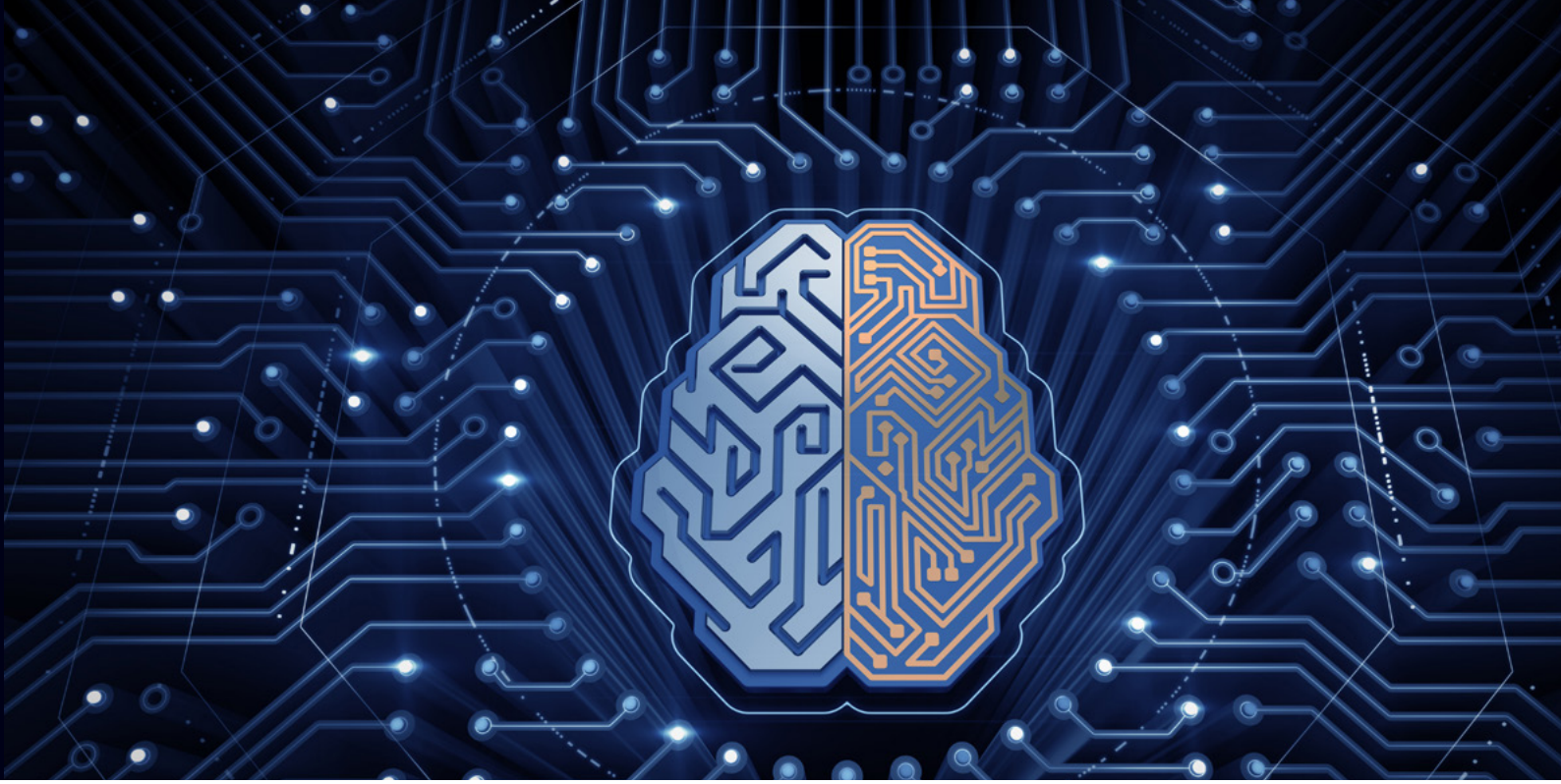

Artificial intelligence, blockchain and the future of Europe:

How disruptive technologies create opportunities for a green and digital economy

European Commission

European Investment Bank
The EU bank

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Main Report
June 2021

Prepared for:

The European Commission (DG CONNECT)

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This report was produced with funding from the European Union, under the InnovFin mandate.

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Consultancy support: Oliver Wyman

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Table of contents

Foreword

Artificial intelligence (AI) and blockchain are two of the most transformative and disruptive technologies of our times. The ongoing transition towards a digital economy has undeniably been accelerated by the COVID-19 pandemic. These technologies will play a central role on the path towards a sustainable and resilient recovery, and towards Europe's technological sovereignty.

This report presents a compelling case for allocating more resources to increase Europe's innovation capacity, to look beyond immediate needs and to think long-term, to think strategically and to think visionary, asking ourselves: where do we want to be in 10, 20, 30 years from now? What type of innovations and technologies will lay the ground for future generations?

All major economies in the world are racing to achieve a leading position in the development and deployment of AI and blockchain technologies. Europe, despite its scientific excellence, is lagging behind in particular on the financing front, where we only account for 7% of annual global equity investments in these technologies. We need to give our emerging startups more firepower to compete globally, and to instil confidence and conviction to back our future tech champions.

However, finance only is not enough. We also need to strengthen and connect our ecosystems further in order to translate brilliant ideas into commercial value better and faster. However, we equally must pay close attention to the challenges and risks associated with AI and blockchain technologies, despite their countless benefits and opportunities. The risks notably relate to the trustworthy, responsible and ethical implications of AI and ensuring technologies will be developed and deployed in line with our European values.

At the EIB Group, we understand this nexus and are ready to provide finance and advisory support to leverage on the AI and blockchain opportunity while keeping a human-centric and inclusive approach in mind. In close collaboration with the European Commission, our colleagues at the European Investment Fund (EIF) recently launched a successful €100 million pilot project for a dedicated AI and blockchain investment scheme, while the EIB has launched a €150 million co-investment facility to invest in AI and blockchain projects alongside EIF-backed fund managers and private sector investors. This report will further guide us in our efforts.

I would like to thank my colleagues at the European Commission for their excellent collaboration with our Innovation Finance Advisory team. I am looking forward to continuing our close cooperation to boost Europe's performance in AI and blockchain for the benefit of our economy, our people and wider society.

European Investment Bank Vice-President
Teresa Czerwińska

Executive summary

Introduction

Artificial intelligence and blockchain defined

The High-Level Expert Group on Artificial Intelligence set up by the European Commission defines **artificial intelligence (AI)** as "systems that display intelligent behaviour by analysing their environment and taking actions – with some degree of autonomy – to achieve specific goals."[1] AI-based systems can be purely software-based, acting in the virtual world (such as voice assistants, image analysis software, search engines, and speech and face recognition systems), or embedded in hardware devices (such as advanced robots, autonomous cars, drones or internet of things applications). **Blockchain (BC)** is defined as "a technology that allows people and organisations to reach agreement on and permanently record transactions and information in a transparent way without a central authority." [2] The potential of blockchain technologies goes well beyond cryptocurrencies and financial applications, and use cases outside the financial sector are growing in number.

Artificial intelligence (AI) and blockchain (BC) are two of the most significant disruptive technologies of our time, set to have a major impact on future societies and economies. As transversal technologies, AI and blockchain can potentially disrupt a wide range of sectors and will likely play central roles in the success of Europe's green and digital transitions, and in strengthening its technological sovereignty. Regions lagging behind in the AI race will probably see diminished global market shares in several industries, from finance and e-commerce to manufacturing and mining. Investments in AI research and development (R&D) are also crucial for security and defence, so underinvestment could undermine Europe's national security.[3] AI is expected to have a significant impact on progress towards achieving the Sustainable Development Goals (SDGs), especially on climate[4] but also on diversity and inclusion, notably "gender smart" technological development. Both AI and blockchain have their own degree of complexity, but their development can be mutually reinforcing, for example on the integration of machine learning (ML).

In 2019 it was estimated that global gross domestic product (GDP) could increase by up to 14% (the equivalent of €13.3 trillion) by 2030 because of the accelerating development and take-up of AI.[5] Blockchain was also forecast to have a wide-reaching impact on GDP by 2025.[6] Both of these technologies can drive digitalisation across virtually all economic sectors. In addition, researchers and practitioners alike envisage increasing disruptions from the convergence of AI and blockchain, laying the groundwork for a fully digital economy. Their integration with the system of internet connectivity

1 A definition of artificial intelligence: Main capabilities and scientific disciplines, High-Level Expert Group on Artificial Intelligence, 8 April 2019 (link, accessed 6 April 2020).
2 Shaping Europe's digital future. Blockchain strategy (link, accessed 11 May 2020).
3 Artificial intelligence and national security, US Congressional Research Service, Washington, DC, 30 January 2019 (link).
4 Vinuesa, R., Azizpour, H., Leite, I. et al. The role of artificial intelligence in achieving the Sustainable Development Goals. Nature Communications 11, 233 (2020).
5 Sizing the prize: What's the real value of AI for your business and how can you capitalise? PwC, 2018.
6 Building Block(chain)s for a better planet, World Economic Forum, 2018.

across devices (internet of things, IoT) can lead to even greater opportunities. While this convergence is only just beginning, it has already started within large corporates and is showing powerful use cases.[7]

Global equity investments in AI and blockchain technologies amounted to €80–85 billion[8] between 2010 and 2019 (annual growth rate of 38%[9]). The COVID-19 crisis may have a negative short-term impact on access to finance for AI and blockchain technologies (for example, on availability of capital and on valuations). However, the current situation is also expected to generate positive commercial momentum for these technologies due to their potential to accelerate digitalisation and reinvent the key sectors hit hard by the crisis, such as financial services, healthcare and business intelligence. AI and blockchain technologies can increase the resilience of the EU economy. For example, in light of the COVID-19 pandemic, AI can significantly help to accelerate drug discovery processes or facilitate the crucial sharing of information from clinical trials and insights on how the disease develops. Meanwhile, blockchain technologies provide a remarkably transparent and decentralised way of recording lists of transactions, which can facilitate anything from the sharing economy to smart contracts and supply chain management, the latter having proven notably vulnerable during the pandemic.

All major world economies, including the European Union, are racing to achieve a leading global position in the development and deployment of AI and blockchain. The European Commission has taken several measures to advance these technologies: the Horizon 2020 programme allocated €1.5 billion to AI in 2018–2020; the Digital Europe Programme (DEP), as part of the 2021–2027 Multiannual Financial Framework (MFF), will complement this by dedicating an additional €2.5 billion to investing in and opening up the use of AI by businesses and public administrations.

On the investment front, the European Investment Bank (EIB) launched a €150 million co-investment facility to invest alongside fund managers and private investors backed by the European Investment Fund (EIF), while the EIF recently launched a pilot for a dedicated AI and blockchain investment scheme of €100 million. Beyond such dedicated funds, the European Commission has made additional resources available under the new Multiannual Financial Framework and the post-pandemic NextGenerationEU programme, particularly the Recovery and Resilience Facility (RRF), which will be deployed with particular attention to strategic technologies.[10]

These EU-wide initiatives are complemented by actions at Member State level, such as in France, Germany, Italy and the Netherlands. These measures are helping to catalyse broad-based AI and blockchain expertise in the European Union, which now has more specialised AI researchers (~40 000) than the United States (~30 000) and China (~20 000). The European Union also contributed to 30% of the global AI research publications in 2013–2017.[11]

Companies and governments in Europe are substantially underinvesting in AI and blockchain compared to other leading regions, and it has become clear that the European Union struggles to translate its scientific excellence into business application and economic success. Compared to other major economic systems, there are no fundamental structural differences in the economy of the European Union that could justify lower business demand to deploy these technologies and take up digital transformation.[12] However, the United States and China together account for over 80% of the €25 billion of annual equity investments in AI and blockchain technologies, while the EU27 only

7 Come together: The convergence of blockchain, AI and IoT, EU Blockchain Observatory and Forum, 2019.

8 All currency figures in this report are converted according to annual averages of the corresponding year, presented in euro.

9 Preqin data, Oliver Wyman analysis.

10 MFF Factsheets. European Commission (link, accessed 15 June 2020).

11 Who Is winning the AI race: China, the EU or the United States? Center for Data Innovation, 2019.

12 For example, as measured by the I-DESI index for 2018 (link, accessed 15 May 2020), digital economy performance is higher in the European Union (on average) than in China and Israel, while only South Korea outperforms the top-4 EU countries.

accounts for 7% of this global amount, investing around €1.75 billion.[13] Europe's venture capital (VC) ecosystem seems to mainly provide early-stage finance for AI/blockchain-based small and medium-sized enterprises (SMEs) (10% of total venture capital investments in the European Union, versus 5% in the United States[14,15]), but clearly underperforms in subsequent rounds of financing (expansion and growth stages).

Triangulating various methodologies, this study estimates a total investment gap in AI and blockchain technologies in the European Union of about €5–10 billion per year. This gap appears: (i) to consist for the most part of equity investments – as compared to debt; (ii) to be dominated by AI (~80%) – as compared to a gap in blockchain investments; and (iii) to be more prominent in the later stages of financing, such as Series A onwards – as compared to the seed stage.[16] Although the pandemic's long-term commercial impact on these technologies is expected to be positive, access to finance may become more challenging in the short run as a result of market conditions, potentially widening the investment gap. EU and Member State support schemes could plug part of the gap, but private markets will clearly need to contribute the balance.

Study approach

The study comprised three steps:

- Step 1: The study analysed the global AI and blockchain landscape based on Oliver Wyman's experience and expertise in the sector, as well as on other existing research, market analyses, published reports and expertise in the sector. Based on proprietary databases, the study benchmarked the European Union with other international geographies and estimated a range for the equity and debt investment gap for the two technologies, respectively.
- Step 2: The researchers surveyed over 100 AI and blockchain small and medium-sized enterprises (SMEs) located in the 27 Member States and conducted in-depth interviews with 18 of those SMEs, as well as 19 financial market participants (including VC funds, corporate venture capital (CVC) funds, private equity (PE) firms, banks, national promotional banks (NPBs), and innovation agencies). The aim was to identify potential market failures and access-to-finance barriers.
- Step 3. The study presents a set of recommendations targeting the key market failures and barriers identified in the previous steps, supported by a high-level cost–benefit analysis and a high-level action plan for implementing these recommendations.

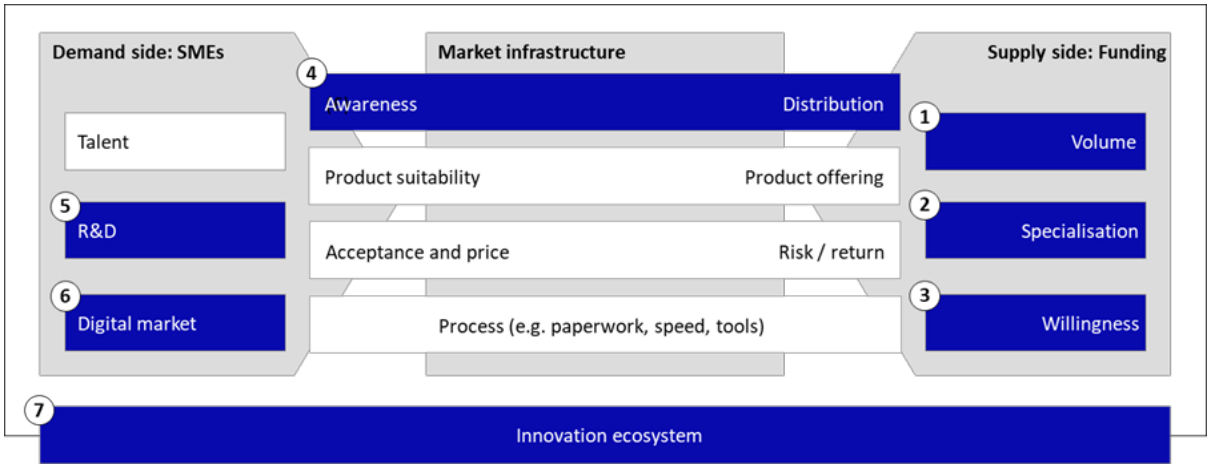
13 Preqin data, Oliver Wyman analysis.
14 Preqin data, Oliver Wyman analysis.
15 European small business finance outlook, EIF, 2019, p. 51.
16 Preqin data, Oliver Wyman analysis.

Bottlenecks in AI and blockchain financing

The analysis, survey and interviews have identified several bottlenecks constraining access to finance for AI and blockchain companies in Europe. These are shown graphically in Figure 1.

The study looked at the demand and supply sides. On the demand side, it is critical that small and medium businesses have the right talent to push innovation and produce high-quality R&D, and can scale up their products in a unified digital market. On the supply side, venture capital investors, banks and other financial providers need to have sufficient available capital to invest, the right tools to assess complicated technologies, and willingness to invest in them. Between supply and demand, the study also examined the market matching system, which brings together small and medium firms and investors to the benefit of all parties. Finally, the study analysed the overall innovation ecosystem and its value chain, in which all players need to cooperate in a coordinated manner, with government initiatives having a central role in defining strategy, and prioritising and enabling the cooperation of such key players.

Figure 1: Framework for the analysis of AI and blockchain access-to-finance conditions



The highlighted dimensions of the framework include the key findings of the analysis.

Table 1: Bottlenecks in AI and blockchain financing

Element	Bottleneck	Description
Supply side	**1. Volume**	**Limited availability of venture capital and private investments** **Despite a tenfold increase in AI and blockchain investments in Europe from 2016 to 2019, the overall availability of venture capital funding remains a key issue for Europe.** In 2019, for example, the funding volume provided by the EU27 venture capital market to AI and blockchain small and medium businesses (€1.9 billion) was considerably smaller than the equivalent volumes in the United States (€17.9 billion) and China (€4.5 billion). [17] According to the interviewees, this might be explained by European venture capitalists being mostly financed by government agencies, family offices (FOs) and corporate investors, whereas large institutional investors – which can typically deploy larger cheques

[17] Preqin data, Oliver Wyman analysis.

particularly relevant for later business life-cycle stages – only account for about 14% of the venture capital market. In the United States, by contrast, large institutional investors such as pension funds and university endowments account for around 35% of the venture capital market.[18]

Corporate investors play an important role as sources of capital in the European venture capital system, but only a limited role in the global acquisition landscape. In 2019, corporate venture capital-backed funding to AI startups reached an all-time high of €9.5 billion globally (+70% vs. 2018),[19] of which the European Union accounted for around 7–8%. More generally, large EU corporates contributed about 17% of total venture capital funds (vs. 5% in the United States). However, they play a limited role in the acquisition of AI and blockchain companies, which is somewhat preventing the European Union from achieving high independence from non-EU investors. In particular, after the initial financing stages, several Europe-born AI and blockchain companies have been acquired by non-EU investors (for example, UiPath and DeepMind). From 2000 to 2019 there were 526 acquisitions of AI companies in the United States but only 139 in the European Union (including the United Kingdom). Similarly, during the same period, all of the top ten companies by number of global AI acquisitions were US-based, including Alphabet, Apple, Microsoft, Amazon and Facebook.[20]

Another factor that could explain the low exit opportunities for AI and blockchain investments in the European Union is the limited value of tech initial public offerings (IPOs). In 2019 the United States was the leading country for "Computer & Electronics" IPOs (note that three IPOs accounted for over 50% of the total: Uber, Pinterest and Lyft); China ranked second and the EU27 third – with a value less than one-quarter of the US value.[21]

2. Specialisation

Limited specialisation of EU venture capital funds in AI and blockchain

Compared to the United States, the European Union has fewer venture capital investors specialising in AI and blockchain. Several such investors have emerged in recent years, with US blockchain funds including Paradigm, Andreessen Horowitz, Polychain, Pantera Capital and many others raising a combined total of more than €1.8 billion between 2010 and 2019 – more than four times the total of blockchain equity investments in the EU27. US-based venture capital funds are typically equipped with highly experienced engineering teams, which support due diligence and provide portfolio companies with relevant technical support to develop and scale up their products. AI/blockchain

[18] European small business finance outlook, EIF, 2019, p. 41; The state of European tech 2017, Atomico, 2017.
[19] The state of European tech 2019, Atomico, 2019.
[20] Who is winning the AI race: China, the EU or the United States? Center for Data Innovation, 2019.
[21] Dealogic database.

specialist funds are far less common in Europe; those that do exist tend to be much smaller compared to their US peers and do not always have the required capability for in-house technical due diligence (17–18% of surveyed small and medium businesses reported this as a key constraint on access to finance in 2019 and 2020).

	3. Willingness	**Limited appetite for investments in AI and, particularly blockchain due to high upfront investment needs and the lack of knowledge and low visibility of commercial applications** **While AI is central to many European funds' investment strategies, the same amount of funding is not available to blockchain initiatives.** According to the EIF VC Survey 2019, while 76% of respondents already had at least one AI company in their portfolio, only 23% had a portfolio including a blockchain company. Nevertheless, 51% considered it likely or highly likely that they would invest in blockchain in the future (compared to 87% for AI).[22] For blockchain there is an estimated annual equity investment gap of €1–2 billion, against an annual investment of €0.1 billion in 2019.[23] Limited appetite for blockchain is notably attributable to lack of knowledge, particularly the misconception that "blockchain is Bitcoin." However, as the technology matures and its commercial viability improves, investments are likely to follow. **Despite the perceived importance of AI technologies, investors might still refrain from investing for three reasons:** (i) the business model requires higher upfront investments in R&D; (ii) cash flows and commercial traction occur after early adopters have tested the technologies; and (iii) AI technologies need to be incorporated into ready-to-use products or services with direct applicability, which takes time.
Market infrastructure	**4. Awareness and distribution**	**Limited matching between small and medium businesses and investors** **Small and medium businesses are struggling to connect with investors, especially in the early stages when investments tend to be more concentrated in local markets.** In the market consultation, 30% of respondents reported struggling to find the right investors in 2019, while 25% said they would benefit from initiatives that help match small firms and investors across the European Union. [24] Furthermore, limited matching troubles companies developing horizontal, core technologies and those addressing a need in a specific "vertical" area, whether a business function or within a specific sector.

22 EIF VC Survey 2019.

23 Preqin data, Crunchbase data, Oliver Wyman analysis.

24 Responses to question: "What could be possible solutions to improve your access to finance?" (select up to three answers)

Demand side

5. R&D

Strong science base, but limited valorisation-related R&D spending

The EU27 has more specialised researchers than the United States and China, and is the leader in the production of technology-related academic research; however, compared to peers, it has a lower share of valorisation-related R&D spending. The European Union has the largest talent pool of AI researchers, numbering around 40 000, compared to some 30 000 in the United States and 20 000 in China.[25] Europe has also been leading in the publication of AI-related research over the last two decades, although China recently surpassed it in this field.

However, the EU27 is notably lagging behind its peers in R&D spending. In terms of recent growth in investments, EU-based companies are being outpaced by their US and Chinese counterparts. Using R&D spending by software and computer services firms as an indicator for corporate R&D spending on AI and blockchain, 62 of the top 100 firms are in the United States whereas only 13 are in Europe.[26] In 2019, the total amount of R&D spending by software and computer services firms among the global top 2 500 (by R&D spending) reached €70 billion in the United States, compared to €9 billion in Europe.[27] Similarly, the top ten companies granted the most patents in AI technologies contained no European representative[28] – despite Europe's strong science base.

6. Digital market

While Europe's domestic market is comparable in size (GDP) to those of the United States and China, the incompleteness of the EU single market is hampering the scale-up of AI and blockchain small and medium businesses, hence limiting their ability to compete in the global market. US tech companies can benefit from a large, fully integrated domestic market. The same applies to Chinese companies, which can also benefit from partial protection against foreign competition, allowing them to scale up. This is not possible for European companies that need to operate across several, not fully integrated markets. Beyond the most common areas where the lack of a fully fledged single market can disadvantage European companies (for example language barriers), two specific areas are particularly relevant for AI and blockchain players: data and regulation.

Limited availability of data

As stated in the European strategy for data,[29] a small number of non-EU Big Tech firms hold a large part of the world's data, which could reduce the incentives for data-driven businesses to

25 Who is winning the AI race: China, the EU or the United States? Center for Data Innovation, 2019.
26 Ibid.
27 Ibid.
28 China AI development report 2018, China Institute for Science and Technology Policy at Tsinghua University, July 2018.
29 Communication on a European strategy for data, European Commission, 19 February 2020.

emerge, grow and innovate in the European Union. Datasets are key for AI firms to train their models, grow and compete in the global market. Large amounts of data help companies develop accurate models to recognise patterns in large databases and perform several tasks. Firms and countries with access to vast datasets have a competitive advantage in the development and deployment of AI-based solutions. In the United States the collection and management of data are left to the private sector, with a considerable concentration in a few Big Techs. China has a combination of government surveillance and the strong control of Big Tech companies over massive amounts of data. In the European Union, the lack of a fully integrated digital market significantly constrains the creation of large, cross-country datasets. This, in turn, limits the access of AI firms to large pools of data for building and testing their algorithms, while the need to work in parallel on various national-based datasets increases their costs. Overall, this reduces European AI firms' competitiveness vis-à-vis Chinese or American players.

Evolving regulatory landscape

To mitigate the risks of using AI and blockchain, the European regulatory landscape has evolved quickly, creating several challenges. Since 2014, the European Union has implemented several regulations to facilitate and regulate the development of data-intensive industries such as AI and blockchain. Regulatory involvement is set to increase further as AI and blockchain are increasingly deployed in "high-risk" areas (such as transport, healthcare, defence and public services), which require clear rules on safety, legal liability and rights protection. Member States are currently highlighting the absence of a common European framework. It is crucial to have common EU standards to avoid cross-border uncertainties and the potential for arbitrage by innovators in the field of data-driven technologies. Any regulations should be limited to clearly identified problems for which feasible solutions exist. Using a risk-based approach should help prioritise regulatory focus and avoid overburdening AI developers and service providers. In practice, however, it might be difficult to set clear boundaries for what should be considered higher or lower risk. As a major step in this regard, in April 2021, the European Commission laid out proposals[30] for new rules and actions that aim to turn Europe into the global hub for trustworthy AI. The efforts include the first-ever legal framework on AI and a new Coordinated Plan with Member States that will guarantee the safety and fundamental rights of people and businesses, at the same time strengthening AI uptake, investment and innovation across the European Union. This will be complemented by new

[30] On 21 April 2021, the European Commission launched a proposal on new rules and actions for excellence and trust in Artificial Intelligence, including Proposal for a Regulation laying down harmonised rules on artificial intelligence (Artificial Intelligence Act); Coordinated Plan on Artificial Intelligence 2021 Review; and Proposal for a Regulation of the European Parliament and of the Council on machinery product (link).

rules on machinery that will adapt safety rules to increase trust in the new, versatile generation of products.

Innovation ecosystem	**7. Ecosystem**	**Fragmented innovation ecosystem** **Economies of scale derived from concentration, integration and proximity of talent and financing are the foundations for successful experiences of innovation ecosystems like Silicon Valley.** As recognised in the European Commission *White paper on artificial intelligence*,[31] efforts at European, national and regional level should be coordinated to create an ecosystem of excellence along the entire innovation value chain. This means creating connected, specialised innovation clusters with universities, startups, large corporates, investors, the public sector and all other stakeholders located in close proximity and fully cooperating. While the white paper focuses on AI, the same arguments could be advanced for blockchain. **The European landscape currently features several non-interconnected and non-specialised AI and blockchain innovation centres.** Four countries are home to 55% of all European AI and blockchain small and medium businesses (Germany, France, Spain and the Netherlands). A further eight Member States have above 40 AI/blockchain small firms each, while the remaining just have a few. At city level, the top ten EU cities account for over 40% of all AI and blockchain small businesses; however, there is substantial dispersion in other smaller centres within each country.[32] On the investment side, Germany and France account for about 70% of the total amount invested by European venture capitalists in AI and blockchain since 2010. Other prominent AI and blockchain centres do not receive investments in proportion to the number of small and medium businesses they have.[33] Similarly, despite the large amount of technology-related academic research in some EU countries (for example Italy, Spain and Poland), relatively few of these projects attract venture capital investments. This is to some extent explained by the maturity levels of local ecosystems (some are mature and visible, others still emerging) and information asymmetries, amplified by the overall lower levels of venture capital and startup financing in Europe compared to other leading regions. **The lack of integration can also affect innovation programmes and initiatives promoted by the public sector, leading to fragmentation of resources across countries and technologies, which hampers scaling up and developing big champions in**

[31] On 19 February 2020, the European Commission published an ambitious package on the European Union's digital policy, including a series of documents including the White paper on artificial intelligence – A European approach to excellence and trust, the European strategy for data, and Shaping Europe's digital future.

[32] Crunchbase data, Oliver Wyman analysis.

[33] Preqin data, Oliver Wyman analysis.

strategic fields for Europe. While there are EU-wide coordinated plans for AI and blockchain, Member States are concurrently pursuing their own strategies, posing a risk of dispersing European resources and creating inefficiencies. Public and private resources are not sufficiently well channelled into creating big champions and investing in them throughout all life-cycle stages (for AI and blockchain in particular, fast scaling is the key to success and a major competitive advantage).

Despite a broad range of financing schemes available to tech companies at the EU and Member State level, EU initiatives are struggling to reach Eastern and Southern European countries.

None of the EU13 countries[34] are in the EU top ten in terms of equity venture capital investments, even though some (such as Poland and Estonia) have several AI and blockchain small and medium businesses. The Central, Eastern and South-Eastern European (CESEE) region is lagging far behind the EU averages for startup and unicorn emergence and small business digitalisation.[35] Aiming to boost digital innovations and the scale-up of digital startups in this region, the European Commission, EIB Group, European Bank for Reconstruction and Development, and World Bank recently launched the Digital Innovation and Scale-up Initiative (DISC). This initiative is still in its early days, and much hinges on its design and implementation, which is still to be concretised. Yet such initiatives could provide an important boost to the region's innovation ecosystem.

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[34] EU13 refers to the 13 countries that have joined the European Union since 2004: Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia.

[35] See recent study by the EIB Innovation Finance Advisory, Financing the digitalisation of small and medium-sized enterprises - The enabling role of digital innovation hubs.

Recommendations

The study identified three major areas needing improvement in Europe's AI and blockchain landscape. The bottlenecks in financing of AI and blockchain require a strategic and comprehensive public-private response. The challenges identified span the development of AI and blockchain technologies, their deployment in the market, and the wider EU innovation ecosystem. Accordingly, the study makes several recommendations for addressing the three key objectives:

1. **Development:** Boost financing for AI and blockchain development and scale-up
2. **Deployment:** Support take-up of AI and blockchain technologies in the market
3. **EU innovation ecosystem:** Develop a European integrated innovation ecosystem

The recommendations for each of these objectives are outlined in Figure 2 and discussed in more detail in the remainder of this summary.

Figure 2: Mapping of recommendations to key identified objectives

Development	Deployment
Boost financing for AI and BC development and scale-up	**Support take up of AI and BC technologies in market**
A. **Intensify fundraising** for AI/BC investment scheme with institutional investors, corporates, FOs and NPBs; and **carve out funds for growth-stage VCs**	E. Provide **advisory services to EU MS** in deployment of AI/ BC investment programmes and **support the deployment of AI/BC technologies by traditional companies** (esp. SMEs) that want to transform their business models in the aftermath of COVID-19 – links to RRF and DEP
B. Monitor the deployment of and consider expanding **AI co-investment facility** to provide additional firepower to successful AI/BC fund managers backed by the EIF	F. Develop a risk framework to **assess and certify AI/BC-based technologies** that meet EU-wide "trustworthiness" and regulatory requirements; this would help build trust with investors and deployers
C. Expand the **EIB Venture Debt programme** to support successful SMEs recovering from the COVID-19 crisis, starting with the development of a customised thematic (pilot) facility	G. Adapt EU and Member State **public procurement processes** to accommodate participation of small, young and innovative AI/ BC companies to help turn the European Union's strong research outputs into successful businesses
D. Launch a **dedicated AI/BC call for projects as part of the EIC**, similar to the recent one on COVID-19, and consider transforming part of the new and existing grant budget of the EIC **into contingent grants and/or forgivable loans**	

Innovation ecosystem
Develop a European integrated innovation ecosystem
H. Strengthen **DIHs to connect stakeholders of the AI/BC ecosystem** across the European Union and foster clusters of specialisation, as per recommendations included in the EIB report titled *Financing the digitalisation of small and medium-sized enterprises: The enabling role of digital innovation hubs*
I. As part of the EIF AI/BC investment scheme, **fuel competition and specialisation** in the VC market by supporting the creation of new specialised VCs (first-time funds)
J. Scale up the **Investment Support Programme** within the AI/BC investment scheme to establish a networking platform connecting AI/BC companies with relevant investors across the European Union, with **particular focus on addressing the investment imbalance in Central, Eastern and South-Eastern Europe (CESEE)**

Objective	Recommendation
Boost financing for AI and blockchain development and scale-up	**A. Intensify fundraising for the AI/blockchain investment scheme with institutional investors, corporates, family offices and national promotional banks, and carve out funds for growth-stage venture capitalists** • The EIF could, within its capacity, leverage its visibility in the European venture capital space and its track record to focus fundraising for the dedicated AI/blockchain investment scheme among private institutional investors, large corporates and family offices. This could be done via an investment structure aimed at optimising the trade-off for participating parties with a lower risk-return profile, for example through a dedicated fund-of-funds (FoF) and/or downside guarantee mechanisms to attract institutional investors (for example with asymmetric returns, to the extent that appropriate products would be made available to the EIF). The EIF could also maximise fundraising with Member States (via national promotional banks) to further increase the scheme's capacity, and aim for optimal complementarity with other national programmes. • The EIF could then carve out funds dedicated to growth-stage venture capitalists investing in AI scale-ups. This could be done as a pilot similar to the recently launched European Scale-up Action for Risk Capital Programme, and could focus purely on AI technologies (blockchain is still in the early stages). In the longer term, funds could be carved out within the dedicated AI/blockchain investment scheme (currently focused on the startup phase only, up to Series A). This would contribute to improving opportunities within the European Union for growth-stage small and medium businesses that might alternatively get financing outside the European Union, hence also improving exit opportunities for EU venture capitalists that invested in earlier stages.
	B. Monitor the deployment of and consider expanding the AI co-investment facility to provide additional firepower to AI/blockchain fund managers backed by the EIF that invested in successful small and medium businesses • The EIB could leverage the InvestEU programme to monitor and eventually expand the recent AI co-investment facility to successful venture capitalists backed by the EIF, while also extending its scope to include blockchain investments. This facility amounts to €150 million and deployment began in January 2021. The proposed expansion would complement the AI/blockchain investment scheme in sustaining the growth of successful startups and scale-ups through co-investments between the EIB Group and top-ranked venture capital funds and investment partners. The operational burden would be limited by leveraging due diligence performed by the EIF. The facility would invest pari passu with other investors, and would also be able to deploy smaller tickets. If proven successful, the scale-up of the initiative could be highly impactful.
	C. Expand the overall capacity of the EIB Venture Debt programme to support successful and innovative small and medium businesses recovering from the COVID-19 crisis; potentially also develop a customised thematic (pilot) facility for AI and blockchain (or a wider "deep-tech" facility) • The EIB could leverage the InvestEU programme to expand the capacity of its Venture Debt programme and strategically focus on innovative firms struggling to raise their next round of financing in the aftermath of COVID-19. Venture debt financing would allow these innovation-driven small

	and medium businesses to extend the cash runway until more favourable market conditions return for a new independent round of financing, and prevent them suffering depressed valuations because of the pandemic. The EIB could also consider expanding programme eligibility to earlier financing stages (such as after Series A, instead of B/C) and smaller tickets (minimum ticket size is €7.5 million under the European Growth Finance Facility but €3 million for companies in moderate innovator countries and €5 million in other countries under the Pan-European Guarantee Fund (EGF)). A similar setup could also be envisaged under InvestEU. • Furthermore, the EIB – in close collaboration with the European Commission – could explore the development of a thematic (pilot) facility dedicated to AI/blockchain companies, or a facility with a broader scope covering deep tech. The setup could be similar to those of successful concepts such as the Energy Demo Project, Future Mobility Facility and InnovFin Infectious Diseases Facility. Compared to the EIB's generic venture debt product, a dedicated facility such as this could benefit from higher risk-sharing capacity and allow for increased risk-taking, in line with the profile of AI and blockchain companies.
	D. Launch a dedicated AI/blockchain call for projects as part of the European Investment Council (EIC), similar to a recent dedicated EIC call on COVID-19, and consider transforming part of the new and existing grant budget of the EIC into contingent grants and/or forgivable loans • Up to €2.5 million in grants and €15 million in equity are provided by the EIC to innovative startups in Horizon 2020 countries. The EIC could launch a specific AI/blockchain call (similar to its recent call for COVID-19) to give a dedicated opportunity for researchers and young startups active in this field to turn their projects into successful business solutions. This call should award grants/equity funding and European Commission Seals of Excellence. • With applications to the EIC having more than doubled since the pandemic began, the European Commission could consider transforming part of the new and existing EIC grant budget into forgivable loans or contingent grants. These could be repaid as a loan if the company is successful and not repaid otherwise, thus increasing the capacity of the EIC scheme as repaid grants are made available for new grants. The EIC could "outsource" the recovery function (to the EIB or other financial institutions).
Support take-up of AI and blockchain technologies in the market	**E. Provide advisory services to EU Member States in the deployment of AI/blockchain investment programmes to enhance coordination between the European Union and Member States, and support the deployment of AI/blockchain technologies by traditional companies (especially small and medium businesses) that want to transform their business models in the aftermath of COVID-19. There are potential links to the Recovery and Resilience Facility and the Digital Europe Programme.** The European Commission and Member States have launched several huge support schemes to promote economic recovery from the COVID-19 crisis. Accordingly, key recommendations include: • The Commission could consider drawing on some components of the EU-level schemes (such as InvestEU) to encourage investments in AI/blockchain technologies that could accelerate the recovery of the hardest-hit sectors. For example, conditional grants/forgivable loans could be attached to the deployment of AI/blockchain technology-based solutions and assigned via

specific competitions. In particular, anchoring business models more robustly in AI/blockchain could materially benefit sectors such as automotive, manufacturing, hospitality and education. The Commission would also need to ensure coordination between the European Union and Member States in deploying EU and local AI/blockchain investment programmes.

- Most national promotional banks have launched support schemes in the aftermath of COVID-19. The EIB Group could deploy coordinated co-funding models with national promotional banks to ensure that AI/blockchain technology and startups become more central in local financing responses to recover from the crisis generated by COVID-19 (for example via the EGF).
- Under the Recovery and Resilience Facility, Member States will prepare recovery and resilience plans for a coherent package of reforms and public investment projects. Each plan must devote at least 20% of expenditure to fostering the digital transition. To step up financing from other sources, the EIB could closely collaborate with the European Commission to support Member States in the design and implementation of these plans, exploring and encouraging top-up possibilities by Member States for particular thematic areas, for example, focusing on the development and deployment of AI/blockchain technologies.

  AI is one of the five high-level components of the Digital Europe Programme. Given the complexity of AI technologies, deep specialist knowledge could be required to assess their potential and mitigate significant information asymmetries that could limit deep tech developers' access to finance. To bridge the information gap and improve the positioning of digital companies with respect to investors, one key recommendation is to implement dedicated advisory support, perhaps through the EIB's Innovation Finance Advisory team. The activities envisaged could help create the necessary financial preconditions (for example through market intelligence and development of the investor ecosystem, financial products and blending structures) and pilot initiatives (such as flagship/demonstration projects) that could be further scaled up under InvestEU (complementary to other financial sources such as the Recovery and Resilience Facility).

F. Develop a risk-based framework to assess and certify AI/blockchain technologies that meet EU-wide "trustworthiness," ethical and regulatory requirements; this would help build trust with investors in and deployers of these technologies

- The European Commission could develop a risk-based framework to determine whether AI/blockchain-based startups meet "trustworthiness," ethical and regulatory requirements (for example on data protection and transparency for AI or on energy consumption for blockchain). The level of risk could be driven by the sector and intended use of the technology. Assessment of specific projects could be coordinated by EU digital innovation hubs (DIHs), with projects receiving a "green stamp" to denote EU-wide recognition that their AI/blockchain systems have been developed according to European standards and regulations. Potentially, certification could also be used to grant these projects access to specific EU-wide initiatives, such as pools of data established under the EU Data Strategy. The EIF could use the trademark, among other tools, to guide its investments and give confidence to private investors about a specific technology/company. Digital innovation

hubs could also coordinate regulatory sandboxes to drive the fine-tuning of existing (and potentially new) EU regulations to accommodate the specific features of AI/blockchain (based on the EU "innovation principle"), recognising that AI's true value lies in sustainability and human-centricity to ensure fairness and unbiasedness in which EU citizens can trust.

- Regarding trustworthy and ethical AI, focus on "gender smart" AI is particularly recommended to ensure gender equality (linked to SDG 5: "*Achieve gender equality and empower all women and girls*"). Europe is at the global forefront of considering AI's ethical implications,[36] aiming to ensure transparency, diversity, non-discrimination and fairness, and societal and environmental well-being. Europe is also first in the world to lay out a proposed legal framework for AI,[37] with the goal to turn Europe into the global hub for trustworthy AI. These aspects are key for the successful development and deployment of AI across the whole European Union.

G. Fine-tune EU and Member State public procurement processes to accommodate the participation of small, young and innovative AI/blockchain companies to help turn the European Union's strong research outputs into successful businesses

- In line with Open Innovation principles, the European Commission could further facilitate and encourage the participation of small, young and innovative European AI/blockchain companies in procurement processes at the EU and Member State level. This would give opportunities for researchers and young startups to develop AI and blockchain solutions for direct deployment by the public sector, helping realise the potential of the European Union's strong research outputs by giving researchers a lead "client" for their products in the early stages. It would also help the deployment of these solutions by the public sector. The Commission could also link public procurement to EU research priorities in AI/blockchain, such as the digitalisation of public administration, defence and climate policy. This could involve, for example, lowering certain thresholds, adjusting minimum required financial conditions or introducing more flexible timelines.

H. Strengthen digital innovation hubs to connect stakeholders of the AI/blockchain ecosystem across the European Union and foster clusters of specialisation, as per recommendations in the EIB report titled *Financing the digitalisation of small and medium-sized enterprises: The enabling role of digital innovation hubs*

- EU digital innovation hubs are key to creating a network of smart one-stop advisory hubs to connect AI and blockchain small and medium businesses across the European Union with one another and with investors, large corporates, research centres, businesses wishing to deploy these technologies, and all other stakeholders of the innovation landscape. The hubs should also direct small businesses to entities providing advisory services and in particular advice on available funding programmes (for firms wishing to develop or already deploying AI/blockchain technologies). In each country, digital innovation hubs could also foster the creation of AI/blockchain specialisation clusters in specific EU sector/priority areas (such as healthcare, transport, agriculture, climate and energy).

