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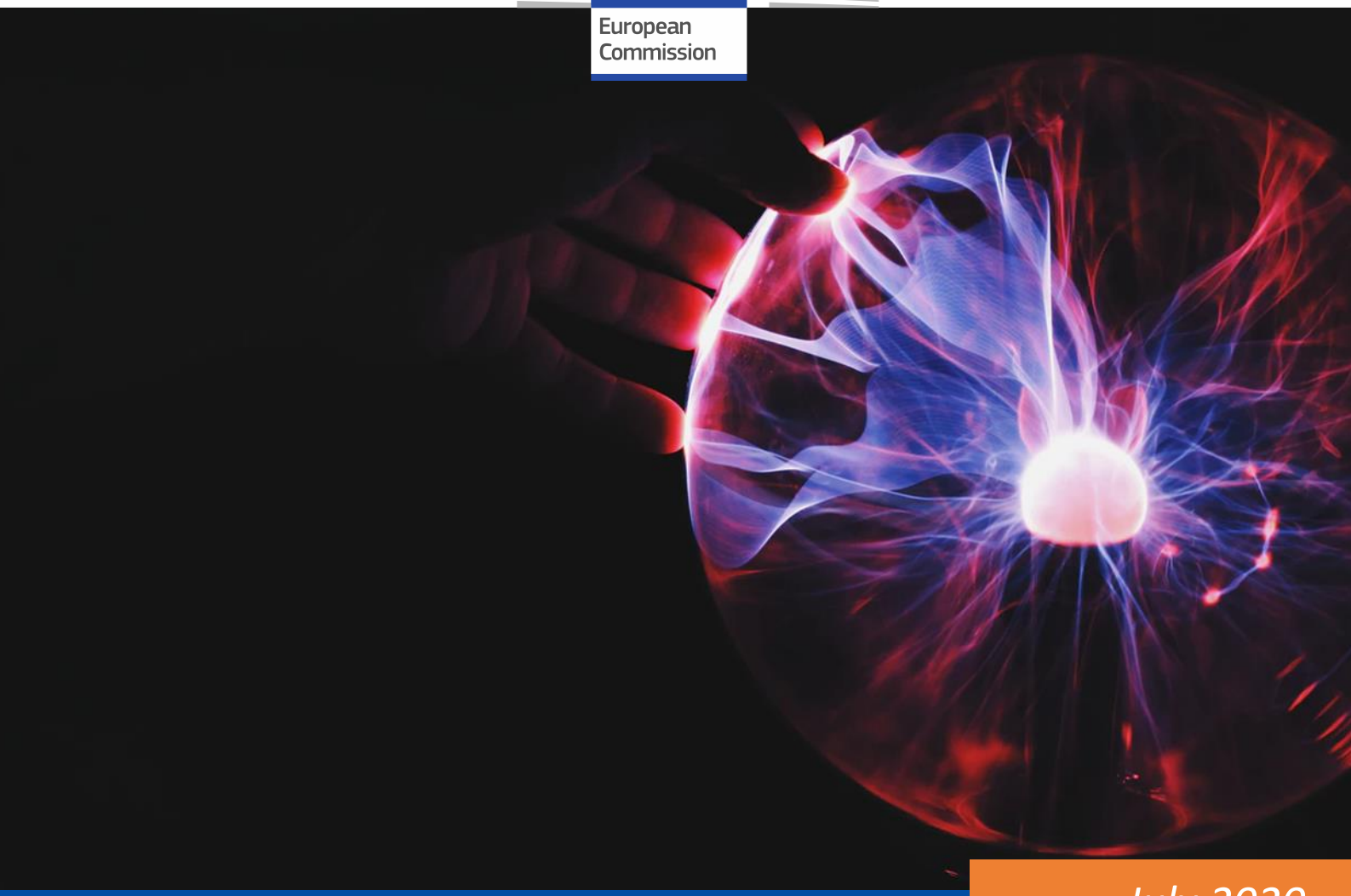

July 2020

Advanced Technologies for Industry – AT WATCH

Technology Focus on Artificial Intelligence

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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 Executive Agency for Small and Medium-sized Enterprises.

As part of a series of analytical reports on advanced technologies' trends, this report represents the first issue of a comprehensive monitoring tool endowing policymakers, industry, researchers, and other relevant stakeholders with regularly updatable research. 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).

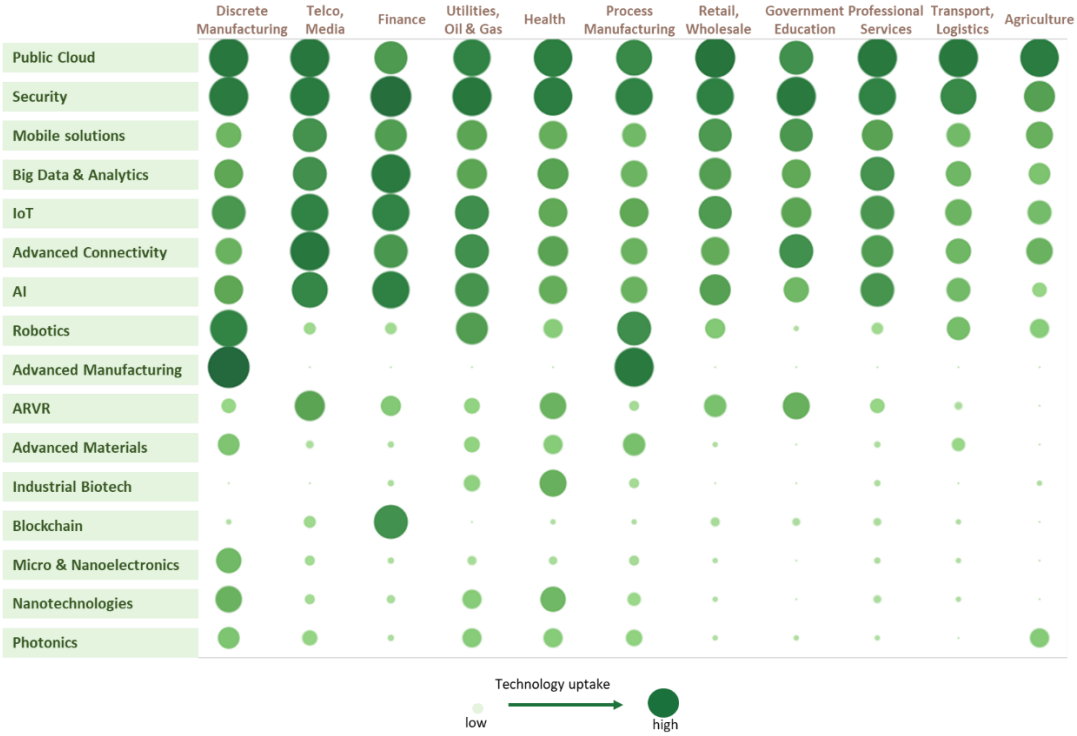
In this report, section 2 is devoted to Artificial Intelligence (AI) as one the most significant technologies that are currently shaping the whole process of digital transformation and industrial modernisation in Europe and Worldwide.

1.1 The Advanced Technologies 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. In such a dynamic scenario, advanced technologies' deployment may take different forms across European industries, depending on the levels of their technological maturity, the availability and relevance of industry-specific applications and the expected and desired business, operational and societal outcomes that a sector intends to achieve.

The different mix of advanced technologies adopted by each industry is visualised in Figure 1 below. 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 88%). The data is based on the Advanced Technologies for Industry Survey (July 2019)[1] and on a sample of European enterprises from 11 Member States, representing altogether 85% of the EU GDP in 2019.

Figure 1: Advanced Technologies Uptake by European Industries, 2019



Source: Advanced Technologies for Industry Survey July 2019, (N=900). Legend: Bubble size represents the % of enterprises in the industry adopting the technology in the same row. The maximum value is 88%. Appendix B provides the definition of each technology.

The visualisation highlights how a distinct group of technologies **features a marked horizontal diffusion** across all industries (general purpose technologies including public cloud, Security, mobile solutions, Big Data, Internet of Things (IoT), Advanced Connectivity and Artificial Intelligence): 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. Taking Blockchain as an example, the technology initially found its ground in financial applications. 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, Blockchain is used to keep track and certify product sources along the value chain. Similarly, Blockchain exhibits a great potential also in the art market where it can be used not only for tokenisation of artworks sales, but also to verify the provenance and authenticity of artworks - one of the biggest challenges for the industry.

[1] The survey interviewed a sample of 900 enterprises with more than 10 employees in CZ, DK, DE, FR, ES, HU, IT, NL, PL, SE, UK.

