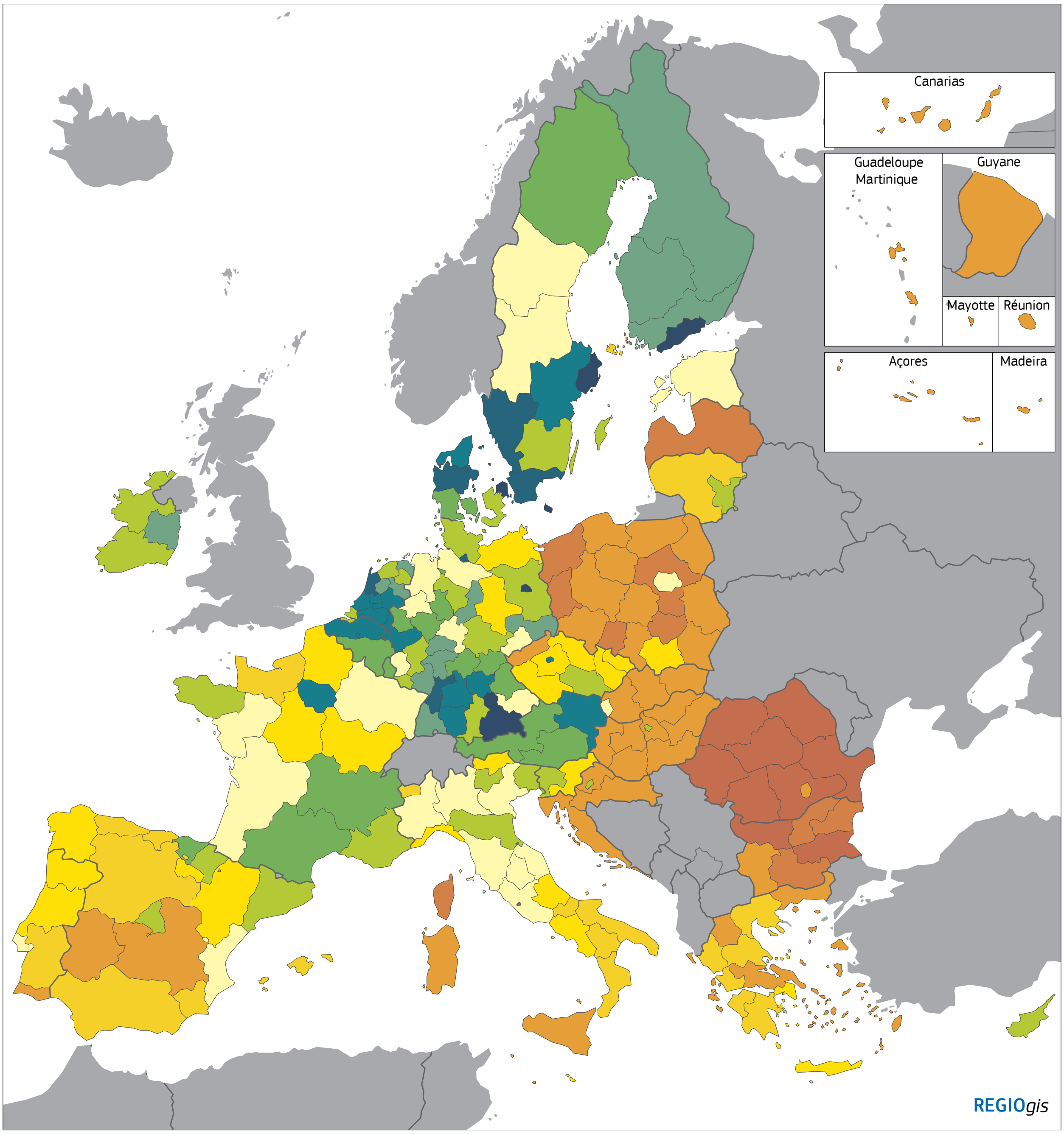
2.4 The Regional Innovation Scoreboard

The Regional Innovation Scoreboard (RIS) for 2023 highlights the key role played by innovation in regional development and a persistent divide in innovation performance[23]. The RIS, an extension of the European Innovation Scoreboard (EIS), measures the innovation performance of regions on the basis of a sub-set of indicators included in the EIS. Despite some regional variation within countries, the ranking of regions largely matches that of Member States (Map 5.3), suggesting that indicator values at the regional level are affected by national characteristics or policies (e.g. most R&D support schemes are national). Most regional 'innovation leaders' are in countries also identified as 'innovation leaders' or as 'strong innovators', and almost all the regional 'moderate' and 'modest' innovators are in countries classified in the same way. However, there are regional 'pockets of excellence' in some 'moderate innovator' countries, including capital city regions in Czechia, Lithuania and Spain, as well as País Vasco in the last. Conversely, there are many regions in 'strong innovation' countries that lag behind.

There is a close relationship between the level of development of regions and the innovation score (Figure 5.4). In less developed regions, an increasing proportion of the population live in 'emerging innovator' regions (i.e. the bottom category) rather than 'moderate innovating' ones – 60 % in 2021, twice as much as in 2016, indicating that the innovation performance of the regions concerned has worsened over time. At the same time, in both southern and eastern regions, there was an increase in the share of people

22 Kerr and Lincoln (2010); Fry (2023).

23 The RIS 2023 follows the same methodology as the EIS in the same year to develop a composite indicator of 21 different indicators of regional innovation. Regions are classified into four innovation performance groups according to this: innovation leaders (36 regions), strong innovators (70 regions), moderate innovators (69 regions), and emerging innovators (64 regions). For a list of the 21 indicators used, see Table 4 (page 17) of the RIS methodological report (https://research-and-innovation.ec.europa.eu/system/files/2023-07/ec_rtd_ris-2023-methodology-report.pdf).



Map 5.3 Regional Innovation Scoreboard, 2023

- Emerging innovator -
- Emerging innovator
- Emerging innovator +
- Moderate innovator -
- Moderate innovator
- Moderate innovator +
- Strong innovator -
- Strong innovator
- Strong innovator +
- Innovation leader -
- Innovation leader
- Innovation leader +

Source: European Commission – Regional Innovation Scoreboard 2023 and European Innovation Scoreboard 2023.

