Digital Economy and Society Index (DESI) 2020

Emerging technologies

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Emerging technologies

This chapter presents the current state of play of four emerging technologies: blockchain, High Performance Computing (HPC), quantum technology, and data and edge computing. On artificial intelligence, the Commission will soon publish an analytical report based on a large scale survey of enterprises. Consequently no assessment is included in this report.

The objective of this chapter is to provide an overview of: (i) the current and future size of the global market; (ii) public and private investment; (iii) jobs and education; and (iv) research and innovation activity. All the dimensions are only available for some technologies. In addition, given the lack of data, the trend analysis at Member State level is not available for most of the indicators.

1. Blockchain

Blockchain is a decentralised technology (a type of Distributed Ledger Technology) employing cryptographic techniques to record and synchronise data in 'chains of blocks'. It allows people and organisations to reach agreement and permanently record transactions and information in a transparent way without a central authority. Therefore, it facilitates the creation of decentralised, trusted, transparent and user-centric digital services. The combination of blockchain with other cutting-edge technologies, like the Internet of Things (IoT) or artificial intelligence can improve the security, performance, and management of the new systems[(1)]. Blockchain technologies will play an important role as a trust protocol and its development alongside quantum computing is fundamental to define quantum-resistant solutions for blockchain[(2)].

Blockchain is one of the major technological breakthroughs of the past decade. It has evolved from the technology enabling Bitcoin to include a myriad of possible applications in other areas such as industry, trade and the public sector. Although blockchain is expected to transform the way the world uses the internet and digital services over the next 10-to-15 years, it is still in its infancy. Blockchain systems still face many challenges, including performance; scalability; energy consumption; integration with legacy infrastructures; interoperability; potential collusion between participants; management of public-private keys; and the protection of personal, sensitive or confidential data[(3)].

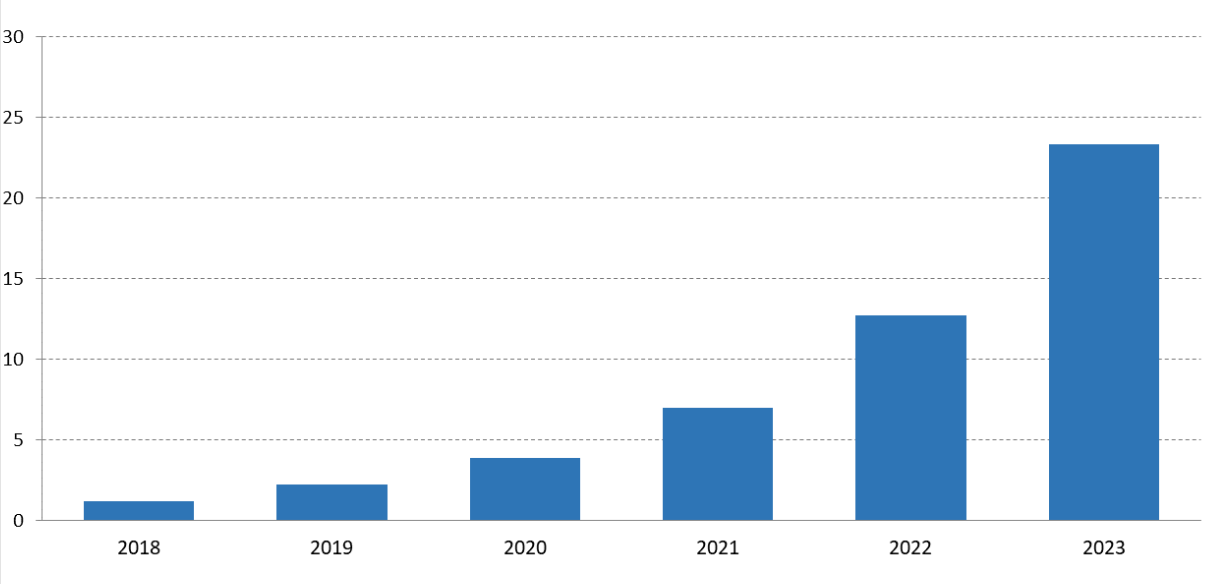
The market revenues for blockchain-based technologies are expected to grow significantly in the coming years from around $2.2 billion in 2019 to over $23.3 billion by 2030.

[(1)] Weingärtner, Tim, *Tokenization of Physical Assets and the Impact of IoT and AI*, EU Blockchain Observatory and Forum, Brussels, 2019.

[(2)] The European Union Blockchain Observatory & Forum, *Blockchain innovation in Europe*, 2018.

[(3)] European Commission, JRC, *Blockchain Now and Tomorrow*, June 2019.

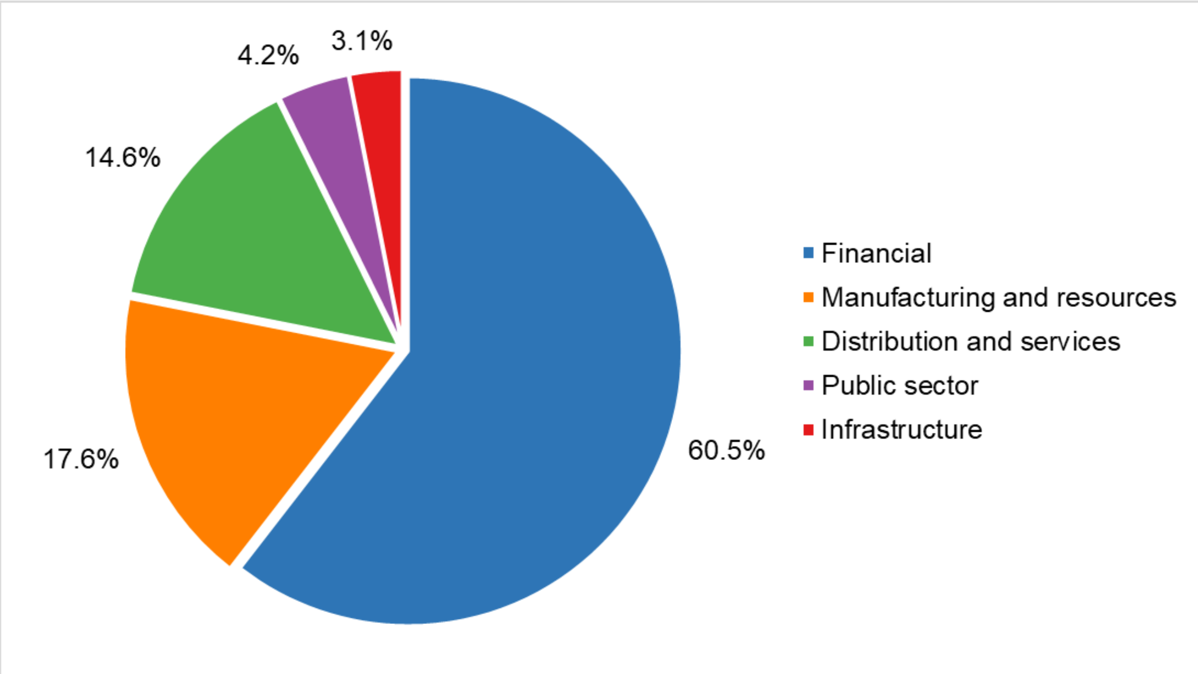
Figure 1 Size of the blockchain market worldwide, 2018-2023, in $ billion