[36] Ethics guidelines for Trustworthy AI, European Commission, 2019.

[37] Proposal for a Regulation laying down harmonised rules on artificial intelligence (Artificial Intelligence Act), European Commission, 21 April 2021.

I. As part of the EIF AI/blockchain investment scheme, fuel competition and specialisation in the venture capital market by supporting the creation of new specialised venture capitalists (first-time funds)

- The EIF, with relevant resources, could focus the AI/blockchain investment scheme on helping to create new venture capital firms specialised in AI/blockchain (possessing a mix of business and engineering teams) and support/sponsor them until they achieve a critical mass and track record allowing them to raise funds in the market independently. This could fuel competition and expertise in the EU venture capital market by creating a multitude of specialised (and eventually large) funds that could give technical and financial support to European AI and blockchain small and medium businesses.

J. Scale up the Investment Support Programme within the AI/blockchain investment scheme to establish a networking platform connecting AI/blockchain companies with relevant investors across the European Union, with particular focus on addressing the investment imbalance in Central, Eastern and South-Eastern Europe (CESEE)

- The European Commission could establish a networking platform (by scaling up the Investment Support Programme of the AI/blockchain investment scheme) to facilitate matchmaking between AI and blockchain small and medium businesses, investors and available EIB Group funding programmes. The platform could help match small firms with appropriate investors based on expertise, financing stage, location and industry. It could also foster information exchange between early-stage and growth-stage investors to share best practices for scaling up in the EU market, offering advice and knowledge on cross-border tax and legal affairs. As part of a larger digitalisation effort, the platform could focus particularly on addressing investment needs in CESEE via cooperation and synergy creation with other EU programmes such as the Digital Innovation and Scale-up Initiative.

The above recommendations clearly demonstrate that Europe needs an integrated approach for the development and deployment of AI and blockchain technologies. Financing for AI and blockchain development and scale-up in the market needs to be stepped up further at all levels, but it is equally important to strengthen the EU innovation ecosystem.

1. Context, objectives and approach

1.1. Context

Disruptive technologies such as artificial intelligence (AI) and blockchain (BC) offer great opportunities for growth in Europe given their transformational impact on companies' products, processes and business models, as well as on the public sector. In 2019 it was estimated that global GDP could increase by up to 14% (the equivalent of €13.3 trillion) by 2030 as a result of the accelerating development and take-up of AI.[38] BC is also predicted to have a wide-reaching impact on global GDP by 2025.[39]

AI and BC are transversal technologies that can be used for industrial purposes across several sectors. Their disruptive potential derives from the fact that algorithms can be increasingly open-sourced and deployed by users across industries. Researchers and practitioners alike also envisage increasing disruptions from the convergence of these two technologies, laying the groundwork for a fully digital economy. Integrating AI and BC with the system of internet connectivity across devices (internet of things, IoT) can lead to even greater opportunities. While this convergence is only just beginning, it has already started within large corporates and is showing powerful use cases.[40]

AI and BC technologies play increasingly important roles in our economy and are already having many effects. The economic benefits of AI are visible across several industries. For example, many retailers are implementing machine learning (ML) algorithms to forecast promotions that will best drive sales and profits; these forecasts are already outperforming human decisions.[41] In manufacturing, advanced analytics based on big-data exploitation are providing opportunities to increase the efficiency of quality control, lowering the required number of quality inspectors by 60% while reducing the risk of false defect detection and defect slippage by 21%.[42] In banking, it has been estimated that AI could increase banks' revenues by as much as 30% and potentially reduce their costs by 25% or more.[43] For BC, different use cases are being developed across many industries beyond financial services. For example, a German power company is testing BC technology to manage billing for autonomous electric-vehicle charging stations, while a large French supermarket company plans to use BC to increase transparency and drive value at every step of the supply chain.

AI and BC technologies will also have broader societal impact, bringing opportunities but also challenges.[44] These technologies will change our lives by improving healthcare (e.g. diagnosis precision, disease prevention), increasing the efficiency of farming, contributing to climate change mitigation and adaptation, transforming ways of working across different sectors, increasing citizens' security, and introducing possibilities we can only begin to imagine. Besides opportunities, the associated risks must also be considered, including opaque decision-making, gender-based or other kinds of discrimination, intrusion in private lives and use for illegal purposes. AI is expected to change how we work in industries across Europe: it is forecast that about 14% of jobs will be automated by AI and an additional 32% will change significantly. Further challenges are arising around data protection and ownership.[45]

AI and BC technologies are of strategic importance to the European Union and likely to play central roles in strengthening technological sovereignty. As key enabling technologies (KETs), AI and BC are the basis for evolving cornerstone industries in Europe and enabling businesses that use them to thrive in the long run. Therefore, it is important to keep a competitive edge and avoid losing out to other

38 Sizing the prize: What's the real value of AI for your business and how can you capitalise?, PwC, 2018.
39 Building Block(chain)s for a better planet, World Economic Forum, 2018.
40 Come together: The convergence of blockchain, AI and IoT, EU Blockchain Observatory and Forum, 2019.
41 Machine learning for retail, Oliver Wyman, 2018.
42 Applying machine learning to manufacturing, Oliver Wyman, 2016.
43 How banks can lead the shift to AI-first, Oliver Wyman, 2018.
44 White paper on artificial intelligence - A European approach to excellence and trust, European Commission, 2020.
45 The risk of machine-learning bias (and how to prevent it), Oliver Wyman, 2018.

international digital hubs such as Silicon Valley (United States) and the Digital Silk Road (China). A study of the European Union's positioning has outlined these challenges and concluded that scientific, technological and competitive strengths will become globally dispersed in a multipolar world.[46] Besides their economic importance for the European Union, AI technologies are expected to have a broad impact on some of its key ethical and societal goals, e.g. in achieving the Sustainable Development Goals (SDGs), supporting democratic process and social rights, and attaining the goals of the EU Green Deal.[47]

Access to finance for AI and BC companies is a key factor in successfully strengthening this sector across Europe and thereby reinforcing the European Union's international positioning. If AI and BC technology innovators thrive in Europe, significant parts of the European economy will likely benefit. Small and medium-sized enterprises (SMEs) will have access to cheaper, more efficient financing options through smarter funding mechanisms. Larger companies will be ahead of or at least level with international competitors in terms of automation and innovation, enabling them to reduce costs and provide improved services. Meanwhile, the public sector will be able to trial AI and BC technologies for increasing the effectiveness of administration and other services.

The European Commission has taken several measures to sustain the development and deployment of AI and BC technologies in Europe. Significant funding and other support are provided through the Digital Europe Programme (DEP), InvestEU Programme, Horizon Europe (and before that Horizon 2020), the EIF AI and BC Pilot, EIB AI and BC co-investment facility, and many more initiatives covered in the rest of this report.

Impact of COVID-19 pandemic

The effects of the pandemic are not fully known at the time of writing this report (autumn 2020). Although all companies across the economy face significant danger, technology-based companies might be more resilient in the long term than more traditional enterprises. Most AI and BC SMEs involved in the study stated that the COVID-19 crisis has significantly slowed their growth: the share of already profitable or expecting to be so within one year dropped from 55% before the outbreak to 32% (as of September 2020).

However, the market surveys indicate an expectation that the crisis will generate positive commercial momentum for AI and BC technologies because of their potential to accelerate digitalisation and re-invent key sectors negatively impacted by the situation. At least 50% of the AI and BC SMEs expected their competitive position to be strengthened by focusing more on technology-based products and services. The sectors most positively affected are financial services, healthcare and business intelligence. For companies developing core, horizontal AI and BC technologies (riskier but with higher potential to disrupt several industries), the situation is less clear-cut: about 9% of respondents expected their competitive position to be strengthened as a result of COVID-19, while 6% anticipated becoming less competitive.

[46] An Analysis of the international positioning of the EU using revealed comparative advantages and the control of key technologies, European Commission, 2016.

[47] Communication: Building trust in human-centric artificial intelligence, European Commission, April 2019.

Figure 3: Impact of COVID-19 on profits of AI and BC SMEs (SME survey results)

When was your enterprise expected to make profits?

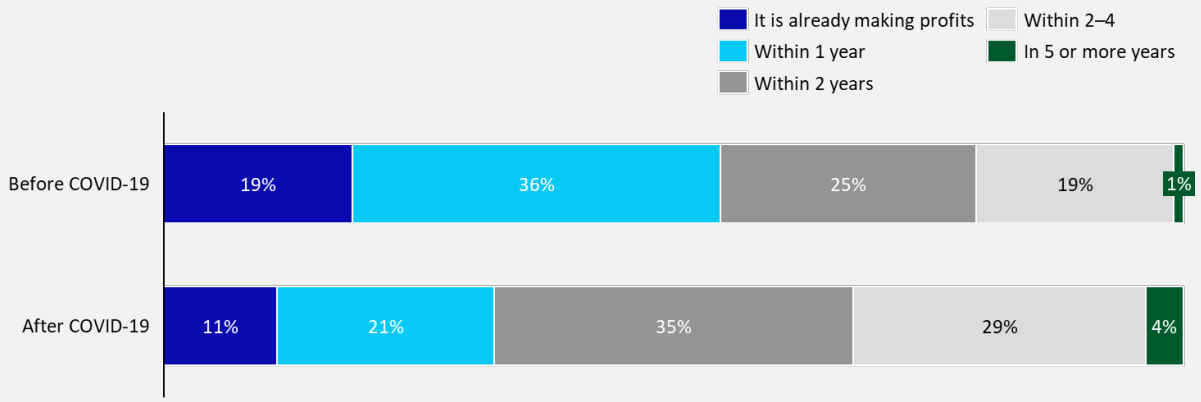
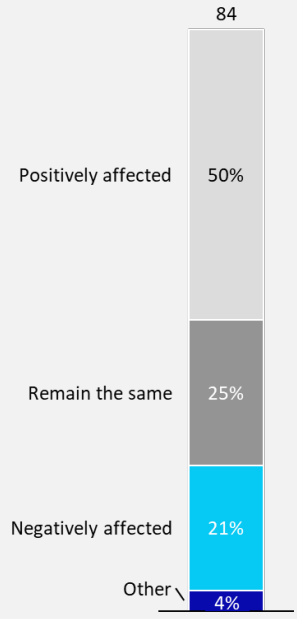


Figure 4: Impact of COVID-19 on competitive position of AI and BC SMEs (SME survey results)

Do you believe your competitive position in the market vs. other more traditional SMEs will be affected by the outbreak of COVID-19?



Sector	%
Financial Services, Fintech, KYC	**11**
Core Developers	**9**
Healthcare	**5**
Business Intelligence	**5**
Energy	4
Legal, Accounting, Insurance	4
Media, Entertainment, Publishing	2
Human Resources	2
Education, Academic Research	2

Sector	%
Industrials, Manufacturing	2
Logistics, Supply Chain	2
Sales, Marketing	1
Customer Service	1
Mobility	1
Personal Assistance	1
Security	1
Real Estate	1

Sector	%
Core Developers	**6**
Human Resources	3
Healthcare	2
Business Intelligence	2
Energy	2

Sector	%
Media, Entertainment, Publishing	2
Sales, Marketing	2
Mobility	1
Security	1
Financial Services, Fintech, KYC	1

1.2. Objectives

This study's overall objective is to provide a set of recommendations and actions for improving access-to-finance conditions for AI and BC companies in Europe, thereby better supporting the development and deployment of these technologies. The study builds on current activities performed by the European Commission, EIB and EIF to evaluate further initiatives to improve access to finance.

The focus is on SMEs developing AI and BC technologies. As defined in EU Recommendation 2003/361, companies need to fulfil certain criteria to be considered as SMEs:

Table 2: EU definition criteria for SMEs[48]

Company category	Staff headcount	Turnover	or	Balance sheet total
Medium-sized	< 250	≤ €50m		≤ €43m
Small	< 50	≤ €10m		≤ €10m
Micro	< 10	≤ €2m		≤ €2m

When relevant, the study gives specific conclusions on startups (a subset of SMEs). While there is no official definition of startups, they typically fulfil the following three criteria:[49]

- Have operated for less than five years;
- Innovate in products, services and/or business model (which covers all SMEs in this study); and
- Are in the early stages of financing (i.e. development and introduction, see Appendix A) and aim to scale up their business.

1.3. Approach

The study comprises three steps:

- Step 1. The study analysed the global AI and BC landscape based on Oliver Wyman's experience and expertise in the sector, as well as on other existing research, market analyses, published reports and expertise in the sector. Based on proprietary databases, the study benchmarked the European Union with other international geographies and estimated a range for the equity and debt investment gap for the two technologies, respectively.
- Step 2. The researchers surveyed over 100 AI and BC SMEs located in the 27 Member States and conducted in-depth interviews with 18 of those SMEs, as well as 19 financial market participants (including VC funds, corporate venture capital (CVC) funds, private equity (PE) firms, banks, national promotional banks (NPBs), and innovation agencies). The aim was to identify potential market failures and access-to-finance barriers.
- Step 3. The study presents a set of recommendations targeting the key market failures and barriers identified in the previous steps, supported by a high-level cost–benefit analysis and a high-level action plan for implementing these recommendations.

[48] Commission Recommendation of 6 May 2003 concerning the definition of micro, small and medium-sized enterprises. EUR-lex (link, accessed 20 May 2020).

[49] EU Startup Monitor 2018 report, EU Startup Monitor, 2018 (link, accessed 20 May 2020).

1.4. Key inputs

1.4.1. Databases

Data limitations have, until recently, made it difficult to understand access-to-market conditions for AI and BC SMEs in Europe. Several studies have investigated aggregated access-to-finance conditions for European SMEs across all sectors and compared against other geographies. Other studies have analysed access-to-finance conditions using firm-level data but focused only on established firms, thus under-representing young and innovative companies central to AI and BC development and deployment. Most importantly, no prior studies have specifically examined AI and BC SMEs using firm-level data, which are the focus of the reported survey and investment gap estimations.

This study used a specific data set of young AI and BC companies with high growth ambitions. The starting point for data collection was Crunchbase, an online platform where young firms around the world can present their businesses and financing needs. As stated in the EIB's 2019/20 Investment Report (which also relies on Crunchbase data for access-to-finance analyses), firms' main incentive to be listed in this database is to attract risk capital. Crunchbase has grown substantially in recent years, today covering basically all young firms with high growth ambitions, making it a unique data source for studying such firms.

The data analysed in this study cover all AI and BC SMEs registered on Crunchbase that have previously received funding (whether VC, PE, debt financing, grants, etc.) within five key geographies: the EU27, the United States, China, the United Kingdom, Canada and Japan. Available information on these firms includes age, type of service/product, location, number of employees, growth potential (as per the Crunchbase rank), and several other indicators. Available financial information includes the total amount of financing raised, the type and amount of the last financing received.

The above information has been complemented using other sources, notably the Preqin database, which includes the total number and value of VC equity investments (at deal level) across sectors, time and geographies.

1.4.2. SME survey and interviews

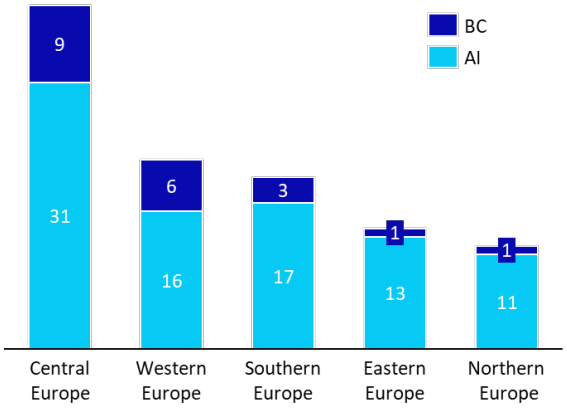
To understand the key bottlenecks on the demand side that may limit access to finance for AI and BC SMEs, the researchers conducted a detailed survey of 108 AI and BC SMEs in the EU27 and follow-up interviews with 18 of them to discuss specific insights in more detail. Figure 6 shows the proportion of SMEs surveyed by region, technology (AI vs. BC), annual turnover and financing life-cycle stage (development, introduction, or growth – due to the young nature of these industries, no surveyed SMEs are in the maturity stage).

The study covers about 9% of all EU27 SMEs labelled as AI and/or BC that have previously received funding (this population in Crunchbase numbers around 1 250 firms). The vast majority of SMEs in the target population are at early financing stages (i.e. development and introduction). Annual turnover is below €1 million for more than 70% of these SMEs, and €1–10 million –for most of the remainder.

Survey respondents provide wide coverage of EU27 countries and are well balanced between regions. About 37% of respondents are in Central Europe, 20% in Western Europe, 19% in Southern Europe, 14% in Eastern Europe and 11% in Northern Europe. This distribution is in line with the overall population of AI and BC SMEs in the Crunchbase database.

Figure 5: Overview of surveyed and interviewed SMEs

Geographic origin

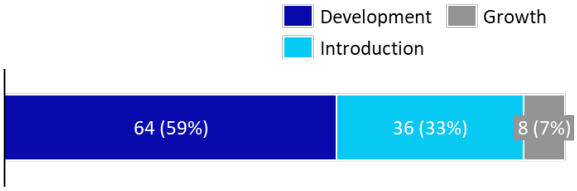


Technology	#	%
Artificial intelligence	87	81%
Blockchain	21	19%

Turnover

Annual turnover	#	%
Up to €1m	84	78%
More than €1m, up to €10m	23	21%
More than €10m	1	1%

Financing life-cycle stage



1.4.3. Interviews with financial market participants

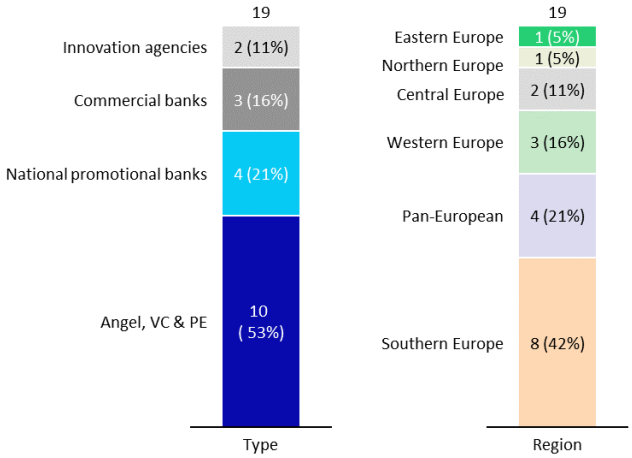
To understand the key bottlenecks on the supply side that may limit access to finance for AI and BC SMEs, the researchers conducted 19 interviews with a broad range of financial market participants. Figure 7 shows the proportion of institutions interviewed by region and type.

The study focused on VC, CVC and PE firms, as most SMEs expressed a preference for equity financing.[50] The targeted investors included specialists in AI and BC investments, as well as more generalist funds interested (but not specialised) in innovative companies. Also, representatives from a selection of commercial banks, NPBs and innovation agencies were interviewed. Finally, the EIF VC Investment and Research teams and the EIB Venture Debt team were interviewed, given their role in financing innovative companies in Europe.

The interviewees provide wide coverage of the EU27 and additional insights from non-EU case studies. The significant proportion of interviewed institutions operating primarily in Western Europe is due to the higher prevalence of AI and BC SMEs in this region. Nonetheless, EU13-based institutions are also included to ensure that the study's results are representative across all Member States.

[50] Crunchbase data, Oliver Wyman analysis.

Figure 6: Overview of interviewed financial market participants



1.4.4. Case studies

Six case studies were selected based on three characteristics: 1) host countries at the forefront of the global innovation economy; 2) activities covering a wide variety of regions and approaches; and 3) potential for transferability of lessons learned.

Table 3: Selected case studies[51]

AMUF (EU)	KfW's Gründerplattform (GER)
Innovate UK (UK)	SBIC (USA)
X-Gaia (GER)	DISC (EU)

1.4.5. Desk-based research

Academic articles and expert studies supplement all the other inputs. Leveraging academic literature is necessary to ensure the proposed solutions are theoretically sound and empirically tested where applicable, while expert studies provide insights into practical aspects of the financial industry.

[51] AMUF, Asset Management Umbrella Fund; SBIC, Small Business Investment Company; DISC, Digital Innovation and Scale-up Initiative.

2. The AI and BC landscape

2.1. Artificial intelligence

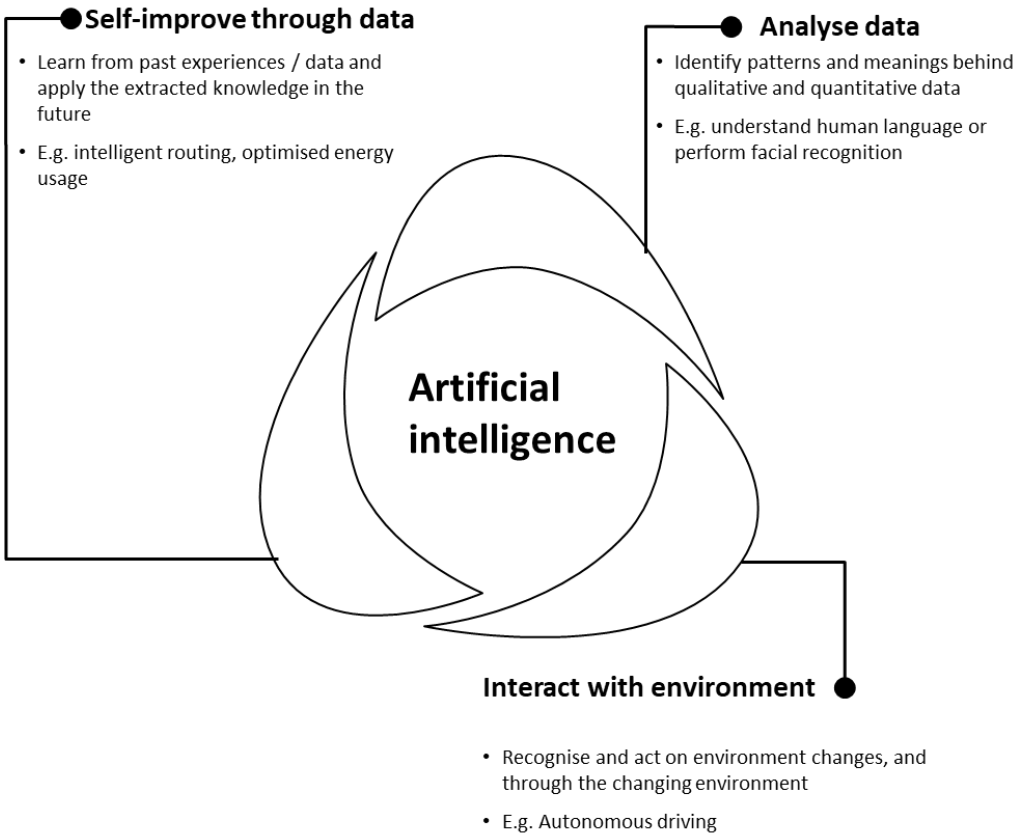
2.1.1. Definition

The High-Level Expert Group on Artificial Intelligence (set up by the European Commission) defines AI as "systems that display intelligent behaviour by analysing their environment and taking actions – with some degree of autonomy – to achieve specific goals."[52] AI-based systems can be purely software-based, acting in the virtual world (e.g. voice assistants, image-analysis software, search engines, speech- and face-recognition systems), or embedded in hardware devices (e.g. advanced robots, autonomous cars, drones or IoT applications).

The most notable abilities of AI technologies include:

- Learning from past experiences and applying the insights in future situations (e.g. intelligent routing, optimised energy usage);
- Identifying patterns and meanings behind qualitative and quantitative data (e.g. understanding human language, performing facial recognition); and
- Recognising and acting on environment changes (e.g. autonomous driving).

Figure 7: Key features of AI



[52] A definition of Artificial Intelligence: Main capabilities and scientific disciplines, High-Level Expert Group on Artificial Intelligence, 8 April 2019 (link, accessed 6 April 2020).

2.1.2. Key trends across domains and sectors

The AI landscape can be analysed in terms of the core technology of the AI service/product (domain) and the sector in which the AI service/product is deployed. Different technologies will have different maturity levels and financing requirements, e.g. depending on whether hardware or software and on the development time required for the specific product/sector. Virtually all sectors in the EU economy are embracing AI technologies, but some sectors have so far deployed them more systematically.

This section overviews AI subdomains and key sectors, drawing on information from several recent studies. Please refer to the European Commission's *AI watch: TES analysis of AI worldwide ecosystem in 2009–2018* for a detailed and rigorous analysis of this topic.

AI key domains

AI embraces a broad group of domains, including:[53]

- **Machine learning (ML)** – the study of computer algorithms that improve automatically through experience.[54] Since the 2000s, with the advent of faster central and graphics processing units, ML algorithms have become increasingly accurate and are now used in tasks across all economic activities, especially for pattern detection.
- **Natural language processing (NLP)** – a range of computational techniques for analysing and representing naturally occurring text to achieve human-like language processing.[55] NLP has developed quickly since the 2000s and is now typically used in tasks such as speech-to-text transcription and machine translation.
- **Computer vision** – the development of computers to gain high-level understanding from digital images or videos. With significant recent increases in computing power and available data, accuracy rates of computer vision algorithms have increased from 50% to 99% in less than a decade.[56] Computer vision is often used in tasks such as image analysis and classification or facial recognition.
- **Robotics and automation** – using the potential of AI to automate processes or program robots to perform specific tasks autonomously. This is a relatively young field of AI, but growing quickly. Between 2012 and 2018, the number of industrial robots more than doubled from 150 000 to over 400 000 installed units, performing repetitive but physically challenging tasks in the manufacturing sector.[57]
- **Connected and automated vehicles (CAVs)** – a range of computational techniques to allow the interaction of autonomous vehicles with the environment, subject to varying degrees of human intervention. These technologies can potentially have a large impact on the economy and environment, including fewer vehicles per household, increased traffic efficiency, and fewer traffic accidents.
- **AI processing units –** hardware devices optimised for using AI technology. Though a relatively new field of AI, it is projected to grow strongly from a total market size of $6.6 billion in 2018 to $91 billion in 2025.[58] The increased need for AI processing units is driven by several factors, most importantly the development of smart cities, rising demand for smart homes, and the emergence of quantum computing.

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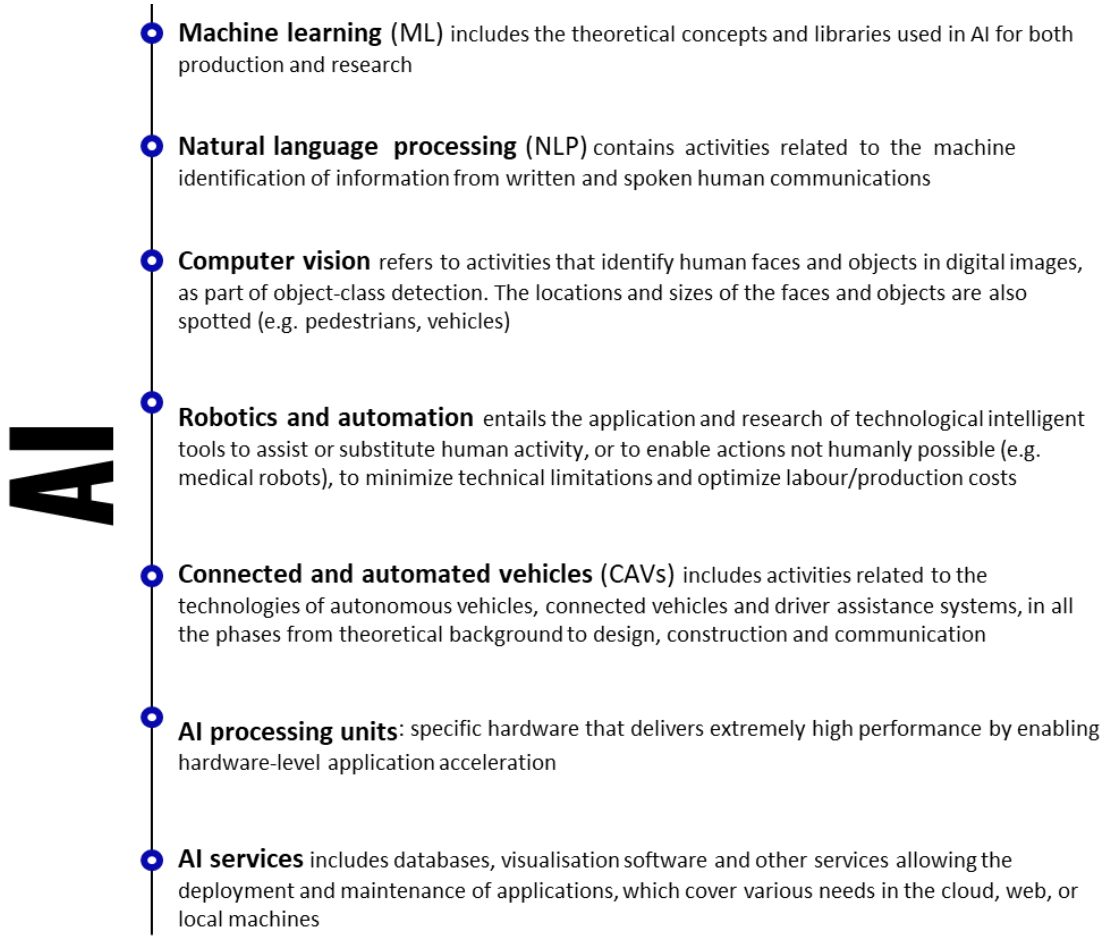
53 AI watch – TES analysis of AI worldwide ecosystem in 2009-2018, European Commission (link, accessed on 20 May 2020).
54 Tom Mitchell, Machine learning, 1997.
55 Elizabeth Liddy, Natural language processing, 2001 (link, accessed 20 May 2020).
56 Computer vision, SAS Insights (link, accessed 20 May 2020).
57 Annual installations of industrial robots, International Federation of Robotics, 2019.
58 AI chip market, Allied Market Research (link, accessed 20 May 2020).

- **AI services** – the broadest domain of AI, containing all related services not classified in any of the above categories, such as databases and visualisation software that either use AI technologies to improve the service or allow the user to use AI technologies him/herself.

Figure 8: AI segmentation by domain

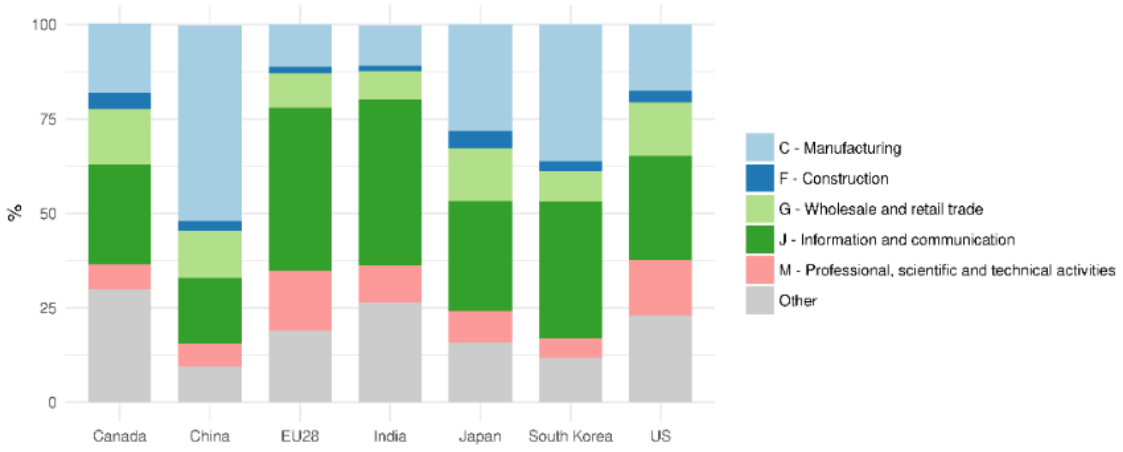


AI key sectors

While virtually all sectors in the EU economy are embracing AI technologies, deployment has been more systematic in certain sectors and the application of AI varies across jurisdictions. In Europe, the United States and India, a relatively large share of AI firms operate in information and communications or in professional, scientific and technical activities. By contrast, in China, about half of the country's AI firms operate in the manufacturing sector,[59] mirroring the overall strength of China in the manufacturing sector. Japan presents a more balanced distribution of AI firms across different sectors; in particular, more than 25% operate in manufacturing and a prominent share in wholesale and retail trade, which is similar to the situation in the United States and Canada.

[59] AI watch – TES analysis of AI worldwide ecosystem in 2009-2018, European Commission.

Figure 9: AI firms by economic sector (%), 2009–2018[60]



Reaffirming the findings of several prior studies, interviewees were almost unanimous in expecting AI technologies to have an increasingly disruptive impact on all sectors of the EU economy. A more granular segmentation of the main sectors affected by AI technologies is available in Appendix B, including example usages of AI services/products in each sector.

2.1.3. Key benefits of AI for companies

Across domains and sectors, companies embracing AI solutions typically benefit from higher productivity and efficiency. Research suggests that AI could double economic growth rates by 2035 and increase labour productivity by up to 40%.[61] In particular, companies can benefit from:

- Increased productivity, typically achieved via better decision-making processes.[62] For example:
  - AI can accelerate decision-making, enabling early pattern detection. In healthcare, for instance, this translates into the possibility of using NLP to detect early symptoms of a heart attack during a call to emergency services by analysing speech patterns and unconscious signals;
  - AI can also enable more accurate decision-making by spotting anomalies or longer-term trends that cannot be easily detected by other methods. Again in healthcare, computer vision technology can support doctors in identifying specific signs of a disease in X-ray and MRI scans;[63]
- Higher efficiency, typically achieved via automating manual processes.[64] For example:
  - AI can facilitate the automatic generation of machine-readable legal and compliance documentation, reducing the time needed for drafting and analysing such documents; and
  - AI can also enable automated language and speech recognition. In practice, enterprises can use this function to deploy chatbots, thus decreasing the time employees spend in calls.

Companies embracing AI solutions typically also benefit from more reliable and unbiased processes. AI can help improve diagnostics and the reliability of frequent, structured, specific tasks, for example by helping diagnose the abrasion status of machines and scheduling preventive maintenance.[65] Moreover, AI can mitigate human bias and errors caused by psychological or emotional factors.[66]

60 AI watch – TES analysis of AI worldwide ecosystem in 2009-2018, European Commission.
61 Accenture research (link, accessed 26 May 2020).
62 Artificial intelligence innovation report, Deloitte, 2018 (link, accessed 20 May 2020).
63 Hosny et al., Artificial intelligence in radiology, 2018 (link, accessed 18 May 2020).
64 Understanding the benefits of AI, Goetzpartners, 2018 (link, accessed 18 May 2020).
65 Introduction to the advantages of AI, EDUCBA (link, accessed on 15 May 2020).
66 Ben Hartwig, Benefits of artificial intelligence (link accessed on 15 May 2020).

Additionally, AI systems can become increasingly accurate over time as more data are used to refine models.

2.1.4. Key ongoing initiatives within the European Union

The European Union has taken important actions and initiatives to support the development of AI in Europe, including through the "European approach to Artificial Intelligence and Robotics."[67] This approach addresses technological, ethical, legal and socio-economic aspects of AI to boost the European Union's research and industrial capacity and to put AI at the service of European citizens and economy. The European approach is based on three pillars:

1. Being ahead of technological developments and encouraging uptake by the public and private sectors, with a target of reaching €20 billion investment per year over the next decade;
2. Prepare for socio-economic changes brought about by AI; and
3. Ensure an appropriate ethical and legal framework.

The European Commission has also introduced several additional initiatives covering different aspects of AI, such as the *Coordinated plan on AI*, the *Ethics guidelines for a Trustworthy AI*, the *Declaration of cooperation on artificial intelligence*, and the *new rules and actions for excellence and trust in Artificial Intelligence, including a Proposal for a Regulation*.

In early 2020 the European Union published four documents that clearly indicate the Commission's key priorities and anticipated next steps. Among these, the *White paper on artificial intelligence – A European approach to excellence and trust* proposes several measures to streamline research, foster collaboration between Member States and increase investment into AI development and deployment. It also includes policy options for a future EU regulatory framework that would determine the types of legal requirements applicable to relevant actors, particularly focusing on high-risk applications. The four documents are overviewed in Table 4.

[67] Shaping Europe's digital future. A European approach to Artificial intelligence. EC (link, accessed 15 May 2020).

Table 4: European Commission strategies for AI and data

Document Title	Summary
White paper on artificial intelligence – A European approach to excellence and trust	• Emphasises the importance of **establishing a uniform approach to AI** in the European Union to avoid barriers to the EU Single Market • Plans a **risk-based approach** to regulating AI. Specifically, the Commission proposes to focus in the near term on "high-risk" AI applications: – High-risk sectors: healthcare, transport, energy, and parts of the public sector – High-risk applications: those with potential to produce legal or similarly significant effects on the rights of an individual or company, and those used for remote biometric ID • High-risk applications would require **mandatory pre-marketing conformity assessment requirements**, while lower-risk applications could be subject to a voluntary labelling scheme • Proposes several measures for promoting an "ecosystem of AI excellence," including **research funding, skills development and partnerships with the private sector**
Communication on a European strategy for data	• Articulates the European Union's **aspiration to be a role model** of a society powered by data to make better decisions • Proposes a **four-pillar strategy** that includes: – **A cross-sectoral governance framework** for data access and use that will cover, among other measures, new EU mechanisms and guidance on data sharing – **Enablers: investments** in data and strengthening of the European Union's **capabilities and infrastructures** for hosting, processing and using data, and fostering interoperability – Building **competencies** through greater investment in **digital skills and in SMEs**; – Development of **common European data spaces** in strategic sectors and domains of public interest
Communication on shaping Europe's digital future	• Sets out a **vision** for a European society powered by digital solutions and rooted in common European values: – Ensure that technology **works for people** – Foster a fair and competitive economy – Enable an open, democratic and sustainable society • Describes the European Union's **plans to increase European investment** in technological innovation, to reduce reliance on digital solutions developed outside Europe • Recommends **enhancing regulatory frameworks** to ensure fairness, support user choice, prevent the over-concentration of market power, etc.
Report on the safety and liability implications of AI, the IoT and robotics	• Focuses on the current **EU product safety regime,** drawing the conclusion that it contains a number of gaps that need to be addressed • Proposes updating the existing framework to ensure, for example, that compensation is always available for damage caused by products that are defective because of software or other digital features • The new challenges posed by AI in terms of safety create also new challenges in terms of liability; pointing toward the need for certain adjustments to the Product Liability Directive and national liability regimes through appropriate EU initiatives

One key priority of the European Commission's *Coordinated plan on AI* is to encourage Member States to develop their national AI strategies, outlining investment levels and implementation measures.[68] While several EU Member States have already signalled their commitment to AI by publishing national AI strategies, others are still developing their strategies. As of February 2020, 20 Members States have published their AI strategies or have a final draft at hand, one has an action plan as an initial step towards developing the national strategy, and six have started consultations with intergovernmental working groups to develop their strategies.

Figure 10: Overview of Member States' AI strategies as of February 2020[69]

Country	Status	Date
Austria	Final draft	June 2019
Belgium	In progress	
Bulgaria	In progress	
Croatia	Final draft	Nov. 2019
Cyprus	Published	Jan. 2020
Czech Republic	Published	May 2019
Denmark	Published	March 2019
Estonia	Published	July 2019
Finland	Published	Oct. 2017
France	Published	March 2018
Germany	Published	Nov. 2018
Greece	In progress	
Hungary	Action plan	Nov. 2019
Ireland	In progress	

Country	Status	Date
Italy	Final draft	July 2019
Latvia	Published	Feb. 2020
Lithuania	Published	April 2019
Luxembourg	Published	May 2019
Malta	Published	Oct. 2019
Netherlands	Published	Oct. 2019
Poland	Final draft	Aug. 2019
Portugal	Published	June 2019
Romania	In progress	
Slovakia	Published	Oct. 2019
Slovenia	In progress	
Spain	Final draft	Nov. 2019
Sweden	Published	May 2019

68 AI watch – National strategies on Artificial Intelligence: A European perspective in 2019, European Commission.
69 AI watch – National strategies on Artificial Intelligence: A European perspective in 2019, European Commission.

2.2. Blockchain

2.2.1. Definition

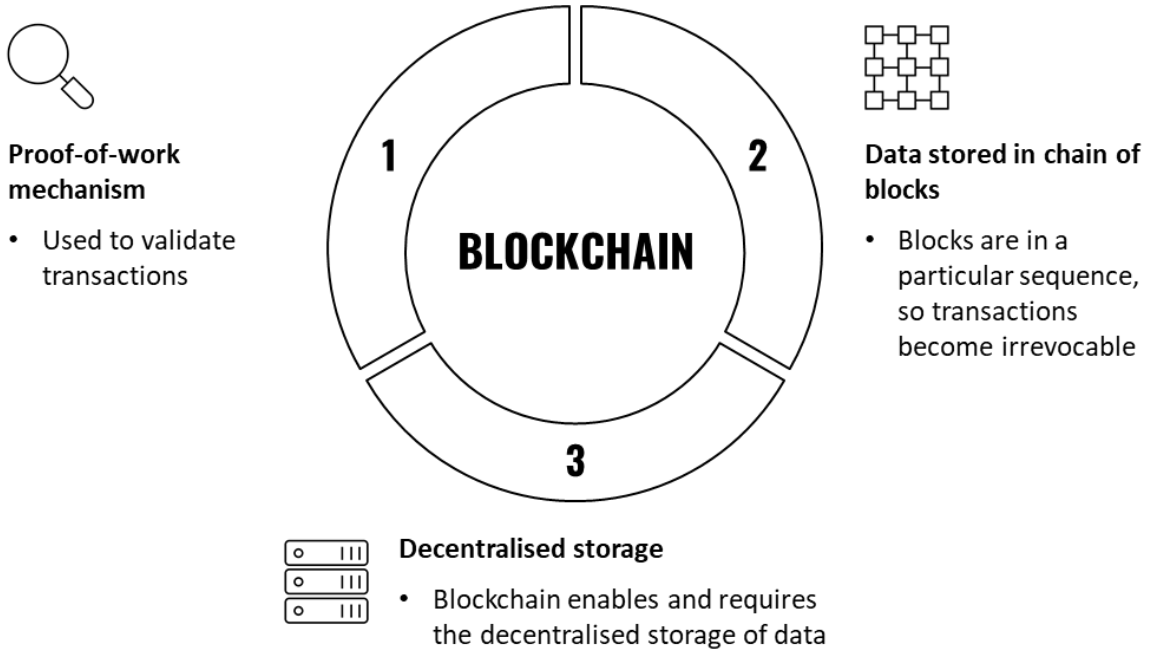
BC is defined as "a technology that allows people and organisations to reach agreement on and permanently record transactions and information in a transparent way without a central authority."[70]

Since its creation in 2008, BC technology has been mainly linked to financial services and cryptocurrencies; however, it is now expanding into other domains. The potential of BC technologies goes well beyond cryptocurrencies and finance, and there is a growing number of use cases outside the financial sector. While the fintech sector remains at the forefront of BC developments, more organisations in other sectors, such as media and telecommunications, healthcare and government services, are expanding and diversifying their BC initiatives.