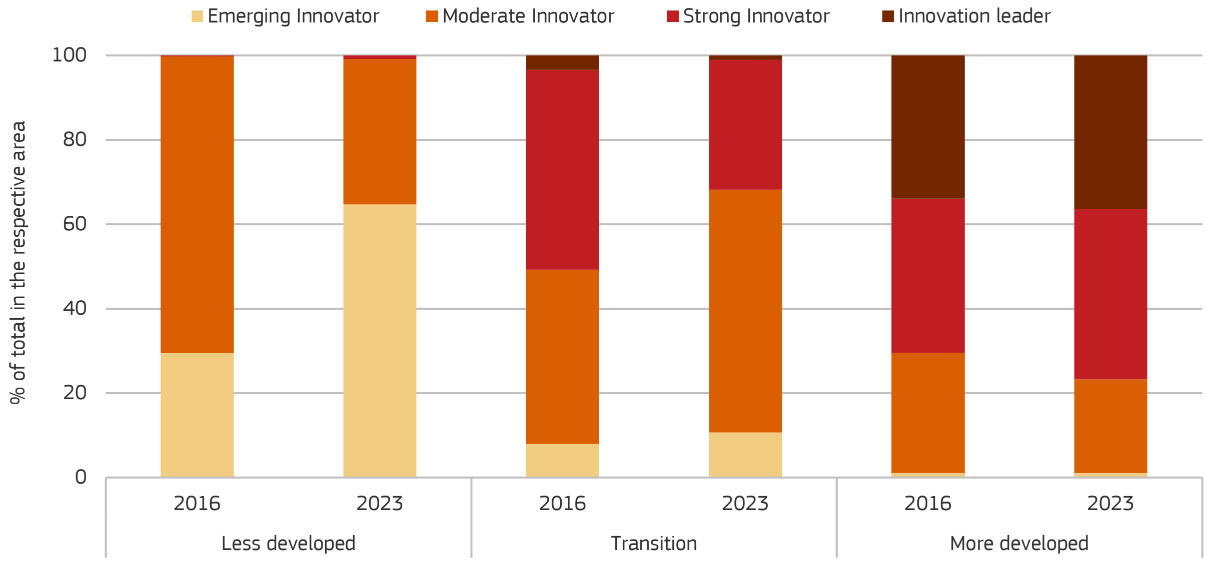
0 500 km

living in 'strong innovator' regions. Nevertheless, innovation leaders have remained largely clustered in the more developed, north-western regions.

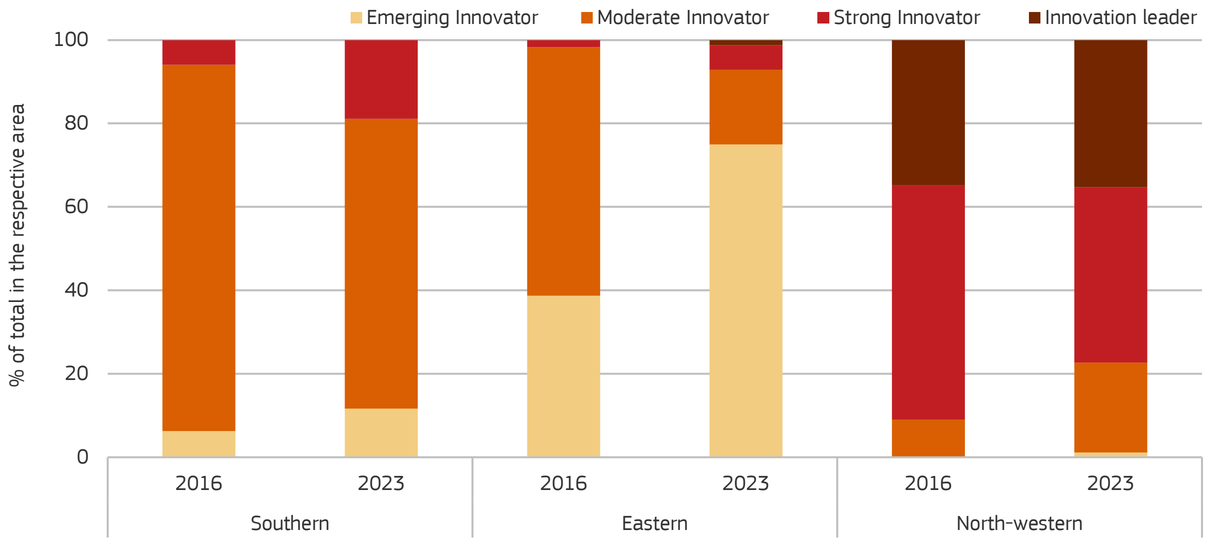
In general, the RIS confirms the wide diversity of EU regions in terms of innovation performance, so highlighting the strong regional dimension of innovation. Because of this, measures supporting innovation, including Cohesion Policy programmes, need to take explicit account of the regional context when considering the most useful kind of support to provide. As it is inherently place-based, the smart specialisation approach helps in this regard.

Figure 5.4 Share of EU population by RIS category, level of development and geographic group of Member States, 2016 and 2023

a) Share of EU population by RIS category and level of development, 2016 and 2023



b) Share of EU population by RIS category and geographic group of Member States, 2016 and 2023



Note: In cases where the RIS score is only available at NUTS1 level, it is assumed that the same score applies to the constituent NUTS2 regions. Calculations for both years are based on 2021 population data and level of development classification.
Source: Regional Innovation Scoreboard 2023 and DG REGIO calculations.

Box 5.2 Smart specialisation: strengthening industrial and innovation ecosystems

Smart specialisation strategies are part of Cohesion Policy intended to foster regional innovation ecosystems. They do so by building on the 'partnership approach' of Cohesion Policy and enabling regions to develop a regional innovation strategy that builds on their assets and strengths. Smart specialisation strategies are structured around three pillars: location (place-based approach), prioritisation (making strategic choices), and participation (stakeholders' involvement). Smart specialisation has a strong 'regional development' objective. Around 85 % of the overall financial allocation for 2014–2020 (about €40 billion) was concentrated in less developed and transition regions where it is often the main source of innovation support. Periañez-Forte et al. (2021) have carried out case studies to assess the lessons learned during the setting-up of governance structures and have underlined the importance of these for the success of the policy.

In the 2021–2027 programming period, smart specialisation strategies remain the key requirement for Cohesion Policy support for R&I. A total of EUR 34.5 billion is currently programmed for support of R&I investment, in line with 175 smart specialisation strategies in EU regions and Member States.

Thematic smart specialisation platforms and partnerships are key means of bringing together innovators with similar or complementary strengths and priorities in areas that are important for strengthening regional ecosystems while addressing EU priorities, notably in the context of the digital and green transitions. These include hydrogen, bioeconomy, healthcare and AI. At present, there are 38 partnerships covering 191 regions in all 27 Member States and nine non-EU countries.

The interregional innovation investment instrument ('I3') under Cohesion Policy helps to support existing efforts to strengthen value chains and to link regional industrial and innovation ecosystems in less developed regions with complementary ones in more developed regions.

3. Harnessing the potential of the digital transition: digital skills, accessibility, and firm take-up of digital technologies

The last decade has seen a rapid increase in the adoption of digital technologies by businesses, people, and governments alike. In the health sector, for instance, digitalisation became a crucial element in the reorganisation of service-provision in the wake of the pandemic, with regional and local health authorities at the forefront of this process in several countries across Europe. More broadly, companies have increased investment in ICT substantially in recent years and this digital transition has greatly accelerated with the COVID-19 pandemic[24], with significant national and EU investments put forward to also improve the digital skills of students and teachers. The evidence suggests that digitalisation has increased the productivity of businesses, improving their efficiency, and stimulating domestic sales and exports[25]. While the impact on businesses has been positive, the overall impact on local economies and people, both up to now and in the future, is more difficult to assess. Recent studies indicate that while it has been generally positive for the EU, the effect has varied across regions depending on the structure of their economies and skills of the workforce[26].

