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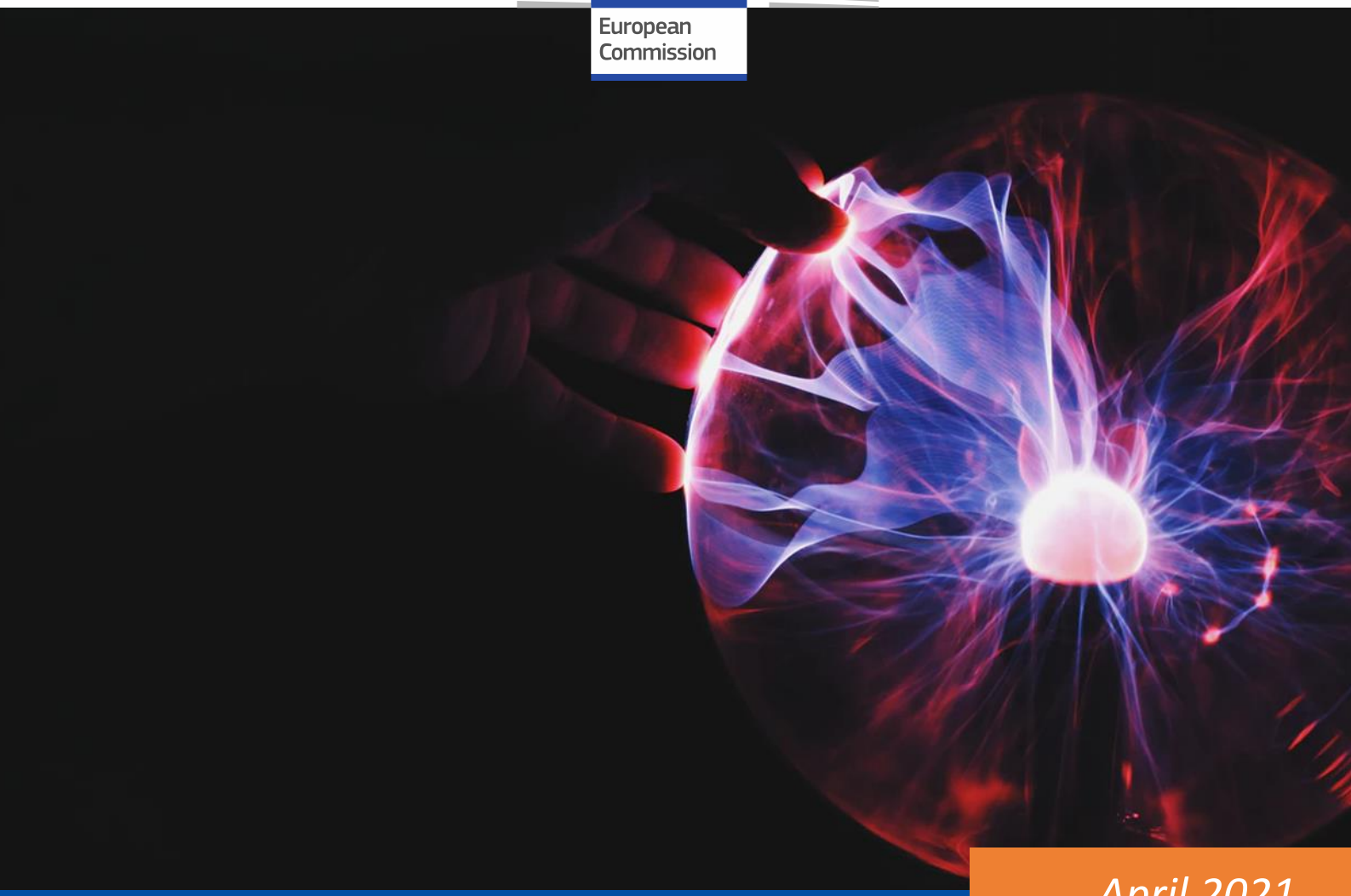

April 2021

Advanced Technologies for Industry – AT WATCH

Technology Focus on Blockchain

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Section 1

1. Introduction

This Advanced Technology Watch report has been developed in the framework of the 'Advanced Technologies for Industry' (ATI) project, initiated by the European Commission, Directorate General for Internal Market, Industry, Entrepreneurship and SMEs and the European Innovaiton Council and Small and Medium-sized Enterprises Executive Agency.

As part of a series of analytical reports on advanced technologies' trends, this report focuses on Blockchain as one of the key technologies that are currently bringing about impactful changes in Europe's banking and finance sectors, as well as in other European industries. The AT Watch report series is meant to play a complementary role to the other analytical, policy and statistical reports of the project, by focusing on market, business and socio-economic trends driven by technology innovation. This Advanced Technology Watch encompasses therefore the whole set of advanced technologies that are a priority for the European industrial policy. These technologies enable process, product and service innovation throughout the economy, thus fostering industrial modernisation.

The qualitative and quantitative analysis included in this Advanced Technology Watch is specifically designed to provide novel insight and up-to-date content to technology users across the whole set of the European industry. This, with the aim to unveil the potential opportunities emerging from the most recent applications of advanced technologies.

The AT Watch report series aims at:

- a primary audience of industry stakeholders, including SMEs, and industry associations interested to learn about upcoming technology trends and business opportunities;
- a complementary audience of national/regional/local policy makers, interested to support industry in the exploitation of technology innovation and emerging business opportunities, by removing barriers and creating favourable market conditions;
- a complementary audience of research and technology stakeholders interested in the applied research challenges to be solved in order to capture the emerging business opportunities.

Each report is thus structured along two main sections:

- A brief overview of all Advanced Technologies uptake and demand trends by industry (Section 1: Technology Landscape)
- A more in-depth analysis of one of the Advanced Technologies, selected because of its relevance in terms of emerging business opportunities and disruptive potential (Section 2: Technology Focus).

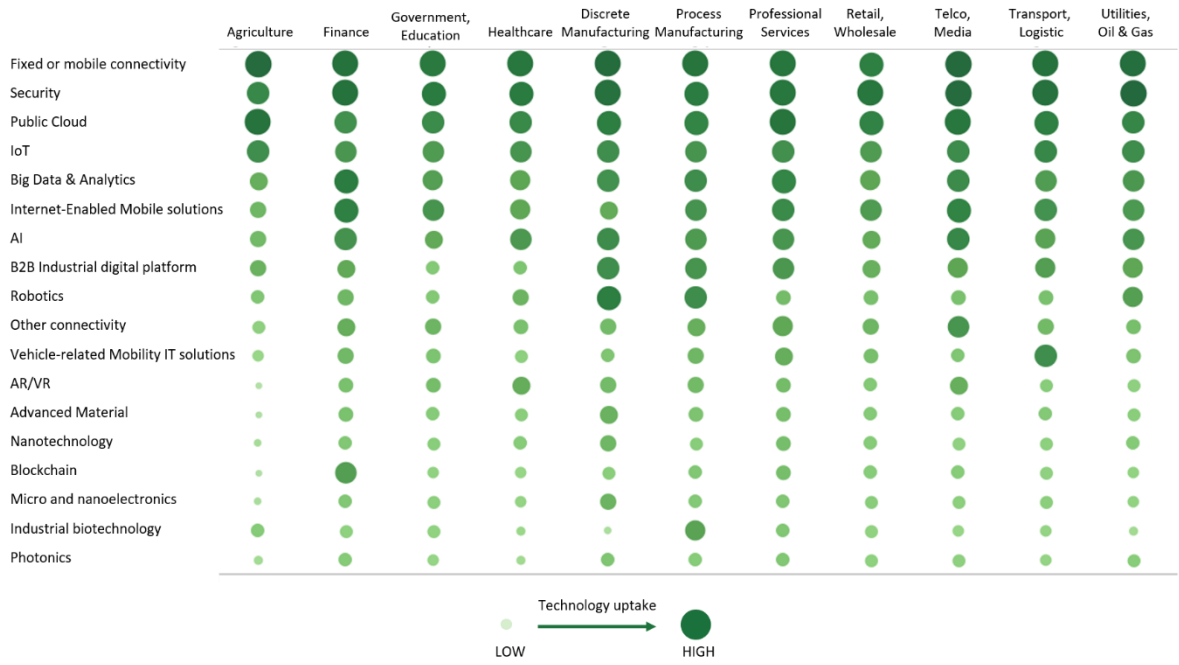
1.1. The Advanced Technologies for Industry landscape

The digitisation and industry modernisation process in Europe is progressing at different speeds across all industry sectors, driven by a whole set of changing priorities, challenges and use cases. Advanced technology adoption has been impacted by the pandemic, resulting in a slowdown necessary to allow companies to focus on more business contingency related initiatives. At the same time, the COVID-19 has sped up the adoption of some specific technologies through forced digitisation of customers and supply-chains interactions and all the related internal processes. These technologies are acting as 'return-to-growth' accelerators, making businesses and organisations as a whole more resilient for the future scenario. However, throughout the path to recovery, the focus will be more on safe bets than big bets.

The different mix of advanced technologies adopted by each industry is visualised in

Figure 1 The figure shows the percentage share of enterprises in each industry adopting or planning to adopt each technology (the size of bubbles corresponds to the level of uptake, with the highest value being 85%). The data is based on the Advanced Technologies for Industry Survey (November 2020)[1] and on a sample of European enterprises from 7 Member States, representing more than 60% of the EU GDP in 2020. This is an updated version of last year the ATI Survey conducted in July 2019.

Figure 1: Advanced Technologies Uptake by European Industries, 2020



Source: Advanced Technologies for Industry Survey November 2020, (N=1 547).

Note: Bubble size represents the % of enterprises in the industry adopting the technology in the same row. The maximum value is 85%.[2] Technologies are ordered top-down based on the total sample average adoption.

