Digital Economy and Society Index (DESI) 2022

Thematic chapters

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1 Introduction

The European Commission has monitored Member States' progress on digital and published annual Digital Economy and Society Index (DESI) reports since 2014.

Each year, the reports include country profiles helping Member States identify areas for priority action and thematic chapters providing an EU-level analysis in the key digital policy areas.

The DESI 2020 discussed the increased use of digital solutions during the COVID-19 pandemic. This trend towards more digitalisation is confirmed by the slightly higher growth rate in the adoption of digital technologies by both citizens and businesses at EU level[1].

Overall, the pandemic is estimated to have accelerated existing trends in remote work worldwide, e-commerce and automation as well as exacerbated labour mobility[2]. These trends, however, have not affected citizens and enterprises in the same manner. Results suggest that the large expansion of telework since the COVID-19 outbreak has been strongly skewed towards high-paid white-collar employment. This reflects the differences in the employment structure where only 33 to 44% of jobs structurally permit teleworking.[3] Individuals for their part, increased online customer interactions during the pandemic from 32% in December 2019 to 55% in July 2020[4], and more than 1 million ICT specialists entered the market in Europe[5]. Businesses provided more fully digitised products and services: 34% before the Covid-19 crisis and 50% during the pandemic[6]; and bought more cloud computing services: 24% before the pandemic in 2019 and 41% in 2021.[7] Significant differences continue to persist between large enterprises and SMEs[8], given that 72% of large enterprises subscribed to cloud computing services compared to 40% of SMEs.

The DESI 2022 results show that while most of the Member States are making progress in their digital transformation, the adoption of key digital technologies by businesses, such as artificial intelligence and big data remains low, also among the EU frontrunners. Insufficient levels of digital skills hamper the prospects of future growth, deepen the digital divide and increase risks of digital exclusion as

[1] Based on the results of the Eurostat surveys: European Union survey on ICT usage and e-commerce in enterprises and European Union survey on ICT usage in households and by individuals.

[2] McKinsey special report: The future of work after Covid-19 report assesses the lasting impact of the pandemic on labour demand, the mix of occupations, and the workforce skills required in eight countries with diverse economic and labour market models: China, France, Germany, India, Japan, Spain, the United Kingdom, and the United States. Together, these eight countries account for almost half the global population and 62 percent of GDP. https://www.mckinsey.com/featured-insights/future-of-work/the-future-of-work-after-covid-19

[3] JRC paper: Teleworkability and the COVID-19 crisis- a new digital divide? JRC Working Papers Series on Labour, Education and Technology No. 2020/05 http://hdl.handle.net/10419/231337

[4] According to an online survey by Mc Kinsey with 899 respondents of C-level executives and senior managers representing the full range of regions, industries, company sizes, and functional specialities; https://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/how-covid-19-has-pushed-companies-over-the-technology-tipping-point-and-transformed-business-forever

[5] https://ec.europa.eu/eurostat/databrowser/view/isoc_sks_itspt/default/table?lang=en

[5] According to Eurostat data on total employed ICT specialists in 2019 7, 857 million persons were IT specialists in EU 27 compared to 8,940 million persons in 2021. https://ec.europa.eu/eurostat/databrowser/view/isoc_sks_itspt/default/table?lang=en

[6] According to an online survey by Mc Kinsey with 899 respondents of C-level executives and senior managers representing the full range of regions, industries, company sizes, and functional specialities; https://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/how-covid-19-has-pushed-companies-over-the-technology-tipping-point-and-transformed-business-forever

[7] According to Eurostat data on cloud computing services https://ec.europa.eu/eurostat/databrowser/view/ISOC_CICCE_USE/default/table?lang=en&category=isoc.isoc_e.isoc_eb

[8] see Figure 46.

more and more services, including essential ones, are shifted online. Efforts need to be stepped up to ensure the full deployment of ubiquitous connectivity infrastructure (notably 5G) that is required for highly innovative services and applications.

Finland, Denmark, the Netherlands and Sweden continue to be the EU frontrunners. However, the European Semester 2022 cycle identified that digital challenges remain also for most of the frontrunners.[9]

The other Member States are advancing and there is an overall upward convergence trend in the EU. This means that the EU as a whole continues to improve its level of digitalisation, and in particular those Member States that started from lower levels are gradually catching up, by growing at a faster rate. For example, amongst the Member States that lagged behind, Italy, Poland and Greece improved their DESI scores substantially over the past five years and implemented sustained investments with a reinforced political focus on digital, supported by European funding.

In all Member States future policy developments will be largely facilitated by the EUR 127 billion[10] dedicated to digital reforms and investments in the 25 national Recovery and Resilience Plans adopted by the Council at the time of writing, investments under Cohesion Policy as well as the joint effort to reach the EU level targets set out in the Digital Decade.

The proposed 'Path to the Digital Decade' introduces a structured cooperation process between the Commission and Member States, involving the European Parliament, to work collectively towards EU-level targets as well as towards common broader objectives and progress in the putting into practice of the proposed Declaration on Digital Rights and Principles. The proposed targets are organised under four cardinal points: a digitally skilled population and highly skilled digital professionals, secure and sustainable digital infrastructures, the digital transformation of businesses, and the digitalisation of public services. Once implemented, this process will contribute to greater convergence between Member States and reinforce their collective competitiveness and resilience in the global context.

The current geopolitical context with Russia's invasion in Ukraine renders the implementation of innovative digital solutions, technologies and infrastructures based on EU's values and principles, as well as strengthening cybersecurity, even more relevant. For example, it demonstrated the substantial dangers and risks online disinformation presents to security, and to the functioning of our democracies, societies and economies. As a result, the EU institutions and national authorities have intensified cooperation and information sharing in relation to cybersecurity. Moreover, the revision of the EU Code of Practice on Disinformation and the Digital Services Act will provide efficient means to ensure that online platforms take decisive measures to counter disinformation online.

Some of the targeted sanctions introduced in view of the situation in Ukraine and in response to Belarus's involvement in the aggression[11] relate to halting disinformation, by banning operators in the EU from broadcasting any content by Russian media outlets, including Russia Today (RT) and Sputnik.

Moreover, on 8 April 2022, 24 telecom operators based in the EU together with those 3 operators based in Ukraine, have signed a joint statement on their coordinated efforts to secure and stabilise affordable or free roaming and international calls between the EU and Ukraine, providing affordable connectivity to refugees from Ukraine.

[9] More precisely, addressing the labour shortages in digital jobs are part of a country-specific recommendation for the Netherlands. In the European Semester Country Reports for Denmark and Finland, supporting the digital transformation is highlighted as a key factor to improve productivity.

[10] Calculations related to the Recovery and Resilience Facility in this and subsequent sections are based on the methodology set out in Annex VII of the RRF Regulation (Regulation (EU) 2021/241).

[11] amending Regulation (EC) 765/2006 concerning restrictive measures in view of the situation in Belarus and Regulation (EU) 833/2014 concerning Russia's actions destabilising the situation in Ukraine

The initiatives taken at national level to counter the effects of the Russian invasion of Ukraine are outlined in the DESI country reports.

The 'Path to the Digital Decade' supports this renewed emphasis on EU values, resilience and security by linking specific digital targets to values-based objectives and digital principles. Only a digitally sovereign EU can shape its digital transformation in line with European values.

Each Member State will contribute to this ambitious goal from a different starting point, based on available resources, comparative economic advantages, and societal needs. Once the Programme enters into force, the performance of each Member State in DESI will be considered in the perspective of their future contribution to Europe's Digital Decade.

1.1 The digital measures in the Recovery and Resilience Facility (RRF)

The Recovery and Resilience Facility represents an unprecedented opportunity for Member States to invest in their own digital transformation and to collectively contribute to increasing the Union's resilience and innovative potential, as well as to reducing the EU's external dependencies.

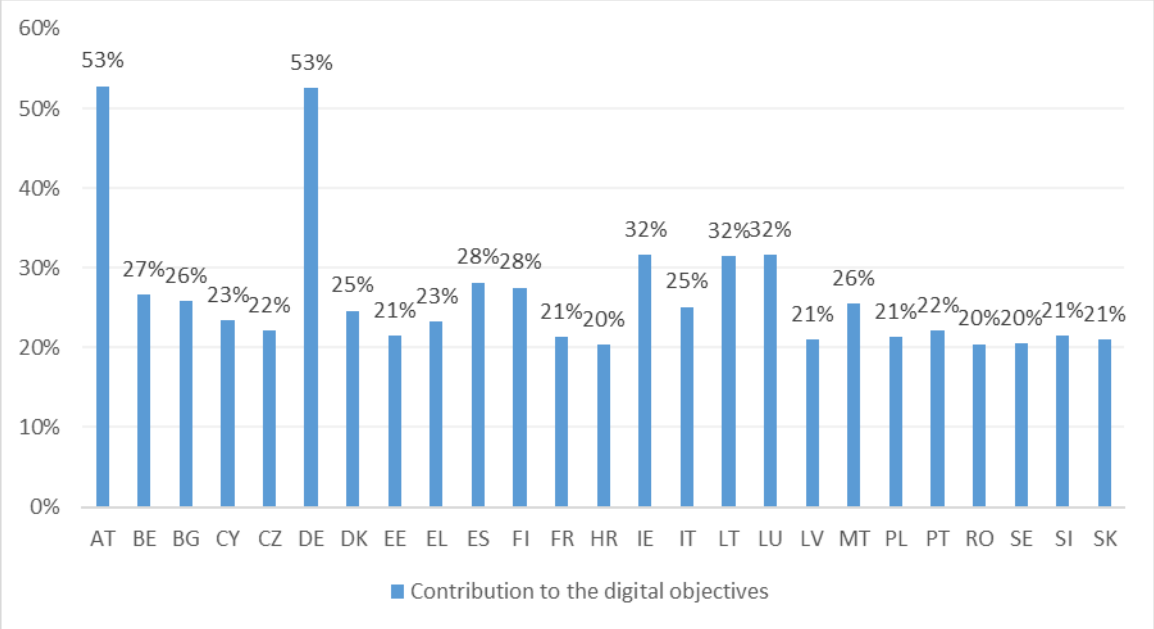
To date, 25 plans have been approved by the Council of the European Union.[12] So far, the amount allocated in these plans totals EUR 490 billion (EUR 325 billion in grants and EUR 165 billion in loans). The approvals of the Hungarian and Dutch plans are still pending.

The implementation of the approved plans is well underway. 21 Member States have received pre-financing disbursements and five of those Member States (Spain, France, Greece, Italy and Portugal) have received subsequent payments, following the submissions of their first payment requests and the subsequent positive assessments of these requests. In total, EUR 67.02 billion in grants and EUR 33.37 billion in loans have already been disbursed.

Under the RRF Regulation, each Member State must dedicate at least 20% of its Recovery and Resilience Plan's (RRP) total allocation to measures contributing to the digital transition or to addressing the challenges resulting from it. To date, an amount of EUR 127 billion, representing 26% of the total allocation of the approved plans, supports the digital transformation. The estimated expenditure towards digital transformation per Member State is illustrated below.

[12] Entire analysis is limited to plans approved by the Council as of 22.06.2022.

Figure 1 Share of RRPs estimated expenditure towards digital objectives in the 25 Recovery and Resilience Plans approved by the Council



Source: European Commission

Of those EUR 127 billion, about 13% aim to promote the roll-out of very high capacity networks (VHCN), 37% the digitalisation of public services and government processes, 19% the digitalisation of businesses, in particular SMEs, 17% the development of basic and advanced digital skills, and 14% digital-related R&D and the deployment of advanced technologies[13]. RRF investments and reforms are expected to make an important contribution to the Digital Decade targets and objectives.

In addition, the Technical Support Instrument[14] supports Member States in designing, developing and implementing reforms. The support is provided upon request and covers a wide range of areas, including the reforms and investments linked to the digital transformation within the Recovery and Resilience Plans.

21 out of the 25 plans approved, with the exception of Bulgaria, Denmark, Malta and Sweden make commitments towards key digital multi-country projects, presented in the Digital Compass Communication and in the Path to the Digital Decade Policy Programme. In total, more than 60 measures (or sub-measures) are relevant to digital multi-country projects, for a total of about EUR 5 billion. The two potential IPCEIs on microelectronics (12 plans) and cloud technologies (7 plans) are amongst the multi-country projects with the highest take-up. Several RRPs also include investments in multi-country projects related to the European Digital Innovation Hubs, 5G corridors and quantum communication. The table below summarises the uptake of digital multi-country projects in the adopted RRPs.

[13] Calculation based on the digital tagging methodology of Annex VII of the RRF regulation (Regulation (EU) 2021/241).

[14] Regulation (EU) 2021/240 of the European Parliament and of the Council of 10 February 2021 establishing a Technical Support Instrument OJ L 57, 18.2.2021, pp. 1–16.

Table 1 Multi-country projects in the RRPs

	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	*Total*
Micro-electronics	•	•			•	•				•	•	•				•			•					•		•	•	12
European Digital Innovation Hubs					•					•			•		•	•			•				•				•	8
5G corridors					•				•	•						•	•		•									6
Cloud						•				•		•				•			•			•				•		7
Euro Quantum Communi-cation Infra-structures					•				•									•								•		4
Euro High Perf. Computing									•							•											•	3
Connected public administration									•				•										•					3
Genome of Europe										•							•		•									3
Submarine cables				•					•																			2
Blockchain (EBSI)					•																					•		2
Security Operation Centers									•							•												2
Skills + education																												0
Other					•			•	•	•	•					•			•					•			•	9

Source: European Commission

The impact of the RRF investments on the ground will be monitored, among others, via the Recovery and Resilience Scoreboard. The Scoreboard will publish the progress of the RRF measures along a set of common indicators related to the objectives of the RRF.

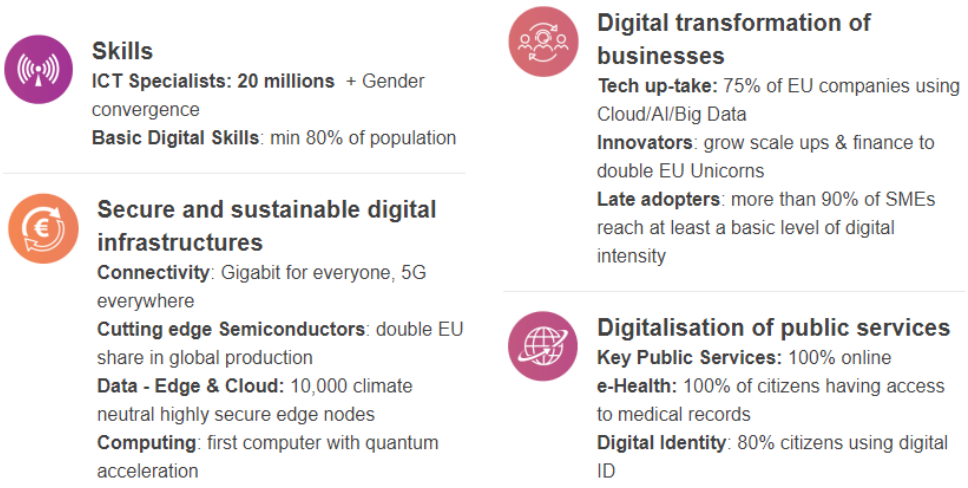
The European Semester and the RRF are fully integrated. The European Semester and its country-specific recommendations continue to be closely interlinked with the Recovery and Resilience Plans. The plans contribute to address all or a significant subset of challenges identified in the country-specific recommendations. The result of this analysis is an integral part of the key findings in the European Semester Country reports and the analytical underpinning for the challenges ahead set out in the Country Reports. Moreover, the state of play of the RRP implementation is annexed to the European Semester Country Reports.

Importantly, Member States' DESI performance feeds into the European Semester Country Reports as well as the analysis of country-specific recommendations in a systematic way via a dedicated annex.

1.2 The Digital Compass and the Path to the Digital Decade

The Commission proposed a Decision establishing the 2030 Policy Programme 'Path to the Digital Decade' to empower Member States to make collective progress in the shaping of their digital transformation. The proposal was adopted on 15 September 2021 in response to a call from the Council of the European Union[15], following the Communication '2030 Digital Compass: the European Way for the Digital Decade'. In particular, it sets out common digital targets the EU as a whole is expected to reach by 2030, as detailed in Figure 2. A Declaration on Digital Rights and Principles, proposed by the Commission on 26 January 2022, complements the targets ("what") with a shared reference framework ("why and how") that aims to guide policy makers and private actors in shaping the Digital Decade according to European values, and the rights and freedoms enshrined in the EU's legal framework.

Figure 2 The targets of the proposed Path to the Digital Decade



Source: European Commission

To achieve the broad policy objectives (e.g. human centred, resilient, sustainable, sovereign information space) and targets and promote the principles, the proposed Decision will establish a cycle of cooperation during which Member States and EU institutions regularly assess progress and coordinate actions, for example through multi-country projects (MCPs). A new mechanism included in the proposal will enable Member States to set up and implement such projects faster and more efficiently, and thereby contribute to strengthening Europe's digital capacities and competitiveness in critical areas.

The monitoring of progress towards objectives, targets and MCPs at EU level, as well as of the underlying national digitalisation trends, will be part of an enhanced DESI. For each digital target, the Commission proposed key performance indicators (KPIs) to be set out in secondary legislation to be adopted by the Commission after the Decision enters into force. The KPIs would be updated as necessary to ensure effective monitoring and to take account of technological developments. Member States' data collection mechanisms would be adjusted to measure progress towards the Digital Decade targets, as well as to provide information on relevant national policies, programmes and initiatives that are important to contribute to the overall achievement of the Digital Decade proposal. To this end, the Commission would prepare, based on current work and in consultation with the Member States, a roadmap to set out future data collection needs.

[15] European Council Conclusions 25 March 2021.

In 2021, DESI was aligned with the cardinal points and partly also with the corresponding targets of the proposed Path to the Digital Decade and this is reflected in this year's structure, too.

Table 2 Structure of DESI 2022

DESI Dimension	DESI sub-dimension
1 Human capital[16]	Internet user skills and advanced digital skills
2 Connectivity[17]	Fixed broadband take-up, fixed broadband coverage, mobile broadband and broadband prices
3 Integration of digital technology[18]	Business digitalisation and e-commerce
4 Digital public services[19]	e-Government

Source: European Commission

The 2022 DESI already includes eleven indicators to assess progress towards a large part of the Digital Decade targets at Member State level. Going forward, DESI will be further aligned with the proposed Path to the Digital Decade to ensure that all targets are measured and discussed in the reports.

Table 3 DESI 2022 dimensions and indicators related to the targets of the Path to the Digital proposal

DESI Dimension	Indicators related to the Path to the Digital Decade proposal
1 Human capital	At least basic digital skills ICT specialists Female ICT specialists
2 Connectivity	Gigabit for everyone (Fixed very high capacity network coverage) 5G coverage
3 Integration of digital technology	SMEs with a basic level of digital intensity AI Cloud Big data
4 Digital public services	Digital public services for citizens Digital public services for businesses

Source: European Commission

The index has been re-calculated for all countries for previous years to reflect the changes in the choice of indicators and the corrections made to the underlying data. Country scores and rankings

[16] Equivalent to intervention field 3 (Human Capital) of the RRF Regulation (Regulation (EU) 2021/241 of the European Parliament and of the Council of 12 February 2021 establishing the Recovery and Resilience Facility, OJ L 57, 18.2.2021, p. 17).
[17] Equivalent to intervention field 1 (Connectivity) of the RRF Regulation.
[18] Equivalent to intervention fields 5 (Digitalisation of businesses) and 6 (Investment in digital capacities and deployment of advanced technologies) of the RRF Regulation.
[19] Equivalent to intervention field 4 (e-government, digital public services and local digital ecosystems) of the RRF Regulation.

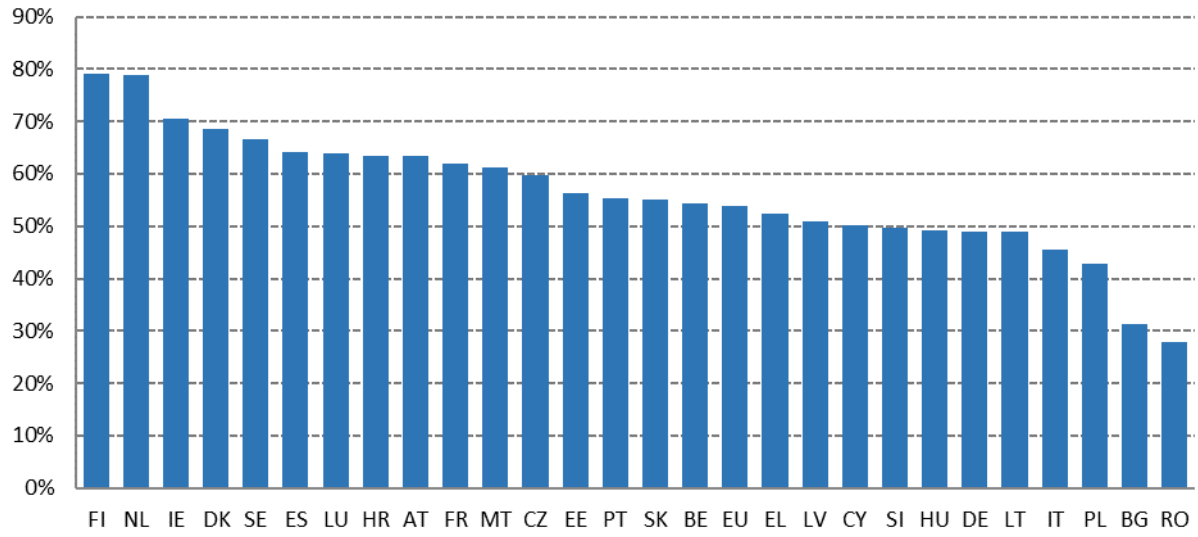
may thus have changed compared with previous publications. For further information, consult the DESI website.

1.3 DESI 2022 results

Human capital – digital skills

While 87% of people (aged 16-74) used the internet regularly in 2021, only 54% possessed at least basic digital skills. The Netherlands and Finland are the frontrunners in the EU, while Romania and Bulgaria are lagging behind. A large part of the EU population still lacks basic digital skills, even though most jobs require such skills. The proposed 2030 target of the Path to the Digital Decade is that at least 80% of citizens have at least basic digital skills.

Figure 3 At least basic digital skills (% of individuals), 2021



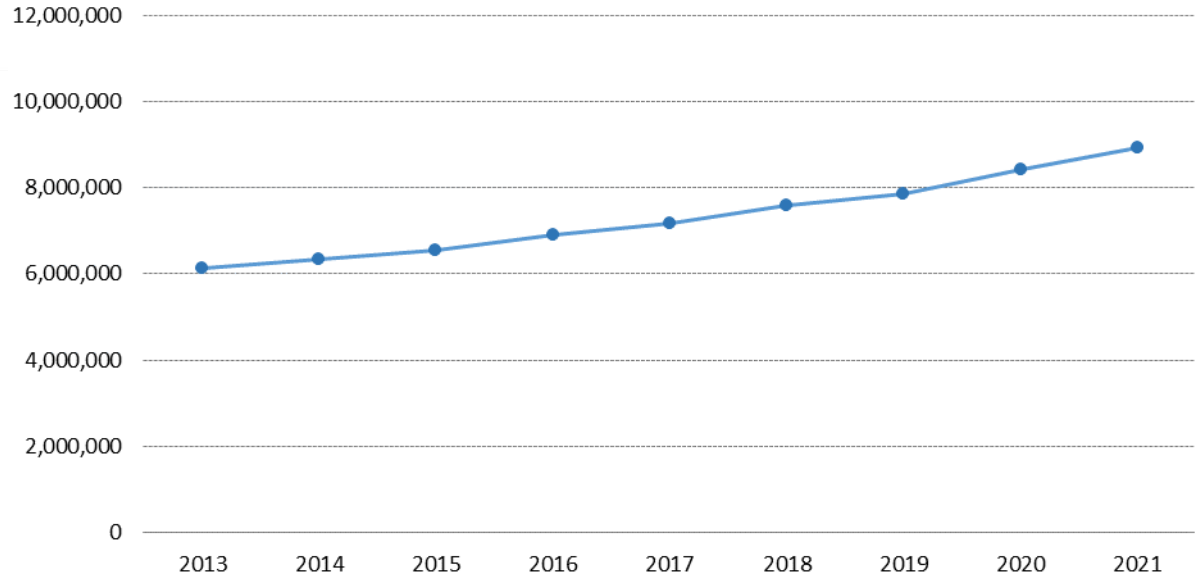
Source: Eurostat, European Union survey on the use of ICT in Households and by Individuals

There remains a general shortage of ICT specialists on the EU labour market, and the number of vacancies keeps growing as new jobs emerge. During 2020, 55% of enterprises that recruited or tried to recruit ICT specialists reported difficulties in filling such vacancies.

There is also a severe gender balance issue, with only 19% of ICT specialists and one in three science, technology, engineering and/or mathematics (STEM) graduates being women. The Path to the Digital Decade proposal set the target of gender convergence for ICT specialists.

The Path to the Digital Decade proposal aims to increase the number of employed ICT specialists in the EU to at least 20 million by 2030, compared to 8.9 million in 2021 (corresponding to 4.5% of the labour force). Although there has been steady growth since 2013, an acceleration is needed to reach the target. As of 2021, Sweden – with 8% – and Finland – with 7.4% – have the highest proportion of ICT specialists in the labour force.

Figure 4 ICT specialists, 2013-2021

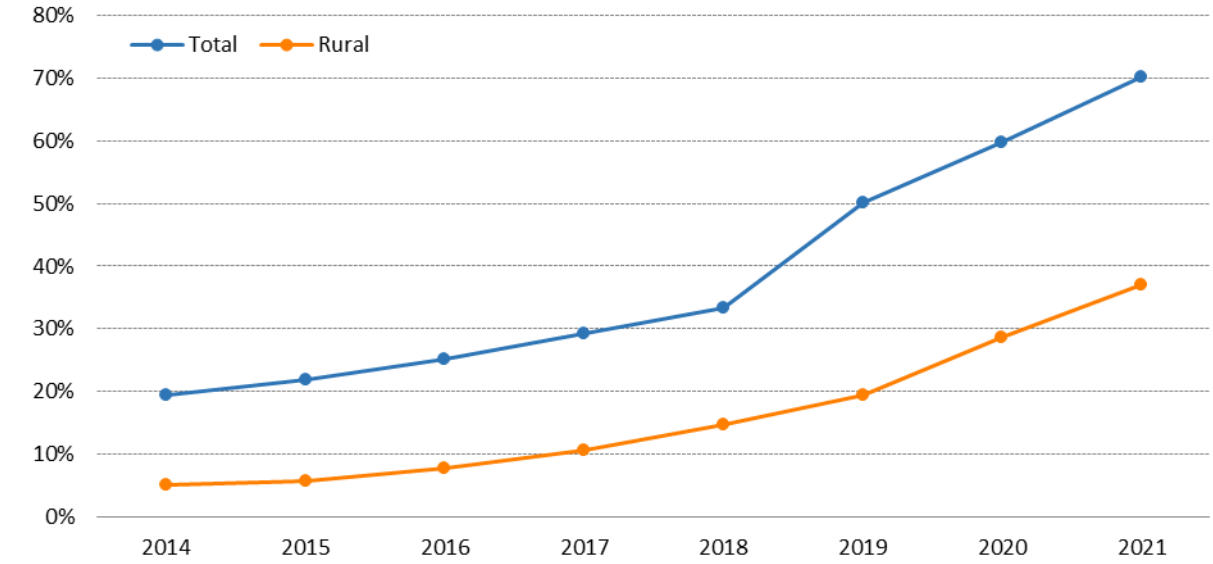


Source: Eurostat, Labour Force Survey

Broadband connectivity

While the EU has full coverage of broadband, only 70% of households can benefit from fixed very high capacity network (VHCN) connectivity with the potential of offering gigabit speeds. In the DESI reports, fixed VHCN includes FTTP (fibre-to-the-premises) and cable DOCSIS 3.1 (data over cable service interface specification) technologies. FTTP coverage grew from 43% in 2020 to 50% in 2021, while DOCSIS 3.1 coverage increased from 28% in 2020 to 32% in 2021. Rural fixed VHCN coverage also improved from 29% in 2020 to 37% in 2021. However, a large gap between rural and national figures remains. Malta, Luxembourg, Denmark, Spain, Latvia, the Netherlands and Portugal are the most advanced Member States on total fixed VHCN coverage (all with more than 90% of homes covered). By contrast, in Greece, only 1 in 5 households have access to fixed VHCN. The Path to a Digital Decade proposal sets the target that gigabit networks should be available to all households by 2030.

Figure 5 Fixed very high capacity network (VHCN) coverage (% of households) in the EU, 2014-2021



Source: IHS Markit, Omdia, Point Topic and VVA, Broadband coverage in Europe studies

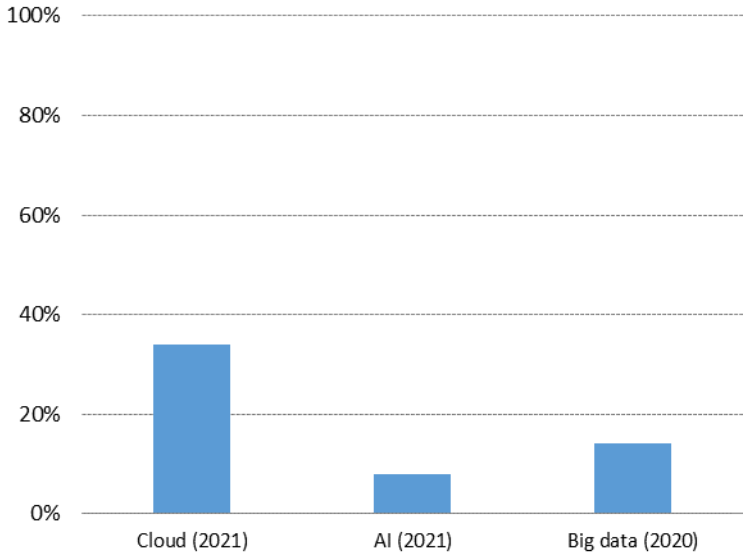
5G coverage also went up last year to 66% of populated areas in the EU. Nonetheless, spectrum assignment, an important precondition for the commercial launch of 5G, is still not complete: only 56% of the total 5G harmonized spectrum has been assigned. Moreover, the very high coverage figures in some Member States are due to operators using spectrum sharing on the basis of 4G frequencies or low band 5G spectrum (700 MHz), which does not yet allow for the full deployment of advanced applications. Closing these gaps is essential to unleash the potential of 5G and enable new services with a high economic and societal value, such as connected and automated mobility, advanced manufacturing, smart energy systems or e-health.

Integration of digital technology by businesses

In 2021, only 55% of small and medium-sized enterprises (SMEs) reached at least a basic level in the adoption of digital technologies. Sweden and Finland have the most digitalised SMEs (86% and 82% having a basic level of digital intensity respectively), while Romania and Bulgaria have the lowest rates of SME digitalisation. To reach the Digital Decade target, at least 90% of SMEs in the EU should have a basic level of digital intensity by 2030.

Businesses are getting more and more digitalised, but the use of advanced digital technologies remains low. Although already 34% of enterprises rely on cloud computing (in 2021)[20], only 8% use AI (in 2021) and 14% big data (in 2020). Following the Path to the Digital Decade proposal, at least 75% of companies should take up AI, cloud and big data technologies by 2030.

Figure 6 Adoption of advanced technologies (% of enterprises) in the EU, 2020/2021



Source: Eurostat, European Union survey on ICT usage and e-commerce in enterprises

There is a substantial gap between large companies and SMEs, not only in the use of advanced technologies, but also of basic digital solutions, such as having an enterprise resource planning (ERP) software package and engaging in e-Commerce.

Finland, Denmark and Sweden rank highest overall in the digital transformation of businesses.

[20] Sophisticated or intermediate cloud computing services.

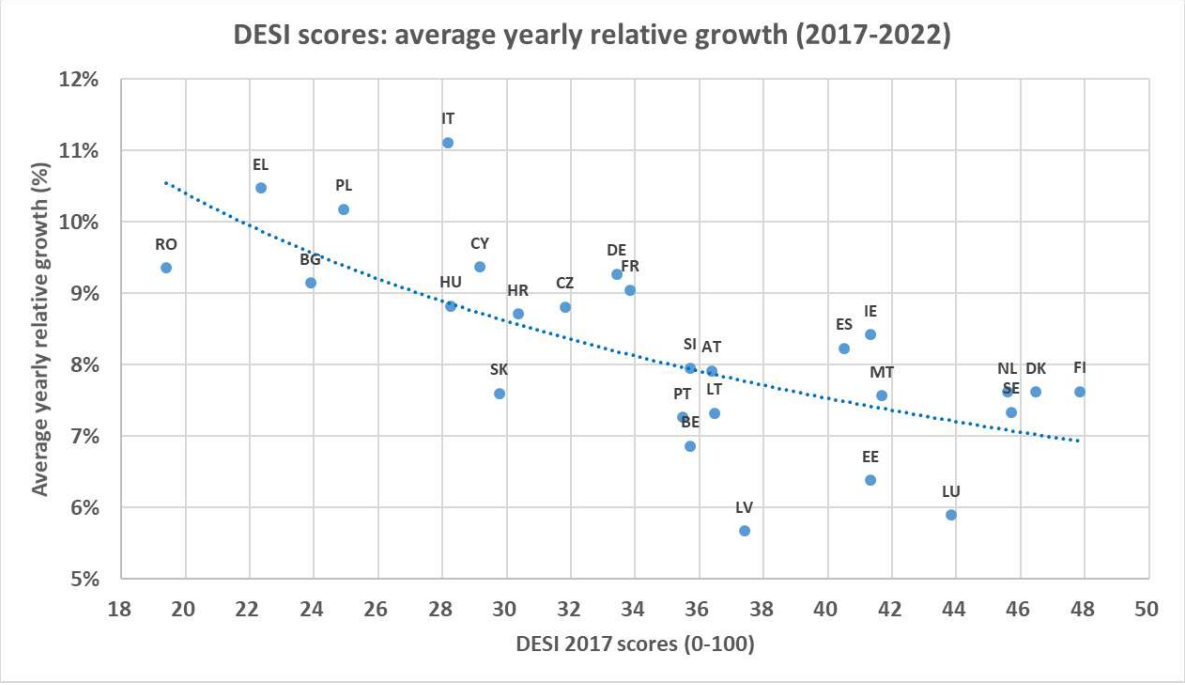
Digital public services

DESI monitors online public services by scoring Member States on whether or not it is possible to complete each step of key services fully online. The quality scores reached 75 out of 100 for digital public services for citizens and 82 out of 100 for businesses in 2021. Estonia, Finland, Malta and the Netherlands have the highest scores for Digital public services in DESI, while Romania and Greece have the lowest. The Path to the Digital Decade proposal sets the target that all key public services for citizens and businesses should be fully online by 2030.