Key features of BC technologies include the following:[71]

- A decentralised consensus mechanism is used to validate transactions and guarantee the authenticity of data;
- Data are represented as blocks in a sequence, making new data (e.g. new transactions) irrevocable. Each data point added is a new block that references its predecessor. A change is, therefore, impossible as all blocks are connected; and
- Data are stored in a chain of blocks in several locations. As long as each block has access to its predecessor, all other data can be stored in different locations, i.e. in a decentralised manner.

Figure 11: Key features of BC



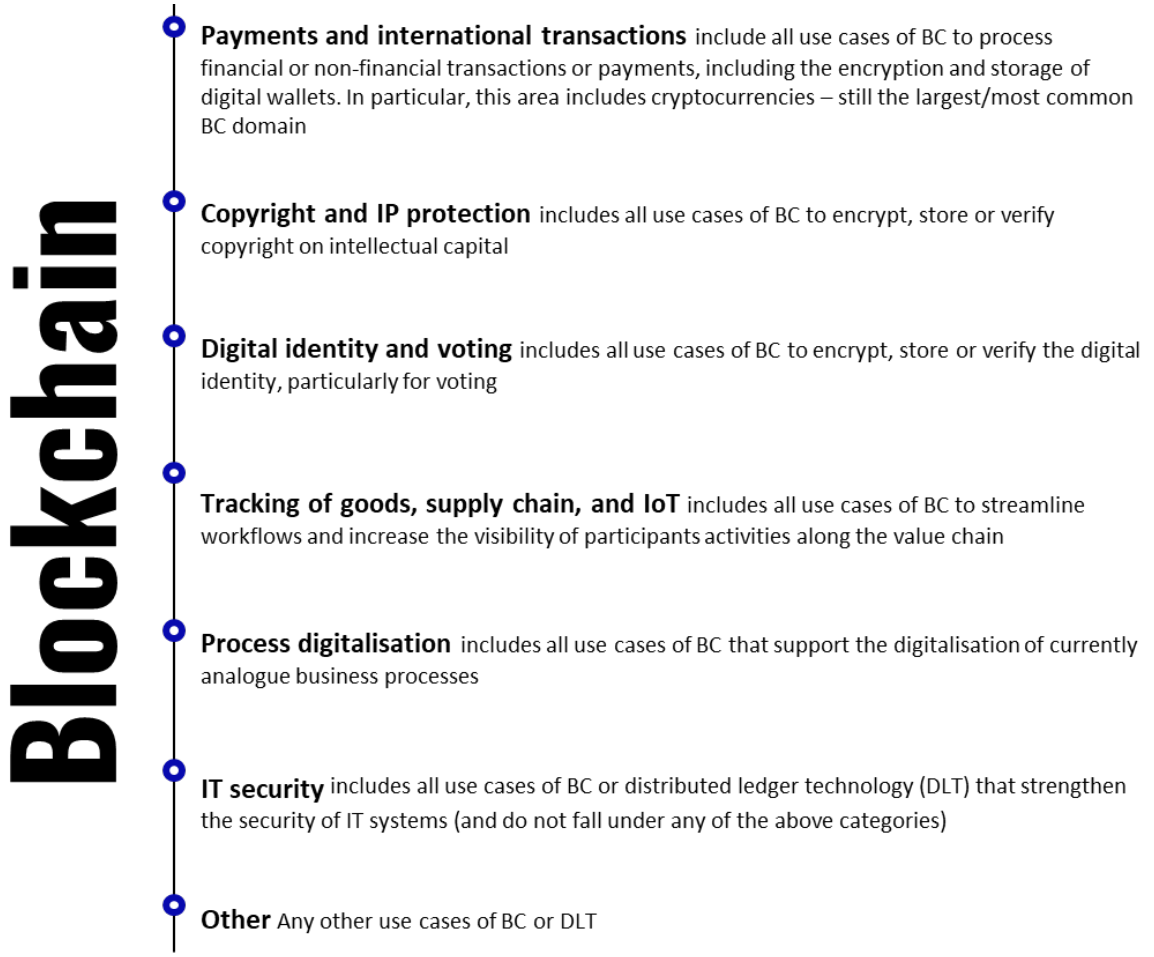
[70] Shaping Europe's digital future. Blockchain Strategy. EC (link, accessed on 11 May 2020).
[71] Shaping Europe's digital future. Blockchain Strategy. EC (link, accessed on 11 May 2020).

2.2.2. Key trends across domains and sectors

BC domains

In line with the EU Blockchain Observatory and Forum's map [72], BC can cover several different domains, as represented Figure 13. Payments and international transactions is the most common BC domain so far, reflecting the historical development of this technology in relation to cryptocurrencies and the financial sector more broadly. IT security, copyright and intellectual property (IP) protection, and digital identity and voting are other emerging domains, all of which build their use cases predominantly on the security aspect of BC. Other domains include process digitalisation, and tracking of goods, supply chain, and IoT.

Figure 12: BC segmentation by domain



BC sectors

BC has a wide range of use-cases in the financial services sector. The most common functions are:[73]

- **Payments and remittance**: Cross-border payments are usually intermediated by clearing firms, and thus usually subject to intermediation costs in multiple layers that induce operational complexity and counterparty risks. By contrast, BC allows for direct peer-to-peer transactions that limit the need for intermediaries;

[72] EU Blockchain Observatory and Forum (link).
[73] Analysing the deployment of blockchain and DLT in the financial sector, N-ABLE, 2019.

- **Credit and lending**: The use of smart contracts presents potential benefits that could make lending safe and prevent crises. BC technologies are also used to raise capital through crowdfunding and other means and can potentially impact on classic and new financial intermediaries. Examples include BC-based tokens and initial coin offerings (ICOs);
- **Trading and settlement**: The use of BC technologies can lead to near-real-time clearing and settlement, reducing risks related to duplicated records and associated time lags;
- **Compliance**: BC technologies can be implemented to specifically address financial reporting and compliance issues. BC could allow for recording players and actions in a transparent, streamlined fashion and in line with regulatory requirements; and
- **Asset management:** There are multiple use cases in this area, such as initiatives focused on the fund distribution value chain and the development of smart transfer agents.

Beyond finance, BC represents a possible breakthrough for a broad range of industrial sectors, thanks to new technological notions such as disintermediation and efficiency gains that could be key to these industries.[74] Having begun as the basis of cryptocurrencies such as Bitcoin, BC technology – essentially a virtual ledger for recording and verifying a high volume of digital transactions – is now spreading across a wave of industries. Annual global spending on BC applications has almost tripled since 2017 and is expected to reach nearly $16 billion by 2023.[75]

Bitcoin's popularity helped demonstrate the application of BC in finance, but entrepreneurs now believe that BC could transform many more industries. Ultimately, the use cases for a transparent, verifiable register of transaction data span across several sectors. Industries from insurance to gaming to real estate are starting to realise the value of BC applications. Examples of potential applications are manifold and encompass secure data sharing between healthcare providers, documentation of transactions along a supply chain, and connecting buyers and sellers without an intermediary in the retail sector.[76]

2.2.3. Key benefits of BC for companies

Companies that embrace BC technologies can benefit from several improvements:[77]

- **Stronger trust and security** through decentralised storage and common acceptance by all participants of the security of stored data. This supports combating fraud, proving the quality and origin of goods, and tracing faulty materials in supply chains;[78]
- **Verified information**, which includes the possibility to confirm the authenticity of a document, diploma or other information stored by BC enterprises; and
- **Reduced complexity and increased reliability**, as using decentralised storage decreases the probability that a server shutdown will make data inaccessible.

2.2.4. Key ongoing initiatives within the European Union

The European Commission has outlined a holistic approach to BC technologies, which aims to position Europe at the forefront of BC innovation and uptake. In this rapidly evolving context, the European Union relies on several initiatives to enable globally inclusive governance, reinforce cooperation and investments in deploying BC-based applications, and support international standard-

74 Banking Is Only The Beginning: 58 Big Industries Blockchain Could Transform. CB Insights (link, accessed 20 May 2020).
75 CB Insights' Market Sizing tool. CB Insights (link)
76 Banking Is Only The Beginning: 58 Big Industries Blockchain Could Transform. CB Insights (link, accessed 20 May 2020).
77 Blockchain in trade finance and supply chain, European Union Blockchain Observatory and Forum (link, accessed 25 May 2020).
78 How blockchain will change organizations, MIT Sloan (link, accessed 25 May 2020).

setting. These initiatives aim to facilitate dialogue between industry stakeholders and regulators, notably towards a regulatory framework that builds on the EU acquis.

The several initiatives that the European Union is promoting to foster a more coordinated EU-wide approach to developing and deploying BC technologies include:

- **The European Blockchain Partnership (EBP):** Created through a signed declaration in April 2018, the EBP establishes political collaboration between all EU Member States and members of the European Economic Area (Norway and Liechtenstein) towards realising the potential of BC-based services to benefit citizens, society and economy.
- **The European Blockchain Services Infrastructure (EBSI):** This joint initiative between the European Commission and the EBP aims to deliver EU-wide cross-border public services using BC technology. The EBSI will form a network of distributed nodes across Europe, leveraging an increasing number of applications focused on specific use cases. In 2020 the EBSI became a a fully operational Connecting Europe (CEF) Facility Building Block, providing reusable software, specifications and services to support adoption by EU institutions and European public administrations.
- **The European Blockchain Observatory and Forum:** The mission of the forum is to promote BC in Europe by mapping existing BC initiatives, analysing and reporting on important BC themes, promoting BC education and knowledge sharing, and holding events to promote debate and discussion.
- **The International Association for Trusted Blockchain Applications (INATBA):** Launched on 3 April 2019, INATBA is a Brussels-based multistakeholder organisation that brings together suppliers and users of distributed ledger technology (DLT) with representatives of governmental organisations and standard-setting bodies. Members share the common vision of promoting transparent governance, interoperability, legal certainty and trust in services enabled by BC and DLT.

Additional BC initiatives at the EU level include the formation of an industry-driven community, established at the EU Blockchain Industry Roundtable held in 2018;[79] the #Blockchain4EU initiative touching upon BC for industrial transformations;[80] and the launch of the "Blockchain for Social Good" challenge and associated prize.[81]

As of April 2020 only five of the EU27 countries have published a national BC strategy, though another five are developing or planning to develop a strategy, while a further five are using government-supported activities to promote BC. This shows that BC is at an earlier stage than AI in the EU27. However, some of the countries not currently shaping a BC strategy are undertaking other initiatives to advance BC technologies: for example, the Estonian government strongly promotes BC and applies the technology in its services,[82] while the Lithuanian government has created a dedicated BC sandbox.[83]

[79] Shaping Europe's digital future. The EU Blockchain Roundtable supports efforts to deploy blockchain technologies in the EU. EC, November 2018 (link, accessed 11 May 2020).
[80] EU Science Hub. #Blockchain4EU: Blockchain for Industrial Transformations. EC (Link, accessed 11 May 2020).
[81] European Innovation Council. EC (link, accessed 11 May 2020).
[82] Estonia – the digital republic secured by blockchain, PwC, 2019.
[83] LBChain. Bank of Lithuania (link, accessed 20 May 2020).

Figure 13: Overview of Member States' BC strategies as of May 2020[84]

Country	Status	Date
Austria	None	
Belgium	None	
Bulgaria	None	
Croatia	None	
Cyprus	Published	Jun 2019
Czech Republic	Other activities	May 2019
Denmark	None	
Estonia	Other activities	
Finland	Proposed	May 2019
France	In progress	Apr 2019
Germany	Published	Sep 2019
Greece	None	
Hungary	None	
Ireland	Other activities	May 2019

Country	Status	Date
Italy	In progress	Dec 2018
Latvia	In progress	Feb 2019
Lithuania	Other activities	Mar 2020
Luxembourg	Other activities	Jun 2018
Malta	Published	May 2018
Netherlands	Published	Jun 2018
Poland	None	
Portugal	None	
Romania	None	
Slovakia	Published	2019
Slovenia	Action planned	May 2018
Spain	None	
Sweden	None	

84 Oliver Wyman research. Note: Spain has regional-level strategies.

2.3. Convergence of AI, BC and IoT

The opportunities presented by AI and BC technologies are likely to be applied in conjunction with each other, converging in new kinds of platforms, products and services. Their integration with systems of internet connectivity across devices (IoT) can lead to even greater opportunities.[85] In this technological convergence, IoT can be considered the "sensing" part, AI the "thinking" part, and BC the "remembering" part.[86] For large-scale emerging use cases such as smart cities, converged technologies can be applied in infrastructure to manage critical systems and improve residents' quality of life through safer and better-designed urban environments.[87]

Both IoT and BC can be deployed as key enablers for developing and implementing AI by providing the large data sets required for AI learning.[88] IoT is a key element for data generation and collection; as IoT devices become cheaper and more widely utilised, they will provide increasingly large amounts of data. BC can serve as a large repository of validated records, and could thus support AI learning. In combination, IoT and BC can significantly lower the cost of data collection, thus avoiding the concentration of AI among only a few large stakeholders.[89]

The decentralised network system of BC can offer ways to address the needs of companies and individuals for security, privacy and resilience in the context of AI and IoT.[90] As IoT becomes more widespread, more consumer data will be collected, thereby increasing society's needs for security and data protection. BC could make IoT infrastructures more scalable and robust, provide secure audit trails of information, and increase the interoperability of IoT devices by providing a trusted, common communications layer. BC could also support the establishment of open, decentralised markets in which data producers can sell, rent or share their data, AI models and resources.

The combination of AI, BC and IoT can open new operational and commercial opportunities. Potential future examples of combined applications include:[91]

- Retail: AI can enable predictive action based on data collected from IoT devices (e.g. ordering food), while BC can support secure transaction processing;
- Healthcare: AI can enable monitoring of medical data, early detection of abnormalities and automatic scheduling of appointments, while BC can provide a secure, accurate medical history;
- Cybersecurity: AI can enable fast, accurate data analysis, making logical decisions and taking autonomous actions, while BC can store a secure record of potential evidence; and
- Manufacturing: AI can enable comprehensive remote status and performance monitoring of machines across the globe, ML-powered proactive maintenance, and assignment of the most-suitable technician with replacement parts, while BC can provide a secure way of purchasing.

Conversely, the combined application of these technologies poses risks and challenges to consider and mitigate.[92] From a technological perspective, this convergence will bring the difficulty of protecting billions of entry points in IoT. It will also exacerbate legal and regulatory complexities, for example on data protection, and create challenges related to governance, privacy and data ethics compliance.

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85 The European Commission describes the IoT as "the next step towards digitisation where all objects and people can be interconnected through communication networks, in and across private, public and industrial spaces, and report about their status and/or about the status of the surrounding environment." See Advancing the internet of things in Europe, Commission staff working document, European Commission, 2016.

86 Transformational technologies: Today - How IoT, AI, and blockchain will revolutionize business, Oracle, 2018.

87 Convergence of blockchain, AI and IoT, EU Blockchain Observatory and Forum, 2020.

88 Blockchain-enabled convergence, Outlier Ventures Research, 2018.

89 Convergence of blockchain, AI and IoT, EU Blockchain Observatory and Forum, 2020.

90 Blockchain-enabled convergence, Outlier Ventures Research, 2018.

91 Transformational technologies: Today - How IoT, AI, and blockchain will revolutionize business, Oracle, 2018.

92 Convergence of blockchain, AI and IoT, EU Blockchain Observatory and Forum, 2020.

Convergence is expected to be a long-term process, and individual technologies are advancing at different paces in different industries.[93]

[93] Blockchain-enabled convergence, Outlier Ventures Research, 2018.

3. The EU and international ecosystems for AI and BC

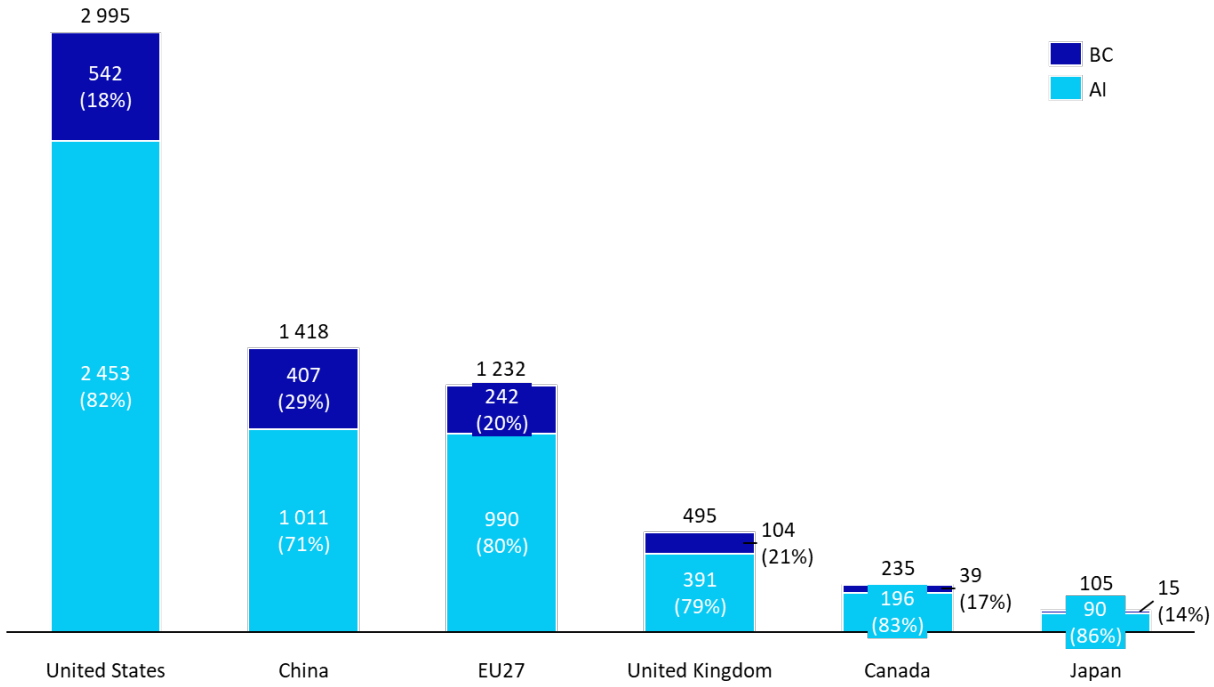
3.1. Number of AI and BC SMEs

As discussed in Section 1.4.1, the study selected all AI and BC SMEs registered on Crunchbase that have previously received funding (whether VC, PE, debt financing, grants, etc.) within five key geographies: the EU27, the United States, China, the United Kingdom, Canada and Japan. While Crunchbase can be seen as representative for most countries,[94] its coverage in China is less complete. Hence, data for Chinese AI SMEs were taken from the *China AI development report,* and the number of Chinese BC SMEs covered in the Crunchbase database were interpolated accordingly.

The highest number of AI and BC SMEs is in the United States (2 995), more than China (1 418) and the EU27 (1 232) combined. The United Kingdom is another notable player (495).

Across all geographies, AI SMEs dominate over BC SMEs, representing 70–85% of the total. In the United States, EU27 and United Kingdom, around 80% of SMEs in the AI/BC landscape are AI-focused. In China, the share of AI SMEs is slightly lower (71%), whereas Canada (84%) and Japan (86%) have higher shares of AI-focused SMEs.

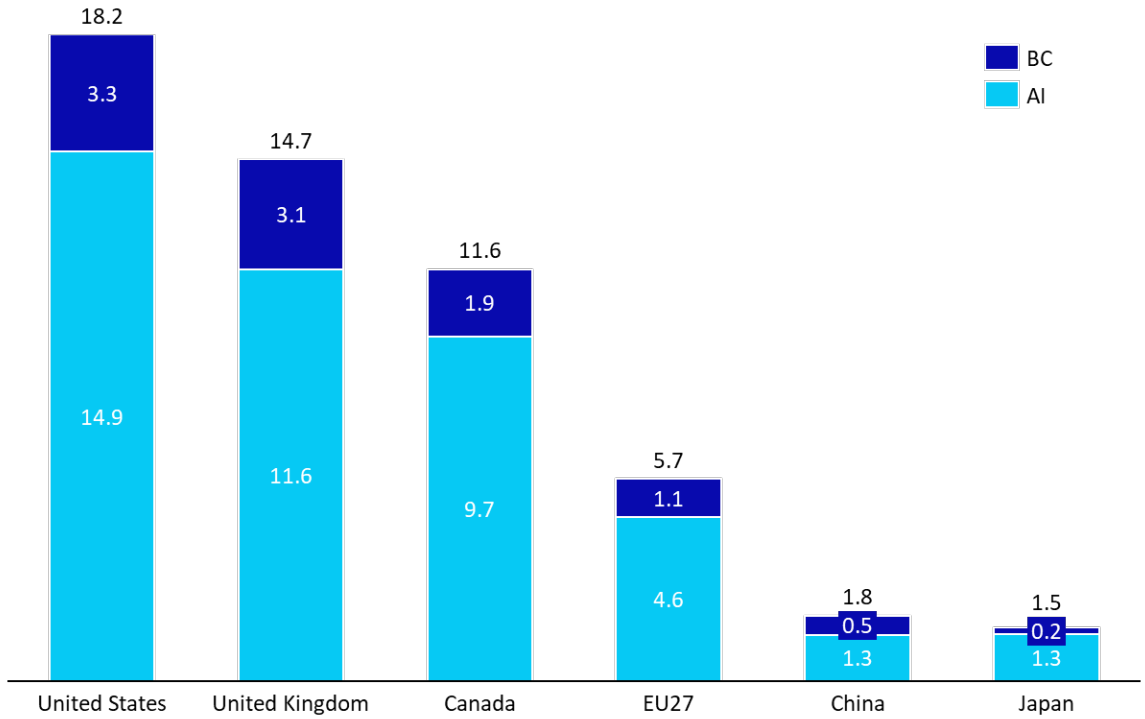
Figure 14: Total number of AI and BC SMEs across international geographies, April 2020[95]



The picture changes when considering the density of AI/BC SMEs based on the size of the workforce in each geography. The United States remains the leading region, with 18.2 SMEs per 1 million workers, followed by the United Kingdom (14.7) and Canada (11.6). The EU27 shows a density of 5.7 AI/BC SMEs per 1 million workers, about one-third of the US figure, while China exhibits a significantly lower density (1.8).

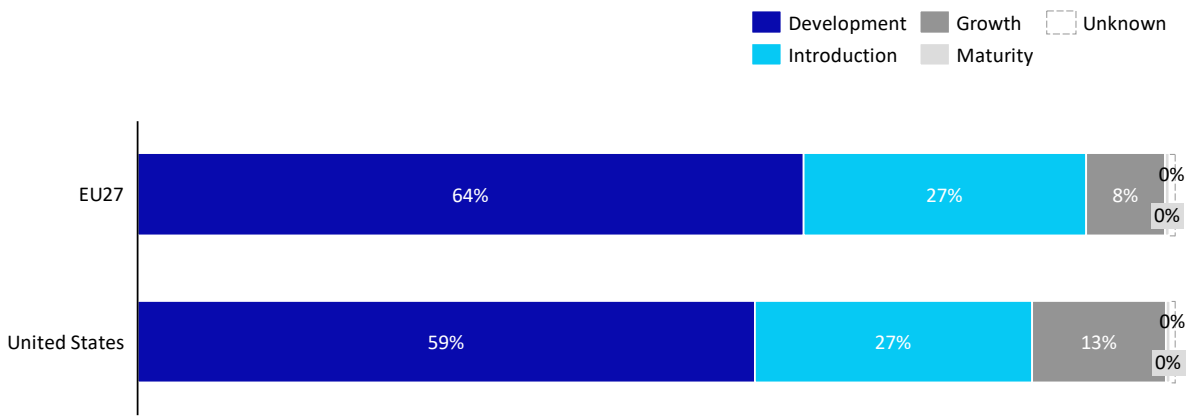
94 China AI development report, China Institute for Science and Technology Policy at Tsinghua University, 2018.
95 Crunchbase data, Oliver Wyman analysis.

Figure 15: Total number of AI and BC SMEs per 1 million workers, April 2020[96]



Looking at the financing life cycle, the European Union has a significantly larger proportion of AI and BC SMEs in the development stage, compared to the United States, where SMEs are more financially mature (see Appendix A for an overview of financing at different life-cycle stages). The proportion of growth-stage SMEs is lower in the EU27 than in the United States, while the two geographies have a very similar proportion of SMEs in the introduction stage. Very few AI/BC SMEs in either region have reached the maturity stage of financing – they typically become large corporates at this stage and the two industries, especially BC, are relatively young.

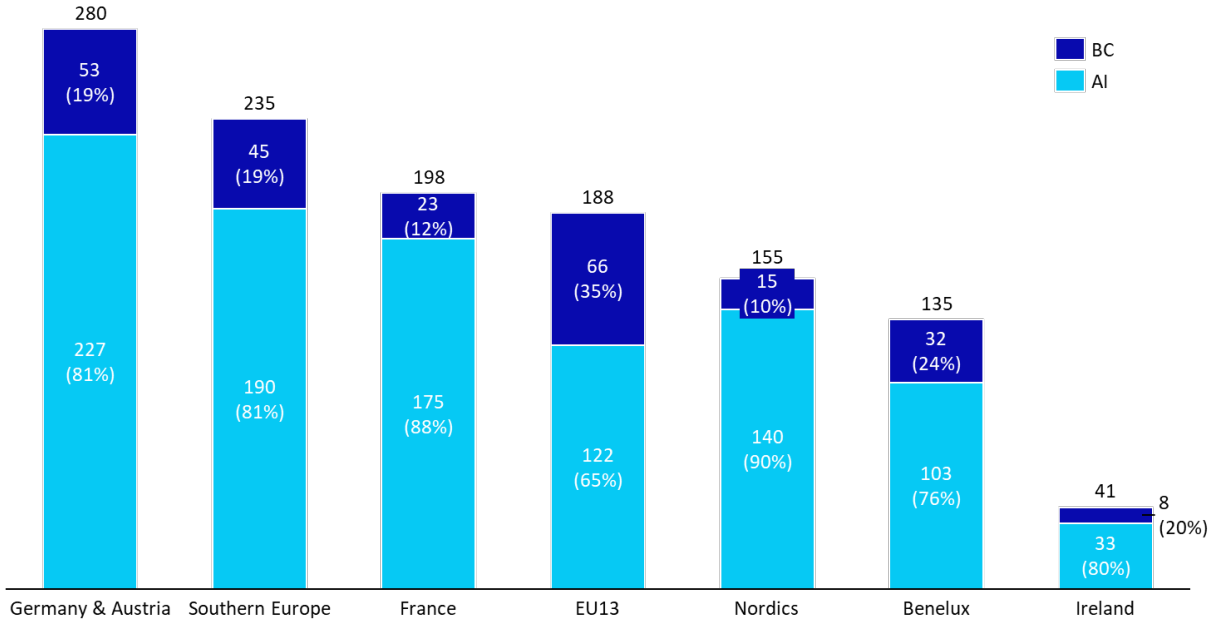
Figure 16: Distribution of SMEs across the financing life cycle in the EU27 and United States, April 2020[97]



[96] Crunchbase data, World Bank data (link, accessed 20 May 2020), Oliver Wyman analysis.
[97] Crunchbase data, Oliver Wyman analysis. Based on last funding type, estimated revenue range and number of employees

Within the EU27, the highest number of AI/BC SMEs is located in Germany and Austria, followed by Southern Europe, France and the EU13. In most regions AI SMEs represent ≥76% of the total, but the EU13 has a more balanced split between AI (65%) and BC (35%) SMEs. The EU13 also has the highest absolute number of BC SMEs, followed by Germany and Austria, Southern Europe and Benelux.

Figure 17: Total number of AI and BC SMEs per EU27 region, April 2020[98]



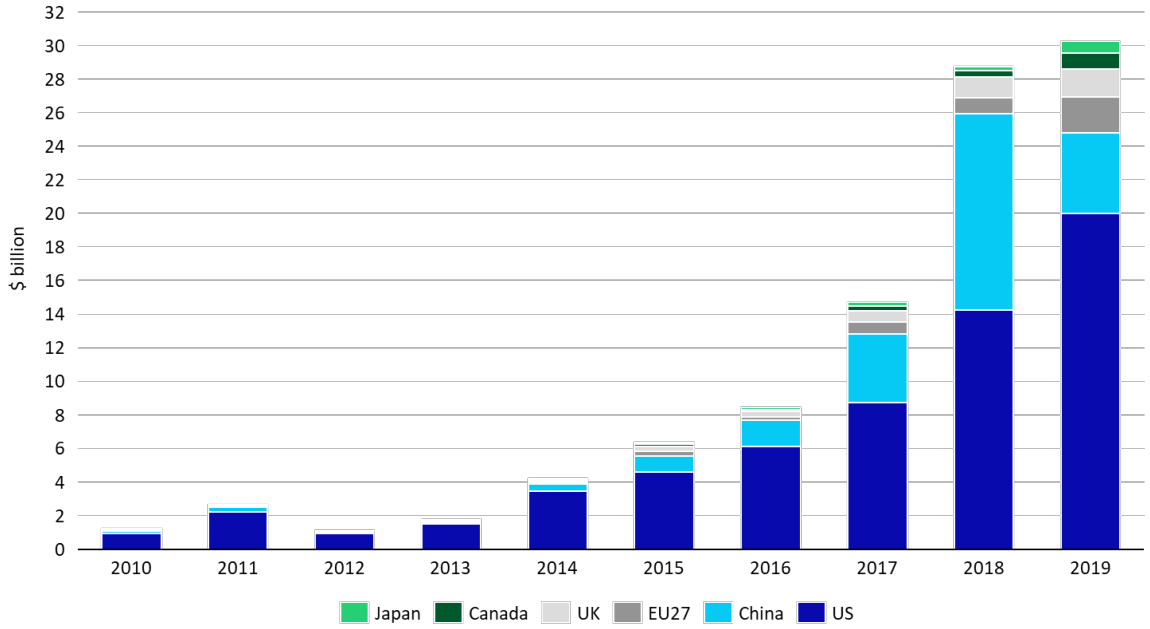
3.2. Global equity investments in AI and BC

Data on VC investments in AI and BC SMEs during 2010–2019 were sourced from the Preqin database, covering the EU27, United States, China, United Kingdom, Canada and Japan. These data are broadly consistent those used by the OECD (Crunchbase)[99] and CB Insights.[100]

Globally, VC investments in AI and BC have grown rapidly over the past decade, exceeding $30 billion in 2019, dominated by the United States and China. In the EU27 these investments grew from $0.3 billion in 2016 to over $2 billion in 2019, representing an increase from 3% to 7% of the global total. After relatively steady growth from 2012 to 2016, global investments dramatically increased in 2017 and 2018, mainly driven by investments in China. As shown in Figure 19, investments in the United States doubled between 2016 and 2018, while those in China increased eightfold. It should be noted that seven deals of over $500 million each were transacted in China in 2018, which explains that year's exceptionally high figures. In 2019 global investments grew only slightly compared to 2018, mainly reflecting lower investments in China. However, from 2018 to 2019, investments increased by about 45% in the United States and more than doubled in the EU27 (from $0.9 billion in 2018 to $2.16 billion).

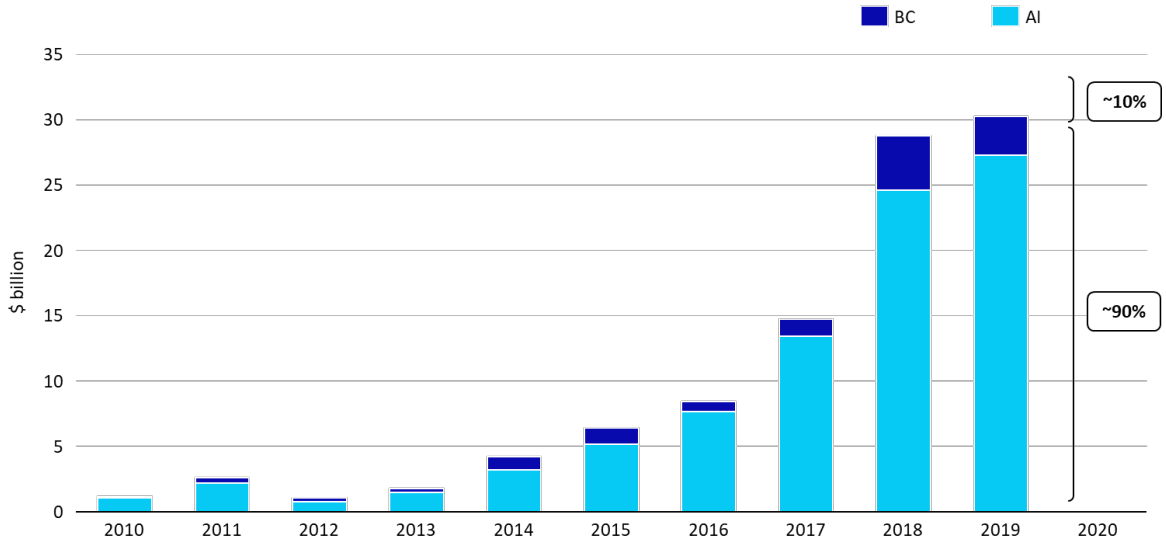
[99] Private equity investment in artificial intelligence, OECD, 2018 (link, accessed 26 May 2020).
[100] The blockchain report 2020, CB Insights, 2020.

Figure 18: Total estimated VC equity investment in AI and BC SMEs by geography, 2010–2019[101]



AI accounts for the largest share of these VC investments (about 90%). In 2019 over $28 billion was invested in AI SMEs in the six focal regions, while BC accounted for about $3 billion of investments. AI investments grew almost exponentially between 2012 and 2018, then rose more slowly in 2019. BC investments peaked in 2018 but then decreased in 2019 – a delayed reaction to the falling value of cryptocurrencies during 2018.[102]

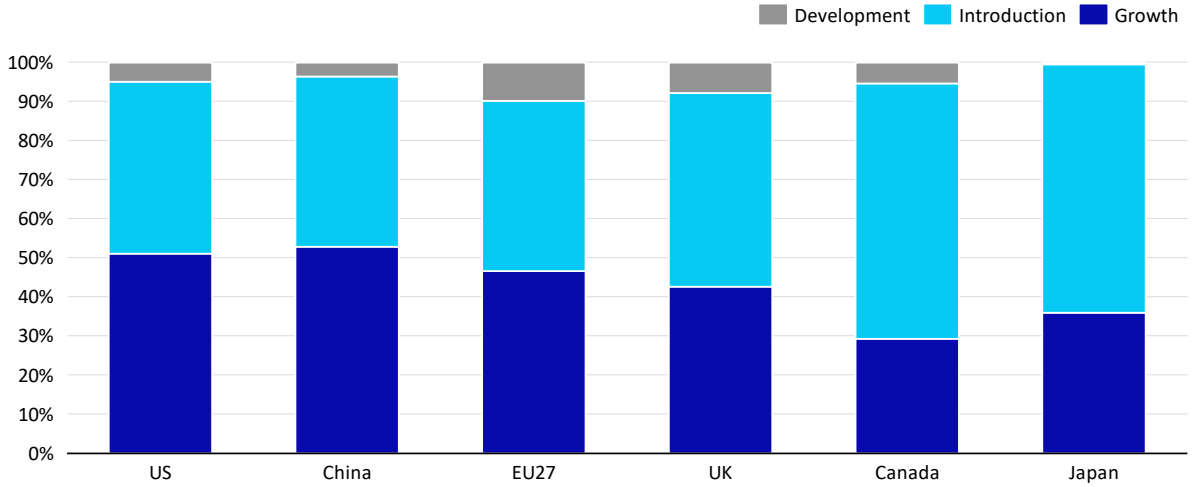
Figure 19: Total global estimated VC equity investment in AI and BC SMEs by technology, 2010–2019[103]



101 Preqin data, Oliver Wyman analysis.
102 Blockchain trends in review, CB Insights, 2019.
103 Preqin data, Oliver Wyman analysis.

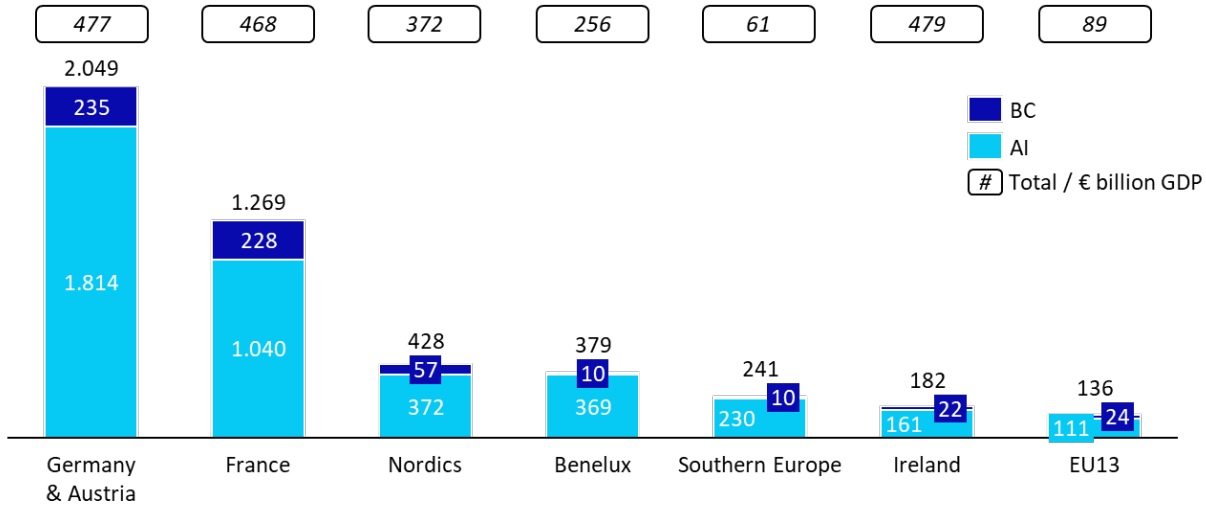
The EU27 has the highest proportion of estimated equity financing to SMEs in the development (i.e. earliest) stage, representing about 10% of total VC investments. This is in line with the above finding that the EU27 has a higher proportion of development-stage SMEs compared to the United States. Conversely, the United States and China have the highest proportion of VC investments in growth-stage SMEs (i.e. Series C onwards), indicating greater focus on more mature companies.

Figure 20: Total estimated VC equity investments in AI and BC SMEs by financing life-cycle stage, 2019[104]



Within the EU27, Germany & Austria and France raised the highest amounts of VC equity investments (more than 70% of the total). The combined VC equity investments in the Nordics, Benelux, Southern Europe and Ireland amount to about the same value as that of France alone. The EU13 had the lowest VC equity investments at just above €100 million. When considering nominal GDP per region, VC equity investments were comparatively strong in the Nordics, Benelux and Ireland, but lagging behind in Southern Europe and the EU13.

Figure 21: Total estimated VC equity investment in AI and BC SMEs by EU27 region, 2010–2019[105]



[104] Preqin data for deals with disclosed financing type.
[105] Preqin data, Oliver Wyman analysis.

3.3. Key enablers for AI and BC technologies

This section discusses selected key enablers to assess the level of readiness to develop and deploy AI and BC technologies across the EU27 and other major geographies. Comparisons focus mostly on the United States and China, as these counties have the largest number of AI and BC SMEs and the highest total, average and median VC investments in the field. More generally, the EU27, United States and China are widely considered to be among the main competitors for global leadership in AI and BC.[106] The study concentrates on three dimensions:

- Talent and research publications;
- Digital economy performance; and
- Data availability.

Overall, the EU27's business environment provides a strong basis for competing with the United States and China, the two leading regions in AI and BC. The EU27 has more specialised researchers than its peers, and typically produces the most technology-related academic research. Some Member States also show rather strong digital performance (as measured by the International Digital Economy and Society Index, I-DESI), indicating that the region is well positioned to deploy AI and BC technologies across different sectors. It also shows a revealed competitive advantage (RCA) in the development of several key domains of AI. However, in terms of data availability the EU27 is currently disadvantaged compared to China and the United States, which could especially limit the development of AI technologies (whose models need to be trained with large amounts of data). Linking these findings to those above on the number of AI and BC SMEs and total, average and median VC investments, the EU27 has a strong set of enablers in place but is struggling to put its talent and digital readiness to economic and social uses.

3.3.1. Talent and research publications

Talent is a key enabler for a region's competitiveness in developing and deploying innovative technologies in the current and future ecosystems. As growing numbers of industries and firms are likely to adopt these technologies, the availability of talent needs to match the expected rise in demand over the coming years. Thus, it is essential to ensure access to a large pool of highly qualified potential staff. This analysis employs the results of a study by the Center for Data Innovation that compared Europe, the United States and China across several talent-related dimensions.[107]

The European Union has a large pool of talent; in certain areas it is ahead of the United States and China. In terms of total AI researchers, Europe has the largest talent pool, with an estimated 43 064 AI researchers (of which 7 998 are in the United Kingdom), compared with 28 536 in the United States and 18 232 in China (although Europe and the United States have a similar number when adjusting for workforce size).[108] Europe is also strongly positioned in the quality of AI researchers as measured by the h-index. In 2017 Europe had an estimated 5 787 top AI researchers (of which 1 117 are in the United Kingdom), ahead of the United States (5 158) and China (977).[109] On the second measure of quality, i.e. the number of authors publishing at leading AI academic conferences around the world, the United States ranked top (10 295), followed by Europe (4 840).

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[106] Digital transformation monitor. USA-China-EU plans for AI: Where do we stand?, European Commission, 2018.

[107] Who is winning the AI race: China, the EU or the United States?, Center for Data Innovation, 2019.

[108] AI researchers are those who published an AI-related journal article or registered an AI patent between 2007 and 2017.

[109] The h-index measures the productivity and influence of researchers: see J. E. Hirsch, An index to quantify an individual's scientific research output, 2005 (link, accessed 20 May 2020).