The visualisation highlights how a distinct group of technologies **features a marked horizontal diffusion** across all industries (general purpose technologies Connectivity, Security, Public Cloud, Mobile solutions, Big Data & Analytics, Internet of Things (IoT) and Industrial Digital Platform): they represent the technology portfolio necessary (but not sufficient) for digital transformation. **Other technologies clearly display a niche or industry-specific orientation**. However, this does not mean that they do not provide opportunities for investments outside their main industry niche. Robotics is a very interesting example: the technology was initially developed in manufacturing, where it served as a substitute to human workforce in several time-consuming tasks, helping human to save time and speed up production. New areas of applications are now emerging, and multiple novel use cases proliferate in order to drive business value in other industries. For instance, in manufacturing, Robotics

[1] The survey interviewed a sample of 1,547 enterprises with more than 10 employees in DK, DE, FR, ES, IT, PL, SE.
[2] The technology definitions can be found in the methodological report at https://ati.ec.europa.eu/reports/eu-reports/advanced-technologies-industry-methodological-report

is used for a wide variety of tasks, from shop floor production automation to warehouse inventory management. Similarly, Robotics exhibits a great potential in the healthcare sector where it can be used to support the medical personnel enhancing procedures' safety, reducing operative costs, disinfecting rooms, preparing and storing medications and much more. Compared to the previous survey, industries show some similar technological patterns: connectivity, public cloud and security technologies are among the most adopted technologies, with small differences across industries, while advanced materials, nanotechnologies and industrial biotechnology represent a niche of few sectors, such as manufacturing and healthcare. Compared to 2019 results, IoT and AI show an interesting increasing pattern in Transport and Healthcare, while B2B industrial digital platform is quickly taking ground in manufacturing and agriculture. Firms in the finance sector are more and more interested in Robotics, which represent the highest increase in adoption rate across industries, proving the high potential this technology can provide to the sector. Referring to Robotics, respondents mainly referred to Robotic Process Automation (RPA), which finds very fertile ground in this sector. On the other side, some technologies are slowing down: while industrial biotechnology is increasingly adopted in manufacturing, it is decelerating in utilities. A similar trend is shown for the public cloud in healthcare and retail.

When looking at the European industries in more detail, we observe that:

- The operational excellence that the **manufacturing industry** is looking for will be achieved through the adoption of advanced technologies. This operational improvement will be of paramount importance in ensuring performance during the next normal. In fact, COVID-19 impact on trade caught many firms unprepared, with negative consequences on supply chains. This event drastically changed the focus from a low-cost country sourcing mantra to a more resilient and simple network. Implementing new technologies is turning supply chain processes and activities towards less uncertainty and complexity. Technologies like **Robotics, AI, IoT, Blockchain and Edge Computing** are the key drivers to achieve these goals, together with efficiency benefits and zero-touch production (ZTP) processes, the latter being pushed significantly during the pandemic and becoming a strategic asset for the future of enterprises. Efficiency is also fostered by **ARVR** solutions that allow experts to provide remote support to on-field operators and guide them through step-by-step instructions. **B2B digital platform** is also a key trend in the manufacturing industry, pushing for a more collaborative relation between colleagues, peers and employees. This opportunity is deeply connected to **Big Data/analytics** technology, which allows to track and analyse processes, improve operational visibility and understand improvements and trends. **3D printing** has shown its huge potential in creating and modifying manufacturing and healthcare products during the pandemic, proving to be a key trend in the next years. Product innovation is also driving the adoption of **Advanced Materials, micro and nanoelectronics, nanotechnologies and photonics** with the aim to improve products and reduce costs.
- In **finance,** besides operational efficiency, the other main business goal driving investments in advanced technologies is the need to attract and retain customers. This is pushing the industry towards piloting new service delivery models. **AI**, **Big Data** and **Blockchain** are among the most promising technologies for the industry as they enable automation of internal operations, improve customer service and enhance protection against security threats. To counter the uncertainty of the new reality and improve loan portfolio health, **Advanced Analytics** is making it possible to analyse every payment that a corporate or small business makes and receives. Key AI trends in the industry include automation of IT operations and opening new digital channels to improve customer experience leveraging voice banking and chatbots. Blockchain main applications include for example cross-border payments and settlements. **Robotics**, mainly in the form of Robotic Process Automation (RPA), is changing how banking and finance companies carry out business through fraud detection, auditing and reducing time-consuming workloads. To keep pace with the information security risks, **Security Technology** represents a key element for the financial sector. The industry has also been central to the emergence of a new digital economy, the open banking, which is connected to the European payment services directive (**PSD2**[3]). Customers will therefore look for more suitable and personalised products and services, not being obliged to use what the traditional financial institutions provide to them, and will drive the next wave of growth of the fintech sector.
- For **telecom and media** providers, new technologies and new customer behaviours are generating several opportunities to boost current income sources and generate new revenue streams. **5G technologies,** for example, are expected to provide many monetisation

[3] https://ec.europa.eu/info/law/payment-services-psd-2-directive-eu-2015-2366_en

opportunities for telco, although the pandemic has led to a delay in the technology's rollout as a result of the post-crisis economic condition. **Robotic and Blockchain** reduce error rates, enhance data quality, improve customer service, ensure transparency and efficiency, while also significantly reducing operational costs. The provision of the necessary network infrastructure and **connectivity** for voice, data, media and other related services will become even more important in next years given that businesses have become more distributed than ever after the COVID-19 pandemic. To ensure that their infrastructure will meet the need for digital initiatives in the coming decade, enterprises and service providers are reconsidering how their networks are architected. The increasing volume of personal data gathered in this sector is pushing towards more and more sophisticated **Security** solutions, making it a real priority even among other high-risk industries. Interesting pockets of growth can be found also in investment in other advanced technologies, such as **Photonics** which are supporting the development of fibre optic network communications. As said at the beginning, media transformation process had been driven by changing customer needs and behaviours: innovation in the industry has been driven by new channels and platforms for distributing, accessing and producing content. Streaming, content-as-a service and new technologies for creating engaging entertainment experiences, such as wearables and **AR/VR** technologies, are major trends under the spotlight.

- **Utilities** and **Oil&Gas** show interesting opportunities in terms of many advanced technologies, but the pandemic outbreak inevitably cooled down European utilities' IT spending ambitions. In this context, **Artificial Intelligence** and **cybersecurity** competencies are more requested than ever as a fundamental asset to come out of the current crisis and be ready for the next normal. Hot spots in the industry are the **e-mobility revolution** and **AI-powered home energy management**. Electric vehicles are expected to be a mass-market revolution, driven by increasing sustainability concerns and blurring industry boundaries between power distribution and retail, transportation and automotive. The quest for **alternative and sustainable energy sources** is also paving the way to the use of advanced technologies such as **photonics** and **nanotechnologies** for power generation and for new and more efficient lighting solutions. **Robotics** and **IoT** are fastly spreading in these sectors, increasing productivity, lowering labour costs and, most importantly, keeping workers safe for dangerous tasks, providing a high degree of accuracy and efficiency. The second mass-market revolution is the smart home ecosystem where utilities can play a big role in providing advanced home energy management solutions and automation functionalities using devices such as smart plugs, thermostats and smart lighting for optimising energy consumption but also for getting insights into consumers' habits.
- The **healthcare industry** shows some interesting investments in **AI, Robotics, AR/VR, Nanotechnology and Advanced Materials**, compared to the other industries. Uptake of advanced technology in the industry is strictly linked to the need to innovate and improve patient care, providing integrated and personalised services. The outbreak of COVID-19 has put enormous pressure on many European healthcare systems but triggered an unprecedented demand for digital health technology solutions at the same time. **AI, Automation** and **advanced analytics** are not just solutions to put on top of a technology stack, but the intelligent core of a new enterprise platform. **Robots**, especially for surgery and logistics purposes, are becoming more affordable, and hospitals will start to invest more significantly in the upcoming years. Investments in **wearables, IoT and AI** are growing with the need to monitor patient behaviour and accidents for elderly people with medical conditions to provide prompt emergency help. **AR/VR** devices are helping doctors improve surgery and diagnosis and are also used for therapeutic purposes (e.g. rehabilitation).
- COVID-19 has disrupted the **retail** sector, with different impacts depending on several variables (brick-and-mortar versus online shops, essential versus non-essential stores, small versus large retailers). Overall, the industry impact has been significant although advanced technologies played a key role in supporting organisations in the industry along their COVID reaction initiatives. The **e-commerce** channel, where consumers can finalise their purchases using their PCs or **mobile** phones, remains a priority for retailers and a successful strategy during the COVID-19 pandemic crisis. A key focus of retailers as an immediate crisis response was accelerating the implementation of retail commerce platform capabilities, providing retailers with the foundations for the execution of new commerce everywhere business models. As more customers are switching to mobile commerce, customer assistance and support are also changing. Through **AI-enabled chatbots**, customers can contact companies on social

platforms to track shipments, request product refunds or raise complaints. COVID-19 will have a long-lasting effect on customer experience, and in the years to come, it will push retailers to permanently integrate contactless solutions into their customer experience road maps. A growing opportunity in the industry is represented by **real-time contextual personalisation** for the customer, which allows retailers to shape the customer experience in relation to multiple parameters such as demographics, location, day/time, weather and purchasing patterns. **Advanced Analytics and Big Data** are crucial to achieve this degree of personalisation. **Photonics** is also gaining ground compared to the other industries, helping for example retailers of Consumer Packaged Goods (CPG) and customers to judge the ripeness of fruit and vegetables, and so reduce the percentage of discarded food, or through more dynamic use of displays.