How did Member States progress in the past 5 years?

The figure below shows the progress of Member States as regards the overall level of digitalisation of their economy and society over the last 5 years. For each country, the figure shows the relation between its DESI 2017 scores (horizontal axis) and the DESI average yearly growth in the period 2017-2022 (vertical axis). As in classical economic growth theory, overall convergence is shown when countries starting at lower levels of digital development grow at a faster pace (left-hand side of the chart). DESI scores clearly show an overall convergence pattern in the EU between 2017 and 2022. The blue line in the figure is the estimated pattern of convergence. Countries that are located above the blue line grew more than expected by the convergence curve and are therefore 'overperforming'. The opposite is valid for the countries located below the blue line.

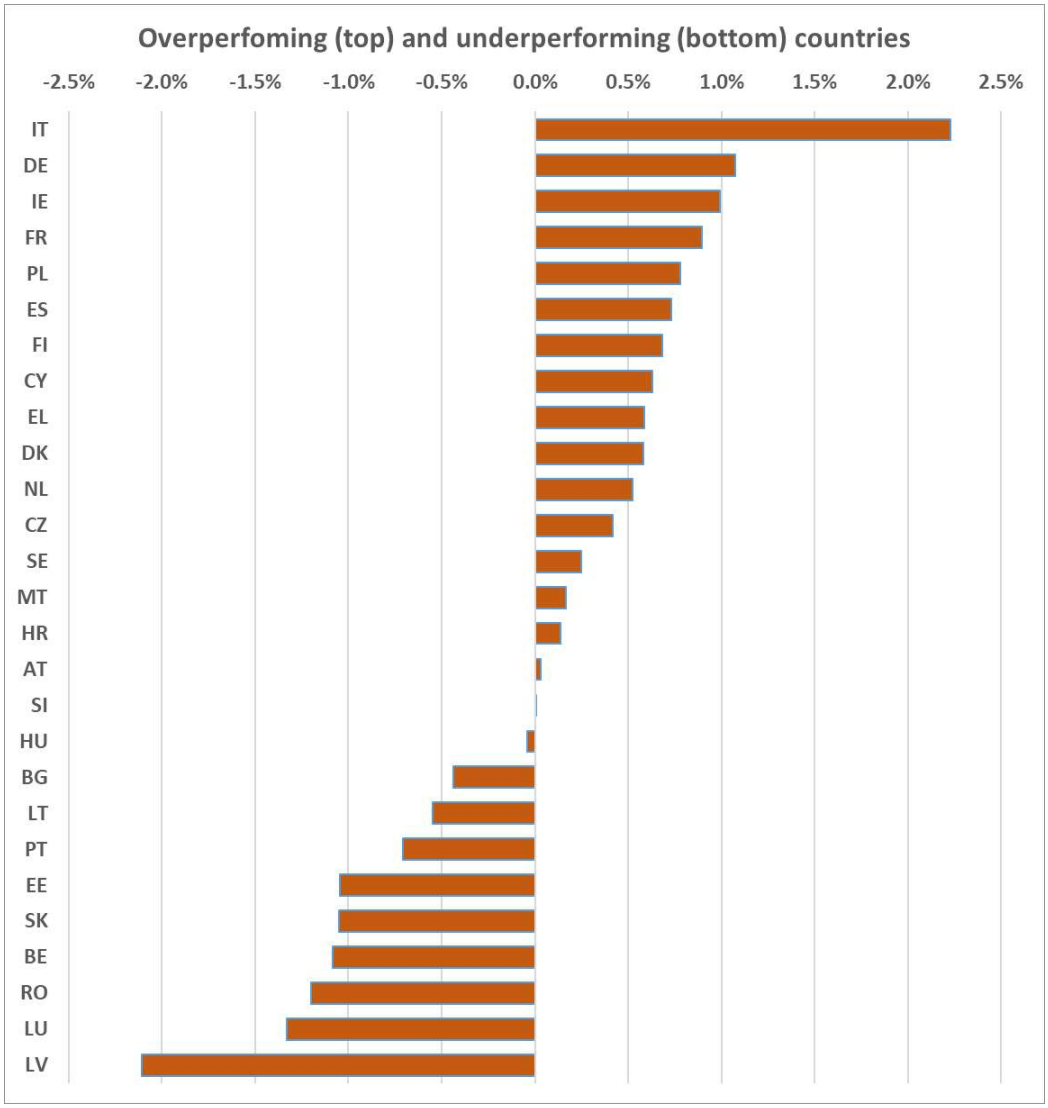
Figure 7 Digital Economy and Society Index – Member States' relative progress in the period 2017-2022



Source: DESI 2022, European Commission

The chart below ranks overperforming (top part of the chart) and underperforming (bottom part of the chart) countries according to their distance from the convergence curve (blue line in the figure above). Italy is the best of the top group as it grew at a pace remarkably superior to what expected in between 2017 and 2022. It is followed by Germany, Ireland, France and Poland among the top 5 overperformers. In the bottom group of countries Latvia improved its DESI score at a much slower pace than expected by the convergence curve, deviating from the overall convergence pattern. Luxembourg, Romania, Belgium, Slovakia and Estonia substantially deviate from convergence as well.

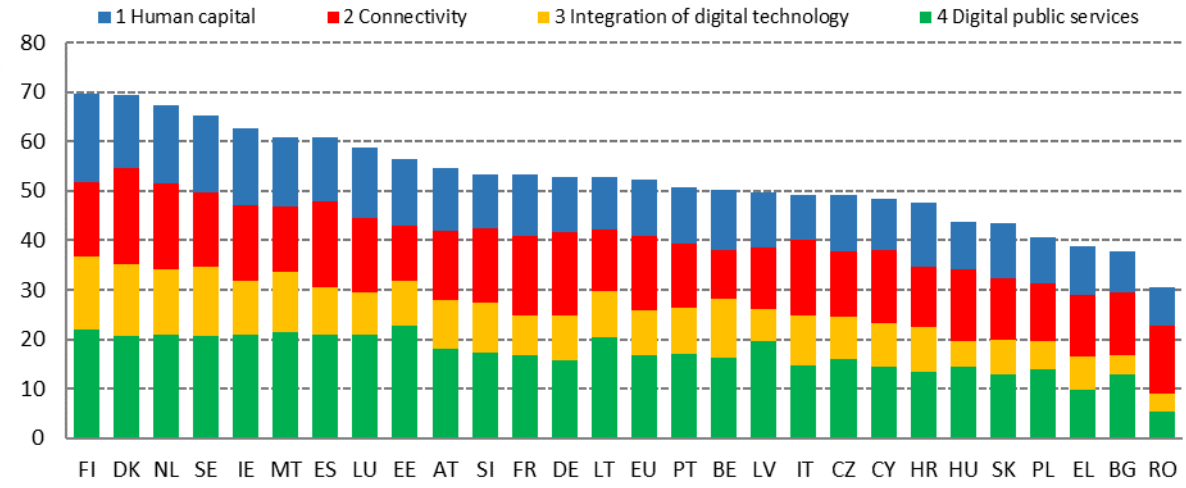
Figure 8 Digital Economy and Society Index – Overperforming and underperforming Member States (2017-2022)



Source: DESI 2022, European Commission

The below figure shows the 2022 DESI ranking of Member States. Finland, Denmark, the Netherlands and Sweden have the most advanced digital economies in the EU, followed by Ireland, Malta and Spain. Romania, Bulgaria and Greece have the lowest DESI scores.

Figure 9 Digital Economy and Society Index, 2022



Source: DESI 2022, European Commission

2 Human Capital

Digital transformation is on the rise and affecting every aspect of life. Digital skills are important because they underpin how we interact and how modern work is conducted. For many modern professions, digital skills are simply essential life skills. The digital skills required in the workplace are more advanced, and companies and institutions – public and private - expect most of their employees to have them. As dependence on the internet and digital technology increases, so the workforce must keep up with the evolving skill demand. Without a firm command of digital skills, there is no way to propel innovation and remain competitive. The same applies to the public that will need digital skills in the day-to-day professional or personal context.

Against this backdrop, the digital transition is a priority for the EU and the Member States. A digitally skilled workforce and public are key to making it happen. The Path to the Digital Decade proposal reflects that salience alongside infrastructure, digital transformation of businesses and public services. Specific targets are proposed to shape and encourage EU and Member States actions by 2030. The EU aims to equip at least 80% of people with at least basic digital skills and increase the number of ICT specialists to 20 million (around 10% of total employment), with convergence between men and women by 2030.

Today, 54% of Europeans have at least basic digital skills[21]: 26 percentage points below the target with stark differences among countries. Some Member States like the Netherlands and Finland approach the target with 79% of people with at least basic digital skills in 2021. In eight Member States, the share of individuals with at least basic digital skills is lower than 50%. Romania, Bulgaria, Poland and Italy rank the lowest.

ICT specialists in employment were 8.9 million in 2021 (4.5% of the total employment). Even the frontrunners are far from the Digital Decade target with Sweden at 8% and Finland at 7.4%. At the current growth rate, the EU will fall short compared to the target set for 2030.

The Digital Skills Indicator is the tool that will monitor Member States' performances in reaching the skills targets of the Digital Decade proposal and provide useful information on citizens' behaviour online and people's skills and competences in different digital domains.

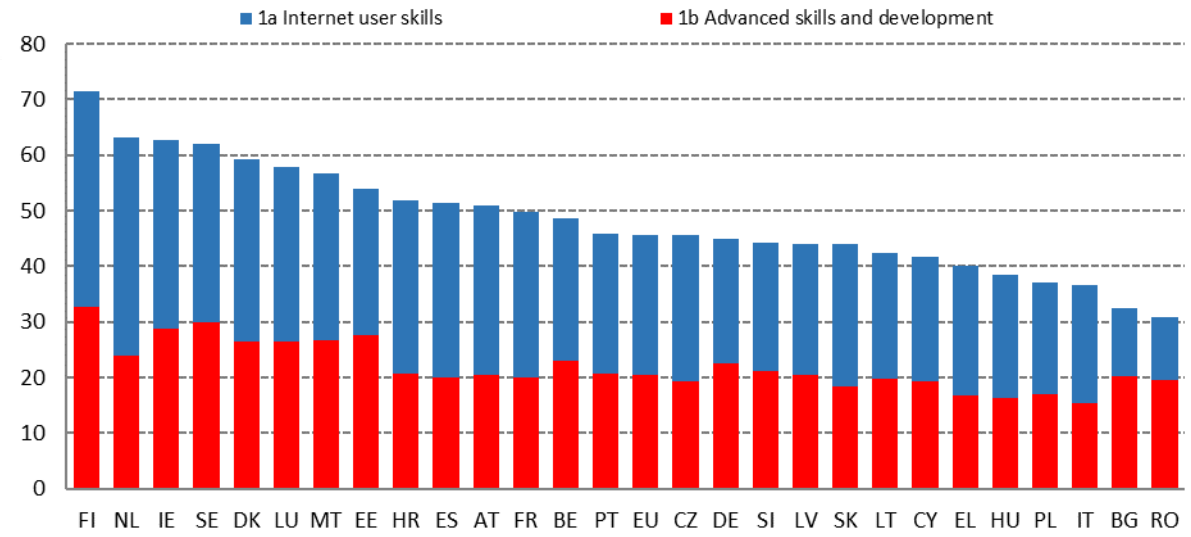
Table 4 Human capital indicators in DESI

	EU DESI 2022
1a1 At least basic digital skills % individuals	**54%** 2021
1a2 Above basic digital skills % individuals	**26%** 2021
1a3 At least basic digital content creation skills % individuals	**66%** 2021
1b1 ICT specialists % individuals in employment aged 15-74	**4.5%** 2021
1b2 Female ICT specialists % ICT specialists	**19%** 2021
1b3 Enterprises providing ICT training % enterprises	**20%** 2020
1b4 ICT graduates % graduates	**3.9%** 2020

Source: DESI 2022, European Commission

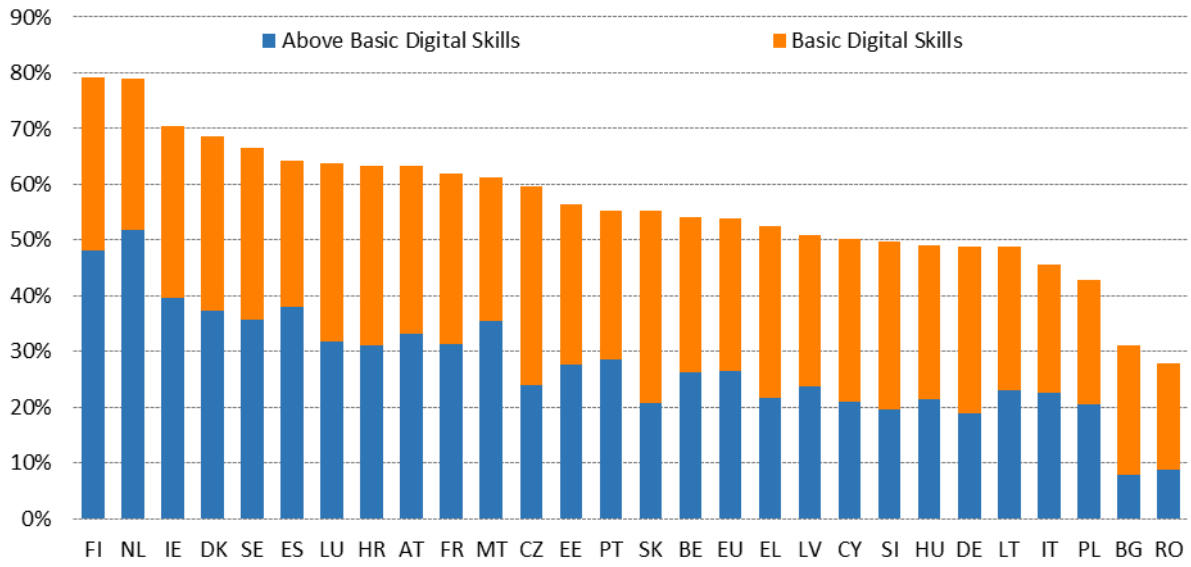
[21] 'At least basic skills' is combining together the number of individuals (16-74 years old) having either 'basic digital skills' or 'above basic digital skills'.

Figure 10 Human capital dimension (Score 0-100), 2022



Source: DESI 2021, European Commission

Figure 11 Basic and above basic digital skills (% of all individuals), 2021



Source: Eurostat, Community survey on ICT usage in Households and by Individuals

2.1 The Digital skills composite indicator

Since 2015, the European Commission has measured citizens' digital skills through the Digital Skills Indicator (DSI). It is a composite indicator based on selected activities related to internet or software use, which are performed by individuals aged 16-74. Due to significant technological changes of the ICT landscape, the methodology was updated through the Joint Research Centre of the European Commission and the Information Society Statistics Working Group with Member State representatives in 2019-2022.

The European Commission's Digital Competence Framework 2.0 was used to update the DSI methodology throughout 2020-2021. The new DSI introduced in 2022, DSI 2.0, measures citizens' activities taking place on the internet in the last 3 months in five specific areas:

- Information and data literacy;
- Communication and collaboration;

- Digital content creation;
- Safety; and
- Problem solving.

According to the Digital Skills Indicator 2.0, it is assumed that individuals having performed certain activities over the internet using digital tools and software have the corresponding skills. Therefore, the individuals' activities measured using the Digital Skills Indicator can be considered as proxy of individuals' digital skills.

According to the number of activities performed in each area, two levels of skills are calculated, i.e. 'basic' and 'above basic'. Based on the level of individual's skills in each area, an overall level is then calculated. For individuals to be considered as having overall 'above basic' level of digital skills, they need to have above basic skills in all five areas. If an individual has 'basic' in some areas and 'above basic' in others, then this individual is considered having overall 'basic digital skills'.

Besides calculating the levels of 'basic' and 'above basic', the DSI 2.0 seeks to gain further insights into different levels of nature of digital skills. The following additional breakdowns of data were calculated in 2021 to provide empirical knowledge on individuals lacking 'basic' digital skills and help policy makers to understand better the challenges related to digital skills development.

- Individuals with *low digital skills*: who have either basic or above basic level in 4 out of the 5 areas;
- Individuals with *narrow digital skills:* who have either basic or above basic level in 3 out of 5 areas;
- Individuals with *limited digital skills*: who have either basic or above basic level in only 2 out of 5 areas;
- Individuals with *no digital skills*: who have no skills in 4 areas or in all 5 areas;
- Digital skills could *not be assessed* because the individual has not used the internet in the last 3 months.

2.2 Internet use

Internet access continued to be widely available in terms of costs and accessibility. The major milestone was crossed in 2007 when 53% of European households had internet subscription. The proportion continued to rise reaching 92% households in the EU with subscription to internet in 2021. Luxembourg and the Netherlands had the highest proportion (99%) of households with internet subscription in 2021, with Ireland, Finland (both with 97%) and Denmark and Spain (96%) closely behind. Bulgaria (84%) and Greece (85%) had the lowest rate of internet take up among Member States, but both together with Cyprus, Romania, Slovenia and Lithuania have swiftly expanded by 15-20 percentage points in the proportion of households with internet subscription over 2016-2021.

The urban-rural divide in internet use persists. Households in cities, towns and suburbs had comparatively higher subscription rates (94% in cities and 92% in towns and suburbs), while those in rural areas were recording slightly lower numbers (89%). The urban-rural divide was particularly visible in Bulgaria, Greece and Portugal (where households in rural areas were recording values lower than 80%). Interestingly, Cypriot towns and suburbs recorded the highest level of internet take-up – 97% compared to cities (93%) and rural areas (91%). Other exceptions were Estonia, Sweden and Poland, where the lowest level of internet access was in towns and suburbs, not in rural areas.

In 2021, regular internet users stood at 87% (at least weekly usage), while almost 80% were using it every day or almost every day. The proportion of the EU's population that had never used the internet was 8% in 2021 (1 percentage point lower than in 2020). However, this figure is higher in some countries, like Greece and Bulgaria, where one in five individuals has never done so. In

contrast, 1% - 0% of the adult population of Ireland, Sweden and Luxembourg had never used the internet.

Although 87% of Europeans use the internet regularly, only 54% possessed at least basic digital skills. It is not enough to have access to the internet in order to make use of it. Use of internet goes hand-in-hand with the appropriate skills to benefit from the digital society.

2.3 Digital skills levels and online information and communication indicator

The new DSI 2.0 introduces more detailed variations of digital skills ('low', 'narrow' and 'limited digital skills'), which allow for a closer monitoring of the uptake of digital skills. In 2021, 3% of individuals had been classified as having no overall digital skills, 5% having skills in 2 out of 5 areas ('*limited digital skills'*) and 9% having '*narrow skills'* (3 out of 5 areas).

17% of individuals had digital skills in 4 out of the 5 areas monitored (*'low digital skills'*). This means that they are a step away from reaching basic digital skills level. Further investment and upskilling opportunities may help them advance and bring the total share of basic digital skills to 71%.

The 'Online information and communication' is a composite indicator, which captures activities in only two specific skills areas (out of five): information literacy and communication and collaboration. The respondents, captured by this indicator, have performed activities in those two areas only, without performing any activities in remaining three areas of DSI 2.0. It means that people belonging to this category use internet to either communicate or get the information. The countries where respondents have skills limited to 'online information and communication' are Romania (10%), Bulgaria (9%) and Cyprus (6%). Together with Poland, these are also the countries with the highest share of respondents having *limited digital skills* (skills in 2 areas out of 5). These individuals are lacking digital skills in categories such as Safety, which means that they are not safe online and are vulnerable to personal data breaches, online frauds and other such attempts. Targeted training for individuals in 'Online information and communication' category in areas such as 'Safety', 'Problem-solving' and 'Digital content creation' would increase their overall digital skills.

2.4 At least basic digital skills

Socio-demographic factors influence the levels of digital skills. For example, 71% of young adults (aged 16-24), 79% of individuals with high formal education[22], and 77% of higher education students have at least basic digital skills (Table 2). By contrast, only 35% of those aged 55-74 and 29% of the retired and the inactive have at least basic digital skills. The gap between rural and urban areas is still substantial regarding the digital skills of the population: only 46% of individuals living in rural areas have at least basic digital skills compared to people living in the predominantly urban areas (61%). For more information on selected socio-demographic background, see the table below.

It is worth noting that being of young age does not determine digital skills, as growing up in a digital world does not necessary make you digitally savvy. At the International Computer and Information Literacy Study (ICILS)[23] of 8th-graders' performance test, which is based on direct testing and assesses a wider set of skills than DSI, demonstrates that young people do not develop sophisticated skills just by growing up using digital devices. In 9 out of 14 EU Member States that have participated in ICILS to date, over a third of the pupils achieved scores below the threshold in digital skills.

In the Council Resolution, on a strategic framework for European cooperation in education and training towards the European Education Area and beyond (2021-2030), Member States agreed to

[22] ISCED11 levels from 5 to 8 - formal tertiary (or higher) education
[23] https://www.iea.nl/studies/iea/icils/2018.

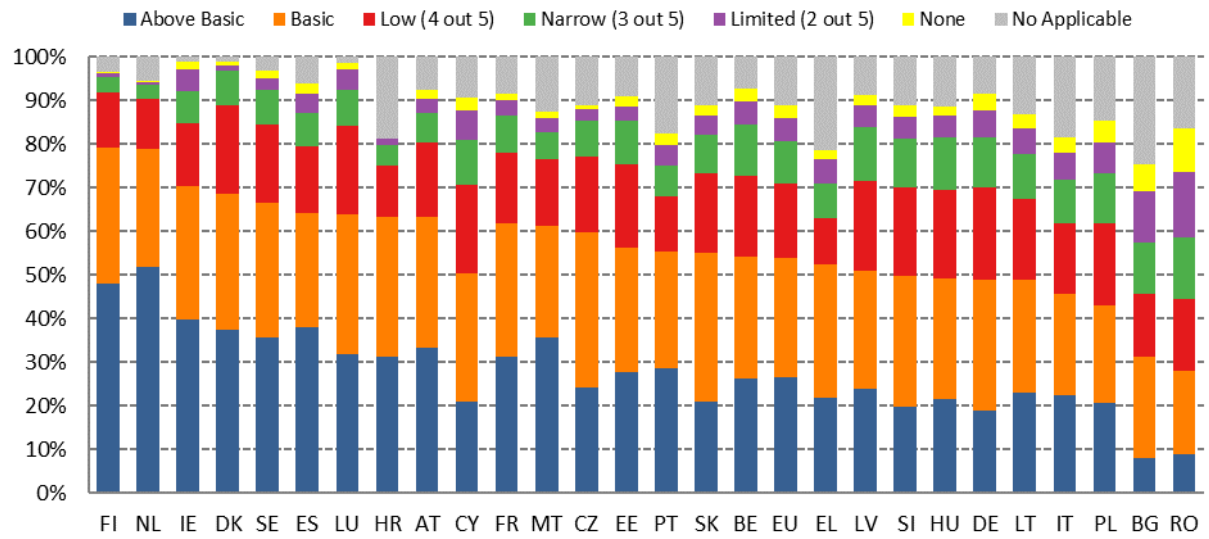
work towards reducing the share of underachievers to below 15% at EU level by 2030. The Digital Education Action Plan 2021-2027 and other EU initiatives contribute towards this goal.

Table 5 At least basic digital skills across different socio-demographic breakdowns (% of all individuals), 2021

Factor	Characteristics	At least Basic Digital Skills in 2021 - the EU average
Age	Individuals, 16 to 24 years old	71%
	Individuals, 25 to 34 years old	69%
	Individuals, 35 to 44 years old	64%
	Individuals, 45 to 54 years old	55%
	Individuals, 55 to 64 years old	42%
	Individuals, 65 to 74 years old	25%
Density	living in a predominantly urban area	61%
	living in an intermediate area	52%
	living in a predominantly rural area	46%
Education	Individuals with no or low formal education	32%
	Individuals with medium formal education	50%
	Individuals with high formal education	79%
Employment	Active labour force (employed and unemployed)	62%
	Retired and other inactive	29%
	Employees, self-employed, family workers	63%
	Students	77%
	Unemployed	49%
Gender	Females, 16 to 74 years old	52%
	Males, 16 to 74 years old	56%

Source: Eurostat, Community survey on ICT usage in Households and by Individuals

Figure 12 Digital Skills (% internet users), 2021

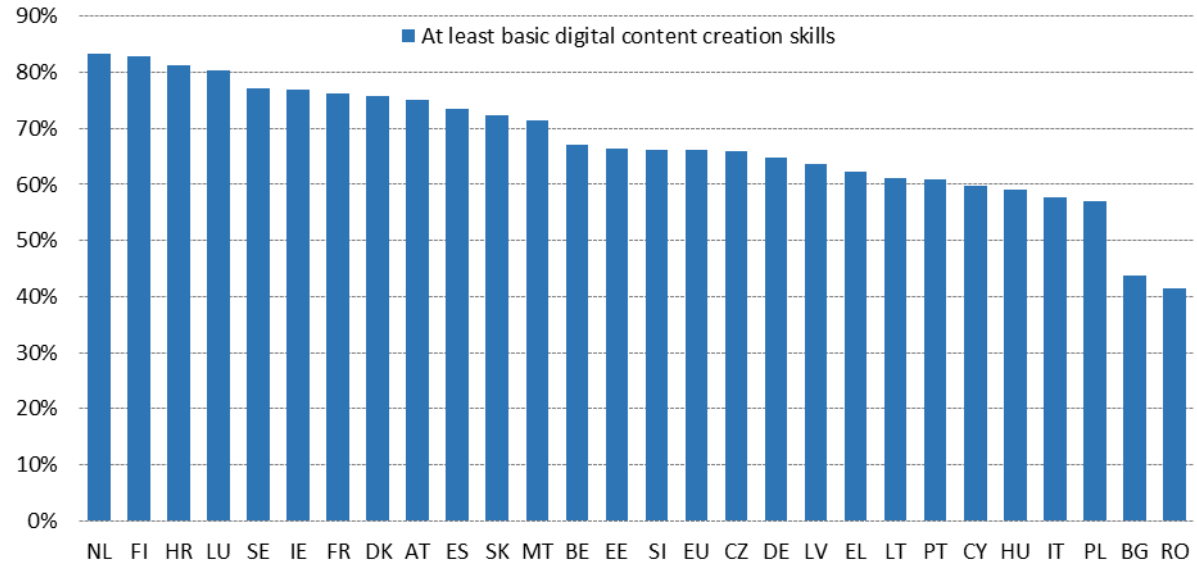


Source: Eurostat, Community survey on ICT usage in Households and by Individuals

2.5 Content creation skills

Individuals' skills in content creation[24], another key indicator of DSI 2.0 included in DESI, are varied. The Netherlands and Finland lead in at least basic digital content creation skills, closely followed by Croatia and Luxembourg with scores above 80%. Romania, Bulgaria, Poland and Italy have the lowest share of individuals with activities accounting for at least basic content creation skills in 2021.

Figure 13 At least basic digital content creation skills (% of all individuals), 2021



Source: Eurostat, Community survey on ICT usage in Households and by Individuals.

2.6 Above basic digital skills

In 2021, 26% of EU individuals had above basic digital skills. It means that they scored above basic in all five areas of the DSI. Having above basic digital skills is important both to grow competitiveness in the labour market and to enable the take-up of digital solutions in business.

2.7 Online Disinformation

The rise of disinformation, false information with the intent to deceive people, has become a major challenge worldwide. People are increasingly likely to encounter online information that misrepresents reality. However, many may not realise it as only 46% of Europeans have encountered untrue or doubtful content or information online in the last 3 months. Checking the truthfulness of information is a way to mitigate the impact of disinformation on the society. 24% of EU individuals had checked the truthfulness of the information or content found on the internet news sites or social media in the last 3 months. 15% did not check the truthfulness, as they already knew it was not reliable. Worrisomely, 5% contested that they lacked skills or knowledge to verify truthfulness.

[24] Definition in Digital Competence Framework 2.0 of 'Content creation skills' is: to create and edit digital content, to improve and integrate information and content into an existing body of knowledge while understanding how copyright and licences are to be applied and to know how to give understandable instructions for a computer system.

2.8 ICT specialists

Digital skills have never been more essential to businesses and the workforce as they are no longer 'optional' but 'critical'. While this trend had been gaining momentum for decades across all industries, today's acceleration is unprecedented. Now, digital adoption and advanced digital skills needed to embrace the transformation that are critical to more secure, in-demand tech careers. Digital skills are also essential to the survival and growth of businesses. As routine tasks are becoming increasingly automated, there is a risk of job loss for workers performing mainly such tasks. A growing number of workers will need to gain new skills to work in tandem with (digital) technologies.

All Member States including frontrunners face a critical shortage of digital experts. That hinders the development, uptake and use of emerging key digital technologies. In key areas such as cybersecurity or data analysis, there are constantly hundreds of thousands of hard-to-fill vacancies.

In 2021, about 9 million people worked as ICT specialists in the EU. The highest numbers were reported in Germany (2 million ICT specialists), which provided work to more than one fifth (22.5%) of the EU ICT workforce. Germany was followed by France with 1.2 million of ICT specialists (13.9% of the EU total) and Italy with 0.8 million (accounting for 9.5% of EU total)[25]. Their combined share accounted for more than 40% of the EU's ICT workforce. The EU target requires to have 20 million of ICT specialists by 2030, representing around 10% of total employment, with a convergence between men and women.

There is still persistent gender gap: only one in five ICT specialists and ICT graduates are women, which may affect the way digital solutions are devised and deployed. This is compounded by the demographic decline across the EU, and a lack of specialised education offer in key digital areas.

In the face of a growing number of jobs for people with advanced digital skills, educational policies encouraging undergraduates to opt for tech studies can improve their employment prospects linked to higher earning potential. Many of these jobs go unfilled, making the advanced digital skills part of a solution to unemployment. Ensuring a wide range of easily accessible and relevant upskilling and reskilling opportunities to the EU workforce can help satisfy the demand for more ICT specialists, advanced digital technology users and above basic digital skills.

2.9 EU Code Week 2021

To thrive in the connected economy and society, digital skills must also function together with other abilities such as strong literacy and numeracy skills, critical and innovative thinking, complex problem solving and an ability to collaborate. EU Code Week[26] is a grassroots initiative that the European Commission supports bringing coding and digital literacy to everyone in a fun and engaging way with activities organised around the world by teachers and coding enthusiasts.

EU Code Week contributes to the target of the Digital Education Action Plan 2021-2027, which aims at reducing the share of 13-14-year-olds with insufficient computing and digital skills from 30% to 15% at the EU level by 2030. EU Code Week also contributes to the targets of the Digital Decade: increasing the number of Europeans with basic digital skills and the number of digital experts.

EU Code Week provides teachers with free resources, ready-made lesson plans, free online introductory courses and other materials to help bring coding and technology to all subjects and classrooms.

[25] Employed ICT specialist can be visualised online both as regards of percentage of total employment and in thousands of person.
[26] https://codeweek.eu/

In the last five years over, 15.5 million people have taken part in the EU Code Week to learn basic programming concepts, practise computational thinking, manipulate data, and tinker with hardware and design games. In 2021, some 4 million people participated in the initiative, with an average age of participants of 11 years and nearly half the participants being girls (49%).

Some 34 000 people, mostly teachers organised over 78 000 activities: a 15% increase compared to 2020. 88% of the activities took place in schools showing teachers' great involvement in the initiative. 11% of the activities were held online and 83% in-person (6% unspecified).

The 10 most active EU countries were Italy (18 000) and Poland (15 000), Greece (2 300 activities), Austria and Romania (both 1 800), Hungary (1 400), Croatia, Spain and Germany (all 1 000). However, in relation to the size of the population Malta and Estonia's activities topped the scoreboard.

The 10th edition of the Code Week will take place between 8 and 23 October 2022.

1.10 Digital skills in the Recovery and Resilience Plans

The EUR 723.8 billion[27] Resilience and Recovery Facility is a financial instrument to accelerate Europe's post-COVID recovery and mitigate the socio-economic consequences of the pandemic. All the 25[28] plans approved by the Council of the European Union meet or exceed the target to allocate at least 20% to digital priorities. Around 17% of the expenditure dedicated to digital objectives (EUR 22 billion), is dedicated to digital skills development. Measures include training in digital skills for SMEs (Spain), digital skills courses for vulnerable groups (France), more study places devoted to ICT in tertiary education (Sweden) and cross-border cooperation in higher education to improve the offer in advanced digital skills training (Italy). The plans also include reforms. Slovakia will update school curricula and learning materials to include digital skills and teach computational thinking. Italy will review its active labour market policies to also encourage job seekers to acquire green and digital skills, among others.

The Recovery and Resilience Facility funds are complemented by national funding as well as other European funds (Erasmus+, ESF, Digital Europe etc.)

1.11 Structured Dialogue on digital education and skills

In October 2021, European Commission President Ursula von der Leyen launched the Structured Dialogue on digital education and skills to increase the political commitments on digital education and skills in the EU and its Member States. It will also feed into two proposals for Council Recommendation on enabling factors for digital education and on improving the provision of digital skills in education and training. The Dialogue will help Member States to prepare the Digital Decade roadmaps for the two digital skills targets, namely 80% of the EU population with basic skills and 20 million ICT specialists in employment by 2030.

[27] Total RRF funds available in current prices.
[28] Except for Hungary and the Netherlands.

3 Digital infrastructures

To enable access to digital services for all citizens and to maintain its prosperity, the European Union needs a digital connectivity infrastructure of top performance, security and sustainability, optimised to leverage the latest optical fibre technologies in fixed networks and to connect innovative wireless systems such as 5G, 6G and Wi-Fi. In September 2020, Commission President Ursula von der Leyen stated in her State of the Union Address[29], "[…] we want to focus our investments on secure connectivity, on the expansion of 5G, 6G and fibre." This was re-emphasised in her State of the Union Address in 2021[30]: "In an unprecedented manner, we will invest in 5G and fibre."

Analysis of household behaviour and upcoming digital use cases suggest that both residential and business consumers will progressively require gigabit connections to meet their needs, such as use of improved video standards, cloud services, applications based on virtual and augmented reality, AI applications, automated driving, logistics and manufacturing processes. For some of these applications, in particular those relying on real-time, distributed data processing capacities, users will produce and share as much data as they consume, requiring the underlying connectivity infrastructure to support in a reliable manner increased balance of upload and download speeds and low latency. The availability of gigabit connectivity services and 5G mobile coverage therefore become an increasingly important factor for the economic attractiveness of Member States, regions, cities.