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

- the **manufacturing industry** has a strong focus on the development of an Industry 4.0 strategy prioritising technologies that can provide clear benefits in terms of driving operational performance and reducing costs. **Automation** is a strong focus and will help companies to simplify complex tasks or processes and relieve human resources of heavy and time-consuming workloads. An important role is played by **Robotics** or collaborative robots (cobots) that help manufacturers achieve efficiency benefits and enable staff to save time. Efficiency gains are also enabled by **Augmented Reality / Virtual Reality (ARVR)** solutions that allow experts to provide remote support to on-field operators and guide them through step-by-step instructions. R&D and product innovation is another strong manufacturing priority driving experimentation with several emerging technologies. In this context, **AI and Big Data/analytics** are helping manufacturers to improve how they design, manufacture and deliver their products. **3D printing** is also poised to grow as it will automate ways to create prototypes or new product parts, reducing production times and improving products. Product innovation is also driving adoption of Advanced Materials, micro and nano electronics, 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 the most promising technologies for the industry as they enable automation of internal operations, improved customer service and greater protection against security threats. 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. The industry has also been central to the emergence of a new digital economy, the open banking. The open banking digital economy is connected to the European payment services directive (**PSD2**[2]). The core of this initiative is the request for banks to share more customer information than ever before via technologies such as application programming interfaces (APIs).
- For **telecom and media** providers new technologies and new customers 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 opportunities for telco unleashing the potential of other technologies such as ARVR and IoT. Streamlining processes, improving network efficiency and improving customer support will be the main drivers of telco's digital investments. Interesting pockets of growth can be found also in investment in other advanced technologies, such as **Photonics** that are supporting the development of fibre optic network communications. Media transformation process had been driven by changing customer needs and behaviours. New channels and platforms for distributing and accessing content and new ways for producing content are driving innovation in the industry. Streaming, content-as-a service and new technologies for creating engaging entertainment experiences, such as wearables and **ARVR** technologies, are major trends under the spotlight.
- **Utilities** and **Oil&Gas** show interesting opportunities in terms of many advanced technologies. 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. Large and small utilities can play different roles across the entire value chain from electric vehicle supply equipment, to management platforms, to meter and grid services, to home and in-network charging. 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. The second growing trend is the smart home ecosystem where utilities can

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

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 **Biotechnology, ARVR, Nanotechnology, Advanced Materials and Photonics**, 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. There is a strong need for data sharing between doctors, different medical units or hospitals to enable faster services and avoid duplicating efforts. Higher investments in **cloud** suggest interest toward infrastructure and operations optimisation. **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. Devices such as **ARVR** devices are helping doctors improve surgery and diagnosis and are also used for therapeutic purposes (e.g. rehabilitation).
- Due to the highly customer-centric nature of **retail**, efforts in providing superior and differentiated customer experience are key in this industry. The **ecommerce** 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. 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. Through deep learning as well as text and voice recognition, AI investments will be heavy across the distribution sector, and they will focus on improving customer experience. 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.
- The pattern of technology adoption by **Government** and **Education** is influenced by the national context. The investments in innovation by public administrations mirror the budget availability at Member State or regional level. Governments are working to streamline internal bureaucratic processes through **automation.** In fact, long back-office tasks slow down critical government work, resulting in longer waiting times for citizens to access services. **AI** solutions based on facial recognition are also seeing significant investment, for example to help police recognise and identify criminals. **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. 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. **Education institutions** in Europe are prioritising investments in **mobile solutions**, for example investing in the provision of mobile devices. Schools are also showing an increasing interest in **distance learning,** with the development of online platforms and e-learning apps for students. After the emergency-driven experience of distance learning during the lockdown period, forced by the COVID-19 pandemic, it is possible that this trend will accelerate as many schools have appreciated their potential advantages (and acknowledged their disadvantages). Many governments and schools are likely to increase investments in distance learning, in a complementary role to in presence education.
- Client expectations, including value-for-money, fast delivery times and high quality of work, together with increasing competition, are putting a lot of pressure on the **Professional Services** industry. Therefore, the industry will continue to invest in advanced technologies to add value to services and business models. 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. **Cloud Computing** continues to attract interest, mainly driven by flexibility that the solution offers in terms of accessing information anytime and increasing collaboration between teams and the low cost to deploy the technology. Professional services are a data intensive vertical investment in security and 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 uptake by the **Transport industry** of advanced technologies is **customer and data-centric,** aiming at delivering enhanced experience to customers while leveraging data and analytics to optimise operations and streamline processes. **IoT** and **AI** play 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. **Smart trucks**[3] are gaining popularity due to the ability of automating processes through the integration of different types of technologies and enabling real-time emergency and incident reactions.
- **The agriculture** sector faces many challenges, including increasing demand for food, climate change and lack of workers. Advanced technologies are increasingly playing a role in responding to some of these challenges. **Data-driven innovation** is transforming farm management through the so-called **precision agriculture** approach. By leveraging **satellites, drones and IoT sensors** 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. This allows farmers to manage irrigation, fertilisation and all the farming processes in a scientific way, minimising costs and the use of pesticides and maximising outputs. 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. This represents a truly digital transformation for a sector which in the past used very little ICT. This innovation process is profoundly changing the culture, organisational processes and skills requirements in the sector, facing barriers of reluctance and difficulties to adapt. 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[4]. 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

[3] The adjective "Smart" refers to multiple tech-enabled scenarios making trucks intelligent, such as e-call equipped trucks (i.e. calling automatically emergency in case of crash), driver fatigue monitoring (systems that track drivers' attention level and notify in case of risk).
[4] ATI General findings (D3.4), Section 5, June 2020

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 Europe.

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 Europe.

Section 2

2. Technology Focus: Artificial Intelligence

Artificial Intelligence (AI) has fascinated human imagination since 1950, when Alan Turing first posed the question of **whether machines can think**, but until recent years it never delivered on its promises. Since 2011, breakthroughs in machine learning (ML), a technique leveraging a statistical approach to make predictions from historical data, and neural networks (a modelling technique) have completely changed the AI technology environment. The availability of huge datasets and technology advances in **Big Data, the Internet of Things (IoT) and fast connectivity are the enablers of AI new systems and services**, digital assistants, robots and drones. Even without an intelligence truly comparable to the human one, the achievements of AI in complementing and substituting intelligent human activities are impressive. The pervasiveness of AI and its disruptive potential of value chains and business models make it both an opportunity and a threat for European enterprises' competitiveness.

Today's AI is a general-purpose technology, a collection of tools that can be combined, extended and packaged into different types of applications across all industries, such as voice and image recognition, machine translation, control of assisted driving and autonomous vehicle navigation. Given this multidimensionality, there are multiple definitions of AI.

The EC's White Paper on artificial intelligence[5], published for public consultation in February 2020, defines AI as "**a collection of technologies that combine data, algorithms and computing power"** and one of the most important applications of the data economy. The EC considers AI as an instrument to harness the value of data in order to build European sustainable economic growth and societal wellbeing. A trustworthy AI is an essential building block of Europe's ambition to build a digital society on European values and rules[6].

The OECD AI Expert Group (AIGO)[7] defines AI more narrowly as "machine-based systems that can, for a given set of human defined objectives, make predictions, recommendations, or decisions influencing real or virtual environments".[8]

This report is focused on a definition, which is coherent with both the EC and the OECD definitions and is focused on AI's capability to support decision making, classifying AI "as systems that learn, reason, and self-correct. These systems hypothesise and formulate possible answers based on available evidence, can be trained through the ingestion of vast amounts of content, and automatically adapt and learn from their mistakes and failures"[9].

Recommendations, predictions, and advice based on this AI framework provide users with answers and assistance in a wide range of applications and use cases. The operational definition in focus specifies that **AI software technologies include natural language processing (NLP), image and video analytics, machine learning (ML),** knowledge graphs and other technologies to answer questions, discover insights and provide recommendations. AI also empowers innovation in Robotic Process Automation (RPA: software solutions powering robots) and drones.

The new generation of AI technologies entering the market is far from mature. Its full exploitation will require deep transformation of organisational and business processes as well as skill changes and new ways of working. Digital transformation remains the key to the successful adoption of these technologies. As for every new technology, AI will need to be "domesticated" by the socio-economic system to reach its full potential. Issues such as trust, transparency, ethical and social challenges will need to be addressed, as discussed in Section 2.4 "Policy, Regulatory and ethical implications".

Unsurprisingly, the advent of AI plays a pivotal role in the EU and Member States' policy strategies. Alarmed by a gap in R&D investments in innovative technologies compared with China and the US, the EU launched an ambitious strategy already in 2018[10].

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[5] European Commission "White Paper on Artificial Intelligence - A European approach to excellence and trust"
[6] European Commission "Shaping Europe's Digital Future", February 2020
[7] OECD (2019), "Scoping the OECD AI principles: Deliberations of the Expert Group on Artificial Intelligence at the OECD (AIGO)",
[8] OECD, "Recommendation of the Council on Artificial Intelligence" (2019)
[9] IDC' Worldwide Artificial Intelligence Taxonomy, 2019
[10] EC Communications "Artificial Intelligence for Europe" and "Coordinated Plan on Artificial Intelligence", 2018

The **White Paper on Artificial Intelligence**[11] published in February 2020 builds on these previous steps with renewed ambition and investments to build cutting-edge digital capabilities in the field. Two main strands of policy are planned. The first aims at building an AI European ecosystem of excellence, leveraging the forthcoming Framework Programs Horizon Europe (HE) and Digital Europe (DE) in the period 2021-2027, including a new public-private partnership in AI and Robotics. The plan includes investments in AI research excellence centres and AI Digital Innovation hubs, as well as increased equity funding through the European Investment Fund. The second policy strand aims at building an ecosystem of trust, developing a legislative framework favourable to the development of AI, dealing with AI-related risks, guaranteeing the respect of human rights and European values. In fact, concerns about the social and ethical risks from the development of AI have given raise to multiple guidelines from international organisations and governments, as illustrated in Section 2.4.1 "Recent policy developments".

To help industry stakeholders, national/regional/local policy makers, as well as researchers and technology stakeholders to obtain an up-to-date picture of AI's latest developments in Europe, the report will now focus on the market potential associated with AI. It will further investigate AI value proposition in terms of leading use cases of this technology in Europe, in order to highlight the concrete business opportunities stemming from the adoption of the AI. Finally, the social dimension and impacts of AI on the society as whole, together with their policy-related and ethical implications, will be considered in Section 2.4 .