- The pattern of technology adoption by **Government** and **Education** is influenced by the national context and the coronavirus crisis. Public sectors of all countries tried to cope at their best with the current downturn, through massive injection of resources to support the economy and by putting in place multiple advanced technology-enabled emergency solutions. Governments are working to streamline internal bureaucratic processes through **automation** to speed up critical government work, resulting in more agile access services. **AI** solutions will support citizens with the right level of speed, quality and personalisation, while it will provide remote management of the workforce. After the emergency-driven experience of distance learning during the lockdown period, **Education institutions** in Europe are prioritising investments in **mobile solutions**, for example investing in the provision of mobile devices. Lesson are carried out via **distance learning,** with the development of online platforms and e-learning apps for students. At the same time, some changes accelerated by COVID-19 are likely to become permanent: governments are moving towards **permanent remote working**, where secure remote access to data and applications, and collaborative tools enable them to work across departmental silos. **Smart city** projects, combining **mobile, IoT and Big Data/Analytics** solutions, are expected to push investments in technology, especially for safety purposes (such as video surveillance) and for public transport optimisation. **Security** of digital services is therefore a top priority so that both citizens and civil servants can trust their reliability and the stewardship of sensitive data. Another driving trend in the industry is represented by the **open data portals**, with the aim to improve transparency, openness and interaction by sharing public data with citizens.
- Although the pandemic has significantly tested **Professional Services** firms, they reacted with agility, evolving their services and business models to cope with the changing environment. Despite considerable challenges, this sector performed quite well, mainly when they had an adequate technological infrastructure that allowed to continue their daily business processes and operations. Professional services are carrying out their activities in a more agile and flexible way, such as **working from home**, which is supporting investments in devices (laptops, smartphones, tablets), collaborative apps, video linking, cloud and content sharing. Tech providers in this industry will also be on high pressure to provide strong digital platforms and will be required to enhance their existing **cloud solutions**. As a data-intensive vertical sector, an important share of Professional services' investments in security will be driven by the implementation of GDPR (General Data Protection Regulation). This will drive the industry to raise technology barriers to protect client sensitive information and avoid data breaches. The pandemic has changed the relation between customers and services providers but **Big Data/analytics** together with **AI** and machine learning are providing deep analysis of customers, leading to more accurate customers intention prediction and competitive advantage. Digital technologies are changing the industry in their client-facing and back-end activities. For example, advanced technologies will be able to automatically process documents such as legal, shareholder and market reports, impacting positively on timing and freeing staff from tasks that can be automated.
- **Transport** has been one of the main affected industries from the pandemic, squeezed between safeguarding its workforce health and keeping a core transportation system operational. However, this crisis is expected to accelerate the digitisation of mobility. **Cloud** computing and **Big Data/Analytics** are playing a crucial role in collecting, sharing and analysing real-time data, providing an effective way to identify and quantify disruption. These data will also allow restoring adequate transport services accordingly to the increasing demand as we move towards

a new normal. Mobility as a Service is offering people an available alternative to get around safely during the pandemic. Other technologies, such as **IoT** and **AI** will keep playing a key role in supporting industry companies to regulate traffic flows, streamline security checkpoints with biometrics such as facial recognition, and reduce the number of lost bags using electronic luggage tags. In logistics, heavy workloads can be eased by introducing solutions to create collaborative environments in which **humans coexist with robots**, with the latter taking over heavy, repetitive and time-consuming tasks.

- The pandemic has exacerbated the challenges **agriculture** was already facing, including increasing demand for food, and lack of workers. This is the reason why this sector has to rely even more on advanced technologies, which will increasingly play a fundamental role in addressing these issues. **Data-driven innovation** is transforming farm management through the so-called **precision agriculture** approach. By leveraging **satellites, drones and IoT sensors**[4] in farm equipment (such as tractors), an unprecedented amount of data can be collected to monitor the conditions of the crops, soil and other key elements for cultivation, as well as cattle. **Cloud computing** – that is finally taking ground in this sector, especially among large players - will help aggregating all the data gathered, allowing farmers to manage irrigation, fertilisation and all the farming processes in a scientific way, minimising costs and the use of pesticides and maximising outputs. Without a solid **Connectivity** infrastructure, a successful application of all these innovations is unthinkable. The digitisation of the farming processes represents also the first step for the emerging food track-and-tracing systems developed to guarantee quality and safety, highly appreciated in the food-agriculture value chain. Advanced technologies show interesting uses also in fighting **climate change and related risks** (such as the loss of arable land and increased urbanisation). For example, a growing trend is represented by **urban or vertical farms,** leveraging technologies to minimise the use of natural resources such as soil, water and energy. This is done by using **IoT** and **Photonics** to manage parameters such as humidity, light and irrigation to get the most out of crops. **Industrial biotechnology** shows also interesting promises for obtaining alternative healthy, protein-rich and nutritionally balanced food raw material responding to increasing population and food demand.

This overall picture of advanced technologies' deployment in the European industry is to a certain extent reflected by the analysis of the demand and supply of advanced technologies' skills carried out in the report on the General Findings within the framework of the present project[5]. In terms of skills supply, and based on the profile of registered users on LinkedIn, the share of advanced technology skilled professionals (vis-à-vis the total number of professionals) in selected industries reveals that Europe's manufacturing industry absorbs the highest number of skilled professionals. This is particularly true for the Automotive sector where technologies such as Advanced Manufacturing and IoT are clearly instrumental for the development of Industry 4.0 strategies.

Other industries such as Electronics and, to a lesser extent, Chemicals, employ a large amount of skilled professionals, especially for technologies like Advanced Manufacturing and IoT (in Electronics) and Advanced Materials and Industrial Biotech (in Chemicals), confirming that manufacturing as a whole remains at the forefront of the the digital transformation and modernisation processes in the European Union.

In terms of skills demand, manufacturing exhibits high levels of hiring positions measured by the number of online job advertisement requiring specific skills. Again, the Automotive sector requires specific skills in Advanced Manufacturing, AI and Robotics, just like the Electrical & Electronics exhibits strong demand of skills in Advanced Materials, Micro-nanoelectronics, nanotechnologies and Robotics. The prominence of the Manufacturing industry is challenged only by the Finance sector where, both in Banking and Financial Services, specialised skills for Big Data, Blockchain, Cloud Computing and cybersecurity are very much in demand across the European Union

[4] ATI Product Watch (D3.6) "Satellites and drones for less intensive farming and arable crops", January 2021, https://ati.ec.europa.eu/reports/product-watch/satellites-and-drones-less-intensive-farming-and-arable-crops

[5] ATI General findings (D3.4), Section 5, June 2020, https://ati.ec.europa.eu/reports/eu-reports/report-technology-trends-technology-uptake-investment-and-skills-advanced. An updated version of this report including the AT skills analysis will be published this year (2021).

Section 2

2. Technology focus: Blockchain

Few emerging technologies that rose to prominence in the last 10 years have been subject to so much interest, expectations and misunderstanding as Blockchain. The genesis of the technology began in 2008 when the pseudonymous Satoshi Nakamoto published a paper titled 'Bitcoin: A Peer-to-Peer Electronic Cash System', though precursors of Blockchain can be traced back to the early 90's. Nakamoto's paper outlined a system for peer-to-peer transactions and without relying on trust (and financial institutions to serve as intermediaries). The ideas in the paper were put into practice in early 2009 when the Bitcoin Blockchain network was launched.

Bitcoin set the template for what Blockchain technology is: a digital, distributed ledger of transactions or records. The Blockchain ledger, which stores the information or data, exists across multiple participants in a peer-to-peer network. There is no single central repository that stores the ledger. Blockchain allows new transactions to be added to an existing chain of transactions using a secure digital or cryptographic signature. Blockchain technology allows the data to exist on a network of instances or 'nodes', allowing for copies of the ledger to exist rather than being managed in one centralised instance, as seen in many traditional systems. Blockchain is designed to be an incorruptible, decentralised network with enhanced security properties, allowing data and transactions to be immutable.

The exact mechanism through which Blockchain aggregates, validates and relays transactions can vary but all Blockchain ledgers have common features: distributed, decentralised consensus, transparency. **Distributed** is a critical area that distinguishes Blockchain from traditional databases and allows transactions to be stored on a network of participants. It eliminates the risks that come with data being held or validated centrally as everyone has access to the ledger. **Decentralised consensus** eliminates the role of a designated administrator to approve, clear and settle transactions on the ledger. This differs from the centralised database that most companies use today. **Transparency** comes with Blockchain-based time-stamping of a date and location. As each transaction and asset has a distinguished provenance, it enhances trust among participants.

The terms **Distributed Ledger Technology (DLT)** and Blockchain are often used interchangeably, but from a technological standpoint they are not the same. Distributed ledger technology is an umbrella term that is used to describe technologies that distribute information, data or records. Blockchain is one form of distributed ledger technology, as not all distributed ledgers require a chain of blocks to aggregate, validate and relay transactions in a secure manner. While every Blockchain is a distributed ledger, not every distributed ledger is a Blockchain. For the sake of simplicity, we will use Blockchain and DLT interchangeably in this report.

The first few years following the creation of Bitcoin saw a proliferation in the number of cryptocurrencies. Though these new cryptocurrencies may have differed in their architecture they essentially emulated Bitcoin and presented a limited vision of what Blockchain can do: store and transfer of value directly between two participants without the need for intermediaries such as banks. In practice Blockchain and cryptocurrency were the same thing as this was the only application of the technology.

Little by little early experimenters realised that Blockchain technology has a potential to be applied in industries and use cases far removed from the financial industry. Basically, the technology underpinning Bitcoin can be separated from the cryptocurrency application and used for interorganisational cooperation. A big development in that direction was the launch of the Ethereum Blockchain in 2015. Ethereum not only provided its own cryptocurrency Ether but added the ability to record other assets and additional functionality such as running distributed applications (software applications that run on multiple systems simultaneously) and smart contracts (self-executing contract with the terms of the agreement written into lines of code).

After these crucial breakthroughs there was a proliferation of use cases that spread to virtually all major industries. By 2017 expectations around the technology reached such a fever pitch that many predicted the technology would usher in such a disruptive change that would rival the creation of the Internet. When inevitably such expectations were not realised there was a disillusionment on part of the business

community. Overinflated expectations led to negative perceptions that still linger to this day and have made some organisations lose interest in the potential and opportunities that Blockchain holds.

Blockchain technology remains widely misunderstood but still presents clear opportunities for the private and public sector. These opportunities may not meet the sky-high expectations a few years prior but harnessed properly they can bring enormous benefit to both the private and public sector. That is why the goal of this report is to examine market potential of Blockchain as well as to present leading Blockchain use cases and business opportunities that stem from it. It will also examine how the technology can be harnessed for social and environmental good and how public and private sector entities within the EU can take advantage of the opportunities presented.