Next to connectivity technologies, semiconductors are another fundamental technology for a secure and sustainable digital transformation. Emerging data processing capabilities, new applications for AI, the shift towards edge-computing and the growing need for cloud and infrastructure to support a distributed workforce, accelerated by the COVID-19 pandemic, all require the computational power, reduced energy consumption and added security offered by cutting-edge semiconductor technologies. The market for AI chips is expected to be a major driver of growth for the whole industry during the Digital Decade.

Globally and in the EU, the volume of generated data are greatly increasing and a growing proportion of data are being processed at the edge, moving from the traditional centralised model of data processing to a highly distributed one [31]. The intention of the Path to the Digital Decade is to ensure an edge node density that would allow for an optimal coverage across the EU territory, including in less populated areas. The target of the Digital Decade is that at least 10 000 climate-neutral highly secure edge nodes are deployed in the EU by 2030.

In the next 10 years a whole generation of new quantum technologies is likely to emerge, with far-reaching impacts on many activities. The first devices, in the form of experimental physical platforms or advanced simulators, are already in use. Researchers are starting to build pilot quantum computers to act as accelerators interconnected with supercomputers, forming 'hybrid' machines that blend the best of quantum and classical computing technologies. Quantum computing facilitates innovation in complex fields of research (e.g., climate change, health, brain science, biology, sustainable energy, materials, etc.) and industrial development (e.g., simulation sciences, data analytics, AI, digital twins, etc.). The Digital Decade target ist that by 2025, the EU has its first computer with quantum acceleration, paving the way for the EU to be at the cutting edge of quantum capabilities by 2030.

This report provides an analysis of broadband connectivity and semiconductors[32] .

[29] State of the Union Address by President von der Leyen (europa.eu)
[30] State of the Union Address by President von der Leyen (europa.eu)
[31] European Commission, SWD(2021) 352 final *Strategic dependencies and capacities*.
[32] Key performance indicators are being developed for edge nodes and quantum computing.

3.1 Broadband connectivity

The connectivity dimension of the DESI looks at both the demand (take-up) and the supply side (coverage) of fixed and mobile broadband. Under fixed broadband, it assesses the take-up of overall, at least 100 Mbps and at least 1 Gbps broadband, the coverage of fast broadband (next generation access of at least 30 Mbps) and of fixed very high capacity networks (VHCNs)[33]. Under mobile broadband, it includes the population coverage of 5G networks, the assignment of radio spectrum for 5G (5G spectrum indicator) as well as the take-up of mobile broadband[34]. In addition, it captures the retail prices of fixed and mobile offers (price plans) and also those of converged bundles (consisting of fixed and mobile service components).

Table 6 Connectivity indicators in DESI

	EU	
	DESI 2020	**DESI 2022**
2a1 Overall fixed broadband take-up % households	**75%** 2019	**78%** 2021
2a2 At least 100 Mbps fixed broadband take-up % households	**28%** 2019	**41%** 2021
2a3 At least 1 Gbps take-up % households	**NA**	**7.6%** 2021
2b1 Fast broadband (NGA) coverage % households	**84%** 2019	**90%** 2021
2b2 Fixed Very High Capacity Network (VHCN) coverage % households	**50%** 2019	**70%** 2021
2b3 Fibre to the Premises (FTTP) coverage % households	**38%** 2019	**50%** 2021
2c1 5G spectrum Assigned spectrum as a % of total harmonised 5G spectrum	**20%** 04/2020	**56%** 04/2022
2c2 5G coverage % populated areas	**NA**	**66%** 2021
2c3 Mobile broadband take-up % individuals	**80%** 2018	**87%** 2021
2d1 Broadband price index Score (0-100)	**64** 2019	**73** 2021

Source: DESI 2022, European Commission

The Digital Decade defines two targets in the area of broadband connectivity for 2030: gigabit coverage for all households and 5G in all populated areas. To date, 21 Member States with Council approved plans have connectivity measures in their RRPs, with an estimated total cost of about EUR 16 billion, which either directly or indirectly contribute to the Digital Decade Gigabit and 5G targets. Italy, Spain, Poland and Greece have the largest amounts so far (between EUR 1.2 and EUR 6.7 billion each). Moreover, several Member States include both investments and reforms in their plans. Examples of reforms are streamlining procedures and fees for the rollout of networks, incorporating the 5G Security Toolbox, etc.

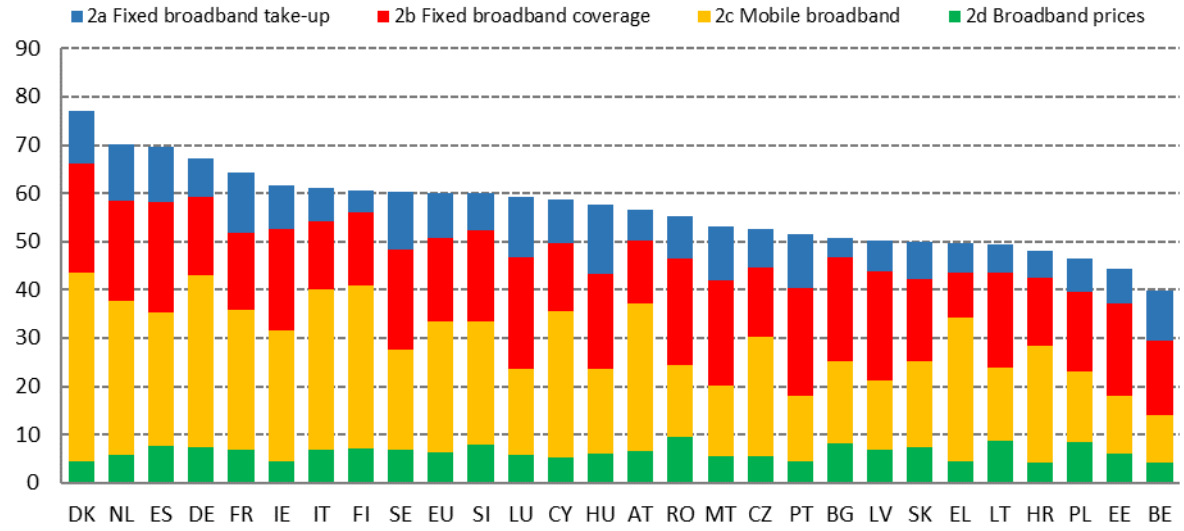
Despite progress over the last years, broadband coverage remains uneven between rural and urban areas, with large differences especially when it comes to VHCNs. Setting up a predictable regulatory environment, providing the conditions to incentivise investment and minimising deployment costs will continue to play an important role in accelerating the universal availability of gigabit connectivity

[33] Fixed VHCN coverage refers to the combined coverage of FTTP and DOCSIS 3.1 cable networks.
[34] The mobile broadband take-up indicator has been revised, see the DESI methodological note for further details.

services and 5G mobile coverage. Moreover, these targets are strongly interlinked with other targets of the Digital Decade, e.g. take-up of digital technologies by enterprises, which will both drive and rely on a strong gigabit infrastructure.

In connectivity, Denmark has the highest score, followed by the Netherlands and Spain. Belgium and Estonia have the weakest performance on this dimension of the DESI.

Figure 14 Digital Economy and Society Index 2022, Connectivity



Source: DESI 2022, European Commission

3.1.1. Broadband coverage

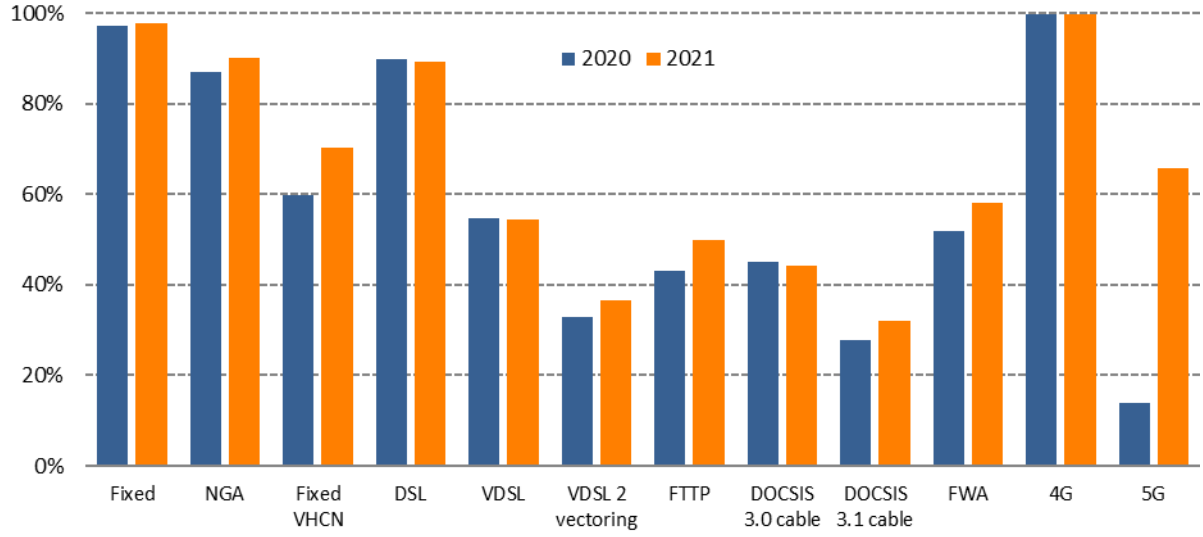
At least one broadband network has been available to all households in the EU since 2013, when considering all major technologies (xDSL, cable, fibre to the premises - FTTP, fixed wireless access - FWA, 4G and satellite). Internet access at home is provided mainly through fixed technologies, with stable coverage at 98%. Among these technologies, xDSL continued to have the largest footprint (89%) followed by FWA (58%), FTTP (50%) and DOCSIS 3.0 cable (44%).

Coverage of Next generation access (NGA) technologies (VDSL, VDSL2 vectoring, FTTP, DOCSIS 3.0, DOCSIS 3.1) capable of delivering download speeds of at least 30 Mbps reached 90% in 2021, following a slight increase of 2.9 percentage points compared to the previous year. This mainly resulted from a 7-point growth in FTTP. VDSL coverage remained stable, while cable DOCSIS 3.0 declined slightly (by 0.8 percentage points).

Fixed very high capacity networks (VHCN) covered 70% of EU homes in 2021, up from 60% in the previous year. FTTP deployments were mainly responsible for this increase.

Regarding mobile technologies, while 4G coverage of populated areas is almost universal, reaching 99.8%, 5G commercial services were launched in all but two Member States (Latvia and Portugal) by mid-2021. 5G coverage grew substantially from 14% in 2020 to 66% of populated areas in 2021.

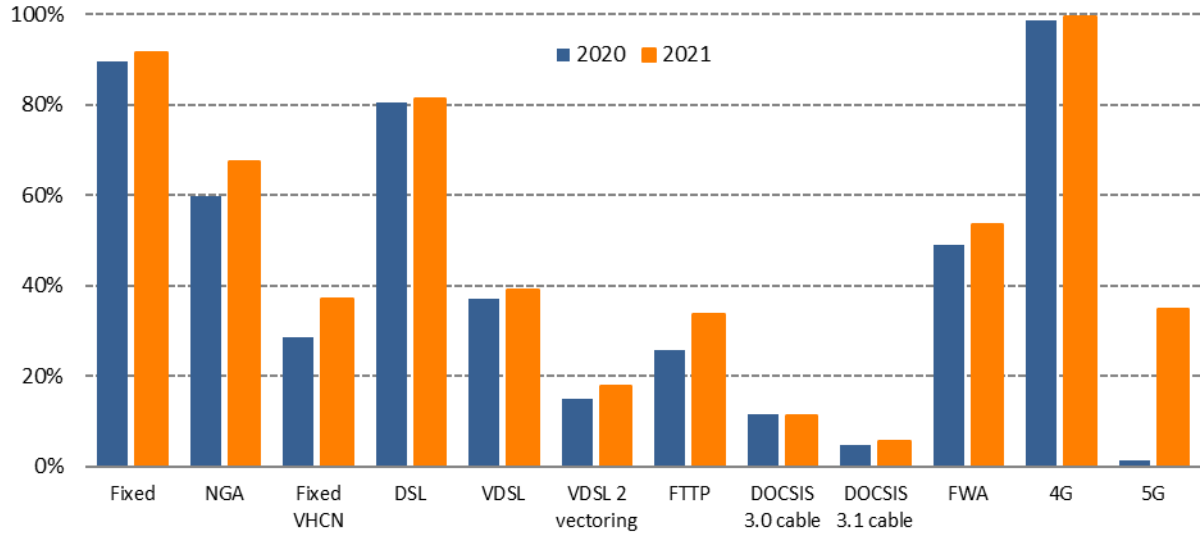
Figure 15 Total coverage by technology at EU level (% of households, % of populated areas for 4G and 5G), 2020-2021



Source: IHS Markit, Omdia and Point Topic, Broadband coverage in Europe studies

Broadband coverage of rural areas[35] remains challenging, as 8.5% of households are not covered by any fixed network, and 32.5% are not served by any NGA technology. However, 4G is widely available also in rural areas (99.6%). On fixed technologies, there was a marked increase in the rural coverage of FTTP (from 26% in 2010 to 34% in 2021).

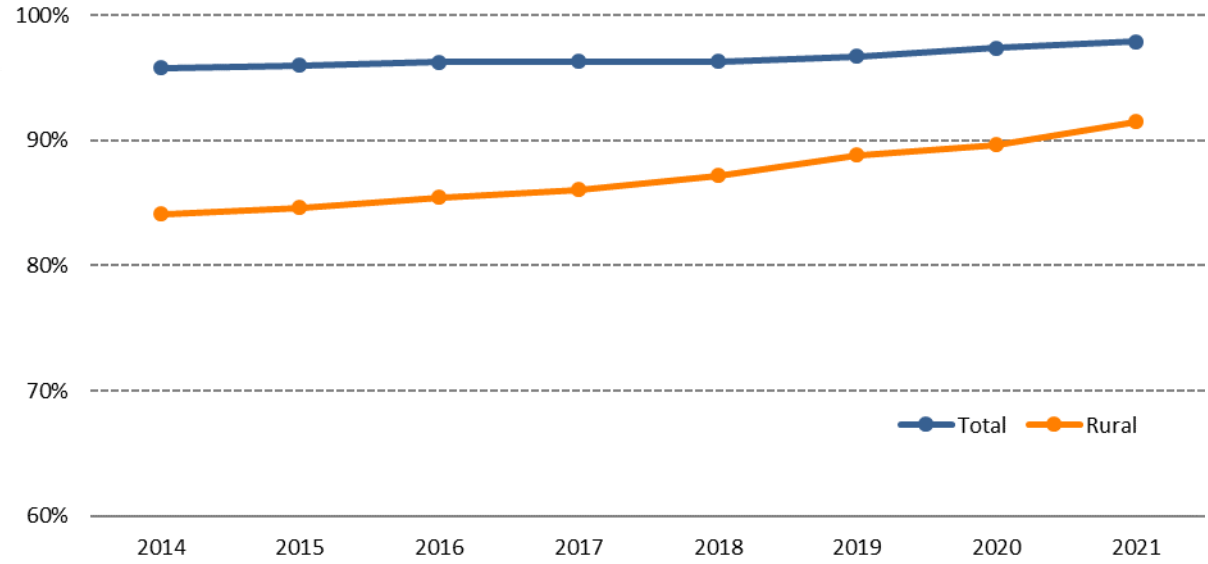
Figure 16 Rural coverage by technology at EU level (% of households, % of populated areas for 4G and 5G), 2020 – 2021



Source: IHS Markit, Omdia and Point Topic, Broadband coverage in Europe studies

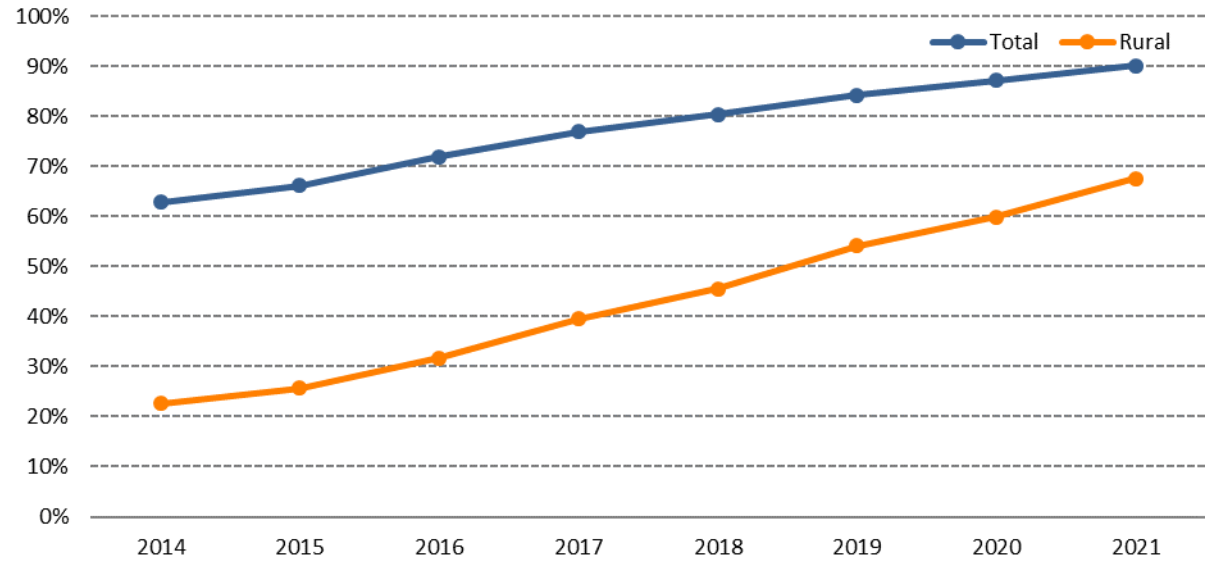
[35] For the definition of rural areas see sub-chapter '3.2 Defining households and rural areas' in the methodology of the study 'Broadband Coverage in Europe 2018', page 16, by IHS Markit and Point Topic (https://ec.europa.eu/digital-single-market/en/news/study-broadband-coverage-europe-2018).

Figure 17 Fixed broadband coverage in the EU (% of households), 2014 - 2021



Source: IHS Markit, Omdia, Point Topic and VVA, Broadband coverage in Europe studies

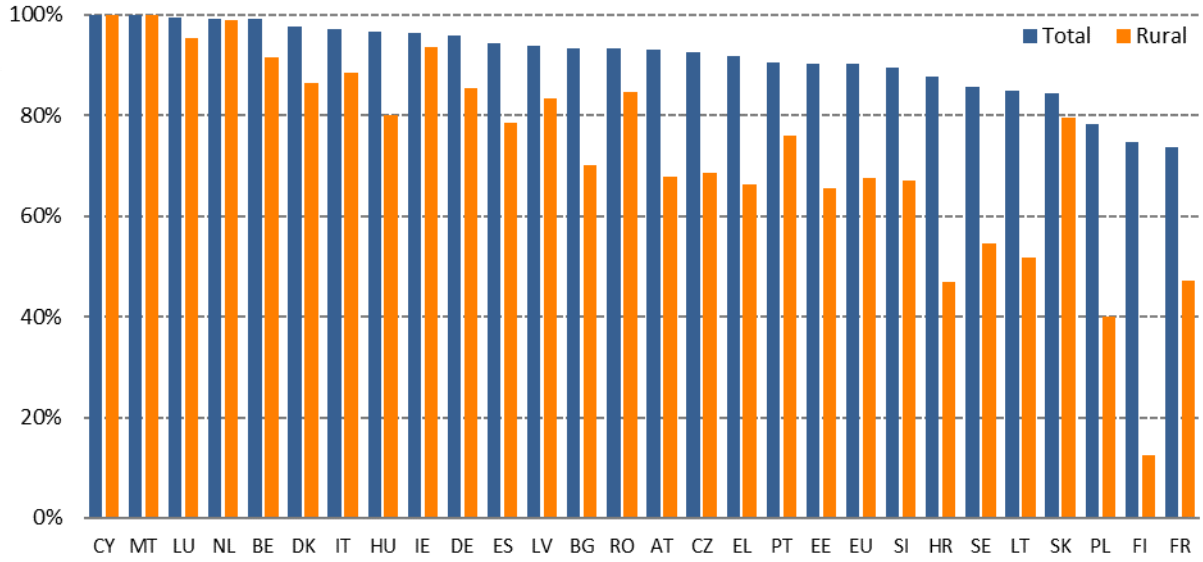
Figure 18 Next generation access (NGA) broadband coverage in the EU (% of households), 2014-2021



Source: IHS Markit, Omdia, Point Topic and VVA, Broadband coverage in Europe studies

In Cyprus, Malta, Luxembourg, the Netherlands and Belgium, NGA is available in more than 99% of households. The situation remained challenging in France (74%), Finland (75%) and Poland (78%).

Figure 19 Next generation access (NGA) broadband coverage in the EU (% of households), mid-2021



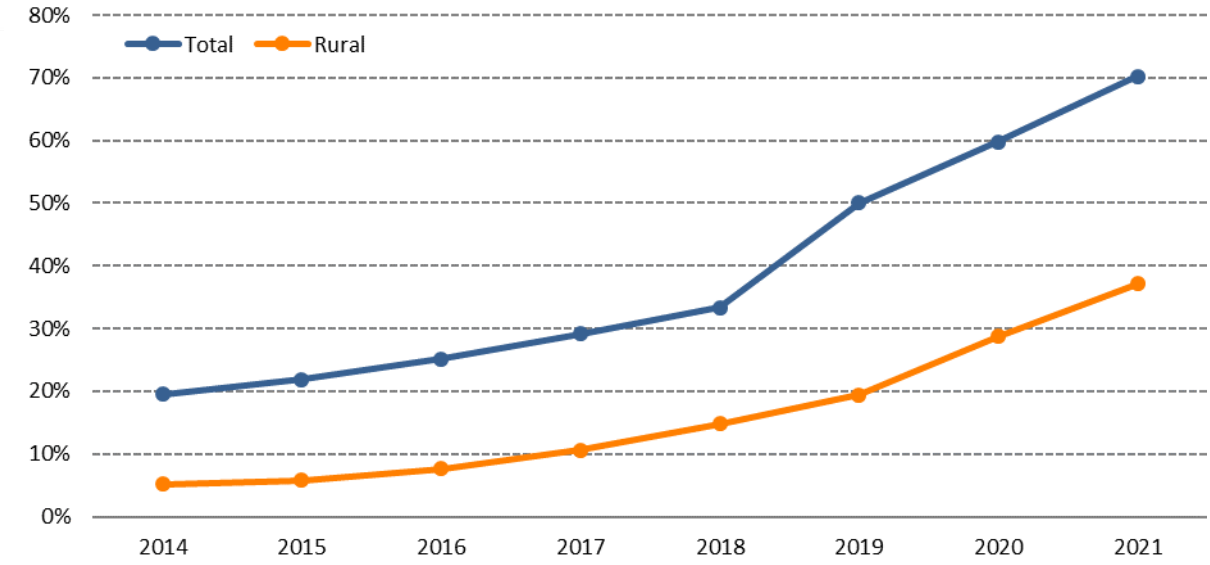
Source: IHS Markit, Omdia and Point Topic, Broadband coverage in Europe studies

VHCN coverage increased significantly between 2014 and 2020 from 19.5% to 70%. Coverage more than doubled in the last three years, thanks to the upgrade of cable networks to DOCSIS 3.1 (e.g. in Malta, Luxembourg, the Netherlands, Belgium, Denmark and Germany) and accelerated FTTP deployments (e.g. in Ireland, Cyprus, Bulgaria, Hungary, France and Romania).

In rural areas, growth was lower, but still substantial, from 4% to 37% over the same time period. The large gap between total and rural VHCN coverage shows the regional disparities in digital opportunities and confirms that more investment is needed for rural areas to catch up.

To close the digital divide in rural and remote areas, the EU supports investments in an unprecedented manner. Around EUR 16 billion RRF reforms and investments have already been approved to roll out digital connectivity networks in the next four years, especially in rural regions. Moreover, the EU will also leverage connectivity investments through the new Cohesion Funds, the EAFRD, InvestEU and EIB loans, and, last but not least, through CEF Digital. CEF Digital, a programme directly managed by the Commission through its HADEA Agency, will grant EUR 2 billion over 7 years for high-performance connectivity infrastructures, with the aim of leveraging between EUR 3 and 6 billion targeted investments in line with the 2030 digital connectivity targets.

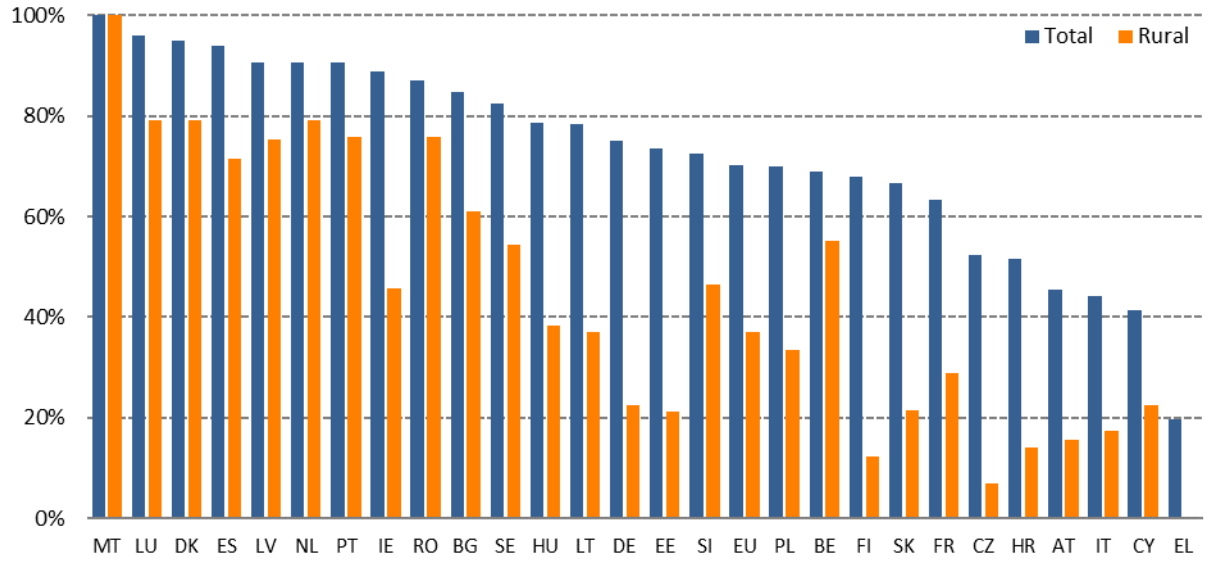
Figure 20 Fixed very high capacity network (VHCN) coverage (% of households) in the EU, 2014-2021



Source: IHS Markit, Omdia and Point Topic, Broadband coverage in Europe studies

In mid-2021, Malta was leading with 100% of VHCN coverage, followed by Luxembourg, Denmark Spain, Latvia, the Netherlands and Portugal with above 90% coverage. The poorest performers were Greece (20%), Cyprus (41%), Italy (44%) and Austria (45%). There has been significant progress in Hungary (30 percentage points), Czechia and Germany (each 19 percentage points).

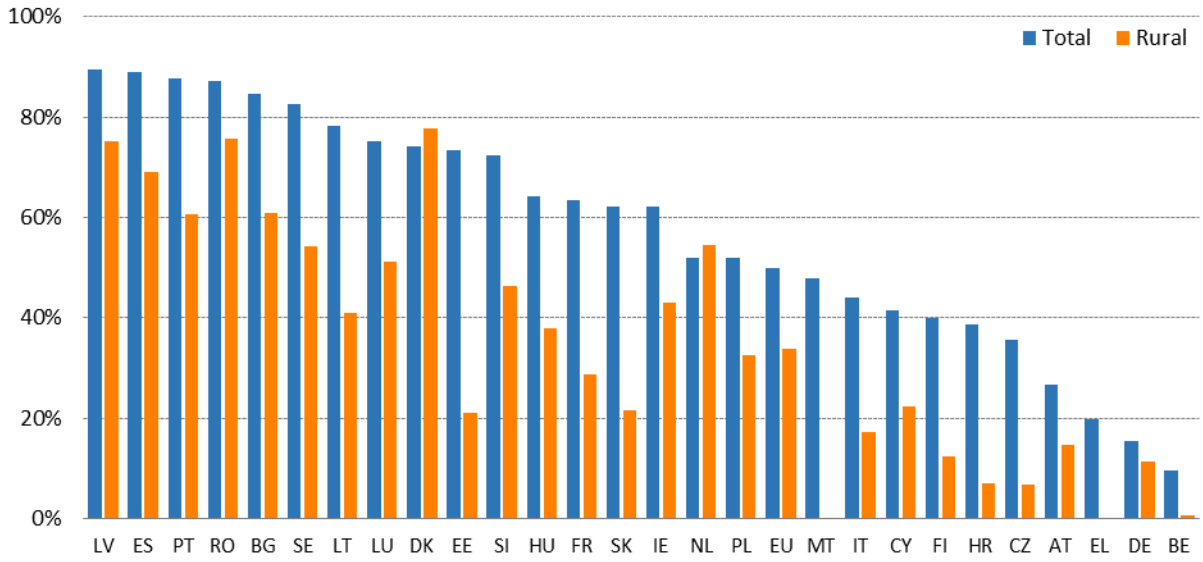
Figure 21 Fixed very high capacity network (VHCN) coverage (% of households), mid-2021



Source: IHS Markit, Omdia and Point Topic, Broadband coverage in Europe studies

Fibre to the premises (FTTP) coverage doubled in the last 5 years and reached 50% in 2021 in the EU. Latvia, Spain, Portugal, Romania and Bulgaria are leading with at least or above 85% FTTP coverage. Belgium, Germany and Greece are lagging behind the other EU countries, with below 20% coverage. Rural FTTP coverage is much lower than overall coverage, standing at 34%.

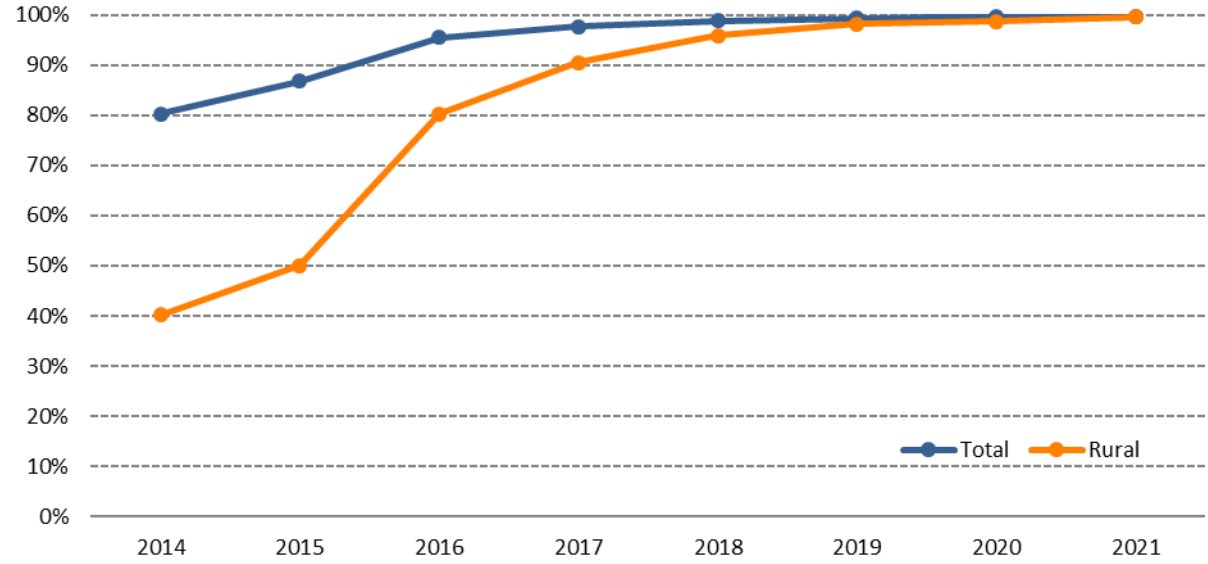
Figure 22 Fibre to the Premises (FTTP) coverage (% of households), mid-2021



Source: IHS Markit, Omdia and Point Topic, Broadband coverage in Europe studies

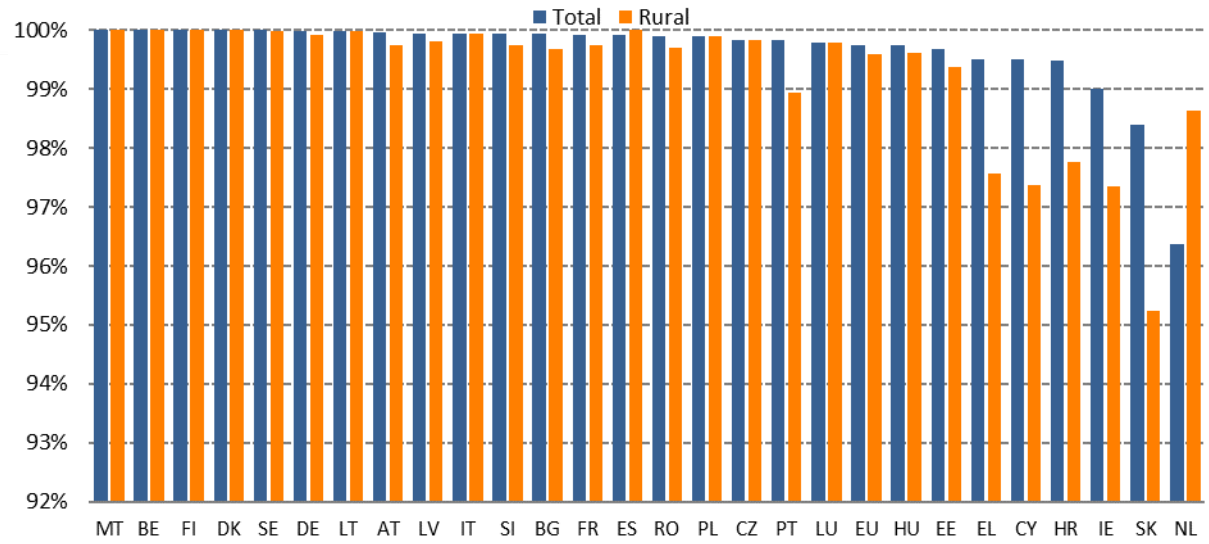
4G is almost ubiquitous with 99.8% of populated areas covered by at least one operator in the EU, being even more widely available than fixed broadband (97.9%). In the last three years, the gap between rural and overall 4G coverage closed. Rural coverage stood at 99.6% in 2021. All Member States have well above 95% coverage of 4G.