2.1 The Market Potential

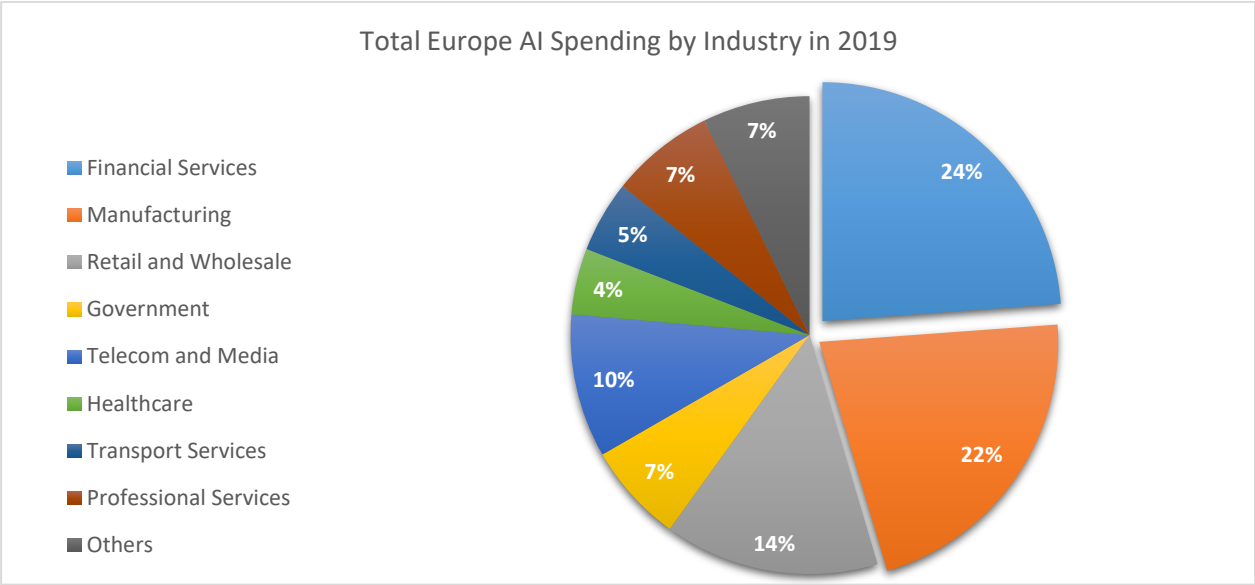
2.1.1 Adoption and industry trends

After an early stage dominated by innovative players and exploratory applications in specific business and societal scenarios, artificial intelligence has rapidly gained in importance and diffusion and is now beyond the nascent phase. The potential for future growth and economic impacts is still impressive, because AI is a general-purpose technology expected to be adopted in different ways by all industries and all social actors. According to Mc Kinsey estimates presented in 2019[12] "If Europe develops and diffuses AI according to its current assets and digital position relative to the world, it could add some €2.7 tn, or 19 percent, to output by 2030. Such an impact would be roughly double that of other general-purpose technologies adopted by developed countries in the past". Even if these estimates need to be revised because of the disruption caused by the COVID-19 pandemic, there is still no doubt about the relevance of the potential impacts of AI-driven innovation. Other sources, such as the OECD[13], confirm that artificial intelligence is poised to span every aspect of our daily lives.

The speed of evolution of the market is impressive. At worldwide level, IDC forecasts[14] the total spending on AI to grow at a 5-years Compound Annual Growth Rate (CAGR) of 26.5% for the period 2018–2023, up to €96 bn at the end of that period. The European Union market is expected to grow faster than the global market, representing a share of 23% of total by 2023 (versus 18% in 2018). An overview of the current AI spending in Europe in terms of percentage shares across the different industries in offered in Figure 2 below.

[11] European Commission Communication, "White Paper on Artificial Intelligence - A European approach to excellence and trust" 2020
[12] Mc Kinsey Global Institute, Notes from the AI Frontier: "Tackling Europe's gap in digital and AI", 2019
[13] OECD (2019) "Artificial Intelligence in Society"
[14] IDC Worldwide Artificial Spending Guide, March 2020

Figure 2: Total AI spending % value by Industry, Europe, 2019



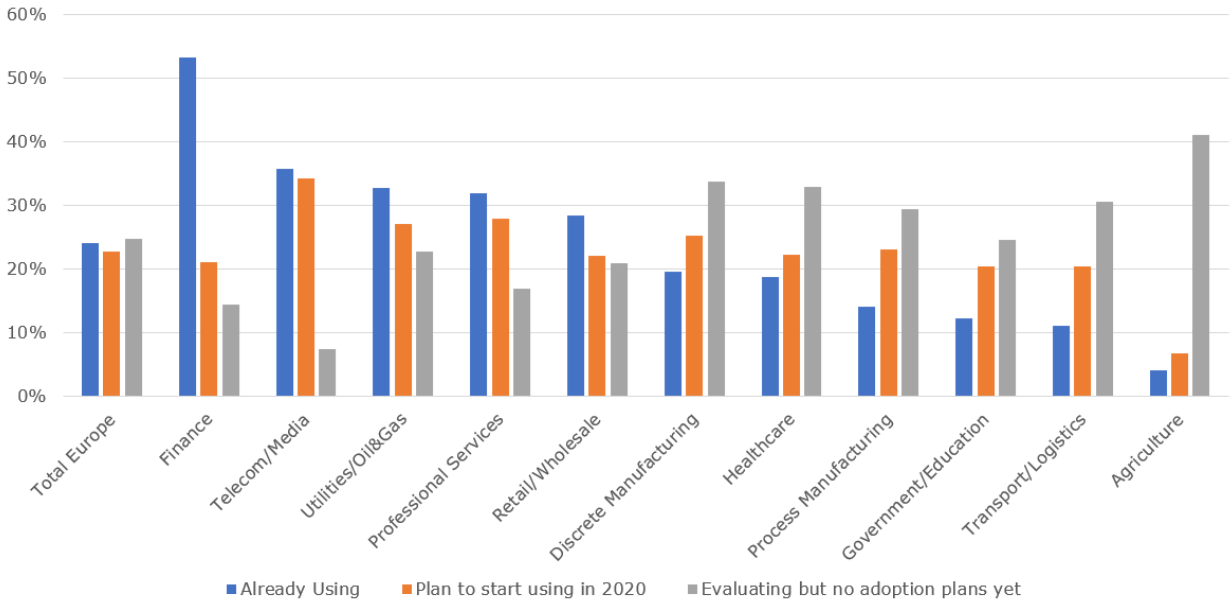
Source: IDC Worldwide Artificial Intelligence Spending Guide, March 2020[15]

In Europe, the use of AI is growing as existing users deepen their investments and new users enter the market. According to the Advanced Technologies for Industry Survey (July 2019), more than one fourth of European organisations are currently adopting AI and another half are planning or evaluating to adopt AI systems in the near term. Figure 3 below displays the AI adoption rates across European industries according to the results of the Advanced Technologies for Industry Survey (July 2019).

Sectors such as **Finance, Telecom/media** and **Utilities/Oil & Gas** take the front seat in the European AI scenario. Having been trailblazers since the first years of AI experiments and proof-of-concepts, they continue to lead the way in terms of AI adoption, driven by their data-intensive business nature that provides a fertile ground to AI applications. For example, one out of two European financial companies are already adopting AI technologies[16], enhancing their workforce skills with AI tools that provide better analysis and investigation capabilities.

[15] Total Europe (as per IDC definition):
AL, AT, BE, BA, BGR, HR, CZ, DK, EE, FI, FR, DE, GR, HU, IRL, IT, KAZ, LVA, LT, MK, MNE, NL, NO, PL, PT, RO, RU, RS, SK, SI, ES, SE, CH, UA, UK and Rest of CEE.
[16] Source: Advanced Technologies for Industry Survey July 2019

Figure 3: AI Adoption across European Industries (share of respondents)



Source: Advanced Technologies for Industry Survey July 2019, (N=900)

Both Discrete and Process Manufacturing show a percentage of respondents planning to adopt AI this year (25.4% and 23.1%, respectively) above total European average (22.8%) (Figure 3), driven by AI capability to support end-to-end value chain visibility and implement data-driven processes in factories. Even if the 2020 recession due to the COVID-19 pandemic will slow down technology adoption plans in the short term, AI investments are expected to start growing again soon in the post-crisis scenario, to fuel recovery through digital transformation and increased automation.

2.1.2 Main Barriers and Challenges

The actual deployment of AI use cases is hindered by multiple challenges and implementation barriers. To reap concrete business opportunities, enterprises must be aware of these challenges and of the countermeasures that industry and policy makers are trying to implement in Europe. Enterprises should also face these challenges in a proactive way, without waiting for them to be solved, to avoid losing the competitive AI race.

The main challenges standing in the way of a full-blown AI development and deployment in Europe are:

- The need to **strengthen the AI research and innovation environment**, which is fragmented[17]. This creates difficulties to bring competitive innovations to the global market. The AI Digital Innovation Hubs to be created across Europe have the objective to help bridge this gap between research and industry. Building essential digital capabilities in Europe for AI is one of the strategic objectives of the forthcoming Digital Europe Programme[18].
- **Increasing demand for skills and know-how**. The number of tech-savvy professionals does not meet the exponentially increasing current demand. Many European organisations do not have the skills needed to deploy and manage AI solutions[19]. The hiring demand for AI is particularly high in the Financial services and Automotive sectors.[20] Developing advanced digital skills for AI as well as other strategic technologies is one of the missions of the forthcoming Digital Europe Programme, as the EC has identified the lack of skills as one of the critical bottlenecks of European digital innovation capability.
- **An insufficient availability of data and data sharing**. Datasets are the lifeblood of Artificial Intelligence. Global platforms such as Google and Facebook dominate the access to personal

[17] "European Artificial Intelligence. (AI) leadership, the path for an integrated vision". Policy Department for Economic, Scientific and Quality of Life Policies, Directorate-General for Internal Policies. Laura Del Ponte (CSIL) 2018
[18] https://ec.europa.eu/digital-single-market/en/news/digital-europe-programme-proposed-eu92-billion-funding-2021-2027
[19] IDC's Western Europe AI/Cognitive Solutions Survey, June 2018
[20] ATI General findings (D3.4), Section 5, May 2020

data. European enterprises, especially SMEs, are reluctant to share data. Insufficient data sharing and re-use is a major barrier to the implementation of advanced AI in the supply chains. Improving the availability of data and data flows across Europe is one of the strategic objectives of the European Data Strategy[21].