Source: Statista.

The financial sector was one of the first sectors to invest in blockchain technologies. In 2018, the financial sector accounted for around 60% of the market value, followed by the manufacturing and resources sector (17.6%) and the distribution and services sector (14.6%). The public sector and the infrastructure sector accounted for lower shares of 4.2% and 3.1% respectively[(4)].

Figure 2 Blockchain market value worldwide in 2018, by sector



Source: Statista.

Blockchain start-ups began to emerge in 2009. In 2018, the largest number of blockchain start-ups were established in the USA and China, and only 15% in the EU. The UK hosts almost half of the EU's blockchain start-ups, followed by Germany, France and Estonia, with shares of 8%, 7% and 6%, respectively[(3)].

[(4)] Statista, IDC (based on survey H1 2017)

The vast majority of investment in blockchain technologies is concentrated in early fundraising rounds, being venture capital and Initial Coin Offerings (ICOs) the two largest funding sources. ICOs are a new type of funding. They allow start-ups to raise money by selling 'tokens' directly to investors, bypassing the venture capitalists and investment bankers who have traditionally been the conduits for start-up or corporate financing(2). The first significant investment in blockchain start-ups came in 2014 from venture capital funds (around €450 million). The surge in ICOs and venture capital investments meant that investment then rapidly increased to €3.9 billion in 2017 and more than €7.4 billion in 2018(3).

In 2009-2018, the global level of blockchain funding of all types, including venture capital, grants and ICOs exceeded €13.1 billion. US firms received 33% of the funding, followed by the EU with 22% (€2.9 billion) and China with 21%. Of the investment attracted by EU firms, the UK received almost 70% of the total funding (€2.02 billion), followed by the Netherlands with 12% (€352 million). Companies in France received 6% (€167 million), followed by Estonia and Germany (€110 million and €97 million, respectively) (see *Figure 3)*. European start-ups obtained 60% of their total funding through ICOs, while the equivalent figure for US blockchain start-ups did not exceed 18%(5).

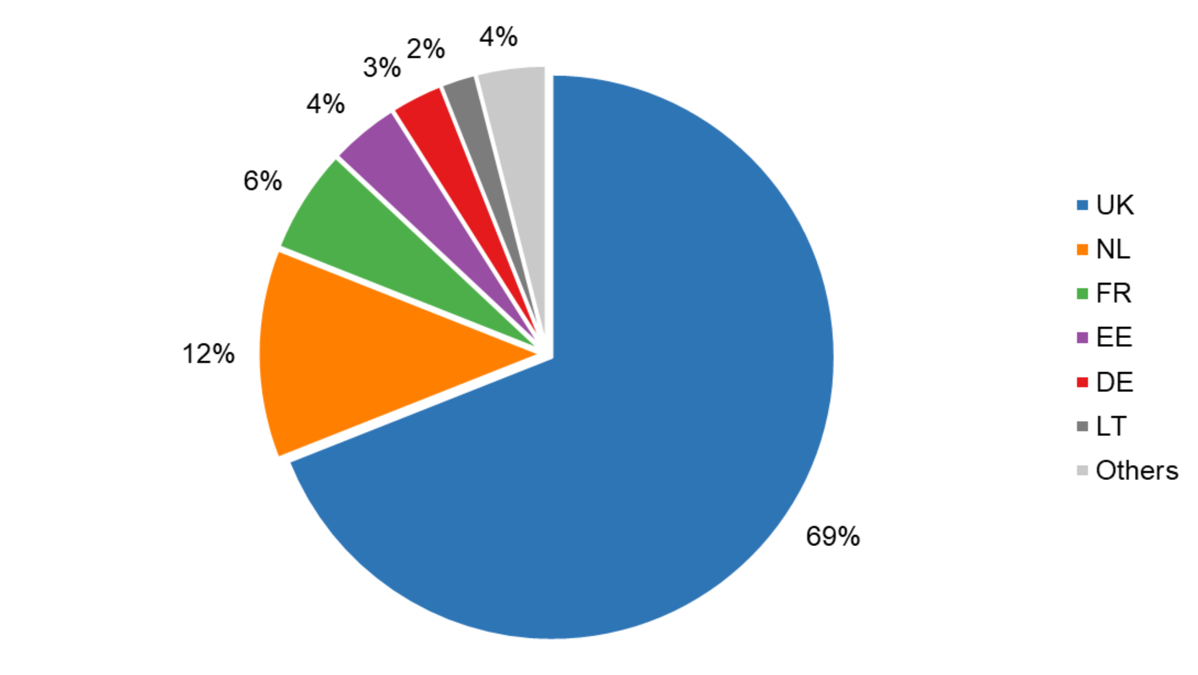
Empirical evidence points to a significant overall investment gap in AI and blockchain technologies in Europe in comparison with the US and China. One of the underlying differences between the US and Europe is that, between 2009 and 2018, European blockchain start-ups made far greater use of alternative forms of finance than their US counterparts. For example, European start-ups obtained a large amount of funding through ICOs. Innovative European companies managed to raise almost 60% of their total financing in this way during this period, while the equivalent figure for US blockchain start-ups did not exceed 18%.

Despite this rapid increase in investment and accompanying investor interest, investors still lack the knowledge about emerging technologies like blockchain and quantum computing. This knowledge gap is preventing investors from adequately assessing the technical and financial viability of deep-tech solutions. Investors often lack the necessary knowledge and tools to recognise truly disruptive technologies that are likely to lead to the next wave of innovations. Information asymmetries are therefore a major bottleneck preventing European blockchain start-ups from accessing funding. This has led to significant underinvestment in such businesses in Europe(6).