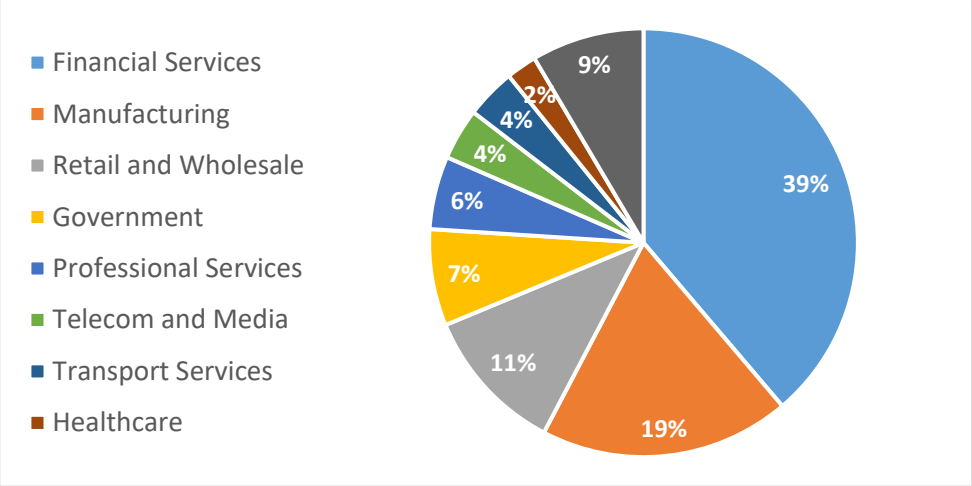
2.1 The market potential

2.1.1 Adoption and industry trends

As the technology behind a few nascent cryptocurrencies[6], Blockchain saw very little increase in adoption in the first five years of its existence. The key proponents of Blockchain were developers and very-technically minded people who were fascinated by the technology itself and did not necessarily worry about making Blockchain very accessible. Eventually, when Blockchain branched out from its cryptocurrency beginnings around 2015, there was an explosion of projects aiming to harness the power of Blockchain for variety of use cases across industries. Some of them focused on building new Blockchain protocols (the foundation on which Blockchain-based solutions are built) while others decided to concentrate more on the solutions themselves. Large multinational tech giants were also attracted by the opportunities that the technology presented. By 2017 Blockchain had spread from the fringes of the tech world into the boardrooms of large corporations and into the minds of many entrepreneurs around the globe.

The explosion in activity and interest pushed companies across industries to experiment with Blockchain and that was reflected in Blockchain spending across Europe. According to the IDC Worldwide Blockchain Spending Guide, European spending on Blockchain grew from around $400 m (approximately €330 m) in 2018 to $1 200 m (approximately €990 m) in 2020 and is projected to grow to $5.7 bn (approximately €4.7 bn) by 2024. The impressive growth in spending for the past couple of years has been fueled by the spread of Blockchain-based solutions in all major industries (far beyond finance), diversification in the type of use cases, maturation and enterprise-readiness of the technology, and scaling up of pilot projects. However, spending is unevenly distributed and concentrated in a few major industries.

Figure 2: Total Blockchain spending % value by industry, Europe, 2020



Source: IDC Worldwide Blockchain Spending Guide, August 2020

Note: "Others" include the following industries: Resource Industries, Education, Construction, Personal and Consumer Services, Utilities)

The financial sector is by far the largest sector with close to 40% of total Blockchain spending in Europe. The massive size of the sector is no surprise, considering the cryptocurrency origin of the technology and the fact that finance was the first industry to embrace Blockchain technology. That

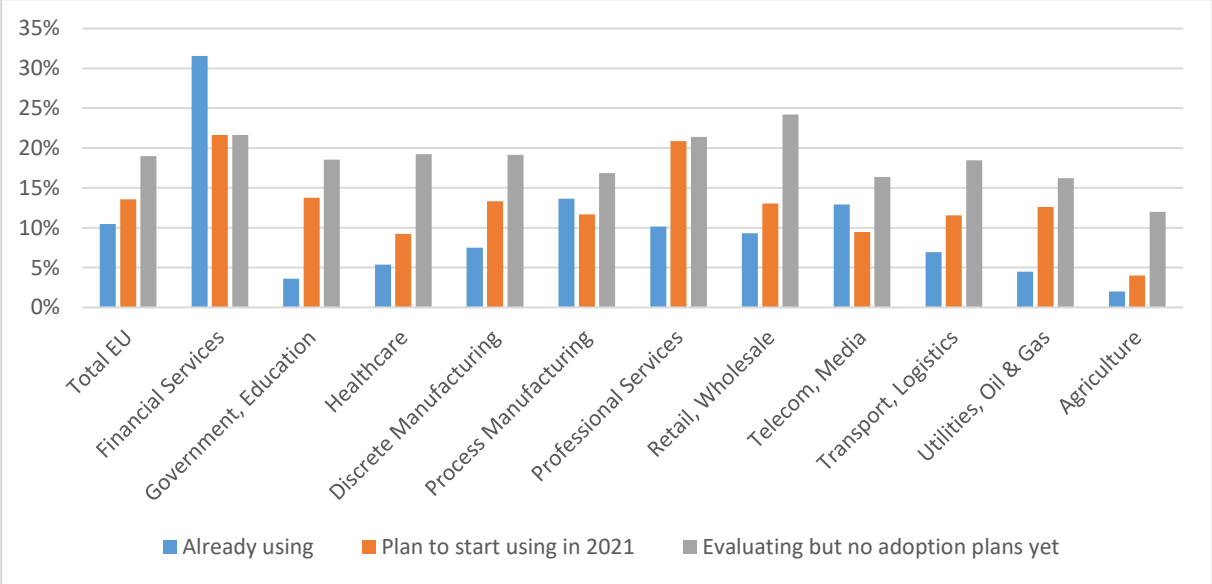
[6] https://link.springer.com/article/10.1007/s11187-019-00309-8

sizeable share of spending is even more impressive when taking into account that it does not count central bank digital currencies, digital currencies or cryptocurrencies. Nevertheless, the share of total spending has gradually fallen as Blockchain-based solutions are applied in more and more industries.

The manufacturing and retail/wholesale were the first industries to experiment with and adopt Blockchain after the financial sector and collectively they are responsible for 30% Blockchain spending in Europe. These industries rely on sourcing products, parts and ingredients by leveraging a network of suppliers that span the globe. Having long, complex supply chains means dealing with an avalanche of information, analysing inventory across partners, warding against counterfeits, making sure that products are properly sourced and guaranteeing that they meet stringent quality requirements. On top of that there are stringent compliance rules and complex bureaucracy that has to be followed when products cross country borders. The COVID-19 pandemic has amply demonstrated how even one break in a supply chain can cause whole industries to halt vital operations. Blockchain is particularly well suited to address these challenges because it increases transparency, trust and accountability among all participants by providing a single source of truth, automating compliance and providing an immutable audit trail. The need for more transparent and resilient supply chains will continue to drive Blockchain adoption across manufacturing, retail and wholesale.

European **governments** have recognised the potential that the Blockchain technology is offering by providing a more secure and efficient way to store and retrieve sensitive information. Thanks to the decentralised way data is managed, Blockchain enables governments to consider new models of trust that are not controlled through a single organisation or dependent on legacy models of identity verification. In the wake of social distancing measures, Blockchain can help agencies simplify interactions with citizens or make services accessible online. Services can be automated by enabling data in a Blockchain to be seamlessly shared with other agencies or third parties once predefined conditions are met. The shining example here is Estonia whose e-government provides 99% of its services online and uses Blockchain-like technology to store information.

Figure 3: Blockchain adoption across industries within the European Union (share of respondents)

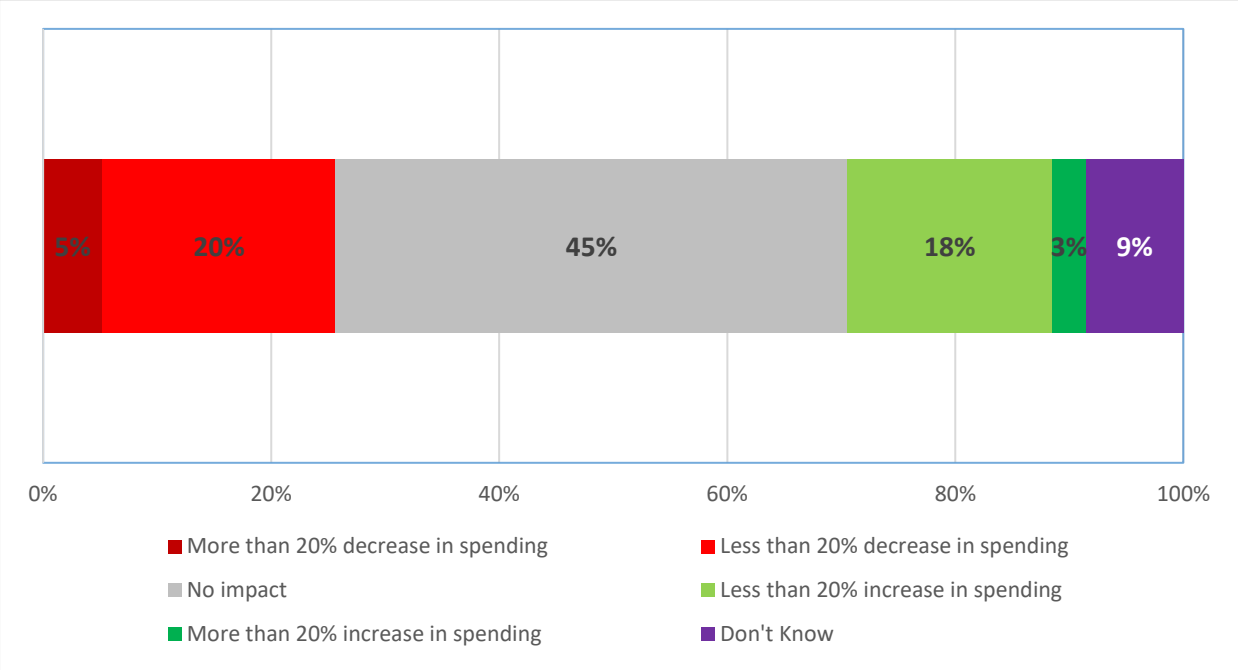


Source: European Advanced Technologies for Industry Survey, November 2020, (N=1547)

The ATI Survey shows that at the end of the 2020 around 10% of EU companies across all major industries are using Blockchain. The adoption rate shows that the technology is no longer on the fringes, but it still needs a lot of growth to reach anything close to a critical mass of adopters. That 10% adoption rate does not tell the whole story as most of the European companies are still experimenting with the technology and running small scale projects and trials, with a fraction of them scaling up these initiatives. It is no surprise that industries that spend more on Blockchain like finance, retails/wholesale and manufacturing have higher percentage of companies adopting the technology. Though that relationship is not perfect and companies in an industry like telecom and media have a high adoption

rate despite spending disproportionally less on Blockchain. One reason is that telecom and media companies tend to go for smaller Blockchain-based projects and deployment is generally quicker. Another reason is also the composition (number and size) of companies in each industry, so an imperfect match between spending and adoption is normal.