Figure 22: Selected metrics for AI talent per geography in 2017[110]

Metric	Europe	United States	China
Number of AI researchers	43 064	28 536	18 232
Number of AI researchers per 1 million workers	172.9	173.1	23.2
Number of top AI researchers	5 787	5 158	977
Number of top AI researchers per 1 million workers	23.2	31.3	1.2
Number of top AI researchers (academic conferences)	4 840	10 295	2 525
Number of top AI researchers (academic conferences) per 1 million workers	19.4	62.4	3.2

However, despite the large availability of AI talent in Europe, European businesses have less AI employees than US firms. For example, half of the global top-20 companies for AI patents are based in the United States and have a combined total of 1 623 AI-specialist researchers (averaging about 160 per company). By contrast, six of the top-20 are in the EU27, with a combined total of 552 AI researchers (averaging less than 90 per company).[111]

Europe has made a leading contribution to publishing AI-related research over the last two decades. However, China recently took the lead in this domain. Neither AI nor BC are mature technologies and research in both fields is expected to drive great advancements in the coming years. Thus, it is important to assess the research potential across different regions. The volume of published AI research has increased globally over the past decade, especially over the last 5 years (see Figure 24). In the number of published AI papers, Europe led China until recently and still has considerable sources of knowledge and innovation at its disposal for European startups to build on. In terms of the quality of AI research (based on the FWCI[112] index), Europe ranks behind the United States and seems to have been stagnating since 2016; China ranks third but is catching up very quickly, having almost doubled its research impact since 2016.[113]

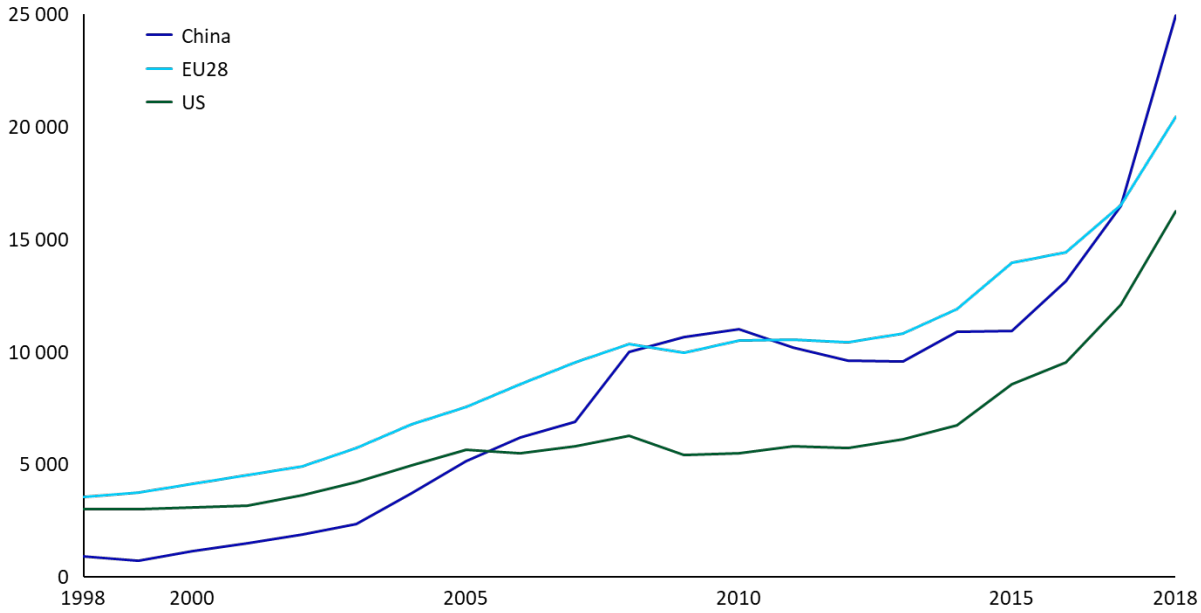
[110] Who is winning the AI race: China, the EU or the United States?, Center for Data Innovation, 2019

[111] China AI development report 2018, China Institute for Science and Technology Policy at Tsinghua University, July 2018, Figure 2-37.

[112] Field-Weighted Citation Impact: Ratio of total citations received by a publication to average citations received in the field.

[113] Who is winning the AI race: China, the EU or the United States?, Center for Data Innovation, 2019, based on data from Elsevier.

Figure 23: Annual number of AI papers per geography[114]



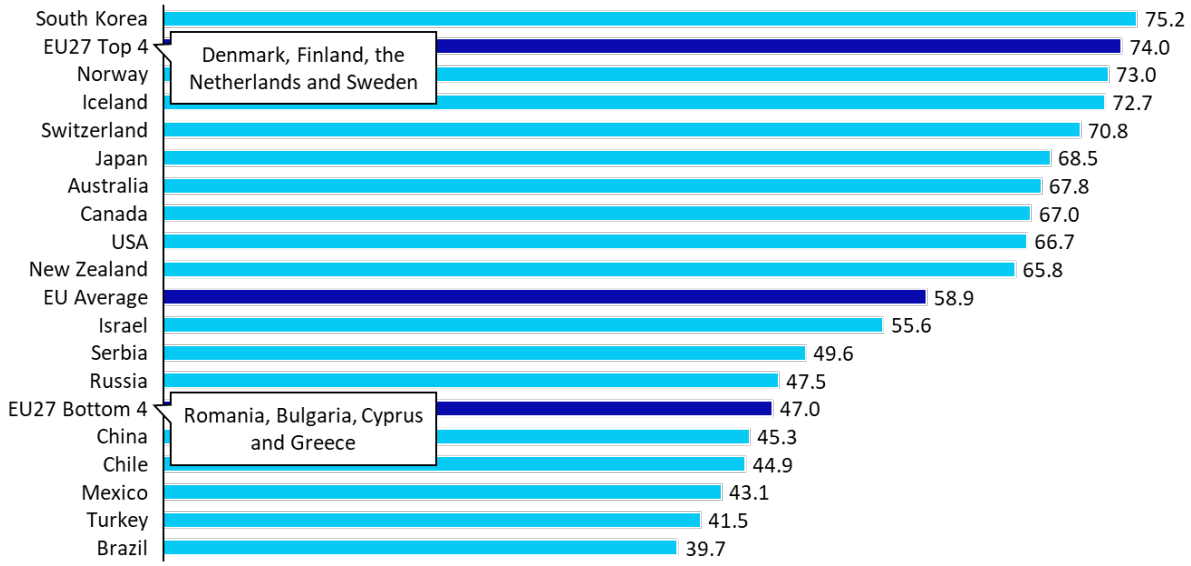
3.3.2. Digital economy performance

The potential for an economy to embrace AI and BC technologies is another key element of the ecosystem. This study refers to the I-DESI to understand the relative maturity of different economies with respect to AI and BC technologies.

Several European countries perform strongly in the I-DESI, but there is large variance within Europe. The I-DESI is a composite index from the European Commission that summarises the relative digital performance of several economies around the world. In the 2018 I-DESI report the average value of the index across all European countries was lower than the values of the United States, Canada and Japan, but higher than that of China. However, there is large variance across the EU27 Member States. While the top-4 EU countries (i.e. Denmark, Finland, the Netherlands and Sweden) were ranked second globally, only behind South Korea, the bottom-4 EU countries found themselves at the lower end of the global ranking, although still ahead of China.

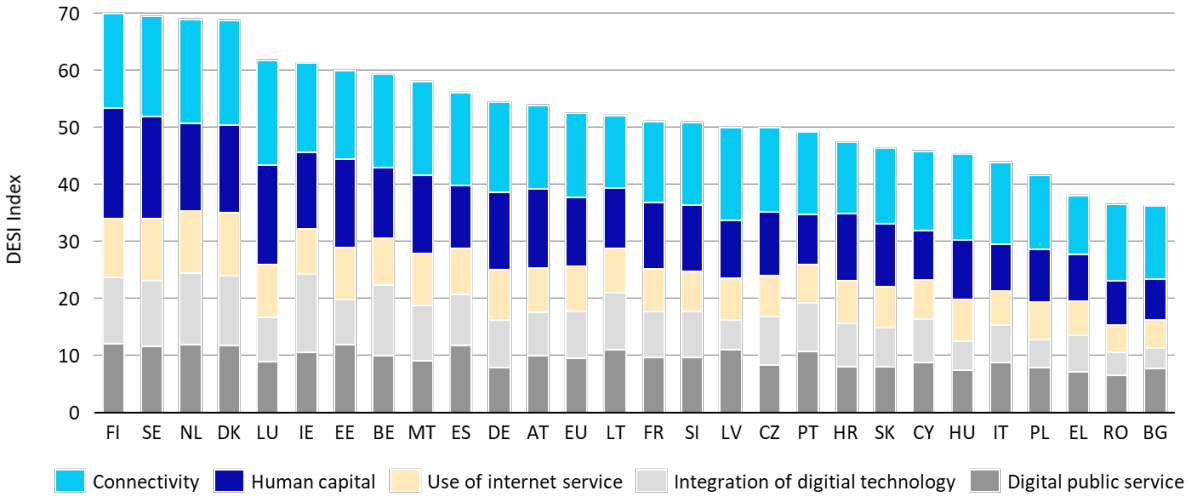
[114] Based on data from Artificial intelligence index report 2019, Stanford University, 2019, based on data from Elsevier; papers indexed in SCOPUS.

Figure 24: International Digital Economy and Society Index (I-DESI) 2018 ranking[115]



As discussed above, while the European Union overall exhibits readiness for deployment of AI and BC technologies, there are significant differences between the EU27 countries. All Member States score between 36.2 and 69.9 (out of 100), with the Nordics among the top group. The highest score (Finland) is close to double the lowest score (Bulgaria), demonstrating a significant deviation in the level of digital performance and readiness to deploy technological applications.

Figure 25: International Digital Economy and Society Index (I-DESI) 2019 ranking[116]



[115] International digital economy and society index 2018, Tech4i2 (for the European Commission), 2018.
[116] The Digital Economy and Society Index (DESI). EC (link, accessed 15 May 2020).

3.3.3. Data availability

Data are a critical component for developing AI technologies and an essential resource for SMEs developing products and services. The availability of data is essential for training AI systems, whose products and services are rapidly moving from pattern recognition and insight generation to more sophisticated forecasting techniques requiring extensive databases.[117] The amount of data produced in the world is growing rapidly: it is expected to rise from 33 zettabytes[118] in 2018 to 175 zettabytes in 2025, presenting major opportunities for the European Union to position itself in this space.[119] Limited availability of large data sets in a market can pose significant challenges for innovative SMEs. BC does not rely on data availability to the same extent as AI, and is expected to act as an enabler for security, privacy and resilience in data collection, storage and management.

The European Union seems to be disadvantaged compared to China and the United States.[120] As outlined by the Center for Data Innovation, there is no straightforward metric for measuring the relative amount of data available for AI in a particular place. One estimation approach is to consider the percentage of the population engaging in digital activities that lead to the creation of large data sets, such as broadband subscriptions and mobile payments.[121] These metrics for data availability generally place the European Union either second or third when compared to China and the United States. As discussed further in Section 5.3.2, one of the main challenges for the European Union (aside from its smaller population vs. China) is the fragmentation of the digital market across Member States, which prevents the creation of large, integrated data sets for training AI models. In the United States the collection and management of data are left to the private sector, with considerable concentration in a few Big Techs; conversely, China combines government surveillance with strong control by Big Techs over massive amounts of data that are made available to Chinese AI developers.

Table 5: Data availability per geography

Year	Metric	China	European Union	United States
2018	Fixed broadband subscriptions (millions)	394	176	110
2018	Number of individuals using mobile payments (millions)	525	45	55
2018	Internet of things data (million TB)	152	53.5	69
2018	Productivity data (million TB)	684	583	966
2019	Electronic health records (rank)	3	2	1
2019	Mapping data (rank)	3	2	1
2019	Genetic data (rank)	2	3	1
2019	Regulatory barriers (rank)	1	3	2

[117] Communication on a European strategy for data, European Commission, 19 February 2020.
[118] One zettabyte is approximately equal to one billion terabytes.
[119] The digitization of the world from edge to core, IDC, 2018.
[120] Communication on a European strategy for data, European Commission, 19 February 2020.
[121] Who is winning the AI race: China, the EU or the United States?, Center for Data Innovation, 2019.

Revealed comparative advantage (RCA) across AI domains

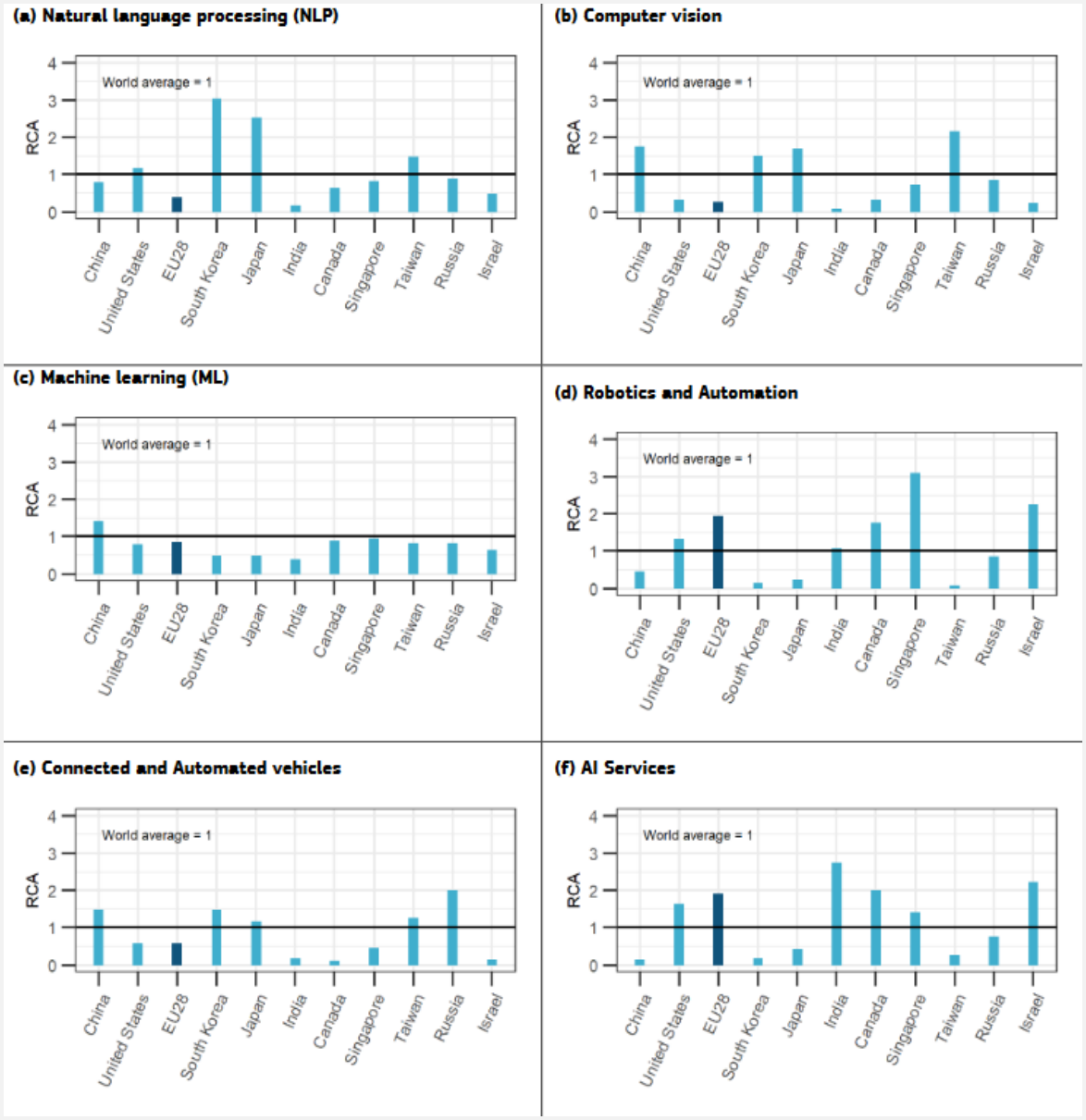
The study *AI watch – TES analysis of AI worldwide ecosystem in 2009–2018* provides interesting insights into different countries' specialisation in the field of AI. It uses a thematic RCA indicator to measure each country's specialisation against the world average in that area.[122] An RCA score >1 in a specific domain indicates that a country is relatively specialised therein.[123]

Europe demonstrates a particular comparative advantage in the thematic areas of Robotics and Automation and of AI Services, with values of the RCA indicator above world benchmarks. Europe's leading position in robotics can be partly explained by its strong and innovative industry. Regarding AI Services, Europe's advantage may be explained by the strength of its software industry, which has grown at five times the rate of the rest of the EU economy.[124]

Another strong area for Europe is ML. Although its RCA score of 0.9 does not reach the world average, Europe is among the three top performers globally, just below the benchmark of China (RCA score > 1). Connected and Automated vehicles is not among Europe's relative specialisations, although in number of patent applications, research publications and firms' activities Europe ranks third after only China and the United States. Finally, while AI processing units were not included in the *AI watch* analysis the United States is market leader in producing AI processing units, followed by Europe.[125]

[122] Note that the domain "AI processing units" is not included in this study's analysis.
[123] Note this analysis is based on the EU28: it was conducted before the United Kingdom left the European Union.
[124] The State of Europea Tech. Atomico, 2018.
[125] AI chip market, Allied Market Research (link, accessed 18 May 2020).

Figure 26: Revealed comparative advantage (RCA) of the top geographical areas for AI, 2009–2018[126]

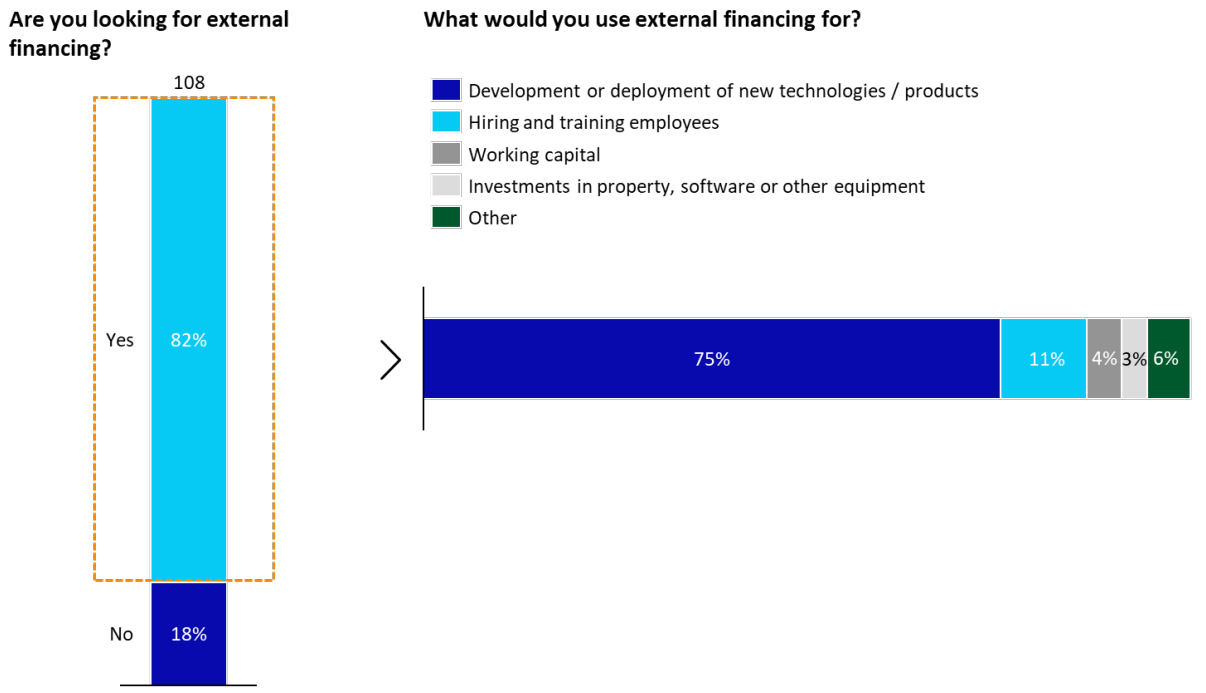


[126] AI watch – TES analysis of AI worldwide ecosystem in 2009-2018, European Commission.

4. The investment gap for AI and BC

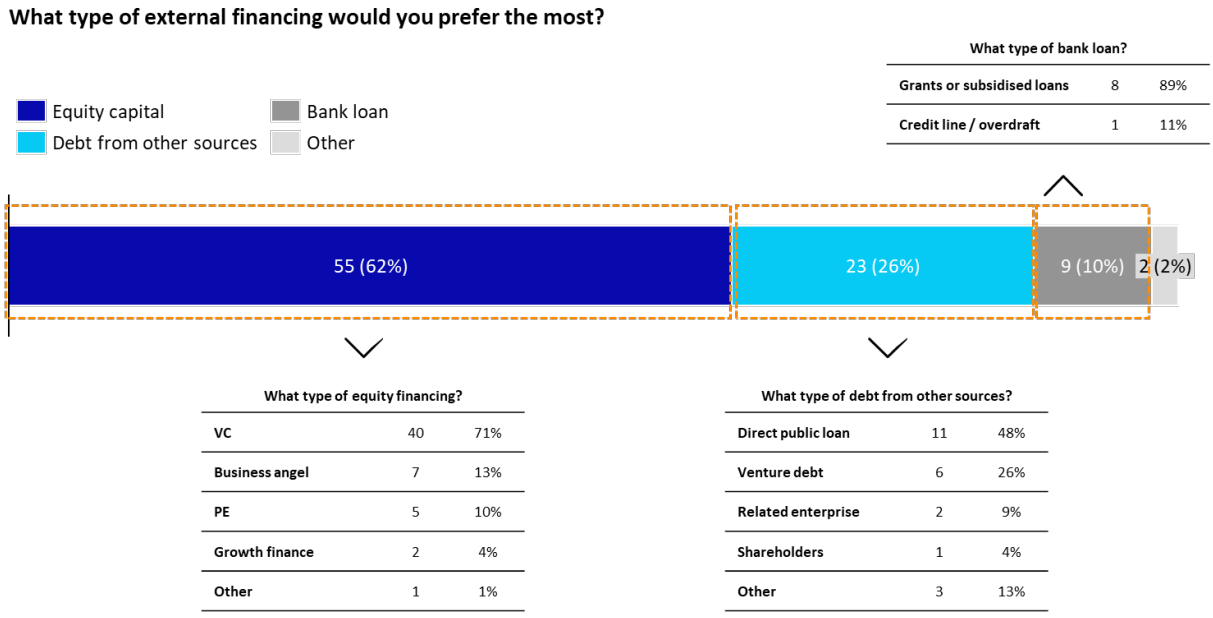
The analysis outlined in the previous section shows that the total, average and median VC investments in AI and BC are lower in the EU27 than in the United States and China. Several factors might be driving this difference (e.g. market characteristics and size; appetite for AI and BC investments); these are investigated in Section 5. This section presents a simple analysis of the investment gap in the EU27. **Rather than precisely calculating granular investment demand and supply components, the section provides approximations based on comparisons between Europe and other relevant geographies. The aim is to compute the level of equity and debt investments required for the European Union to attain the levels of the United States and China.**

Figure 27: AI and BC SMEs seeking external financing (SME survey results)



The study identified an annual investment gap for EU27-based AI and BC SMEs of about €5–10 billion. In line with the results of the survey and interviews, most of this gap is attributable to equity. Only a small percentage (10–20%) is attributable to debt, particularly venture debt, which emerged from the survey as a preferred form of debt for AI and BC SMEs (especially in later life-cycle stages). In absolute values, AI SMEs account for the largest part of the equity gap (70–80%, compared with 20–30% for BC SMEs). In relative values, the equity gap for AI SMEs is up to four times the value of current investments, while the equity gap for BC SMEs amounts to about 10–15 times the value of current investments. Most of the equity gap is in the introduction stage (i.e. Series A and B, ~47%) and in the growth stage (i.e. Series C onwards, ~35%).

Figure 28: Preferred type of external financing for AI and BC SMEs (SME survey results)



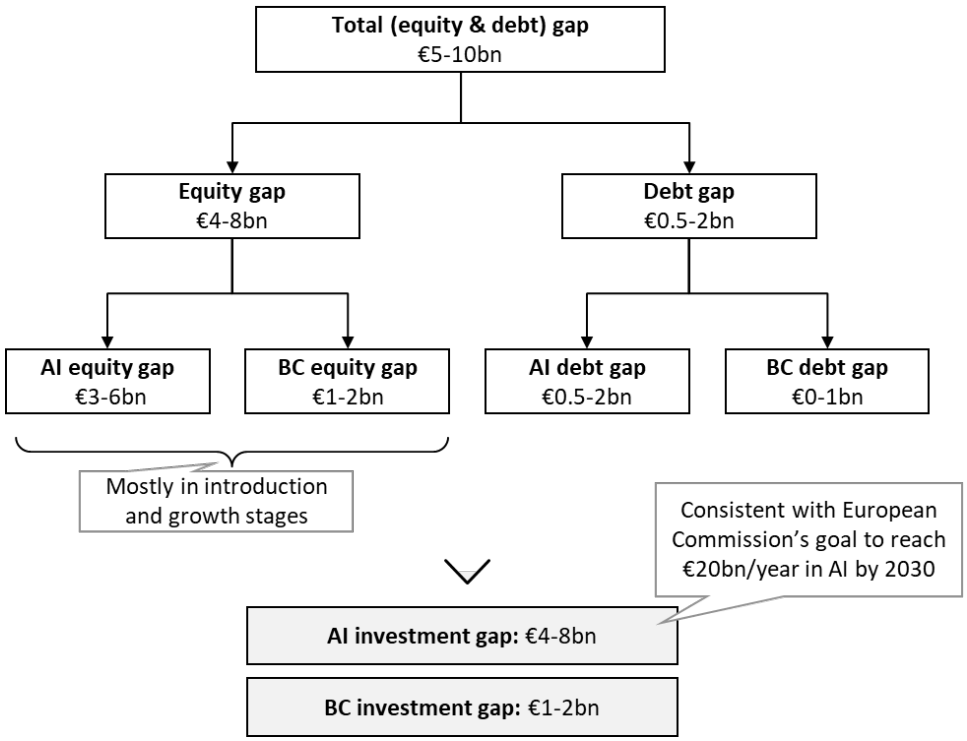
What type of bank loan?		
Grants or subsidised loans	8	89%
Credit line / overdraft	1	11%

What type of equity financing?		
VC	40	71%
Business angel	7	13%
PE	5	10%
Growth finance	2	4%
Other	1	1%

What type of debt from other sources?		
Direct public loan	11	48%
Venture debt	6	26%
Related enterprise	2	9%
Shareholders	1	4%
Other	3	13%

Key findings are presented in Figure 30 and reported in more detail in the following subsections.

Figure 29: Estimated equity and debt investment gap for AI and BC SMEs in the EU27



4.1. Equity investment gap

The study triangulated results across two different approaches to estimate the total equity investment gap for AI and BC SMEs in Europe:

1. A **bottom-up approach**, which calculates the 2019 delta in median VC investments in AI and BC SMEs in the United States and EU27 (using Preqin) and multiplies this difference by the total number of AI and BC SMEs in the EU27 (using Crunchbase). The study computed the investment gap at aggregate level and split by financing life-cycle stage. This approach is in line with that deployed in previous EIB studies;[127] and
2. A **top-down approach**, which calculates the required VC investments to bring the share in AI and BC SMEs (as a proportion of total VC investments) to the same level in the EU27 as in the United States in 2019, and adjusts this value to reflect the relative size of the EU27 and US VC markets.

Each approach highlights different components of the investment gap. Results deriving from the two approaches are broadly consistent and give a good approximation of the size of the gap.

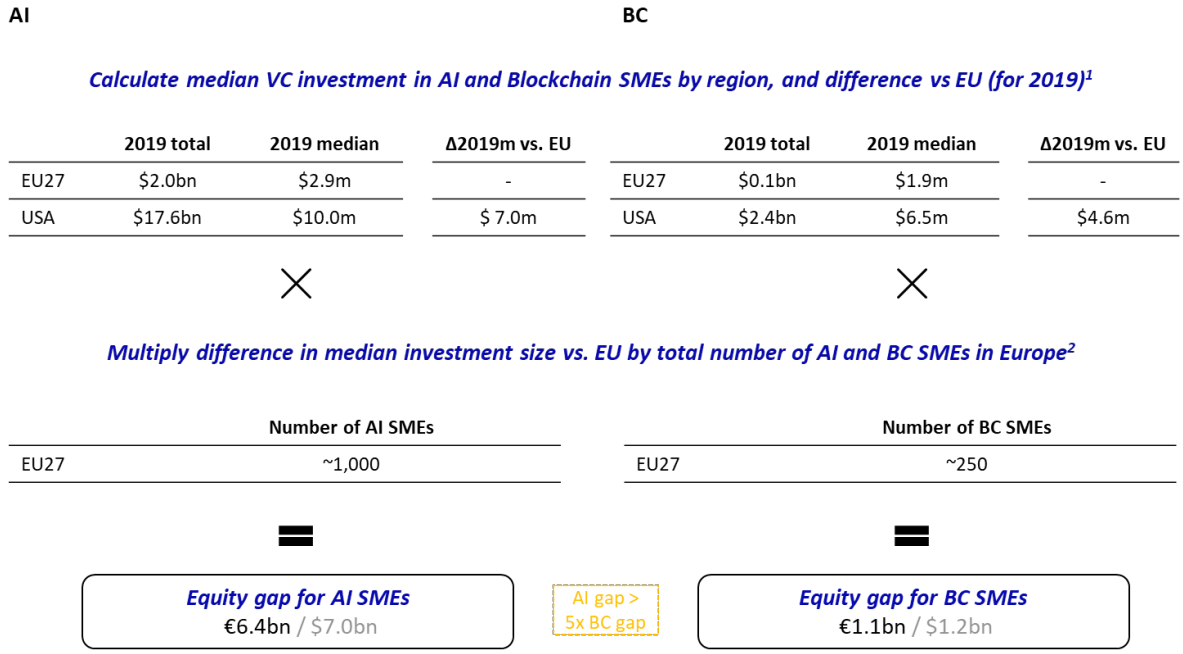
4.1.1. Bottom-up approach

The bottom-up approach estimates the equity funding gap to be about €7.5 billion – €6.4 billion for AI, €1.1 billion for BC – calculated in two steps:

- In the first step, calculate the median VC investments for both geographies: for AI, this amounts to $10 million in the United States and $2.9 million in the EU27; for BC, the respective values are $6.5 million and $1.9 million; and
- In the second step, multiply the differences in median investments for the two technologies by the number of SMEs in the EU27.

[127] Feeding future generations (2019) and Financing innovation in mobility (2018).

Figure 30: Bottom-up approach: Median equity investment gap in the EU27 vs. the United States (aggregate)[128]



1. Preqin database, total VC investments in the sector; 2. Crunchbase database

In absolute terms, AI SMEs account for most of the equity gap. In relative terms, however, about 10 times the current BC investments but only about 2.5 times the current AI investments are required to close the gap. The results do not change substantially when using alternative reference geographies and years, as shown in Table 6 and detailed further in Appendix D.[129]

Table 6: Sensitivity of bottom-up estimates to alternative reference geographies and years

Reference geography and year[130]	AI equity gap	BC equity gap	Total equity gap
United States 2018 vs. EU27 2018	€5.2bn	€0.5bn	€5.7bn
China 2019 vs. EU27 2019	€7.6bn	€0.7bn	€8.3bn
Germany 2019 vs. EU26 (excl. GER) 2019	-	-	€5.1bn

Using the same approach as above but differentiating between financing life-cycle stages, the study estimates a total equity gap of €4.4 billion, 82% of which is in the introduction and growth stages. The estimated equity gap is largest in the introduction stage (rounds A and B), both at the aggregate EU27 level (€2.0 billion) and as a percentage of missing funding at the level of individual SMEs (103% of median investment). The second largest gap is in the growth stage (rounds C onwards), totalling about €1.6 billion. The estimated equity gap is smallest in the development stage (seed and angel), totalling about €0.8 billion. The 82% estimate is likely conservative considering that several EU-born SMEs have moved outside the European Union at the introduction and growth stages to get the funding required to sustain their expansion.

128 Preqin data, Crunchbase data, Oliver Wyman analysis. See Appendix C for the exact types of equity financing considered.
129 Comparable results for BC can be found in Enterprise blockchain 2020, LeadBlock Partners, 2020.
130 Sources for US 2018, China 2019 and Germany 2019: Preqin data, Crunchbase data, Oliver Wyman analysis.

Figure 31: Bottom-up approach: Median equity investment gap in the EU27 vs. the United States (by life-cycle stage)[131]

AI and BC

Calculate median VC investment in AI and BC SMEs by region and life-cycle stage, and difference vs. EU (2019)[1]

	Development stage	Introduction stage	Growth stage
EU27	$1.3m	$ 6.2m	$ 23.3m
US	$ 2.4m	$ 12.5m	$ 40.0m

	Development stage	Introduction stage	Growth stage
Δ2019 vs EU27	$1.1m	$6.3m	$16.7m
As % of current EU27 investment	79%	103%	72%

×

Multiply the difference in median investment size vs. EU by total number of AI and BC SMEs in EU per life-cycle stage[2]

	Development stage	Introduction stage	Growth stage
# SMEs	~800 (64%)	~350 (28%)	~100 (8%)

=

	Development stage	Introduction stage	Growth stage
Equity gap	€0.8bn (19%) $0.8bn	€2.0bn (47%) $2.2bn	€1.6bn (35%) $1.7bn

AI: €3.5bn (~80%)
BC: €0.9bn (~20%)

> €4.4bn

1. Preqin database, total VC investments in the sector; 2. Crunchase database

4.1.2. Top-down approach

The top-down approach estimates an investment gap of €3.2 billion – €2.7 for AI, €0.5 billion for BC. The AI share of total VC investment is about 1.2 times larger in the United States than in the EU27 (13.6% vs. 11.3%, respectively), while the BC share is about 1.4 times larger in the United States vs. the EU27 (1.0% vs. 0.7%, respectively). This suggests that, for AI, the gap is not driven by low willingness of VC investors but rather by the smaller overall size of the VC market in Europe (a common issue across several EU sectors). By contrast, VC investors' appetite for BC is significantly lower in the EU27 than in the United States. This topic is discussed in further detail in Section 5.1.3.

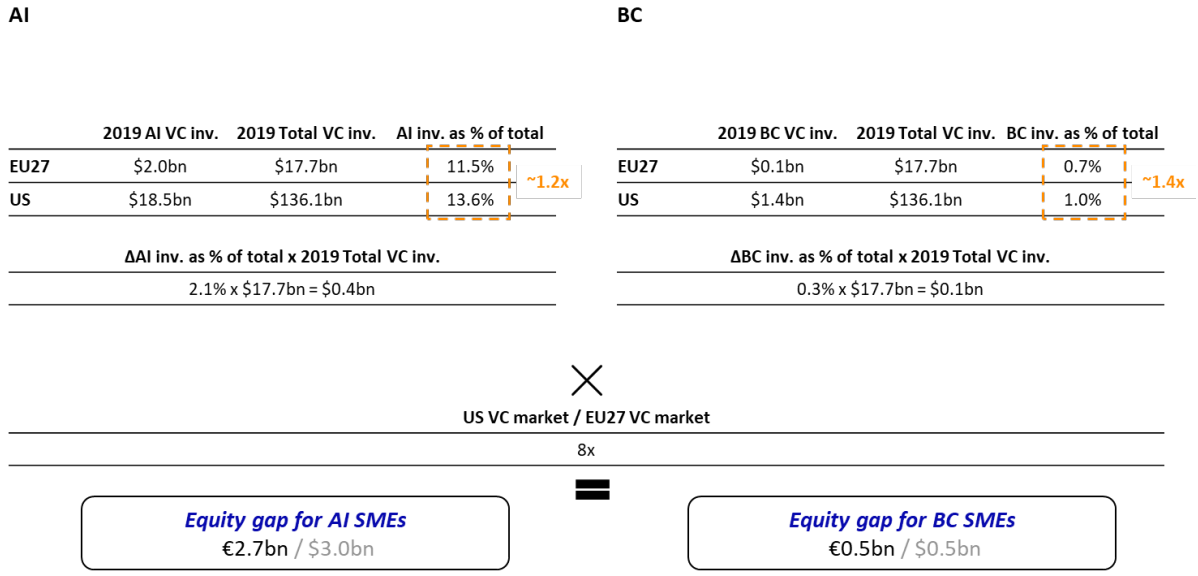
The results from the two approaches are in the same order of magnitude. The study triangulated several different sources for the top-down approach to obtain estimates robust to the values of the VC market in available studies.[132,133]

Figure 32: Top-down approach: Median equity investment gap in the EU27 vs. the United States (aggregate)

131 Preqin data, Crunchbase data, Oliver Wyman analysis.

132 EU27 values are based on Preqin data (total VC investments in the sector). For US 2019, total VC investments ($136.1 billion) is taken from the Venture monitor Q1 2020 (National Venture Capital Association (NVCA) & Pitchbook, 2020) and the AI share ($18.5 billion) is based on data from the NVCA (link, accessed 11 May 2020). Global VC investments in BC-related companies were reported to be $2.8 billion in 2019, while 51% of BC investments globally in 2015–2019 were made in the United States (The blockchain report 2020, CB Insights, 2020). Accordingly, US VC investments in 2019 were estimated to be $1.4 billion. For the US and EU27 GDP size, OECD data were used.

133 VC investments in European AI companies in 2019 amounted to $4.9 billion, of which $2.9 billion was invested in the United Kingdom: see State of tech 2019 report, Atomico, 2019. The Crunchbase database reports VC investments in the EU27 of $21.7 billion in 2019 (link, accessed 11 May 2020).



4.2. Debt investment gap

As reported in Figure 29 (above), AI and BC SMEs strongly prefer equity to debt financing. Their most preferred types of debt financing are direct public loans or subsidised loans (particularly amid the COVID-19 pandemic, with several interviewed SMEs targeting dedicated resources from public support schemes) and venture debt, a very relevant financing source for firms in later life-cycle stages. Except for personal credit lines and/or credit card overdrafts, loans from traditional banks do not seem to be favoured by AI and BC SMEs.

The study used two different approaches to estimate the total debt investment gap for AI and BC SMEs in Europe. The first approach focuses only on the venture debt gap, and thus represents the lower bound of the debt investment gap range (i.e. the gap if AI and BC SMEs only need venture debt). The second approach includes a broader definition of debt (including venture debt and other types of loans) and could, thus, be considered the upper bound of the debt investment gap range.

Specifically, the two approaches make the following calculations:

1. The **venture debt approach** calculates the required investment to increase the venture debt share of total VC investments to the same level in the EU27 as in the United States in 2019, and adjusts this value to reflect the relative size of the EU27 and US VC markets as a percentage of GDP; and

2. The **SME debt gap approach** assumes that the debt gap for SMEs is within the GDP range estimated by McCahery *et al.* (2015),[134] and adjusts this value by the size of the "new technology" sector (the same approach used in previous EIB studies).[135]

4.2.1. The venture debt approach

In line with previous EIB studies, the survey and interviews revealed that traditional senior loans to highly innovative SMEs are rarely economically viable for commercial banks. Thus, typical bank loans are not commonly used for starting and scaling up AI and BC SMEs. More viable forms of debt include venture debt, which is being raised and is becoming more popular among highly innovative firms.[136]

[134] McCahery, Lopez de Silanes, Schoenmaker & Stanisic, 2015.
[135] For example, Feeding future generations (2019) and Financing innovation in clean and sustainable mobility (2018).
[136] Financing the deep tech revolution: How investors assess risks in key enabling technologies (KETs), EIB, 2018.

The study estimates that the annual venture debt investment gap for AI and BC SMEs is €0.2–1.6 billion. The gap was estimated by analysing the investments required to increase the venture debt share of total VC investments to the same level in the EU27 as in the United States in 2019, adjusted for the relative size of the EU and US VC markets. In the first step, EIB estimates were used to calculate the difference between the venture debt share of total VC investments in the United States (~15%) and the equivalent share in Europe (only 5%).[137] By multiplying this percentage difference (15% − 5% = 10%) by the total annual VC investments in AI and BC in Europe (about €2.1 billion in 2019), the lower bound estimate of the annual venture debt gap is calculated as €0.2 billion.[138] In the second step, based on the VC market in AI and BC being about eight times larger in the United States than in the EU27, the upper bound estimate of the venture debt gap is calculated as €1.6 billion (i.e. €0.2 billion × 8).[139] Thus, the estimated annual venture debt gap of the EU27 is €0.2–1.6 billion.

4.2.2. The SME debt gap approach

As an alternative approach to calculating the debt investment gap, the study also uses the SME debt gap method deployed in several previous EIB studies.[140] This approach estimates the debt investment gap for AI and BC SMEs in the EU27 to be €1.3–2.8 billion per year. As the first step, the debt gap for all SMEs is assumed to lie within 2.7% and 6.0% of GDP, as estimated by McCahery *et al.* (2015).[141] The AI/BC share of EU27 GDP is then estimated using the share of the "new technology" within the ICT sector. Finally, the range of the SME debt gap is applied to this GDP share estimate. The calculations are shown in Figure 34. Since "new technology" is not limited to AI and BC, the results obtained from this approach can be considered an upper bound for the SME debt investment gap. Also, while McCahery *et al.* (2015) based their estimates on all SMEs in the economy, AI and BC SMEs tend to have lower need for debt than other SMEs (especially in the earlier stages); this consideration further reduces the potential debt gap.

[137] EIB calculations (link, accessed 20 May 2020); see also The shortage of risk capital for Europe's high growth businesses, AFME, 2017.