(5) https://ec.europa.eu/digital-single-market/en/blogposts/forging-new-frontiers-finance-digital-innovations

(6) Bjorn-Soren Gigler, *Financing the Deep Tech Revolution. How investors assess risks in Key Enabling Technologies (KETs)*, European Investment Bank, 2018.

Figure 3 Share of blockchain funding in the EU, 2009-2018



Source: European Commission, JRC, Blockchain Now and Tomorrow, June 2019.

In Europe, the European Blockchain Partnership (EBP) was created in 2018 through a ministerial declaration signed by Member States. The EBP established a European Blockchain Services Infrastructure (EBSI) to support the delivery of cross-border digital public services with the highest standards of security and privacy. In 2020, EBSI will deploy a network of distributed blockchain nodes across Europe, supporting applications focused on selected use cases[(7)]. In parallel, the European strategy on blockchain is currently being drawn up and is expected to be adopted by mid-2020[(8)].

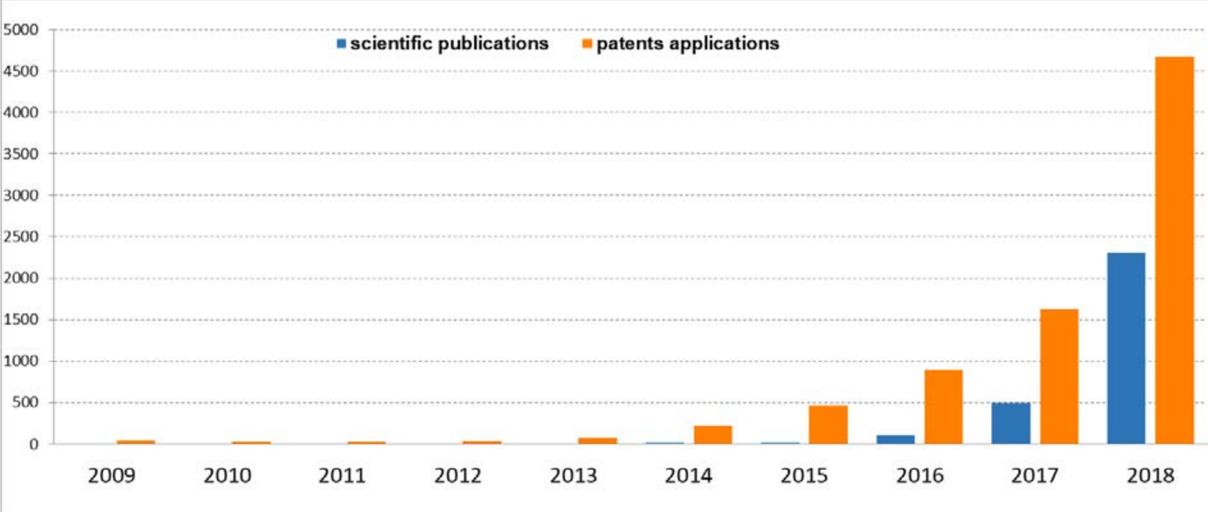
Research programmes are supporting the development and market update of blockchain and distributed ledger technologies. In 2020, the European Commission launched a new artificial intelligence and blockchain investment fund of €100 million. This equity investment instrument will support innovative companies and start-ups through the Horizon 2020 programme. Thanks to the leveraging of the European Fund for Strategic Investments (EFSI) and the European Investment Fund (EIF), the AI and blockchain investment fund will 'crowd-in' private investment. It is estimated that the total investment volume in the first phase 2020-2021 will be around €300-400 million. The plan is to scale up the AI and blockchain investment fund under the InvestEU programme starting in 2021, to eventually reach an investment volume of approximately €1-2 billion[(5)].

On research and innovation, the number of scientific publications about blockchain technologies has increased significantly since 2014, and particularly since 2018. More than half of the publications are conference papers, and around 30% are scientific articles[(9)]. A similar trend can be seen in the number of blockchain patent applications worldwide, which rose from 72 in 2013 to more than 4,600 in 2018[(10)]. China and the US are global leaders in scientific publications and patent

[(7)] https://ec.europa.eu/digital-single-market/en/blockchain-technologies
[(8)] European Commission, *Shaping Europe's digital future*, COM(2020)67 final, 19.2.2020.
[(9)] Scopus analyzer, keyword (blockchain).
[(10)] Statista.

applications. The EU is third in blockchain patent applications. In Europe, the UK and Germany are among the top 10 countries in both areas[9], [10].

Figure 4 Total number of blockchain scientific publications vs. patent applications worldwide, 2009-2018



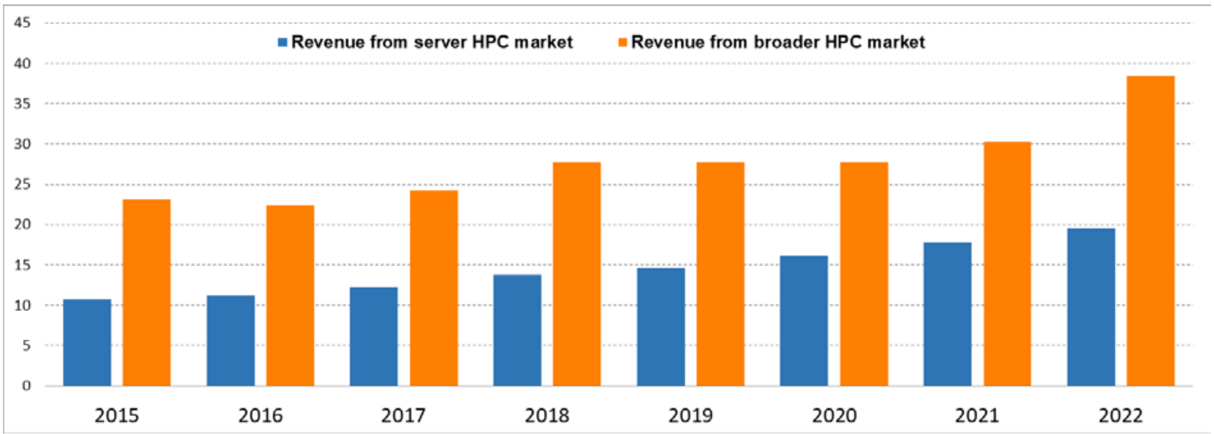
Source: Scopus (scientific publications), Statista (patent applications worldwide).