- **An immature legislative framework**. Uncertainty about data governance and the management of AI-related liability, safety, security risks is slowing down adoption of AI solutions. Again, this challenge is recognised and addressed by White Paper on AI.
- **A limited access to AI data and infrastructure**: The lack of AI infrastructures and access to datasets across borders can represent a bottleneck for scaling up AI deployments, particularly for innovative entrepreneurs, SMEs and start-ups. Academics and innovators need good access to world class innovation infrastructure including access to data and resources such as High-Performance Computing (HPC) and test environments[22]. Removing this barrier would be particularly important, since the number of AI start-ups has been growing in the recent period in Europe[23].
- **High Complexity of AI in Industry and Public sector**: Implementing AI, data and Robotics relies on incorporating the domain knowledge of underlying processes. Handling these challenges requires combining domain specific process knowledge with AI based knowledge.[24]
- **A lack of social trust**. Public opinion perceives the risks to social cohesion, democracy and human rights from AI innovation even more than the potential for social good.[25] There are also risks for enterprise reputation and financial welfare. European policies aim at building a trustworthy AI, but this is not sufficient: enterprises must be aware of these threats and be proactive in building trust for their customers and markets.
- The presence of **several technological barriers**: There is considerable complexity and cost in creating AI systems with the ability to collect, process and analyse large quantities of data in order to make robust and trustworthy decisions and implement autonomy. The main technology challenges are presented for example in the BDVA-EU Robotics research agenda[26]. Enterprises cannot simply wait for researchers to solve the technology challenges but should work with them to identify and solve them, particularly in standardisation and interoperability.

Following the COVID-19 outbreak, many industries such as Transportation/logistics, Manufacturing and Retail will be forced to revise their technology investments downwards. On the other hand, AI is a technology that can play a significant role in helping businesses and societies to deal with large scale disruption caused by quarantines and lockdowns. Of all industries, the Government and the Healthcare sectors, will experience an acceleration of AI investments. For example, hospitals are looking at AI to speed up COVID-19 diagnosis and testing and to provide automated remote consultations to patients in self-isolation through chatbots. At the same time, governments are investing in AI to support track and tracing applications and monitor compliance with social distancing (see also Section 2.3.3 for more information).

[21] European Data Strategy, chapter 4 "Problems"
[22] BDVA and EU Robotics, SRIDA, 2019
[23] ATI General Findings report (D.3.4), Section 5, May 2020
[24] BDVA and EU Robotics, Strategic Research, Innovation and Development Agenda, September 2019
[25] Renda, A. (2019). Artificial intelligence: Ethics, governance and policy challenges. CEPS Task Force Report.
[26]BDVA and EU Robotics, Strategic Research, Innovation and Development Agenda, September 2019

2.2 Use cases and business opportunities

2.2.1 AI value proposition

The multi-faceted set of technologies falling under the name of AI can be applied to multiple business processes, thus generating a wide variety of business opportunities. A good overview of the AI-value proposition can be found in the research and innovation agenda developed jointly by the BDVA (Big Data Value Association) and EU Robotics research communities for the forthcoming AI Public-Private Partnership AI[27]. They include the following:

- By weaving AI into the design, manufacturing, production and deployment processes, productivity can be raised.
- By using AI to increase autonomy, higher operational flexibility can be achieved.
- By using AI to improve the usability of products and services (e.g. by allowing greater variations in the human-machine interaction), the user value can be increased and new customer segments addressed, therefore creating new markets.
- By using AI for supporting complex decision-making processes in dynamic environments, people can get help in situations of rising complexity (e.g. technical complexity, increasing volatility in markets).
- By using AI to improve general public services and for social good, social welfare can be improved substantially.

As the AI landscape matures, application-specific products will emerge and improved commercial development tools will be made available to industries with lower high technology awareness and higher barriers to adoption. This is already taking place in the European AI market, driving impressive spending growth even in those sectors that are normally resistant to new technologies adoption.

2.2.2 Leading AI Use Cases

In this report a use case is defined as a discrete funding effort supporting the implementation of a technology to achieve a business or societal objective, in a specific business process or application area. The identification of the main use cases of a new technology helps to pinpoint its market and business value and to track users' choices and priorities. Successful use cases demonstrate the viability and positive return on investment of new technology solutions in concrete application environments, rather than pilots or trials. Particularly in the digital environment, in fact, there is often a "hype" factor around innovative technologies, which tends to overstate their maturity and potential business benefits and may mislead interested users or developers. In the case of a technology such as AI, with a very broad range of potential applications, but also complex requirements in terms of actual implementation, the analysis of emerging use cases is especially useful. In this paragraph we provide an overview of the leading and emerging AI use cases and the related business opportunities for both the technology providers and the business users.

The way Artificial Intelligence is applied in real-life situations, and within the different industry sectors, encompasses a mix of **horizontal applications and industry-specific scenarios**. As with other advanced technologies, the way AI brings forward the process of digital transformation and industry modernisation is becoming more and more demand-driven, where industry users tend to direct their efforts towards a better understanding of the business and operational opportunities offered by the technologies rather than focusing on the technologies per se.

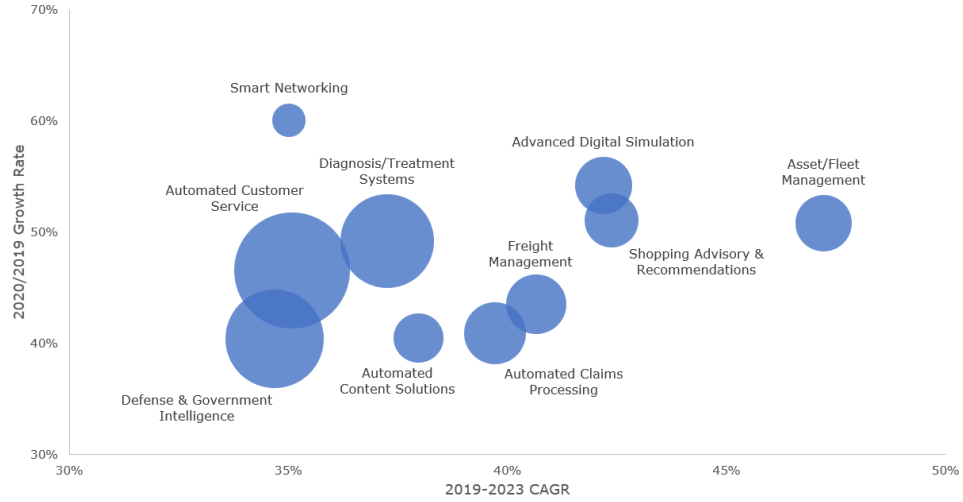
Figure 4 below provides a snapshot of the top 10 AI use cases in Europe, in terms of value growth (forecast spending increase) in the period 2019-2023. The size of the bubbles corresponds to the users' spending for each use case in 2019. Even if the growth rate forecast for 2020 on 2019 should now be considered with caution, because of the 2020 recession caused by COVID-19, digital markets are expected to rebound fast from 2021 onwards, as investments are made to fuel the recovery.

The top AI use cases are a mix of horizontal and vertical-specific. For example, the use case *Automated Customer service* is widespread across the customer-facing industries, from banking to retail to telecommunication or even utilities, but it does extend to manufacturing too. As a result, it shows the highest spending value in 2019 (€413 m, Table 1) and is still expected to grow in the next years. The Asset/Fleet management use case is specific to the Transport sector (so it has a smaller potential market), but it provides valuable business benefits and shows the highest expected growth rate to 2023

[27] BDVA and EU Robotics, SRIDA, 2019

(47% CAGR, Compound Annual Growth Rate, Table 1). Different use cases may also share **common business or societal outcomes objectives,** such as higher internal automation or enhanced customer or user experience. These outcomes should be the reference and starting point for those European organisations looking with interest at the AI landscape in order to capture new business opportunities.

Figure 4: Top 10 AI Use Cases in Europe by value growth (spending growth, € m)



Source: IDC Worldwide Semi-annual Artificial Intelligence Systems Spending Guide, March 2020

Legend: The bubble size represents the spending value by use case in 2019, CAGR: Compound Annual Growth Rate.

Table 1: Top 10 AI Use cases Spending (€ m) (Ranking by Value)

Top 10 AI Use cases	2019-2023 CAGR	2020/2019 Growth Rate	2019 Spending (€ m)
Automated Customer Service	35%	47%	413
Defense & Government Intelligence	35%	40%	298
Diagnosis/Treatment Systems	37%	49%	271
Automated Claims Processing	40%	41%	117
Freight Management	41%	44%	111
Advanced Digital Simulation	42%	54%	100
Asset/Fleet Management	47%	51%	98
Shopping Advisory & Recommendations	42%	51%	90
Automated Content Solutions	38%	40%	75
Smart Networking	35%	60%	35

Source: IDC Worldwide Semi-annual Artificial Intelligence Systems Spending Guide, March 2020. Further information about the leading use cases is presented below.