Figure 23 4G mobile coverage in the EU (% of populated areas), 2014-2021



Source: IHS Markit, Omdia, Point Topic and VVA, Broadband coverage in Europe studies

Figure 24 4G mobile coverage (% of populated areas), mid-2021



Source: IHS Markit, Omdia and Point Topic, Broadband coverage in Europe studies

The 5G spectrum indicator in the DESI shows the portion of spectrum assigned for 5G purposes in each Member State in the 5G pioneer bands identified in the EU. The percentage score of the 5G spectrum indicator is based on the amount of spectrum assigned in a specific Member State and ready for 5G use.

This score is calculated based on the portion of spectrum assigned in each 5G pioneer band in comparison with the maximum feasible amounts, which are as follows:

- 700 MHz band: 60 MHz (703-733 & 758-788 MHz);
- 3.6 GHz band: 400 MHz (3,400-3,800 MHz);
- 26 GHz band: 1000 MHz within 24,250-27,500 MHz.

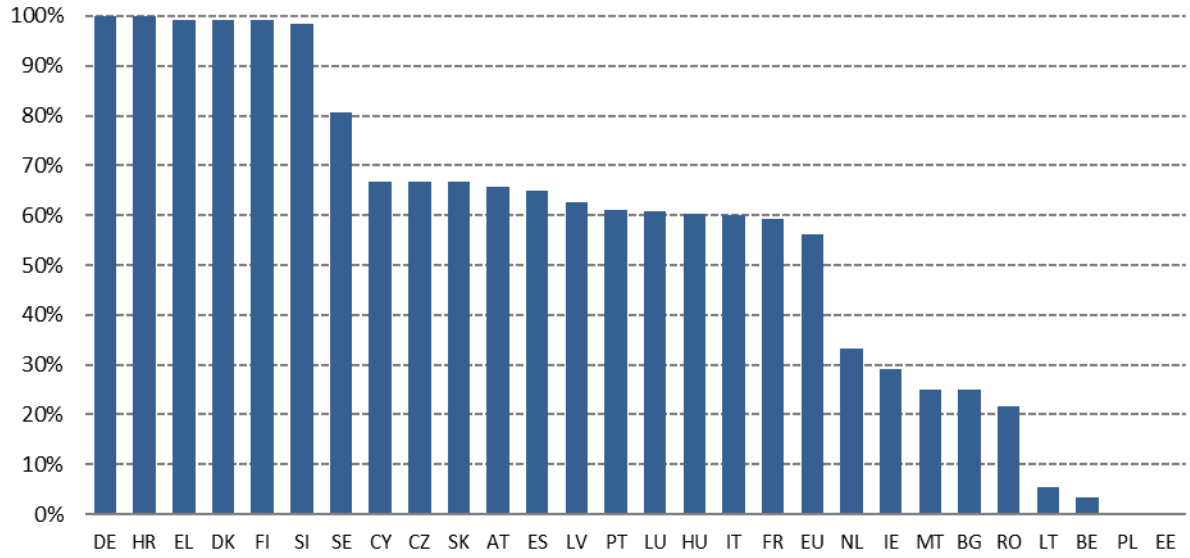
All three spectrum bands have an equal weight, so having the maximum feasible amount assigned – and ready for 5G use – in the range of one of these bands will result in a score of 33.3%, i.e. one third of the total maximum score.

Remarks:

1. For the 700 MHz band, there are a number of derogations allowing for a delay until 30 June 2022. However, the 5G spectrum indicator is about factual reporting, not a judgement on legal compliance.
2. For the 3,400-3,800 MHz band, only licences aligned with the latest technical conditions (in line with Commission Implementing Decision (EU) 2019/235) were considered ready for 5G use.
3. For the 26 GHz band, at least a portion of 1,000 MHz within the band must be assigned and ready for 5G use, as required by the European Electronic Communications Code.

By the end of March 2022, 25 of the 27 Member States had assigned spectrum in the 5G pioneer bands. Germany, Croatia, Denmark, Greece, Finland and Slovenia assigned more than 90% of spectrum. On the other hand, Estonia and Poland have not yet assigned any 5G spectrum (according to the conditions mentioned above).

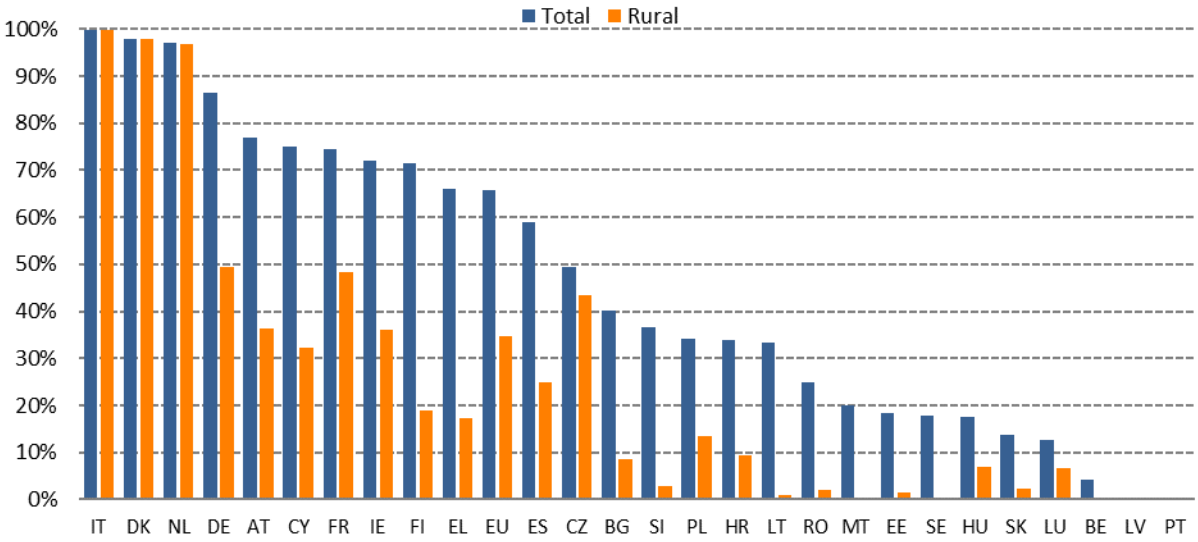
Figure 25 5G spectrum (assigned spectrum as a % of total harmonised 5G spectrum), end of March 2022



Source: Communications Committee (COCOM) based on iDATE

Following the spectrum assignments, 25 Member States started commercial 5G network deployments by mid-2021. 5G coverage increased substantially from 14% of populated areas in 2020 to 66% in 2021. Highest coverage levels were recorded in Italy, Denmark and the Netherlands, all three being above 90%. A significant share of this coverage was achieved using 4G spectrum (60% of 5G enabled base stations) rather than 5G pioneer bands, which allow for higher performance potential. Spectrum sharing is deployed by operators in order to accelerate their 5G rollouts, but also to optimise overall spectrum use. This is a solution to enable frequency sharing between 5G and 4G (and sometimes 3G too). An area has 5G coverage if it is in the stated coverage area for at least one 5G mobile network as reported by operators and national regulatory authorities. It is expressed as the percentage of populated areas. The user experience is not measured in this indicator and it may be affected by a variety of factors such as the spectrum, the device used, environmental conditions, number of concurrent users and network capacity. Such factors make it difficult to compare operators' 5G rollouts using just population coverage metrics, headline data rates, etc.

Figure 26 5G mobile coverage (% of populated areas), mid-2021

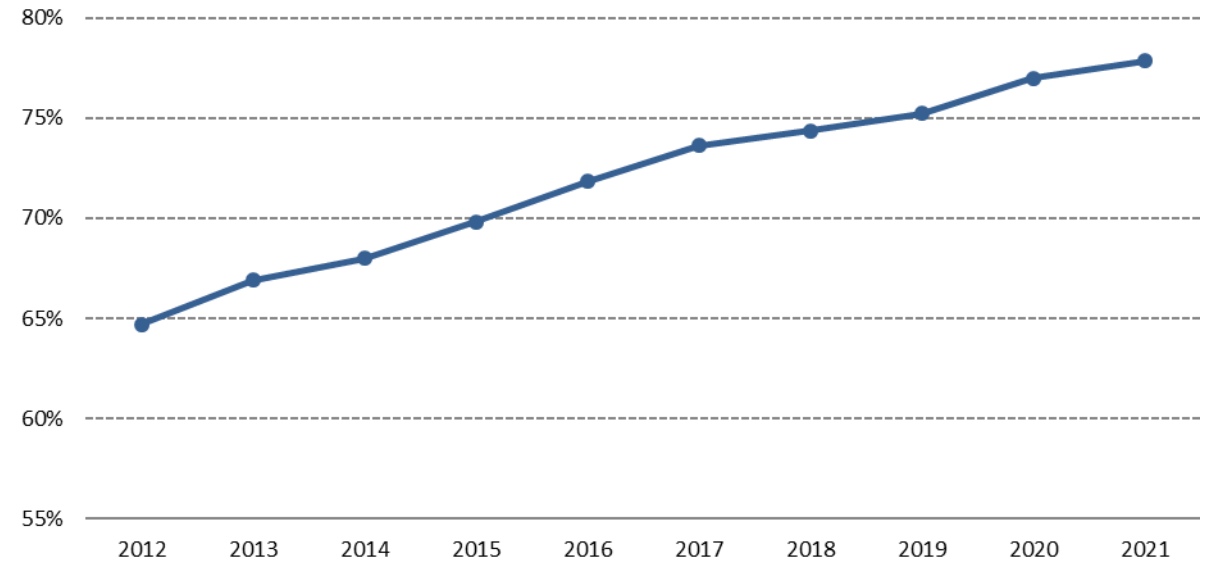


Source: IHS Markit, Omdia and Point Topic, Broadband coverage in Europe study

3.1.2. Fixed broadband take-up

Over three quarter of EU households (78%) had a fixed broadband subscription in 2021, following a steady growth) over the last 9 years.

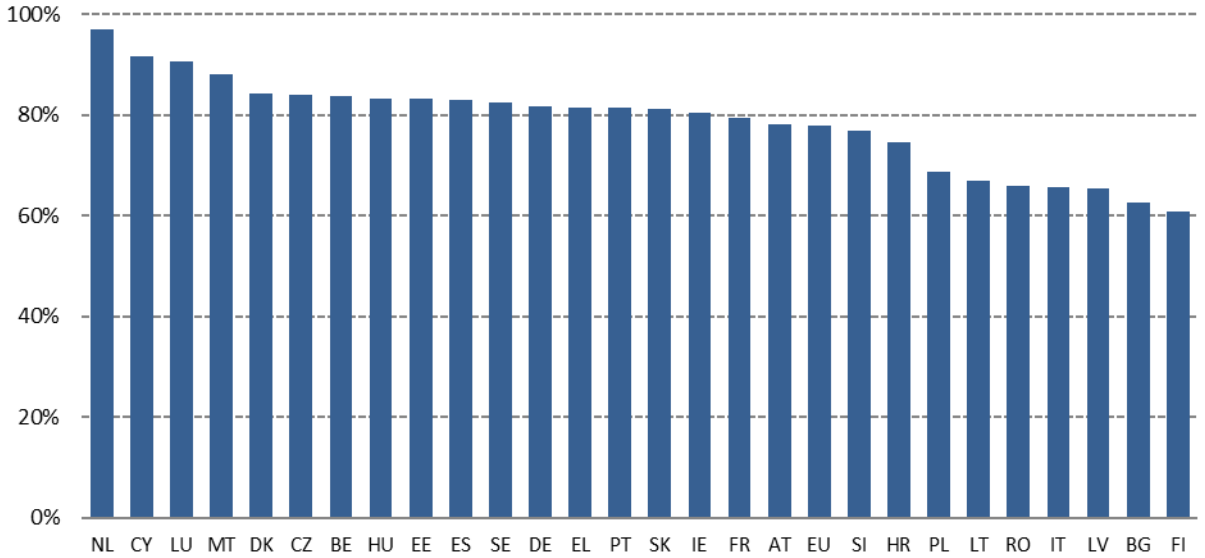
Figure 27 Households with a fixed broadband subscription in the EU (% of households), 2012-2021



Source: Eurostat, European Union survey on ICT usage in Households and by Individuals

National take-up rates ranged from 61% to 97%. The Netherlands, Cyprus, Luxembourg and Malta registered the highest figures, while Finland, Bulgaria, Latvia, Romania, Lithuania and Poland registered the lowest. The relatively low take-up rates in Finland may partly be due to fixed-mobile substitution. In Bulgaria, Latvia, Romania and Poland, the very low levels of basic digital skills could contribute to the low take-up of fixed broadband.

Figure 28 Households with a fixed broadband subscription (% of households), 2021



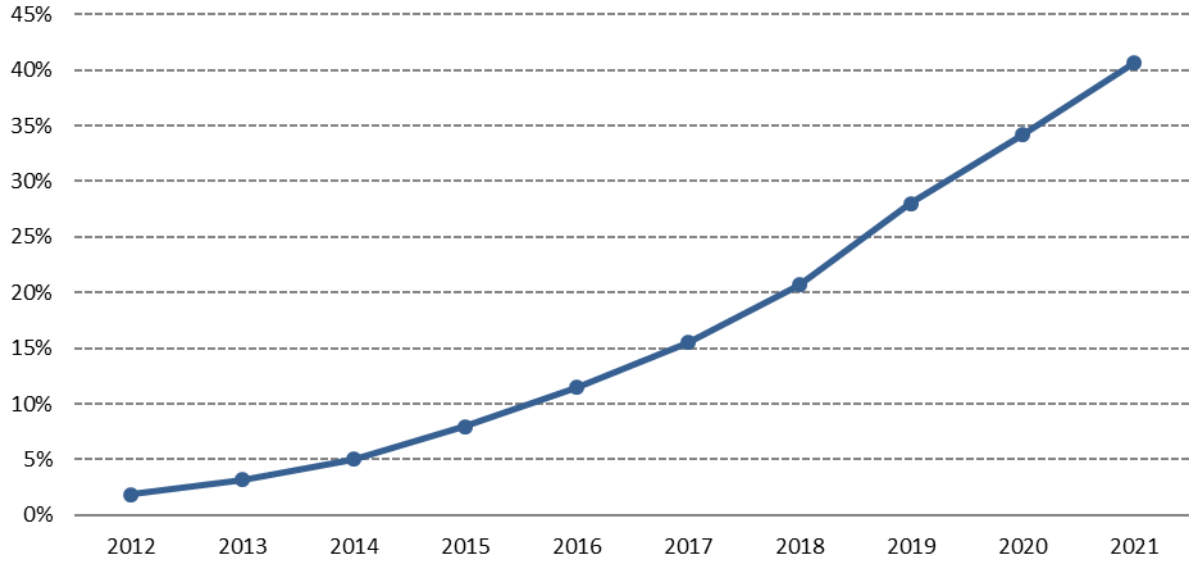
Source: Eurostat, European Union survey on ICT usage in Households and by Individuals

Similarly to broadband coverage, there is still a large difference between urban and rural figures. Only 70% of rural households have a fixed broadband subscription compared with 83% of households

in cities. The rural-urban gap is the largest in Finland (46% vs. 76%), Romania (53% vs. 78%) and Bulgaria (48% vs 72%).

Looking at broadband speeds, there has been a sharp upward trend in at least 100 Mbps fixed broadband penetration since 2012. In 2021, 41% of EU households subscribed to such a service, up from 2% nine years ago.

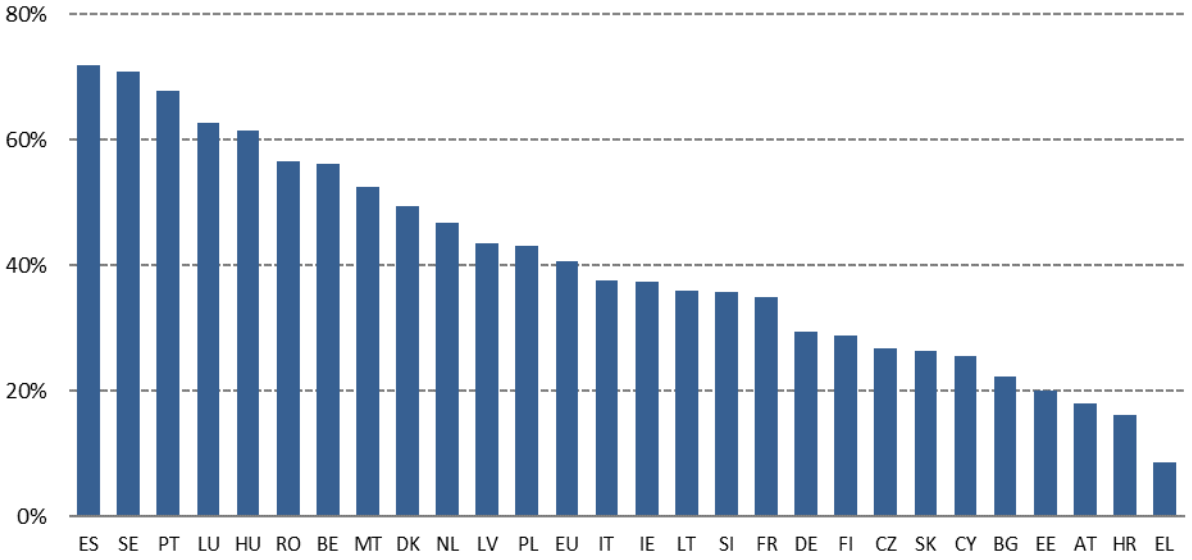
Figure 29 Households with a fixed broadband subscription of at least 100 Mbps (% of households) 2012 – 2021



Source: Estimated based on the European Union survey on ICT usage in Households and by Individuals and data from the Communications Committee (COCOM)

Spain, Sweden, Portugal, Luxembourg and Hungary lead on this indicator with over 60% of households subscribing to at least 100 Mbps. In Greece, Croatia and Austria, by contrast, uptake is very low (less than 20%).

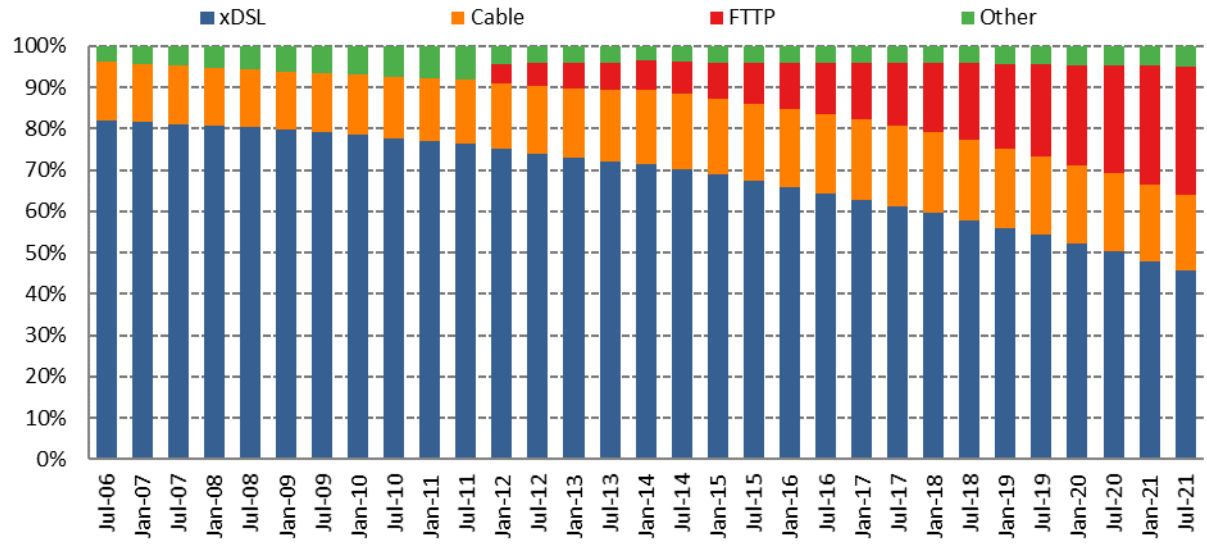
Figure 30 Households with a fixed broadband subscription of at least 100 Mbps (% of households), 2021



Source Estimated based on the European Union survey on ICT usage in Households and by Individuals and data from the Communications Committee (COCOM)

xDSL remained the most widely used fixed broadband technology, although its market share decreased to 46% in 2021 from 82% in 2006. FTTP became xDSL's main challenger over the last years: the share of FTTP lines increased from 5% in 2012 to 31% in 2021. Cable lines[36] represented 18% of fixed broadband lines in 2021, compared with 14% in 2006.

Figure 31 Fixed broadband subscriptions – technology market shares in the EU (% of subscriptions), July 2006-July 2021[37]



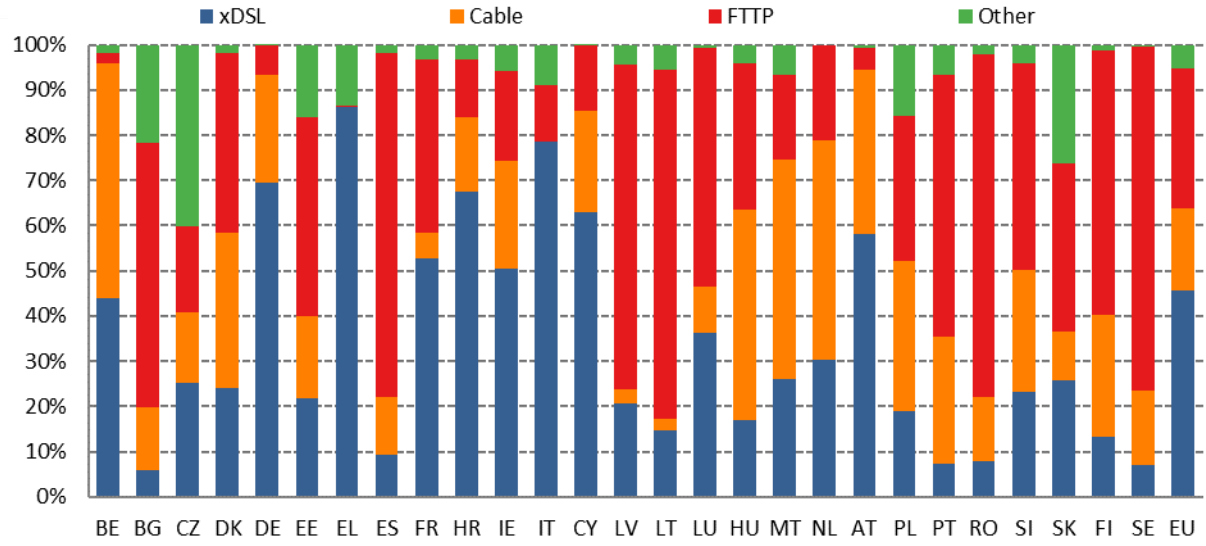
Source: Communications Committee (COCOM)

The market share of xDSL varies from 6% to 86% and is generally lower in Eastern Europe, where FTTP is more widely used. Cable is present in all but two Member States (Greece and Italy).

xDSL is particularly prevalent in Greece (86%) and Italy (79%), and has the lowest market share in Bulgaria, Sweden, Portugal, Romania, and Spain (below 10%). FTTP is the most widely used technology in a growing number of Member States, and has the highest market share in Lithuania (77%), Spain, Sweden, Romania (76% each) and Latvia (72%). On the other hand, cable is dominant in Belgium (52%), the Netherlands, Malta (both at 48%) and Hungary (46%).

[36] Any DOCSIS standard.
[37] FTTP is part of 'other' technologies until June 2011 on the chart.

Figure 32 Fixed broadband subscriptions – technology market shares in the EU (% of subscriptions), July 2021

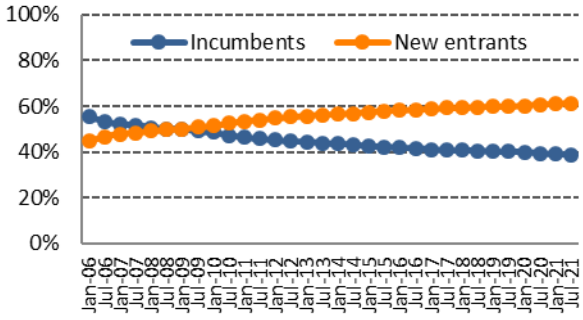


Source: Communications Committee (COCOM)

Market shares are calculated at national level for incumbents and new entrants. However, broadband markets are geographically fragmented, suggesting that a large number of households are served by only one provider (most likely the incumbent operator).

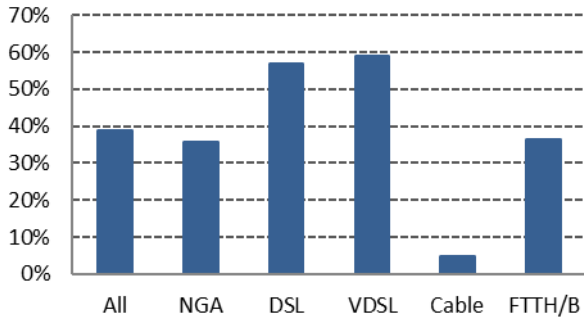
New entrant operators continued to slightly gain market share and held 61.3% of fixed lines in 2021, compared with 45% in 2006. The market share of incumbents is the highest in Luxembourg (61%), Cyprus (57%), Estonia (56%) and Latvia (54%) while it is lowest in Romania (14%) and Czechia (22%). However, incumbent operators remained predominant in the xDSL market.

Figure 33 Fixed broadband subscriptions – operator market shares in the EU (% of subscriptions), January 2006-July 2021



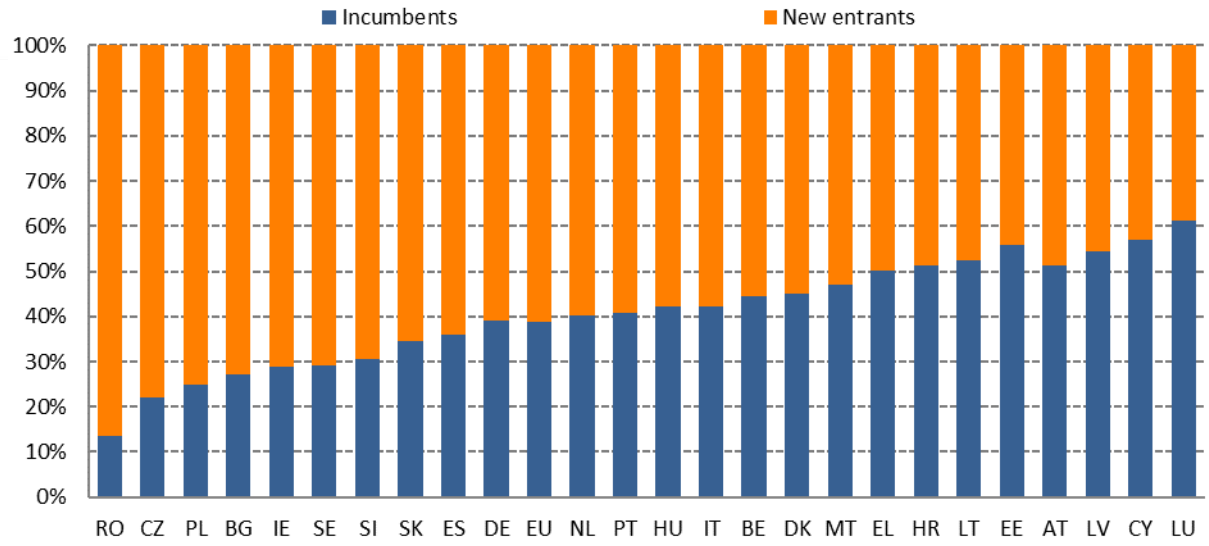
Source: Communications Committee (COCOM)

Figure 34 Incumbent operator market share by technology in the EU (% of subscriptions), July 2021



Source: Communications Committee (COCOM)

Figure 35 Fixed broadband subscriptions – operator market shares in the EU (% of subscriptions), July 2021

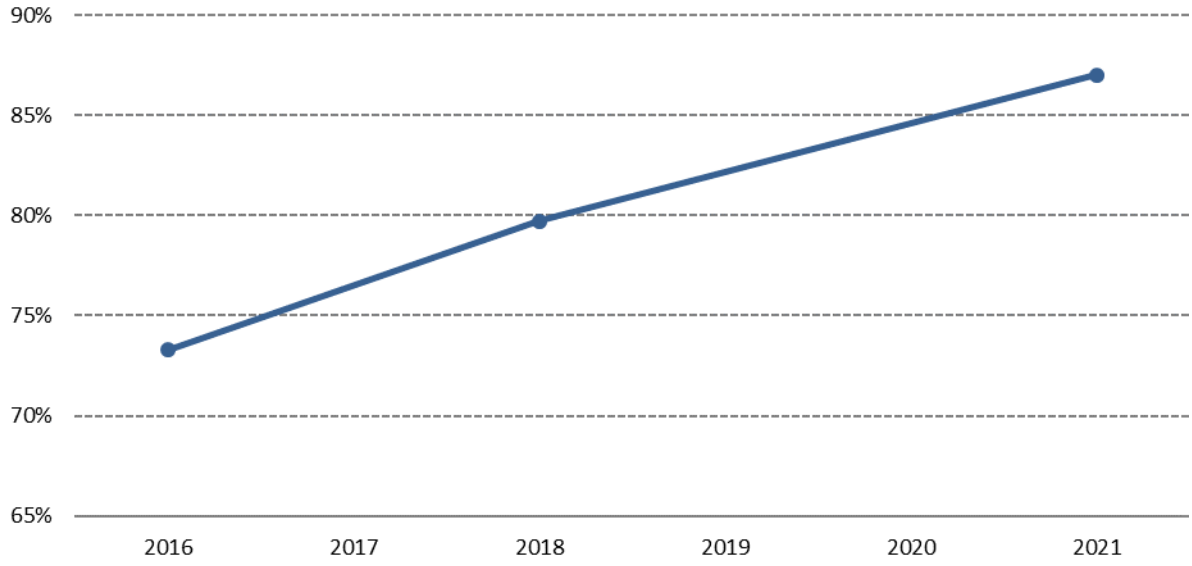


Source: Communications Committee (COCOM)

3.1.3. Mobile broadband take-up

In 2021, 87% of people used a mobile device to access the internet (up from 73% in 2016), which corresponds to the number of regular internet users (87% of people in 2021).

Figure 36 Mobile broadband penetration in the EU (% of individuals), 2016-2021[38]

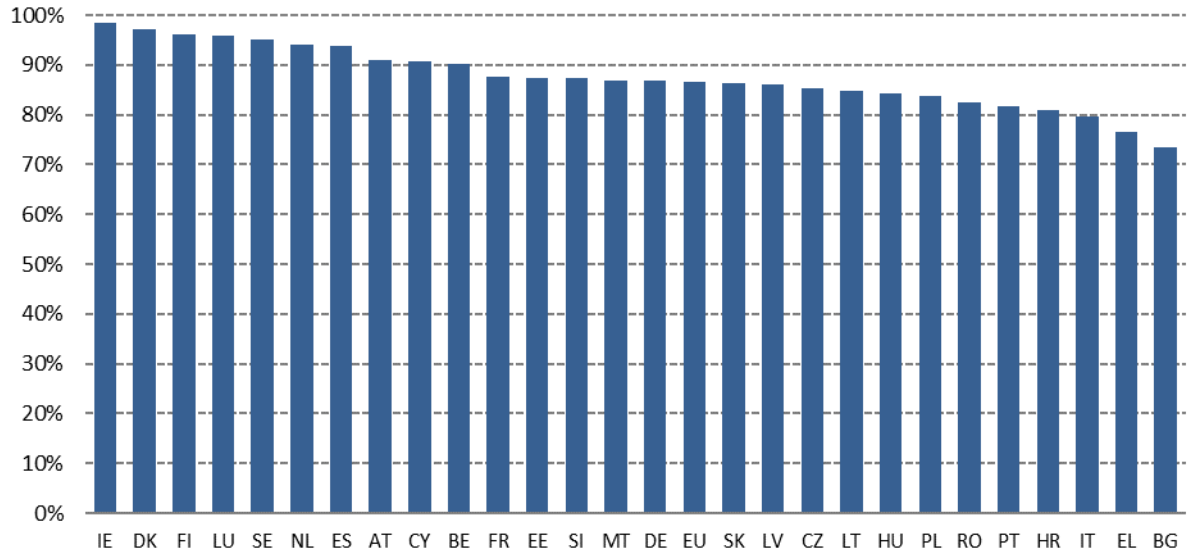


Source: Eurostat, European Union survey on ICT usage in Households and by Individuals

Mobile broadband is widely used in every Member State; national penetration rates vary between 73% in Bulgaria and 98% in Ireland.

[38] Data refers to individuals using a mobile device to access the internet.

Figure 37 Mobile broadband penetration (% of individuals), 2021[39]



Source: Eurostat, European Union survey on ICT usage in Households and by Individuals

Mobile broadband is, however, still mainly complementary to fixed broadband, when it comes to subscriptions for households. Europeans primarily use fixed technologies at home to access the internet (even if using a mobile device). In 2021, 13% of EU households accessed the internet only through mobile technologies. Finland (34% of households), Latvia (24%), Poland (23%), Romania (22%) and Bulgaria (21%) were the leaders in mobile-only access.

3.1.4. Broadband prices

The Broadband Price Index measures the prices of representative baskets of fixed, mobile and converged broadband offers.