2. High Performance Computing (HPC)

High Performance Computing (HPC), also known as supercomputers, is used by public and private sector users to solve highly complex computational or data intensive problems. HPC helps people to better understand and better respond to a variety of socioeconomic challenges in areas such as aerospace, automotive, manufacturing, health, and climate change. The demand for HPC will increase considerably in the coming years. The combination of HPC with artificial intelligence, big data and cloud computing will foster the rapid development of new applications and services across multiple sectors, including more traditional parts of the economy.

Revenues from the broader HPC market worldwide is expected to grow from around $27 billion in 2018 to almost $40 billion in 2022. The broader HPC market includes servers, storage, middleware, applications and services. Within the broader HPC market, revenues for the server market alone are expected to increase worldwide from around $13 billion in 2018 to almost $20 billion in 2022.

Figure 5 HPC server market vs. HPC broader market revenue worldwide, 2015-2022, in $ billion

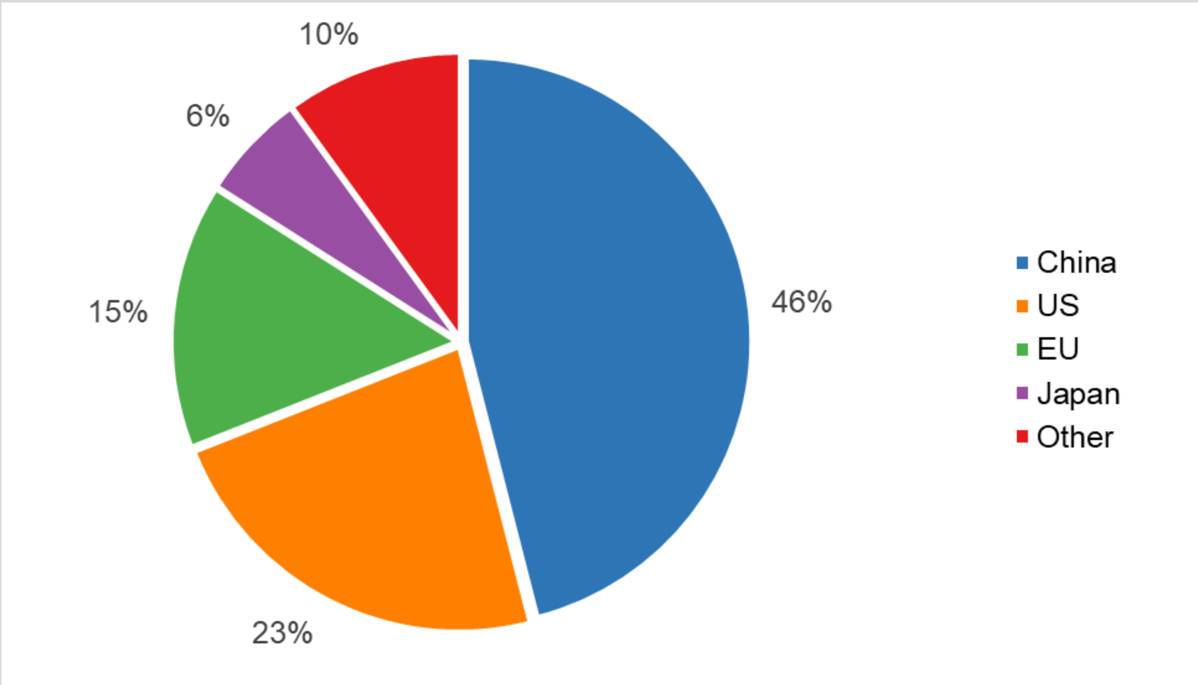


Source: Statista, insideHPC.

Europe is a leader in HPC applications, but its supercomputing infrastructure is falling behind in world rankings. An accepted headline indicator of competitiveness in HPC is the number of systems in the top-10 and top-500 lists of supercomputers in each of the world regions. This number reveals a country's or region's access to the most powerful supercomputers. As of September 2019, only 1 of the world's top-10 supercomputers was installed in the EU, ranking number 9. This is a decline since 2012, when the EU had 4 such systems. The current supercomputing power available in the EU is less than half of that available in the US or China, according to the list of the world's top-500 supercomputers (see *Figure 6*). Of the top-500 systems, 76 are installed in EU Member States, compared with 117 in the US and 228 in China.

Europe consumes one third of supercomputer resources worldwide, but provides only around 5% of those[11]. In addition, HPC use in Europe is currently concentrated in the public sector. Most HPC capacity and usage (over 90% of operating time) is installed at universities or research centres, and the remaining 10% serves commercial purposes and/or HPC end users. The main commercial users are large corporations in industrial sectors (e.g. automotive, aerospace, defence or energy) who use HPC systems, in particular to reduce research and development costs or to reduce time-to-market for their products. Although SMEs have recently started to use HPC, they still face many barriers limiting their use.

Figure 6 World Top 500 supercomputers, regional share 2019



Source: Top500.org list.

The combination of HPC services with cloud computing can make HPC capabilities much more accessible to a broader user base, particularly SMEs. The EU is funding R&D projects like the *Fortissimo Marketplace*[12], which offers HPC resources, software applications, expertise and tools. These are offered on a self-service basis and are mainly cloud-based, and are delivered by major HPC technology providers in Europe. In addition, national HPC competence centres will be created in each participating state of the Euro HPC Joint Undertaking (JU) to provide HPC services to industry (including SMEs), academia and public administrations. The aim of these competence centres will be to foster the transition towards wider uptake of HPC in Europe.