Access to a sufficiently fast internet connection is essential for ensuring that all regions can harness the potential of the digital transition[27]. The acceleration of digitalisation in both the private and public sectors across the EU, as a result of the

24 European Investment Bank (2021).

25 Rossato and Castellani (2020); Cincera et al. (2020); Eduardsen (2018).

26 Marques Santos et al. (2023); see Box 5.3.

27 Batista e Silva and Dijkstra (2024).

COVID-19 pandemic[28], is evident in the improvement in broadband connectivity in most regions. The performance of fixed networks has improved in all Member States over the past three years but remains highly variable within them, with Greece, Cyprus and Croatia having the lowest speeds (Figure 5.5 and Figure 5.6). Capital city regions generally have the highest speeds, but with exceptions (France, the Netherlands and Germany).

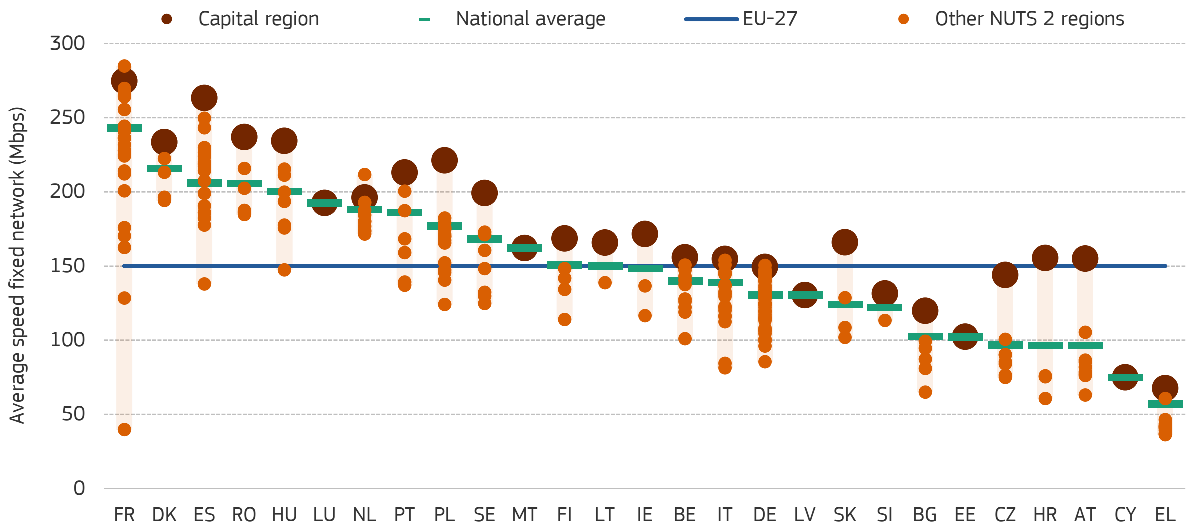
At the national level, France, Denmark, Spain and Romania have average speeds above 200 Mbps, although several regions in these countries have lower speeds, particularly in France). Over the three years 2020–2023, average speeds increased in all Member States. This is especially so in Cyprus and Greece, with over 70 % of the population being able to access good network speeds in 2023 as against zero in 2020. Speeds also increased significantly in Denmark, Spain and France, with around 80 % of the population being able to access network speeds of above 190 Mbps.

Significant differences exist between places within each country. While broadband speeds have generally increased, they have done so more in cities, but with marked differences between them, those in central and south-east Europe generally having much lower speeds (Map 5.4). In several countries, the biggest increase in speed has been in rural areas (in Estonia, France, Italy and Poland, especially), reflecting the effort made to bridge the digital gap between regions across the EU, though gaps still remain, especially in terms of access to very-high-capacity networks for rural areas[29].

At a more detailed level, large variations in network speed are evident between municipalities. (Map 5.5, which shows the average speed in local administrative units – LAUS)[30]. This is particularly so in Spain, France and Romania, where speeds are partly correlated with population density (see Chapter 3). On the other hand, speeds are more similar between municipalities in Greece, Bulgaria and Austria, with low average speeds, and in the Netherlands (with a speed of over 200 Mbps), while in Ireland, Poland and Italy, the variation in speeds across the country reflects the distribution of urban areas.

Besides access to high-speed broadband, the take-up of digital technologies by EU firms is a precondition for taking advantage of the potential

Figure 5.5 Average download speed per Member State and NUTS 2 region calculated for the fixed network, Q1.2023



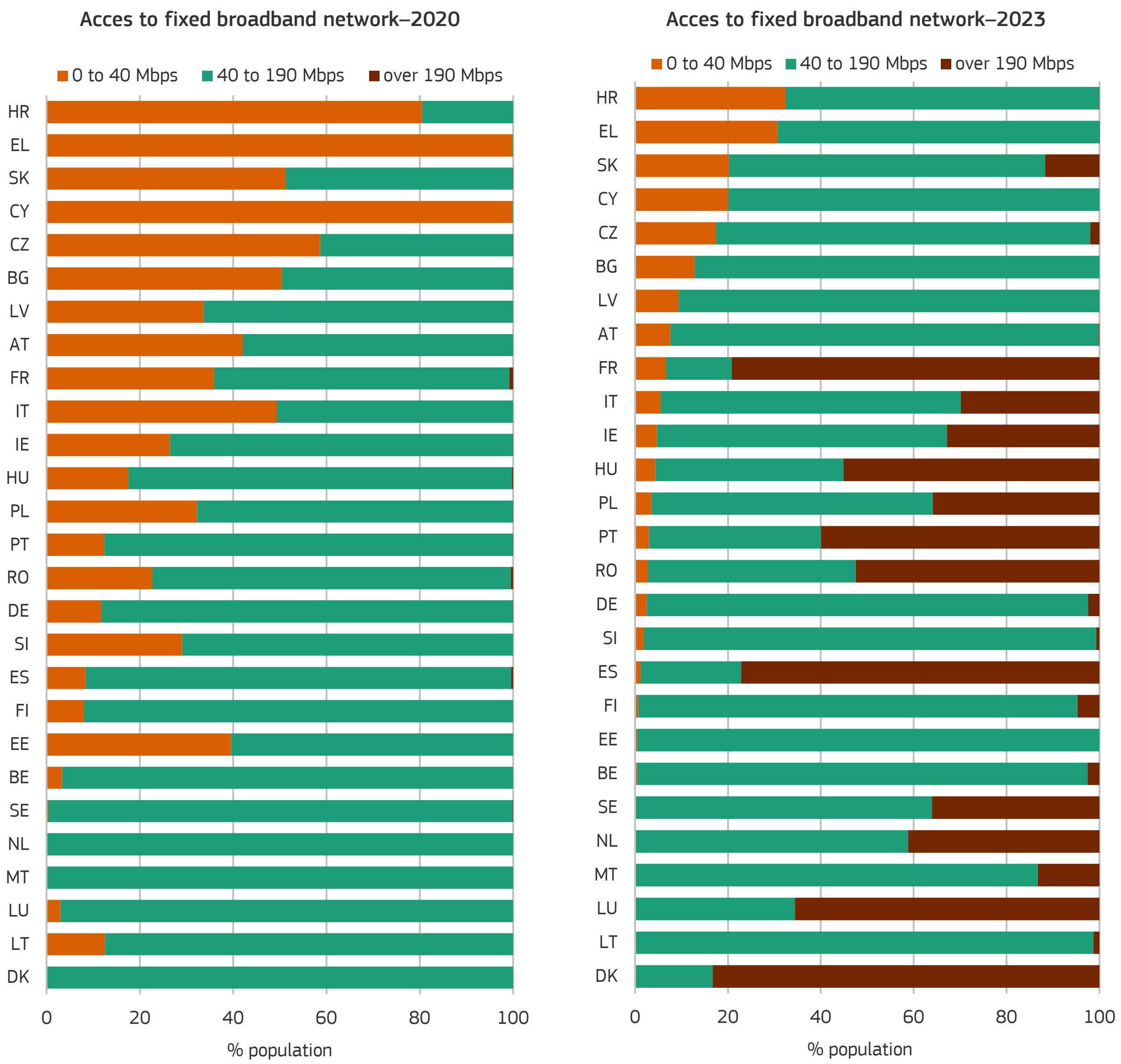
Source: DG REGIO calculations on Batista e Silva, Dijkstra and Sulis, 2024.