Automated Customer Service

The use of AI in Customer Experience scenarios is one of the most mature applications, enabling faster and automated customer support via online chatbots and customer enquiries triage tools, improving productivity and customer satisfaction. AI solutions applied to automated customer services help understand customer needs and problems and reduce the time and resources spent in achieving customer issue resolution: they can be adopted in most industries, from manufacturing to healthcare, but are particularly relevant in consumer-facing industries such as finance and retail. Even though this use case already generates a high level of spending, it also has a high forecast growth thanks to a significant potential for further uptake by new users. Moreover, the use of AI in customer interaction is fast becoming a competitive imperative. This use case is also a valuable business opportunity for potential suppliers because its implementation often requires personalisation and adaptation services on top of standard solutions.

Defence and Government Intelligence

Governments around the world are embedding AI functions and applications in their advanced intelligence practices, to increase the level of automation of the identification and management of public risks. In this context, AI solutions deliver critical data, information, and intelligence that help national security agencies identify, monitor and respond to personnel, assets and infrastructure threats.

Diagnosis/ Treatment Systems

AI systems allow to extract insights from the intersection of diverse data sets, including medical records, lab tests, clinical studies, medical images, and other sources, to assist in diagnosis and provide personalised treatment at the individual patient level. Hospitals were already implementing this use case before the COVID-19 pandemic, which has highlighted its usefulness and is likely to accelerate its adoption. AI is transforming patient care models through intelligent diagnosis assistance and personalised treatments delivery.

Automated claims processing

The insurance industry is leveraging AI in the automated processing of the data generated by claims to increase the productivity and effectiveness of their investigation and adjudication. This is a typical case of data-driven, intelligent decision support innovation which is already generating substantial value for the industry. The insurance industry is very fragmented and the potential of growth in the next years with further uptake of this use case is quite high.

Freight Management

The implementation of AI in freight management logistics for all transportation modes (air, rail, land, and water) combined with supply chain logistics leads to intelligent monitoring and end-to-end visibility, enabling the optimisation of truck loads, container management, spare parts planning, dock availability, and customer experience management. In addition, this use cases helps suppliers to gain intelligent insights on the type of product, place, and time of delivery to guarantee best pricing.

Asset & Fleet Tracking in Transportation

This use case helps to increase visibility of assets and real-time operational intelligence in the transport and aviation industries improving profitability and productivity. With these tools, it is possible to implement remote management or resources, allowing to achieve route optimisation; provide actionable responses to vehicle condition (remote diagnostics); monitor driver behaviour (tracking of idle or stopped time).

Shopping Advisory & Recommendations

Leading companies such as Amazon or Netflix have built their fortune on profiling customer tastes and offering personalised advice. The news is that thanks to maturing AI many more retail enterprises can take advantage of this technology to enhance marketing and advertising practices and to combine physical and virtual commerce.

Advanced Digital Simulation

This use case is applied in Manufacturing to improve product design and production through a continuously learning system (deep learning) which can be queried automatically or by voice. The use

of deep learning and AI results in a virtual model that is essentially the intelligent counterpart to an actual, physical object (digital twin): in this way engineers can test the simulated product, anticipate problems, learn about weaknesses. This provides valuable productivity and efficiency benefits, but also customer satisfaction by allowing to improve the quality of new products.

Automated Content Solutions

This use case leverages AI for the content workflow process. Examples include, but are not limited to, content marketing, standard research procedures, research reports, white papers, product data sheets, and journalism (news articles, stories produced automatically by AI rather than human reporters or authors). This use case is still in the emerging phase but shows high growth potential. **Smart Networking**

The telecommunication industry is exploiting AI to expand network management and real-time analytics applications. In this specific context, AI solutions provide design and implementation of rules and parameters governing the routing of inbound calling together with an expanded use of real-time analytics to make the network smarter and more efficient.

In conclusion, AI plays a key accelerator role behind all these established and emerging use cases. However, it is **the combination of AI with other advanced technologies that makes these digital use cases possible**. This is the reason why it becomes so crucial for the European industry to chart out a forward-looking digital roadmap across different maturity time horizons; a roadmap that, starting from business and societal outcomes, identifies the leading enabling use cases, while pinpointing at the same time the technologies required to successfully support the use case implementation.

2.3 Social and Sustainability Impacts

2.3.1 Introduction

The influence of AI-driven predictions, recommendations and decisions is gradually affecting all dimensions of life. The awareness of the potential positive impacts on social welfare and the economy is counterbalanced by the emergence of new ethical and fairness risks. Fortunately, the same AI technologies that generate ethical risks can also be used to fight them and create social good. A case in point is the spread of fake news, such as "deep-fakes" (realistic, hard to detect and surprisingly easy-to-create facsimiles of real people[28], used for example to spread disinformation in political elections[29]) which can be revealed with AI tools. This is another motivation to promote a human-centered and trustworthy AI.

The achievement of social goals can be complementary or alternative to business goals. We can identify three main categories of stakeholders engaged in the achievement of social goals, in different and not mutually exclusive ways:

- Public or private organisations providing general public services, including government, social services, education, healthcare, public transport and other utilities. In these sectors, organisations pursue public value in addition to efficiency and effectiveness, to improve social welfare and quality of life. Technology innovation can be used for example to improve democracy, transparency, social inclusion, equal access to basic services, the respect of human rights.
- Public or private organisations investing in technology initiatives for social good, for example in the context of the achievement of the UN 2030 Sustainable Development Goals (SDG). For example, Google.org launched an open call[30] to identify projects using AI for social good, collected proposals from 119 countries and selected 20 winner initiatives to be funded. Some private organisations do so in the context of their Corporate Social Responsibility (CSR) strategies.
- Governmental or non-governmental organisations and other non-profit organisations (part of the so-called Third sector) who by definition pursue social goals and can use technology to do so.

In this chapter we examine the emerging application domains and use cases of AI which contribute to social welfare, quality of life and environmental sustainability, to raise the awareness of stakeholders

[28] https://threatpost.com/deepfakes-ai-fighting-cybersecurity-fire/154978/
[29] https://www.stern.nyu.edu/experience-stern/faculty-research/disinformation-and-2020-election-how-social-media-industry-should-prepare
[30] https://ai.google/social-good/impact-challenge

about this category of impacts and encourage their initiatives in this domain. This is structured in two main topics:

- The use of AI for social good, reviewing innovative initiatives by international organisations as well as private and public actors;
- The social impacts of AI in the healthcare sector, with a specific focus on the actual and potential use of AI to manage the COVID-19 pandemic and its consequences.

2.3.2 AI for social good

The research, business and social communities are becoming increasingly aware of the need to support and promote the use of AI for social good, with a proactive approach complementing private initiative where necessary. This is recognised by leading AI policies and guidelines. For example, the first priority of the OECD Principles on Artificial Intelligence[31] (the first international standards agreed by governments adopted in May 2019) is that human-centred AI should contribute to inclusive and sustainable growth and well-being. The EC's "White Paper on Artificial Intelligence - A European approach to excellence and trust", published for consultation in February 2020, underlines that the use of **AI systems impacts not only individuals and businesses, but also society as a whole and "can have a significant role in achieving the UN 2030 Sustainable Development Goals (SDG), in supporting the democratic process and social rights".** The EC expects AI technologies to play an important role also in the implementation of the European Green Deal, to deal with environmental challenges.

The range of social impacts covered by AI for social good is quite broad, as shown by the initiatives presented in the Table 2 below. A study[32] identified already in 2018 **more than 160 use cases of AI applied to the UN SDG domains** and generally able to improve social welfare. The areas of impact include:

- Leveraging AI to provide **high quality healthcare** in regions with few resources, as for example the Médicins sans Frontières project to use image recognition and a smartphone app to help medical staff in remote areas to diagnose antibiograms and prescribe the right treatment.
- **Prevent hunger**, one of the priority SDG goals, as the American University of Beirut is doing in Lebanon using machine learning applied to weather and agriculture data to help farmers with irrigation schedules. AI can help agriculture in poor countries to make a quality leap and fight the ravages of climate change. Several initiatives are helping to translate AI-driven innovation in the food-agriculture ecosystem from advanced economies to low-income countries.
- Improving general public services such as **waste management**. For example, the Grinngo Indonesia Foundation is pioneering the use of AI-driven image recognition for waste collection supporting informal-sector waste collectors.
- Several AI-driven initiatives address **equality and inclusion**. Particularly interesting is the case of Skillab, a Dutch NGO, which uses the natural language processing and automated translation capabilities of AI to document migrants' skills and help them to identify job and career opportunities in the European labour market.
- AI can also help to ensure **security and justice** for all, for example the Swiss NGO HURIDOCS is testing the use of AI to help human rights lawyers extract relevant information from documents, a type of service available until now only to advanced law firms for profit.
- Supporting **social welfare** and social services: multiple initiatives are leveraging AI natural language processing and sentiment analysis capabilities to help social services deal with requests for help, as for example the Crisis Text Line NGO is doing to optimise the allocation of telephone calls to counsellors and reduce wait times.