The US and China are investing intensively in HPC technologies, and the funding gap in Europe is expected to amount to €500 million per year. To address this issue in the period 2014-2018,

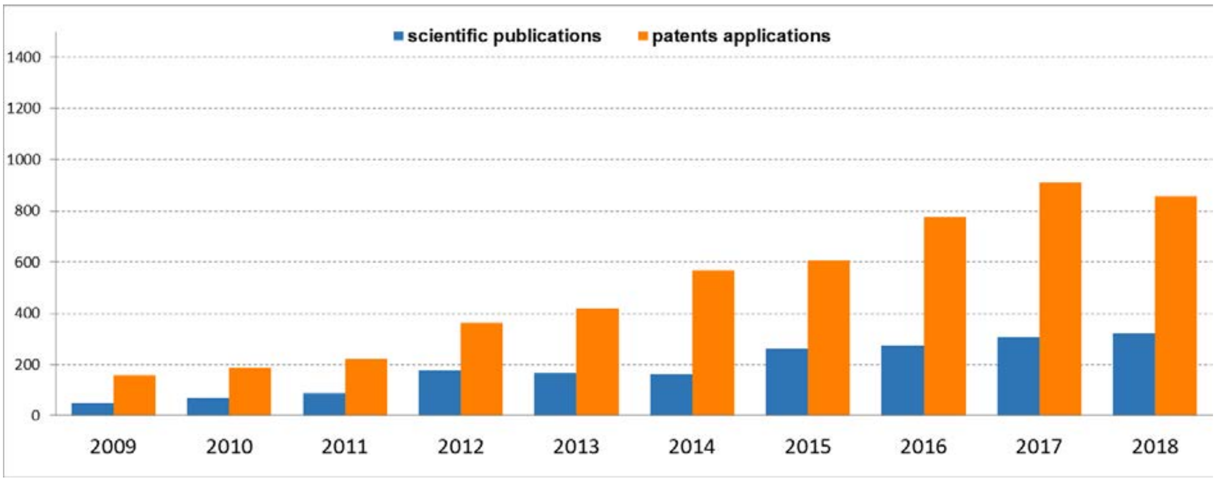
[11] European Commission, HPC factsheet https://ec.europa.eu/digital-single-market/en/news/high-performance-computing-factsheet
[12] https://www.fortissimo-project.eu/

different R&I investments supported the development of HPC technology in Europe to a total of €700 million(13). In September 2018, the Euro HPC JU was established. Its main objective is to coordinate the efforts in Europe to: (i) deploy a world-class supercomputing infrastructure; (ii) build a competitive innovation ecosystem for HPC; (iii) promote HPC applications; and (iv) develop skills in HPC. The JU currently has 32 participating states: all EU Member States (with the exception of Malta), Montenegro, North Macedonia, Norway, Switzerland, Iceland and Turkey(14). The initial co-investment with Member States is of €1 billion. An additional around €400 million will be contributed by private or industrial players in the form of in-kind contributions to the JU's activities. This initiative is expected to generate around €10 billion in investments in HPC applications(13). By the end of 2020, the EuroHPC JU will acquire and install 8 supercomputers: 3 high-range (pre-exascale) supercomputers in Finland, Spain, and Italy that will place Europe back in the world's top-10; and 5 mid-to-high range (petascale) supercomputers in Luxembourg, Portugal, Czechia, Slovenia, and Bulgaria.

For 2021-2027, under the new Multiannual Financial Framework, the EU plans to invest more than €1 billion for R&I to create a leading European innovation ecosystem. It also plans to invest more than €5 billion for large-scale deployments and capability building, including: (i) the acquisition of exascale supercomputers and quantum computers; and (ii) the coordination of national HPC competence centres, large-scale training and skills upgrades.

As regards global activity on HPC research and innovation, the number of scientific publications has increased steadily since 2009, and particularly since 2014. Almost 70% of the publications are conference papers, and around 25% are scientific articles. Between 2009 and 2018, the number of patent applications worldwide grew at an annual average of about 20%(15), but it remains low compared to other emerging technologies.

Figure 7 Total number of HPC scientific publications vs. patent applications worldwide, 2009-2018



Source: Scopus (scientific publications and patent applications).

The US is by far the global leader in HPC scientific publications and patent applications, with around 50% of total publications and 80% of total patent applications. Germany and China follow close behind for HPC scientific publications, and the Japan Patent Office is the second most active in HPC patent applications(15).

Through the Horizon 2020 programme, the EU is fostering an HPC ecosystem capable of developing new European technology such as high performance energy efficient HPC chips. For example, the

(13) European Commission, HPC brochure.
(14) https://eurohpc-ju.europa.eu/
(15) Scopus analyzer, keyword (hpc AND high performance computing).

European R&D project European Processor Initiative[16] is, among other activities, conducting research to design and implement a roadmap for a new family of low-power European processors for extreme scale computing and high performance big data.

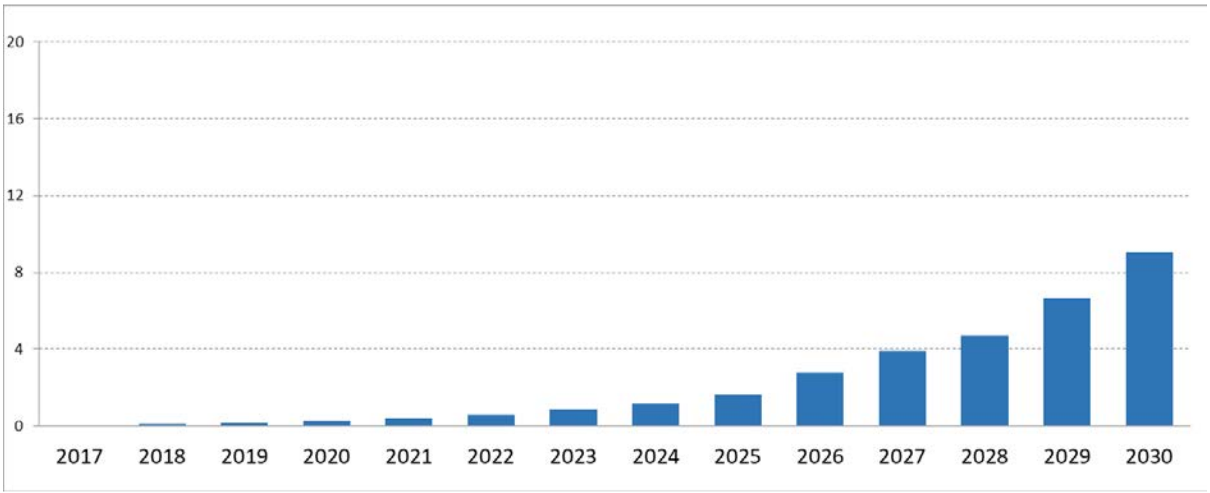
In Europe, there is an acute skills mismatch in emerging technologies between academic offer and the demand for skills profiles by industry. This problem is growing as the offer lags significantly behind market needs. Most Member States are facing shortages of ICT professionals and technicians, while the current educational offering of specialised, higher education programmes is limited. The academic offer of HPC courses/curricula in Europe is generally taught at masters level (two thirds of the total academic offer are at masters level). There are fewer specialised programmes in HPC than other technologies such as artificial intelligence: specialised programmes represent 20% of all HPC masters and 15% of all HPC bachelor programmes[17].