Figure 4: Impact of COVID-19 on Blockchain spending in Europe



Source: IDC European IT Buyer Sentiment Survey Wave 15, 4-14 December 2020, (n=430)

The economic toll of the COVID-19 pandemic has forced many European enterprises to reduce technology spending. The pandemic also pushed for stronger financial discipline, and for many European companies, Blockchain is still not part of their core business activities. Therefore, Blockchain investment faced reduced growth in 2020 than previously expected. It is important to point out that there was still growth in Blockchain spending. Moreover, there were a few bright spots such as supply chain management and contact tracing where Blockchain has seen increased interest in the wake of the pandemic. By providing help in the COVID-19 crisis and recovery, Blockchain can play a pivotal role in accelerating post-crisis digital transformation initiatives and solving the problems highlighted in the current system. The post-COVID-19 world will create greater need for security and instantaneous data exchange. The recovery will be bolstered by the European Blockchain ecosystem, with the biggest players in the market working together with a variety of smaller, innovative companies. Blockchain can provide that foundation on which innovative solutions can be built.

2.1.2 Drivers of Adoption

Blockchain can differentiate organisations as they look to optimise costs and **build business resiliency** through economic challenges ahead. Blockchain can be a 'recovery accelerator' that pushes European organisations on their future enterprise trajectories. The impact of COVID-19 has pushed many European organisations to fast-track their **digital transformation initiatives** and Blockchain can be a key component of that process. This will impact Blockchain spending in the medium and long term considering an expected spending recovery in 2021 and 2022, with European companies forced to push digital transformation processes now more than ever.

The **arrival of BaaS (Blockchain-as-a-Service)** has allowed companies to easily develop and deploy their own Blockchain apps with the Blockchain infrastructure developed and maintained by a separate vendor. BaaS enables developers, entrepreneurs and enterprises to focus on building applications and smart contracts rather than the operational aspects of Blockchain. The potential of BaaS has already been recognised by some of the world's largest software companies. Big cloud providers have developed

BaaS platforms that are already available to their cloud customers. At a time when budgets and appetite for innovation are limited, BaaS removes some of the adoption hurdles and enables fast deployment.

The COVID-19 crisis has highlighted the vulnerability of many industries to disruption and sudden changes in demand. Many European companies have recognised the benefits of responsible **data exchange** in which greater **interconnectivity** benefits all participants in an industry, even if they are competitors. In the short term, the impact will be most pronounced in a few use cases such as lot lineage/provenance, asset/goods management and trade finance. But in the medium and long terms, this trend can extend to other use cases as attitudes regarding data sharing shift and Blockchain adoption increases.

2.1.3 Main Barriers and Challenges

The fever pitch excitement surrounding between 2017 and 2018 subsided and was replaced by a more measured and practical approach. The prevailing sentiment can be tinged with pessimism due to the lofty expectations during the period of exuberance. The disillusionment led to the realisation that Blockchain is not the solution to all problems and should not be forced into all digital scenarios and use cases.

While growth in Blockchain spending in Europe is quite impressive, it still represents a small portion of total ICT spending on new technologies. Almost a quarter of companies in the *ATI Survey* have adopted or plan to adopt Blockchain. Awareness of Blockchain technology is high, though three quarters of companies have not adopted or plan to use Blockchain. A lot of decision makers within companies still have a hard time understanding the technology in practical terms. Part of the reason is **scarcity of Blockchain talent** in Europe. LinkedIn Learning, the online learning platform of the world's largest professional network, published its list of most in-demand skills for 2020. Blockchain was the most sought-after skill in the hard skills category with a very lopsided ratio of supply and demand. A certain concentration of Blockchain talent is needed to advocate for the technology and explain its relevance to colleagues and business acquaintances. Otherwise, resistance to change can remain high.

Legislation often must play catch up to rapid technological change. Blockchain is no exception, and it has presented EU legislators with unique challenges. As a decentralised system that can have nodes around the entire European continent and beyond, Blockchain presents a problem of jurisdiction. Regulators have to legislate how jurisdiction is determined and which governing laws are applied. The legislative grey area surrounding creates uncertainty and makes companies more hesitant to adopt.

Particularly important to EU countries is data privacy, specifically the General Data Protection Regulation (**GDPR**) which gives citizens control over their data. EU citizens also have the right to delete or amend their information, which seems to contradict the immutable nature of Blockchain. In July 2019, the EU published 'Blockchain and the General Data Protection Regulation: Can distributed ledgers be squared with European data protection law?' The study did not resolve the tension between GDPR and immutability of Blockchains, and it recommended case-by-case assessment. Private permissioned Blockchains were deemed more likely to clear GDPR requirements.

There is also a general sense of **Blockchain fatigue** among some CXOs, and the term can even carry negative connotation. There is significant pressure from CEOs and CIOs to deliver on their digital transformation strategies. But due to the predominance of legacy systems in traditional businesses, many CIOs focus attention and effort on maintenance. Often stuck in operational mode, senior managers do not have much patience for technology that cannot deliver results quickly. One of the reasons why Blockchain implementation cannot deliver fast return on investment (especially in the context of pilot projects) is that it is a technology dependent on the network effect – additional users increase the utility of the service exponentially. However, most Blockchain implementations are small in scale and do not involve that many other organisations, thus delivering lackluster results.

The proliferation of Blockchain platforms has been marked more by experimentation and innovation rather than a drive for **interoperability** or an effort to arrive at a universal standard. In the past 10 years, we have seen the rise of large platforms especially regarding enterprise adoptions. For the most part, connecting Blockchain platforms to legacy systems has not been a problem, and vendors offer easy solutions to make the connection. However, these new platforms lack interoperability between each other (i.e. they cannot freely communicate and exchange information without the need for intermediaries). Creating interoperability between different networks presents a great technological challenge. Different Blockchain platforms differ in several crucial aspects: consensus mechanism,

governance structure, smart contract functionality and privacy policy. Beyond that Blockchain platforms do not have the strong incentive to assure interoperability because their standard may emerge to be the dominant one. This leads to platform fragmentation that hampers the entire industry.

None of these challenges, whether technological, business or institutional, are insurmountable. Interoperability is a big stumbling block, but large tech providers have recognised the problem and are working on standardisation and solutions for interoperability. Regulation is one area where there is an ongoing process of standardisation on an EU level and soon there will be clarity on host of important issues related to DLT and digital assets based on the technology. Adoption will reach a tipping in industries like finance and specific use cases in the medium term and that will have positive spill over effect into other industries where Blockchain is proving its utility. Thus, it is just a matter of time before many challenges recede in importance.

2.2 Use cases and business opportunities

2.2.1 Blockchain Value Proposition

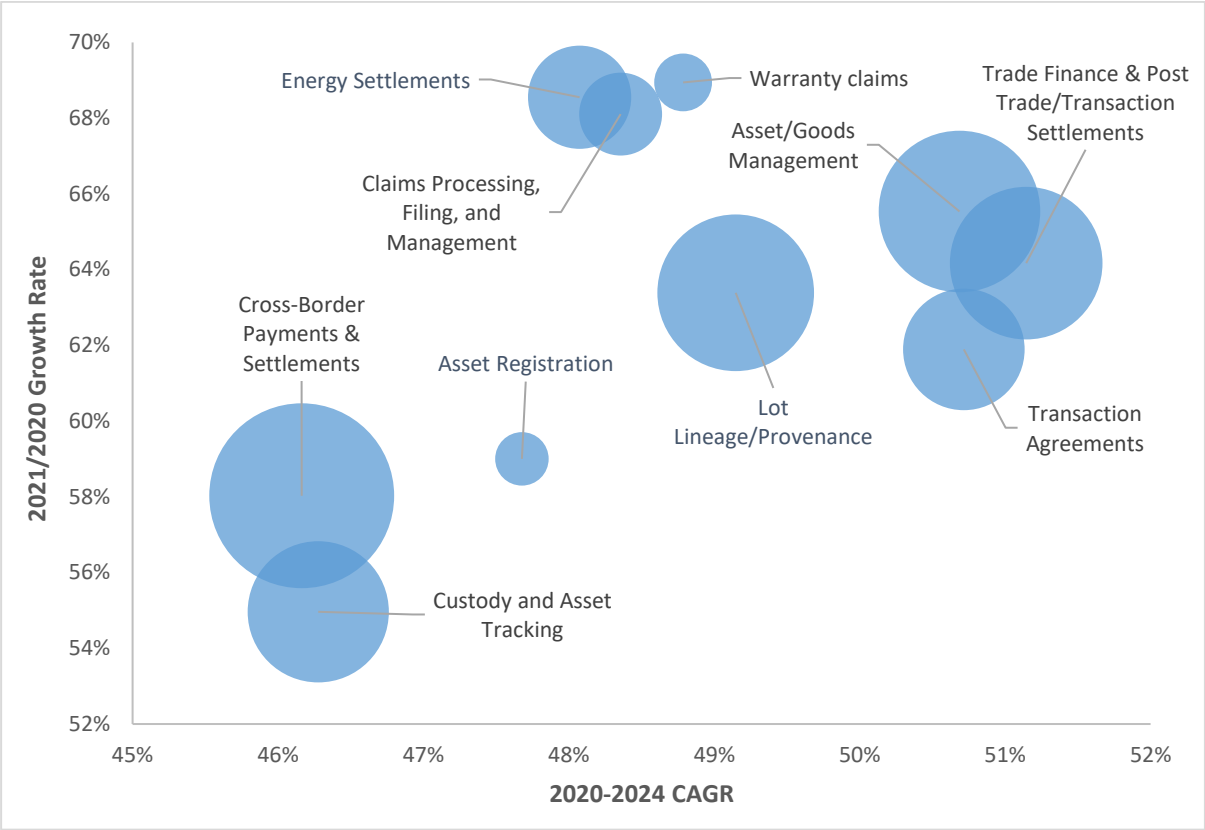
The world's most valuable resource is no longer oil, but data and Blockchain promises a new model of delivering information in an immediate, shared and transparent manner. The technology garnered so much attention because it provides a highly secure environment to immutably store and share data. It provides enhanced security through cryptography, consensus of participants, and the fact that decentralisation provides no central point of failure. Blockchain diminishes the need to reconcile multiple ledgers and by cutting out intermediaries it increases efficiency and speed. It also improves trust because it provides single source of truth each participant sees the same version of events and provides an immutable audit trail of all transactions.