[31] https://www.oecd.org/going-digital/ai/principles/
[32] https://www.mckinsey.com/featured-insights/artificial-intelligence/applying-artificial-intelligence-for-social-good

Table 2: AI for Social Good – selected initiatives

Name	Description	Country	Domain	Source
Nexleaf analytics	AI-driven data models to improve the management of vaccine cold chain systems in low-income regions	US	Healthcare	https://ai.google/social-good/impact-challenge/
Fondation Médicins sans Frontières	Using image recognition and a smartphone app to help medical staff in remote areas to identify antibiograms and prescribe treatment	FR	Healthcare	https://ai.google/social-good/impact-challenge/
European Emergency Number Association (EENA) & Corti	Piloting AI to support emergency medical service operations for patients with cardiac arrest outside of hospital	BE, FR, IT	Healthcare	https://eena.org/artificial-intelligence-eena-corti-project/
Wadwhani AI	AI-based data model based on farmers-sourced iPhone photos of pest traps to monitor pests and provide advice on pesticide use	India	Hunger prevention/ Precision Agriculture	https://ai.google/social-good/impact-challenge/
American University of Beirut	Applying ML to weather and remotely sensed agricultural data to provide farmers with irrigation schedules	Lebanon	Hunger prevention/ Precision agriculture	https://ai.google/social-good/impact-challenge/
Gringgo Indonesia Foundation	Image-recognition tool for informal-sector waste collectors and independent waste management companies from low-income regions	Indonesia	Waste Management	https://ai.google/social-good/impact-challenge/
Skillab BV	AI app helping refugees to document skills in native languages and transfer it into European labour market categories to identify potential career paths	NL	Equality and inclusion	https://ai.google/social-good/impact-challenge/
Talking Points	AI-powered two-way translated communication and personalised coaching content to guide parents' engagement with teachers and children and overcome linguistic and cultural barriers	US	Equality and inclusion	https://ai.google/social-good/impact-challenge/
Quill.org	Structured DL system to provide students with automated, immediate feedback on their writing to improve skills, filling skills gap particularly for low-income students	US	Equality and inclusion	https://ai.google/social-good/impact-challenge/
HURIDOCS	NLP and ML methods to extract information and relevant facts from documents for human rights lawyers	CH	Security and Justice	https://ai.google/social-good/impact-challenge/
AILIRA	Artificially Intelligent Legal Information Research Assistant for free	Australia	Security and Justice	https://www.itu.int/en/ITU-T/AI/Pages/ai-repository.aspx
Full Fact	AI-driven monitoring and clustering tools for fact-checking of news and other information	UK	Information verification	https://ai.google/social-good/impact-challenge/
Crisis Text Line, Inc.	NPL and AI-driven data analytics to optimise the allocation of text	US	Social welfare	https://ai.google/social-good/impact-challenge/

Name	Description	Country	Domain	Source
	messages to counsellors reducing wait times and improving effectiveness			

Source: shown in the table

The protection of the environment is a domain where AI is expected to have a strong positive social impact, as shown by the initiatives further presented in Table 3 below. As in the cases of healthcare and agriculture, there is a trend to transfer advanced solutions pioneered in the private sector, for example in the mining or energy industries, to the public domain for the public good. A key trend is the use of ML (machine learning) and DL (Deep learning) techniques to interpret and forecast data from various sources to detect pollution, illegal activities such as logging, and protect the environment. This is done for example to detect illegal mines (Colombia) or improve the prediction of landslides (Pennsylvania) or monitor the air quality (Uganda). The combination of mobile technologies with DL techniques for bio-acoustic monitoring of threats to rainforests (US) is particularly creative.

NGOs in the environmental sector are also experimenting with AI. For example, the Wildlife Conservation Society and World Wildlife Fund are adopting an AI-driven system (PAWS) to help prevent poaching in wildlife reserves.

Table 3: AI for the Environment – selected initiatives

Name	Description	Country	Domain	Source
Colegio Mayor de Nuestra Señora del Rosario	ML-based analysis of satellite images to detect illegal mines polluting the environment	Colombia	Environment monitoring	https://ai.google/social-good/impact-challenge/
Rainforest Connection	Mobile technology combined with DL for bioacoustics monitoring of threats to rainforests health such as illegal logging	US	Environment monitoring	https://ai.google/social-good/impact-challenge/
Makerere University	AI to analyse data from low-cost air sensors from Taxis and other locations to improve air quality monitoring and forecasting	Uganda	Environment monitoring	https://ai.google/social-good/impact-challenge/
WattTime	Global, open source monitoring platform using images processing of satellite images to measure emissions of major fossil fuel power plants where local monitoring is too	US	Environment Protection	https://ai.google/social-good/impact-challenge/

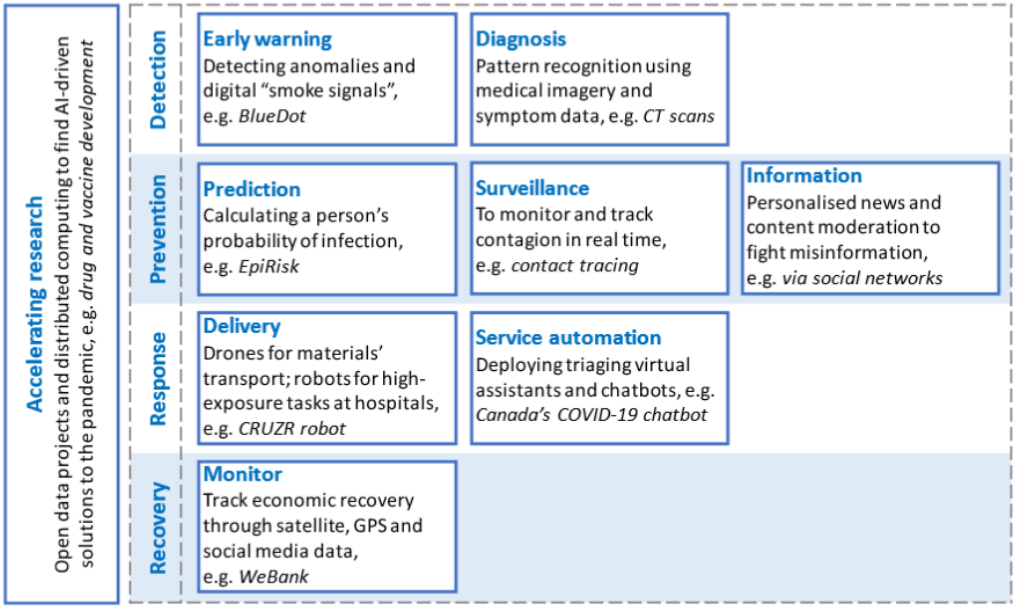
Name	Description	Country	Domain	Source
	expensive or not possible			
PAWS (Protection Assistant for Wildlife Security)	An Artificial Intelligence system that predicts poaching risk levels in different areas of a wildlife preserve and helps rangers patrol more efficiently. PAWS will be integrated into SMART (Spatial Monitoring and Reporting Tool), a system used by the Wildlife Conservation Society and World Wildlife Fund.	Africa	Environment Protection	https://www.seas.harvard.edu/news/2019/10/outsmarting-poachers
ConvNetQuake	Convolutional Neural Network for Earthquake detection and location (ConvNetQuake) open source tool. It is trained on data from Oklahoma (USA).	US	Environment Protection	https://github.com/tperol/ConvNetQuake
The Pennsylvania State University	Development and use of DL tools to improve prediction of landslides and create warning systems to minimise damages and save lives	US	Emergency services/ Environment protection	https://ai.google/social-good/impact-challenge/

Source: shown in the table

2.3.3 AI in the Healthcare Sector

The outbreak of COVID-19 has put enormous pressure on many European healthcare systems, stretching the available resources and support to breaking limits. However, it has also triggered an unprecedented demand for digital health technology solutions and has revealed successful solutions supporting healthcare systems, single hospitals and healthcare providers. Innovative digital solutions can play an integral role in flattening the curve, limiting the spread of the virus, and assisting in the treatment of infected individuals. Artificial Intelligence solutions have become one of the first lines of defence in the pandemic.

Figure 5: Examples of AI applications at different stages of the COVID-19



Source: OECD, "Using Artificial intelligence to help combat COVID-19"[33]

Figure 5 shows how AI tools and techniques can help policymakers and the medical community understand the COVID-19 virus and accelerate research on treatments by rapidly analysing large volumes of research data. AI text and data mining tools can uncover the virus' history, transmission, and diagnostics, management measures, and lessons from previous epidemics.

Specific applications of AI are available at two different levels: at the **healthcare system** level and at the **hospital** level.

Large health-care systems are turning to AI to monitor patients and to regulate the flow of visitors as they attempt to contain the spread of the novel coronavirus. They are scanning faces to check temperatures and harnessing fitness tracker data, to zero in on individual cases and potential clusters. They are also using AI to keep tabs on the virus in their own communities. Leveraging multisource data, advanced analytics and AI technology, platforms have the potential to help public health bodies in multiple ways:

- **Epidemiological surveillance, identifying early signals of the outbreak and tracking the infection.**

As widely reported, many public health authorities are limiting test eligibility to symptomatic patients and healthcare workers. Furthermore, there is a time delay between the onset of physical symptoms and, if the infected individual gets a diagnostic test, the receipt of results. Health authorities can be more effective, in terms of response times, by accelerating research and make more informed data-driven decisions, including optimising and triaging of scarce resources and slowing the spread. Skilful initial selection of optimal tools and approaches improves the investigation. Some existing epidemiological surveillance platforms have shown promising results using AI and machine learning for tracing infection spread across time and space and for predictive risk mapping to support epidemic monitoring response. As an example, the European Centre for Disease Prevention and Control uses NLP and social listening techniques to analyse data from the internet and social networks to monitor disease outbreaks. As part of the epidemic intelligence project, data specialists and medical epidemiologists are analysing the internet, the media and social networks in search of new cases.[34]

Nevertheless, the success of the global effort to use AI techniques to address the COVID-19 pandemic hinges upon sufficient access to data. Machine Learning (ML) and Deep Learning (DL) require notoriously large amounts of data and computing power to develop and train new algorithms and neural network architectures. Several European countries have worked in this direction.