3. Quantum technology

Quantum technologies exploit the properties of quantum mechanics and physics to solve complex problems much faster or much better than traditional methods. They make possible the development of radically new technologies in computing, communication, security, and sensing. Quantum computing can be applied in many sectors (e.g. aerospace, agriculture, health, manufacturing, automotive or energy) and in combination with other digital technologies. For example, advanced cryptography techniques can help develop secure communications and improve detection of network intrusions.

Revenues from quantum computing market worldwide are expected to reach $260 million in 2020, of which $96 million will come from Europe. A significant increase in these revenues is estimated over the next 10 years to around $9 billion by 2030. North America is projected to be in the lead by 2030 with $2.7 billion, followed closely by Europe with $2.6 billion, and the Asia Pacific region with $2.1 billion[18].

Figure 8 Size of the enterprise quantum computing market worldwide 2017-2030, in $ billion



Source: Statista, Quantum Computing for Enterprise Markets report of Tractica.

A great deal of investment and expertise will be needed to help quantum technologies transition from the research and development phase to deployment. The US, Japan, China, Korea, Canada and

[16] https://www.european-processor-initiative.eu/project/epi/

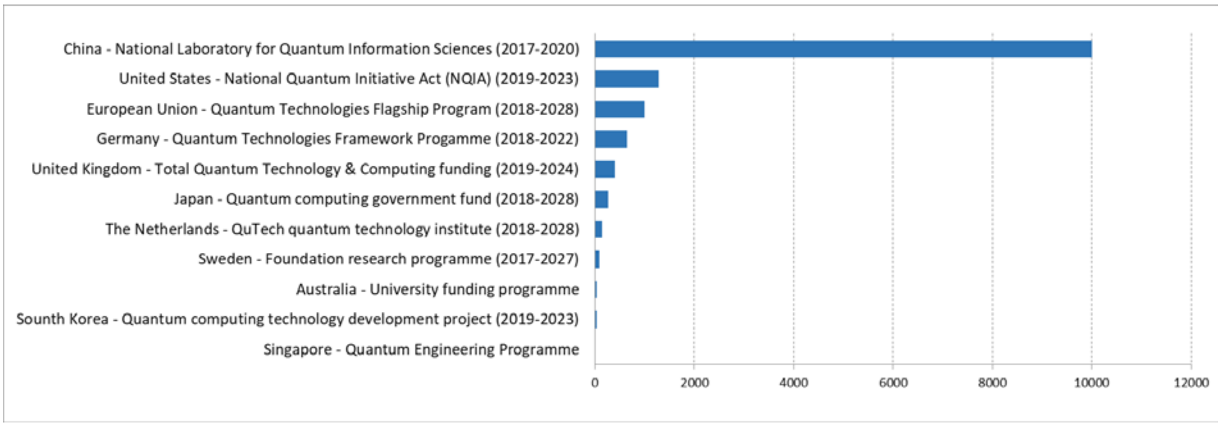
[17] European Commission, JRC, *Academic offer and demand for advanced profiles in the EU*, 2019.

[18] Quantum Computing, a dossier-plus on the state and outlook of the 5th generation of computing, Statista, October 2019.

Europe are investing strongly in quantum technologies. However, they still rely largely on public funds, and most of fundamental research is done in universities and research facilities. In 2017, China launched a $10 billion programme to build a national laboratory for quantum information sciences by 2020 (see *Figure 9*). Given its current technology readiness level, equity funding is still low for quantum computing compared to other emerging technologies.

In 2018, the EU launched the first phase of a ten-year, strategic Quantum Flagship research initiative with a budget of €1 billion. It covers five fields: quantum communication; quantum computing; quantum simulation; quantum metrology and sensing; and the basic science behind quantum technologies. In the period 2021-2027, quantum technologies will be supported by the Digital Europe programme (strategic digital capacities in Europe), the Horizon Europe programme (research and space applications) and the InvestEU programme (mobilising public and private investment using an EU budget guarantee).

Figure 9 Government funding/investment in quantum technology



Source: Statista, March 2019.

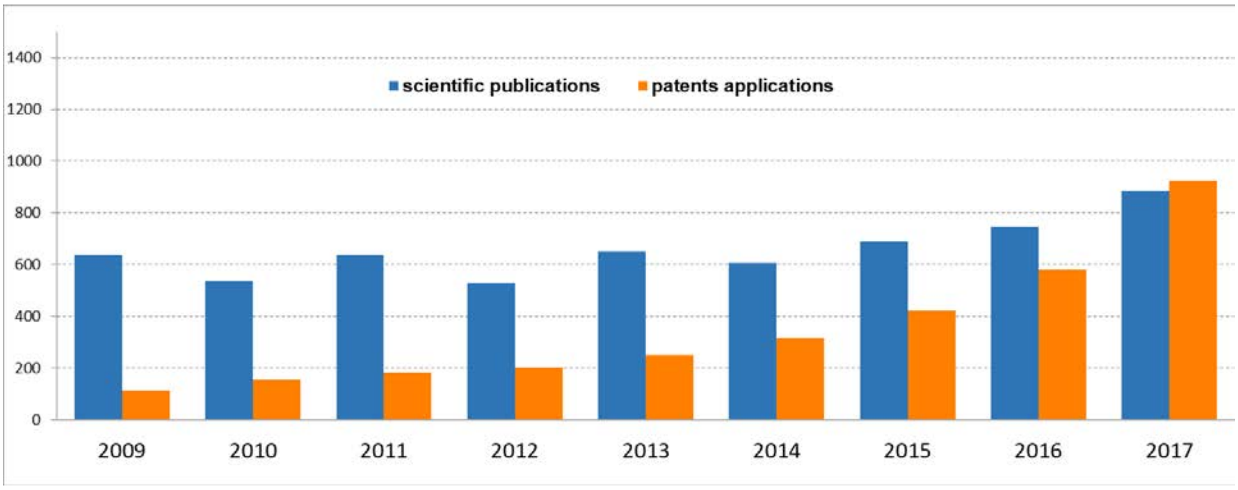
In June 2019, the European Commission and several Member States signed a ministerial declaration agreeing to explore together, over a period of 12 months, how to develop and deploy a quantum communication infrastructure (QCI) across the EU within the next 10 years[19]. In addition, the European strategy on quantum is under preparation and is expected to be adopted by mid-2020[8].