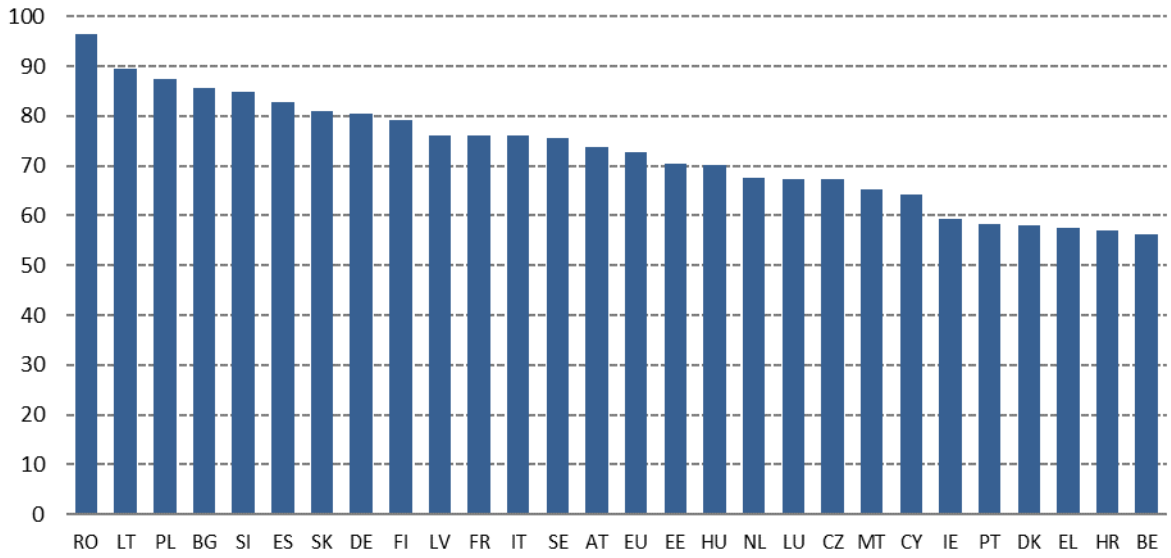
The Broadband Price Index is a score[40] that measures the prices of over 30 representative broadband consumption baskets of different speeds and different products (standalone internet, double play, triple play and quadruple play).

Romania, Lithuania, Poland and Bulgaria have the lowest broadband prices, while Belgium, Croatia and Greece are the most expensive.

[39] Data refers to individuals using a mobile device to access the internet.

[40] 0 to 100, 100 being the best. A score close to 100 means that the country is among the least expensive ones in almost all baskets.

Figure 38 Broadband price index – all baskets (score 0-100, 100 meaning the lowest prices) 2021



Source: Commission, based on Empirica (Retail broadband prices study)

3.2 Semiconductors

Semiconductors are at the centre of strong geostrategic interests and of the global technological race. Currently, in terms of revenues across the semiconductors value chain, the US is the market leader, followed by South Korea, Taiwan, Japan, and the EU, whose revenues are around 10% of the market. The Path to the Digital Decade set the target that the EU's market share should double by 2030.

To date 12 Member States, among the 25 for which the RRPs are adopted[41], have included measures which are expected to cover their participation to the multi-country project on Low Power Processors and Semiconductor Chips, which is expected to contribute to this specific Digital Decade target. The largest expected contributions are from Austria, Germany and Romania.

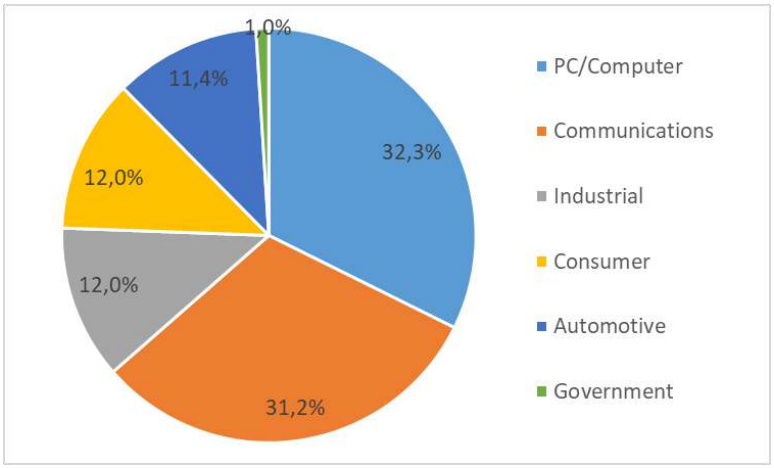
As the digital transition accelerates, worldwide demand for chips will grow rapidly and is expected to exceed USD 1 trillion by 2030, essentially doubling its value in this decade, which means the EU's value of revenues in semiconductors should quadruple by 2030.

The world's leading economies are keen to secure their supply in the most advanced chips as this increasingly conditions their capacity to act (economically, industrially, militarily) and drives the digital transformation. They are already heavily investing and rolling out public support measures to innovate and strengthen their production capacities. The US Chips Act plans to allocate USD 52 billion of public funding to semiconductors manufacturing and R&D until 2026, and this may soon be coupled with tax credits for semiconductor facilities offered by the FABS Act; China is on a path to surpass its targeted USD 150 billion investments in the decade 2015-2025, Japan is offering public support for semiconductor projects, among which USD 8 billion for a new fabrication plant, and South Korea will bolster its semiconductor industry by supporting, through tax incentives, its domestic companies' private investments in R&D and manufacturing, which are estimated at USD 450 billion until 2030.

Looking at the demand side, computing and communication devices represent over 60% of the market, EU chipmakers do not have a strong presence in those segment, whereas they are leaders in the Automotive and Industry automation sectors, where Europe has strong industrial activities. Overall, they control less than 10% of the global semiconductors market share.

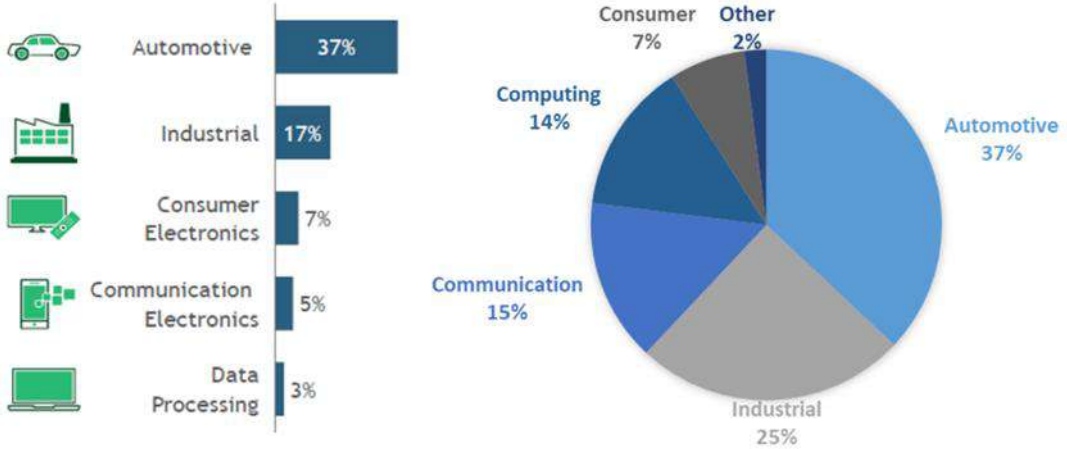
[41] See 1.1 for more details.

Figure 39 Global semiconductor demand by end-use (2020)
(military end-use is included in Government).



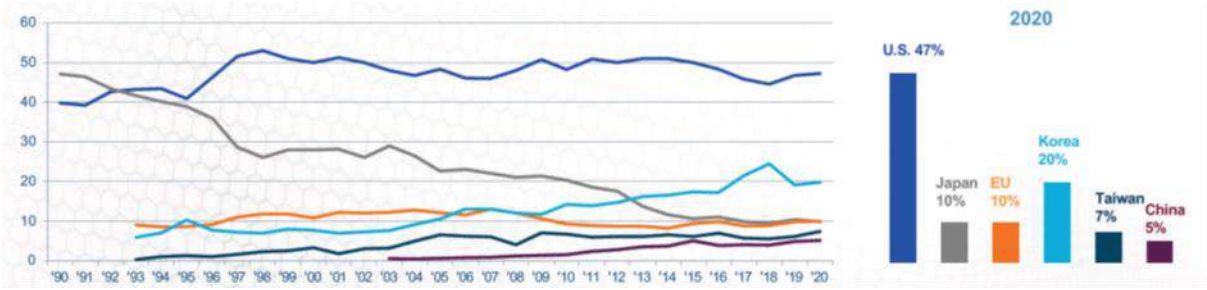
Source: World Semiconductor Trade Statistics (WSTS)

Figure 40 European share of semiconductor market segments, and demand by end market



Source: Decision, ZVEI, 2019

Figure 41 Global market shares in semiconductor industry evolution



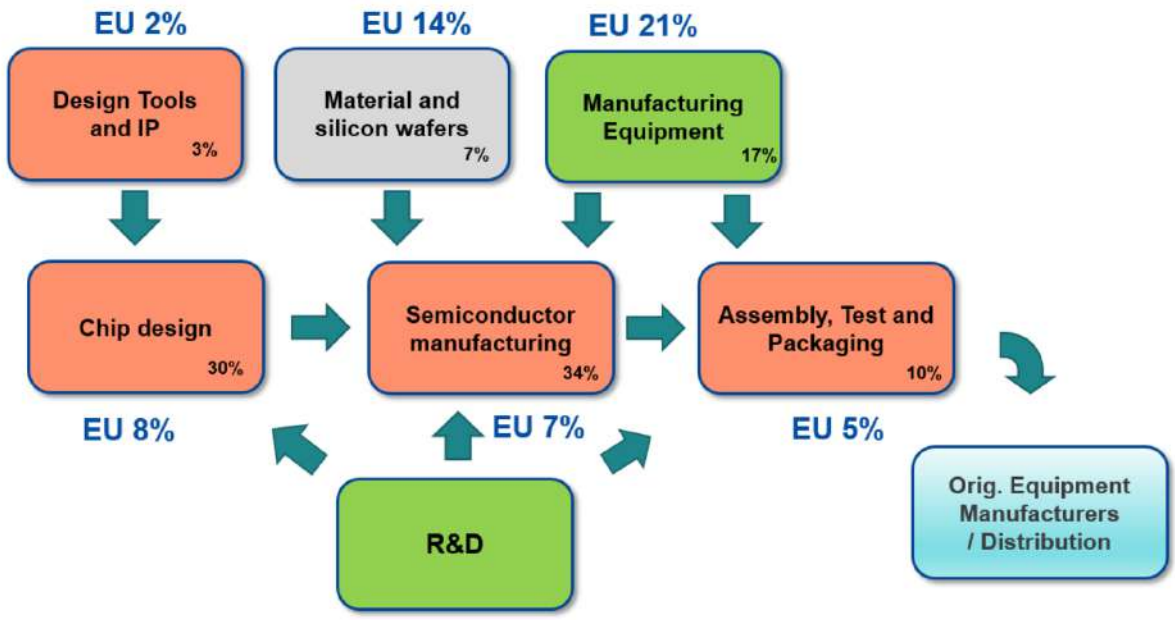
Source: SIA, WSTS, Omdia

In terms of electronic systems, on the other side, Europe's consumption is around 20% of the global market and largely relies on chipsets from third-country suppliers. In case of disruption of the supply chain, Europe's chips' reserves in some industrial sectors, such as automotive, may run out in a few weeks, forcing many European industries to slow down or halt production. Moreover, Europe has limited chip manufacturing capabilities, mainly in mature production nodes (at 22 nm and above), which are suitable for analogue, sensing and power components, but none in leading-edge nodes (at 7 nm and below) necessary for advanced digital processing. Currently, only three companies in the world are able to produce chips below 10nm: Intel, Samsung and TSMC, therefore international

partnerships are necessary to address gaps in this field. Hosting advanced fabrication plants brings multiple benefits to the EU semiconductor ecosystem, with spill-over benefits in terms of competence and innovation.

The EU has core strengths in R&D and in manufacturing equipment (see fig. 41), but besides advanced manufacturing, it must address current weaknesses in chip design and in packaging & assembly, that represent a good part of the added value in the supply chain.

Figure 42 Semiconductor value chain segments with EU market shares



Source: Data in % within each block represents added value of that segment in the value chain (from AT Kearney, CSET, IC insights, WSTS, SEMI)

Several factors explain why the EU is lagging in the semiconductor race. Investment has been insufficient to keep up with the sector growth. Moreover, the production of semiconductors in Europe has focused on satisfying the demand of important sectors in the EU, such as the automotive, which do not require the use of the most advanced semiconductors. Consequently, the European semiconductor sector had limited incentives to evolve and keep up with the technological advances of US, Korean and Taiwanese firms. Against this backdrop, reaching the Digital Decade target will require major public and private investments, not only to increase production and designing capacity but also to boost the knowledge needed to produce cutting-edge semiconductors.

The European Chips Act, proposed by the European Commission on 8 February 2022, seeks to strengthen the European semiconductor ecosystem, increasing the resilience of supply chains and reducing external dependencies. It is a key step for the EU's technological sovereignty. It also aims to ensure Europe's achievement of the relevant Digital Decade target.

4 Integration of digital technology

Digital technologies enable businesses to gain competitive advantage, improve their services and products and expand their markets.

In a recent study by McKinsey, 93% of surveyed EU executives believe that better access to data would be important to their organisation (with approximately 40% designating this as very important)[42]. Research by the Organisation for Economic Co-operation and Development (OECD) suggests that productivity of companies investing in data-driven innovation and data analytics grows by approximately 5% to 10% faster than that of companies not investing[43].

The EU's digital sovereignty will depend on the capacity to store, extract and process data while satisfying requirements of trust, security and fundamental rights[44]. This requires a high-capacity infrastructure and the adoption of innovative technologies, which will enable the development of energy-saving, climate-neutral, high-efficiency and interconnected services. Additionally, the EU's digital sovereignty should be restored through more resilient supply chains and less dependence on imports, notably of semiconductors.

This DESI dimension measures the digitalisation of businesses and e-commerce and in particular the uptake of digital technologies by businesses from a very basic to an advanced level. These include electronic information sharing, the use of social media, but also the use of more advanced technologies such as big data analytics, cloud services and artificial intelligence (AI). Specific emphasis is put on e-Commerce, with indicators related to SMEs selling online both nationally and in other EU countries (i.e., cross-border), and the share of turnover stemming from these. These indicators are sourced from the European Union survey on ICT usage and e-commerce in enterprises. Given the growing importance of sustainability within enterprises, the indicator on ICT for environmental sustainability captures the share of enterprises having medium/high intensity of green action[45] through ICT.

In its Path to the Digital Decade proposal, the European Commission set out the following ambitious targets to be reached by 2030 in the Integration of Digital technologies dimension: more than 90% of European SMEs to reach at least a basic level of digital intensity, 75% of EU companies to use cloud, AI and big data and grow scale ups & finance to double EU Unicorns. The DESI monitors the implementation of the first two groups of targets on basic digital intensity and adoption of advanced technologies. Digital intensity is measured via the Digital Intensity Index (DII) (details provided below). As the target for unicorns is set at EU level, it is not included in the DESI index, which compares performance on a Member State level. A separate section below is dedicated to unicorns.

Significant amounts of RRF funding could directly or indirectly contribute to the Digital Decade targets related to the digitalisation of business, including measures worth EUR 24 billion supporting the digitalisation of business and the measures worth EUR 18 billion supporting digital-related R&D and the deployment of digital capacities.

23 Member States propose investments (and some also reforms) generally supporting the digitalisation of businesses, with the largest investments coming from Italy, Spain, Germany and Greece. A multi-country project establishing a network of European Digital Innovation Hubs is also supported in 8 RRPs[46].

[42] McKinsey. Shaping the digital transformation in Europe, September 2020.
[43] OECD (2015). *Data-driven innovation: big data for growth and well-being*, OECD Publishing, Paris.
[44] Strategic Foresight Report 2021, COM (2021)750 final.
[45] For a list of green actions, see p. 12 of the DESI 2021 report on the Integration of digital technology (https://ec.europa.eu/newsroom/dae/redirection/document/80555)
[46] See 1.1 for more details.

Table 7 Integration of digital technology indicators in DESI

	EU DESI 2020	EU DESI 2022
3a1 SMEs with at least a basic level of digital intensity % SMEs	**NA**	**55%** 2021
3b1 Electronic information sharing % enterprises	**36%** 2019	**38%** 2021
3b2 Social media[47] % enterprises	**23%** 2019	**29%** 2021
3b3 Big data % enterprises	**12%** 2018	**14%** 2020
3b4 Cloud[48] % enterprises	**NA**	**34%** 2021
3b5 AI % enterprises	**NA**	**8%** 2021
3b6 ICT for environmental sustainability % enterprises having medium/high intensity of green action through ICT	**NA**	**66%** 2021
3b7 e-Invoices % enterprises	**25%** 2018	**32%** 2020
3c1 SMEs selling online % SMEs	**17%** 2019	**18%** 2021
3c2 e-Commerce turnover % SME turnover	**11%** 2019	**12%** 2021
3c3 Selling online cross-border % SMEs	**8%** 2019	**9%** 2021

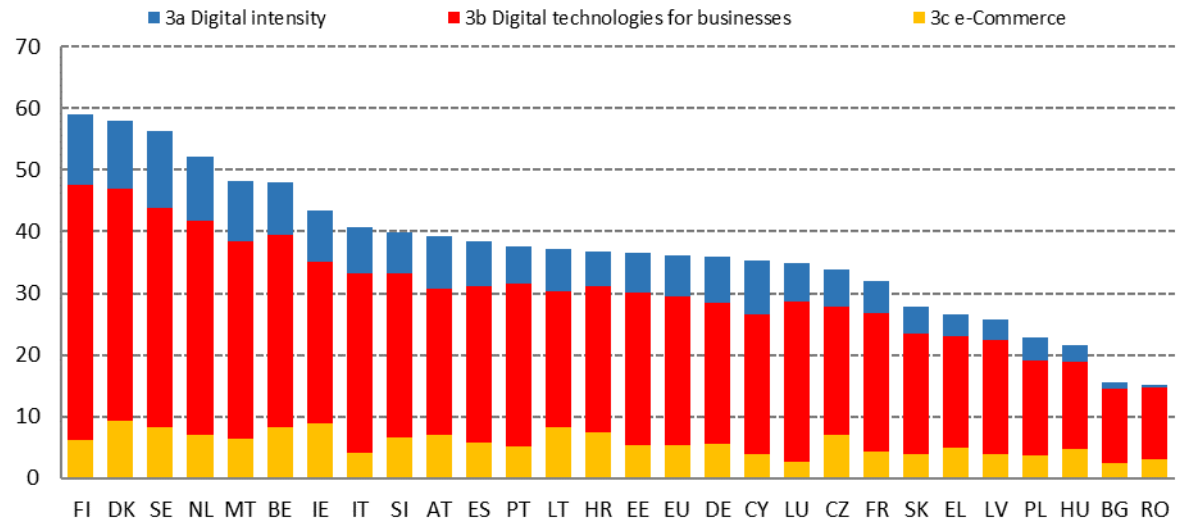
Source: DESI 2022, European Commission.

The top performers in the integration of digital technologies are Finland, Denmark and Sweden. Romania, Bulgaria and Hungary show the weakest performance.

[47] For social media the Eurostat indicator *'Use two or more social media'* (code: E_SM1_GE2) is used. See DESI methodological manual.

[48] For cloud the Eurostat indicator '*Enterprises buying sophisticated or intermediate cloud computing services' (code:* E_CC1_SI) is used. See DESI methodological manual.

Figure 43 Digital Economy and Society Index (DESI) 2022, Integration of digital technology



Source: DESI 2021, European Commission.

4.1 Digital Intensity Index[49]

The Digital Intensity Index (DII) measures the use of different digital technologies at enterprise level. The DII score of an enterprise is based on counting how many out of 12 selected technologies are used.

Figure 43 shows the composition of the DII in 2021. It also shows the degree of penetration and speed of adoption of the different technologies monitored by the DII. Large companies in the EU are more digitised than SMEs. While some aspects seem to be reaching saturation, at least for large companies, there is still room for improvement for most indicators.

Figure 44 Digital Intensity Index indicators tracking digitisation processes (% enterprises), 2021[50]

	Large	SMEs
The maximum contracted download speed of the fastest fixed line internet connection is at least 30 Mb/s	95%	80%
Use any social media	83%	58%
Enterprises where more than 50% of the persons employed used computers with access to the internet for business purposes	58%	49%
Use of any cloud service	72%	40%
Have ERP software package to share information between different functional areas	81%	37%
Have CRM	65%	34%
Buy intermediate-sophisticated CC services	60%	33%
Use of at least 2 social media	61%	28%
Use any IoT	48%	28%
Enterprises with e-commerce sales of at least 1% turnover	38%	18%
Enterprises where web sales are more than 1% of the total turnover and B2C web sales more than 10% of the web sales	12%	11%
Use any AI technology	28%	7%

Source: Eurostat, European Union survey on ICT usage and e-commerce in enterprises.

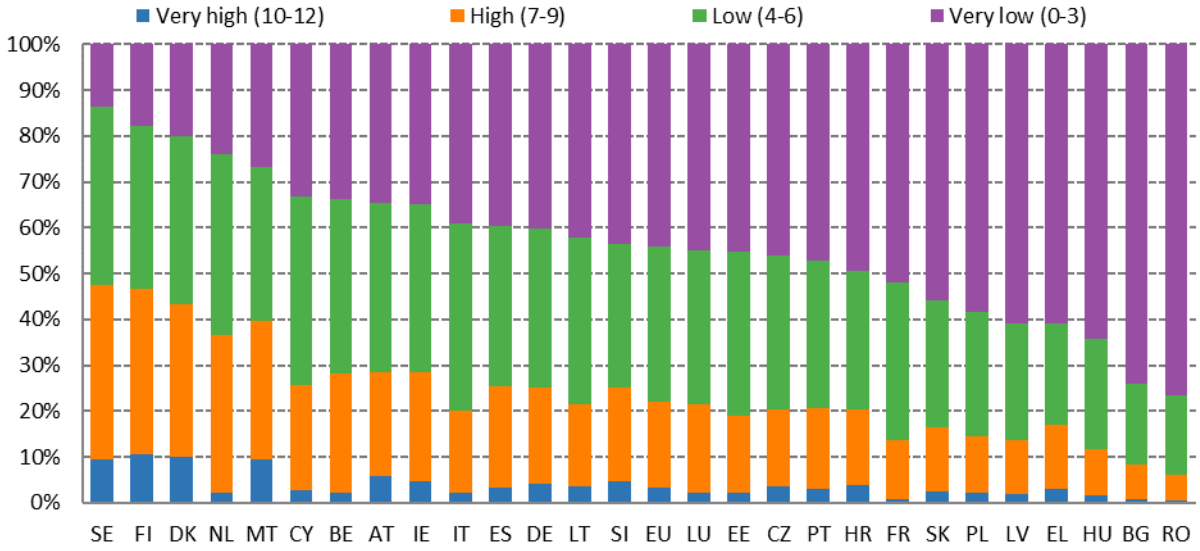
[49] The digital intensity index 2021 is not comparable with the DII from 2020 as other technologies have been considered compared to last year.

[50] ERP stands for enterprise resource planning. CRM stands for customer relationship management. CC stands for cloud computing. IoT stands for Internet of Things.

According to the target of the Path to the Digital Decade proposal, by 2030 more than 90% of SMEs should reach at least a basic level of digital intensity. Basic DII level requires usage of at least four technologies and comprises SMEs with very high, high and low DII.

There are only four countries (Finland, Denmark, Malta and Sweden) in the EU where the share of enterprises with a very high DII (i.e., possessing at least 10 out of the 12 monitored digital technologies) is above 9%, followed by Austria, Ireland, Slovenia and Germany with above 4%. By contrast, in countries such as Romania, Bulgaria, Hungary, Greece and Latvia, more than 60% of businesses have made only a small investment in digital technologies (i.e. have a very low DII).

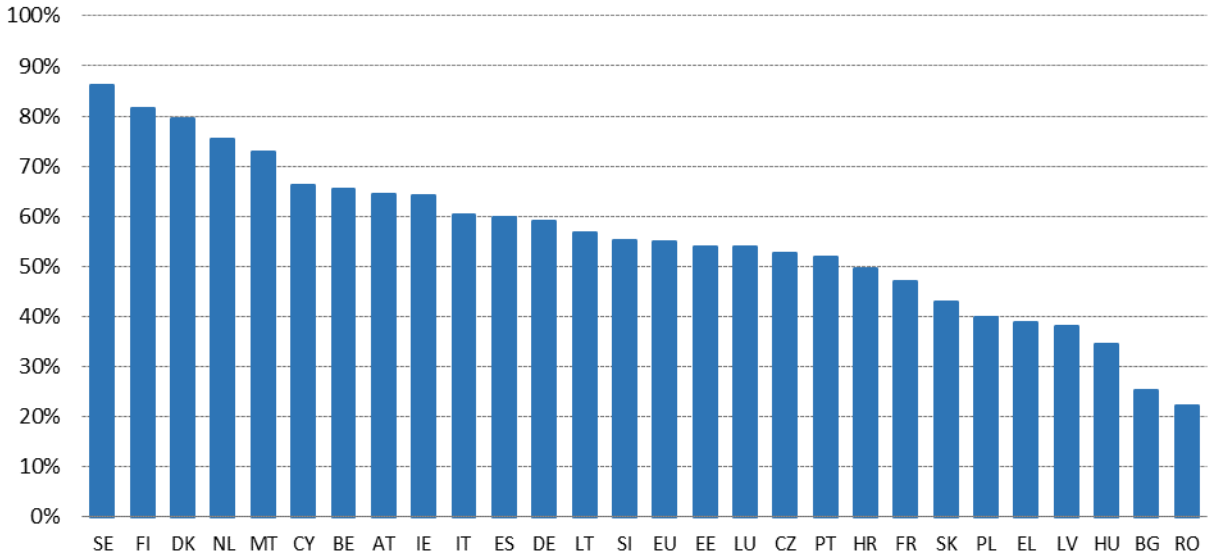
Figure 45 Digital Intensity Index by level (% of enterprises), 2021



Source: Eurostat, European Union survey on ICT usage and e-commerce in enterprises.

Figure 45 shows the share of SMEs with basic DII score. At least 80% of enterprises in the Nordic countries (Sweden, Finland and Denmark) reached at least basic level of digital intensity, while in Romania and Bulgaria it is below 30%.

Figure 46 SMEs with at least basic level of digital intensity, 2021



Source: Eurostat, European Union survey on ICT usage and e-commerce in enterprises.

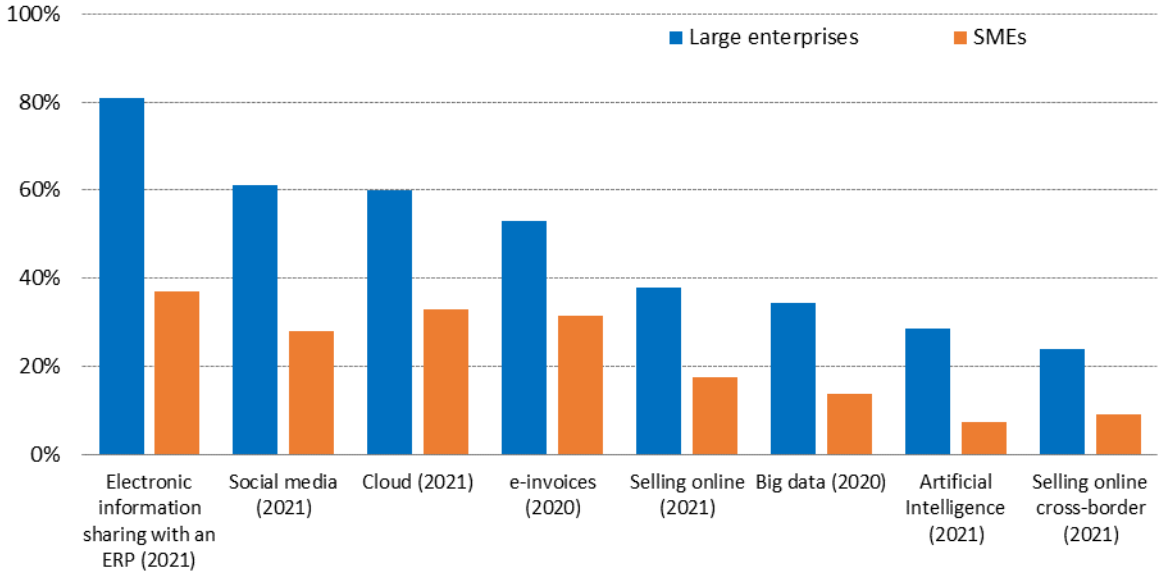
Overall, the level of digitalisation of SMEs remains uneven across MSs and economic sectors. A key barrier to be overcome is the lack of awareness of the potential of digital technologies and the lack of skills and technical expertise among the employees to integrate basic or advanced digital technologies in the business operations.

4.2 Adoption of digital technologies by enterprises

Large enterprises are more likely to adopt new technologies. For example, electronic information sharing through enterprise resource planning (ERP) software is much more common in large enterprises (81%) than in SMEs (37%). On social media[51], more than twice as many large enterprises (61%) make use of it if compared to SMEs (28%). SMEs exploit e-commerce opportunities only to a limited extent, with only 18% selling online (versus 38% of large enterprises) and only 9% selling cross border online (versus 24% of large enterprises). There are many other technological opportunities yet to be exploited by SMEs such as cloud services[52], AI and big data. The possibility of extracting information from data through advanced data analytics techniques will be essential for the competitiveness of the EU's economy. Reaching 75% adoption of advanced big data analytics by businesses across sectors will enable European companies to match the growth in data uptake at global level and fully exploit the rich new ways to explore and interpret data using AI, natural language processing and eXtended reality technologies.

There are common factors that play a critical role in enabling and boosting the uptake of cloud services, big data and AI, such as the availability of staff with advanced digital skills. Additionally, ensuring legal certainty and addressing data protection and liability issues is very important to enable the use of data and minimise the risks of breaches in security and data protection.

Figure 47 Adoption of digital technologies (% entreprises), 2020, 2021[53]



Source: Eurostat, European Union survey on ICT usage and e-commerce in enterprises.

[51] For social media the Eurostat indicator 'Use two or more social media' (code: E_SM1_GE2) is used. See DESI methodological note.

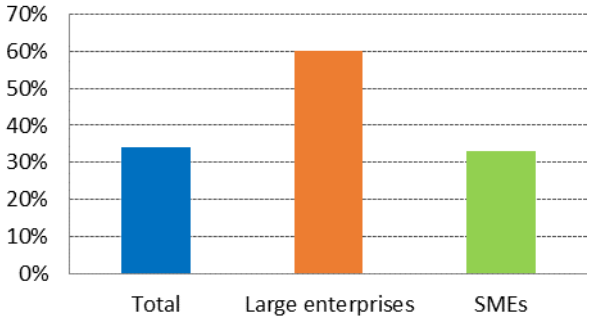
[52] For cloud the Eurostat indicator '*Enterprises buying sophisticated or intermediate cloud computing services' (code:* E_CC1_SI) is used. See DESI methodological note.

[53] These are the DESI 2022 indicators under the sub-dimension 3b and 3c of the Integration of digital technology dimension. For exact definitions, please see the DESI methodological note.

4.3 Cloud computing

The Path to the Digital Decade proposal requires that more than 75% of EU companies adopt cloud computing by 2030. In 2021, 34% of EU enterprises purchased sophisticated or intermediate cloud computing services (i.e. at least one of the following: finance or accounting software applications; enterprise resource planning (ERP) software applications; customer relationship management (CRM) software applications; security software applications; hosting the enterprise's database(s); computing platform providing a hosted environment for application development, testing or deployment) and incorporated cloud technologies to improve their operations while reducing costs. The cloud uptake of large companies (60%) almost doubled that of SMEs (33%) in 2021.

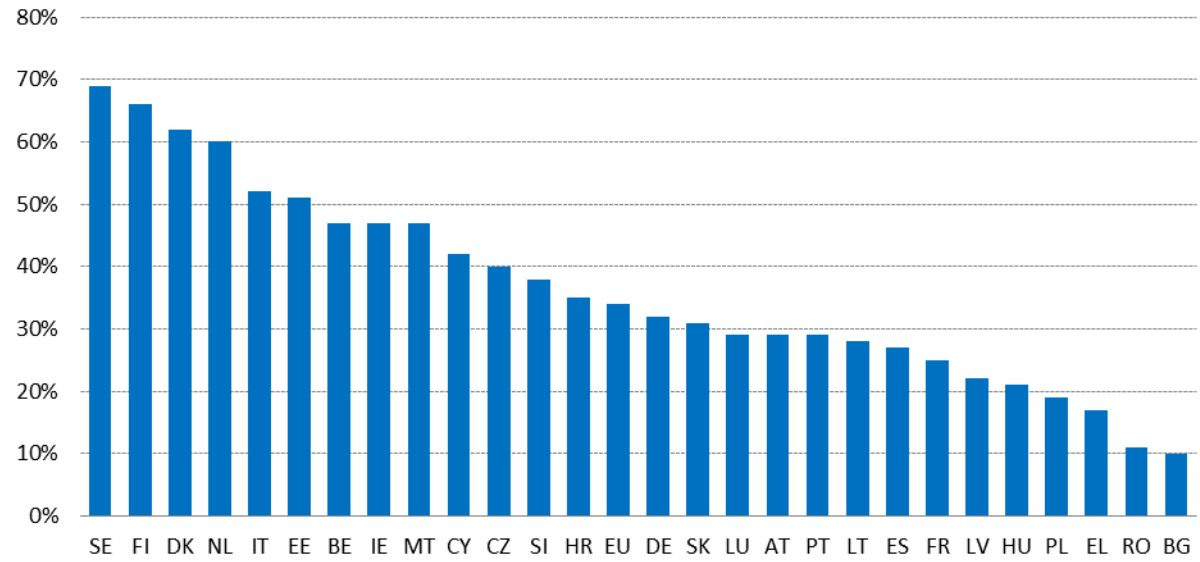
Figure 48 Cloud computing services of sophisticated or intermediate level (% of enterprises), 2021



Source: Eurostat, European Union survey on ICT usage and e-commerce in enterprises.

Nordic enterprises are leaders in incorporating sophisticated or intermediate cloud services. More than 60% of enterprises in Sweden, Finland, Denmark and the Netherlands buy such services. Italy and Estonia follow at more than 50%. However, the gap between top and low performers remains large, with Bulgaria and Romania scoring below 15%.

Figure 49 Cloud computing services of sophisticated or intermediate level per country (% of enterprises), 2021

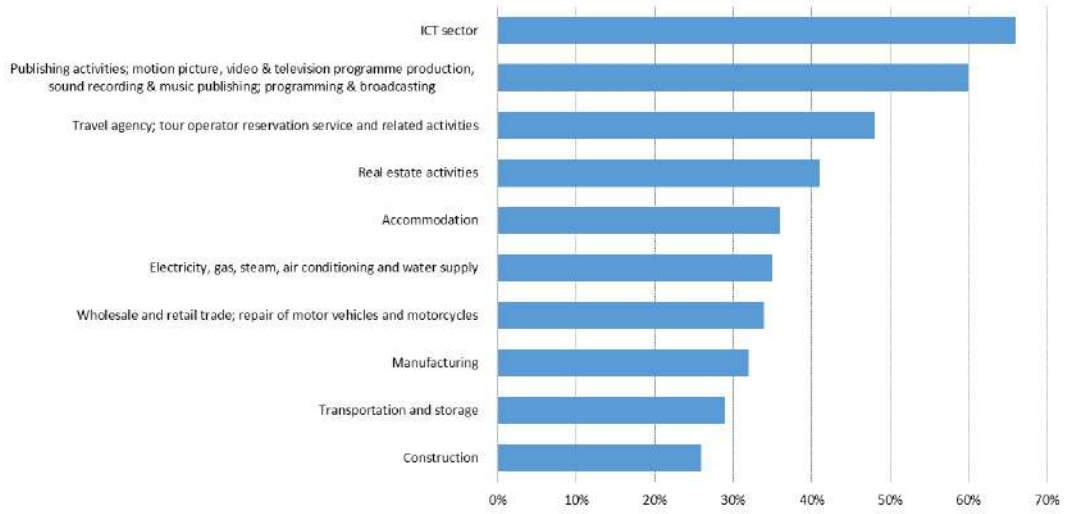


Source: Eurostat, European Union survey on ICT usage and e-commerce in enterprises.