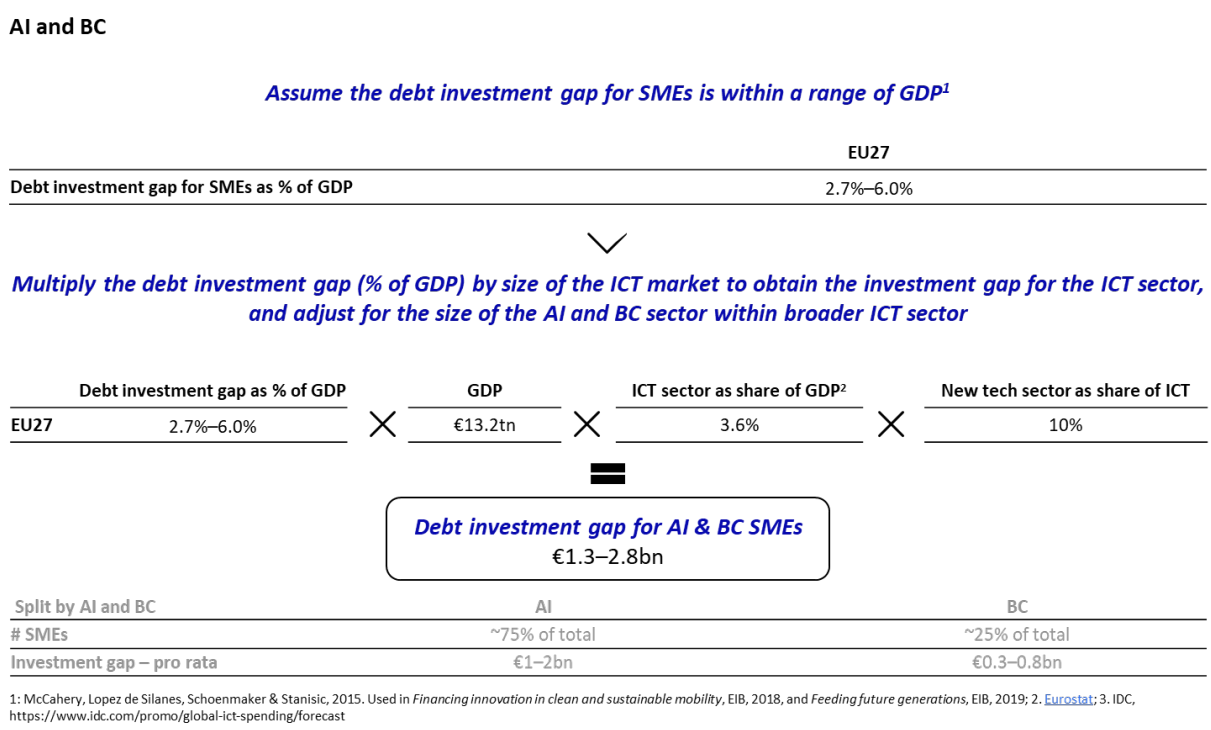
[138] For simplicity and based on available data, the delta % of venture debt / venture financing is considered as 10% of venture capital investments.

[139] Total VC investment in 2019: $2.1 billion in the European Union vs. $20.0 billion in the United States.

[140] Feeding future generations (2019); Financing innovation in mobility (2018).

[141] McCahery, Lopez de Silanes, Schoenmaker & Stanisic, 2015.

Figure 33: SME debt gap approach: Debt investment gap for SMEs in relation to market size[142]



1: McCahery, Lopez de Silanes, Schoenmaker & Stanisic, 2015. Used in *Financing innovation in clean and sustainable mobility*, EIB, 2018, and *Feeding future generations*, EIB, 2019; 2. Eurostat; 3. IDC, https://www.idc.com/promo/global-ict-spending/forecast

4.3. Available EU programmes for AI and BC

The European Commission has taken several measures to sustain the development and deployment of AI and BC technologies in Europe. The AI strategy presented in April 2018 targeted increased coordination and synergy of investments, with public (EU and national) and private investments in AI research and innovation (R&I) reaching at least €20 billion from 2018 until the end of 2020, then over €20 billion per year throughout the following decade.[143]

At the EU level, the European Commission plans to dedicate funds in the form of grants and guarantees for AI and BC across several programmes of the next long-term EU budget 2021–2027.[144]

- **Digital Europe Programme:** The DEP focuses on building the strategic digital capacities of the European Union and on facilitating the wide deployment of digital technologies for use by Europe's citizens and businesses. The planned overall budget is €8.2 billion, of which:
  - €2.5 billion will be specifically dedicated to investing in and opening up the use of AI by businesses and public administrations, facilitating safe access to and storage of large sets of data and algorithms, and strengthening and supporting existing AI testing and experimentation facilities in areas such as health and mobility in Member States, whose cooperation will be encouraged; and
  - €1.3 billion will be dedicated to fostering the wide use of digital technologies across the economy and society, notably through supporting DIHs.

142 McCahery, Lopez de Silanes, Schoenmaker, & Stanisic, 2015; Eurostat; IDC (link, accessed 11 May 2020).
143 Coordinated plan on AI, European Commission, 2018.
144 European Commission (link, accessed 19 May 2020); MFF Factsheets. European Commission (link, accessed 1 July 2020).

- **Horizon Europe programme:** The European Commission's proposal for Horizon Europe is an ambitious ~€95 billion R&I programme to succeed Horizon 2020. The Commission is willing to reinforce focus on AI and BC technologies via this programme (supplementing the €1.5 billion for investments in AI under the R&I framework of **Horizon 2020**).
- **InvestEU Programme:** This programme builds on the successful model of the Investment Plan for Europe (the Juncker Plan). It will bring together the European Fund for Strategic Investments and 13 EU financial instruments. InvestEU will include an EU budget guarantee of ~€75 billion for financing investment projects via the EIB Group and NPBs to support long-term green and digital transitions. The funds are expected to be split as follows: R&I (€10 billion), SMEs (€10 billion), Social Investments and Skills (€3.6 billion), Strategic EU Investments (€31 billion) and Sustainable Infrastructure (€20 billion).

Additional EU-level financing will be provided as indirect equity investments through the EIF AI and BC investment scheme. This programme was launched in early 2020 with the objective of financing the development of highly innovative AI and BC companies, as part of a wider move to create a dynamic EU-wide innovation ecosystem.

The EIF AI/BC investment scheme – key facts

- **Programme size:** €100 million, to be approved for selected investments by December 2020, enabling a portfolio of ~4–8 funds and co-investments in AI/BC-related technologies
- **Tools:** New direct fund investments and co-investments, alongside existing EIF fund managers and business angels
- **Fund strategies:** AI and BC technologies-focused funds or generalist funds with an opportunistic focus on these areas (required to invest at least double the programme allocation in AI/BC)
- **Investment in a single fund:** up to €50 million (min. 7.5% and max. 50% of the fund)
- **Targeted final beneficiaries:** SMEs developing or operating in the field of AI or BC
- **Stage focus:** early, expansion and growth

These EU-level investments are complemented by national efforts and initiatives. In response to the European Commission's *Coordinated plan on AI*, many Member States have published national AI strategies and announced public funding to implement these strategies. Among the largest public investment plans are those of:

- the **German federal government**, which committed in 2018 to spend around €3 billion during 2019–2025;[145]
- the **French government**, which will dedicate €1.5 billion to developing AI by the end of 2022, including €700 million for research;[146]
- the **Italian government**, which earmarked around €1 billion until 2025;[147] and
- the **Dutch government**, which will dedicate ~€45 million per year until 2023, in addition to €18 million for developing supercomputers and €200 million for training opportunities in AI.[148]

However, many EU27 countries have not yet allocated a budget to AI (and BC) investments.[149] The *AI Watch – National strategies on artificial intelligence* report by the Joint Research Centre (European Commission) details additional information about Member States' programmes.

[145] Germany AI Strategy Report. European Commission (link, accessed 19 May 2020).
[146] France AI Strategy Report. European Commission (link, accessed 19 May 2020).
[147] Italy AI Strategy Report. European Commission (link, accessed 19 May 2020).
[148] Netherlands AI Strategy Report. European Commission (link, accessed 19 May 2020).
[149] AI watch – TES analysis of AI worldwide ecosystem in 2009-2018, European Commission, 2020.

Examples of public initiatives in AI and BC from the United States and China

The review of US and Chinese public programmes provide useful illustrations.

In 2019 President Trump launched the American AI Initiative, a strategy for promoting American leadership in AI. The *MIT Technology Review* reports that, as part of this strategy, the US federal government alone planned to spend a total of $5.9 billion on AI R&D in 2020, comprising $4.9 billion on defence and $1 billion on non-defence programmes (the latter being expected to grow to $2 billion by the end of 2022).[150] The US Department of Defense had already announced (in 2018) a $2 billion five-year campaign led by the Defense Advanced Research Projects Agency (DARPA) for AI technologies, called "AI Next."[151] Moreover, the 2020 National Artificial Intelligence Initiative Act allocates another $6.5 billion to AI research and development (R&D), education, and standards development. Initiatives include, for example, setting up a national cloud computing task force and establishing AI networking security.[152]

While US government spending on BC is still much lower than that devoted to AI, studies predict considerable growth over the coming years.[153] Also, several government agencies are exploring potential applications of BC in their domain, including the United States Agency for International Development, the Centre for Disease Control and the Department of Defense.[154]

China's central government presented the *New generation AI development plan* in 2017, which targets making China the world leader in AI. The strategy calls for extensive investments in R&D and other initiatives from government bodies and private entities, though the values are difficult to estimate based on publicly available data.[155] China's public R&D spending on AI is estimated to be no more than $10 billion per year,[156] while the amount spent by central government is estimated by some studies to be as low as a few hundred million US dollars.[157] However, when also considering financing by local authorities, state-owned enterprises and other actors close to the government, as well as other forms of support to AI (e.g. public equity investment, loans and tax breaks), overall support for AI by the Chinese government appears substantial.

150 MIT Technology Review, based on data from the US government & Bloomberg Government (link, accessed 19 May 2020).
151 AI next campaign. DARPA (link, accessed 19 May 2020).
152 AI legislation 2020. Center for Data Innovation (link, accessed 15 July 2020).
153 U.S. Government blockchain spending forecast, 2019–2022: Healthy four-year growth predicted for government blockchain spending, IDC, 2019.
154 Emerging Tech. Emerging Citizen Technology Office (link, accessed 19 May 2020).
155 Digital transformation monitor. USA-China-EU plans for AI: Where do we stand?, European Commission, 2018.
156 Chinese public AI R&D spending: Provisional findings, Center for Security and Emerging Technology, 2019.
157 A brief examination of Chinese government expenditures on artificial intelligence R&D, IDA Science & Technology Policy Institute, 2020.

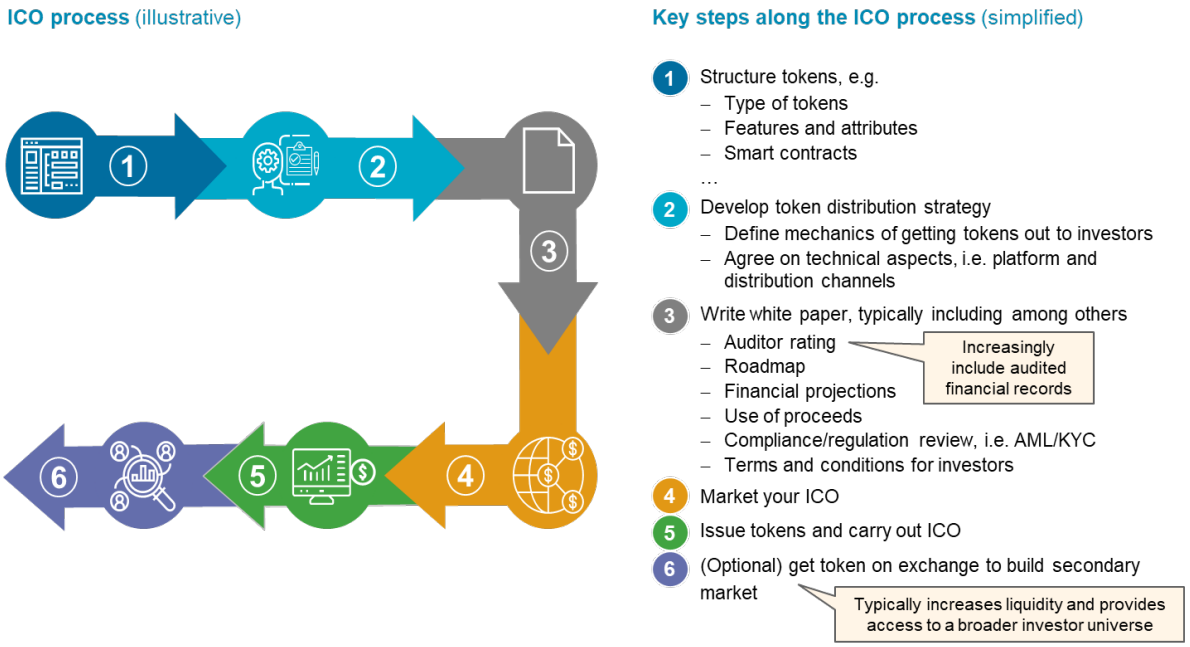
4.4. Alternative investment schemes based on BC

BC technology allows firms to use alternative investment schemes (beyond equity and debt) to raise financing; ICOs are probably the most common BC-based investment scheme. ICOs allow companies to raise funds with digital assets (tokens), created using DLT.[158] They are often considered a cryptocoin-based version of traditional initial public offerings (IPOs). ICOs are mechanisms for companies to:

- Access new funding sources without necessarily giving away any equity and control;
- Simplify asset distribution; and
- Access a broader investor universe than is typically available to early-stage firms.

In the ICO process, fundraisers issue newly denominated tokens and sell them to investors at an initial rate, in exchange for conventional currency or established cryptocoins (e.g. Ethereum). Tokens do not necessarily imply any ownership/equity in the company, although they can be designed to have aspects of securities, if desired. The issuer then uses the capital raised to meet development costs/fund future operations or acquisitions, as they would following an IPO. The purchasers are free to trade the tokens on exchanges or hold them for future use on the platform. The price is largely driven by the token's "utility" or "underlying value," i.e. demand for the coin as a unit of value on the platform itself and performance of the underlying value. ICOs originated in the payment and utility token space as a means to fund specific technologies/projects; only recently have they been used to fund investments in equity and physical commodities. ICOs currently face significantly lower barriers to entry than IPOs and target different issuers/investors with different products and regulations.

Figure 34: Six key steps of the ICO process[159]



Between January 2016 and December 2019 a total of $14.6 billion was raised through ICOs globally. ICO activity peaked at the end of 2017 and continued strongly in the first half of 2018. With a global volume of $7.8 billion raised across 1 253 ICOs (average ICO size of $6.2 million), BC firms globally raised considerably more funding via ICOs than via "traditional" equity investments ($4.1 billion) in 2018.[160] However, global ICO activity dramatically declined by year end 2018, and there was very little activity in 2019, with 109 ICOs raising just $0.4 billion, representing a 95% year-on-year decline. In

158 Autonomous NEXT analysis; WePower white paper; Oliver Wyman analysis.
159 ico4you.com, Oliver Wyman analysis.
160 ICOdata.io (link, accessed 25 May 2020).

terms of timing, this pattern is similar to that for VC equity investments in BC, which also peaked in 2018 then dropped significantly in 2019.[161]

Figure 35: Funds raised through ICOs, January 2016 – December 2019 (*$ billion*)[162]

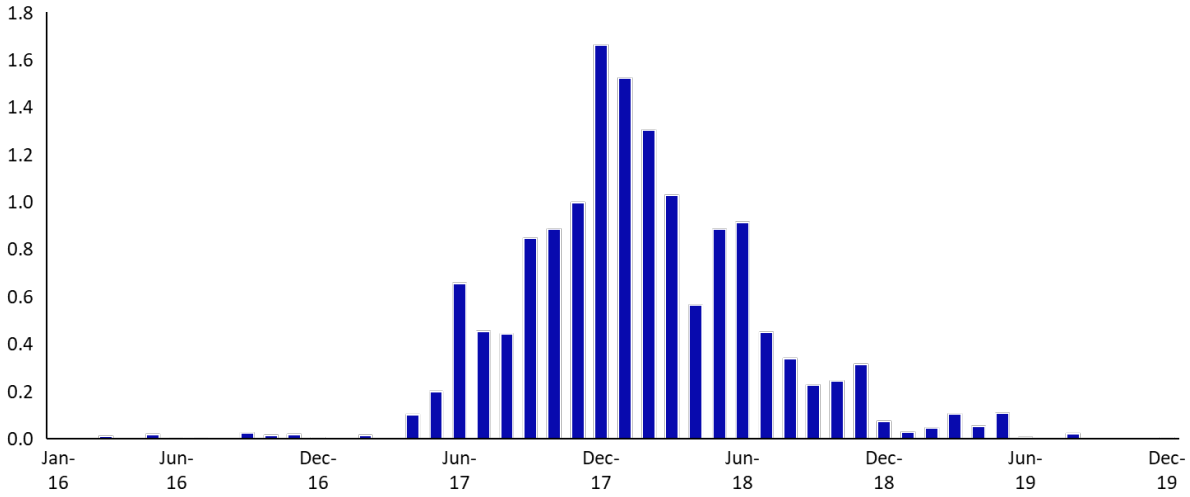
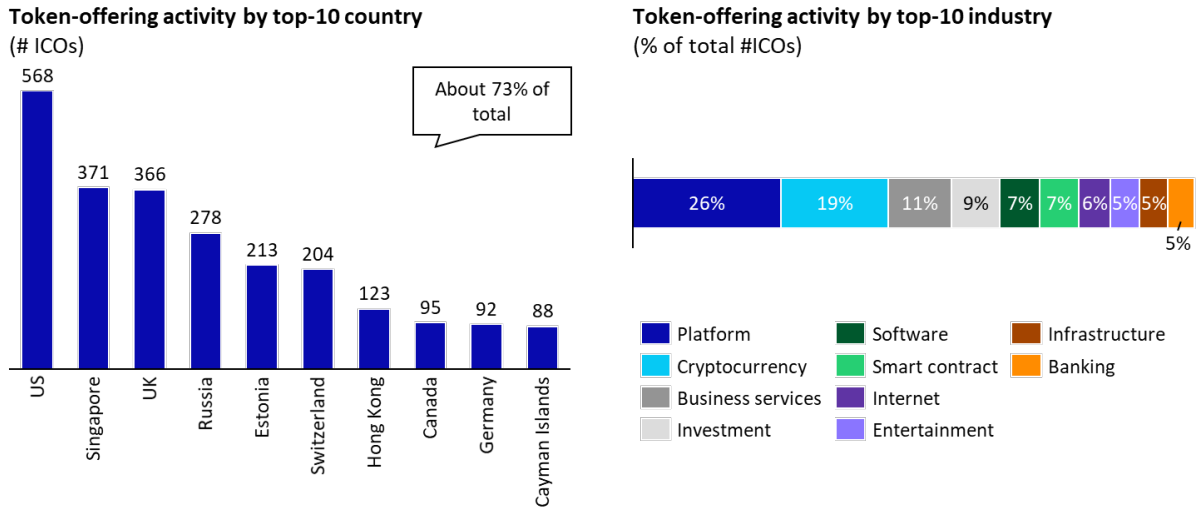


Figure 36: Token-offering activity by top-10 country and industry, Jan. 2017–October 2018[163]



Globally, there is a trend among regulators to advance regulation of the crypto finance ecosystem, but no international agreement on the categorisation of ICOs in terms of existing regulation.[164,165] In the European Union, most Member States have not implemented dedicated regulation for BC-based investment schemes; among the few countries where dedicated regulation is already implemented or in progress are Malta, Liechtenstein and France.

There are alternatives available to ICOs, based on a very similar approach. One alternative is initial exchange offerings (IEOs), which mainly differ from ICOs by introducing an intermediary into the process, with tokens of the issuing startup sold through a crypto exchange, rather than directly to investors (as in ICOs). Another alternative is security token offerings (STOs), in which tokens are typically attached to real-world assets (as opposed to cryptocoins under ICOs). There is growing

161 ICOdata.io (link, accessed 25 May 2020).
162 ICOdata.io (link, accessed 25 May 2020).
163 Token offerings: A revolution in corporate finance, The Capco Institute Journal of Financial Transformation, 2019.
164 5th ICO / STO report, PwC, 2019.
165 Initial coin offerings – too soon or too late?, CFA Institute, 2019.

interest among investors in tokenised real-world assets entering the traditional investment universe, offering a more advanced technological solution. In fact, STOs are classified as securities and so generally subject to regulation by a financial market supervisory authority.[166,167]

A recent OECD study shows that BC-based investment schemes can contribute to enhancing access to finance for SMEs. These schemes potentially offer access to a large pool of potential investors, without intermediaries such as banks, often at a lower cost than traditional financing options. Figure 38 presents a comprehensive overview of the benefits of ICOs for SMEs. Risks and challenges around ICOs entail regulatory uncertainty, the structuring of token offerings, investor protection, corporate governance, and regulatory compliance and operational and business risks.[168]

Figure 37: Benefits of ICOs for SMEs[169]

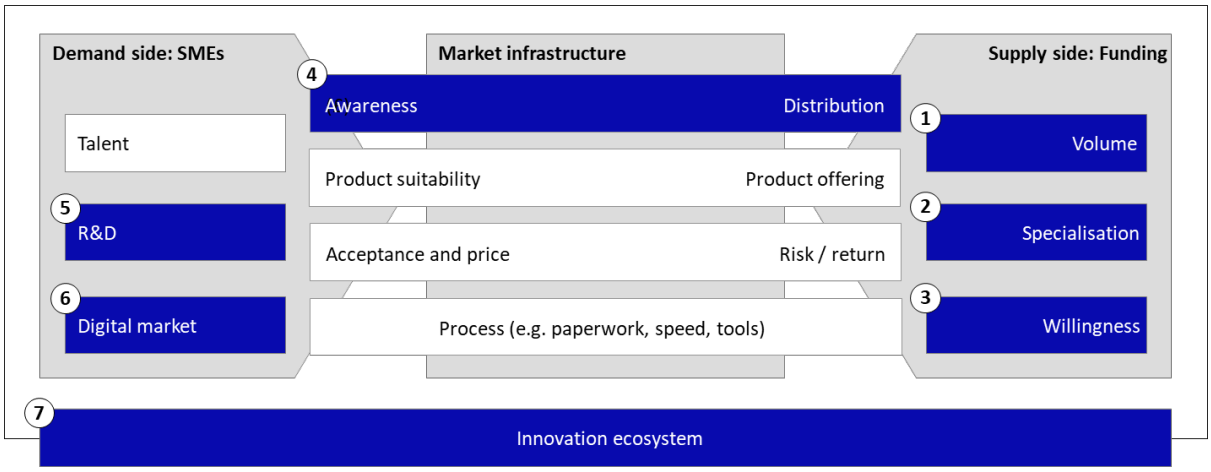
166 What is the current regulatory status of STOs at EU level. Blockchain4Europe (link, accessed 25 May 2020).
167 Second advisory letter on prospectus and authorisation requirements in connection with the issuance of crypto tokens, Bafin, 2019.
168 Initial coin offerings (ICOs) for SME financing, OECD, 2019.
169 Initial coin offerings (ICOs) for SME financing, OECD, 2019.

5. Bottlenecks in AI and BC financing

Access to finance does not only concern the availability of capital – it encompasses the whole innovation ecosystem. As summarised in Figure 39, access-to-finance conditions for the deployment of AI and BC technologies are assessed by analysing:

- The **demand side**, where it is critical that SMEs have the right talent to push innovation, produce high-quality research and development (R&D), and scale up their products in a unified digital market;
- The **supply side**, in which stakeholders that provide financing need to have sufficient available capital to invest, possess the right tools to assess complicated technologies, and be willing to invest in those technologies;
- In between them, the **market matching system**, which needs to bring together SMEs and investors to benefit all parties involved. This includes marketing efforts, joint product and proposition developments, and pricing mechanisms; and
- The extent to which all three are included in an **integrated innovation ecosystem**, where all stakeholders of the innovation value chain can cooperate in a coordinated manner. This includes government initiatives playing a central role in defining strategy and in prioritising and enabling the cooperation among key players of the ecosystem.

Figure 38: Framework for the analysis of AI and BC SMEs' access-to-finance conditions[170]



The rest of this section will focus on the highlighted dimensions of the framework, reporting the key findings of this study's analysis (as outlined in the Executive Summary).

5.1. Supply side

5.1.1. Volume

Despite the large increase in AI and BC investments over recent years (approximately tenfold rise from 2016 to 2019), the limited availability of VC funding remains a key issue in Europe.

The funding volume provided by the VC market to AI and BC SMEs is considerably smaller in the EU27 ($2.1 billion annually) than in the United States ($20 billion) and China ($5 billion) (see Section 4.1.1). China and the United States also exhibit a high average and median equity investments in AI and BC SMEs. On both of these metrics, the European Union is ranked fifth behind Canada and the United

[170] Oliver Wyman analysis.

Kingdom. The median investment is significantly lower than the average across geography and years, which suggests that there are few very large investments in late-stage SMEs across all regions.

"There are plenty of opportunities VC funds cannot take because of the lack of funds"

- VC fund

Figure 39: Average estimated VC equity investment in AI and BC SMEs, by international geography, 2015–2019[171]

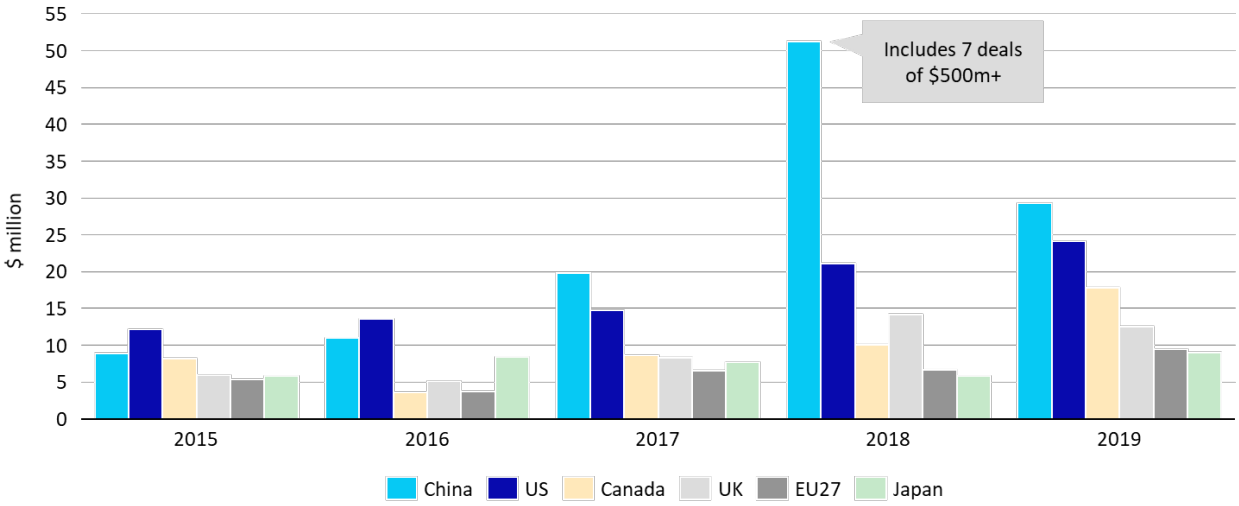
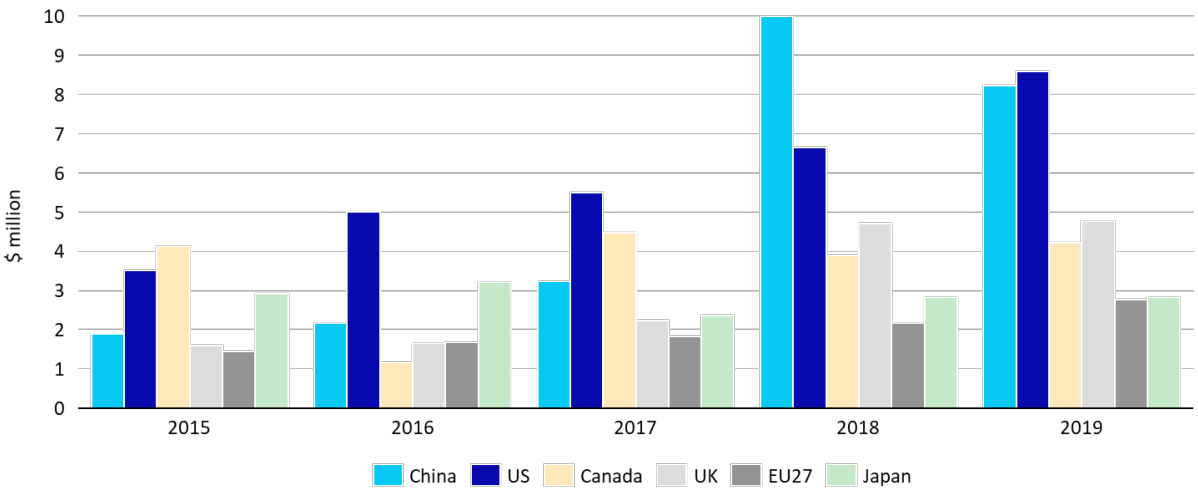


Figure 40: Median estimated VC equity investment in AI and BC SMEs by international geography, 2015–2019[172]



As several interviews revealed, one explanation for the lower availability of VC investments in Europe is the fact that European VCs are mostly financed by government agencies, family offices (FOs) and corporate investors; by contrast, large institutional investors – which can typically deploy larger cheques – do not contribute as much as in the United States. As Figure 42 shows, the largest contributors to VC funds in Europe were government agencies (24%), FOs and high-net-worth individuals (HNWIs, 19%), and corporate investors (17%). While FOs and HNWIs also play a significant role in the United States (contributing about 17% of total VC funds), government agencies and corporate investors there make much smaller contributions (10% and 5%, respectively). Notably, the

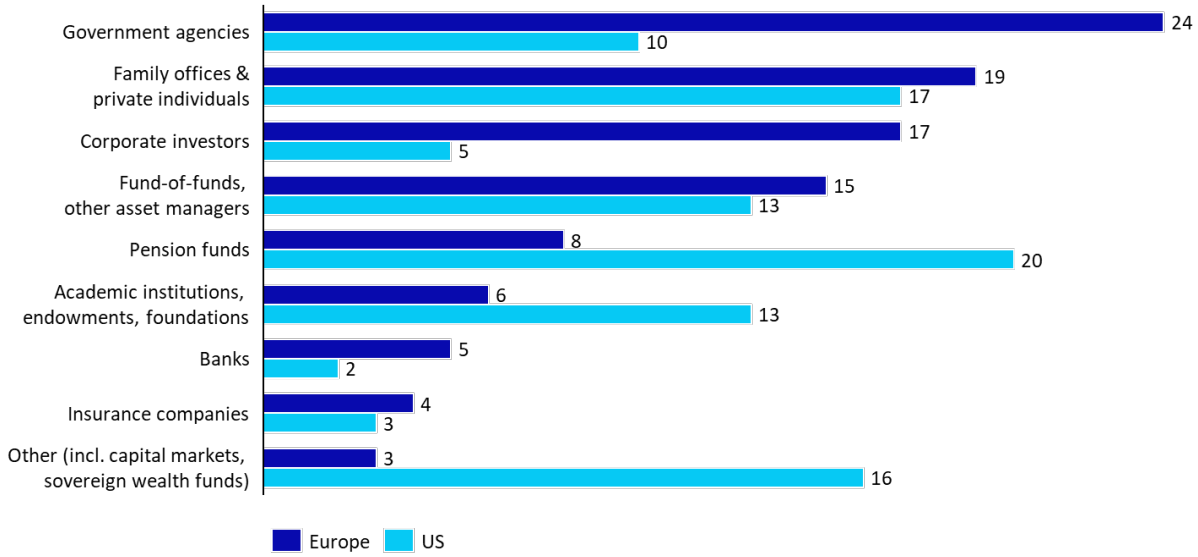
171 Preqin data (only deals with disclosed amounts), Oliver Wyman analysis.
172 Ibid.

public sector's role in financing the VC market is much larger (at least in relative terms) in Europe than in the United States. Pensions funds are the largest source of VC funds in the United States (20% vs. 8% in Europe), while academic institutions, endowments and foundations also play a much larger role (13% vs. 6% in Europe). According to a recent survey, the structure of VC sources does not seem to have changed recently: European VCs reported experiencing rising interest from FOs, corporates and sovereign wealth funds, but a drop in already low interest from pension funds and endowments.[173]

"The largest investors in US VCs are pension funds, endowments, insurance companies – this is very limited in the EU and it is a major competitive disadvantage"

- VC fund

Figure 41: VC funding raised by limited partner type and region (% of total funding raised)[174]

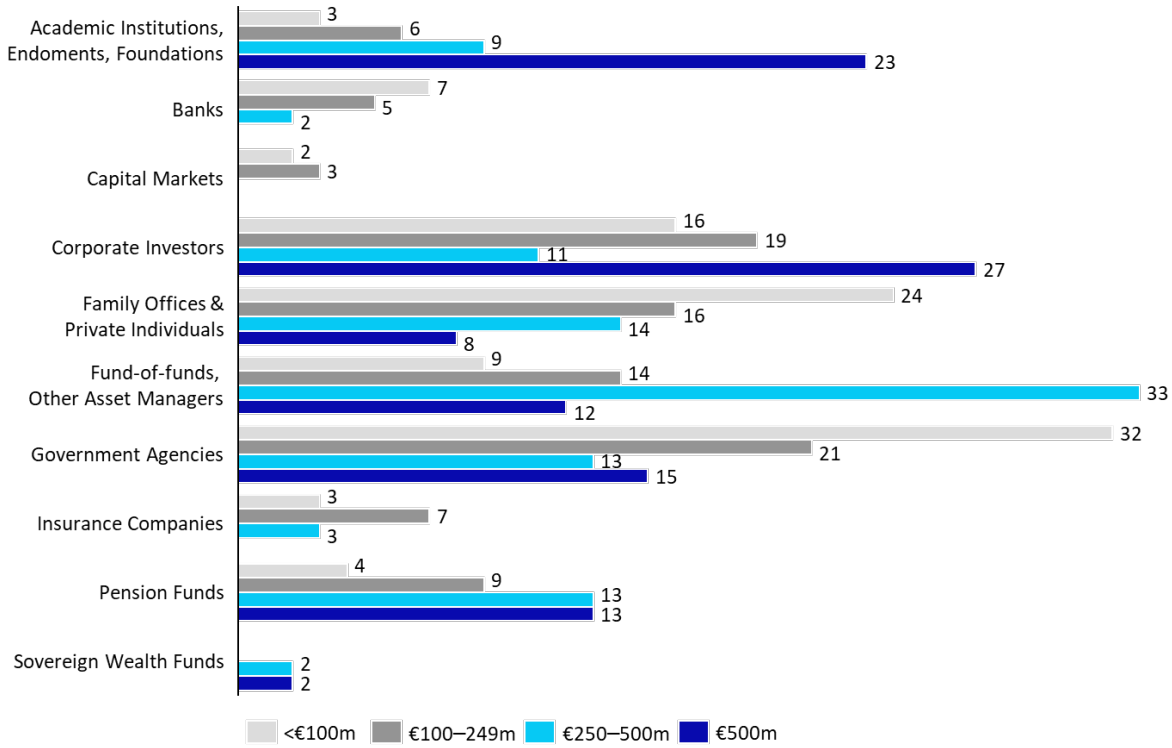


The investors most actively contributing to VC funds in Europe (i.e. Government Agencies and FOs) mostly invest in smaller VC funds. Figure 43 shows the distribution of VC funding raised by fund size and limited partner (LP) type. Academic institutions, pension funds, funds-of-funds and corporate investors exhibit a clear tendency to invest in large funds (over €250 million in size), whereas FOs and HNWIs, as well as government agencies, tend to invest in smaller funds (below €100million in size).

[173] State of European tech 2019, Atomico, 2019.

[174] State of European tech 2017, Atomico, 2017. Note: European data based on funding raised between 2012 and 1H 2017. All percentages are only calculated for known LP allocations. Unclassified allocations were extrapolated. US VC LP allocations based on data from Preqin. Source: Invest Europe/EDC.

Figure 42: VC funding raised by fund size and LP type (%)[175]



The limited role played in Europe by large institutional investors such as pensions funds, insurers and endowments might be a main driver behind the large equity investment gap at later stages of the financing life cycle. As Section 4.1 illustrated, the EU27 equity gap occurs mostly in the later stages (Series A onwards), where larger amounts of capital are required. As large institutional investors typically deploy larger amounts of capital, their limited role may significantly disadvantage European SMEs seeking to raise funds in Europe. The EIF has established the Asset Management Umbrella Fund (AMUF) to offer a structure for institutional Investors to invest in European VCs. Moreover, the European Innovation Council (EIC) Accelerator was created to help SMEs developing high-risk, high-impact technologies to bring their products to the market and scale up their ideas.[176]

The limited presence of institutional investors in Europe can be explained by two main factors.[177] First, the risk–return profile of VC investments is perceived as unattractive in Europe compared to the United States (due to lower GDP growth, higher debt-to-GDP ratio, lower investment liquidity and less efficient legal systems in the EU27 overall). Second, there are internal limitations related to institutional investors' investment policies, such as the minimum ticket/fund size and the lack of a target for allocation to VC (somewhat related to the lack of VC-specialising teams).

Corporate investors play an important role as sources of capital in the European VC system. In 2019 CVC-backed funding to AI startups reached an all-time high of $10.6 billion globally (+70% vs. 2018). As Figure 44 shows, the average size of global CVC-backed deals in AI doubled from 2014 to 2019. In 2019 Europe accounted for ~16% of global number of CVC-backed AI deals (see Figure 45). On average, EU CVC deals across all sectors amounted to about 46% the size of US CVC deals ($12.3 million vs. $26.2 million, respectively). While the same granularity of data is not available for BC, CVC-backed deals

[175] State of European tech 2017, Atomico, 2017. Note: Based on total funds raised between 2012 and 2016. All percentages are only calculated for known LP allocations. Unclassified allocations were extrapolated. Source: Invest Europe

[176] European Innovation Council. (link, accessed 18 May 2020).

[177] Institutional investors' shareholdings in large European non-financial listed companies, University of Oxford, 2018.

represented 20% of the value of all BC VC deals globally in 2019 (up from 11% in 2015); however, the total number of CVC deals decreased by 5% in 2019 after a large increase in 2018.[178]

Figure 43: Global annual CVC-backed funding to AI startups, 2014–2019 (*$ billion*)[179]

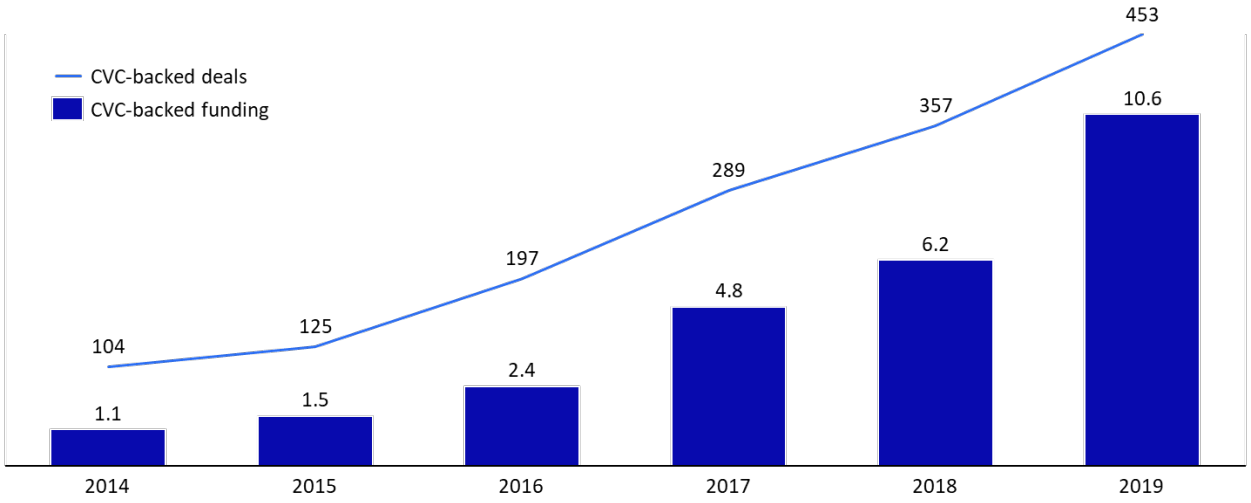
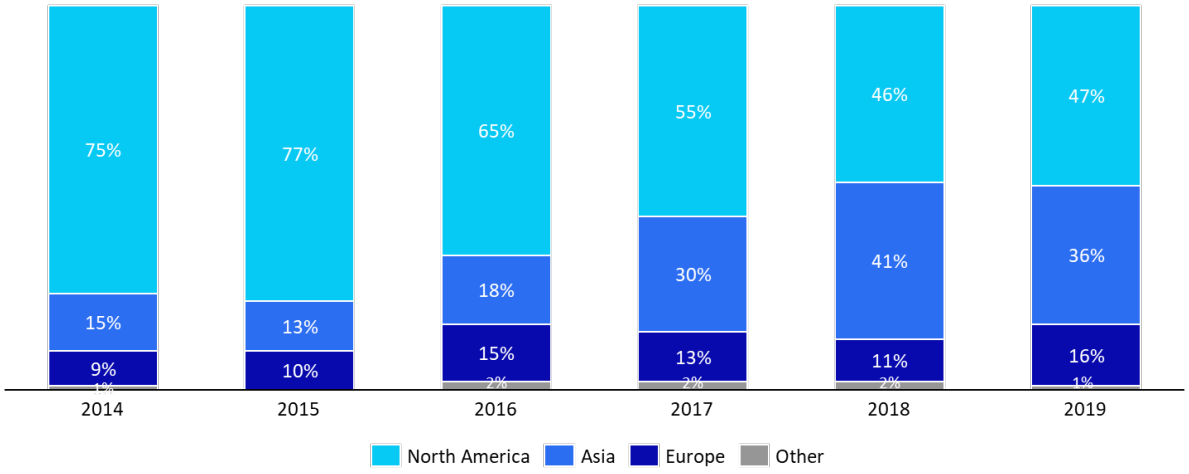


Figure 44: Global annual CVC-backed AI deals, 2014–2019[180]



However, in the EU large corporates play a limited role in acquisitions of AI and BC companies, which is somewhat preventing independence from non-EU investors. From 2000 to 2019, there were only 139 acquisitions of AI companies in the EU28 countries, compared to 526 in the United States (only 9 in China). In 2019 all ten of the world's leading corporates in AI company acquisitions were US-based.

178 The blockchain report 2020, CB Insights, 2020.
179 The 2019 global CVC report, CB Insights, 2020.
180 The 2019 global CVC report, CB Insights, 2020.