28 OECD (2020).

29 The data on broadband fixed network speed is available at the EU rural observatory.

30 Sulis and Perpina (2022); Melchiorri et al. (forthcoming).

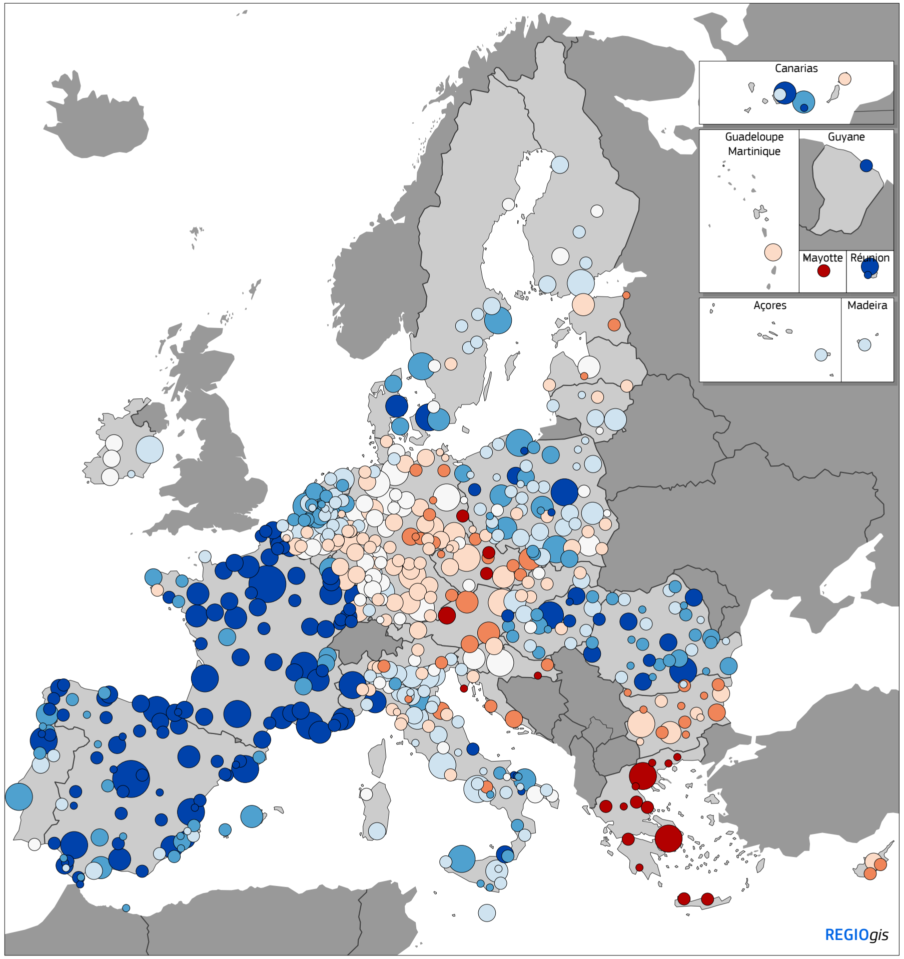
Figure 5.6 Share of population with access to fixed broadband network at different speeds (Mbps) in Member State, 2020 (left panel) and 2023 (right panel)



Source: DG REGIO calculations on Batista e Silva, Dijkstra and Sulis, 2024.

of the digital transition, which can increase efficiency, improve the accessibility of services and help to maintain competitiveness. As part of the digital transition, a goal of the EU is that by 2030, 75 % of businesses in the EU will have taken up three digital technologies, cloud computing, use of big data and AI. In 2021, over 40 % of businesses had adopted cloud computing, while only 15 % were using big data and under 10 % AI (Figure 5.7). The difference may be because of the newness of the latter two and their possibly less general applicability at the time. For all three technologies, however, the take-up was much greater, on average, in north-western Member States than in other parts of the EU, especially in the eastern countries.

As the digital transition in the EU takes place, digital skills will become increasingly important for labour market participation and inclusion. In 2021, over 60 % of EU enterprises that tried to fill vacancies for ICT specialists had difficulties. The EU has set the target that, by 2030, at least 80 % of the



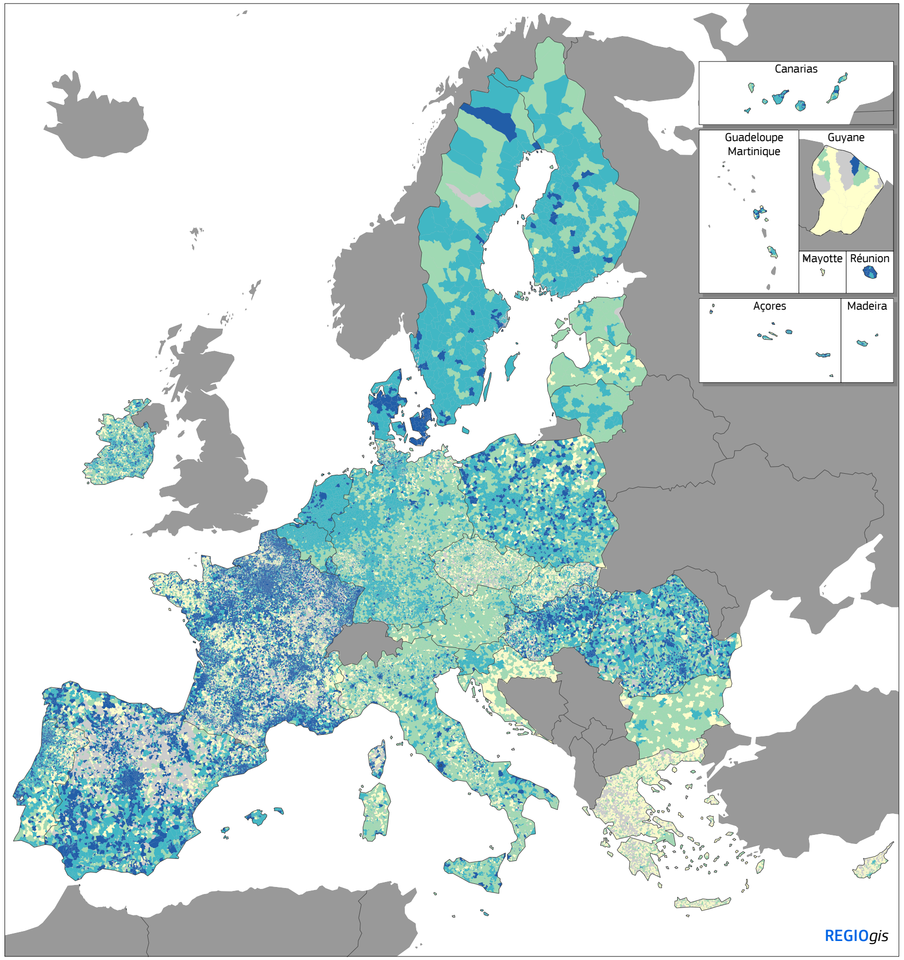
Map 5.4 Internet fixed network speed in Functional Urban Areas, Q1 2023