In relation to research and innovation activities for quantum technologies, the number of annual scientific publication remained roughly unchanged until 2016, with a slight increase in 2017. Half of the publications are conference papers, and around 40% are scientific articles[20]. The US is the most active in this field, followed by China and Germany.

[19] https://ec.europa.eu/digital-single-market/en/news/future-quantum-eu-countries-plan-ultra-secure-communication-network

[20] Scopus analyzer, keyword (quantum tecnolog*).

Figure 10 Total number of Quantum scientific publications vs. patent applications worldwide, 2009-2017



Source: Scopus (scientific publications), Statista (patent applications worldwide).

Patenting activity in the field of quantum computing started to accelerate in 2012. Quantum computing and quantum key distribution are the applications for which by far the most patent applications have been filed to date. The US leads in quantum computing and China leads in quantum key distribution(21). Likewise, quantum metrology and sensing saw an increase in patent applications starting in 2009, but the number of patent applications is still low in absolute terms, and mainly driven by research institutes (patent applications in the field rose from 8 applications in 2009 to 83 in 2017). The leading patent authorities in this sub-sector are China, the US and the European Patent Office(22). Even though commercial products based on quantum-computing are starting to emerge (for example in quantum sensing), the market for quantum technologies still appears to be limited. This might be explained by insufficient technological maturity and a lack of clear business cases: most of the patents do not target specific applications, and are instead directed at improving technologies(21).

4. Data and edge computing

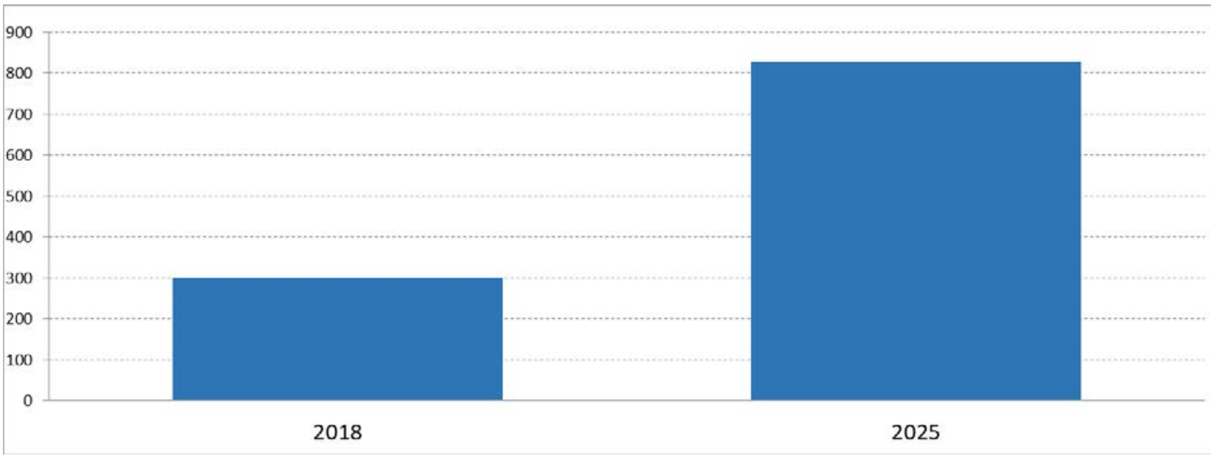
Data is an enabler of digital transformation and an accelerator of innovation for technologies such as the Internet of Things, artificial intelligence, cybersecurity or robotics. Large volumes of data are fuelling data-driven innovations. For example, they can help artificial intelligence to make breakthroughs in machine learning, as massive amounts of data are needed to train neural networks(23). Likewise, using HPC and cloud computing together can make it possible to access and develop advanced analyses of large amounts of data in a very short time.

The volume of data produced in the world is growing rapidly, from 33 zettabytes in 2018 to an expected 175 zettabytes in 2025(24). It is estimated that the EU27's data economy (the overall impacts of the data market on the economy as a whole) exceeded the threshold of €300 billion in 2018, up nearly 12% over the previous year. In addition, it is expected to reach €829 billion by 2025,

(21) Martino Travagnin, *Patent analysis of selected quantum technologies*, 2019.
(22) European Patent Office, *Landscape study on patent filling, quantum metrology and sensing,* 2019.
(23) European Commission, The European Data Market Monitoring Tool, *Data as the engine of Europe's digital future*, IDC report, 2019.
(24) European Commission, *A European strategy for data*, COM(2020)66 final, 19.2.2020.

accounting for 5.8% of EU GDP[25]. There were 5.7 million data professionals in the EU27 in 2018, and this figure is soon expected to double, reaching 10.9 million people by 2025[24].

Figure 11 Size of data economy in EU27, 2018 vs. 2025, in € billion



Source: The European data strategy, Shaping Europe's Digital Future, factsheet, February 2020.

This trend is also confirmed by the data market, which has increased significantly from €47 billion in 2014 to €72 billion in 2018 (EU28). This increase was registered in all EU Member States. The UK, France, Germany, Italy, Spain and the Netherlands accounted for approximately three quarters of the EU28 data market in 2018[23].

Open data (making data accessible for use and re-use by researchers and the general public) has a tremendous potential to create new products and services in many areas such as healthcare, transport, or energy. Open data is considered an enabler for the economy and is therefore similar to infrastructure. The size of the open data market in the EU27+[26] is expected to increase from about €184 billion in 2019 to about €199 billion in 2025 under a baseline scenario, or to about €334 billion in 2025 under an optimistic scenario[27]. The baseline scenario assumes that the impact of open data only grows at the same pace as EU GDP, while the optimistic scenario assumes higher growth rates based on several studies and forecasts by experts. The potential for job creation through publishing and re-using open data in both the public and private sector is significant. The number of employees working on open data in the EU27+[26] might increase from 1.09 million in 2019 to 1.12 million in 2025 under a baseline scenario, or to about 1.97 million in 2025 under an optimistic scenario[27].