[33] https://read.oecd-ilibrary.org/view/?ref=130_130771-3jtyra9uoh&title=Using-artificial-intelligence-to-help-combat-COVID-19
[34] https://www.ecdc.europa.eu/en/publications-data/epidemic-intelligence-information-system-epis

- **Population screening, detecting and forecasting COVID-19 spread patterns.**

Big Data and AI can help identify persons at risk and sites with heightened risk of contagion. Chatbots, dedicated contact centres and other tools have been put in place to screen patients (asking them questions about their symptoms and travel history), inform individuals about infection risks and hygiene practice and manage triage for potential new cases. As an example, the Italian digital health platform company Paginemediche has developed a chatbot based on the guidelines of the Italian Ministry of Health, which supports phone triaging of potential cases. However, chatbot developers need to constantly update the algorithm based on official guidelines, which is rather challenging in a fast-paced evolving scenario.[35]

- **Contact tracing and social distancing deployment, observing population movements and monitoring compliance to laws and guidelines.**

AI-enabled mobile apps for contact tracing have helped accelerating the process of identifying people at risk of being infected, thanks to the immediate analysis of the contact network and location history of individuals. The Italian government has called on start-ups and ICT companies to develop apps to support smart social distancing, contract tracing and quarantine compliance. To this end, healthcare service provider Centro Medico Sant Agostino, app developer Bending Spoons, digital marketing company Jakala and location tech company GeoUniq, have developed a geolocation mobile app to trace movements of newly diagnosed COVID-19 patients with a margin error of 10 m. Patients may enrol on a voluntary basis and anonymised data will be shared with healthcare authorities and civil protection.[36]

When turning from the healthcare system as a whole to the hospital level in particular, it is worth noting that the latter are being hit by an unprecedented demand for services at an unbearable speed, with limited organisational resources. The whole system, from clinical to administrative, is put under great pressure to care for infected as well as usual patients, while limiting virus spread and safeguarding patients, clinical and non-clinical staff. In this scenario, timing and resource management are the most critical elements and digital technologies, AI in particular, are playing a primary role to win the race and provide immediate and efficient clinical decision support.

Hospitals are using AI to help and triage patients and identify those patients that most likely to develop severe symptoms, thus alleviating the clinical load of physicians. These AI systems have learned about patterns of illness by processing data from thousands of patient records – and while there is not enough data from COVID-19 patients yet to create entirely new prediction tools, researchers are checking to see if existing tools can be customised to help with COVID-19. Most clinical applications of AI to the COVID-19 response have focused on diagnosis based on medical imaging.

A group of European hospitals and research institutions, for instance, have recently come together to collaborate in a European Multicentre to automate the diagnosis of COVID-19 on computer tomography (CT) scans and to quantify disease burden in the lungs of infected patients. The developed AI model will be made freely accessible to all participating hospitals and institutions. The project is supported by the European Society of Medical Imaging Informatics (EuSoMII). The research collaboration will be coordinated by the Netherlands Cancer Institute, who are experienced in applying Artificial Intelligence to medical imaging.[37]

Under mounting pressure, hospitals organisations need to shift resources in an agile manner and remove non-essential workloads away from key staff to lighten their burden. For example, the strain on intensive care departments can be somehow mitigated by providing clinicians with AI-enabled decision support tools that can help predict survival rates for patients, speed up diagnosis, monitor patients' vitals evolution and predict possible complications. AI-based imaging analytics solutions can help in reading large volumes of medical images. These solutions can help spot lung lesions characteristic to COVID-19, helping identify high-risk patients and expedite early identification of cases for further confirmation.

[35] https://digitalhealthitalia.com/emergenza-coronavirus-parte-la-campagna-tivideovisito-e-in-soccorso-dei-medici-arriva-la-telemedicina-con-paginemediche-it/
[36] http://www.salute.gov.it/portale/nuovocoronavirus/dettaglioNotizieNuovoCoronavirus.jsp?lingua=italiano&menu=notizie&p=dalministero&id=4513
[37] https://imagingcovid19ai.eu/#the-project

2.4 Policy, Regulatory and Ethical Implications

2.4.1 Recent Policy Developments: An Overview

Artificial Intelligence (AI) is poised to span every aspect of our daily lives. According to a recent research carried out by CEPS, AI has "an enormous potential, [but is] in need of a direction". Indeed, beyond its outstanding promise, many commentators also argue that AI, if badly governed, can represent an existential risk for our society ; whereas others observed that AI can make catastrophic events such as a nuclear war more likely. In this respect, the AI disruptive potential has not only drawn the attention of businesses, but also of national and international policymakers and regulators. In the last two years, the growing attention paid to this topic has resulted in various policy initiatives, both at European and international level.

The EU has an important role to fulfil in providing consistency among the relevant regulatory frameworks. In June 2018, the High-Level Expert Group on Artificial Intelligence (AI HLEG) was created to support the implementation of the European Strategy on Artificial Intelligence. This includes the elaboration of recommendations on future-related policy development and on ethical, legal and societal issues related to AI, including socio-economic challenges.[38] During the first year of activities, the AI HLEG focused on two major initiatives:

1. The Ethics Guidelines for Trustworthy Artificial Intelligence (AI) (April 2019)
2. Policy and investment recommendations for trustworthy Artificial Intelligence (June 2019)

The guidelines propose seven key requirements that AI systems should meet: *Human agency and oversight, Technical robustness and safety, Privacy and Data governance, Transparency, Diversity, non-discrimination and fairness, Societal and environmental well-being and Accountability*. A practical implementation guide is put forward for every key requirement. The second deliverable includes 33 practical recommendations on how to empower and protect humans and society in the AI era, while creating multi-stakeholders Alliances, which can enact a tailored approach to exploit new technological opportunities in the Single European Market.[39]

The European approach was fundamentally endorsed by the OECD, which, in May 2019, adopted principles[40] on Artificial Intelligence inspired by EU guidelines. According to the OECD[41], AI implementations should be informed by:

1. **inclusive growth, sustainability and well-being** and they should benefit people and ultimately the whole planet;
2. the rule of law, democratic values and human rights and they should ensure a fair and just society;
3. **transparency and social responsibility** so that users understand AI-based outcomes and are empowered to possibly challenged them;
4. **security and safety** so that potential risks can be continuously assessed and managed;
5. **accountability** for individuals and organisations deploying AI in line with the above principles.

In a complementary move to the five principles, the OECD launched the AI Policy Observatory[42] earlier this year. In this context, the OECD will collaborate with the EU by firstly focusing on building a database of national AI strategies and policies. The next phase will focus on making EC publications and reports available on the OECD AI Policy Observatory, sharing data more extensively and collaborating more closely on the design of improved methodologies for data collection.

In February 2020, the Commission took a fresh look into AI and published **the White Paper** "A European approach to excellence and trust"[43]. The White Paper presented policy options for public consultation and a "Commission Report on safety and liability implications of AI, the Internet of Things

[38] Retrieved at: https://ec.europa.eu/digital-single-market/en/high-level-expert-group-artificial-intelligence
[39] More information at: https://ec.europa.eu/digital-single-market/en/news/policy-and-investment-recommendations-trustworthy-artificial-intelligence
[40] https://www.oecd.org/going-digital/ai/principles/
[41] ibidem
[42] https://www.oecd.ai/
[43] See also https://ec.europa.eu/info/publications/white-paper-artificial-intelligence-european-approach-excellence-and-trust_en

and Robotics", providing background information on the type of risks that the White Paper proposes to deal with (to be followed by legislative proposals in the 4th quarter of 2020).

Figure 6: White Paper on AI- takeaways

Source: White paper "On Artificial Intelligence - A European approach to excellence and trust" Brussels, 19.2.2020 COM(2020) 65 final

The White Paper is organised around two main goals, the creation of an "ecosystem of excellence" to build European capabilities for AI and an "ecosystem of trust", to make sure that the legislative system is updated to deal with new challenges, based on the choice to develop a risk-based approach where only technologies and solutions with high potential risks for human rights and social welfare are managed through regulation or other tools. This approach will be finalised and completed based on the feedback from public consultation.

With this initiative, the Commission encourages governments, businesses and stakeholders to pursue a uniform approach to AI across Europe, in order to avoid risky barriers in its single market. Moreover, whenever the AI was deployed in a high-risk sector, the White Paper states that any future legislation should "specifically and exhaustively" list such sectors.

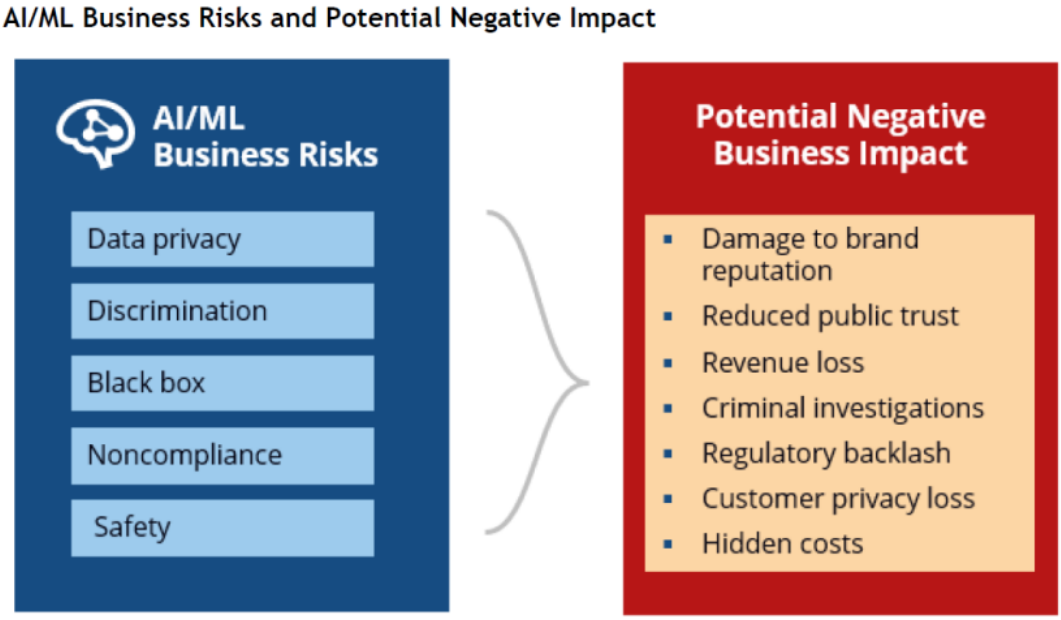
The Commission complemented the White Paper on AI with a new and comprehensive data strategy, aiming to make more data sets available for business and government. The strategy aims to promote AI development, creating "a single market for data will allow it to flow freely within the EU and across sectors for the benefit of businesses, researchers and public administrations." [44] The new European Data strategy outlines the ambition for Europe to become a leading role model for a society empowered by data to make better decisions in business and the public sector and a global leader in the data-agile economy.