Percentage deviation from EU median
- < -50
- -30- – 50
- -5- – 30
- -5 – 5
- 30 – 5
- 50 – 30
- > 50
- no data

Population size
- < 000 100
- 000 250 – 000 100
- 000 500 – 000 250
- 000 000 1 – 000 500
- 000 000 5 – 000 000 1
- >= 000 000 5

Deviation relative to EU median (weighted).
Source: JRC.

0 500 km



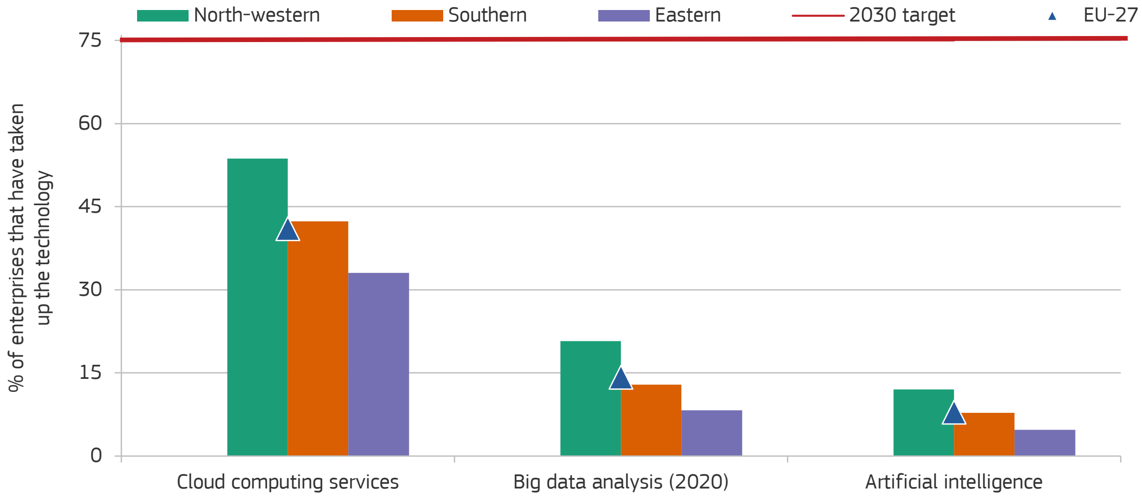
Map 5.5 Average speed for fixed network at municipality level (LAU), 2023

Average speed (Mbps) fixed network
- <= 30
- 30 – 100
- 100 – 200
- > 200
- no data

Source: JRC.

0 500 km

Figure 5.7 EU enterprise take-up of digital technologies, 2021



Note: All EU enterprises outside the financial sector with 10 or more persons employed are covered (Eurostat code 10_C10_S951_XK).
Source: Eurostat [isoc_eb] and DG REGIO calculations.

adult population should have basic digital skills[31]. In 2021, this was the case for only 54 % of people aged 16 to 74, well below the target, with major differences between countries, rates ranging from 79 % in Finland and the Netherlands to only 28 % in Romania. Throughout the EU, people living in cities (61 %) are more likely to have at least basic digital skills than those in towns and suburbs (52 %) and rural areas (46 %). While no data on basic digital skills are available at regional level, there are major differences between regions in the extent to which people use the internet on a daily basis, participate in online social networks, use internet banking and take part in e-commerce[32]. The number of ICT specialists in the EU is estimated to be around 12 million, well below the target of 20 million for 2030 set in the EU's '2030 digital decade'[33]. Here as well, there are major differences across countries, with Greece and Romania among the countries with the lowest percentage of ICT specialists (respectively 2.5 % and 2.8 % of total employment). Meanwhile, Sweden, Luxembourg and Finland are the countries with the biggest share of ICT specialists (respectively 8.6 %, 7.7 % and 7.6 % of total employment).

4. Synergies to harness the potential of the digital transition across regions: the role of cross-border co-operation

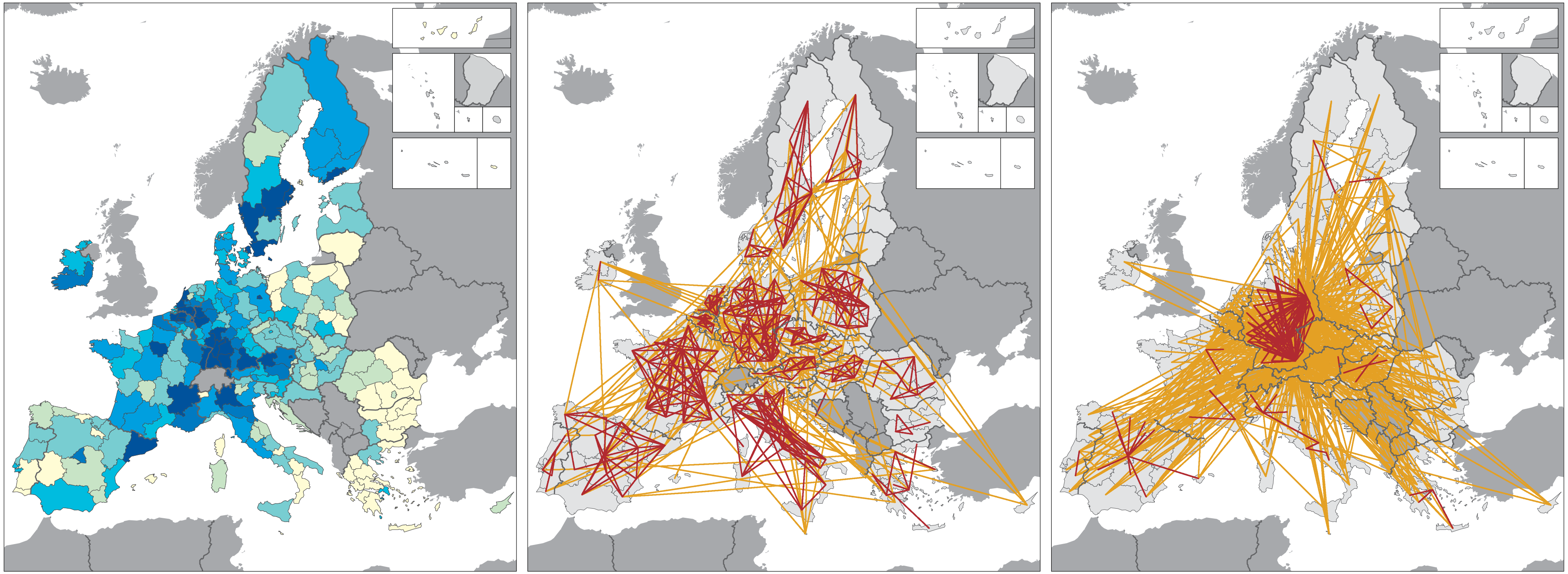
Cross-border innovation activity has increased in the EU over time but there is much room for further growth. A useful indicator of regional synergies in R&I is co-patenting. This has increased dramatically in Europe over the past four decades, rising from 1 000 co-patents in 1980 to over 100 000 in 2020. However, most co-patents are filed between firms or organisations located in the same region – around 75 % over the period 1980–2020. Almost 20 % were between organisations in different regions but in the same country and 7 % involved organisations in different European countries (Map 5.6).