2.2.2 Leading Blockchain Use Cases

Figure 5 below provides a snapshot of the top 10 Blockchain use cases in Europe, in terms of value growth (forecast spending increase) in the period 2020-2024. The size of the bubbles corresponds to the users' spending for each use case in 2020. It is important to point out that the effects of the first wave of COVID-19 have been taken into account and forecasts have been revised down from previous expectations. The top Blockchain use cases are a mix of horizontal and vertical-specific.

All but two of the top 10 Blockchain use cases in terms of spending are horizontal (serve the needs of more than one industry). For example, Asset/Goods Management is a prominent use case across several industries including Manufacturing, Retail, Wholesale, Transportation and Resource Industries. As a result, it shows one of the highest spending values in 2020 (€116 m, Table 1) and is still expected to grow in the next years. The most popular use cases are related to financial transactions, supply chain management and management of sensitive information. Popular use cases make great use of Blockchain's ability to bring securely and immutably stored information, inspire trust in stakeholders and increase data exchange between them.

Figure 5: Top 10 Blockchain use cases in Europe by spending growth



Source: IDC Worldwide Blockchain Spending Guide, August 2020

Legend: The bubble size represents the spending value by use case in 2020, CAGR: Compound Annual Growth Rate.

Table 1: Top 10 Blockchain use cases in Europe by spending (€ m)

Top 10 Blockchain use cases in Europe	2021/2020 GR	2020–2024 CAGR	2020 Blockchain spending (€ m)
Cross-Border Payments & Settlements	53%	46%	152
Identity Management	59%	46%	124
Asset/Goods Management	59%	51%	116
Lot Lineage/Provenance	58%	49%	109
Trade Finance & Post Trade/Transaction Settlements	61%	51%	104
Regulatory compliance	55%	45%	96
Custody and Asset Tracking	57%	46%	89
Transaction Agreements	58%	51%	66
Energy Settlements	55%	48%	47

Top 10 Blockchain use cases in Europe	2021/2020 GR	2020–2024 CAGR	2020 Blockchain spending (€ m)
Equipment and Service/Parts Management	54%	46%	43

Source: IDC Worldwide Blockchain Spending Guide, August 2020. Further information about the leading use cases is presented below.

Cross-Border Payments & Settlements

The bulk of spending on Blockchain spending is in finance and it is no surprise that Cross-Border Payments & Settlements is the most spent on use case. It refers to the tracking, tracing and managing cross-border/international payments and settlements. European companies use Blockchain to create alternate payment and settlement 'rails' built for immediate payment and settlement. Such deployments rely on smart contracts — which trigger predetermined actions once certain conditions are met — for reaching trade agreements, tracking goods and making payments.

Identity Management

Identity management is a cross-industry use case popular in Banking, Government, Telecommunications and Healthcare. It refers to solutions to authenticate identities of clients and providers, manage personal, medical and financial data, and assist in identity as a service. It plays to the strength of Blockchain in that information is secured, shared across organisations but accessed only by authorised individuals.

Asset/Goods Management

Assets/Goods Management (along with the similar Lot Lineage/Provenance) were the first popular use cases unrelated to finance. A shared digital ledger is a great solution to monitor the movement of assets and goods by creating a digital paper trail of the movement of goods. Companies in manufacturing, retail and wholesale use Blockchain to monitor the movement of merchandise, goods and materials and registering each leg of a trip or movement throughout the supply value chain.

Lot Lineage/Provenance

Though the two supply chain use cases Asset/Goods Management and Lot Lineage/Provenance are similar there are some differences. Lot Lineage/Provenance is about verifying origin and authenticity of a product as it moves throughout the value chain. Companies in manufacturing are concerned with quality control or responsible sourcing and use Blockchain to capture information about all inputs of a product, enabling accurate visibility and traceability into the history of a product. This can include environmental impacts on the product such as storage container conditions as the product is transported. Companies also use Lot Lineage/Provenance solutions to detect and prevent counterfeit products or ingredients.

Trade Finance & Post Trade/Transaction Settlements

Trade Finance & Post Trade/Transaction Settlements is only number five in terms of Blockchain spending in Europe but it has serious momentum behind it and is projected to be one of the fastest growing use cases in the next several years. It is very popular with shipping companies who use Blockchain-based solutions to securely exchange trade documents such as bills and letters of credit. These solutions facilitate the movement or flow of trade receivables and provide trade delivery and payment confirmation. They can also provide a record of transactions in payments between parties involved in the transaction.

Regulatory compliance

Regulatory compliance is a popular use case across Manufacturing, Retail and Wholesale. Companies use Blockchain to maintain secure records for regulatory compliance and checks. Automotive companies can use it to certify the compliance of all vehicle components, from design to production. Regulatory compliance solutions can be designed to handle consumer data as specified by the EU's General Data Protection Regulation (GDPR).

Custody and Asset Tracking

Another great use for the security and immutability of Blockchain is in custody and asset tracking to maintain records of financial agreements and asset ownership. Blockchain is used to digitally represent a record of ownership in order to significantly reduce settlement time and eliminate the need for paper. This can include the record management of various assets such as cash, loans, mortgages property and others.

Transaction Agreements

Transaction agreements in banking make great use of Blockchain's main features: smart contracts that enforce and execute commercial transactions and agreements such as smart property contracts. Enforceable agreements are automatically executed on a distributed ledger when conditions set by all involved parties are met.

Energy Settlements

Energy settlement is a powerful use case in the growing utilities sector. Blockchain is used to maintain transactions and track the energy that is being produced and consumed. The most promising application is in facilitating peer-to-peer energy transactions and global trade automation. European utilities have already participated in tests to create a trading platform for electricity and gas. Blockchain offers a reliable, low-cost way to record and validate financial or operational transactions across a distributed network with no central point of authority.

Equipment and Service/Parts Management

Companies across Transport, Manufacturing and Resources are applying Blockchain to collect inspection and maintenance information of equipment involved in general operations or goods production or distribution. This can include tracking repaired equipment and monitoring product parts and services that were performed. Blockchain can give manufacturers reassurance that all parts, services and supplies are ethically sourced and that companies are fully compliant with key legislation.

2.3 Social and sustainability Impacts

2.3.1 Introduction

Many of the core features of Blockchain – transparency, single source of truth, incorruptibility of stored information, auditability – make it a perfect ally for variety of initiatives that bring environmental and social benefits. The key enabling factor is trust and the modern world has alarming paucity of it: citizens often mistrust public institutions and private companies, companies in long and complex supply chains do not necessarily trust each other, and overall there is lack of trust when companies tout their Environmental, Social and Corporate Governance (ESG) values and accomplishments. Blockchain cannot magically create trust but it can create the necessary pre-conditions for trust between all stakeholders in a society. Just as importantly, it can do so in an efficient, secure and cost-effective manner. Blockchain used for social and environmental good is not just peripheral application of the technology but a large part of how Blockchain is applied today. Below we will explore a few areas where Blockchain is making a positive difference.

2.3.2 Blockchain for environmental protection and carbon sequestration

As the new decade began the looming threat of climate change has never been more on the minds of governments, citizens and corporations. Scientists warn that by 2060 temperatures can rise by 2°C above pre-industrial levels and as much as +6°C by the end of the century.[7] With no course correction there will be devastating loss to biodiversity, not to mention the destructive effect on human-made systems and infrastructure. EU is not only one of the signatories to the Paris Agreement on Climate Change but recently revised up its binding target to 55% reduction (compared to 1990 levels) in greenhouse gas by 2030[8].

There is a lot enthusiasm and funding for environmental protection initiatives and sustainable use of resources but also ongoing problems. One issue is the lack of precise Measurement, Reporting and Verification (MRV) of climate change mitigation initiatives and projects. Data is often collected manually using paper-based records and often lacks in quality. This lack of accuracy and reliable data gathering

[7] https://www.consilium.europa.eu/en/policies/climate-change/
[8] https://www.europarl.europa.eu/factsheets/en/sheet/72/climate-change-and-the-environment

makes it difficult to assess how effective an initiative is. Companies and sponsors are reluctant to invest in projects that do not have a reliable measurement of success and impact.

Blockchain is tailor-made to address the problem of unreliable data collection and storage. Blockchain-based solutions can provide an immutable system and fully auditable system to record carbon footprint of products or the impact of environmental protection initiatives. It can also be used to record the positive effect sustainability initiatives can have on the environment. For example, solutions like **CarbonBlock** and **Mining and Metals Blockchain Initiative** provide a carbon tracing platform and tools to help companies estimate the carbon footprint of their activity. The activity and trace emissions of all participants in the supply chain is recorded on the Blockchain. Every participant in the supply chain can have access to the same ledger (single source of truth) and the information is updated in real time across all authorised participants. Such solutions discourage bad actors who may report misleading information because they would leave an immutable trail of their false claim or unethical practice.

Once data on sustainable initiatives is captured it can be used to mint and trade carbon credit tokens. Carbon credit is defined as any tradable certificate or permit that gives the right to the company that holds it to emit one ton of carbon dioxide or the equivalent amount of a different greenhouse gas. Companies essentially pay someone else to offset their carbon footprint by purchasing carbon credits. Blockchain promises not only to have a tamper-proof way of storing carbon offset activities but also to use that information to automatically mint carbon credit tokens. Currently, the process is quite cumbersome and using Blockchain to digitally represent carbon credits on a token can streamline and automate the process, and also ensure higher liquidity in the market. A recent example is Universal Carbon that produces tokens that are backed by a Voluntary Carbon Unit (represents one year-tonne of carbon dioxide averted), a digital certificate issued by standards body Verra. Trading such carbon credit tokens on the open market makes it much easier for companies to purchase and offset their activity.

There is a project called the Open Reforestation Protocol (ORP) that skillfully combines the different ways that Blockchain is used to mitigate the effects of climate change. It is a digital platform and reforestation management system with 3 main capabilities: it allows anyone with existing or nascent reforestation projects to create projects on the Blockchain, it connects project operators with investors to sponsor the project, and it hosts a community of validators who continuously assess project data to ensure its validity. The ORP standardises measurement, reporting and verification processes that are persistent problems in reforestation initiatives. Once verified, reforestation data is stored on an immutable, tamper-proof ledger, thereby providing a record that is universally available and permanently backed-up. This data is then used to mint carbon credit tokens, prove legitimacy to potential investors and ensure the continued growth of reforested trees. The Blockchain basis of the ORP introduces a novel collaborative funding mechanism for reforestation, allowing project owners to secure capital from diverse sources and meet funding goals more rapidly. Co-founder Michael Kelly stated "*The Open Reforestation Protocol is a natural next step in creating effective climate solutions that are also designed to scale. It is an open and inclusive solution that allows us to address the climate crisis collectively and transparently*[9]."