Table 7: Number of AI acquisitions by global top-10 acquirers, January 2000–May 2019[181]

Acquiring company	Location	# AI acquisitions	Acquiring company	Location	# AI acquisitions
Alphabet	USA	19	Intel	USA	7
Apple	USA	16	Salesforce	USA	7
Microsoft	USA	10	Cisco	USA	6
Amazon	USA	7	Oracle	USA	6
Facebook	USA	7	Yahoo	USA	6

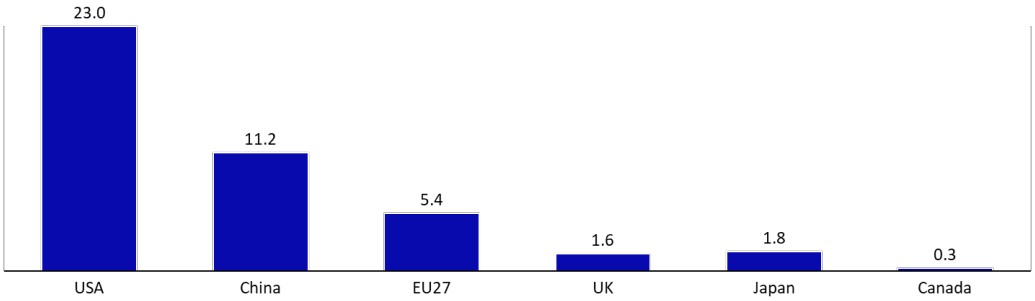
There has been a particularly strong movement of companies from the European Union to the United States. US companies account for about 44% of European startup acquisitions.[182] Also, a significant proportion of European startups have moved their headquarters abroad, particularly among those raising higher amounts of capital: it is estimated that one in seven startups raising $10–100 million has relocated its headquarters outside Europe, compared to one in four startups raising over $100 million.[183]

"Origination and seed are relatively well developed in the EU. SMEs do seed and angel in the EU, then they go to the US and grow their financial network there"

- VC fund

Another factor potentially constraining within-EU exit opportunities for AI and BC investments is the limited value of IPOs within the European Union. While there are currently little data on AI and BC IPOs, this study analysed the value of IPOs in "Computer & Electronics": in 2019 the United States was the leading country (note that three IPOs accounted for more than 50% of the total: Uber, Pinterest and Lyft); China ranked second and the EU27 third (with a value less than one-fourth of that in the United States).

Figure 45: Global value of "Computer & Electronics" IPOs in 2019 (*$ billion*)[184]



Interviewees often mentioned the limited within-EU exit opportunities as a main driver behind several European-born AI and BC firms being sold to extra-EU investors after initial financing stages. When this happens, these European firms can no longer promote long-term EU competitiveness and help spread the benefits of digital transformations across industries and countries within the European Union.

"SMEs tend to move to other, more developed markets (e.g. US) after initial rounds when they grow and need more capital (or as soon as they can afford it)"

- SME

[181] Who is winning the AI race: China, the EU or the United States?, Center for Data Innovation, 2019.
[182] Startup transatlantic M&As US vs. EU, Mind the Bridge and Crunchbase, 2016.
[183] Move to Silicon Valley vital for ambitious European tech groups. Financial Times (link, accessed 26 May 2020).
[184] Dealogic database.

5.1.2. Specialisation

Compared to the United States, there are fewer VC investors specialised AI and BC in the European Union.

Recent years have seen the emergence of several AI- and BC-specialist VC funds in the United States. US BC funds raised over $2 billion in the past decade – more than four times the total of BC investments in the EU27. These funds are typically equipped with highly experienced engineering teams, which support due diligence and offer portfolio companies relevant technical support to develop and scale up their products. Some notable examples of specialised US BC funds are listed in Table 8: note that this list is not exhaustive and excludes a number of smaller, specialised BC VC funds that also play key roles in the US market.

Table 8: Capital raised by BC VC funds (notable examples)

Fund	Capital raised
Paradigm	$400m[185]
Andreessen Horowitz	$865m in two funds[186]
Polychai	$175m; plus new round of $200m as of May 2019[187]
Pantera Capital	$470m; plus new round as of May 2019[188]

AI- and BC-specialist funds are smaller and less common in the European Union. Of the surveyed SMEs, 17–18% identified the lack of technical expertise among investors as the most important constraint on accessing finance in 2019 and 2020. The limited number of specialised VC investors in the European Union may especially inhibit the seed stage, where investments are typically more localised: AI and BC SMEs may struggle to find local investors able deploy the knowledge required for such technical investments (especially if not located in a "hub city" for innovations – see Figure 54). Interviewees identified reduced competition between VCs and limited diversity of expertise as consequences of the low number of VCs. Both factors make it more difficult for SMEs to find investors.

"It is not just the money, it is also (or most importantly) the expertise that pushes growing AI companies to go to the US"

- VC fund

[185] Coindesk (link, accessed 19 May 2020).

[186] Andreessen Horowitz aims to raise $450m for second cryptocurrency fund. Financial Times (link, accessed 19 May 2020); Crypto Fund II Andreessen Horowitz (link, accessed 19 May 2020).

[187] Polychain Capital Targets $200M for Second Venture Fund, Slide Deck Reveals. Coindesk (link, accessed 19 May 2020).

[188] Pantera Crypto Hedge Funds Are Losing Double Digits, Bitcoin Fund Is Up 10,000% to Date. Coindesk (link, accessed 19 May 2020).

Figure 46: Biggest constraints on access to finance for SMEs in 2019 and 2020 (SME survey results)

If you have applied for external financing in 2019, what was the most important limiting factor encountered?

Response	#	%
Could not find and connect with the right investors	20	29%
No obstacles	14	20%
Limited capability of the investors to assess the proposed business plan and underlying technology	12	17%
Financing not available at all	4	6%
Insufficient collateral or guarantee	4	6%
Too much paperwork	4	6%
Reduced control over the enterprise	3	4%
Interest rates or price too high	1	1%
Other	7	10%

If you have applied for external financing in 2020, what was the most important limiting factor encountered?

Response	#	%
Could not find and connect with the right investors	13	23%
Limited capability of the investors to assess the proposed business plan and underlying technology	10	18%
No obstacles	7	13%
Financing not available at all	6	11%
Too much paperwork	5	9%
Insufficient collateral or guarantee	2	4%
Other	13	23%

Other factors include:
- Coronavirus (13%)
- Did not meet KPIs (4%)

5.1.3. Willingness

Although AI is core to the investment strategies of many funds in Europe, investors' appetite is lower for BC initiatives.

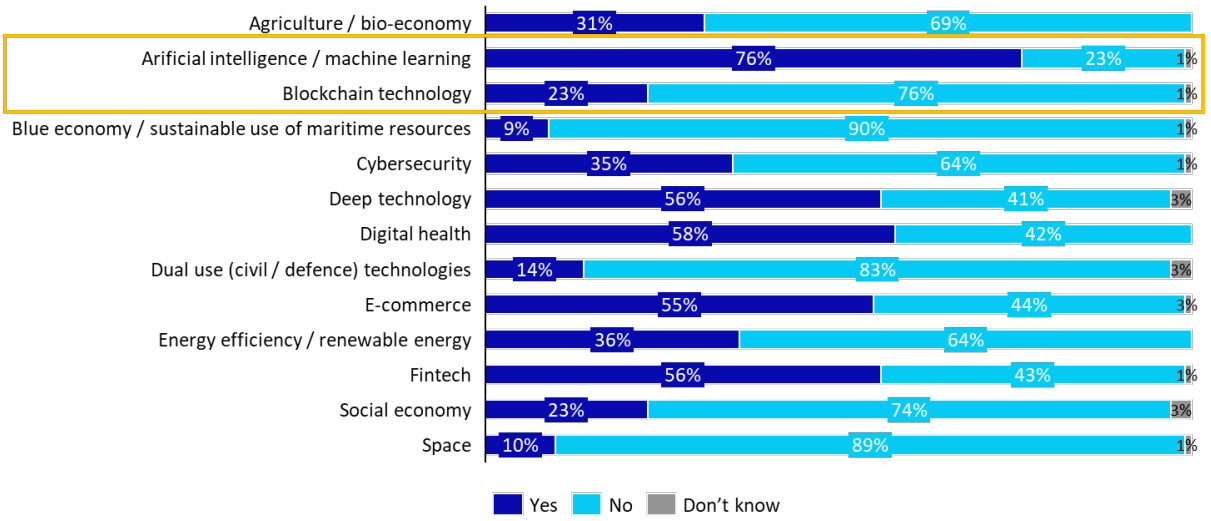
Figure 48 shows the share of European VCs that have included in their portfolio an investee in a specific industry, according to the 2019 EIF VC Survey.[189] While 76% of respondents have already invested in at least one AI company, only 23% have invested in BC (fourth lowest of the 13 innovative industries considered). Deep technology, an area related to AI, had received investments from 56% of respondents. Moreover, the results indicate that future VC investments will target companies in AI (87% of respondents) and deep technology (72%) more than those in BC (51%). It is, nevertheless, notable that over 50% of the surveyed VCs will consider investing in BC in the future. In this study's interviews, it was often explained that while BC is perceived as a very-early-stage technology, VCs will likely have a higher appetite to invest when it becomes more mature and has solid use cases outside the financial sector.

"The appetite for AI is not lagging behind the US or China in terms of strategies or intentions, but in terms of realisation"

- VC fund

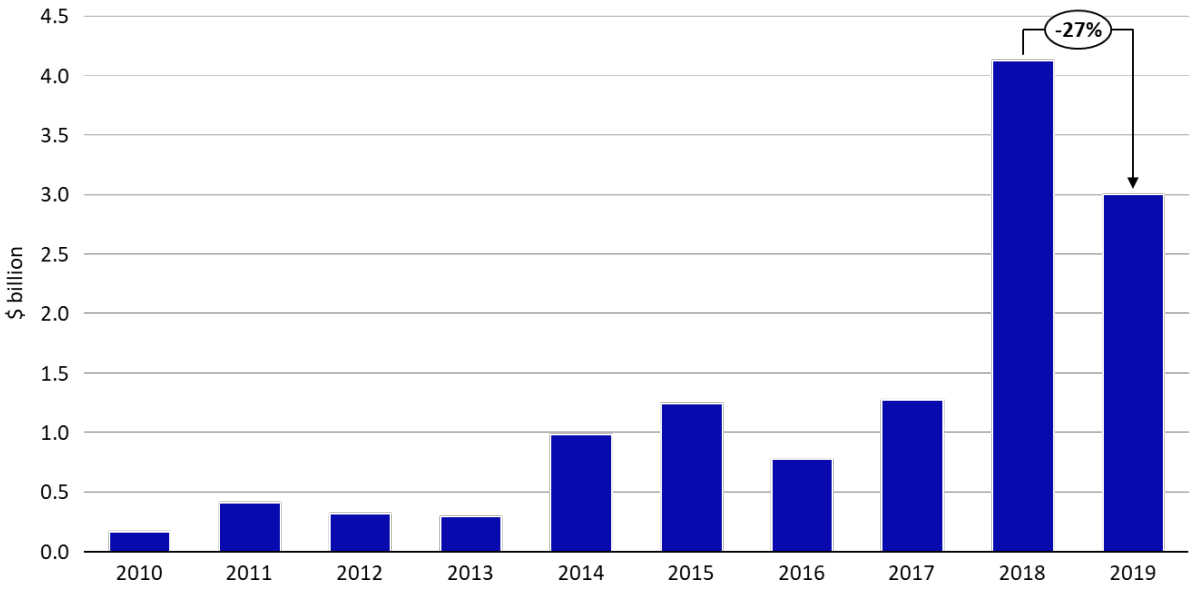
[189] EIF VC Survey 2019, based on responses to the question: "Does your current investment portfolio include an investee in the area of … ?"

Figure 47: Share of investors with investees in specific industries (EIC VC Survey results)[190]



The appetite for BC investment in Europe was hit by the drop in the cryptocurrency market at the end of 2018, reflecting investors' perception that this technology is mostly applicable in financial services. Globally, VC investments in BC amounted to almost $3 billion in 2019, a decline of about 27% compared to 2018. While this drop was certainly caused by several factors, one key issue according to interviewees was investors' view that BC technology is mostly suited to financial services and has little application in other industries.

Figure 48: Total estimated VC equity investment in BC SMEs, 2010–2019[191]



"70–80% of the investors we met were just not interested in investing in blockchain"

- SME

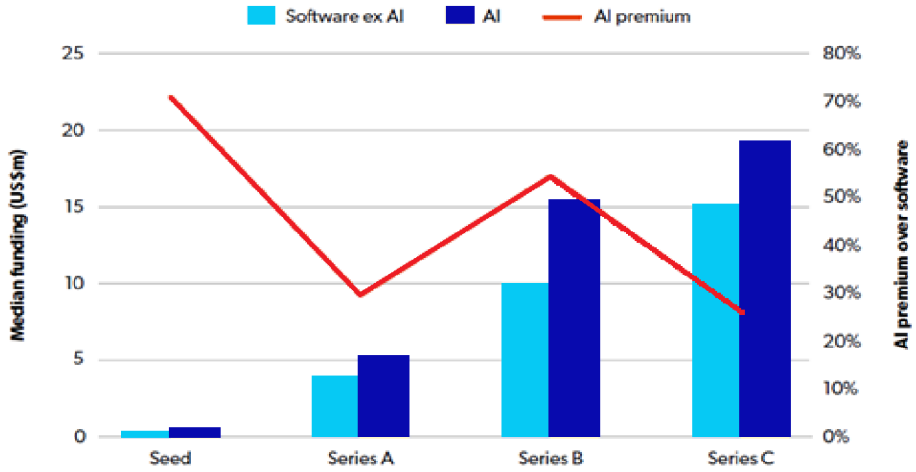
[190] EIF VC Survey 2019, based on responses to the question: "Does your current investment portfolio include an investee in the area of … ?"

[191] Preqin data, Oliver Wyman analysis.

By contrast, the appetite for AI investments is high and growing in Europe, as AI is truly seen as a KET with applications across all economic sectors. A recent study revealed a significant premium in the valuation of AI companies compared to other software companies (globally): AI companies received a median funding volume higher than that of other software companies across all funding rounds, but especially in the seed funding round (over 60% higher).[192] The same study also found that up to 40% of European startups claiming to be AI companies show no evidence that AI is a material component of their value proposition, the aim being to attract more funding.

Despite the perceived importance of AI, investors might still refrain from investing due to a number of complexities related to this technology: (i) the business model requires higher upfront investments into R&D; (ii) cash flows/commercial traction occur only at a later technological maturity stage, after early adopters have tested the technologies; and (iii) AI technologies need to be incorporated into ready-to-use products/services with direct applicability, which takes time.

Figure 49: Median funding of AI companies vs. other software companies *($ million)*[193]



European VCs prefer to invest in those AI firms capable of getting quicker traction in the market, whereas global Big Tech corporates prefer to invest in those AI firms developing horizontal, core technologies. About 90% of AI startups address a need in a specific vertical area (whether a business function or sector), leaving only about 10% developing core, horizontal AI technologies (i.e. a sector-agnostic capability or platform).[194] While core technology providers represent only one-tenth of European AI startups, they attract one-fifth of equity investments. According to the interviewees, this is driven by global Big Tech corporates' extensive focus on development and deployment of core AI technologies, due to their disruptive potential across many industries. The extensive R&D budgets of these large corporates are, therefore, mostly directed towards horizontal, core technologies (which typically also take longer to develop). European VCs instead target companies developing vertical technologies that directly focus on a specific market need and typically have a shorter time-to-market (hence offering a more attractive risk profile).

"US West Coast VCs' ambition is to find the "Moonshot," East Coast VCs' ambition is to find future to-be-acquired corporates, whereas Europe VCs focus from Day 1 on profitability"

- VC fund

[192] The state of AI: Divergence 2019, MMC Ventures, 2019, based on data from MMC Ventures, Beauhurst, Crunchbase, Tracxn.

[193] The state of AI: Divergence 2019, MMC Ventures, 2019, based on data from MMC Ventures, Beauhurst, Crunchbase, Tracxn.

[194] The state of AI: Divergence 2019, MMC Ventures, 2019, based on data from MMC Ventures, Beauhurst, Crunchbase, Tracxn.

5.2. Market infrastructure

5.2.1. Awareness and distribution

There is limited matching in Europe between SMEs and potential investors, making it difficult for available capital in the market to reach the best projects.

According to the interviewees, several SMEs are struggling to connect with investors, especially in the early life-cycle stages in which investments tend to be more localised in origin markets. In the study's survey, 29% of respondents highlighted the difficulty of finding the right investors in 2019 (see Figure 51). Moreover, 25% of the respondents stated that they would benefit from initiatives facilitating matching between SMEs and investors across the European Union (second most-selected option).

Figure 50: Preferred solutions for improving access to finance (SME survey results)[195]

Possible solution	%
Co-investment mechanism for private and public funding	29%
Initiatives to match SMEs with private investors across the European Union	25%
More easily available venture debt instruments	23%
Less dilutive equity instruments	17%
More coaching / training	6%
Other	1%

5.3. Demand side

5.3.1. R&D

The EU27 has more specialised researchers than the United States and China, and typically produces the most technology-related academic research (see Section 3.3.1). The European Union also has the world's largest pool of talent in AI research, with an estimated 40 000 AI researchers (vs. just under 30 000 in the United States and just under 20 000 in China).[196] Moreover, although very recently supplanted by China, Europe led the way in publishing AI-related research over the last two decades, with about 30% of global AI research published in the region in 2017.[197]

"The genesis of core AI and blockchain technologies comes to a large extent from academia: we need to put in place pre-seed solutions to push academics to commercialise their ideas"

- SME

However, the share of corporate R&D spending is lower in the European Union than in peer regions. Despite the recent growth in R&D investment by EU-based companies, they are being outpaced by their United States and Chinese counterparts. Using R&D spending by software and computer services firms as an indicator for corporate R&D spending on AI and BC, 62 of the top-100 firms are in the United

[195] Responses to the question: "What could be possible solutions to improve your access to finance?" (select up to three answers).

[196] Who is winning the AI race: China, the EU or the United States?, Center for Data Innovation, 2019.

[197] Based on data from Artificial intelligence index report 2019, Stanford University, 2019, based on data from Elsevier; papers indexed in SCOPUS.

States whereas only 13 are in Europe.[198] In 2019, the total amount of R&D spending by software and computer services firms among the global top 2 500 (by R&D spending) reached €70 billion in the United States, compared to €9 billion in Europe.[199] However, the lack of R&D spending in European firms goes beyond the software and computer services sector. Taking into account all sectors of the economy, the firms spending the most on R&D tend to be headquartered in non-EU countries. For example, only four of the top-20 R&D spenders are based in the European Union (all in Germany).

The comparatively low R&D spending by European large corporates might be one reason for relatively few EU research projects becoming economic use cases. As seen in Section 5.1.3, large corporates typically focus on companies developing core, horizontal technologies (riskier but with higher potential to disrupt many industries), whereas VCs tend to focus on companies addressing a specific vertical area (which can get quicker traction in the market). Several interviewees confirmed that the limited role of European large corporates in R&D partly explains why many European researchers struggle to turn their research into economically viable projects. Given also that European VCs tend to require profitability from very early life-cycle stages, the transition from research to products/services is particularly challenging in Europe (sometimes termed the "European Paradox").[200] To mitigate this barrier, the European Commission recently launched the Enhanced EIC pilot[201] to support top-class innovators, entrepreneurs, small companies and scientists with innovative ideas and the ambition to scale up internationally. The pilot brings together the parts of Horizon 2020 that provide funding, advice and networking opportunities for those at the cutting edge of innovation. It includes two programmes dedicated to different types of innovators:

- **The Pathfinder programme**, for radically new technologies emerging from collaborative research. This provides grant funding of up to €4 million (as well as additional coaching and mentoring services); and
- **The Accelerator programme**, for development and scaling-up of high-risk innovations by startups and SMEs. It provides grant funding of up to €2.5 million and an option for equity investment of up to €15 million (as well as additional coaching and mentoring services, support for pitches with VCs/corporates, and other assistance).

"We need to enable researchers from academia to feel comfortable and pursue commercial application of their research"

- VC fund

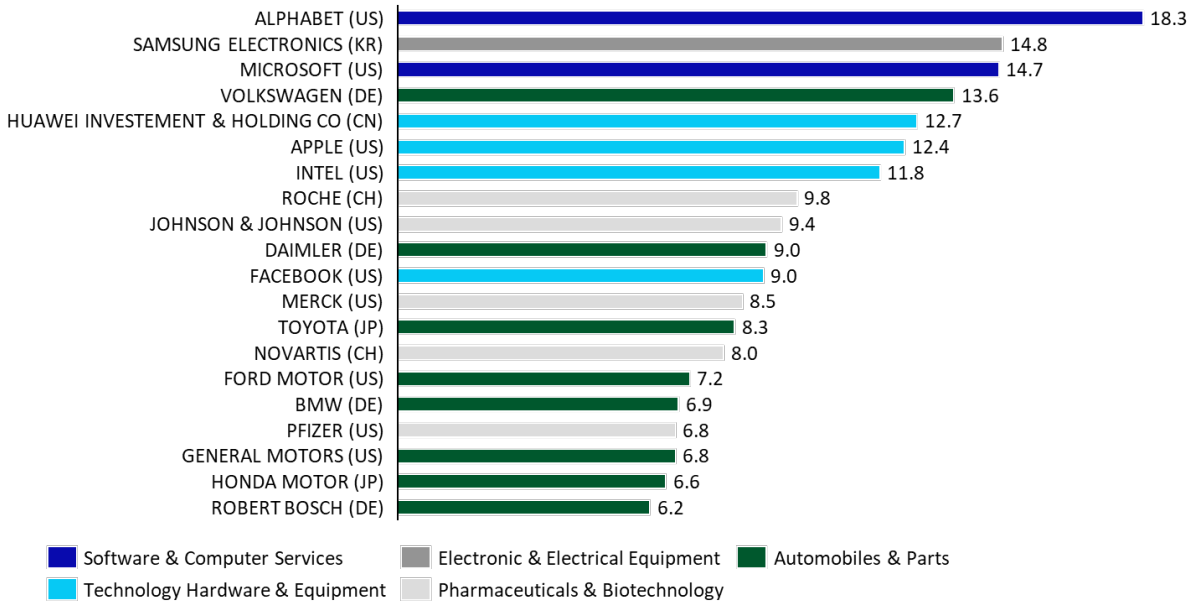
[198] Who is winning the AI race: China, the EU or the United States?, Center for Data Innovation, 2019, based on data from The 2019 EU industrial R&D investment scoreboard, European Commission - Joint Research Centre, 2019.

[199] Who is winning the AI race: China, the EU or the United States?, Center for Data Innovation, 2019, based on data from The 2019 EU industrial R&D investment scoreboard, European Commission - Joint Research Centre, 2019.

[200] Innovation - How to convert research into commercial success story? Part 1: Analysis of EU-funded research projects in the field of industrial technologies, European Commission, 2013.

[201] European Innovation Council. European Commission (link, accessed 18 July 2020).

Figure 51: Global top-20 companies in R&D spending, 2018/19 (*€ billion*)[202]



Relatedly, no large EU corporate is in the world's top-10 companies for number of AI patents.

Table 9: Global top-10 large corporates in number of AI patents[203]

Company	# AI patents	Company	# AI patents
IBM (US)	7 276	Sony (JP)	3 090
Microsoft (US)	5 356	NEC Corporation (JP)	2 932
Samsung Electronics (KR)	5 255	Fujitsu (JP)	2 868
SGCC (CH)	3 794	Google (US)	2 757
Canon (JP)	3 569	Mitsubishi Electric (JP)	2 716

5.3.2. Digital market

While Europe's domestic market is comparable in size (GDP) to the United States and China, its incomplete integration limits the ability of AI and BC SMEs to scale up and compete in the global market.

US tech companies can benefit from a large, fully integrated domestic market, while Chinese companies can benefit from domestic protection against competition from foreign companies, which allows them to scale up as needed. By contrast, European companies need to operate across several, not fully integrated markets. Beyond the most common areas disadvantaging European companies (e.g. the language barriers across Member States), two are particularly relevant to AI and BC: data and regulation.

Limited availability of data

Data are a key enabler for disruptive technologies such as AI and BC. For AI companies, datasets are key to training their models, growing, and competing in the global market; large amounts of data help them develop highly accurate models to recognise patterns in large databases and perform several

[202] The 2019 EU industrial R&D investment scoreboard, European Commission, 2019. Note: Only the top 2 500 companies are considered.

[203] China AI development report 2018, China Institute for Science and Technology Policy at Tsinghua University, July 2018.

tasks. BC is less reliant than AI on the availability of data and may act as an enabler for security, privacy and resilience in data collection and management. Moreover, BC could support the establishment of open, decentralised markets for data, AI models and other resources for AI development.[204]

As Section 3.3.3 discussed, Europe is lagging behind the United States and China in data availability and the possibility of connecting cross-country databases. The European Commission has identified several specific factors preventing the European Union from realising its full potential in the data economy.[205] According to the Commission, the insufficient availability of data is especially related to limited sharing across stakeholders, including business use of public sector information; the sharing and use of privately held data by other companies; the use of privately held data by government authorities; and the sharing of data between public authorities. Imbalances in market power also constrain data accessibility, particularly for European SMEs. Data are often accumulated by large corporates and online platforms, with limited access for smaller companies. In this context, it is essential that large corporates allow AI product/service SMEs to access their data, thereby enabling the full potential of AI technologies in Europe to be exploited.

Another challenge is that a very small number of extra-EU Big Tech firms hold a large part of the world's data.[206] The US private sector is free to dominate the collection and management of data, resulting in considerable concentration in only a few Big Techs. Meanwhile, China combines government surveillance with strong control of Big Tech companies over massive amounts of data. In Europe, data cannot become concentrated among only a few corporations because of EU regulations and the current structure of the digital market.

This situation could disincentivise data-driven businesses from emerging, growing and innovating in the European Union, now and in the future. The volume of data produced in the world is growing rapidly, from 33 zettabytes in 2018 to an expected 175 zettabytes in 2025: if properly captured, this growing amount of available data could bring major opportunities for data-driven AI innovation across all economic sectors.[207] Furthermore, the way in which data are stored and processed will change dramatically over the coming years: as stated by the European Commission, "*today 80% of the processing and analysis of data takes place in data centres and centralised computing facilities, and 20% in smart connected objects, such as cars, home appliances or manufacturing robots, and in computing facilities close to the user ('edge computing'); by 2025 these proportions are likely to be inverted.*"[208] This trend presents increasing possibilities for companies to develop innovative ways of managing data, e.g. via BC. Firms and countries with vast access to data (now and in the future) have a competitive advantage in the development and deployment of AI- and BC-based solutions, and it is essential that the European Union is well positioned to capture the benefits.

The European Commission has recognised the importance of data for the future of the European economy, and articulated the aspiration to be a role model of a society powered by data to make better decisions. The Commission proposes a four-pillar strategy:[209]

- A cross-sectoral governance framework for data access and use, covering new EU mechanisms and guidance on data sharing;
- Investments in data and strengthening of the European Union's capabilities and infrastructures for hosting, processing and using data, and fostering interoperability;
- Building competencies through greater investment in digital skills and in SMEs; and
- Developing common European data spaces in strategic sectors and domains of public interest.

[204] See also Section 3.3.3.
[205] Communication on a European strategy for data, European Commission, 19 February 2020.
[206] Ibid.
[207] The digitization of the world from edge to core, IDC, 2018.
[208] Communication on a European strategy for data, European Commission, 19 February 2020.
[209] Ibid.

Evolving regulatory landscape

The use of AI and BC brings opportunities and risks. These technologies can help increase economic productivity, and help solve several of the European Union's strategic priorities around healthcare, climate and agriculture. However, they could also have unintended effects on society, potentially resulting in unethical outcomes or being used for malicious purposes (see Section 6 for a more detailed discussion of the societal and ethical impact of AI and BC technologies).

To mitigate these risks, the European regulatory landscape for AI and BC has evolved quickly. Since 2014 the European Union has implemented several regulations to facilitate and regulate the development of data-intensive industries such as AI and BC. These measures include:

- the Regulation on the free flow of non-personal data;[210]
- the Cybersecurity Act;[211]
- the 5th Anti-Money Laundering Directive;[212]
- the Open Data Directive;[213] and
- the General Data Protection Regulation (GDPR).[214]

As a major step in this regard, in **April 2021**[215], the European Commission laid out proposals for new rules and actions that aim to turn Europe into the global hub for trustworthy AI. The efforts include the first-ever **legal framework on AI** and a new Coordinated Plan with Member States that will guarantee the safety and fundamental rights of people and businesses, at the same time strengthening AI uptake, investment and innovation across the European Union. Further to complement this, new rules on Machinery that will adapt safety rules to increase trust in the new, versatile generation of products.

Regulatory involvement will likely increase in the future as AI and BC are increasingly deployed in "high-risk" areas such as transport, healthcare, defence and public services. Such deployments must be governed by clear rules regarding safety, legal liability, and protection of rights. With respect to AI, the European Commission has identified seven non-binding requirements that will need to be addressed to create a Trustworthy EU AI ecosystem.[216] These include (see Section 6 for the whole framework):

1. Human agency and oversight;
2. Technical robustness and safety;
3. Privacy and data governance;
4. Transparency;
5. Diversity, non-discrimination and fairness;
6. Societal and environmental well-being; and
7. Accountability.

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[210] Shaping Europe's digital future. Free flow of non-personal data. EC (link, accessed 15 May 2020).
[211] Shaping Europe's digital future. The EU Cybersecurity Act. EC (link, accessed 15 May 2020).
[212] DIRECTIVE (EU) 2018/843 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 May 2018 (link, accessed 15 May 2020).
[213] Shaping Europe's digital future. European legislation on open data. EC (link, accessed 15 May 2020).
[214] REGULATION (EU) 2016/679 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 April 2016 (link, accessed 15 May 2020).
[215] On 21 April 2021, the European Commission launched a proposal on new rules and actions for excellence and trust in Artificial Intelligence, including Proposal for a Regulation laying down harmonised rules on artificial intelligence (Artificial Intelligence Act); Coordinated Plan on Artificial Intelligence 2021 Review; and Proposal for a Regulation of the European Parliament and of the Council on machinery product (link)
[216] Ethics guidelines for Trustworthy AI, High-Level Expert Group on AI (European Commission), 2019.

While several requirements are already reflected in existing legal or regulatory regimes, others (i.e. those regarding transparency, traceability and human oversight) are not specifically covered under current legislation in many economic sectors. Even for those requirements covered by existing regulations, certain aspects of AI can make the application and enforcement of this legislation more difficult; this further complicates the AI landscape in the European Union.

Member States already recognise the absence of a common European framework on these topics.[217] It is crucial to have common European standards to avoid cross-border uncertainties and the potential for arbitrage by innovators in the field of data-driven technologies. Without an EU-wide approach, there is a risk of fragmentation in the EU domestic digital market, which would undermine the objectives of trust, legal certainty and market uptake. Any regulations should be limited to clearly identified problems for which feasible solutions exist. It should also be clear which of these requirements apply to BC as well.

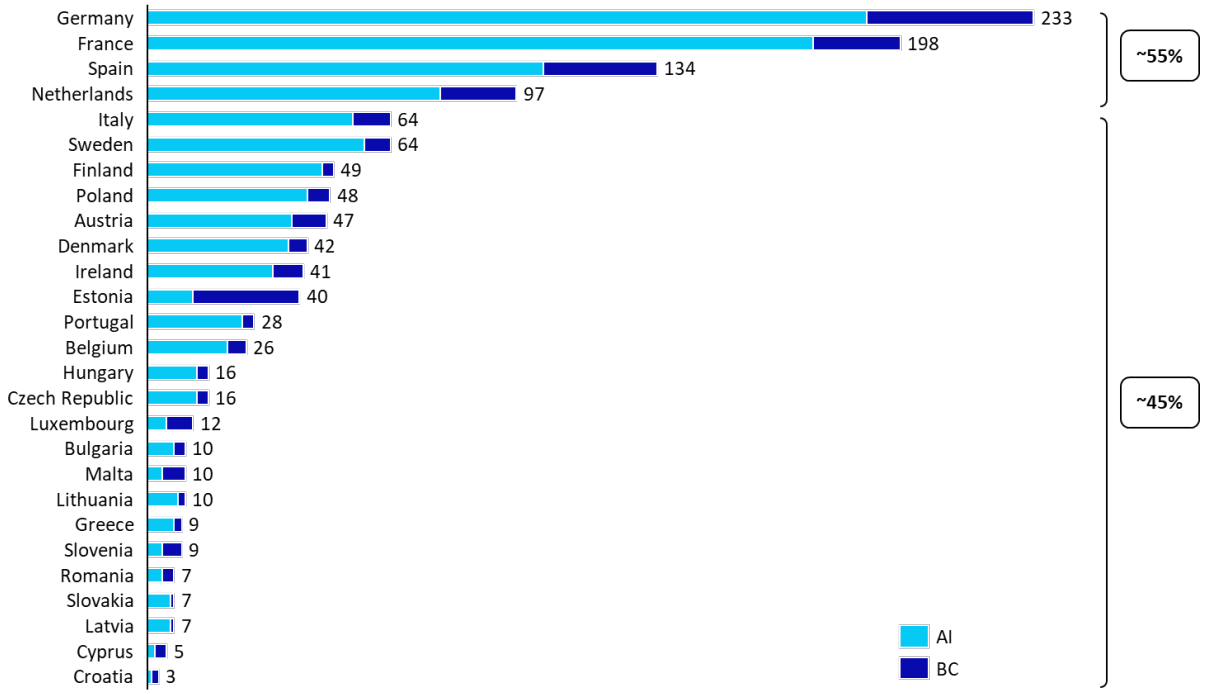
The European Commission proposes a risk-based approach to determine the scope of applicable AI regulations and restrictions.[218] The risk level would depend on the sector and the intended use of the technology. Using a risk-based approach should help prioritise regulatory focus and avoid overburdening AI developers and service providers: for example, many of this study's interviewees asserted that the GDPR might prevent Europe from catching up with the United States and China by limiting the availability of large pools of data for training AI models. In practice, however, it might be difficult to set clear boundaries for what should be considered higher or lower risk.

Economies of scale derived from concentration, integration, and proximity of talent and financing are the bases for successful innovation ecosystems like Silicon Valley. Fully joined-up "ecosystems" create powerful feedback loops between public sector support, large corporates (as "clients" for innovative projects), research institutions and private sector investors.[219] They provide significant benefits for SMEs as well as the overall economy, and can enable step-changes in the quality and coordination of business and operational support for innovative companies as they evolve through their life cycle. As recognised in the recent European Commission *White paper on artificial intelligence*, efforts at European, national and regional levels should be coordinated to create an ecosystem of excellence along the entire innovation value chain. This means creating connected, specialised innovation clusters where universities, SMEs, large corporates, investors, the public sector and all other stakeholders are in close proximity and fully cooperate with one another. Different clusters across the European Union should focus on different research priorities (e.g. healthcare, climate, and digital identity), avoiding overlaps and dispersion of efforts; investments should be directed where the best opportunities are located. While the European Commission paper focuses on AI, the same conditions should hold for BC.

The European landscape appears to comprise several non-interconnected and non-specialised centres of AI and BC innovation. Four countries account for as much as 55% of all European AI and BC SMEs, in line with their share of total EU GDP (Germany, France, Spain and the Netherlands). Another eight countries each have over 40 AI/BC SMEs, while the remaining Member States have few AI/BC SMEs. While most countries have significantly more AI SMEs than BC SMEs, the opposite is true for Estonia, Luxemburg, Malta, Slovenia, Cyprus and Croatia, which have emerged as relatively small centres focused on BC. Notably, there has been significant government support for BC technology in in Estonia, Luxemburg and Malta, which might have contributed to this specialisation (see Section 2.2.4).

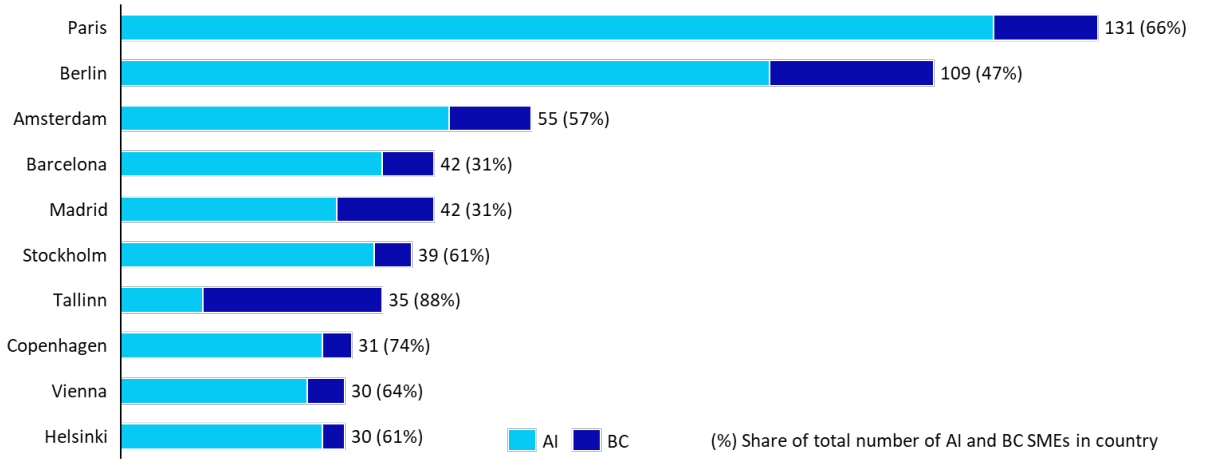
[217] White paper on artificial intelligence - A European approach to excellence and trust, European Commission, 2020.
[218] Ibid.
[219] Financing the deep tech revolution: How investors assess risks in key enabling technologies (KETs), EIB, 2018.

Figure 52: Total number of AI and BC SMEs per EU27 country, April 2020[220]



The ten EU cities with the most AI and BC SMEs account for over 40% of all such companies in Europe; however, there is substantial dispersion of SMEs in other smaller centres within each country. Paris and Berlin are the largest hubs for AI and BC in the EU27, followed by Amsterdam, Barcelona and Madrid with over 40 AI and BC SMEs each. Except for Spain, where Barcelona and Madrid each account for about 30% of total Spanish AI and BC SMEs, all other cities in the top-10 host more than 50% of all AI and BC SMEs in their respective countries. This means that one city in each EU country (usually the capital) hosts most of that country's AI and BC SMEs; however, it also shows that each country has a long tail of SMEs scattered across a number of additional, smaller AI and BC centres.

Figure 53: Top-10 EU27 cities for number of AI and BC SMEs, April 2020[221]

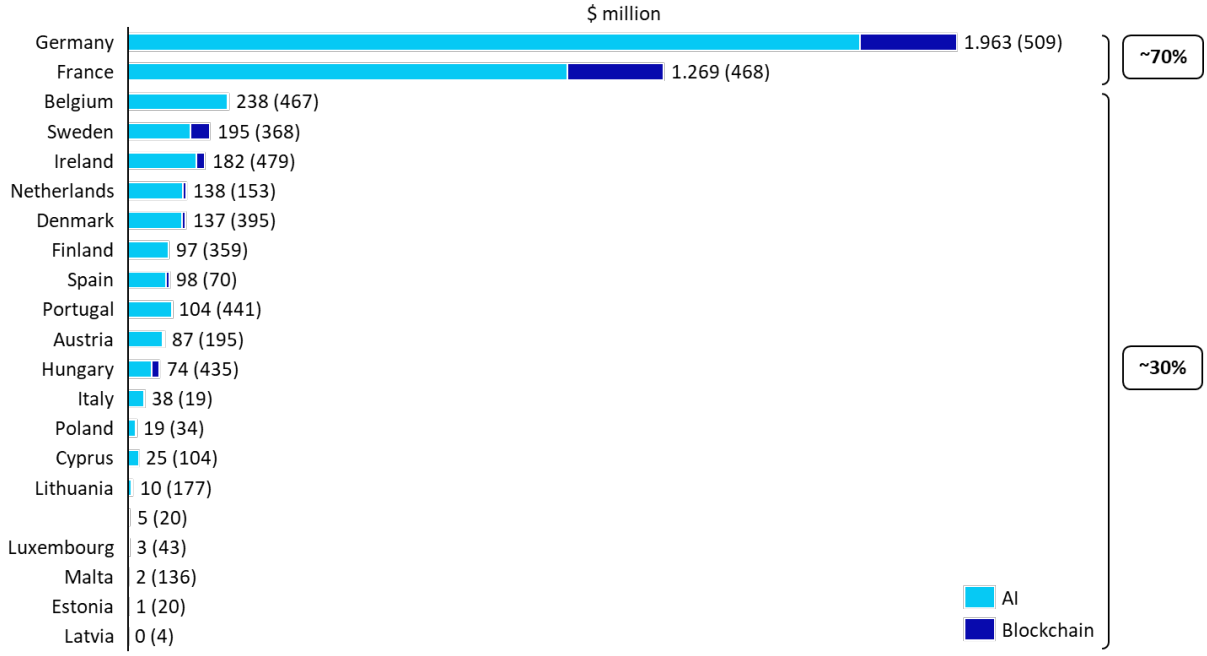


About 70% of total VC investments in AI and BC since 2010 was invested in Germany and France; however, other large AI and BC centres do not receive investments in proportion to the number of SMEs they host. After Germany and France, Belgium and Sweden rank third and fourth respectively,

[220] Crunchbase data, Oliver Wyman analysis.
[221] Ibid.

receiving roughly one-tenth of the level of VC investments in AI/BC in Germany; Ireland completes the top-5. Interestingly, Spain, the Netherlands and Italy rank ninth, sixth, and thirteenth, respectively despite ranking in the EU27's top-5 countries for number of AI and BC SMEs (see Figure 53): this suggests that VC equity investments are not allocated to some centres with largest pools of AI and BC SMEs. Despite Tallinn being among the top-10 EU27 cities by number of AI/BC SMEs (see Figure 54), Estonia ranks very low in total VC investments in these two technologies.

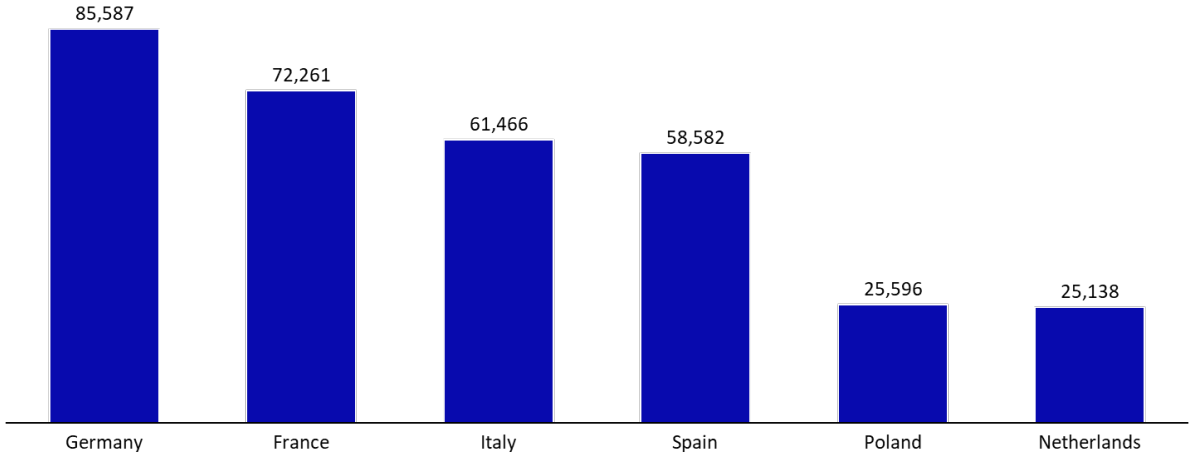
Figure 54: Total estimated VC equity investment (and per $1bn GDP in parenthesis) in AI and BC SMEs by EU27 country, 2010–2019[222]



Similarly, despite the large amount of technology-related academic research in some EU countries, relatively few of these projects attract VC equity investments and become economic use cases. Italy, Spain and Poland are among the top-6 EU countries for AI-related paper output (1997–2017), yet attract relatively little VC equity investment in this area.