In the next 5 years, the computing technologies enabling data storage and analytics will adapt by shifting from data centres and centralised cloud computing facilities (currently accounting for 80% of data storage) to decentralised systems (currently accounting for 20% of data storage) also known as 'edge computing' (e.g. smart connected objects)[24]. Edge computing is one of the emerging solutions to cope with the expected increase in data traffic due to the adoption of Internet of Things technologies. These technologies could lead to the existence of up to 80 billion connected devices worldwide by 2025. Edge computing will perform data processing close to the source where data is generated. It will also allow for smart workload balancing and energy efficient optimisation of data

[25] European Commission, *The European data strategy, Shaping Europe's Digital Future, factsheet, February 2020.*

[26] EU27 and EFTA countries (Iceland, Liechtenstein, Norway and Switzerland).

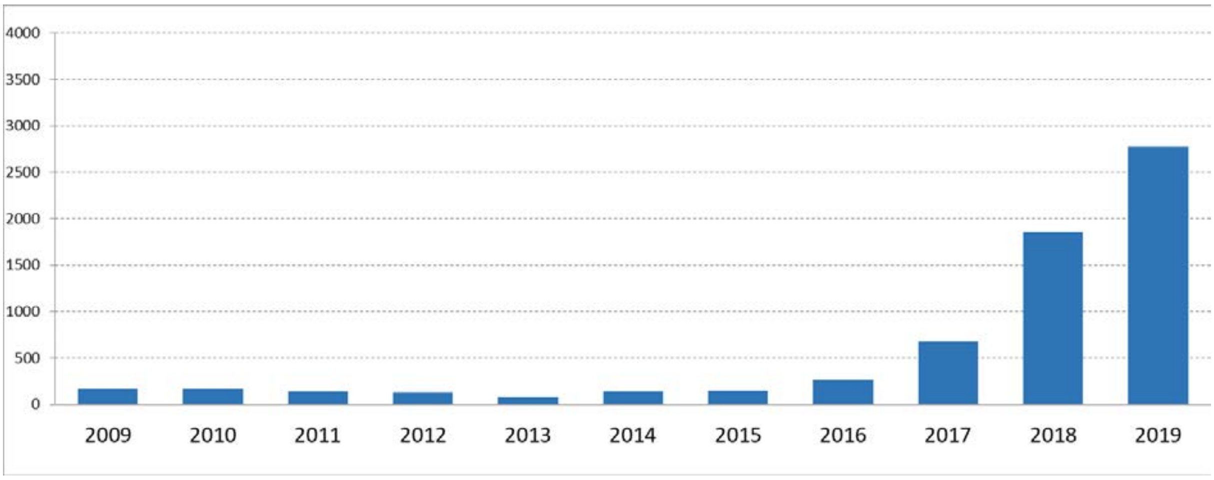
[27] European Commission, European Data Portal, *The economic impact of open data, Opportunities for value creation in Europe,* 2020.

flows between central servers and edge clouds. This approach can also make good use of resources that are not continuously connected to a network, such as smart phones or sensors[28].

Edge computing is expected to benefit market segments such as video surveillance, mobile video distribution, smart cities, transport, artificial intelligence in manufacturing, augmented reality, etc. The market value worldwide of the addressable markets for edge computing is expected to be €108 billion by 2024. This would represent a compound annual growth rate of about 30% for the period 2019-2024. In addition, about half of the market for edge computing is expected to be captured by cloud providers by 2024, while the other half will be shared between industrial, software and telecommunication companies[29].

Scientific activity around edge computing has also increased significantly in recent years, up from 260 scientific publications in 2016 to more than 2,700 in 2019. About 60% of the publications are conference papers, and about 35% are scientific articles[30]. China leads in the number of scientific publications, with almost 50% of total publications in 2019, followed by the US with about 25%.

Figure 12 Total number of Edge Computing scientific publications, 2009-2019



Source: Scopus (scientific publications).

(28) European Commission, JRC, *Artificial Intelligence: A European Perspective*, 2018.
(29) Idate.org, *Edge computing, key figures,* Emerging Tech, 2019.
(30) Scopus analyzer, keyword (edge computing).

ANNEX I Abbreviations

Abbreviation	Explanation
4G / 5G	Fourth/Fifth generation technology standard for cellular networks
AI	Artificial Intelligence
BCO	Broadband competence office
BERD	Business expenditure on R&D
CAGR	Compound annual growth rate
CEF	Connecting Europe Facility
CRM	Customer Relationship Management
CSA	Coordination and Support Actions
DIH	Digital Innovation Hubs
DII	Digital Intensity Index
DOCSIS	Data over cable service interface specification
DSL	Digital subscriber line
DTT	Digital terrestrial television
EBP	European Blockchain Partnership
EBSI	European Blockchain Services Infrastructure
eForm	Electronic Form
EFSI	European Fund for Strategic Investments
eID	Electronic Identification
eider's	Electronic Identification, Authentication and Trust Services
EIF	European Investment Fund
ERA-NET	European Research Area
ERM	Enterprise Risk Management
ERP	Enterprise Resource Planning
Euro HPC JU	Euro High Performance Computing Joint Undertaking
FET	Future & Emerging Technologies
FTTB	Fibre-to-the-building
FTTH	Fibre-to-the-home
FTTP	Fibre-to-the-premises
FWA	Fixed wireless access
GBARD	Government Budget Allocations for R&D
GDP	Gross Domestic Product
GHz	Gigahertz
HES	Secondary and Higher Education Establishments
HPC	High Performance Computing
IA	Innovation Action
IaaS	Infrastructure as a service
ICOs	Initial Coin Offerings
ICT	Information and communication technology
IMSI	International mobile subscriber identity
IoT	Internet of Things
JRC	Joint Research Centre
LEIT	Leadership in Enabling and Industrial Technologies
LTE	Long-term evolution
Mbps	Megabits per second
MHz	Megahertz
MNO	Mobile network operator
MVNO	Mobile virtual network operator

NACE	Statistical Classification of Economic Activities in the European Community
NBP	National broadband plan
NGA	Next generation access
NRA	National regulatory authority
OTT	Over-the-top
PaaS	Platform as a Service
PCP	Pre-Commercial Procurement
PERD	R&D personnel
PPI	Public Procurement for Innovation
PPS	Purchasing Power Standards
PRC	Private for-Profit Companies
PSAP	Public safety answering point
QCI	Quantum Communication Infrastructure
R&D	Research and Development
R&I	Research and Innovation
REC	Research Organisations
SaaS	Software as a Service
SMEs	Small and Medium Enterprises
USO	Universal service obligation
VDSL	Very-high-bit-rate digital subscriber line
VHCN	Very high capacity network