Utilising different facets of Blockchain technology, the Open Reforestation Protocol can usher in a new more collaborative way of approaching the problem of climate change. The UN announced the 2020's to be The Decade of Restoration, meaning the collective effort to prevent, halt and reverse the degradation of ecosystems worldwide. Perhaps the field of restoration and sustainability is one of the areas where Blockchain can live up to the lofty expectations of its most ardent proponents.

[9] https://www.openreforestation.org/blog-1

Table 2: Blockchain for environmental protection and carbon sequestration – selected initiatives

Name	Description	Country	Domain	Source / Website
Open Reforestation Protocol	A platform for managing and funding reforestation projects and reliably measuring, reporting and verifying their progress and the carbon they have sequestered	Switzerland	Carbon sequestration	https://www.openreforestation.org/
Mining and Metals Blockchain Initiative	Carbon Tracing Platform (COT) aims to monitor greenhouse gas emissions from end-to-end. The initiative is a collaboration between seven global companies and the World Economic Forum	International	Carbon footprint	https://www.weforum.org/press/2020/12/Blockchain-can-trace-carbon-emissions-for-mining-metals-companies-proof-of-concept-released/
CarbonBlock	The tool provides the carbon footprint of parts and materials in a supply chain, making greenhouse emissions more transparent	Germany	Carbon footprint	https://circulartree.com/carbonblock/
Universal Carbon	A tradable carbon token backed by a Voluntary Carbon Unit (VCU), a digital certificate issued by standards body Verra	International	Carbon Credit Trading	https://universalcarbon.com/
Green Chain	UN-backed Green Chain initiative will crowdsource renewable energy projects that will use fourth industrial revolution technologies to create the outcome of a greener planet	Germany, International	Renewable energy	https://www.smart-energy.com/industry-sectors/digitalisation/harnessing-Blockchain-to-boost-renewable-energy-use-in-manufacturing/
Drone on the Volga	The project uses a combination of modern robotics, Blockchain and IoT is used for continuous control of pollutants in water environments.	Russia	Environmental monitoring	https://www.libelium.com/libeliumworld/success-stories/drones-sensors-and-Blockchain-for-water-quality-control-in-the-volga-river-to-promote-trustworthy-data-and-transparency/

Source: shown in the table

2.3.3 Blockchain for resilient and transparent supply chains

The public and governments are putting increasing pressure on companies to have an Environmental, Social and corporate Governance (ESG) strategy and conduct their operations with sustainability and ethical practice in mind. What is more, many investors use ESG as an important criterion in their decision to finance a business. A meta-study by Oxford University and Arabesque Partners found out that companies with strong ESG practice have strong financial performance and lower operating costs[10]. Not only can ethical practice coexist with profitability, it can also be a crucial contributing factor.

Transparent supply chains are a huge part of ESG strategy for many businesses and an area where applying Blockchain can contribute the most. In fact, one of the most common applications (outside finance) is in supply chain operations to guarantee transparency, responsible sourcing of ingredients, anti-counterfeit measures and quality control. As was mentioned previously, today's supply chains are a large network of providers that span the globe and cover jurisdictions with laxer or rarely enforceable labor laws and environmental safety measures. The current arrangement and complexity of modern supply chains makes it very difficult to make sure that all parts, material or ingredients comply with all standards even if the final buyer is earnest in pursuing them. Blockchain streamlines the process of sharing information across all stakeholders by providing a single source of truth. It also discourages bad actors because the stated information is immutably recorded and is available for audit should other stakeholders suspect foul play.

The importance and potential of transparent supply chains is so great that in 2020 the World Economic Forum in collaboration with International Trade Centre (a UN entity) and the private sector launched a neutral and public traceability platform capable of visualising Blockchain-based supply chain data from multiple companies and sources. The main goal is to "*help businesses across industries respond to consumer demands for ethical and environmentally friendly products*". Forming a network of companies is one method to scale and share best practice in transparent supply chains. A prominent example is the Responsible Sourcing Blockchain Network whose members include Volvo, Volkswagen and Nornickel. The goal is not just to ensure that minerals are sourced from non-conflict regions but also no child labor is used and the revenues from the mining process are not used to fund wars.

The European Union has a great opportunity to foster a local ecosystem of providers of Blockchain-based services for transparent supply chains and local sourcing. Two first factors can play an important role. The first is stricter regulation and higher standards for imports into the European Union. For example, on 1 January 2021 Conflict Mineral Regulation came into effect and is enacted to prevent the trade of 'conflict minerals' (tin, tantalum, tungsten and gold) from financing human rights abuse practices. The second factor is the availability of funds through EU-backed programs that can help many promising initiatives get off the ground. The EU provided an Artificial Intelligence and Blockchain investment fund to invest €100 m in startups in 2020. The German company Minespider received a grant from the EIT Raw Minerals and has developed a Blockchain-based traceability platform that helps EU importers comply with existing and new mineral import regulation. Another example is the Dutch company Circularise that provides tracking of plastics. It also benefitted from strict environmental legislation and practice in the EU and received funding through EU's Horizon 2020 programme.

[10] Clark, Gordon L. and Feiner, Andreas and Viehs, Michael, From the Stockholder to the Stakeholder: How Sustainability Can Drive Financial Outperformance (March 5, 2015). Available at SSRN: https://ssrn.com/abstract=2508281 or http://dx.doi.org/10.2139/ssrn.2508281

Table 3: Blockchain for resilient and transparent supply chains – selected initiatives

Name	Description	Country	Domain	Source / Website
OreSource	A Blockchain protocol for responsible mineral tracking, developed under a grant by EIT Raw Materials (an EU body)	Germany	Responsible sourcing	https://www.minespider.com/
Circularise	Tracks plastics from the initial resin to the end product and enables brands to trace the product's origin and establish the environmental impact (funded through EU's Horizon 2020 program)	Netherlands	Recycled Plastics Traceability	https://www.circularise.com/
Self-Service Blockchain Track and Trace Platform	The first neutral and public traceability platform capable of visualising Blockchain-based supply chain data from multiple companies and sources	International	Transparent Supply Chain	https://www.weforum.org/press/2020/01/self-service-Blockchain-track-and-trace-platform-for-businesses-launched-2fa007711c/
Responsible Sourcing Blockchain Network	A Blockchain network committed to strengthening human rights and environmental protection in mineral supply chains.	International	Responsible sourcing	https://www.rcsglobal.com/Blockchain-traceability/
Circulor	The platform is used to trace raw materials through the supply chain to ensure sustainability	UK	Transparent Supply Chain	https://www.circulor.com/
OpenSC	A platform to ensure food products are ethically sourced: they should not be illegal or unethical, and they should be environmentally friendly	International	Responsible sourcing	https://opensc.org/

Source: shown in the table

2.3.4 Blockchain for COVID-19 protection and traceability

In its ebbs and flows the COVID-19 pandemic has impacted virtually all businesses. By providing help in the COVID-19 crisis and recovery, Blockchain can play a pivotal role in accelerating post-crisis digital transformation initiatives and solving those problems highlighted in the current system. Blockchain technologies offer great potential in many COVID-impacted scenarios.

One of the first applications to emerge following the initial waves of infection were in contact tracing and health certificates. Blockchain can be used to both gather and collate patient data more efficiently, monitor patients' movements to guarantee social distance and protect their identity at the same time. Citizens are very mistrustful of how their data is handled and are especially reluctant to share infection information. In Blockchain there is no central authority and users are given control of their personal data. They can selectively share information that is important for coronavirus mitigation efforts, while protecting their identity and other sensitive information. With Blockchain a balance can be struck between data gathering and protection of privacy.

Some of these initiatives (such as Open University's Digital certificate for Covid-19 immunity) were spearheaded and developed by academics from public institutions, while most were collaborations between private sector entities. There is an excellent opportunity for public-private partnership for the common good, as the EU hosts some of the best and most innovative academic institutions in the world. What is more, EU's tradition of respecting user's privacy and data through legislation such as GDPR can provide a necessary pre-condition from which many Blockchain-based solutions can be developed and flourish. Governments and healthcare organisations can gain useful information, while users can be assured that their personal information will not be shared.

Table 4: Blockchain for COVID-19 protection and traceability – selected initiatives

Name	Description	Country	Domain	Source / Website
Decentralized Privacy-Preserving Proximity Tracing (DP-3T)	An open protocol developed in response to the COVID-19 pandemic to facilitate digital contact tracing of infected participants	Pan-European	Contact Tracing	https://en.wikipedia.org/wiki/Decentralized_Privacy-Preserving_Proximity_Tracing
Agerona	An open-source app that is designed to help people access anonymous coronavirus testing	US, UK, Israel	Access to COVID testing	https://www.financemagnates.com/cryptocurrency/news/anonymous-coronavirus-testing-app-to-be-launched-by-2-Blockchain-firms/
MYNXG Pandemic Tracker For COVID-19	Blockchain-powered app that enables privacy compliant pandemic tracking on regular smartphones	Germany	Contact Tracing	https://www.mynxg.com/MYNXG-Launches-Privacy-Compliant-Pandemic-Tracker-For-COVID-19-news-17.htm
Health n Go	Blockchain-based app to digitally encrypt health certificate, accessible to users	Switzerland	Health Certificates	https://www.tixngo.io/healthngo/
Open University's Digital certificate for Covid-19 immunity	A tamper-proof immunity passport	UK	Health Certificate	https://www.ukauthority.com/articles/open-university-develops-digital-certificate-for-covid-19-immunity/

Name	Description	Country	Domain	Source / Website
My Care	Blockchain-based infection risk management solution that stores evidence of companies' effective COVID policies	Europe, US, Asia	Infection Risk Management	https://www.dnvgl.com/services/my-care-keeping-you-safe-assess-manage-and-mitigate-infection-risk-and-build-stakeholder-trust-176161

Source: shown in the table

2.4 Policy and regulation

2.4.1 An Overview of policy challenges

The frantic pace of innovation in the emerging tech world has left legislators always playing catch-up. New technologies present both opportunities and challenges and legislators need to have a very balanced approach. If legislation is too restrictive and places many obstacles to adoption, then innovation will be stifled. This can have profound economic implications as other regions will outpace them in innovation, grab significant market share and attract additional capital and R&D. However, a too lax approach to regulation can invite abuse from malicious actors and hurt investors or negatively impact the wider society.