[222] Preqin data, Oliver Wyman analysis.

Figure 55: Top-6 EU countries in AI paper output, 1997–2017 (number of published AI papers)[223]



A non-integrated ecosystem can also affect innovation programmes and initiatives promoted by the public sector, leading to fragmentation of resources across countries and technologies, rather than channelling efforts towards creating big champions in strategic fields for Europe. Despite a broad range of financing schemes available to tech companies at the EU and Member State level, EU initiatives are especially struggling to reach Eastern and Southern European countries, an issue picked up by the Digital Innovation and Scale-up Initiative (DISC) recently launched by the European Commission.[224] Moreover, while there is an EU-wide coordinated plan for AI, each Member State is also pursuing its own strategy, with the risk of dispersing European resources and creating inefficiencies. By contrast, only a few countries have devised their own strategies for BC, while others have not yet taken a systematic approach to developing this technology. Public and private resources are also not being channelled into creating big champions and investing in them throughout all life-cycle stages – especially for AI and BC, scaling is the key to success and a major competitive advantage. According to a recent EIF report, the European innovation ecosystem is an aggregation of several stakeholders (VCs and others) that need to collaborate more effectively to foster better European integration.[225]

"Chinese and US investors focus on creating national champions and invest heavily in those; EU investments are very scattered"

- VC fund

[223] China AI development report, China Institute for Science and Technology Policy at Tsinghua University, 2018.

[224] Shaping Europe's digital future. Launch of the Digital Innovation and Scale-up Initiative (DISC). EC (link, accessed 19 May 2020).

[225] The European venture capital landscape: an EIF perspective Volume I: The impact of EIF on the VC ecosystem, EIF, 2016

6. Ethical and societal implications of AI and BC

AI technologies are expected to have a broad impact on some key ethical and societal goals of the European Union.[226] In its *White paper on artificial intelligence*, the European Commission highlights the potential positive impact of AI systems for European society, for example in achieving the SDGs, supporting democratic process and social rights, and attaining the goals of the EU Green Deal.[227] However, the Commission also stresses that given these technologies' environmental impact, AI systems need to be duly considered throughout their life cycle and across the entire supply chain, for example as regards resource usage for algorithm training and data storage.

AI technologies are also expected to change the everyday lives of European citizens in many ways that we can only begin to imagine. They can potentially improve healthcare (e.g. diagnosis precision, disease prevention), increase the efficiency of farming, contribute to climate change mitigation and adaptation, change ways of working across different sectors, and increase the security of Europeans.[228] Regarding the way we work, AI is expected to change industries across Europe by automating about 14% of jobs and significantly changing a further 32%.[229] AI technologies also entail specific potential risks, such as opaque decision-making, gender-based or other kinds of discrimination, intrusion into private lives, and use for criminal purposes.[230] Further potentially contentious applications of AI include identifying and tracking individuals (e.g. to contain COVID-19), covert AI systems, AI-enabled citizen scoring (in violation of fundamental rights) and lethal autonomous weapon systems.[231]

Despite the potential impact of AI on everyday lives, the technology has yet to overcome a range of challenges. One key challenge is the limited accessibility of data for AI: as reflected in the COVID-19 crisis, where required data are not yet available because of limited collaboration between different public and private stakeholders, algorithms may fail to produce the desired outcomes.[232] To overcome these technical limitations, innovators will have to conduct their research ethically, transparently and accountably to gain public trust and accelerate collaborative problem-solving (see a recent paper by the Alan Turing Institute).[233] A recent study conducted for the European Parliament found five major areas of ethical and societal challenges associated with the development and implementation of AI (see Figure 57).

Figure 56: Key areas of ethical dilemmas and moral questions related to AI[234]

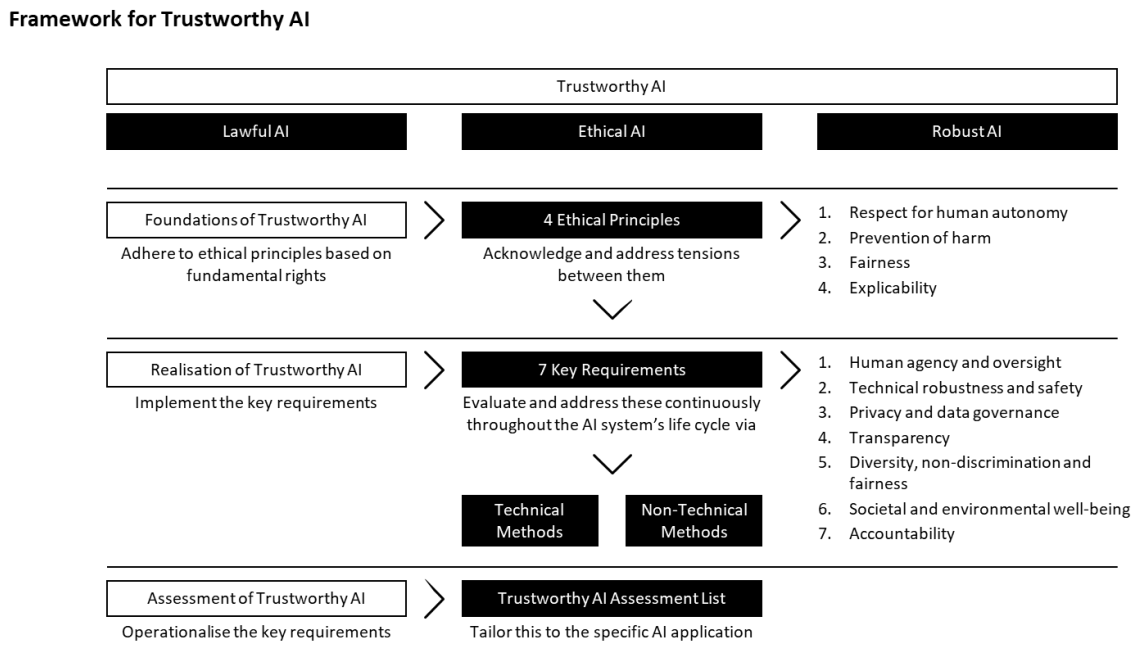
[226] White paper on Artificial Intelligence - A European approach to excellence and trust, European Commission, 2020.
[227] Communication: Building trust in human-centric artificial intelligence, European Commission, April 2019.
[228] Communication: Building trust in human-centric artificial intelligence, European Commission, April 2019.
[229] The risk of machine-learning bias (and how to prevent it), Oliver Wyman, 2018.
[230] Communication: Building trust in human-centric artificial intelligence, European Commission, April 2019.
[231] Ethics guidelines for Trustworthy AI, High-Level Expert Group on AI (European Commission), 2019.
[232] AI struggles to prove its worth in the face of COVID-19. Science Business (link, accessed 16 July 2020).
[233] Tackling COVID-19 through responsible AI innovation: Five steps in the right direction, David Leslie, The Alan Turing Institute, 2020.
[234] The ethics of artificial intelligence: Issues and initiatives, Panel for the Future of Science and Technology, European Parliamentary Research Service, 2020.

As a starting point for constructing "Trustworthy AI for Europe," the European Commission addresses societal and ethical concerns related to AI in its recent *Ethics guidelines for Trustworthy AI*.[235] These guidelines are intended to be a living document that is reviewed and updated over time to ensure continuing relevance as the technology, social environments, and knowledge evolve. As the AI landscape comprises a diverse set of underlying technologies, use cases, and stakeholders – each presenting its own opportunities and challenges – the guidelines set out principles-based guidance that can apply across this diverse ecosystem to support the development of Trustworthy AI. The Commission defines three necessary components for Trustworthy AI, which should all be met throughout the system's entire life cycle:

1. It should be lawful, complying with all applicable laws and regulations;
2. It should be ethical, ensuring adherence to ethical principles and values; and
3. It should be robust, both from a technical and social perspective since, even with good intentions, AI systems can cause unintentional harm.

Based on those three necessary components, the Commission identifies and describes the ethical principles that must be adhered to in order to ensure ethical and robust AI; translates these ethical principles into seven key requirements that AI systems should implement and meet throughout their entire life cycle; and sets out a non-exhaustive Trustworthy AI assessment list to operationalise the requirements.

Figure 57: Framework for Trustworthy AI[236]



As a major step in the aim to turn Europe into the global hub for trustworthy AI, in April 2021, the European Commission laid out proposals for new rules and actions, focusing on a human-centric approach to AI.[237] The efforts include the first-ever legal framework on AI and a new Coordinated Plan

[235] Ethics guidelines for Trustworthy AI, High-Level Expert Group on AI (European Commission), 2019.
[236] Ethics guidelines for Trustworthy AI, High-Level Expert Group on AI (European Commission), 2019.
[237] On 21 April 2021, the European Commission launched a proposal on new rules and actions for excellence and trust in Artificial Intelligence, including Proposal for a Regulation laying down harmonised rules on artificial intelligence (Artificial Intelligence Act); Coordinated Plan on Artificial Intelligence 2021 Review; and Proposal for a Regulation of the European Parliament and of the Council on machinery product (link)

with Member States that will guarantee the safety and fundamental rights of people and businesses, at the same time strengthening AI uptake, investment and innovation across the European Union. Further to complement this, new rules on Machinery that will adapt safety rules to increase trust in the new, versatile generation of products.

Several other countries and organisations besides the European Union have published principles and guidelines on AI ethics, including Australia, Singapore, Japan and the OECD. Overall, they share a degree of commonality and promote similar values, which can be summarised in ten general guiding principles (see Figure 59). Together with the *Ethics guidelines for Trustworthy AI* and potential guidelines of EU Member States, these principles could provide a starting point for investment guidelines to steer decision-making on public and private investments in AI.

Table 10: Ten general guiding principles for ethical AI

Values	Definitions
Human-Centered	AI systems should be designed to be inclusive, accommodating the needs and values of the individuals that interact with them
Mitigate Risks and Promote Benefits	AI systems should be designed and deployed for the benefit of end-users and avoid unintended negative impacts on third parties
Fairness	Governance and technical safeguards are important to identify and mitigate risks of unfair biases, particularly in cases with consequential impact on people
Explicability	AI systems should be understandable; context will dictate what is appropriate for providing transparency about a particular decision-making process
Safety and Reliability	AI systems should be designed to mitigate foreseeable safety risks and adequately tested to ensure that they operate as intended
Accountability	It is important to ensure accountability through the AI lifecycle, including appropriate governance structures for the design phase and redress mechanisms
Risk-based and Proportionate	Risks are context-specific and stakeholders should be encouraged to deploy risk management techniques tailored to specific use cases
Multiple Stakeholders	Multiple stakeholders have important roles to play in mitigating risks involved in the development, deployment and use of AI
Privacy and Security	AI systems should be secure and enable users to make informed choices regarding use of personal information
Promotes Innovation	Government is a key enabler of AI innovation, and should promote a policy environment conducive to cross-border data flows, value-added data services, access to non-sensitive government data, R&D, and workforce development

While the ethical concerns around AI are constantly growing in importance in the public debates, the same amount of attention has not yet been paid to such concerns for BC technologies.[238] Initial research suggests however that several potential ethical issues of BC will need to be addressed, such as:[239]

- Protection of data stored by BC technology;
- Trade-off between benefits of BC and its energy consumption;
- Transparency and regulation around smart contracts;
- Anti-trust matters, e.g. anti-competitive behaviour arising from information sharing or the emergence of a monopoly controlling BC in a specific domain; and
- Potential frauds and other predicate offences deriving from BC anonymity.

[238] Why it's time to start talking about blockchain ethics. MIT Technology Review (link, accessed May 2020).
[239] Ethical and professional implications of blockchain accounting ledgers, Dov Fischer, Brooklyn College, 2018.

Regarding data protection, one concern is the potential tension between BC and the GDPR. Two key factors will need to be addressed. First, the GDPR is based on the underlying assumption that in relation to each personal data point there is at least one natural or legal person – the data controller – against whom data subjects can enforce their rights under EU data protection law. BC, by its very nature, seeks decentralisation and, hence, does not include a data controller. Second, the GDPR assumes that data can be modified or erased where necessary to comply with legal requirements, whereas BC is designed to ensure data integrity, and thus obstructs the modification or deletion of recorded data.[240]

Risks to individuals along the data value chain

The study proposes a high-level framework that could be used to identify risks to individuals from new ways of collecting, using and selling data in the context of AI applications. This framework comprises three key components along the value chain typical of AI models:

- **Collection of data:** The first phase entails collecting vast amounts of data needed to train the AI models. In this phase, risks or harms to citizens can derive from specific products/interfaces used to collect data (e.g. smart devices, online platforms), as well as when and where data from the public are collected (e.g. public photos for facial recognition, smart city sensors);
- **Use of data to improve products/services:** Data are typically used to train AI models and improve the products/services offered by a company. This is done via algorithms that generate insights from data for specific individuals (e.g. targeted pricing or products) or insights about the behaviour of groups of individuals (e.g. consumer analytics); and
- **Use of data-driven insights:** These insights are typically used to generate value for the company, either via better access to individuals (e.g. targeted advertising) or by influencing individual behaviours (e.g. nudges).

The framework is represented in Figure 60.

Figure 58: Risks of AI to individuals along the data value chain[241]

Data value chain		Examples	Selected potential risks or harms to individuals
Collection of data	Via products, interfaces	• Smart devices • Wearables • Online activity	• Intrusion of **privacy** • Breach in **security** • Lack of visibility or control over **totality of data** collected
	From the public	• Facial recognition applied to public photos • Tracking through smart city sensors	• Lack of ability to **opt out** • Constant **surveillance** • Lack of **control** over data collected
Use of data to improve products/services	For individual	• Targeted pricing • Target products / services	• **Price discrimination** • **Social discrimination** due to affiliation (e.g. gender, race) • Lack of **recourse** in case of inaccuracies
	About individuals	• Market trend analysis • Enhanced public services • Consumer analytics	• **Lack of incentives** for firms to invest in privacy/security • Breach due to **triangulation of indirect identifiers** • **Lack of visibility** or control of uses of data
Use of data-driven insights	Access to individual	• Targeted advertising on digital platforms	• **Digital addiction** due to mechanisms implemented to increase engagement • **Unintended consequences** from increased engagement algorithms (e.g. fake news that goes viral)
	Behavior influence	• Nudges (e.g. videogames steering gamers to specific stores) • Remote orchestration (e.g. turn off device if missing payment)	• Behaviour change promoted without **individual awareness** • **Conditioning** of specific behaviours • **Misalignment** with individual values

[240] Blockchain and the General Data Protection Regulation, Panel for the Future of Science and Technology, European Parliamentary Research Service, 2019.

[241] Oliver Wyman Forum analysis.

Impact of AI on the Sustainable Development Goals

The 17 SDGs are at the heart of the 2030 Agenda for Sustainable Development adopted by all UN members in 2015.[242] They aim to provide a shared blueprint for peace and prosperity for people and the planet, now and in the future, through commitment to eliminate poverty, find sustainable and inclusive development solutions, ensure everyone's human rights, and generally make sure no one is left behind by 2030. For each of the goals, associated targets (169 in total) are defined to allow tracking of progress towards achievement. The European Union is committed to implement the SDGs in all its policies and is pushing for each and every Member State to do the same.[243, 244]

Figure 59: The 17 Sustainable Development Goals

AI will transform the European society and economy at large, and is therefore expected to have a significant impact on the progress towards achieving the SDGs. According to a recently published study,[245] AI can potentially support the accomplishment of 134 targets (79%) but potentially inhibit achieving 59 targets (35%). More specifically, 93% of the Environment-related targets, 82% of the Society-related targets and 70% of the Economy-related targets can be positively influenced by AI. However, AI also brings the risk of increasing Inequality, e.g. as educational and computing resources are unevenly distributed across the world.

However – if done right – AI has the potential to unlock benefits that could go far beyond the SDGs within this century. However, the same study stresses the need for dialogue among all stakeholders and for regulatory oversight of this technology to enable sustainable development and avoid potential gaps in transparency, safety and ethical standards.

[242] Resolution adopted by the General Assembly on 25 September 2015. UN (link, accessed 27 May 2020).
[243] The 17 Goals. UN (link, accessed 27 May 2020).
[244] Sustainable Development Goals. European Union, (link, accessed 27 May 2020).
[245] Vinuesa, R., Azizpour, H., Leite, I. et al. The role of artificial intelligence in achieving the Sustainable Development Goals. Nature Communications 11, 233 (2020).

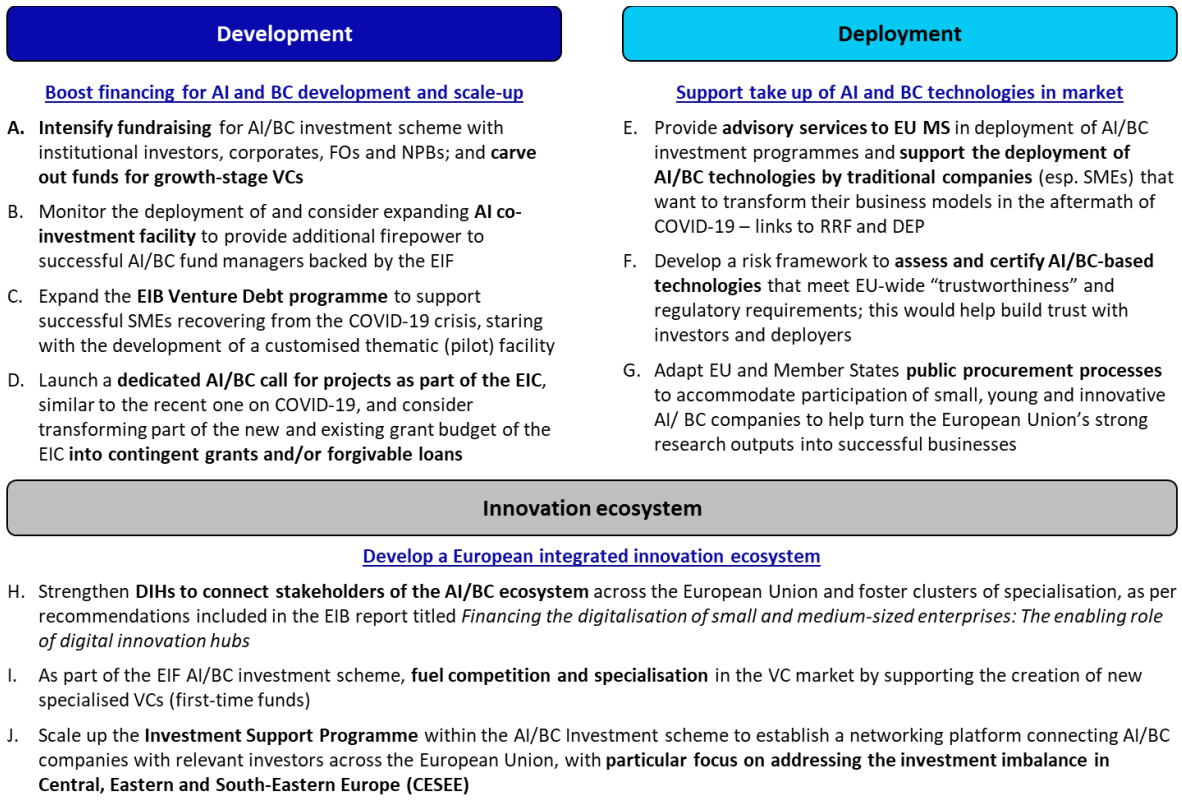
7. Recommendations

The study identified three major areas needing improvement in Europe's AI and BC landscape. The bottlenecks in financing of AI and BC require a strategic and comprehensive public–private response. The challenges identified span the development of AI and BC technologies, their deployment in the market, and the wider EU innovation ecosystem. Accordingly, the study makes several recommendations for addressing the three key objectives:

4. **Development:** Boost financing for AI and BC development and scale-up
5. **Deployment:** Support take-up of AI and BC technologies in the market
6. **EU innovation ecosystem:** Develop a European integrated innovation ecosystem

The recommendations for each of these objectives are outlined in Figure 2 and discussed in more detail in the rest of this section.

Figure 60: Mapping of recommendations to key identified objectives



7.1. Boost financing for AI and BC development and scale-up

The study has identified four key initiatives for this first objective.

Recommendation A: Intensify fundraising for AI/BC investment scheme with institutional investors, corporates, FOs and NPBs; and carve out funds for growth-stage VCs

The EIF could , within its capacity, leverage its visibility in the European VC space and its track record to focus fundraising for the dedicated AI/BC investment scheme among private institutional investors, large corporates and FOs. This could be done via an investment structure aimed at optimising the trade-off for participating parties with lower risk–return profile, e.g. through a dedicated fund-of-funds (FoF) and/or downside guarantee mechanisms to attract institutional investors (e.g. with asymmetric returns, to the extent that appropriate products would be made available to the EIF). The EIF could also maximise fundraising with Member States (via NPBs) to further increase the scheme's capacity, and aim for optimal complementarity with other national programmes.

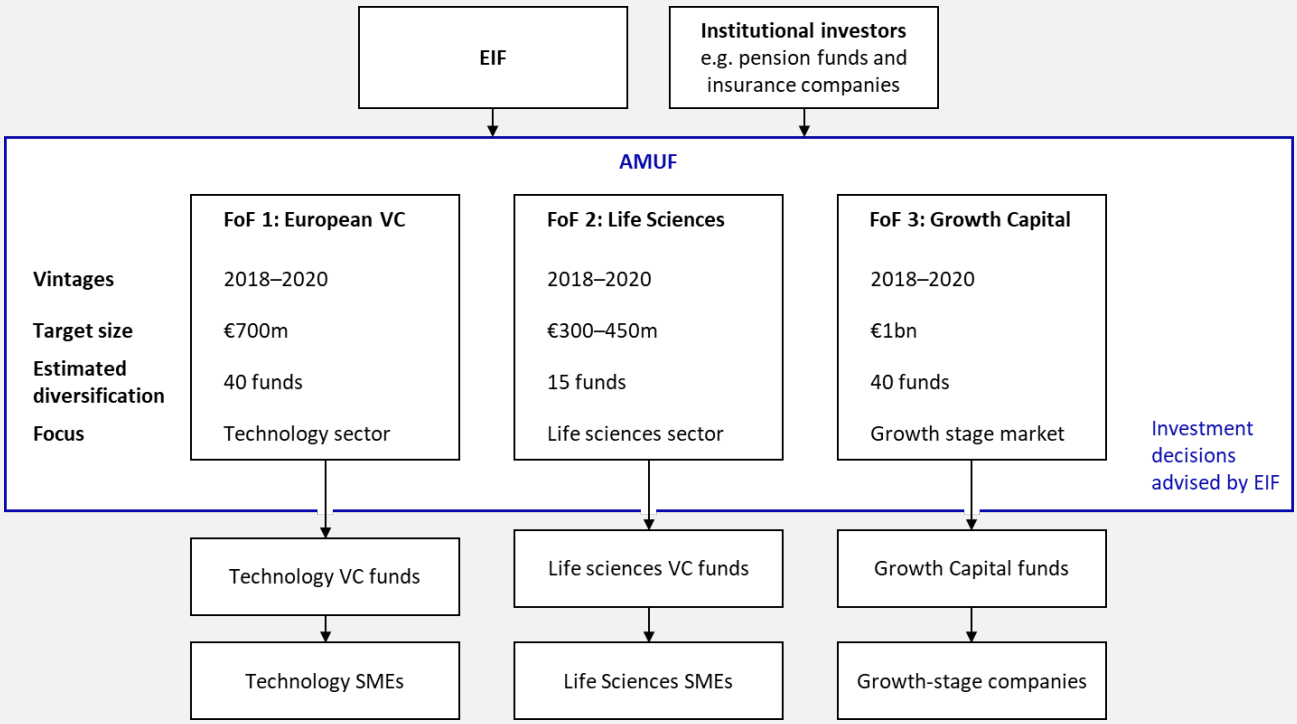
The EIF could then carve out funds dedicated to growth-stage VCs investing in AI scale-ups. This could be done as a pilot similar to the recently launched European Scale-up Action for Risk Capital Programme, and could focus purely on AI technologies (BC is still at early stages). In the longer term, funds could be carved out within the dedicated AI/BC investment scheme (currently focused on startup phase only, up to Series A). This would contribute to improving within-EU opportunities for growth-stage SMEs that might alternatively get financing outside the European Union, hence also improving exit opportunities for EU VCs that invested in earlier stages.

Recommendation overview		
Objective(s)	• Increase mobilisation of private funds (especially from larger institutional investors) • Provide dedicated financing to growth-stage AI SMEs	
Bottleneck(s) addressed	Limited availability of VC and private investments	
Main stakeholder(s)	EIF	
Assessment	Expected impact on AI/BC access to finance	High
	Expected implementation cost/complexity	Medium

Case study: EIF Asset Management Umbrella Fund

The EIF initiated the AMUF in 2017, with the aim of increasing private investments in European VC. The AMUF is an FoF leveraging the EIF's visibility in the European VC space and its track record as a fundraiser among institutional investors and FOs. The AMUF is an investment vehicle managed by a general partner, AMUF GP, and an alternative investment fund manager, Alter Domus. As of April 2019 the AMUF consists of three divisions, each with a specific focus.

Figure 61: Structure of the AMUF



Investors are required to commit a minimum of €80 million of funding to participate. The AMUF invests on behalf of its participants, using the EIF's visibility in funds with a promising track record. To ensure transparency over its investment activities, the AMUF establishes a close relationship with investors, fostered by its client relationship team and regional senior sales teams. Investors also receive access to the EIF's Knowledge Hub, which provides insights into and best practices in the PE market, and EIF information portals such as the Virtual Data Room and the Investment Café, which share PE market insights and act as communication platforms for investors. Finally, AMUF investors are invited to the annual Institutional Investor Global Forum covering the AMUF's investment activities and progress.

By 31 January 2019, the European VC, Life Sciences and Growth Capital divisions had jointly invested €157 million in 14 funds, including IK Small Cap II, Highland Europe III and Fountain Healthcare Partners III.

Recommendation B: Monitor the deployment of and consider expanding the AI co-investment facility to provide additional firepower to AI/BC fund managers backed by the EIF that invested in successful SMEs

The EIB could leverage the InvestEU programme to monitor and eventually expand the recent AI co-investment facility to successful VCs backed by the EIF, while also extending its scope to include BC investments. This facility amounts to €150 million and deployment began in January 2021. The proposed expansion would complement the AI/BC investment scheme in sustaining the growth of

successful startups and scale-ups through co-investments between the EIB Group and top-ranked VC funds and investment partners. The operational burden would be limited by leveraging due diligence performed by the EIF. The facility would invest pari passu with other investors, and would also be able to deploy smaller tickets. If proven successful, scaling up of the initiative could be highly impactful.

Recommendation overview		
Objective(s)	• Increase mobilisation of private funds (especially for follow-up investments) • Stimulate strategic public–private co-investments	
Bottleneck(s) addressed	Limited availability of VC and private investments	
Main stakeholder(s)	EIF	
Assessment	Expected impact on AI/BC access to finance	High
	Expected implementation cost/complexity	Medium

Recommendation C: Expand the overall capacity of the EIB Venture Debt programme to support successful and innovative SMEs recovering from the COVID-19 crisis; potentially also develop a customised thematic (pilot) facility for AI and BC (or a wider deep-tech facility)

The EIB could leverage the InvestEU programme to expand the capacity of its Venture Debt programme and strategically focus on innovative firms struggling to raise their next round of financing in the aftermath of COVID-19. Venture debt financing would allow these innovation-driven SMEs to extend the cash runway until more favourable market conditions return for a new independent round of financing, and prevent those suffering depressed valuations because of the pandemic. The EIB could also consider expanding programme eligibility to earlier financing stages (e.g. after Series A, instead of B/C) and to smaller tickets (minimum ticket size is €7.5 million under the European Growth Finance Facility but €3 million for companies in moderate innovator countries and €5 million in other countries under the Pan-European Guarantee Fund, EGF). A similar setup could also be envisaged under InvestEU.

Further, the EIB – in close collaboration with the European Commission – could explore developing a thematic (pilot) facility dedicated to AI/BC companies, or a facility with a broader scope covering deep tech. The setup could be similar to those of successful concepts such as the Energy Demo Project, Future Mobility Facility and InnovFin Infectious Diseases Facility. Compared to the EIB's generic venture debt product, such a dedicated facility could benefit from higher risk-sharing capacity and allow for increased risk-taking, in line with the profile of AI and BC companies.

Recommendation overview		
Objective(s)	• Support innovative firms that, following COVID-19, are struggling to raise their next round of financing • Conduct a pilot on AI and BC SMEs	
Bottleneck(s) addressed	Limited availability of VC and private investments	
Main stakeholder(s)	EIF	
Assessment	Expected impact on AI/BC access to finance	Medium
	Expected implementation cost/complexity	Medium

Recommendation D: Launch a dedicated AI/BC call for projects as part of the EIC, similar to the recent European Innovation Council (EIC) call dedicated to COVID-19, and consider transforming part of the new and existing grant budget of the EIC into contingent grants and/or forgivable loans

Up to €2.5 million in grants and €15 million in equity are provided by the EIC to innovative startups in Horizon 2020 countries. The EIC could launch a specific AI/BC call (similarly to its recent call dedicated to COVID-19) to give a dedicated opportunity for researchers and young startups active in this field to turn their projects into successful business solutions. This call should award grants/equity funding and European Commission Seals of Excellence.

With applications to the EIC having more than doubled since the pandemic began, the European Commission could consider transforming part of the new and existing EIC grant budget into forgivable loans or contingent grants. These could be repaid as a loan if the company is successful and not repaid otherwise, thus increasing the capacity of the EIC scheme as repaid grants are made available for new grants. The EIC could "outsource" the recovery function (to the EIB or other actors).

Recommendation overview		
Objective(s)	• Stimulate application of successful research projects into business solutions • Broaden access to finance of large pool of innovative projects (through Seals of Excellence)	
Bottleneck(s) addressed	• Strong research base but limited R&D spending • Fragmented innovation ecosystem	
Main stakeholder(s)	EIB, potentially with other actors involved in loan recovery process	
Assessment	Expected impact on AI/BC access to finance	Medium
	Expected implementation cost/complexity	Medium

Case study: Innovate UK: Investment Accelerator Programme

Innovate UK is part of UK Research and Innovation, a public body funded by the UK government. It aims to de-risk and stimulate investments in innovative UK startups active in emerging and enabling technologies, health and life sciences, infrastructure systems, or manufacturing and materials.

Innovate UK's Investment Accelerator Programme (IAP) organises funding competitions to connect startups with private investors. It subsequently matches the equity funding that startups receive from private investors with grant funding. The IAP selects investors either through competitions or from its network of strategic partners (e.g. Sky Ocean Ventures).

The competitions are organised in two rounds through which investors and startups are selected and matched. During the Investor Partner Competition, Innovate UK's Investment Advisory Board selects investors meeting its requirements, ensuring adequate geographic and sectoral coverage.[246] During the second contest, the Investment Accelerator Competition, Innovate UK publishes the list of participating investors and invites startups to apply for the IAP, with the option of applying to a specific investor.[247]

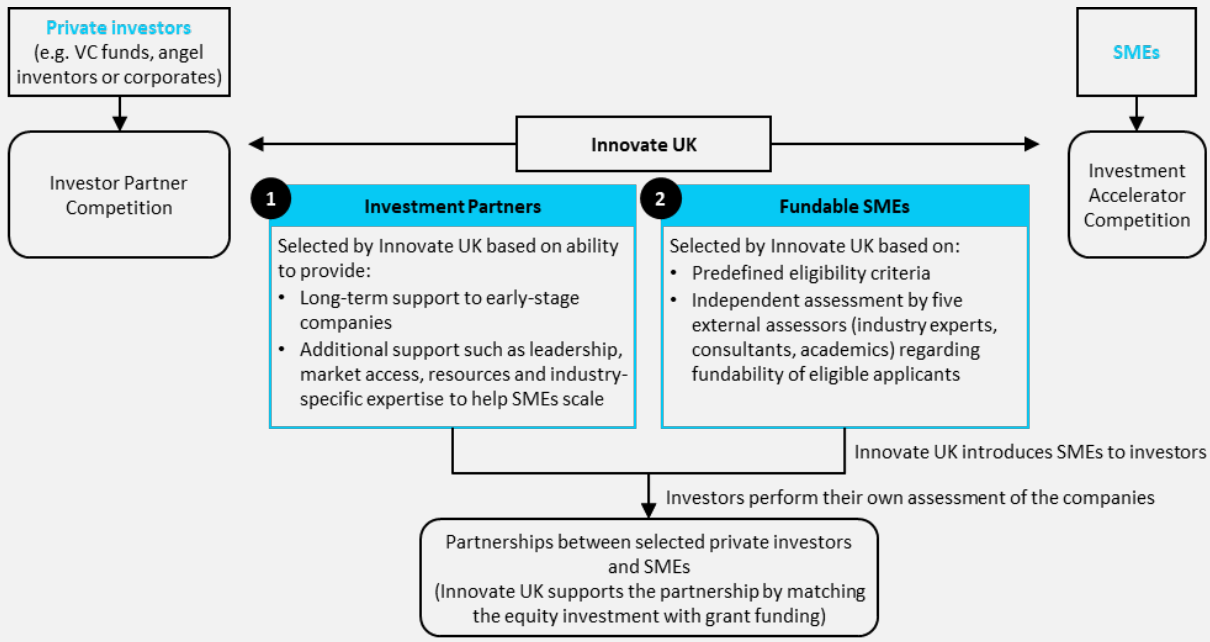
Since 2017 Innovate UK has organised five IAPs. During the pilot, seven private investors active in Health and Life Sciences and Infrastructure Systems were selected; together with Innovate UK, they provided £8.5 million (€9.8 million) in funding to startups (£2.5 million in PE and £6 million in grant funding). In the second IAP, £6 million in

[246] The Investor Partner Competition is skipped where the IAP is initiated in collaboration with a strategic partner.

[247] Applicants should fit the EU definition of an SME: turnover does not exceed €50 million or balance sheet total is below €43 million; staff headcount is below 250.

grant funding and a similar amount of PE was raised, focusing on Infrastructure Systems. The Ocean Plastics Accelerator Competition saw £2 million in grant funding and PE provided to startups fighting waste.

Figure 62: Structure of the Investment Accelerator Programme of Innovate UK



7.2. Support take-up of AI and BC technologies in the market

The study has identified three key initiatives for this second objective.

Recommendation E: Provide advisory services to EU Member States in deployment of AI/BC investment programmes to enhance coordination between the European Union and MS, and support the deployment of AI/BC technologies by traditional companies (especially SMEs) that want to transform their business models in the aftermath of COVID-19. There are potential links to the Recovery and Resilience Facility (RRF) and the DEP

The European Commission and Member States have launched several huge support schemes to promote economic recovery from the COVID-19 crisis. Accordingly, key recommendations include:

1. The Commission could consider drawing on some components of the EU-level schemes (e.g. InvestEU) to encourage investments in AI/BC technologies that could accelerate the recovery of hardest-hit sectors. For example, conditional grants/forgivable loans could be attached to the deployment of AI/BC technology-based solutions and assigned via specific competitions; in particular, anchoring business models more robustly in AI/BC could materially benefit sectors such as automotive, manufacturing, hospitality, and education. The Commission would also need to ensure coordination between the European Union and MS in deploying EU and local AI/BC investment programmes.
2. Most NPBs have launched support schemes in the aftermath of COVID-19. The EIB Group could deploy coordinated co-funding models with NPBs to ensure that AI/BC technology and startups become more central in local financing responses to recover from the crisis generated by COVID-19 (e.g. via the EGF).
3. Under the RRF, Member States will prepare recovery and resilience plans for a coherent package of reforms and public investment projects. Each plan must devote at least 20% of expenditure to fostering the digital transition. To step up financing from other sources, the EIB could closely collaborate with the European Commission to support Member States in the design and

implementation of these plans, exploring and encouraging top-up possibilities by MS for particular thematic areas: e.g. focus on development and deployment of AI and BC technologies.

4. AI is one of the five high-level components of the DEP. Given the complexity of AI technologies, deep specialist knowledge could be required to assess their potential and mitigate significant information asymmetries that could limit deep-tech developers' access to finance. To bridge the information gap and improve the positioning of digital companies with respect to investors, one key recommendation is implementing dedicated advisory support, perhaps through the EIB's Innovation Finance Advisory team. Envisaged activities could help create the necessary financial preconditions (e.g. through market intelligence and development of the investor ecosystem, financial products and blending structures) and pilot initiatives (e.g. flagship/demonstration projects) that could be further scaled up under InvestEU (complementary to other financial sources such as the RRF).

Recommendation overview

Objective(s)	• Leverage COVID-19 support schemes to transform business models in strategic sectors • Facilitate deployment of AI and BC technologies across economy	
Bottleneck(s) addressed	• Limited availability of VC and private investments • Fragmented innovation ecosystem	
Main stakeholder(s)	European Commission, selected NPBs	
Assessment	Expected impact on AI/BC access to finance	High
	Expected implementation cost/complexity	High

Case study: Israel Innovation Authority (IIA) – Conditional grants

The objectives and functions of the IIA include developing Israel's innovation infrastructure, creating jobs and building technological and scientific human resources, promoting innovation by distributing grants and providing financial support, and connecting the economy with the global innovation industry.

Accordingly, the IIA's activities include the provision of financial support to companies across different stages of the enterprise life cycle and the administering of technological incubator programmes to support early-stage companies. The IIA is also in charge of several R&D collaboration initiatives between the academic and commercial sectors.

These objectives and activities are enabled through targeted divisions focused on a particular activity or stage in the company life cycle. Currently, these include a Startup Division focused on pre-sale companies, a Growth Division focused on early-stage companies, a Technology Infrastructure Division focused on collaboration between industry and academia, an Advance Manufacturing Division focused on research implementation, an International Collaboration Division focused on cooperation with other countries, and a Societal Challenges Division focused on improving the effectiveness and quality of public sector services.

Financial support and grants

While the IIA offers traditional R&D grants, its primary financing tool for SMEs is conditional grants, i.e. grants/loans whose repayment is contingent on the success of the project or company. Conditional grants are a hybrid between grants and loans. If the project fails and does not produce revenues, the principal is lost (effectively treated as a grant). Conversely, if the project succeeds and generates sufficient revenues, sales royalties are collected by the IIA until the principal is repaid with a small amount of interest (effectively treated as a loan). Conditional grants thus limit the downside risk faced by new technology ventures while allowing the public sector to benefit from the potential upside of successful projects, therefore increasing its financing capacity. Israel began investing heavily in R&D as early as the 1960s, when the main tools were standard grants

given to companies for R&D purposes. As some successful companies were able to reimburse grant payments to the IIA, conditional grants were born in the mid-1980s, allowing for more financing of innovative SMEs.

Currently, for a company to qualify for a particular conditional grant, it must first meet the eligibility criteria. Different funds are available to support innovative companies across the full life cycle and a variety of industries. The various funds available are elaborated below.

If a company meets the initial requirements, a comprehensive professional assessment is then conducted by an engineer qualified and experienced in the relevant field and by an accountant. The engineer provides insights on the technological risk and feasibility of the proposal, while the accountant analyses the financial statements. The accountant does not currently look into different financing options but will be expected to do so when a richer arsenal of financial instruments becomes available to the IIA. If the R&D proposal and technology are deemed promising and the level of technological risk is appropriate, a conditional grant is given to cover a portion of the expenditures – the exact amount depends on the fund and the company.

Example of programmes

The Startup Division focuses on entrepreneurs with innovative ideas and early-stage startup companies, while the Technology Innovation Labs foster collaboration between established companies and startups to promote knowledge transfer. Financing can be obtained in the form of grants for fundamental research. For example, the Tnufa Incentive Program provides conditional grants of up to ~€50 000 for a period of up to two years, aimed at supporting initial business development and building an initial prototype.

The Growth Division provides funding for more mature companies in the sales or pre-sale growth stages. For instance, the R&D Fund provides a conditional grant of 20–50% of a firm's approved R&D expenditures.

Larger companies are also incentivised to innovate. For instance, generic R&D arrangements can be put in place by the Growth Division for companies with revenues >$100 million. Full grants of up to 50% of approved R&D expenditure are given to such companies for projects executed in cooperation with other Israeli companies. In addition, certain sectors are promoted by providing additional grants. For instance, the R&D for Space Technology Fund provides grants of up to 85% of approved R&D expenditure for a period of 36 months to companies whose product and research focus on space technology.

Development of new products

The IIA will lend directly to companies using traditional loans by depositing money at financial institutions and ensuring that loans are provided to qualifying entities. This will provide more flexibility in structuring loans and selecting the appropriate level of risk for the IIA to take. It will also allow the IIA to recover greater proportions of deployed funds, and thus potentially finance a greater number of innovative companies.

Recommendation F: Develop a risk-based framework to assess and certify AI/BC technologies that meet EU-wide "trustworthiness," ethical and regulatory requirements; this would help build trust with investors in and deployers of these technologies

The European Commission could develop a risk-based framework to determine whether AI/BC-based startups meet "trustworthiness," ethical and regulatory requirements (e.g. on data protection and transparency for AI; on energy consumption for BC). The level of risk could be driven by the sector and intended use of the technology. Assessment of specific projects could be coordinated by EU digital innovation hubs (DIHs), with projects receiving a "green stamp" to denote EU-wide recognition that their AI/BC systems have been developed according to European standards and regulations. Potentially, certification could also be used to grant these projects access to specific EU-wide initiatives, such as pools of data established under the EU Data Strategy. The EIF could also use the trademark, among other tools, to guide its investments and give confidence to private investors

about a specific technology/company. DIHs could also coordinate regulatory sandboxes to drive fine-tuning of existing (and potentially new) EU regulations to accommodate specificities of AI/BC (e.g. based on the EU "innovation principle"), recognising that AI's true value lies in sustainability and human-centricity to ensure fairness and unbiasedness in which EU citizens can trust.

Regarding Trustworthy and ethical AI, focus on "gender smart" AI is particularly recommended to ensure gender equality (linked to SDG 5: "Achieve gender equality and empower all women and girls"). Europe is at the global forefront of considering AI's ethical implications,[248] aiming to ensure transparency, diversity, non-discrimination and fairness, and societal and environmental well-being. These aspects are key for successful development and deployment of AI across the whole European Union.