When looking at cloud usage by sector, more than two thirds of enterprises in the ICT sector (66%) use cloud computing services of sophisticated or intermediate level, followed by publishing activities with 60%. The sectors with the least cloud usage are the construction sector (26% of enterprises)

and the transport and storage sector (29% of enterprises). These are followed by manufacturing at 32% of enterprises. This sectoral distribution is coherent with the general digitisation of sectors, as construction and transport display the lowest level of overall digitisation. This is partly inherent to the characteristics of these sectors that rely less on digital technologies.

Figure 50 Cloud computing services of sophisticated or intermediate level per sector (% of enterprises), 2021



Source: Eurostat, European Union survey on ICT usage and e-commerce in enterprises.

4.4 Big data[54]

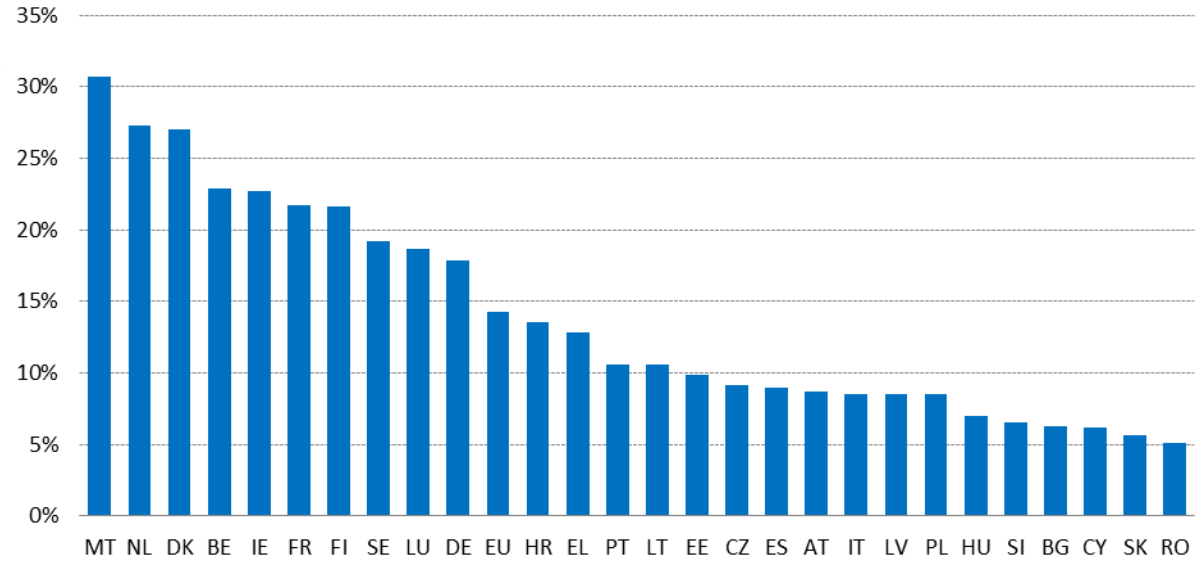
The Path to the Digital Decade target requires that more than 75% of EU companies adopt big data by 2030. Big data are characterised by volume, variety and velocity, i.e., vast amounts of data, which are complex in nature, in different formats and frequently generated. Big data analytics refers to the use of technologies, techniques or software tools such as data or text mining and machine learning, for analysing big data extracted from the enterprise's own data sources or other data sources.

Enterprises all over the EU are constantly adapting to new technologies for collecting, storing and analysing data. In 2020, 14% of companies carried out big data analytics. This helped them to produce near time or real time results from data that come in different format types. Large companies have the lion’s share in big data processing (with 34% of them using big data), while SMEs have still room for improvement to take advantage of all the benefits of big data (14% use big data).

In Malta, almost a third of enterprises analyse big data. The Netherlands and Denmark follow closely behind, with 27%. At the other end of the spectrum only 5-6% of enterprises in Romania, Slovakia, Cyprus and Bulgaria analyse big data.

[54] There was no update of big data figures in 2021.

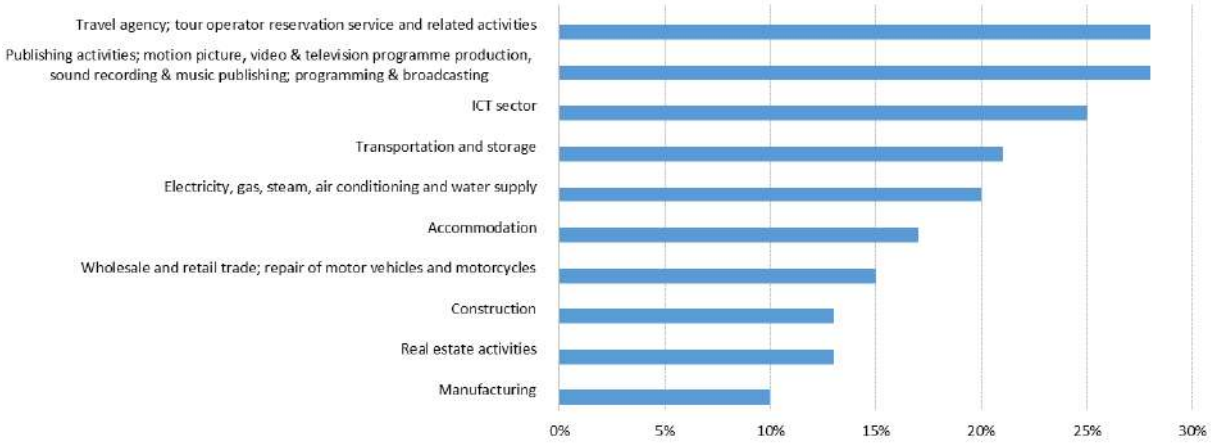
Figure 51 Enterprises analysing big data (% of enterprises), 2020



Source: Eurostat, European Union survey on ICT usage and e-commerce in enterprises.

When looking at a sectoral breakdown, enterprises are more likely to analyse big data in the travel agency; tour operator reservation service and related activities and in the publishing activities[55] sectors (both at 28%), followed by the ICT sector at 25%. Only 15% of enterprises carry out big data analytics in the wholesale and retail trade[56] sector, 13% in construction and in real estate activities, and 10% in the manufacturing sector.

Figure 52 Enterprises analysing big data per sector (% of enterprises), 2020



4.5 Artificial intelligence (AI)

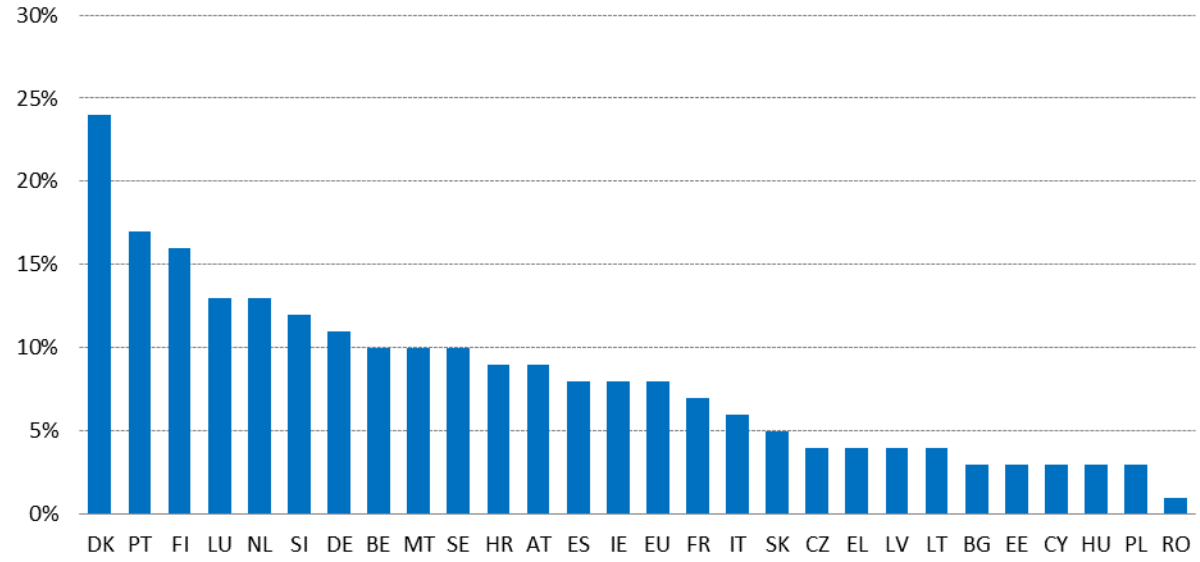
The Path to the Digital Decade target[57] requires that more than 75% of EU companies adopt AI technologies by 2030.

The uptake of AI technologies in the European Union is generally quite low, at 8%. However, there are some differences among Member States. There are 10 countries that have an adoption rate of

[55] Publishing activities; motion picture, video & television programme production, sound recording & music publishing; programming & broadcasting
[56] Wholesale and retail trade; repair of motor vehicles and motorcycles
[57] This indicator is based on the share of enterprises using at least two AI technologies.

AI technologies of more than 10%, with Denmark (24%), Portugal (17%) and Finland (16%) leading this group. There are seven countries with an uptake rate between 5 and 10%, Croatia, Austria, Spain, Ireland, France, Italy and Slovakia. Another 10 countries have a very low adoption rate, and do not reach 5% (such as Bulgaria, Estonia, Cyprus, Hungary and Poland, each 3%). With 1%, Romania has the lowest uptake in the EU. This is in line with the very low level of overall digitisation of enterprises in Romania. Even basic technologies are not widely used by enterprises (the share of SMEs with at least a basic level of digital intensity is the lowest in the EU), consequently more advanced technologies are not widespread either.

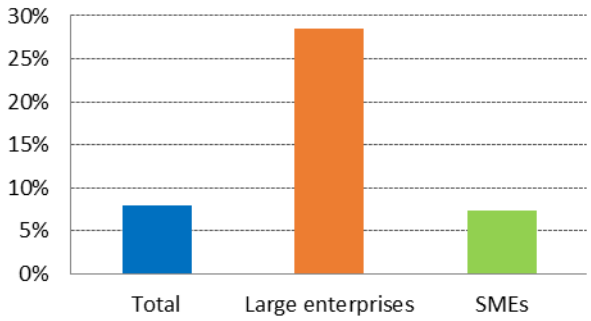
Figure 53 Enterprises using an AI technology (% of enterprises), 2021



Source: Eurostat, European Union survey on ICT usage and e-commerce in enterprises.

As with most advanced technologies, the uptake of AI technologies is much higher in large enterprises compared to SMEs. In 2021 the share of large enterprises adopting AI was three times higher than those of SMEs (29% versus 7%).

Figure 54 Use of AI technology by enterprise size (% of enterprises), 2021

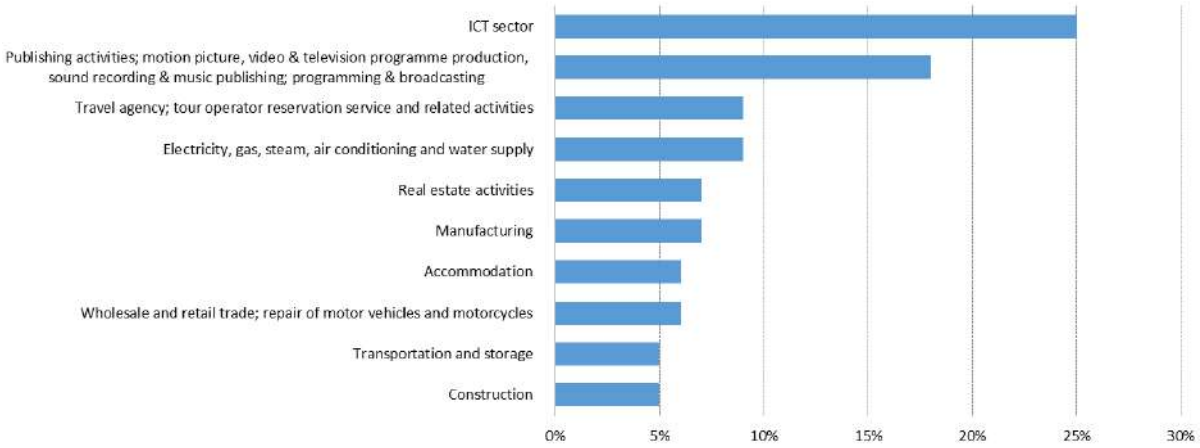


Source: Eurostat, European Union survey on ICT usage and e-commerce in enterprises.

When looking at a sectoral overview, the ICT sector is clearly much ahead in the use of AI technologies with 25% of enterprises adopting AI, followed by publishing activities at 18%. Other sectors, such as real estate activities and manufacturing are much further behind with only 7% of

enterprises using AI. The transportation and storage and the construction sector are the least likely to use AI technologies, with an uptake of about 5%.

Figure 55 Use of AI technology by sector (% of enterprises), 2021



Source: Eurostat, European Union survey on ICT usage and e-commerce in enterprises.

4.6 Unicorns

A unicorn is a privately held start-up company valued at over USD 1 billion. This is a stage of the start-up financial development which proves its maturity and success on the global market. For the current analysis, we include tech companies founded since 1990 that are currently valued at over USD 1 billion, while companies that passed USD 1 billion as a subsidiary are excluded. Companies that may now be worth less than USD 1 billion, but exited at more than USD 1 billion are also included.

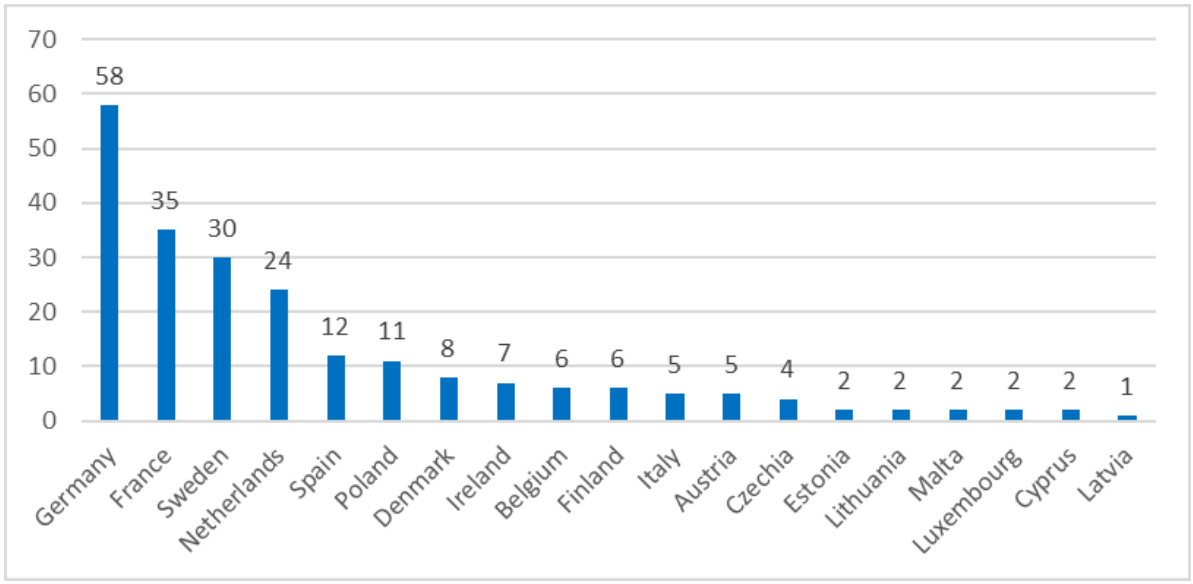
The proposed Digital Decade sets the target of doubling the current number of EU27 unicorns by 2030.

Figure 56 The definition of unicorns included in the analysis

Source: Dealroom

According to Dealroom, as of March 2022 there were 2 282 unicorns in the world. The EU has only 222 (increase from 143 in summer 2021) unicorns, as opposed to 1 243 (increase from 889) in the US, 530 (increase from 414) in Asia (out of which 306 (increase from 272) in China) and 119 (increase from 101) in the UK. Therefore, there is substantial room for improvement. Leading EU countries are Germany 58 (from 44), France 35 (23), Sweden 30 (20) and the Netherlands 24 (19). There are eight EU Member States without a single unicorn. A few countries made significant progress. Poland increased its unicorn count by a factor of more than five (from 2 to 11) and Czechia has now four unicorns having started from zero in 2021.

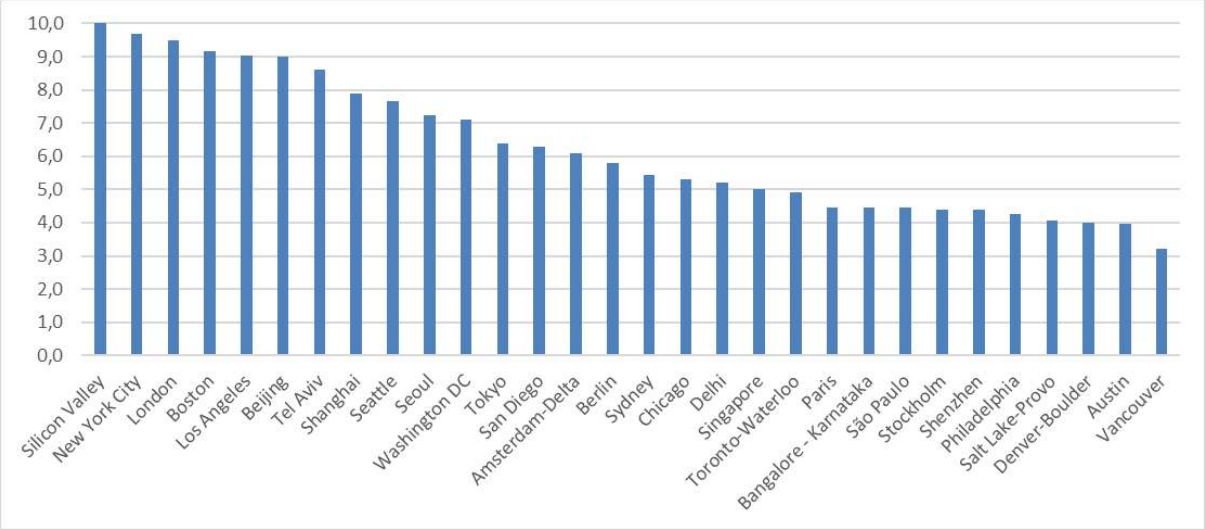
Figure 57 Number of unicorns per EU Member States



Source: Dealroom, March 2022

In order to be considered a unicorn, a company has to steadily and dynamically grow through all the development phases supported by the start-up ecosystem. According to Startup Genome, the best global start-up ecosystems in 2021 were Silicon Valley (1st), New York City (2nd) and London (3rd), similarly to the previous year. There are no EU ecosystems in the top 10, the best EU ecosystem – Amsterdam-Delta – was ranked 14th worldwide followed by Berlin (15th), Paris (21st) and Stockholm (24th). While half of the best 30 ecosystems is located in North America (and also half of the top 10), only four of them are in the EU. Asia is catching up with 8 ecosystems in the top 30.

Figure 58 Global start-up ecosystem ranking 2021



Source: Startup Genome, The Global Startup Ecosystem Report 2022

Out of the 12 most valuable unicorns in the world, the top five are based in the US and the following four in China, with none in the EU. Google valued at USD 1.9 trillion took the 1st place from Amazon, valued currently at USD 1.7 trillion. By comparison, the most valuable EU unicorn Adyen (located in Amsterdam) has a valuation of EUR 56.8 billion.

Figure 59 Most valuable unicorns worldwide as of 2022.03.01

	Name	Market	Type	Valuation (billion USD)	Location
	Google	B2C	Deep tech Artificial intelligence	1 900	Mountain View United States
	Amazon	B2C **Home living** **Transportation** Logistics & delivery	Marketplace & Commerce	1700	Seattle United States
	Tesla Motors	B2C **Energy** **Transportation** Autonomous & sensor tech Clean energy Energy Storage	Artificial intelligence Autonomous & sensor tech Deep tech Selling own inventory Manufacturing	808.6	Palo Alto United States
	Nvidia	B2B, B2C **Gaming** Console & PC gaming	Machine learning Deep learning Artificial intelligence Deep tech Hardware	601.9	Santa Clara United States

	Meta (Facebook)	B2C **Media** Social Media	Big data Artificial intelligence Advertising Saas	510.2	Menlo Park United States
	ByteDance	B2C **Media** **Telecom** Content production	Natural language processing Big data Deep tech Subscription	400.0	Beijing China
	Meituan	B2C **Telecom** **Marketing** Ecommerce solutions	Artificial intelligence Commission Marketplace & Commerce	360.3	Beijing China
	Alibaba	B2B **Enterprise software**	Marketplace & Commerce Saas	283.0	Huangzhou China
	Kuaishou	B2C **Media** **Enterprise software** Content production	Machine learning Artificial intelligence Advertising	214.0	Beijing China
	Salesforce	B2B **Marketing** **Enterprise software** CRM & sales	Artificial intelligence Subscription Saas	202.2	San Franciso United States
	Netflix	B2C **Media** Streaming	Machine learning Artificial intelligence Subsciption	182.6	Los Gatos United States
	BYD Company	B2C **Energy** **Transportation** Energy storage maintenance	Hardware Selling own inventory Manufacturing	155.9	Shenzhen China

Source: Dealroom

In the EU, Adyen is followed by Spotify and Klarna (both based in Stockholm). Out of the 12 most valuable EU unicorns, five are located in Germany, three in Sweden and the Netherlands, Ireland, Denmark and Belgium have one each.

Figure 60 Most valuable unicorns in the EU as of 01.03.2022

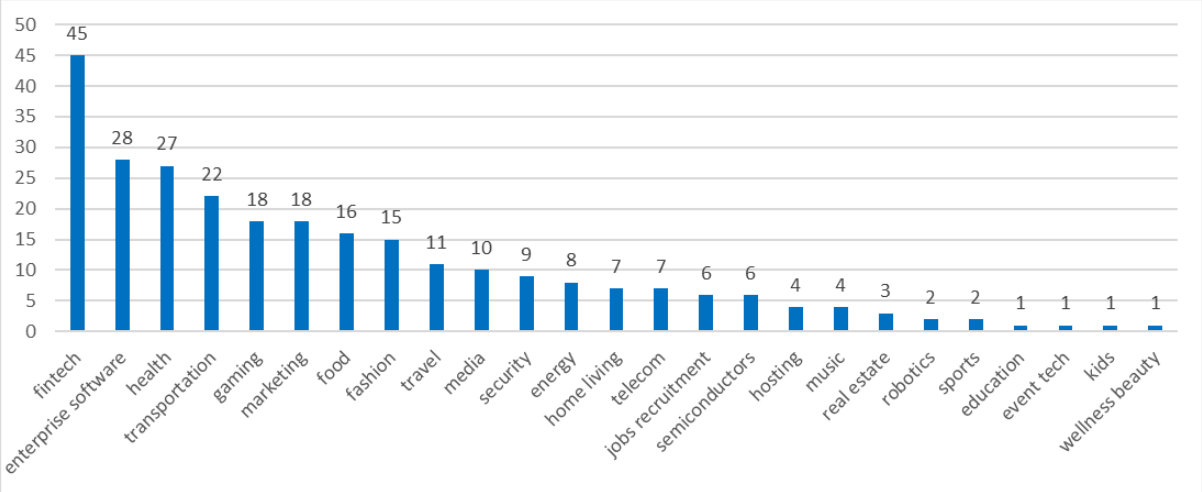
	Name	Market	Type	Valuation (billion USD)	Location
	**Adyen**	B2B **Fintech** Payments	Machine learning Artificial intelligence Commission Saas	56.8	Amsterdam Netherlands
	**Spotify**	B2C **Music** **Media** Streaming	Machine learning Artificial intelligence Subscription	52.0	Stockholm Sweden
	**Klarna**	B2B, B2C **Fintech** Payments	Commission	45.6	Stockholm Sweden
	**BioNTech**	B2B **Health** Biotechnology	Machine learning Artificial intelligence Deep tech	36.4	Mainz Germany
	**Flutter Entertainment**	B2C **Gaming** Betting & Gabling	Commission	29.4	Dublin Ireland
	**Genmab**	B2B **Health** Biotechnology	Deep tech Machine learning Artificial intelligence	17.4	Copenhagen Denmark
	**Delivery Hero**	B2C **Food** Food logistics and delivery	Commission Marketplace & Commerce	15.2	Berlin Germany
	**Zalando**	B2C **Fashion** Footwear	Artificial intelligence Marketplace & Commerce	13.7	Berlin Germany
	**ARGEN-X**	B2B **Health** Biotechnology	Commission	13.0	Ghent Belgium
	**Oatly**	B2C **Food** Innovative food	Selling own inventory Manufacturing	13.0	Malmo Sweden

	AUTO1 Group	B2C Transportation Search, buy & rent	Marketplace & Commerce	12.9	Berlin Germany
	CureVac	B2B **Health** Biotechnology	Manufacturing	12.8	Tubingen Germany

Source: Dealroom

Figure 60 shows that EU unicorns are most active in fintech (20.3%)[58], enterprise software (12.6%) and health (12.2%), in line with worldwide trends, but it is clear that they exist in almost every sector.

Figure 61 EU unicorns by industry as of 2022.03.01

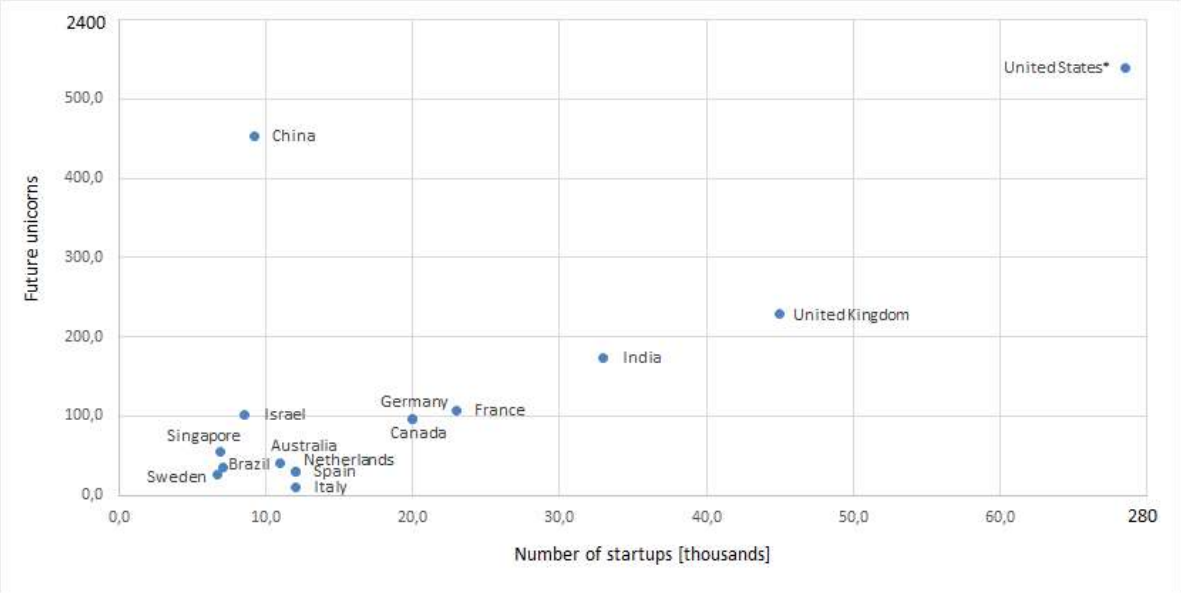


Source: Dealroom

Figure 61 shows that the start-up ecosystem is a cradle and essential development factor for unicorns. The more companies exist in the ecosystem, the higher probability that some of them will reach the valuation of USD 1 billion. The only outlier on the graph is China, where the venture capital is often controlled by the state through quite a few policies to assert more control over its internet sector. Verticals from fintech, social media, gaming and e-commerce to livestreaming have increasingly come under regulatory fire for their unscrupulous growth and the social issues they produce. The US are currently a clear champion (not in scale on the graph, which has been shrunk four times to fit in), but other countries are also on the path of growth. In this view, exploiting the full potential of the EU single market and overcoming the persisting legal and economic barriers between EU Member States is an important factor.

[58] There are 222 unicorns, however some of them are active in more than one sector.

Figure 62 Future unicorns vs number of start-ups (in thousands)

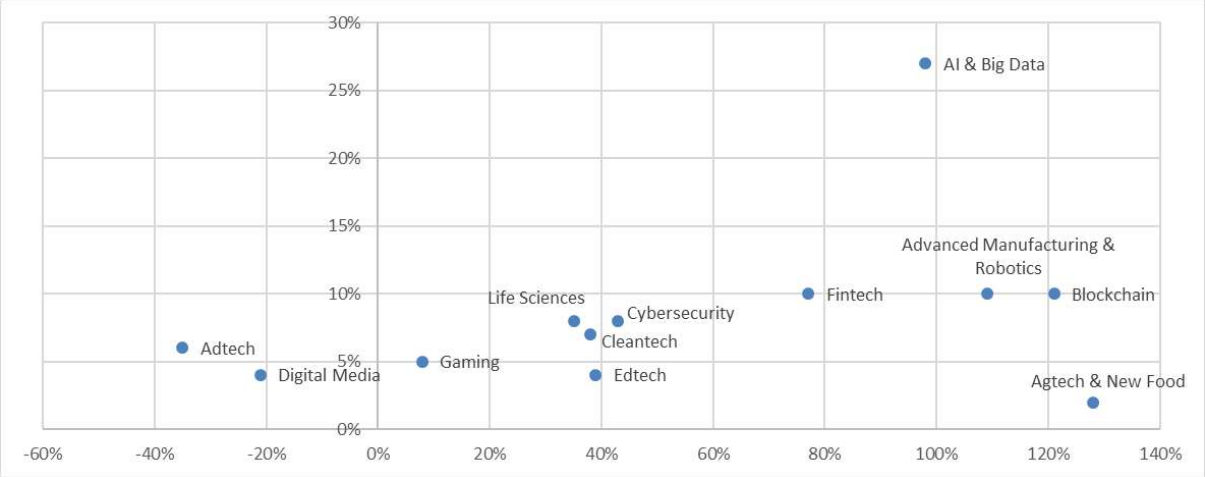


Source: Startup Genome

*United States not to scale

Figure 62 shows that the highest number of start-ups are active in AI and big data, and their number will most likely grow dynamically even further in the future. Three other areas could potentially catch up: (1) advanced manufacturing and robotics; (2) blockchain; and (3) agriculture technology (agtech) and new food, as investments are rising in these technologies. However, investments in advertising technology (adtech) and digital media are falling.

Figure 63 Global share of start-ups vs Series A[59] deals 5 year-growth in 2021



Source: Startup Genome

4.7 e-Commerce

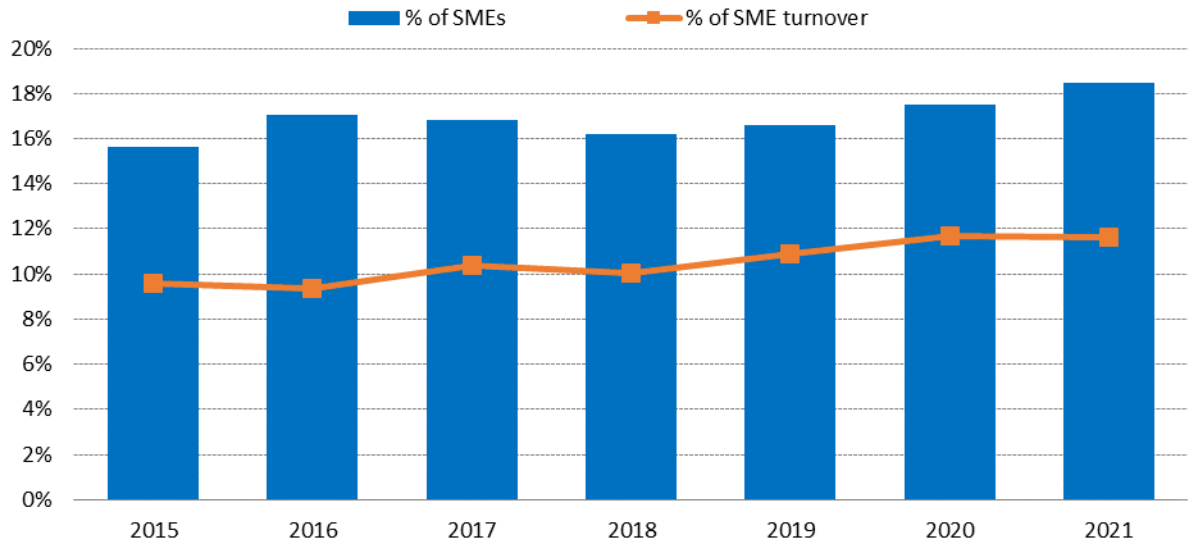
The European Commission put forward two legislative proposals to upgrade rules governing digital services in the EU: the Digital Services Act (DSA) and the Digital Markets Act (DMA). They form a single set of new rules applicable across the whole EU to create a safer and more open digital space.

[59] Series A financing refers to an investment in a privately-held start-up company after it has shown progress in building its business model and demonstrates the potential to grow and generate revenue. It often refers to the first round of venture money a firm raises after seed and angel investors.

The DSA and DMA have two main goals: (i) to create a safer digital space in which the fundamental rights of all users of digital services are protected; and (ii) to establish a level playing field to foster innovation, growth and competitiveness, both in the single market and globally.[60]

Around one in five EU small and medium sized enterprises (SMEs) made online sales in 2021, amounting to 12% of total turnover. Between 2015 and 2021, the percentage of SMEs selling online increased by 3 percentage points and the turnover of these companies achieved from online sales increased by 2 percentage points.