31 See 'digital compass' of the '2030 digital decade' and European Pillar of Social Rights action plan. Overall digital skills refer to five aspects: information and data literacy skills, communication and collaboration skills, digital content creation skills, safety skills and problem-solving skills, which are covered by the revised digital competence framework (DIGCOMP 2.0). To have at least basic overall digital skills, people need to know how to do at least one activity in each area. See Eurostat: https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20220330-1.

32 In 2022, only 7 % of people aged 16–74 in the EU never used the internet, though with major regional differences. In three regions in Sweden (Sydsverige, Stockholm and Småland med öarna.) only 1 % never use the internet., while in Norte (Portugal), the figure was 18 %, in Calabria (Italy), 19 % and in Kentriki Elláda (Greece), 20 %.

33 European Commission (2023b).

Map 5.6 Inter-regional cooperation in innovation and digital technologies



Inter-countries co-patents, 1979–2020

Actual inter-regional collaborations in digital technologies

Potential inter-regional collaborations in digital technologies

Number of patents

- <= 80
- 80 – 200
- 200 – 450
- 450 – 800
- 800 – 1 200
- 1 200 – 2 000
- > 2 000
- no data

Source: DG Research and Innovation - Common R&I Stratey and Foresight Service Chief Economist Unit based on OECD-REGPAT data.

- cross-border
- within country
- NUTS 2 regions

Source: Bachtrögler-Unger et al. (2023)

- cross-border
- within country
- NUTS 2 regions

Source: Bachtrögler-Unger et al. (2023).

0 1 000 km

Box 5.3 Job creation and destruction in the digital age: assessing heterogeneous effects across Member States

In contrast to the potentially positive effects on the competitiveness of firms, many authors have argued that technological change can be detrimental to labour market conditions. According to Ford (2015) and Acemoglu and Restrepo (2020), for instance, automation and robots may replace workers and lead to job destruction. On the other hand, according to others, digitalisation may create new job opportunities as new technologies are adopted[1].

Changes in the structure of the labour market induced by digital technologies have been studied empirically using both micro-economic and macro-economic data[2]. Findings on the net effect of digitalisation on employment are mixed. A majority of studies suggest it may increase high-skilled employment (complementarity effect) and reduce low-skilled employment (substitution effect). The net effect Is likely to depend on the economic characteristics of each country, on its knowledge capacity, sectoral composition, and capacity to upskill or reskill the workforce as the structure of activity changes. As a corollary, regions and countries will tend to be affected differentially by the digital transition.

Marques Santos et al. (2023) have examined whether ICT investment was associated with an increase or decrease in labour demand in Member States between 1995 and 2019. They find an overall positive effect on total employment over the period, but not in all Member States. This suggests that studies of different countries may yield different results because of the structural characteristics of economies and that conclusions based on case studies may not hold generally. At the same time, the findings underline the importance of investigating further the spatial and sectoral impact of digitisation and taking account of the specific economic and employment features of places when formulating policy recommendations.

1 Degryse (2016).

2 For a review, see Marques Santos et al. (2023).

Of the latter, the vast majority involved organisations in cross-border regions, notably along the Rhein valley connecting German, Belgian, French and Swiss regions, though also in capital city regions with a track record of patenting activity. The importance of physical proximity for co-innovation is well established, but the strong national bias in inter-regional collaboration in co-patenting limits the potential to co-operate in the EU Single Market. One way of overcoming this bias is to strengthen inter-regional knowledge flows and to promote co-operation in innovation between leading and lagging regions, such as through the implementation of smart specialisation strategies[34] (Section 3). In this way, the untapped potential for cross-border co-operation could be realised (see Box 5.4).

5. Foreign direct investment (FDI) and access to finance as key drivers of innovation at regional level

FDI is an important means of fostering innovation both directly and indirectly. Direct means are when foreign firms bring new products, technologies or processes into the host economy. In these cases, foreign firms often pay higher wages, have higher levels of productivity and innovate more than domestic firms[35], as well as opening new direct links to global value chains[36]. Indirect means are when there are knowledge and technology spill-overs to local firms, or workers move from foreign-owned firms to domestic ones, bringing know-how and new ideas with them.

34 Balland and Boschma (2021).

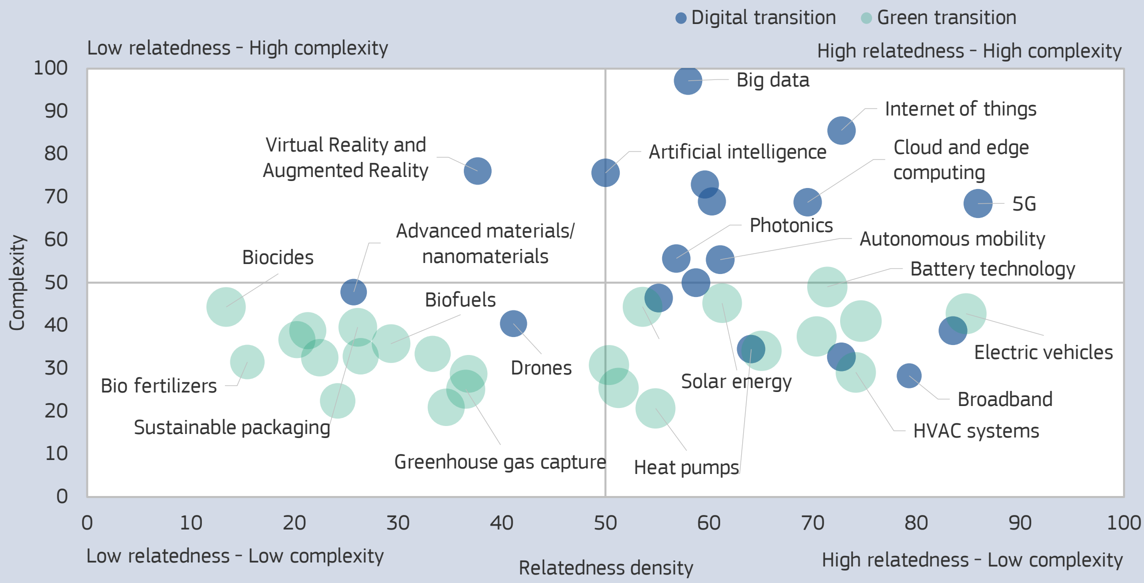
35 OECD (forthcoming).