Recommendation overview		
Objective(s)	• Develop EU-wide recognition in the marketplace that AI/BC systems have been developed according to European standards and regulations, for access-to-finance and other initiatives (e.g. EU-wide data lakes) • Build up trust with investors and deployers of AI/BC technologies • Drive fine-tuning of existing (and potentially new) EU regulations	
Bottleneck(s) addressed	• Evolving regulatory landscape • Limited availability of data	
Main stakeholder(s)	EU DIHs; EIF	
Assessment	Expected impact on AI/BC access to finance	Medium
	Expected implementation cost/complexity	High

Case study: GAIA-X – a Federated Data Infrastructure for Europe

GAIA-X brings together representatives from politics, business and science across Europe with the aim of developing common requirements for a European data infrastructure – a secure, federated system that meets the highest standards of digital sovereignty while promoting innovation. This project is the cradle of an open, transparent digital ecosystem, where data and services can be made available, collated and shared in an environment of trust. Over 300 organisations are already involved in the project.

GAIA-X combines centralised and decentralised infrastructures in a homogeneous, user-friendly system. The resulting federated form of data infrastructure strengthens the ability to access and share data securely and confidently. GAIA-X will strengthen the underlying level of trust, lower the barriers to participation, reduce the amount of work involved in bilateral coordination between individual users, and instantiate the guarantee of data sovereignty.

Technical platform

Federation Services provide value if based on common standards ensuring transparency and interoperability. GAIA-X addresses this requirement by aligning network and interconnection providers, cloud solution providers, high performance computing, and sector-specific clouds and edge systems. GAIA-X also identifies the minimum technical requirements and services necessary to operate the federated GAIA-X Ecosystem.

Technical implementation of the GAIA-X Federation Services will focus on the following areas and be constantly extended to fit the requirements of ecosystem participants:

- Implementation of secure federated identity and trust mechanisms;
- Sovereign data services that ensure the identity of the source and receiver of data;

[248] Ethics guidelines for Trustworthy AI, European Commission, 2019.

- Easy access to available providers, nodes and services (e.g. federated catalogues);
- Integration of existing standards to ensure interoperability and portability; and
- Establishment of a compliance framework and of certification and accreditation services.

Use Cases

Various companies and organisations from European countries have submitted over 40 use cases in eight domains:

- Industry 4.0/SME: Collaborative condition monitoring; Smart manufacturing; Supply chain collaboration in a connected industry; Connected shop floor; Shared production – cross-factory and cross-company; Predictive maintenance.
- Health: AI for clinical studies; AI to beat acute kidney failure; Smart Health Connect; Research platform genomics; Future care platform; Surgical platform for AI-based risk identification; Medical crisis management and research platform; Framework of medical records in Europe; Cognition-based workplace safety for human-machine interaction.
- Finance: Financial big data cluster.
- Public Sector: Digital public administration (chatbot); Space4Cities; High performance and quantum computing as a Service; Smart infrastructure management; Transport infrastructure, Open source orchestration framework.
- Smart Living: Energy efficiency; Smart Living security; Smart Living ambient assisted living.
- Energy: Infrastructure data for new business models.
- Mobility: Data interoperability and data sovereignty; Digital parking management.
- Agriculture: Agri-Gaia.

The GAIA-X project is divided into two workstreams and a cross-functional unit:

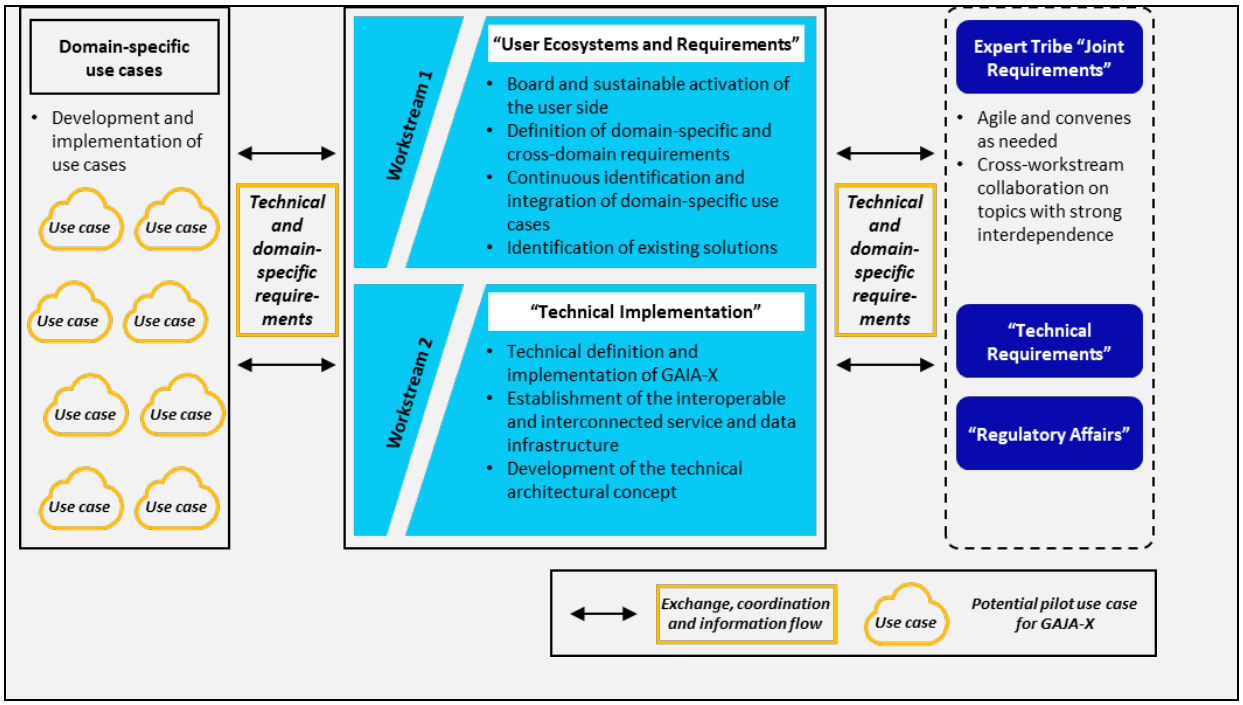
- User Ecosystems and Requirements

  Focus on broad and sustained mobilisation of the user and demand perspective, definition of domain-specific and cross-domain requirements, as well as existing approaches on which GAIA-X should build.
- Technical Implementation

  Focus on building the legally compliant and sovereign European data infrastructure. This workstream is currently developing a technical concept to define the required reference architecture and to describe the basic technical functionalities of the data infrastructure.
- Cross-functional unit: "Joint Requirements"

  The expert groups of this unit deal with topics involving strong interdependency between the workstreams. This includes areas such as general technical requirements and regulatory aspects.

Figure 63: Structure of the GAIA-X project



Recommendation G: Fine-tune EU and Member State public procurement processes to accommodate participation of small, young and innovative AI/BC companies to help turn the European Union's strong research outputs into successful businesses

In line with Open Innovation principles, the European Commission could further facilitate and encourage participation of small, young and innovative European AI/BC companies in procurement processes at the EU and Member State level. This would give opportunities for researchers and young startups to develop AI and BC solutions for direct deployment by the public sector – helping realise the potential of the European Union's strong research outputs by giving researchers a lead "client" for their products in the early stages. It would also help the deployment of these solutions by the public sector. The Commission could also link public procurement to EU research priorities in AI/BC, e.g. digitalisation of public administration, defence and climate policy. This could involve, for example, lowering certain thresholds, adjusting minimum required financial conditions or introducing more flexible timelines.

Recommendation overview		
Objective(s)	• Give innovative researchers a lead "client" for their products from early stage • Support technological deployment in the public sector	
Bottleneck(s) addressed	• Strong research base, but limited R&D spending • Limited appetite for BC investments	
Main stakeholder(s)	European Commission, key stakeholders involved in public procurement processes	
Assessment	Expected impact on AI/BC access to finance	Medium
	Expected implementation cost/complexity	High

7.3. Develop a European, integrated innovation ecosystem

The study has identified three key initiatives for this third objective.

Recommendation H: Strengthen DIHs to connect stakeholders of the AI/BC ecosystem across the European Union and foster clusters of specialisation, as per recommendations in the EIB report titled *Financing the digitalisation of small and medium-sized enterprises: The enabling role of digital innovation hubs*

EU DIHs are key to creating a network of smart one-stop advisory hubs to connect AI and BC SMEs across the European Union with one another, investors, large corporates, research centres, businesses wishing to deploy these technologies, and all other stakeholders of the innovation landscape. The hubs should also direct SMEs to actors providing advisory services and in particular advice on available funding programmes (for firms wishing to develop or already deploying AI/BC technologies). In each country, DIHs could also foster the creation of AI/BC specialisation structures in specific EU sector/priority areas (e.g. healthcare, transport, agriculture, climate, and energy).

Recommendation overview		
Objective(s)	• Support deployment of AI/BC technologies • Foster the creation of AI/BC specialisation clusters in specific EU sectors/priority areas	
Bottleneck(s) addressed	• Fragmented innovation ecosystem • Limited matching between SMEs and investors	
Main stakeholder(s)	EU DIHs	
Assessment	Expected impact on AI/BC access to finance	Medium-High
	Expected implementation cost/complexity	Medium

Case study: KfW's Gründerplattform

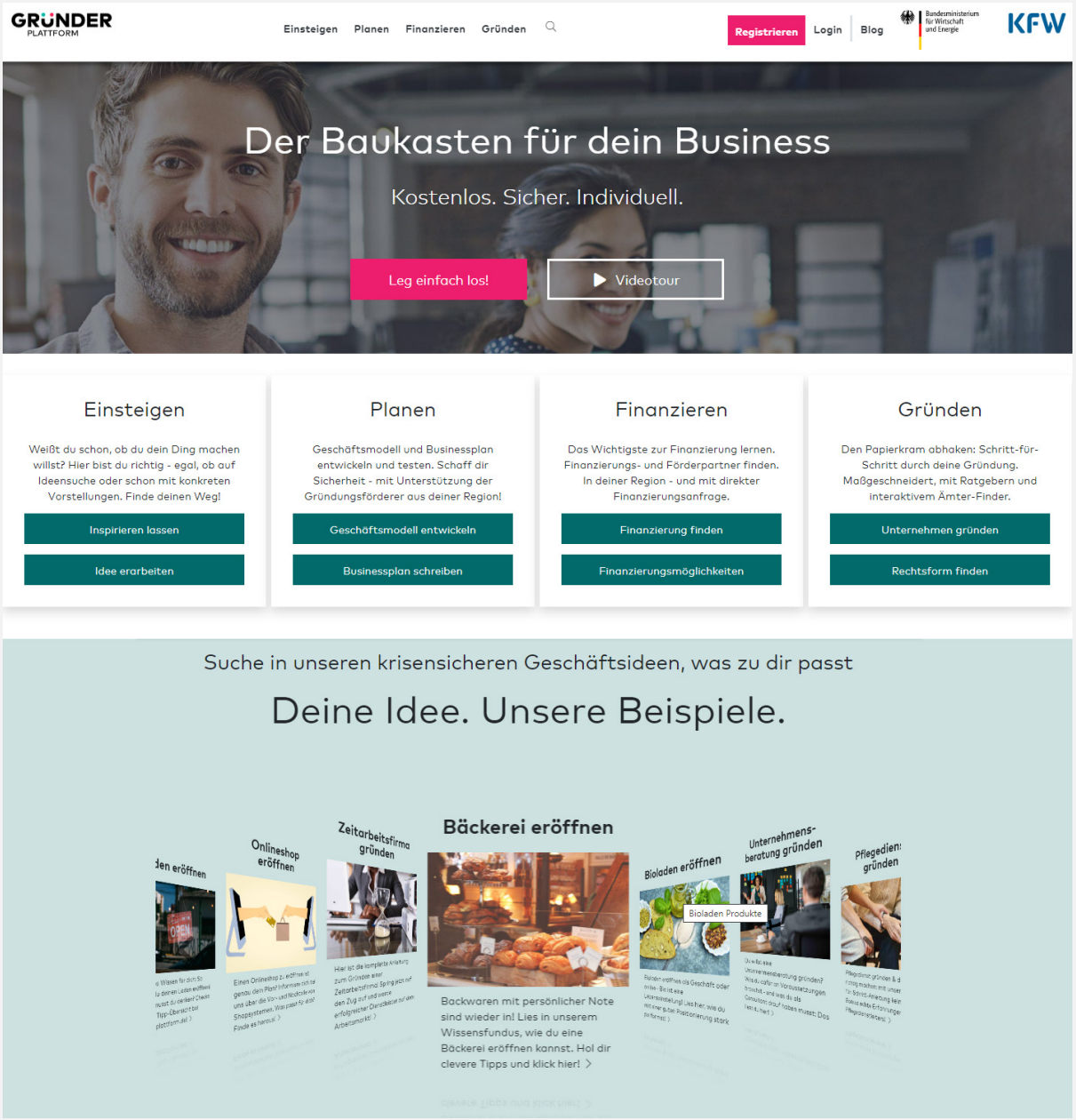
KfW's Gründerplattform is a joint online offer of the Federal Ministry of Economics and KfW. On the platform innovators can, for example, develop initial ideas, write a business plan, learn from successful founders or find funding opportunities, including matchmaking with potential investors. The platform is publicly funded and free to use. A recent KfW survey (Spring 2020, 3 900 participants) showed that four out of five platform users have either already implemented their idea or reached the planning phase.

How it works

The names and offers of key players in startup support (e.g. chambers of commerce, state development institutes, guarantee banks and credit institutions) are included on the platform. It is possible for users to receive direct advice or feedback on a proposed business model or business plan, or to submit a financing request to a credit institution. The platform also facilitates network and community building by inviting participants to exchange ideas.

The platform guides users through a standardised startup process. All digital services required for the process can be found directly on the platform. The process is focused on learning from successful founders (e.g. an extensive video library showcases entrepreneurs describing how they got started) and networking with potential investors.

Figure 64: Landing page of KfW's Gründerplattform (one-stop shop)



In the planning section, an interactive business plan tool supports development of a business plan with a conclusive financial section, completely free of charge. The founder platform guides users through each step pf the calculations. It also provides an overview of key figures and how a bank will assess them.

The financing section offers innovators important information around financing and available possibilities to pursue further. The startup platform shows which financing options are available and which best suit the current business idea. Innovators can receive suggestions on where to find the right contact person in their local area. Multiple tips are available on how to prepare for the funding interview and how to increase the chances of receiving funding. It is also possible to share draft documents with banks or other partners for review – this allows potential lenders to get an idea of the concept before the first conversation and to work on developing the final idea.

Recommendation I: As part of the EIF AI/BC investment scheme, fuel competition and specialisation in the VC market by supporting the creation of new specialised VCs (first-time funds)

The EIF, with relevant resources, could focus the AI/BC investment scheme on helping to create new VC firms specialised in AI/BC (e.g. possessing a mix of business and engineering teams) and support/sponsor them until they achieve a critical mass and track record allowing them to raise funds in the market independently. This could fuel competition and expertise in the EU VC market by creating a multitude of specialised (and eventually large) funds that could give technical and financial support to European AI and BC SMEs.

Recommendation overview		
Objective(s)	Foster creation of new VC firms specialised in AI/BC in the European Union and Horizon 2020 associated countries	
Bottleneck(s) addressed	Limited specialisation of EU VC funds in AI and BC	
Main stakeholder(s)	EIF	
Assessment	Expected impact on AI/BC access to finance	High
	Expected implementation cost/complexity	Medium-High

Case study: Small Business Investment Company

The Small Business Investment Company (SBIC) programme was launched in the United States in 1958 to facilitate the flow of long-term capital, such as equity, to small businesses. This initiative is particularly targeted at younger, innovative companies that face difficulties obtaining funding from traditional lenders.

The Small Business Administration (SBA) licenses qualified investment firms as SBICs, which then use their own capital in addition to funds borrowed with an SBA guarantee to make equity and debt investments. The 301 licensee firms (SBICs) obtain funds from debentures that are issued by the government and then resold on the market at a low cost, given the SBA guarantee. This gives these firms access to cheap funding that they can then deploy without having to share the upside. Typically, an SBIC's funding is matched at a ratio of 1-to-1 or 2-to-1 using SBA funding.

Figure 65: Example of the SBIC investment process

The SBIC programme focuses on increasing the attractiveness of funding small VC firms. The setup increases the financing capacity by boosting total funding through debentures (bonds that are secured by company assets). This results in a "leveraged" structure that magnifies returns (and losses in the downside). The programme has a size of $150 million and SBICs need to invest in small businesses with annual net income below $6.5 million in the last two years prior to investment.

As a result, the returns are asymmetric: the government has lower downside risk as it has seniority over other creditors, but the private sector SBICs obtain all of the upside. This is mutually beneficial as the SBICs effectively leverage their returns while the government's cost is reduced by higher seniority. The additional downside risk for SBICs, given the debenture's higher priority for repayment, does not deter investors from using the

programme as there is a self-selection process: only SBICs with expected high returns are willing to draw down the funds.

The SBIC programme is often credited as instrumental in developing the VC industry in the United States. Currently, there are 301 licensee firms managing over $28 billion in assets. In 201, the programme provided $6 billion in financing to 1 200 small businesses, thereby helping to sustain 122 000 jobs. A multitude of very large technology firms, such as Apple, Intel and Tesla, have received funding from SBICs during their earlier growth stages. More interestingly, the programme has zero cost to the taxpayer as the debentures have high seniority and funds are typically recovered.

Recommendation J: Scale up the Investment Support Programme within the AI/BC investment scheme to establish a networking platform connecting AI/BC companies with relevant investors across the European Union, with particular focus on addressing the investment imbalance in Central, Eastern and South-Eastern Europe (CESEE)

The European Commission could establish a networking platform (e.g. by scaling up the Investment Support Program of the AI/BC investment scheme) to facilitate matchmaking between AI and BC SMEs, investors and available EIB Group funding programmes. The platform could help match SMEs with appropriate investors based on expertise, financing stage, location and industry. The platform could also foster information exchange between early-stage and growth-stage investors to share best practices for scaling up in the EU market, offering advice and knowledge on cross-border tax and legal affairs. As part of a larger digitalisation effort, the platform could focus particularly on addressing investment needs in CESEE via cooperation and synergy creation with other EU programmes such as the DISC.

Recommendation overview		
Objective(s)	• Facilitate matching between AI/BC SMEs, VCs and available EIF funding programmes, especially in CESEE • Facilitate information exchange (e.g. best practices for scaling up across the European Union)	
Bottleneck(s) addressed	• Limited matching between SMEs and investors • Fragmented innovation ecosystem	
Main stakeholder(s)	European Commission (with EIF and EIB support)	
Assessment	Expected impact on AI/BC access to finance	Medium-High
	Expected implementation cost/complexity	Medium-High

Case study: Small Digital Innovation and Scale-up Initiative (DISC)

To address the digital economy investment gap in Central, Eastern and South-Eastern Europe (CESEE), the European Commission, EIB Group, European Bank for Reconstruction and Development, and World Bank Group launched the DISC at the Digital Assembly in Bucharest in 2019. The DISC is setting up the first regional investment facility that specifically targets digital innovations and the scale-up of digital startups in CESEE.

The initiative's targeted financing tools are tailored to the early stage and the scale-up phase of digital startups, which require riskier financing and are underserved by the traditional finance sector. The DISC also offers a technical assistance programme with the goal of strengthening the institutional capacity of public agencies to design, develop and implement digital innovation programmes. Finally, the DISC will boost investment in the

enabling environment for innovation and entrepreneurship, with a focus on cross-border digital infrastructure and digital skills projects.

The programme has the following components:

Investment Facility

- Pooled funding
- Shared risk
- Scale up startups (€2–15 million ticket sizes)
- Strengthen enabling environment for digital innovations

Investment Support Programme

- Awareness-raising
- Community –building
- Matchmaking
- Portfolio development
- Investment portal

One-Stop Shop for Technical Assistance

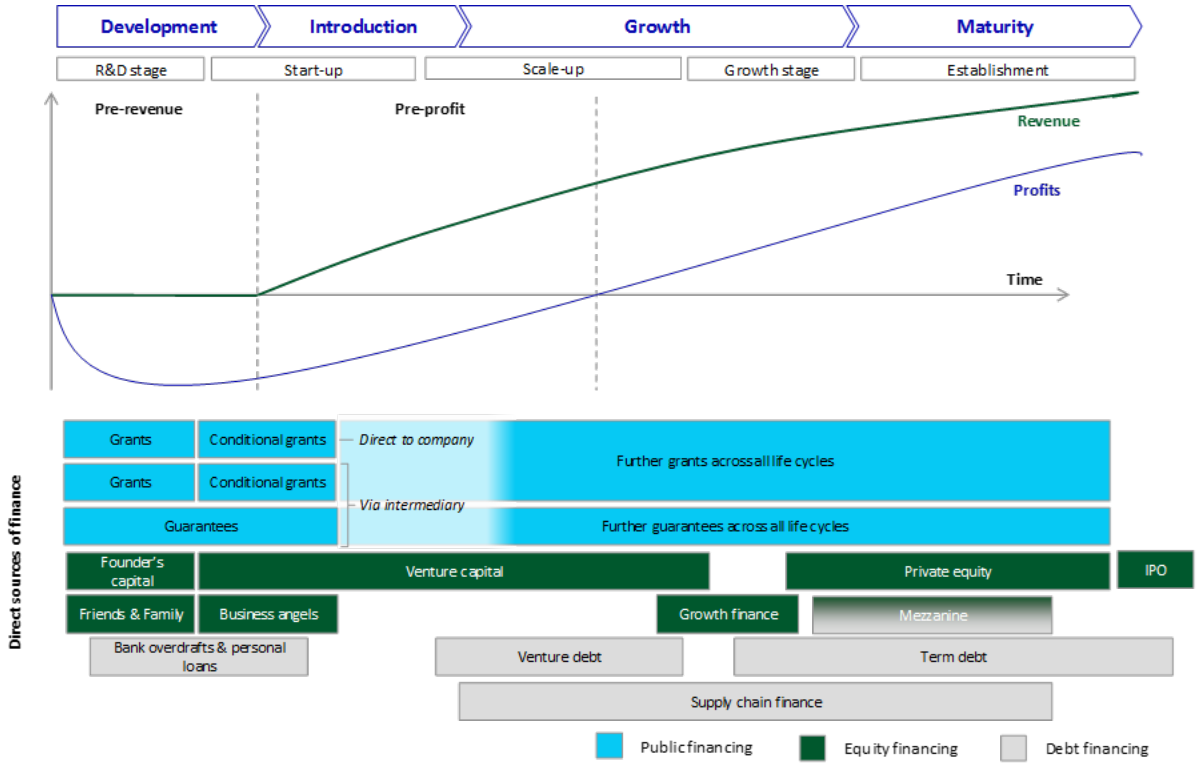
- Capacity-building for public sector
- Advisory services to deep tech startups
- Strengthen regulatory frameworks

Appendix A. Overview of financing at different stages of life cycle

Figure 69 depicts the four stages of the financing life cycle as considered in this analysis:

- Development
- Introduction
- Growth
- Maturity

Figure 66: Overview of financing across the different stages of the company life cycle[249]



[249] Financing the deep tech revolution: How investors assess risks in key enabling technologies (KETs), EIB, 2018.

Appendix B. AI and BC applications across sectors

Table 11: Use cases for AI and BC technologies across sectors

Sector	AI use cases	BC use cases
Agriculture	Use AI to optimise use of fertiliser to boost yields	Store harvesting data in a BC for use in supply chain management
Business intelligence	Use AI to perform revenue forecasts and recommendations based on existing data	Use BC connected with IoT to securely transmit data from Edge devices and inform forecasting
Customer service	Use AI to improve customer interaction through a chatbot	Use BC for better and faster track & trace and verification of package receipt
Education, academic research	Use AI to personalise classes	Use BC technology to authenticate and verify diplomas
Energy	Use AI to optimise energy use in a building	Share data across the energy industry to optimise network usage
Financial services, fintech, KYC, AML/CFT*	Use AI to build a personalised financial assistant	Realise secure, cheap transactions
Government services, social impact	Use AI to better target social welfare programmes	Use BC to share critical data, e.g. on grant performance, and assess them more quickly
Healthcare	Use AI to identify risk groups and/or diseases	Use BC to coordinate care, benefits and payments between all parties in the healthcare system
Human resources	Use AI to improve recruitment processes by selecting optimal candidates	Use BC to securely store personal information or payment data
Industrials, manufacturing	Use ML to schedule preventive maintenance	Use BC to securely store and share manufacturing data
Legal, accounting, insurance	Use AI to design (smart) contracts	Use BC to store and verify smart contracts
Logistics, supply chain	Use AI to optimise routing	Use BC to share information across the supply chain
Media, entertainment, publishing	Use AI to find optimal target groups for advertisements	Use BC to sell, store and verify event tickets
Mobility	Use AI to design autonomous vehicles	Use BC to share location data

Personal assistance	Use NLP to design a voice assistant	Use BC to share payment data
Real estate	Use AI and computer vision to automatically create 3D models and room plans	Use BC to verify transactions
Security	Use AI to optimise cybersecurity	Use BC to verify the origin of news articles

** KYC, know your customer/client; AML/CFT, Anti-money laundering/combating the financing of terrorism.*

Appendix C. Mapping between life-cycle stages and funding rounds

Table 12: Mapping the financing life cycle to VC investment rounds (Preqin)

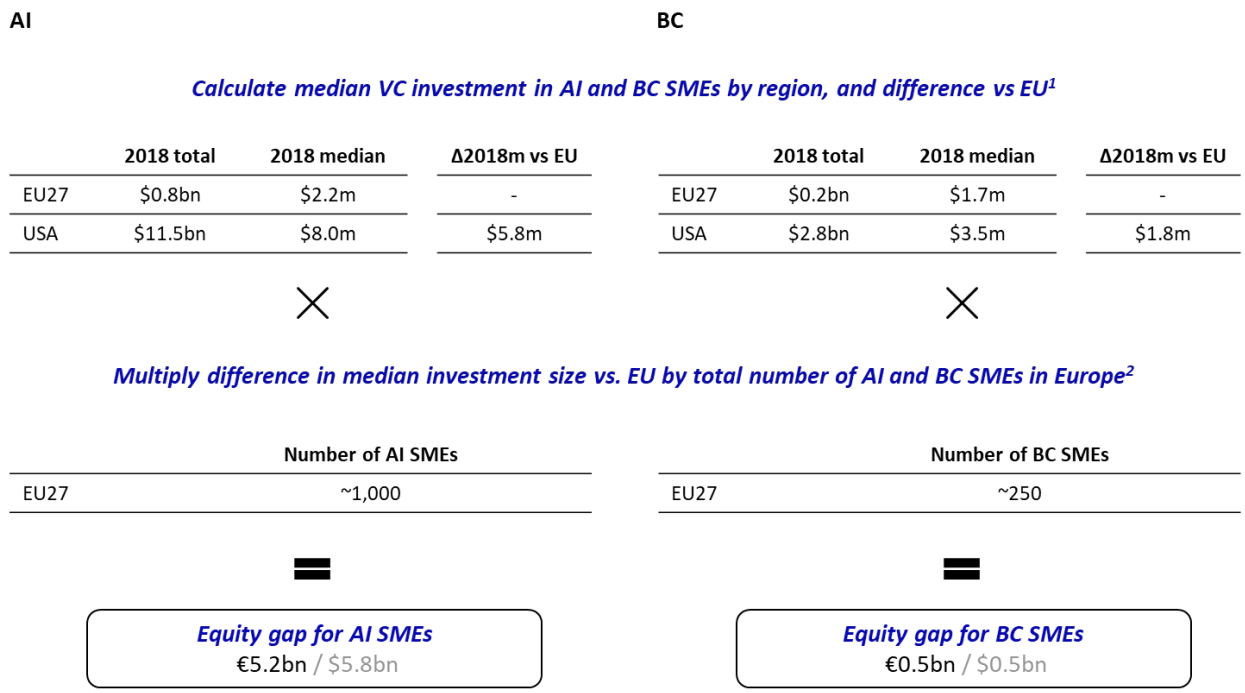
Life cycle	Round
Development	Seed
	Angel
Introduction	Series A/Round 1
	Series B/Round 2
Growth	Series C/Round 3
	Series D/Round 4
	Series E/Round 5
	Series F/Round 6
	Series G/Round 7
	Growth Capital/Expansion
	Add-on
Unknown	Unspecified Round

Table 13: Mapping life-cycle stages to last funding round (Crunchbase)

Life-cycle stage	"Last funding round" from Crunchbase database
Development	Angel
	Equity Crowdfunding
	Product Crowdfunding
	Non-Equity Assistance
	Pre-Seed
	Seed
Introduction	Grant
	Series A
	Series B
Growth	Series C
	Series D
	Series E
	Series F
	Series H
	Corporate Round
	Convertible Note
	Debt Financing
	Initial Coin Offering
	Private Equity
Maturity	Post-IPO Debt
	Post-IPO Equity
	Secondary Market
Unknown	Undisclosed
	Venture - Series Unknown
	#N/A

Appendix D. Additional estimates of equity gap

Figure 67: Bottom-up approach: Median investment gap in the United States vs European Union in 2018[250]



1. Preqin database, total VC investments in the sector; 2. Crunchase database

[250] Preqin data, Crunchbase data, Oliver Wyman analysis.

Figure 68: Bottom-up approach: Median investment gap in China vs. European Union in 2019[251]

AI

Calculate median VC investment in AI and BC SMEs by region, and difference vs EU[1]

	2019 total	2019 median	Δ2019m vs EU
EU27	$2.0bn	$2.9m	-
China	$4.5bn	$11.2m	$8.3m

Multiply difference in median investment size vs. EU by total number of AI and BC SMEs in Europe[2]

	Number of AI SMEs
EU27	~1,000

Equity investment gap for AI SMEs
€7.6bn / $8.3bn

BC

Calculate median VC investment in AI and BC SMEs by region, and difference vs EU[1]

	2019 total	2019 median	Δ2019m vs EU
EU27	$0.1bn	$1.9m	-
China	$0.3bn	$4.6m	$2.7m

Multiply difference in median investment size vs. EU by total number of AI and BC SMEs in Europe[2]

	Number of BC SMEs
EU27	~250

Equity investment gap for BC SMEs
€0.7bn / $0.7bn

1. Preqin database, total VC investments in the sector; 2. Crunchase database

Figure 69: Bottom-up approach: Median investment gap in Germany vs. EU27 in 2019[252]

AI and BC

Germany had the highest median VC investment in AI and BC in 2019 (France ranked second with $4.4m)

Calculate median VC investment in AI and BC SMEs by region, and difference vs EU[1]

	2019 total	2019 median	Δ2019m vs EU
EU27 (excl. GER)	$1.2bn	$2.2m	-
GER	$1bn	$7.8m	$5.6m

Multiply difference in median investment size vs. EU by total number of AI and BC SMEs in Europe[2]

	Number of AI and BC SMEs
EU27 (excl. GER)	~1,000

Equity investment gap for AI and BC SMEs
€5.1bn / $5.6bn

1. Preqin database, total VC investments in the sector; 2. Crunchase database

251 Ibid.

252 Preqin data, Crunchbase data, Oliver Wyman analysis.

Appendix E. Additional survey responses

Figure 70: Most SMEs believe they have the required financial expertise (SME survey results)

Is your enterprise equipped with the required expertise to design a financial strategy, interact with investors and negotiate funding terms?

Response	%
Yes	75%
No, we require more training and coaching	15%
No, we need to hire a finance expert	8%
Other	2%

Figure 71: SMEs believe the public sector could facilitate necessary solutions (SME survey results)

What could the public sector (incl. EIB Group / European Commission) do to promote access to finance / overcome barriers to finance? [You can select up to 3 answers]

Financial support	%
Offer more high-risk type of capital (e.g. venture debt / equity)	27%
Provide more public grants at EU level	17%
Invest more capital in venture capitals	10%
Offer more guarantees to lenders	9%

Enablers	%
Simplify and integrate information about available funding	18%
Facilitate matching between investors and SME beneficiaries (e.g. via online platforms)	10%
Provide more coaching / training	4%
Support incubators / Innovation Hubs	3%
Other	1%

What could the public sector (including the EIB Group/European Commission) do to promote access to finance/overcome barriers to finance? [You can select up to 3 answers]

Financial support	%
Offer more high-risk types of capital (e.g. venture debt/equity)	27%
Provide more public grants at EU level	17%
Invest more capital in venture capitals	10%
Offer more guarantees to lenders	9%

Enablers	%
Simplify and integrate information about available funding	18%
Facilitate matching between investors and SME beneficiaries (e.g. via online platforms)	10%
Provide more coaching/training	4%
Support incubators/Innovation Hubs	3%
Other	1%

Appendix F. Summary of market participant and SME interview responses

Table 14: Market participant interviews

Topic	Key findings	Key quotes
AI/BC market appetite	• **While Europe's VC market still lags behind those of the United States and China, it grew significantly in 2019** – An increasing number of non-European investors entered the European VC market, either directly or by investing into European general partners – EU VC investments in AI/BC grew by ~120% in 2019 vs. 2018 (EU VC investments is about a 10th of total VC investments in AI/BC in the United States) • **AI is core to the investment strategies of many funds around Europe (both specialist – in a few cases – and generalist); however, the same amount of funding is not available to BC initiatives, for which appetite is lower.** According to an EIF survey: – 76% of respondents already have AI companies in their portfolio, whereas only 23% have BC companies – 87% of respondents consider it likely or highly likely they will have AI companies in their portfolio, compared to 51% for BC companies – BC is at an earlier stage and still focused on financial services in investors' minds • **Availability of VC financing is higher in Western Europe but improving in other EU areas** – Germany and France together capture 70% of all AI/BC investments in 2010–2019 – US VCs are increasingly entering the EU market	• *"2019 was possibly the best time ever for European VC, but the coronavirus pandemic has stopped the trend"* • *"The appetite for AI is not lagging much vs. US or China in terms of strategies and intentions, but in terms of realisation"* • *"Western European funds are slowly moving to invest also in Eastern Europe"* • *"There are plenty of opportunities VC funds cannot take because of the lack of funds"* • *"It is not clear how core technology developers are getting funded in the EU"*

	• **Investors have higher preference for sector-specific SMEs (lower risk)**	
Impact of COVID-19	• **VCs are not expected to make further investments until they have more clarity on the crisis, but will eventually resume because their appetite for innovative technologies is strong** • **VCs (especially those relying on public financing) will struggle to raise funds in the market** • **Valuations in the European Union are likely to be substantially reduced** • **SMEs developing core AI/BC applications and those in healthcare, FS and data privacy will likely be positively affected**	• *"Right now, if you have enough funds to invest it is better to make bets on sector-agnostic AI/blockchain developments, because they are not pushed to sell products to companies that deploy them in a sector that might be suffering a crisis"* • *"Pre-crisis valuations were possibly too high. They have decreased now and it is the right time to invest – but we need to raise funds quickly"* • *"What has changed now is that everyone is aware of the need to share data in a systemic way, while keeping the privacy – data privacy technologies will flourish"*
Bottlenecks	• **In the European Union there is a low investment in VCs from big institutional investors (e.g. pension funds, insurance companies); consequently, VCs often cannot finance their portfolio companies beyond initial stages and prefer to sell to make a profit** – EU VC fundraising mostly based on HNWIs and government – Need to find ways to open the market to these investors • **Limited number of private acquisitions and IPOs within the EU27, leading to sale of SMEs to extra-EU investors after initial stages** – There are no big acquirers in Europe (e.g. Oracle) and M&As are rare – EU IPO ecosystem is not well developed, especially for tech • **EU ecosystem is very scattered** – Europe has very little clustering of technology, particularly compared to the United States	• *"Largest investors in US VCs are pension funds, endowments, insurance companies – this is very limited in the EU and it is a major competitive disadvantage"* • *"Chinese and US investors focus on creating national champions and invest heavily in those; EU investments are very scattered"* • *"US West Coast VCs' ambition is to find the "Moonshot," East Coast VCs' ambition is to find future to-be-acquired corporates, whereas Europe VCs focus from Day 1 on profitability"*

  - Resources are not channelled to creating big champions and investing in them throughout all life-cycle stages
- **Public investment programmes make welcome contributions to scaling up the VC market, but have several areas for improvement**
  - Time-to-market is relatively slow
  - They have geographical limitations
  - Criteria are not always transparent
  - (Especially for BC) they do not allow investment in tokens
- **VC investors in the European Union have low appetite for core AI/BC technologies and prefer to invest in products that already have market traction – it is very difficult for AI/BC researchers to access seed/pre-seed financing**
- **Investments in core AI/BC technologies are very technical**
  - This could be particularly limiting in the seed stage, where investments are more localised and it is difficult to deploy the right knowledge
  - Specialised VC/PE firms need to hire technical expertise to perform due diligence (e.g. inspecting code); whereas this is common in the United States, specialised investors are rare in Europe

- *"SMEs tend to move to other, more developed markets (e.g. US) after initial rounds when they grow and need more capital (or as soon as they can afford it)"*
- *"It is not just the money, it is also (or most importantly) the expertise that pushes growing AI companies to go to the US"*
- *"Many SMEs go to the US, because it is more liquid; however, now many US VCs are also coming to the EU, to invest here"*
- *"VCs are not afraid of having sufficient deal flow. They are struggling to raise money"*
- *"Origination and seed are relatively well developed in the EU. SMEs do seed and angel in the EU, then they go to the US and grow their financial network there"*
- *"Banks and other big companies should be pushed to experiment more in partnership with AI and blockchain developers"*
- *"We need to enable researchers from academia to feel comfortable and pursue commercial application of their research"*

Table 15: SME interviews

Topic	Key findings	Key quotes
AI/BC market appetite	• **Appetite in the market is high, especially for AI technologies** • **There is much research in the European Union about AI** • **Appetite is much higher for technologies offering direct/quick market traction, but lower for horizontal technologies**	• *"The EU needs to move fast. COVID-19 is an opportunity to channel resources to climate change and digitalisation"* • *"The EU needs to give strong guidance on where investors should put the money within AI and blockchain, in which sectors"* • *"My strategy is not to use the word blockchain at all"*
Impact of COVID-19	• **Most financing projects are being postponed or cancelled** – Fundraising for SMEs is getting harder, especially in the pre-seed stage (which was already challenging) • **Small SMEs will have to stop hiring, which will affect their growth potential and slow their development** • **Many SMEs see improvements in their competitive position in the aftermath of COVID-19**	• *"It is the worst time for innovative SMEs to raise funds in the last 10–15 years"* • *"Hiring is our main lever for growth. At the moment we cannot grow"*
Bottlenecks	• **Risk appetite is generally lower in the European Union vs. the United States/China, as is investors' patience (core developers need to already have traction with a few customers to raise funding, which poses a significant challenge for many)** • **Most investors that SMEs interact with are not a good match** – Not interested in investing in these technologies – Not equipped with the required expertise to assess underlying technology	• *"70–80% of the investors we met were just not interested in investing in blockchain"* • *"There is still a big reputational problem for blockchain technologies, for which it is not clear what rules apply – investors do not yet fully trust this technology"* • *"SMEs tend to move to other, more developed markets (e.g. US) after initial rounds when they grow and need more capital (or as soon as they can afford it)"*

- **Several SMEs move to other, more developed markets (e.g. the United States) after initial rounds when they grow and need more capital**
- **Europe's SME ecosystem is very dispersed, whereas the United States (for example) has clear technology clusters that help industry flourish**
- **AI developers need access to data to train their models and develop competitive products, which is more complicated in the European Union vs. the United States and China**
  - EU regulations (e.g. GDPR) may prevent growth of AI SMEs and push them abroad
- **Regulatory uncertainty is among the main issues holding back investors, especially in the BC space**
  - Recent regulatory developments (e.g. AMLD5) have helped
  - Several SMEs have moved to geographies with clearer regulation
- **European SMEs (especially AI) lack an ecosystem of corporates partnering with them to give access to more data, develop solutions together (e.g. with banks, retailers) and allow them to grow**
- **Legal, accounting and financial advisory costs are significant in early stages**
- **Public funding programmes can be improved in several respects**
  - Requirements are not clear and transparent
  - Programmes are restrictive on what funds can be used for, but innovative SMEs often need more flexibility

- *"Need investment structures that push investors to take more risks (their risk appetite is low) and be more patient"*
- *"The genesis of core AI and blockchain technologies comes to a large extent from academia: we need to put in place pre-seed solutions to push academics to commercialise their ideas"*
- *"Mix equity, grants and loans so investors can share the risk with other instruments"*

Appendix G. Index

LIST OF FIGURES

LIST OF TABLES

Appendix H. Glossary

Acronym	Definition
AI	Artificial intelligence
AMLD5	5th Anti-Money Laundering Directive (Directive (EU) 2018/843)
AMUF	Asset Management Umbrella Fund
BC	Blockchain
CAV	Connected and automated vehicles
CESEE	Central, Eastern and South-Eastern Europe
COVID-19	Coronavirus disease 2019
CVC	Corporate venture capital
DARPA	Defense Advanced Research Projects Agency
Deep technology	Unique, differentiating, hard to reproduce, technological or scientific advances that require a thorough understanding of the technology and market to understand their potential
DEP	Digital Europe Programme
DIH	Digital innovation hub
DISC	Digital Innovation and Scale-up Initiative
DLT	Distributed ledger technology
EBP	European Blockchain Partnership
EBSI	European Blockchain Services Infrastructure
EIB	European Investment Bank
EIC	European Investment Council
EIF	European Investment Fund
EGF	Pan-European Guarantee Fund
EU13	13 newest members of the EU: Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia
EU27	EU Member States as of 2020
FO	Family office
FoF	Fund-of-funds
FWCI	Field-Weighted Citation Impact
GDPR	General Data Protection Regulation
HNWI	High-net-worth individual
ICO	Initial coin offering
ICT	Information and communications technology
I-DESI	International Digital Economy and Society Index
IEO	Initial exchange offering
IIA	Israel Innovation Authority

INATBA	International Association for Trusted Blockchain Applications
IoT	Internet of things
IP	Intellectual property
IPO	Initial public offering
KETs	Key Enabling Technologies 1) Nanotechnology 2) Advanced manufacturing and processing 3) Biotechnology 4) Advanced materials 5) Micro- and nano-electronics 6) Photonics
LP	Limited partner
MFF	Multiannual Financial Framework
ML	Machine learning
NLP	Natural language processing
NPBs	National promotional banks
OECD	Organisation for Economic Co-operation and Development
RCA	Revealed comparative advantage
R&D	Research and development
R&I	Research and innovation
RRF	Recovery and Resilience Facility
SMEs	Small and medium-sized enterprises
STO	Security token offerings
PE	Private equity
VC	Venture capital

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Artificial intelligence, blockchain and the future of Europe:

How disruptive technologies create opportunities for a green and digital economy

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