Blockchain is no exception to these considerations, and it has presented EU legislators with tough decisions to make. The multifaceted nature of the technology and the different ways it is applied leads to several distinct legislative challenges. The first is the inherent tension between Blockchain as a distributed, immutable ledger and the EU General Data Protection Regulation (GDPR) that gives individuals control over their personal data. The area of most contention is the classification and regulation of new financial instruments and funding mechanisms built on Blockchain technology. Another issue is the status of smart contracts in the broader scope of contract law. This report will examine each of these major legislative as well as recent policy developments and planned legislative initiatives.

2.4.2 Blockchain and GDPR

The General Data Protection Regulation is a legal framework that sets guidelines for the collection and processing of personal information from individuals who live in the European Union. When passed in May 2018 GDPR affected all organisations that collect data related to EU citizens, regardless of where in the world the company is situated. One of the most important consequences of GDPR is that it gives EU citizens 'the right to be forgotten'" (or right of erasure) meaning that people can request organisations to delete their personal data. There are certain instances where the right to be forgotten can be overridden but by large it is a tough privacy and security law. One of the core features of Blockchain, immutability of information, comes into direct conflict with the right to be forgotten.

In July 2019, the EU published 'Blockchain and the General Data Protection Regulation: Can distributed ledgers be squared with European data protection law[11]?' The study did not resolve the tension between GDPR and immutability of Blockchains, and it recommended case-by-case assessment. GDPR is technology neutral and does not make exception for Blockchain but there are several ways to comply with the regulation including fairly complex cryptographic techniques including zero-proof knowledge and ring signature. The most straightforward method is to store only personal data 'off-chain' (i.e. not on a Blockchain) so it can be later removed if need be. Organisations are advised to use permissioned Blockchains, because of better control over personal data governance and transfers outside the EU, which they are able to provide, because Blockchain network membership and members' residency/data privacy compliance can be controlled and assured. While technology solutions to GDPR compliance exist, further general agreement by regulators must be officially announced.

2.4.3 Regulation of Blockchain-enabled Digital Assets

When it comes to the realm of finance, there has been a veritable explosion in the number of financial instruments and ways to raise funds. Examining each of them and the surrounding regulation can fill up several reports. The general picture is that there is currently no uniformity in the taxonomy of Blockchain-based Digital Assets within the EU and every member country differs (even if slightly) in its

[11] Link to access: https://www.europarl.europa.eu/RegData/etudes/STUD/2019/634445/EPRS_STU(2019)634445_EN.pdf

regulation and approach. Regulation of the two main funding mechanisms, Initial Coin Offering (ICO) and Security Token Offering (STO), also differs by country and some of them are more accommodating than others. Here is a sample of the main Digital Assets enabled by Blockchain:

- Payment token: This corresponds to the concept of virtual currency (i.e. presents a means of payment). It can be used to purchase goods or services, to transfer money and value on the Blockchain. The payment token is not a security — it does not give claims against the issuer (e.g. Bitcoin, Ethereum). It falls under the regulation of an Anti-Money Laundering Act (AMLA).
- Utility token: provides digital access to service/application and grants the right to use/access/participate in the Blockchain. This token is subject to AMLA (Anti-Money Laundering Act). When a company creates a utility token, it means that it is essentially creating a form of a digital coupon that can be redeemed in the future for discounted fees or special access to a product or service.The payment function is only an accessory or subordinate service.
- Asset token: this is a security, not a means of payment. It may grant the following rights: rights to participate in profit or revenue, membership rights under corporate law (such as voting rights), derivative rights (financial contracts whose values depend on one or several underlying assets and which are not cash transactions). It is not subject to AMLA, but is subject to securities law requirements.
- Hybrid tokens: These are tokens that play a dual role with elements of payment and utility tokens.

Even this classification differs from country to country and there are even more exotic digital assets being developed. Fortunately, EU has recognised the potential of the technology for innovation and enhanced efficiency in the financial sector and beyond. In September 2020, the European Commission (EC) adopted an expansive new digital finance regulation package. This new regulatory framework includes a comprehensive new legislative proposal on crypto-assets, called Markets in Crypto-assets (MiCA), that was developed to help streamline distributed ledger technology (DLT) and virtual asset regulation in the European Union whilst protecting users and investors.

This proposal focuses strongly on rules to regulate currently out-of-scope crypto-asset types. Once the proposed legislation becomes law there will be harmonisation in the taxonomy and regulation across all EU Member States. This new regulation and standardisation can transform the European economy in the coming decades and improve competitiveness of the fintech market, while mitigating risk and ensuring the financial stability of the European economy.

2.5 Conclusion

For a technology that has been around for little over 10 years, Blockchain has seen more than its fair share of irrational exuberance and unfair dismissal. The hype period between 2017 and 2018 convinced a large number of people that Blockchain will save the world by tackling every major problem of modern society. When these predictions inevitably did not come to pass many in the business world were quick to dismiss it as nothing more than hype. Now that we have some distance in time from that period, we can have a lot more balanced and accurate view of Blockchain and its place in the ever-shifting technological landscape in Europe.

Looking at adoption rate surveys and spending data we can confidently conclude that Blockchain is here to stay. The technology with its ability to create an immutable trail, increase trust and data exchange is clearly more conducive to some industries and use cases more than others. In terms of use cases. Spending patterns also reveal that the success of Blockchain is concentrated in a few industries, most notably in Finance and Manufacturing. The high-profile use cases that have seen a lot of traction are usually horizontal and help companies across multiple industries to make cross-border payments, track products across supply chains and manage sensitive information.

Therefore, we can confidently state that Blockchain will not quickly conquer all industries as was predicted but find ever increasing use in specific areas. This will lead to a tipping point in certain industries where the use of Blockchain will become standard practice and commodified. There will still be some challenges along the way – including technical, regulatory and business – but with time and positive track record they will matter less and less.

With Blockchain spending still relatively low around the world, the question of which region dominates in Blockchain-based solutions and innovation is still very much left wide open. The European Commission has recognised the enormous potential of Blockchain technology in the realm of financial innovation and is working on new legislation to create a common taxonomy for digital assets and standardise regulation. Such forward-thinking actions really distinguish the EU from other regions where regulation is still incomplete or too restrictive. The European Union has another important factor working in its favor. The ambitious sustainability goals of the EU are a perfect match for the growing use of Blockchain to aid in the fight against climate change. Local Blockchain solution companies catering to the strict EU environmental regulation can later export their services around the world. Overall, the European Union is in an excellent position to become the leading region in the development and application of Blockchain technology.

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Appendix A: Advanced Technology uptake

Figure 6: Advanced Technologies Uptake by European Union Industries – Question: Which of the following technologies is your organisation using or planning to use?

Technology	Financial Services	Gov/Edu	Healthcare	Manufacturing discrete	Manufacturing process	Professional Services	Retail, Wholesale	Telecom, Media	Transport, Logistics	Utilities, Oil, Gas	Agriculture
Fixed or mobile connectivity	84%	78%	81%	88%	82%	81%	75%	89%	84%	86%	88%
Security technology solutions	84%	78%	78%	84%	77%	81%	80%	88%	85%	89%	68%
Public cloud	63%	66%	68%	76%	71%	82%	72%	80%	75%	69%	83%
IoT	58%	55%	60%	64%	60%	63%	55%	66%	68%	65%	64%
Big Data and analytics solutions	77%	53%	48%	63%	65%	70%	47%	66%	55%	58%	41%
Internet-Enabled Mobile Solutions	74%	60%	47%	44%	61%	67%	55%	72%	62%	57%	36%
AI	61%	45%	57%	66%	56%	59%	44%	69%	49%	59%	34%
B2B industrial digital platforms	46%	24%	27%	64%	60%	58%	40%	47%	53%	47%	39%
Robotics	36%	25%	38%	76%	65%	33%	30%	29%	29%	52%	26%
Other connectivity	42%	37%	29%	33%	41%	46%	37%	59%	34%	31%	19%
Vehicle-related mobility IT solutions	35%	28%	19%	27%	36%	42%	30%	26%	65%	28%	14%
ARVR	29%	32%	42%	33%	34%	33%	24%	41%	22%	19%	5%
Advanced materials	29%	23%	21%	39%	28%	31%	24%	22%	24%	21%	6%
Nanotechnology	25%	21%	22%	36%	21%	32%	23%	18%	19%	23%	9%
Blockchain	53%	17%	15%	21%	25%	31%	22%	22%	18%	17%	6%
Micro and nanoelectronics	25%	20%	16%	38%	24%	26%	21%	20%	20%	17%	8%
Industrial biotechnology	19%	18%	13%	8%	49%	26%	18%	15%	16%	11%	23%
Photonics	23%	16%	11%	27%	22%	25%	19%	19%	16%	22%	10%

Source: Advanced Technologies for Industries Survey, November 2020

Legend: sum of % of respondents already using or planning to use the technology

About the 'Advanced Technologies for Industry' project

The EU's industrial policy strategy promotes the creation of a competitive European industry. In order to properly support the implementation of policies and initiatives, a systematic monitoring of technological trends and reliable, up-to-date data on advanced technologies is needed. To this end, the Advanced Technologies for Industry (ATI) project has been set up. The project provides policymakers, industry representatives and academia with:

- Statistical data on the production and use of advanced technologies including enabling conditions such as skills, investment or entrepreneurship;
- Analytical reports such as on technological trends, sectoral insights and products;
- Analyses of policy measures and policy tools related to the uptake of advanced technologies;
- Analysis of technological trends in competing economies such as in the US, China or Japan;
- Access to technology centres and innovation hubs across EU countries.

You may find more information about the 16 technologies here: https://ati.ec.europa.eu.

The project is undertaken on behalf of the European Commission, Directorate General for Internal Market, Industry, Entrepreneurship and SMEs and the European Innovation Council and Small and Medium-sized Enterprises Executive Agency (EISMEA) by IDC, Technopolis Group, Capgemini, Fraunhofer, IDEA Consult and NESTA.

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