36 Comotti, Crescenzi and Iammarino (2020).

Box 5.4 Related variety, complexity and the regional potential for the digital transition and cross-border co-operation

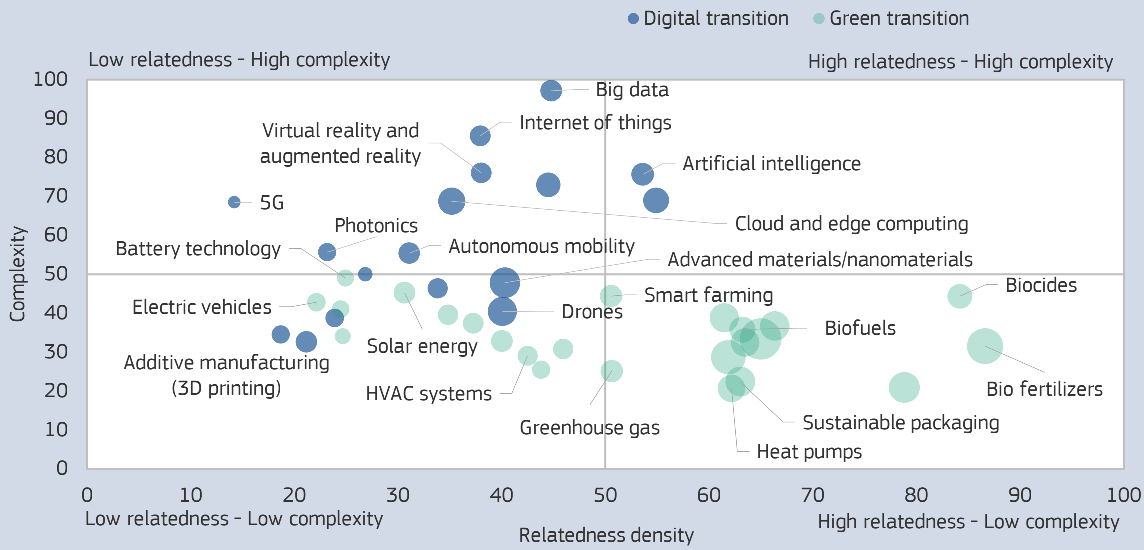
There is significant untapped potential in green and digital technologies. A number of studies have developed a method of identifying the opportunities for regions to diversify, given the capabilities they have accumulated in the past: Balland et al. (2019); Hartmann et al. (2021). They condition which development paths a region is most likely to follow. Using a framework based on the notions of 'relatedness' and 'complexity', Bachtrögler-Unger et al. (2023) determine whether regions have opportunities to diversify into more complex activities linked to the digital transition as well as the technologies needed for the green transition. The results show that more developed regions are more likely to

Figure 5.8 Potential of more developed EU regions to develop twin transition technologies



Source: Bachtrögler-Unger et al. (2023).

Figure 5.9 Potential of less developed EU regions to develop twin transition technologies



Source: Bachtrögler-Unger et al. (2023).

specialise in digital technologies and benefit from the digital transition, but less developed regions are well placed to develop the technologies and activities relating to the green transition.

For both types of region, there appears to be large untapped potential for cross-border co-operation. Figures 5.8 and 5.9 show the technology opportunities from the twin transition for more and less developed regions, with the relatedness of patents to existing technologies on the horizontal axis and the level of complexity on the vertical axis[1]. The blue dots represent digital technologies, the green ones green technologies, their size indicating regional comparative advantage in the technology relative to other regions. On average, more developed regions have high potential in the different technologies. Their highest digital potential is in complex technologies (such as 5G), the lowest in low-complex ones. The picture is similar for green technologies, with strong capability in electric vehicles, battery technology and solar energy. Less developed regions have low patent activity in both areas. While, however, their potential for complex digital technologies is limited, they appear to have high potential in a wide range of green technologies, such as biocides, biofertilisers, geothermal energy, biofuels, waste management and recycling.

There is substantial untapped potential for cross-border co-operation across EU regions in developing the value chains needed for the green and digital transitions. Bachtrögler-Unger et al. (2023) examined whether regions are connected to the right set of other regions to develop the next generation technologies, in the sense of the regions that can give them access to the complementary capabilities needed to develop them. The study compared the ideal collaboration network in which complementarities across regions are fully exploited with the current state of collaboration (as indicated by co-inventor linkages) in the technological areas concerned. shows the three strongest actual collaborations in digital technologies of each region with others and the three inter-regional linkages that represent the largest untapped potential (based on complementarities). Intra-country linkages are coloured in red, cross-border ones in yellow. The actual inter-regional collaborations show a clear national bias, while the largest untapped potential is for cross-border collaborations. This applies for both more developed and less developed regions.

1 Bachtrögler-Unger et al. (2023).

An appropriate place-sensitive approach is important for FDI to have positive spill-over effects. According to a study of manufacturing firms in six Member States, productivity spill-overs can be positive, non-existent, or even negative, depending on how close the firms in a given sector are in technology terms[37]. Embedding FDI can benefit local communities but requires additional elements to ensure firms ‘stick’ to places[38]. The public sector and the third sector can play an important role in this by setting the right framework conditions and generating incentives to co-create value-added with local firms[39].

Co-ordination across places is needed to foster the positive enablers of FDI in terms of efficient institutions, a skilled workforce, an effective research environment and good connectivity. These factors play a key role in shaping regional attractiveness for foreign investors[40]. However, the choice of FDI location can also be motivated by less desirable institutional settings, such as lower labour

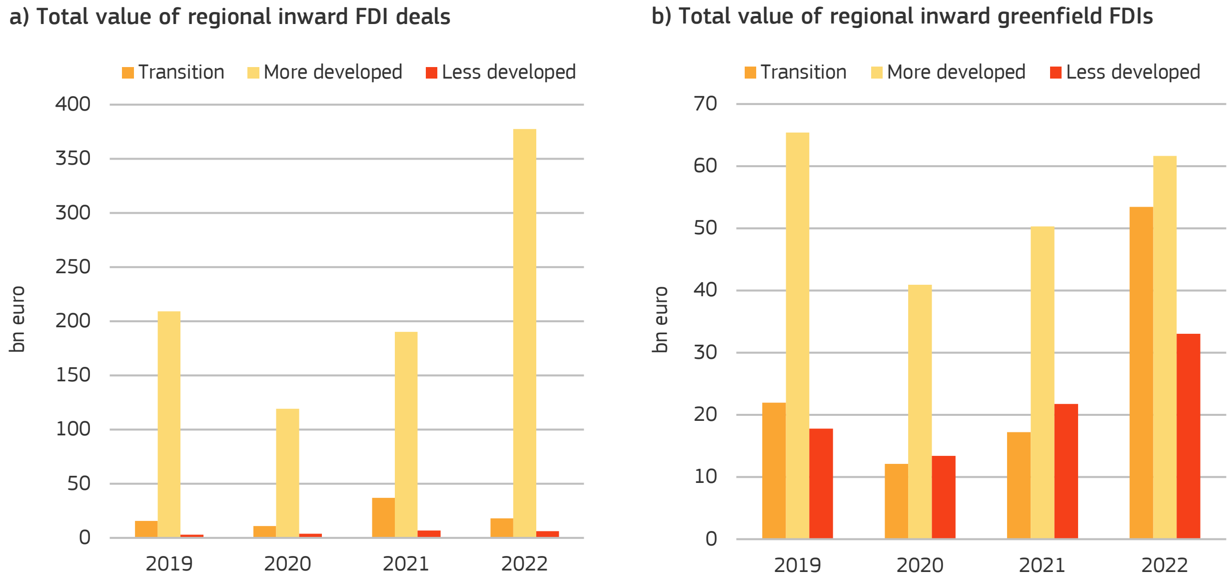
37 Positive spill-overs dominate if domestic firms are using similarly advanced technologies to the foreign firm and operate in the same sector (Fons-Rosen et al., 2018[9]) or in other sectors (Lembcke and Wildnerova, 2020[8]). Negative effects from increased competition dominate if the products of the foreign-owned company are similar to those of domestic ones (Lembcke and Wildnerova, 2020[8]).