Figure 64 Trends in e-commerce (% of SMEs, % of SME turnover), 2015-2021

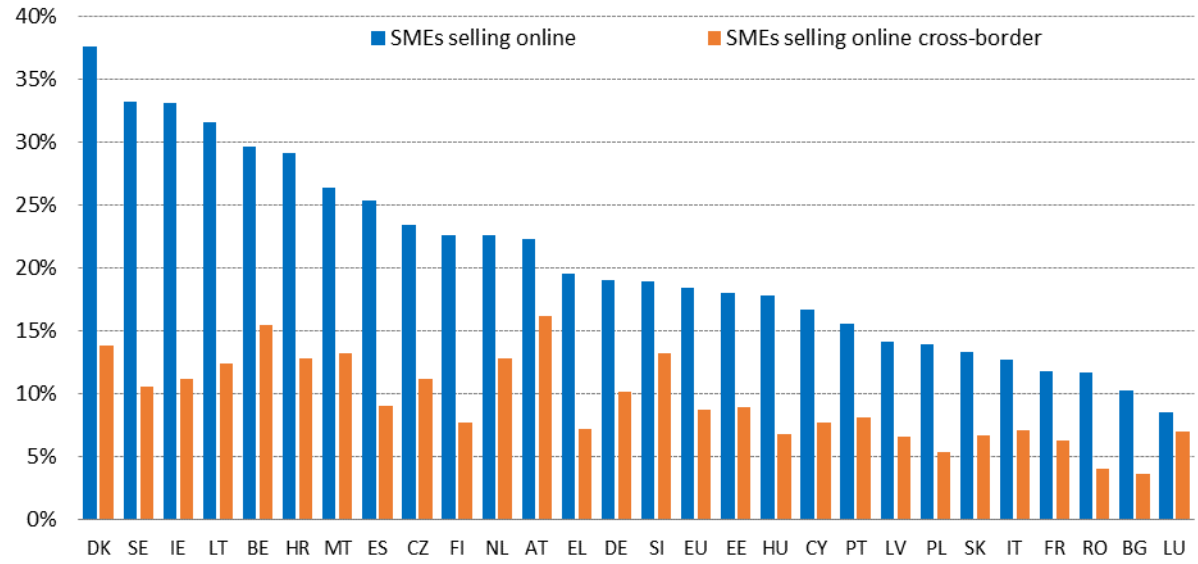


Source: Eurostat, European Union survey on ICT usage and e-commerce in enterprises.

Enterprises benefit from cross-border e-commerce by exploiting economies of scale. This helps to reduce costs, increase efficiency, promote competitiveness and improve productivity. Cross-border e-commerce is even more important for enterprises and especially SMEs that are confined to a small home market. However, only 9% of SMEs made web sales to customers in other EU countries in 2021. SMEs in Denmark, Sweden, Ireland, Lithuania and Belgium have the largest proportion of online sales (30% or more). Austria leads in cross-border online sales (16% of Austrian enterprises have online sales across borders to other EU countries), followed by Belgium, Denmark, Malta and Slovenia (all above 13%).

[60] The Digital Services Act package | Shaping Europe's digital future (europa.eu)

Figure 65 SMEs selling online and selling online cross-border (2021) (% of SMEs)



Source: Eurostat, European Union survey on ICT usage and e-commerce in enterprises.

A majority (56%) of SMEs with web sales to other EU countries have no difficulties when selling to customers in other EU countries. On the other hand, 43% report at least one obstacle that is mainly related to economic factors (e.g. high costs of delivering or returning products, a problem reported by 28% of SMEs). The problems related to resolving complaints and disputes (13%) and the lack of knowledge of foreign languages (10%) are also highlighted as difficulties by the SMEs selling online to other EU countries.

5 Digital public services

Digital technologies increasingly place new demands and expectations on the public sector. Achieving the full potential of these technologies is a key challenge for governmental organisations. Effective e-government can provide a wide variety of benefits including more efficiency and savings for both governments and businesses. It can also increase transparency and openness. The online availability of public services has been growing steadily over the last decade, accelerated by the COVID-19 pandemic during which digital interaction had to become the norm. The Digital Decade's target is for all key public services for businesses and citizens to be fully online by 2030.[61] A number of Member States are already close to the 100% target. However, progress is uneven across and within Member States. Services for citizens are less likely to be available online when compared to services for businesses. While the roll-out of basic digital public services is progressing steadily (e.g., access to online forms, online appointment booking, etc.), the availability of more advanced public services that make use of innovative digital technologies (e.g., AI, big data, robotics, etc.) still requires significant investment. The European Interoperability Framework gives also specific guidance on how to set up interoperable digital public services.

Measures aimed at digitalising public services and at introducing or improving e-government solutions figure prominently across the Recovery and Resilience Plans. The estimated cost of planned investments and reforms under the RFF amount to EUR 46 billion in the field of digitalisation of public services and government processes including e-health, e-justice and the digitalisation of transport and energy systems.[62] The largest parts will be benefitting e-government, eID and e-justice (EUR 24 billion) and e-health (EUR 13 billion). Some Member States are devoting more than half of their digital budget for the digitalisation of public services (e.g., Malta, Lithuania, Finland and Croatia). Overall, Member States seek to modernise and improve public administration processes to make them more user-friendly, citizen-oriented and interoperable. The aim is to boost access to and uptake of digital public services by individuals and businesses. Key reforms supported under the RRF include the integration of eID solutions in all government processes and the implementation of the 'Once Only Principle'. This dimension measures both the demand and supply sides of digital public services as well as open data[63].

[61] Indicators 4a3 and 4a4 are monitoring the progress of these targets.

[62] Intervention field e-government, digital public services and local digital ecosystems from digital tagging methodology of Annex VII of the RRF regulation.

[63] This analysis can be complemented with the factsheets on digital public administration and interoperability of the National Interoperability Framework Observatory and level of alignment to the European Interoperability Framework: https://joinup.ec.europa.eu/collection/nifo-national-interoperability-framework-observatory/digital-public-administration-factsheets-2021

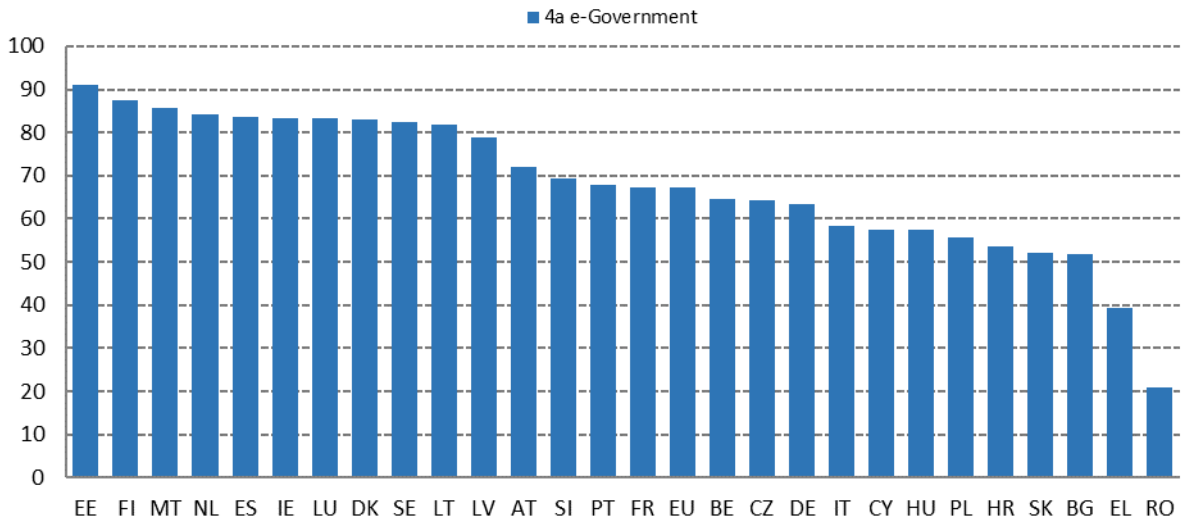
Table 7 Digital public services indicators in DESI

	EU	
	DESI 2020	DESI 2022
4a1 e-Government users % internet users	**61%** 2019	**65%** 2021
4a2 Pre-filled forms Score (0 to 100)	**NA**	**64** 2021
4a3 Digital public services for citizens Score (0 to 100)	**NA**	**75** 2021
4a4 Digital public services for businesses Score (0 to 100)	**NA**	**82** 2021
4a5 Open data % maximum score	**NA**	**81%** 2021

Source: DESI 2022, European Commission.

The top performers are Estonia, Finland, Malta and the Netherlands, while Romania, Greece Bulgaria and Slovakia have the lowest score.

Figure 66 Digital Economy and Society Index (DESI) 2022, Digital public services



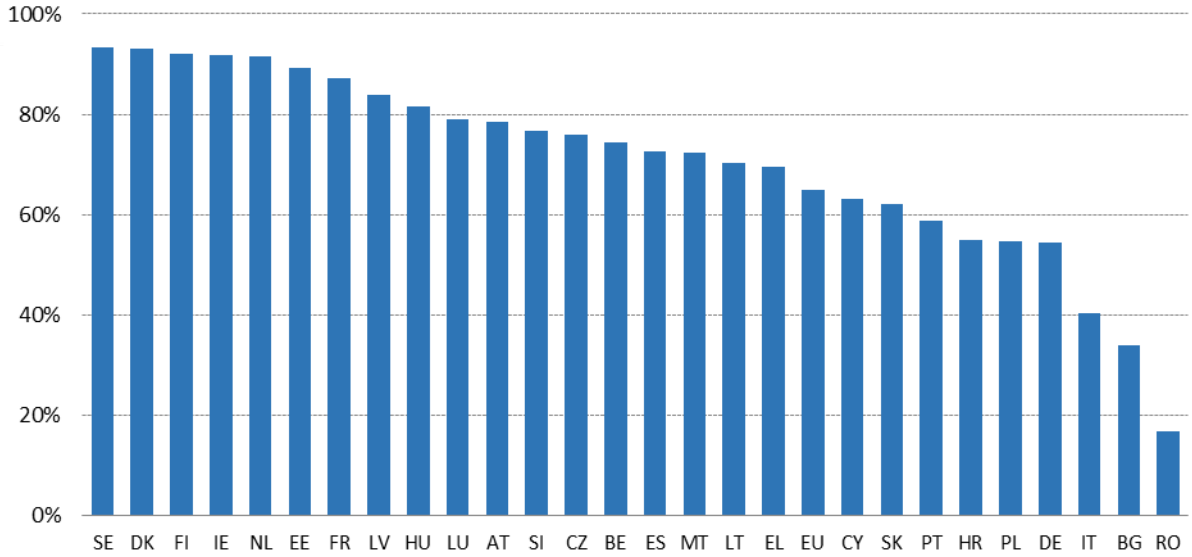
Source: DESI 2022, European Commission.

5.1 e-Government users

This indicator considers out of all internet users, the percentage of individuals who used the Internet in the last 12 months to interact with the public authorities. The indicator was updated to better cover the volume of online interaction between citizens and public authorities. The previous indicator was measuring solely the percentage of citizens submitting forms through online means, and who needed to do so.

Sweden, Denmark, Finland, Ireland and the Netherlands performed very well on this measure, with more than 90% of internet users (aged 16-74) interacting with the public administration choosing government portals. Romania, Bulgaria and Italy performed less well in this measure, and were the only three countries where the percentage of citizens interacting with public administrations was lower than 50%.

Figure 67 e-Government users interacting online with public authorities over the Internet in the last 12 months (% of internet users), 2021



Source: Eurostat, Community survey on ICT usage in Households and by Individuals.

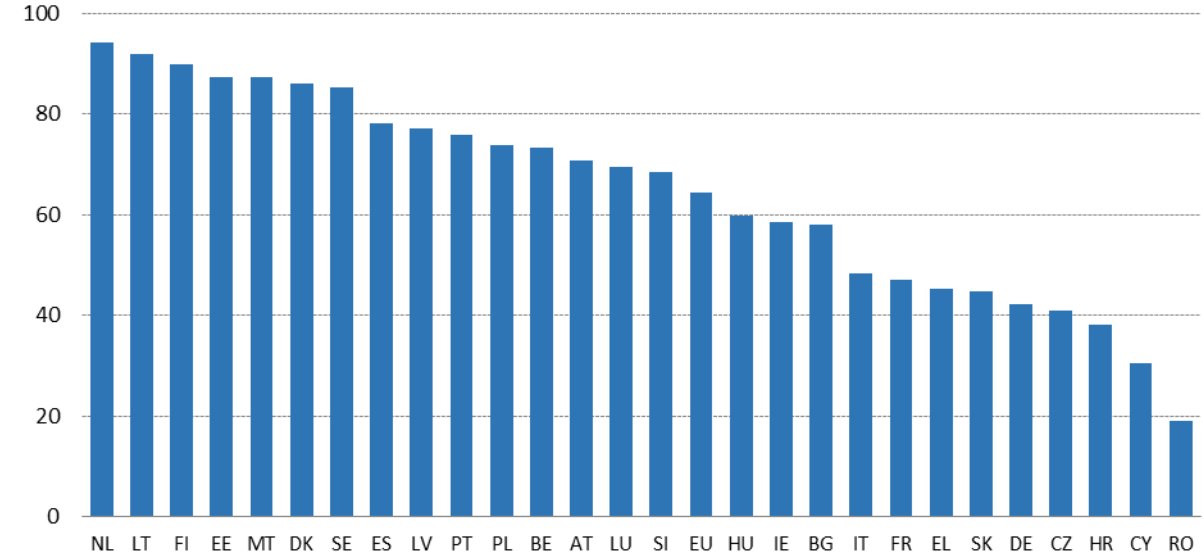
5.2 Pre-filled forms

This indicator[64] measures the extent to which data that is already known to public administrations is pre-filled in forms presented to the user, awarding a maximum overall score of 100. The use of inter-connected registers is key to ensuring that users do not have to resubmit the same data to the public administration (Once Only Principle).

In 2020, the indicator was updated compared to 2019 to align with policy advancements and goals in the field (e.g. updated set of national services).

The best performing countries in 2021 were the Netherlands, Lithuania, Finland, Estonia, Malta, Denmark and Sweden, all of which attained scores above 85 points. However, there is a substantial gap between the best and worst performing countries, with Romania scoring below 20 points, and Cyprus and Croatia below 40 points.

Figure 68 Pre-filled forms (Score 0 to 100), 2021



Source: eGovernment Benchmark, Capgemini.

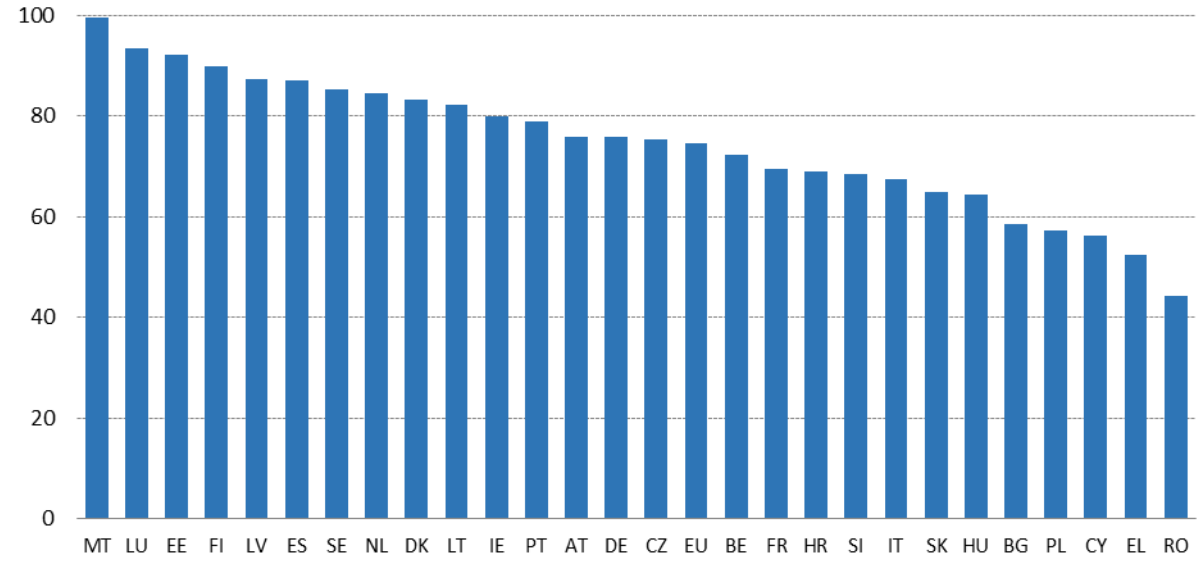
[64] The input for this indicator is the authentic sources indicator of the eGovernment benchmark. The number of services assessed in 2020 and 2021 was 95 (69 for citizens and 26 for businesses).

5.3 Digital public services for citizens

This indicator[65] measures the extent to which a service or information on service for citizens is provided online, and via a government portal. Services may be offered fully, partially or offline only. The indicator represents the share of steps that can be done online for major life events (e.g. register and reschedule an appointment at a hospital, appeal against court decision, etc.) for citizens. It is calculated as the average of the national and cross-border online availability for informational and transactional services[66]. The indicator is in line with policy advancements and goals in the field (e.g. alignment with the Single Digital Gateway Regulation), and balances the importance of the cross-border dimension with the services provided at national level.

Malta, Luxembourg and Estonia performed the best on this measure, scoring more than 90 points. Altogether 11 countries (Malta, Luxembourg, Estonia, Finland, Latvia, Spain, Sweden, the Netherlands, Denmark, Lithuania and Ireland) scored 80 points or above. Romania, Greece, Cyprus, Poland and Bulgaria scored less than 60.

Figure 69 Digital public services for citizens (score 0 to 100), 2021



Source: eGovernment Benchmark, Capgemini.

5.4 Digital public services for businesses

This indicator[67] measures the degree to which public services for businesses are interoperable and work cross-border.

[65] In 2020, the indicator replaced the Online service completion indicator that measured the online availability of all (business and citizen) national services, of which some were already covered by the Digital public services for businesses indicator. The input for this indicator is the online availability indicator and the cross-border online availability indicator of the citizen-related life events from the e-Government Benchmark. The number of services assessed in 2020 and 2021 was 69. Out of these 69 services, 66 were measured at national level and 35 at cross border level. Of course, some services were measured for both the national and the cross-border dimensions.

[66] Informational services: services and procedures that provide users with adequate and personalised insight into his/her situation. Transactional services: services and procedures needed to fulfil the essential requirements of a life event through online interaction.

[67] The input for this indicator is the online availability indicator and the cross-border online availability indicator of the business-related life events from the e-Government Benchmark.

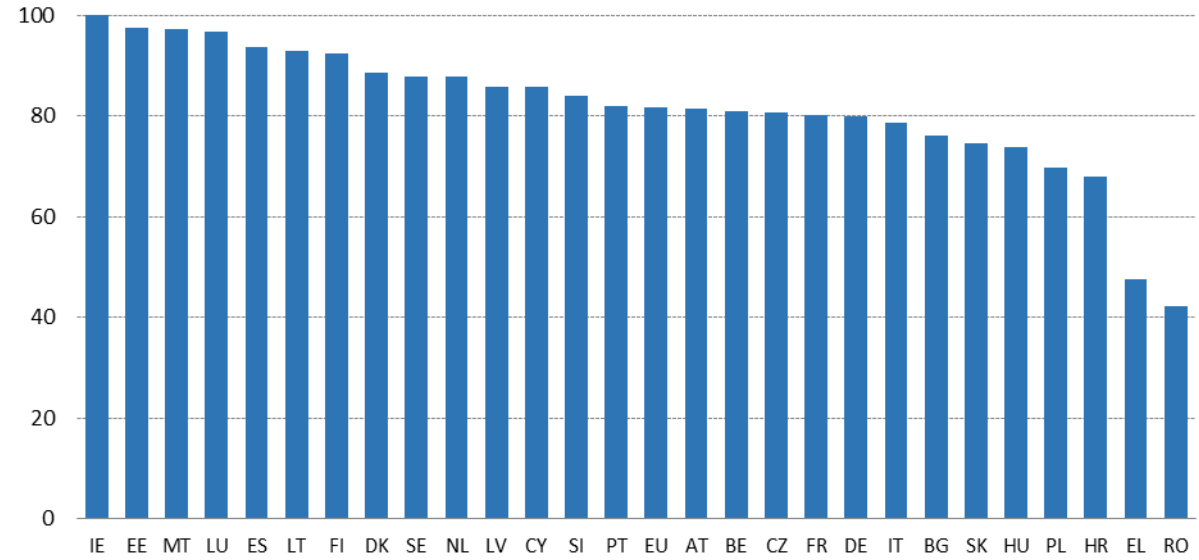
The indicator assesses to what extent informational and transactional services [66]public services for businesses, when starting a business and conducting regular business operations, are available online and across borders in other EU Member States. Services provided through a portal receive a higher score, while services that only provide information online but which require operations to be carried out offline receive a lower score.

In 2020, the indicator was updated to align with policy advancements and goals in the field (e.g. alignment with the Single Digital Gateway Regulation). The eGovernment Benchmark method was updated, and the total number of services assessed[68] was reduced.

This indicator and the Digital public services for citizens are fully complementary and together cover the entire range of services assessed by the eGovernment Benchmark, both from a national and a cross-border perspective.

A total of seven countries (Ireland, Estonia, Malta, Luxembourg, Spain, Lithuania and Finland) scored more than 90 points (out of 100). However, Romania, Greece, Croatia and Poland scored below 70.

Figure 70 Digital public services for businesses (Score 0 to 100), 2021



Source: eGovernment Benchmark, Capgemini.

5.5 Open data

This indicator measures the government's commitment to open data[69].

The level of maturity of open data has been based on the four following indicators:

1. Open data policy:
   (i) the presence at national level of specific policies on open data and licensing norms; and
   (ii) the extent of coordination at national level to: (a) provide guidelines to national, local and regional administrations; and (b) set up coordinated approaches towards data publication.
2. Open data impact:
   (i) the extent to which activities are in place to estimate the impact of open data at country level; and

[68] The number of services assessed in 2020 and 2021 was 26. All 26 were measured at national level and 18 at cross-border level. Of course, some services were measured for both the national and the cross-border dimensions.

[69] Open Data in Europe 2021: https://data.europa.eu/en/dashboard/2021

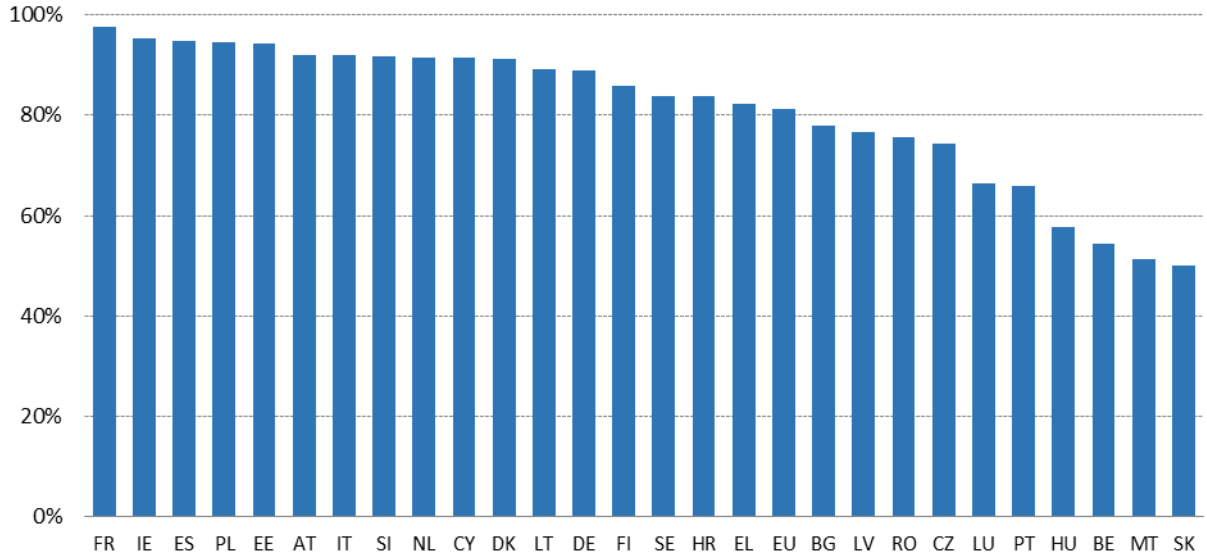
(ii) the estimated impact of open data at country level in four areas: political, social, environmental and economic.

3. Open data portal: the development of national portals and their level of sophistication in featuring available open data.
4. Open data quality:
   (i) the extent to which national portals have a systematic and automated approach to harvesting metadata from sources across the country; and
   (ii) the extent to which national portals comply with the metadata standard DCAT-AP (specification for metadata records).

The overall results across the EU show broad diversity in the speed of transformation and in the priorities that countries have set. The countries that are less advanced in open data typically choose to take what they deem to be the natural first steps. This means investment in modernising their national portals so the portals become the main gateways to open data available throughout the country. The more 'mature' open-data countries take a slightly different approach, focusing instead on improving the quality of their data publication. The middle-performing countries have a different approach to both the less advanced and the more 'mature' countries: they are now focusing on: (i) understanding the impact derived from open data; and (ii) activities to monitor and capture this impact.

A total of 11 countries (France, Ireland, Spain, Poland, Estonia, Austria, Italy, Slovenia, the Netherlands, Cyprus and Denmark) scored above 90%. However, Slovakia, Malta, Belgium and Hungary underperformed with scores below 60%.

Figure 71 Open data (% of the maximum open data score), 2021



Source: European Data Portal.

5.6 The use of eIDs

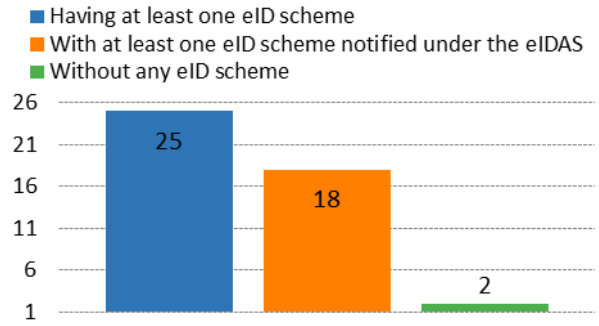
Electronic identification (eID) means the process of using person identification data in electronic form uniquely representing either a natural or legal person, or a natural person representing a legal person.

Based on data provided by Member States, more than 60% of European citizens have an eID. 25 out of 27 Member States have at least one eID scheme in place. Of these 25 Member States, 18 have at

least one eID scheme that is notified under the eIDAS Regulation[70]. The notification process for Slovenia is planned to start in June 2022.

At the same time, the Member States that do not have an eID scheme in place (Cyprus and Romania) are working towards putting them in place. Cyprus is planning to start issuing an eID as a pilot in the third quarter of 2022. Romania included in their RRP an investment that is expected to deliver 8.5 million eIDs by June 2026.

Figure 72 eID schemes in Member States, 2022



Source: European Commission services.

5.7 eGovernment Benchmark

The eGovernment Benchmark compares how governments deliver digital public services across Europe. It has become an internationally recognised study that looks at how platforms for citizens, businesses, tourists and expat communities continue to improve.

This study evaluates online public services on four dimensions, with 14 underlying indicators and 48 related survey questions. The four dimensions are: (1) user centricity, (2) transparency, (3) key enablers and (4) cross-border services.

In 2020, the eGovernment Benchmark method was updated to align with policy advancements and goals in the field (e.g. alignment with the Single Digital Gateway Regulation). The method changes limit historical comparisons to a subset of indicators and services. The 2020 method update has led to a break in the series, which makes one-to-one comparisons with earlier reports impossible.

5.7.1 User centricity

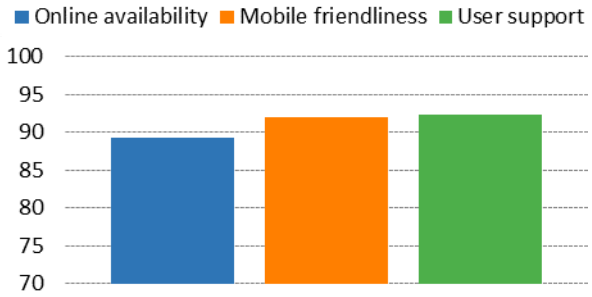
The dimension of user centricity includes three key elements for providing online services:

1. Online availability: the extent to which informational and transactional services and information concerning these services is provided online, and can be reached via a portal website.
2. User support: the extent to which online support, help features and feedback mechanisms are available on government portals.
3. Mobile friendliness: the extent to which services are provided through a mobile-friendly interface, an interface that is responsive to the mobile device.

Similarly to the previous indicators, in 2020, this indicator was updated to align with policy advancements and goals in the field by reducing the total number of services assessed.

[70] eIDAS is shorthand for 'electronic identification and trust services'. It refers to a range of services that include verifying the identity of individuals and businesses online and verifying the authenticity of electronic documents.

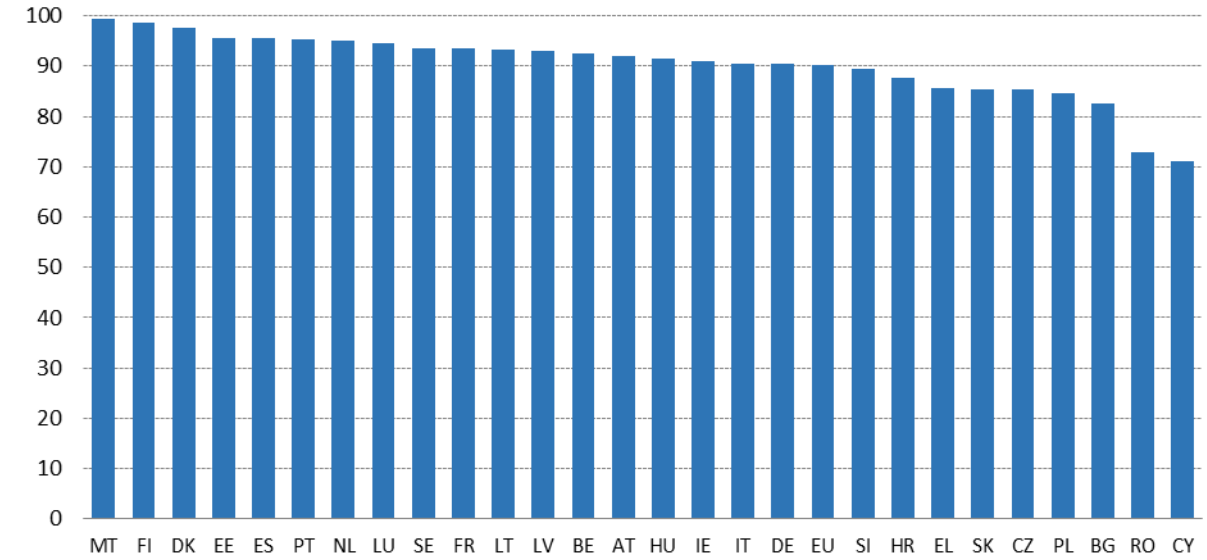
Figure 73 User centricity breakdown (Score 0 to 100), 2021



Source: eGovernment Benchmark, Capgemini.

For 2021, online availability stands at 89.3 (out of 100), with Malta, Denmark, Finland, Portugal, Estonia and Spain scoring more than 95 points. Mobile friendliness stands at 92, with Sweden, Finland, Belgium, Denmark, Austria and Ireland leading with scores close to 100. User support stands at 92.4, with Finland, Italy and Malta scoring 100, while all the countries score more than 75 points. In total, Malta, Finland, Denmark, Estonia, Spain, Portugal and the Netherlands are in the lead on user centricity, all scoring more than 95 points. Cyprus, Romania, Bulgaria and Poland are lagging behind, all scoring less than 85 points.

Figure 74 User centricity status in Member States (Score 0 to 100), 2021



Source: eGovernment Benchmark, Capgemini.

5.7.2 Transparency

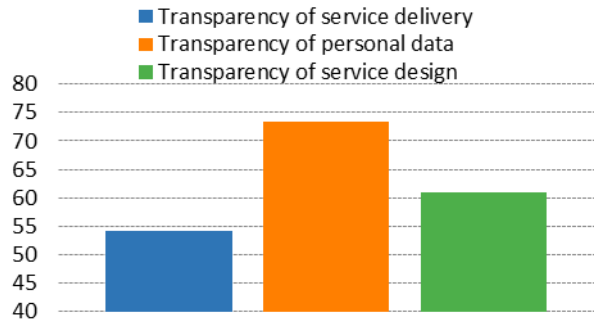
Transparency assesses the extent to which service processes are transparent, services are designed with user involvement and users can manage their personal data. This dimension includes the following three key elements:

1. Transparency of service delivery: the extent to which the service process and expectations are clarified.

2. Transparency of personal data[71]: the extent to which user can manage their personal data held by government organisations.
3. Transparency of service design: the extent to which user are informed on and involved in policy and service design processes.

Similarly to the previous indicators, in 2020, these indicators were updated to align with policy advancements and goals in the field by reducing the total number of services assessed.

Figure 75 Transparency breakdown (Score 0 to 100), 2021

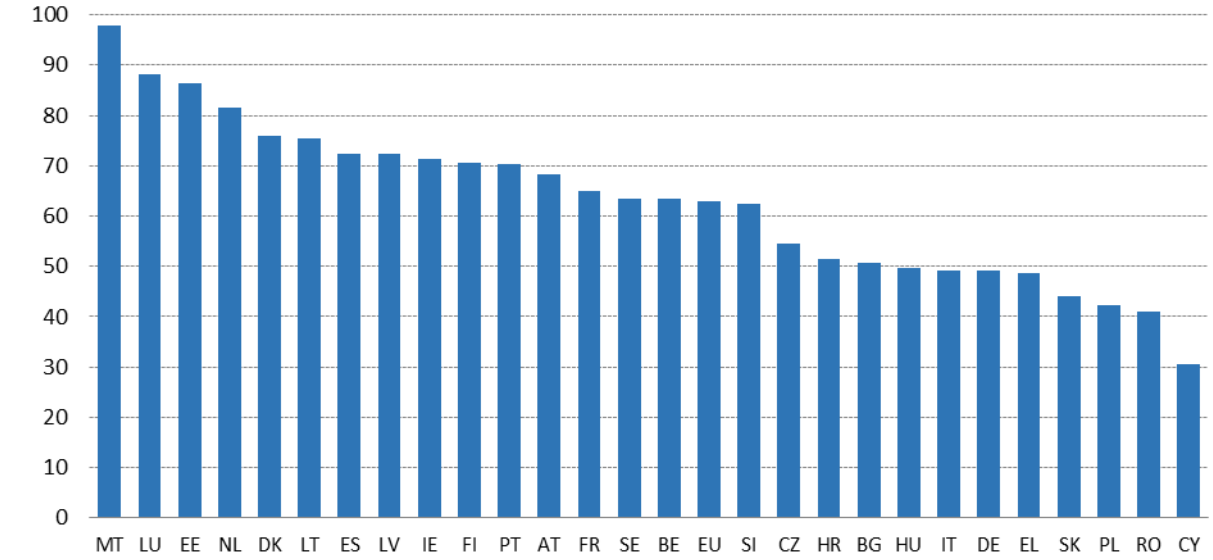


Source: eGovernment Benchmark, Capgemini.