38 These elements are broadly related to the ecosystem of the firm, including links with other firms and clusters with both suppliers and customers, complementary firms and even competitors that can attract workers with the right skill set to a region.

39 Bailey and Tomlinson (2018).

40 OECD (2023).

Figure 5.10 Value of regional inward FDI by degree of regional development, NUTS 2, 2019–2022



Note: The left panel includes all forms of FDI, mergers and acquisitions as well as greenfield FDI. The right panel features only greenfield FDI.
Source: Martinez Cillero et al. (2024) based on Orbis M&A BvD and Orbis Crossborder BvD data.

standards[41], lower tax rates or higher tax credits or subsidies[42], or laxer environmental standards, especially for highly polluting industries[43]. This points to the importance of cross-border co-ordination to ensure a level playing field for investment that minimises the risk of beggar-thy-neighbour competition (both domestic and foreign), while at the same time strengthening the positive enablers of investment.

Less developed and transition regions have increasingly attracted greenfield investment over the past few years[44]. Regional data on FDI enable two types to be distinguished M&A and greenfield investment[45]. On average, 53 % of greenfield FDI in the EU over the period 2019–2022 (with an equivalent value of EUR 218 billion) went to less developed and transition regions, increasing from 38 % in 2019 to 58 % in 2022, when transition regions alone accounted for 36 % (Figure 5.10, right panel). Accordingly, greenfield FDI is relatively high in the eastern EU Member States and in almost all regions of Spain and Portugal, but also in Sweden, Finland, Ireland and the Benelux countries[46].

By contrast, FDI in the form of M&A goes mainly to more developed regions (Figure 5.10, left panel). Capital city regions are major destinations, as in France, Austria, Finland, Spain, Portugal, Poland and Greece, but also regions in northern Italy, north-eastern Spain, southern France, southern and eastern Germany, the North-Rhine-Benelux area, and both sides of the Gulf of Finland. The regions with the highest level of M&A over the period are Wien (Austria), Eastern and Midland (Ireland), Limburg and Noord-Holland (Netherlands), Madrid (Spain), Helsinki-Uusimaa (Finland), and Luxembourg.

41 Davies and Vadlamannati (2013); Olney (2013).

42 Desai et al. (2005); de Mooij et al. (2003).

43 List and Co (2000).

44 Gianelle et al. (forthcoming).

45 Mergers and acquisitions (M&A) involve the acquisition of at least 10 % of the equity of a company resident in an NUTS 2 region in the EU by a company resident in another country, which may be outside the EU (portfolio investments are excluded). Greenfield investment consists of the construction by a company in another country of new facilities (sales office, manufacturing plants, etc.) or the relocation or extension of existing facilities.

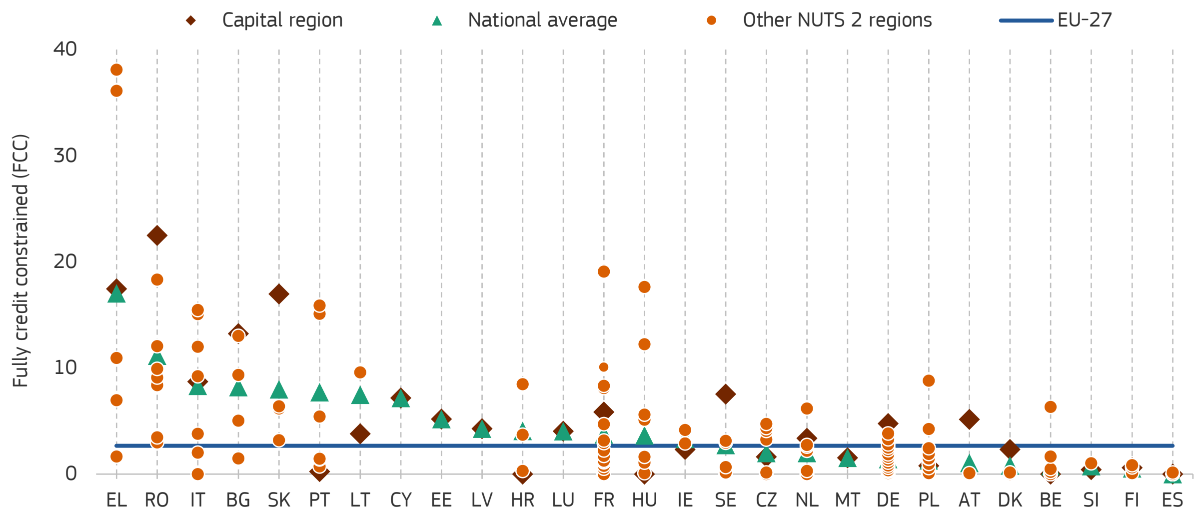
46 The regions with the highest levels of greenfield FDI over the period are Észak-Alföld, Közép-Dunántúl, Dél-Alföld and Pest (all in Hungary), Sachsen-Anhalt (Germany), Alentejo (Portugal), Eastern and Midland (Ireland), and Východné Slovenskom (Slovakia).

5.1 Access to finance and innovation

Access to finance is essential for fostering innovation, but firms in a number of regions find it difficult to obtain bank financing. In comparison with the US, where financial markets are more developed and the risk capital market stronger, the fragmented nature of financial markets in the EU poses challenges. This is especially so for less developed regions, which in many cases may lack liquid capital markets and robust financial infrastructure and accordingly have many firms that are credit constrained[47]. In these cases, targeted support to facilitate access to finance for innovation-related investment can take the form of grants, low-interest loans, guarantees, or equity.

The World Bank Enterprise Survey, conducted in 2019, shows large variations between regions in access to finance. In the survey, a firm is considered to be constrained in accessing external finance if either one of two conditions hold: (1) the firm did not apply for a loan for any reason other than they did not need it; or (2) the firm applied for a loan but was rejected. Firms in many regions in eastern and southern Member States are shown to be constrained in this way (Figure 5.11). The survey also reveals that firms are more constrained in investing in innovation if it is financed through bank loans than if it is financed through equity. The result is in line with equity financing being generally more suitable the higher the risk associated with the investment, encouraging a collaborative approach to risk-taking. Loans and guarantees, on the other hand, tend to be more suitable when the innovation is less risky, giving firms the financial support needed while offering a structured means for repayment.

Figure 5.11 Share of fully credit constrained firms at EU, national and NUTS 2 level, 2019 (%)



Note: the highest point in EL is 72.8 %.
Source: World Bank Enterprise Survey.

47 Financial infrastructure in this context refers to the availability and efficiency of financial services, institutions, and the market generally.

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