For 2021, transparency of service delivery stands at 54.2 (out of 100), with Malta, Latvia, Estonia, and Lithuania scoring more than 70 points. Transparency of personal data stands at 73.4, with Malta, Estonia, Luxembourg and Lithuania leading with scores over 90. Transparency of service design stands at 60.9, with Ireland, Luxembourg, Malta and the Netherlands scoring 100.

In total, Malta, Luxembourg, Estonia, the Netherlands, Denmark and Lithuania are in the lead on transparency, all scoring more than 75 points. Cyprus, Romania, Poland, Slovakia, Greece, Germany, Italy and Hungary are lagging behind, all scoring less than 50 points.

Figure 76 Transparency status in Member States (Score 0 to 100), 2021



Source: eGovernment Benchmark, Capgemini.

[71] The Transparency of personal data indicator analyses the availability and degree of digitalisation regarding online modalities of exercising data subject rights. Importantly, it does not provide a GDPR compliance review (reserved to competent data protection authorities) and does not form any restriction that could be provided by Member State law.

5.7.3 Key enablers

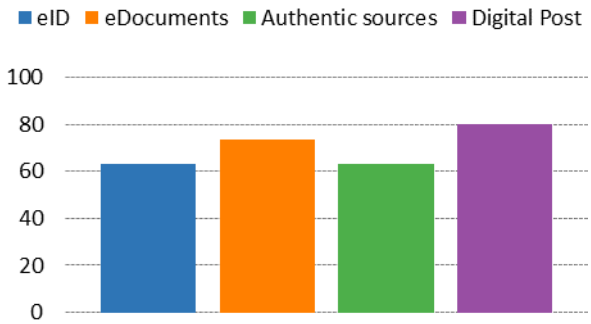
When citizens and businesses interact digitally with their government, they need to prove their identity in a secure manner, provide authenticated documentation, fill in forms, and receive notifications. This includes four key elements:

1. eID: the extent to which electronic Identification (eID), any means accepted by eGovernment services (e.g. smartcards, username and password) for online identification, can be used during service processes.
2. eDocuments: the extent to which electronic documents (eDocuments), any document in digital form that the user needs to submit/upload in order to complete an e-government service, or that the user obtains as a proof or a result of the service (e.g. certificate, diploma, proof of registration) can be used during service processes.
3. Authentic sources (named as Pre-filled forms in DESI): the extent to which authentic sources, base registries used by governments to automatically validate or fetch data relating to citizens or businesses, can be used during the service process.
4. Digital post: the extent to which public authorities allow citizens to receive communications digitally only and opt-out for paper mailings. Digital post refers to the possibility that governments communicate electronically-only with citizens or entrepreneurs through e.g. personal mailboxes or other digital postal solutions.

Similarly to the previous indicators, in 2020, these indicators were updated to align with policy advancements and goals in the field by reducing the total number of services assessed.

For 2021, the eID indicator stands at 65.6 (out of 100), with Denmark, Malta, Finland and Estonia in the lead, while Cyprus, Romania, Ireland and Czechia are lagging behind; eDocuments stands at 76.6, with Portugal, Denmark, Malta and Estonia leading, while Romania, Greece and Czechia scoring less than 60. Authentic sources stands at 64.5, with the Netherlands, Lithuania, Finland, Estonia, Malta, Denmark and Sweden scoring more than 85, while Romania, Cyprus and Croatia are lagging behind scoring less than 40; Digital post stands at 81.1, with several countries scoring 100, while Romania, Ireland, Poland and Slovenia scoring less than 50.

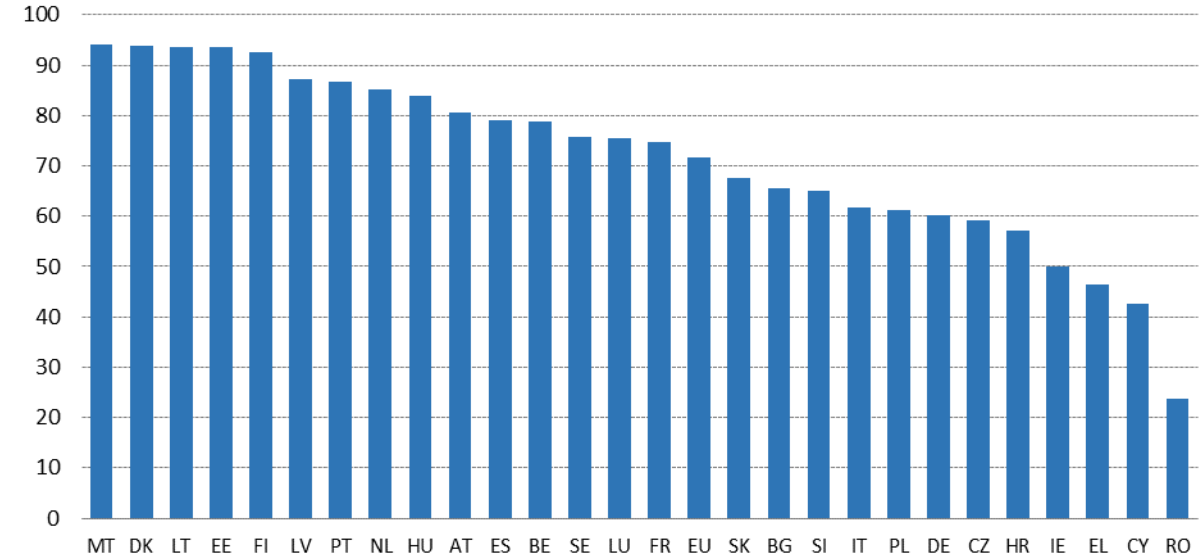
Figure 77 Key enablers (Score 0 to 100), 2021



Source: eGovernment Benchmark, Capgemini

In total, Malta, Denmark, Lithuania, Estonia and Finland are in the lead on key enablers, scoring more than 90 points in 2021. Romania, Cyprus and Greece are lagging behind, all scoring less than 50 points.

Figure 78 Key enablers status in Member States (Score 0 to 100), 2021



Source: eGovernment Benchmark, Capgemini.

5.7.4 Cross-border services

Cross-border services indicates the extent to which information and services are available online, usable, supported with help and feedback functions and integrated with eIDs and eDocuments for users from other European countries. During the pandemic, moving restrictions and check controls made it very difficult or even impossible to travel, which made the development of advanced digital highways absolutely vital. Digital governments became a catalyst for Europeans that want to live, work, do business or study in another European country. Providing high quality digital public services across borders is, therefore, now even more important for the Digital Single Market, than ever before.

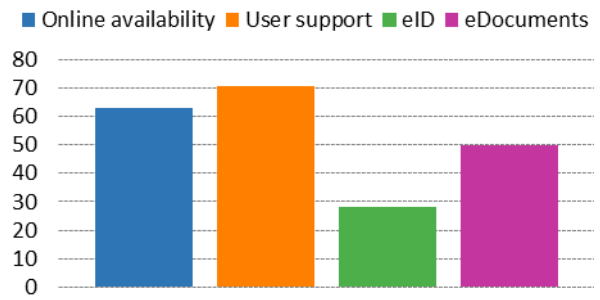
Cross-border services includes four indicators, assessed in a cross-border scenario:

1. Cross-border online availability: the extent to which informational and transactional services and information concerning these services are provided online for users from other European countries.
2. Cross-border user support: the extent to which online support, help features and feedback mechanisms are available for users from other European countries.
3. Cross-border eID: the extent to which electronic Identification (eID) can be used during service processes by users from other European countries, a government-issued document for online identification and authentication.
4. Cross-border eDocuments: the extent to which electronic documents (eDocuments) can be used during service processes by users from other European countries, documents that have been authenticated by its issuer using any means recognised under applicable national law, specifically through the use of electronic signatures, e.g. not a regular PDF or Word file.

For 2021, online availability stands at 63.1 (out of 100), with Malta, Luxembourg, Estonia, Finland, Spain and Latvia scoring above 80, while Greece, Romania, Poland and Hungary scoring below 40. User support stands at 70.8, with Ireland, Luxembourg, Malta and the Netherlands scoring above 95 while Poland, France and Hungary scoring below 50. eID stands at 28.2, with Luxembourg, Lithuania, Austria and the Netherlands scoring above 50, while Romania, Cyprus, Ireland, Italy, Slovakia,

Sweden and Germany lag behind with scores below 10 points. eDocuments stands at 49.7, with Malta and Denmark in the lead while Slovakia, Italy, Slovenia and Croatia score below 20.

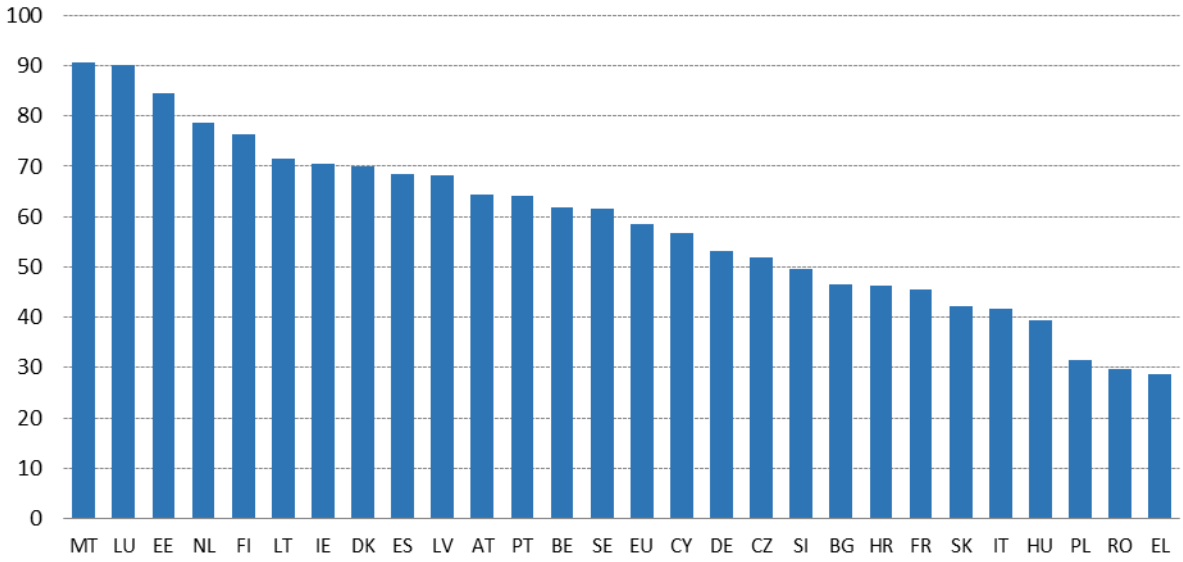
Figure 79 Cross-border services (Score 0 to 100), 2021



Source: eGovernment Benchmark, Capgemini

For cross-border services, Malta, Luxembourg and Estonia lead in the EU, all scoring more than 80 points. The countries with less cross-border flexibility and advancement are Greece, Romania, Poland and Hungary, all of which have scores below 40.

Figure 80 Cross-border services status in Member States (Score 0-100), 2021



Source: eGovernment Benchmark, Capgemini.

6 DESI methodological note

The European Commission has monitored Member States' progress on digital and published annual Digital Economy and Society Index (DESI) reports since 2014.

Each year, the reports include country profiles which help Member States identify areas for priority action, and thematic chapters providing an EU-level analysis in the key digital policy areas.

The Commission have already adjusted DESI to align it with the four cardinal points set out in the Commission proposal for a Decision 'Path to the Digital Decade' which is being negotiated by the co-legislators. It sets EU level targets to be attained by 2030 to deliver a comprehensive and sustainable digital transformation across all sectors of the economy. 11 of the DESI 2022 indicators measure the Digital Decade targets. In future, the DESI will be aligned even more closely with the Digital Decade to ensure that all targets are discussed in the reports.

The DESI scores and rankings of previous years are re-calculated for all countries to reflect changes in the underlying data and the choice of indicators.

Several improvements have been made in the DESI indicators for the DESI 2022 reports. Under Human capital, the digital skills indicators have been modernised to better reflect the required digital competences of people. Due to methodological changes in the European Union Labour Force Survey, there is break in series for the ICT specialists and Female ICT specialists indicators. Under Connectivity, the Fibre to the premises coverage indicator has been added, which allows a more comprehensive analysis of gigabit connectivity. The Mobile broadband take-up indicator has been updated to include use of internet on all kinds of mobile devices. Under the Integration of digital technology, the Cloud indicator now better captures the use of advanced cloud technologies, and for the first time we use official statistics on AI from Eurostat. Under Digital public services, there is break is series for most of the indicators thanks to an improved methodology.

With the DESI, four main types of analysis are possible:

- A general performance assessment: to obtain a general characterisation of the performance of individual Member States by observing their overall index score and the scores of the main dimensions of the index.
- Zooming-in: to pinpoint the areas where Member State performance could be improved by analysing the scores of the index's sub-dimensions and individual indicators.
- Follow-up: to assess whether there is progress over time.
- Comparative analysis: to cluster Member States according to their index scores, comparing countries in similar stages of digital development in order to flag up the need for improvement in relevant policy areas.

The DESI was developed according to the guidelines and recommendations in the OECD/JRC's 'Handbook on constructing composite indicators: methodology and user guide'[72]. The data included in the index were mostly collected from the relevant authorities of the Member States by the European Commission (Directorate-General for Communications Networks, Content and Technology as well as Eurostat) and from ad hoc studies launched by the Commission.

[72] Nardo M, Saisana M, Saltelli A, Tarantola S, Hoffmann A, Giovannini E. Handbook on Constructing Composite Indicators: Methodology and User Guide. Paris (France): OECD publishing; 2008. JRC47008 http://www.oecd.org/els/soc/handbookonconstructingcompositeindicatorsmethodologyanduserguide.htm

6.1 Structure of the DESI

The DESI has a three-level structure as depicted in the below table.

Table 8 DESI structure

Dimension	Sub-dimension	Indicator
1 Human capital	1a Internet user skills	1a1 At least basic digital skills
		1a2 Above basic digital skills
		1a3 At least basic digital content creation skills
	1b Advanced skills and development	1b1 ICT specialists
		1b2 Female ICT specialists
		1b3 Enterprises providing ICT training
		1b4 ICT graduates
2 Connectivity	2a Fixed broadband take-up	2a1 Overall fixed broadband take-up
		2a2 At least 100 Mbps fixed broadband take-up
		2a3 At least 1 Gbps take-up
	2b Fixed broadband coverage	2b1 Fast broadband (NGA) coverage
		2b2 Fixed Very High Capacity Network (VHCN) coverage
	2c Mobile broadband	2c1 5G spectrum
		2c2 5G coverage
		2c3 Mobile broadband take-up
	2d Broadband prices	2d1 Broadband price index
3 Integration of digital technology	3a Digital intensity	3a1 SMEs with at least a basic level of digital intensity
	3b Digital technologies for businesses	3b1 Electronic information sharing
		3b2 Social media
		3b3 Big data
		3b4 Cloud
		3b5 AI
		3b6 ICT for environmental sustainability
		3b7 e-Invoices
	3c e-Commerce	3c1 SMEs selling online
		3c2 e-Commerce turnover
		3c3 Selling online cross-border
4 Digital public services	4a e-Government	4a1 e-Government users
		4a2 Pre-filled forms
		4a3 Digital public services for citizens
		4a4 Digital public services for businesses
		4a5 Open data

At the dimension level, DESI addresses the four principal policy areas of the 2030 Digital Compass. These are not isolated areas that contribute separately to digital development, but in fact interconnected areas. As such, developments in the digital economy and society cannot be achieved through isolated improvements in particular areas but through concerted improvement in all areas. The following sections present the list of indicators in DESI 2022.

6.1.1 Human capital dimension

Table 9 Human capital dimension

Indicator	Description	Unit	Source
1a1 At least basic digital skills	Individuals with 'basic' or 'above basic' digital skills in each of the following five dimensions: information, communication, problem solving and software for content creation and safety	% individuals	Eurostat - European Union survey on ICT usage in Households and by Individuals (I_DSK2_BAB)
1a2 Above basic digital skills	Individuals with 'above basic' digital skills in each of the following five dimensions: information, communication, problem solving and software for content creation and safety	% individuals	Eurostat - European Union survey on ICT usage in Households and by Individuals (I_DSK2_AB)
1a3 At least basic digital content creation skills	Individuals with at least a basic level in using software for digital content creation	% individuals	Eurostat - European Union survey on ICT usage in Households and by Individuals (I_DSK2_DCC_BAB)
1b1 ICT specialists	Employed ICT specialists. Broad definition based on the ISCO-08 classification and including jobs like ICT service managers, ICT professionals, ICT technicians, ICT installers and servicers.	% individuals in employment aged 15-74	Eurostat - Labour force survey (isoc_sks_itspt)
1b2 Female ICT specialists	Employed female ICT specialists. Broad definition based on the ISCO-08 classification and including jobs like ICT service managers, ICT professionals, ICT technicians, ICT installers and servicers.	% ICT specialists	Eurostat - Labour force survey (isoc_sks_itsps)
1b3 Enterprises providing ICT training	Enterprises who provided training in ICT to their personnel	% enterprises	Eurostat - European Union survey on ICT usage and eCommerce in Enterprises (E_ITT2)
1b4 ICT graduates	Individuals with a degree in ICT	% graduates	Eurostat (table educ_uoe_grad03, using selection ISCED11=ED5-8) and ISCEDF_13 [F06] Information and Communication Technologies

The Human capital dimension assesses both internet user skills of citizens and advanced skills of specialists. At least basic skills, ICT specialists and Female ICT specialists measure targets of the Digital Decade Compass.

6.1.2 Connectivity dimension

Table 10 Connectivity dimension

Indicator	Description	Unit	Source
2a1 Overall fixed broadband take-up	% of households subscribing to fixed broadband	% households	Eurostat - European Union survey on ICT usage in Households and by Individuals [H_BBFIX]
2a2 At least 100 Mbps fixed broadband take-up	% of households subscribing to fixed broadband of at least 100 Mbps, calculated as overall fixed broadband take-up (source: Eurostat) multiplied with the percentage of fixed broadband lines of at least 100 Mbps (source: COCOM)	% households	European Commission, through the Communications Committee (COCOM) and Eurostat - European Union survey on ICT usage in Households and by Individuals
2a3 At least 1 Gbps take-up	% of households subscribing to fixed broadband of at least 1 Gbps, calculated as overall fixed broadband take-up (source: Eurostat) multiplied with the percentage of fixed broadband lines of at least 1 Gbps (source: COCOM)	% households	European Commission, through the Communications Committee (COCOM) and Eurostat - European Union survey on ICT usage in Households and by Individuals
2b1 Fast broadband (NGA) coverage	% of households covered by fixed broadband of at least 30 Mbps download. The technologies considered are FTTH, FTTB, Cable Docsis 3.0 and VDSL	% households	Broadband coverage in Europe studies for the European Commission by IHS Markit, Omdia and Point Topic
2b2 Fixed Very High Capacity Network (VHCN) coverage	% of households covered by any fixed VHCN. The technologies considered are FTTH and FTTB for 2015-2018 and FTTH, FTTB and Cable Docsis 3.1 for 2019 onwards	% households	Broadband coverage in Europe studies for the European Commission by IHS Markit, Omdia and Point Topic
2b3 Fibre to the Premises (FTTP) coverage	% of households covered by FTTH and FTTB	% households	Broadband coverage in Europe studies for the European Commission by IHS Markit, Omdia and Point Topic
2c1 5G spectrum	The amount of spectrum assigned and ready for 5G use within the so-called 5G pioneer bands. These bands are 700 MHz (703-733 MHz and 758-788 MHz), 3.6 GHz (3400-3800 MHz) and 26 GHz (1000 MHz within 24250-27500 MHz). All three spectrum bands have an equal weight	Assigned spectrum as a % of total harmonised 5G spectrum	European Commission services, through the Communications Committee (COCOM)
2c2 5G coverage	% of populated areas with coverage by 5G	% populated areas	Broadband coverage in Europe studies for the European Commission by IHS Markit, Omdia and Point Topic
2c3 Mobile broadband take-up	Individuals who used the internet on a mobile device	% individuals	Eurostat - European Union survey on ICT usage in Households and by Individuals [I_IUG_MD]
2d1 Broadband price index	The broadband price index measures the prices of representative baskets of fixed, mobile and converged broadband offers	Score (0-100)	Broadband retail prices study, annual studies for the European Commission realised by Empirica

Under Connectivity, both fixed and mobile broadband are analysed with indicators measuring the supply and the demand side as wells as retail prices. Fixed VHCN and 5G coverage measure targets of the Digital Decade Compass.

6.1.3 Integration of digital technology dimension

Table 11 Integration of digital technology dimension

Indicator	Description	Unit	Source
3a1 SMEs with at least a basic level of digital intensity	The digital intensity score is based on counting how many out of 12 selected technologies are used by enterprises. A basic level requires usage of at least 4 technologies.	% SMEs	Eurostat - European Union survey on ICT usage and eCommerce in Enterprises
3b1 Electronic information sharing	Enterprises who have in use an ERP (enterprise resource planning) software package to share information between different functional areas (e.g. accounting, planning, production, marketing)	% enterprises	Eurostat - European Union survey on ICT usage and eCommerce in Enterprises (E_ERP1)
3b2 Social media	Enterprises using two or more of the following social media: social networks, enterprise's blog or microblog, multimedia content sharing websites, wiki-based knowledge sharing tools. Using social media means that the enterprise has a user profile, an account or a user license depending on the requirements and the type of the social media.	% enterprises	Eurostat - European Union survey on ICT usage and eCommerce in Enterprises (E_SM1_GE2)
3b3 Big data	Enterprises analysing big data from any data source	% enterprises	Eurostat - European Union survey on ICT usage and eCommerce in Enterprises (E_BDA)
3b4 Cloud	Enterprises buying sophisticated or intermediate cloud computing services	% enterprises	Eurostat - European Union survey on ICT usage and e-commerce in enterprises (E_CC1_SI)
3b5 AI	Enterprises using any AI technology	% enterprises	Eurostat - European Union survey on ICT usage and e-commerce in enterprises (E_AI_TANY)
3b6 ICT for environmental sustainability	The indicator measures the level of support that adopted ICT technologies offered to enterprises to engage in more environmentally-friendly actions. The level of intensity is measured based on the number of environmental actions (maximum 10) reported by enterprises to have been facilitated by the use of ICT. The following categorisation was achieved: low intensity (0 to 4 actions), medium intensity (5 to 7 actions) and high intensity (8 to 10 actions).	% enterprises having medium/high intensity of green action through ICT	Survey of businesses on the use of digital technologies by Ipsos and iCite
3b7 e-Invoices	Enterprises sending e-invoices, suitable for automated processing	% enterprises	Eurostat - European Union survey on ICT usage and eCommerce in Enterprises (E_INV4S_AP)
3c1 SMEs selling online	SMEs selling online (at least 1% of turnover)	% SMEs	Eurostat - European Union survey on ICT usage and eCommerce in Enterprises (E_ESELL)
3c2 e-Commerce turnover	SMEs' total turnover from e-commerce	% SME turnover	Eurostat - European Union survey on ICT usage and eCommerce in Enterprises (E_ETURN)
3c3 Selling online cross-border	SMEs that carried out electronic sales to other EU countries	% SMEs	Eurostat - European Union survey on ICT usage and eCommerce in Enterprises (E_AESEU)

The Integration of digital technology dimension is made up of 3 sub-dimensions: digital intensity, take-up of selected technologies by enterprises and e-commerce. SMEs with at least a basic level of digital intensity, take-up of Big data, Cloud and AI are targets of the Digital Decade Compass.

6.1.4 Digital public services dimension

Table 12 Digital public services dimension

Indicator	Description	Unit	Source
4a1 e-Government users	Individuals who used the Internet, in the last 12 months, for interaction with public authorities	% internet users	Eurostat - European Union survey on ICT usage in Households and by Individuals (I_IUGOV12)
4a2 Pre-filled forms	Amount of data that is pre-filled in public service online forms	Score (0 to 100)	eGovernment Benchmark
4a3 Digital public services for citizens	The share of administrative steps that can be done online for major life events (birth of a child, new residence, etc.) for citizens	Score (0 to 100)	eGovernment Benchmark
4a4 Digital public services for businesses	The indicator broadly reflects the share of public services needed for starting a business and conducting regular business operations that are available online for domestic as well as foreign users. Services provided through a portal receive a higher score, services which provide only information (but have to be completed offline) receive a more limited score.	Score (0 to 100)	eGovernment Benchmark
4a5 Open data	This composite indicator measures to what extent countries have an open data policy in place (including the transposition of the revised PSI Directive), the estimated political, social and economic impact of open data and the characteristics (functionalities, data availability and usage) of the national data portal.	% maximum score	European data portal

The Digital public services dimension describes the demand and supply of e-government as well as open data policies. The Digital public services for citizens and businesses indicators assess targets of the Digital Decade Compass.

6.1.5 Data sources

Most of the data in the DESI have been collected directly by national authorities. The below table presents the data sources and the role of national authorities in data collection and validation.

Table 13 Data sources and the role of national authorities

Data source	Data collection process
Eurostat	Data collected and verified by the national statistical offices or by Eurostat.
Communications Committee (COCOM)	Data collected and verified by the national regulatory authorities (by data experts appointed by the members of the Communications Committee in every Member State).
Broadband coverage studies	Data collected by IHS Markit, Omdia and Point Topic and verified by the national regulatory authorities (by data experts appointed by the members of the Communications Committee in every Member State).
Retail broadband prices studies	Data collected by Empirica and verified by the national regulatory authorities (by data experts appointed by the members of the Communications Committee in every Member State).
e-Government benchmark	Data collected by Capgemini and verified by relevant ministries in every Member State.
Survey of businesses on the use of digital technologies	Data collected by Ipsos and iCite, survey results have been reviewed by the Digital Single Market Strategic Group.
European data portal	Data collected by Capgemini from representatives appointed by the relevant ministries in every Member State.

It is important to note that the Commission organises two technical workshops annually under the Digital Single Market Strategic Group to discuss the future evolution of data collections and the index. Changes made in DESI 2022 have been agreed with Member States in the Strategic Group.

6.1.6 Data flags

A limited number of data points include explanatory notes (data flags), which can be consulted directly on the website of Eurostat at https://ec.europa.eu/eurostat/web/digital-economy-and-society. In particular, there is break in the series for the ICT specialists and Female ICT specialists indicators.

6.2 Methodological considerations

6.2.1 Indicator requirements

Indicators used in the DESI comply with the following requirements:

- *Must be collected on a regular basis*. In order to fulfil the monitoring function, the indicators used in the index must be collected ideally on a yearly basis (or at least with a pre-defined regularity).
- *Must be relevant for a policy area of interest*. All indicators in the index must be accepted as relevant metrics in their specific policy areas.
- *Must not be redundant*. The index should not contain redundant indicators, either statistically or in terms of interpretation.

6.2.2 Data updates and corrections

Updates and corrections are part of the lifecycle and nature of statistical data. It is typical that the values for one indicator suffer small amendments and only stabilise completely months or even years after the indicator was originally computed. This is the case for a significant number of DESI indicators.

At each publication, historical data are also reviewed to accommodate such changes. The current report takes account of changes notified to the European Commission before 28 April 2022. Any modification made after this date will be included in the next report, which is expected in 2023.

6.2.3 Normalisation

In order to aggregate indicators expressed in different units into the sub-dimensions and dimensions of the DESI, those indicators were normalised. In DESI, normalisation was done using the *min-max* method, which consists in a linear projection of each indicator onto a scale between 0 and 1. For indicators with positive direction (i.e. where higher is better), the 0 value in the normalised scale was anchored to the minimum value in the indicator original scale, and the value 1 in the normalised scale was anchored to the maximum value in the indicator's scale.

To allow for inter-temporal comparisons of index scores, the minima and maxima for the normalisation of each indicator were fixed and will be used for normalisation in the future versions of the DESI. Table 15 presents the values that were chosen as the minimum and maximum of each indicator for normalisation purposes.

Due to the choice of normalisation minima and maxima that are fixed over time, the values of one or another indicator may surpass the indicator's normalisation maximum or fall below its minimum in the future. The score for such values will become higher than 1 or lower than 0 respectively. While this is not a major methodological concern, the choice of minima and maxima was performed carefully, taking into account the relevant targets of the Digital Decade and the likely evolution of each indicator determined based on the historical trends, in an attempt to minimise the occurrence of such events.

Table 14 Minima and maxima used in indicator normalisation

Indicator	Minima	Maxima
1a1 At least basic digital skills	0%	100%
1a2 Above basic digital skills	0%	66%
1a3 At least digital content creation skills	25%	100%
1b1 ICT specialists	0%	10%
1b2 Female ICT specialists	0%	50%
1b3 Enterprises providing ICT training	0%	50%
1b4 ICT graduates	0%	10%
2a1 Overall fixed broadband take-up	50%	100%
2a2 At least 100 Mbps fixed broadband take-up	0%	100%
2a3 At least 1 Gbps take-up	0%	50%
2b1 Fast broadband (NGA) coverage	25%	100%
2b2 Fixed Very High Capacity Network (VHCN) coverage	0%	100%
2b3 Fibre to the Premises (FTTP) coverage	0%	100%
2c1 5G spectrum	0%	100%
2c2 5G coverage	0%	100%
2c3 Mobile broadband take-up	25%	100%
2d1 Broadband price index	25	100
3a1 SMEs with at least a basic level of digital intensity	20%	100%
3b1 Electronic information sharing	0%	60%
3b2 Social media	0%	60%
3b3 Big data	0%	75%
3b4 Cloud	0%	75%
3b5 AI	0%	75%
3b6 ICT for environmental sustainability	30%	100%
3b7 e-Invoices	0%	100%
3c1 SMEs selling online	0%	50%
3c2 e-Commerce turnover	0%	33%
3c3 Selling online cross-border	0%	25%
4a1 e-Government users	0%	100%
4a2 Pre-filled forms	0	100
4a3 Digital public services for citizens	35	100
4a4 Digital public services for businesses	40	100
4a5 Open data	0%	100%

6.2.4 Imputation of missing observations

Some indicators presented missing observations for some countries. Values for those observations were estimated using different methodologies, such as:

- using available figures from the previous year,
- using available figures from the following year,
- using proxy indicators to identify trends to complete time series[73].

[73] For example the earlier versions of the digital skills indicators (1a1-1a3) were used to estimate the historical data for the new digital skills indicators. The same approach was applied to indicators 4a2-4a5 under Digital public services.

For the latest year (DESI 2022), 0.8% of all observations were imputed.

6.2.5 Weights

The four dimensions of the Digital Compass are of equal importance, which is reflected in the equal weights of each dimension.

Table 15 Weights attributed to the DESI dimensions

Dimension	Weight
1 Human capital	25%
2 Connectivity	25%
4 Integration of digital technology	25%
5 Digital public services	25%

Weights are also assigned at the sub-dimension and individual indicator level. Weights do not change compared to the 2021 edition of the index.

Table 16 Weights attributed to the DESI sub-dimensions

Sub-dimension		Weight
1 Human capital		
	1a Internet user skills	50%
	1b Advanced skills and development	50%
2 Connectivity		
	2a Fixed broadband take-up	25%
	2b Fixed broadband coverage	25%
	2c Mobile broadband	40%
	2d Broadband prices	10%
3 Integration of digital technology		
	3a Digital intensity	15%
	3b Digital technologies for businesses	70%
	3c e-Commerce	15%
4 Digital public services		
	4a e-Government	100%

The majority of individual indicators within each sub-dimension were considered of equal importance and therefore weighted equally within the respective sub-dimension. However, indicators measuring the targets of the 2030 Digital Compass were considered as having higher importance and they therefore have double weights within their sub-dimension. These indicators are presented in the below table.

Table 17 DESI indicators with double weights

1 Human capital	At least basic digital skills ICT specialists Female ICT specialists
2 Connectivity	Gigabit for everyone (Fixed very high capacity networks coverage) 5G coverage
3 Integration of digital technology	SMEs with a basic level of digital intensity AI Cloud Big data
4 Digital public services	Digital public services for citizens Digital public services for businesses

6.2.6 Method of aggregation

In DESI, the aggregation of indicators into sub-dimensions, of sub-dimensions into dimensions, and of dimensions into the overall index was performed from the bottom up using simple weighted arithmetic averages following the structure of the index (Table 8).

As an example, the top-level DESI score for country C was calculated using the formula:

*DESI(C) = Human_capital(C) * 0.25 + Connectivity(C) * 0.25 + Integration_of_Digital_Technology(C) * 0.25 + Digital_Public_Services(C) * 0.25*

Where $Connectivity(C)$ is the score obtained by country C in the Connectivity dimension.

Annex 1 Methodology for the Broadband price index indicator

Scope

The Broadband price index includes all the baskets identified in the Broadband retail prices studies. It covers 34 baskets altogether:

- 13 with fixed services only,
- 12 with mobile service only and
- 9 with converged fixed and mobile services.

Treatment of outliers

For the data series of each basket, the skewness and kurtosis tests are performed. When the absolute value of skewness is larger than 2 and kurtosis is larger than 3.5, the data include outliers, which are treated.

Normalisation

The min-max approach is used to normalise data for each basket separately. Minimum and maximum values were fixed based on the 2019 data and were computed as follows:

- Minimum: Actual minimum value in the basket multiplied by 0.75.
- Maximum: Actual maximum value in the basket multiplied by 1.25.

The multiplicators ensure that actual values do not go below the minimum and above the maximum values over time. Minimum and maximum values have not been updated based on the 2020 and 2021 data to avoid updating 2019 figures. All prices are normalised to a score between 0 and 100, where 100 is the best performance.

Aggregation and missing data

The Broadband price index score is calculated as the arithmetic average of the normalised scores for all baskets in each member state. When data is not available for a given basket (as no such offers exist that meet the criteria of a given basket for example regarding the services covered or speeds), missing data is not estimated, so the index score is calculated based on the available baskets.