2.4.2 AI and the need of trustworthiness

The disruptive potential that AI is likely to bring to our society has focused primarily on the ethical and trustworthiness-related challenges posed by the actual implementation of this technology. While this threatening narrative should not overshadow the positive effects that AI will exert on our daily lives, it is important to map possible risks. In fact, Artificial Intelligence is often perceived as a black box technology, with a lingering fear of unintended negative consequences including the ones that are not yet known or experienced. Organisations are confronted with significant AI/machine learning (ML) business risks and potential negative business impact, if the risks are not mitigated appropriately (see Figure 7 below).

[44] https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/european-data-strategy

Figure 7: AI/ML Business Risks and Potential Negative Impact



Source: IDC, 2020

Within this context, trustworthiness is developing as a dominant prerequisite for AI, and relevant stakeholders must take a proactive stance. The number of firms reporting AI as a risk factor in their annual shareholder reports (filed to the Securities and Exchange Commission in 2018) has more than doubled in 2018 according to a Wall Street Journal article.[45]

A survey conducted in May 2019[46] found that, while automation, business agility and customer satisfaction are the primary drivers for AI initiatives, the cost of the solution, the lack of adequate quality data, the scarcity of data science talent, fear of bias and lack of trust have held organisations back from implementing AI.

Against this background, an organisation that focuses on being ethical in its AI systems gains competitive advantage in the long run[47]. Therefore, there is an intangible value for organisations which build brand reputation, credibility and trustworthiness in their AI systems. To thrive and reap the benefits of AI, organisations need to embrace building trusted and ethical AI today and adhere to a governance framework.

In April 2019, the European Commission presented the "Ethics Guidelines for Trustworthy Artificial Intelligence" (see Section 2.4.1)[48]. According to the Guidelines, trustworthy AI should be **lawful** - respecting all applicable laws and regulations, **ethical** - respecting ethical principles and values and **robust** - both from a technical perspective and considering its social environment.

Trust, bias and ethics considerations are gaining importance. According to a survey, ~50% of organisations have a formalised framework to encourage considerations and ~25% have senior management position established to ensure adherence[49]. Diversity of data science teams is growing. Figure 8 shows the various components of governance framework for trustworthy AI: ethics, elements of trust, validation/monitoring/analysis and accountability.

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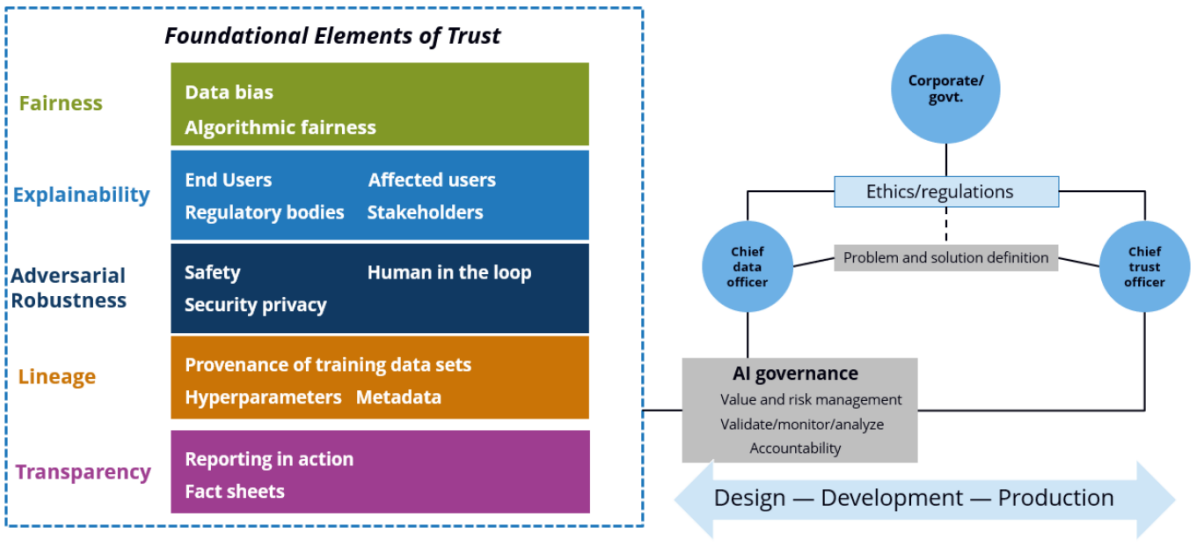
[45] "More Companies Flag a New Risk: Artificial Intelligence" https://www.wsj.com/articles/more-companies-flag-a-new-risk-artificial-intelligence-11547035202
[46] IDC's AI Global Survey, retrieved at https://www.idc.com/getdoc.jsp?containerId=EUR145364419
[47] More evidence can be found at: Floridi, Luciano University of Oxford "The Virtuous Circle of Trusted AI: Turning Ethical and Transparent AI Into a Competitive Advantage" https://www.capgemini.com/research/the-virtuous-circle-of-trusted-ai-turning-ethical-and-transparent-ai-into-a-competitive-advantage-luciano-floridi/, https://www.capgemini.com/news/ethics-in-ai/, Ethical Artificial Intelligence Becomes A Supreme Competitive Advantage https://www.forbes.com/sites/joemckendrick/2019/07/07/ethical-artificial-intelligence-becomes-a-supreme-competitive-advantage/#45ed7daa1a8f
[48] https://ec.europa.eu/digital-single-market/en/news/ethics-guidelines-trustworthy-ai
[49] IDC's AI Global Survey, retrieved at https://www.idc.com/getdoc.jsp?containerId=EUR145364419

Figure 8: AI Governance Framework for Trustworthy and Ethical AI



Source: IDC, 2020

Fairness is the fundamental aspect of AI that is directly related to discrimination as Machine Learning could be considered, by its very nature, a form of statistical discrimination. However, discrimination becomes objectionable when it places certain privileged groups at systematic advantage and certain unprivileged groups at systematic disadvantage. AI fairness is therefore associated with the minimisation of bias in AI agents. At the same time, AI systems tend to be opaque and unable to explain how or why certain results are presented. Understanding how AI models arrive to specific decisions (**explainability**) is a key principle of trusted AI. What is more, AI systems should be robust, thus not vulnerable to tampering or compromising the data they are trained on (**robustness**), as well as safe to use (safety) and resilient to all sorts of attacks, including many based on adversarial AI methods (security). Furthermore, as AI systems are constantly evolving, they should include details on their development, deployment and maintenance so that they can be audited throughout their life cycle (**lineage**). Finally, when discussing trustworthiness as a prerequisite for AI, an element of disclosure and transparency cannot be ignored. **Transparency** can be improved, for example, by establishing factsheets for all the applied AI models, so to help answer basic questions about the dataset models and include bias mitigation mechanisms.

2.5 Conclusions

Advanced Technologies lie at the very heart of Europe's current process of digital transformation. Indeed, these technologies enable process, product, and service innovation throughout the economy, thus fostering and supporting industrial modernisation across a wide range of organisations and industry sectors.

While some of these technologies are clearly horizontal in nature, our analysis has emphasised how other advanced technologies tend to play a more niche and industry-specific role. In this respect the whole spectrum of the European industry appears to be positively affected by the digitisation brought about by advanced technologies. Nevertheless, some sectors are taking the lead in the process. Industries like Manufacturing, Telecommunications & Media and Finance are clearly benefiting from the uptake of technologies such as Robotics, Augmented Reality/Virtual Reality (AR/VR), 3D printing and Advanced Materials (especially in manufacturing), or from AI, Big Data & Analytics and Blockchain (in the finance sector) or again from Cloud Computing, Security. 5G and Photonics (as in the Telco & Media space). Other industries, as in the case of Transport & Logistics or Agriculture, are showing a slower pace of advanced technologies' uptake with technologies such as IoT, AI and Big Data & Analytics making their way into industry-specific applications in these fields but at a reduced speed.

Taking Artificial Intelligence (AI) as one the backbones of digital transformation and industrial modernisation, we observed that the current availability of huge datasets, coupled with recent

technology advances in Big Data, Internet of Things (IoT) and fast connectivity capabilities, are all paving the way to new and more disruptive applications of AI systems and services. AI's potential for future growth and economic impacts is even more significant given that AI is a generic-purpose technology with the ability to be adopted in different ways by all industries and all social actors. Not surprisingly, we found that the speed of evolution of the AI market is impressive - the European Union market alone is expected to grow faster than the global market, representing a share of 23% of total by 2023 (versus 18% in 2018). Sectors such as Finance, Telecom/media and Utilities/Oil & Gas are currently leading the way in terms of AI adoption and will continue to do so over the next couple of years.

Based on the above, we have also investigated how AI is currently being applied in real-life situations. We found that the top AI use cases are a mix of horizontal and vertical-specific applications with customer-centric cases (such as Automated Customer Service, for example) being widespread across a range of customer-facing industries such as banking, retail and telecommunications, and other use cases (AI in asset or fleet management, for instance) being specific to an individual industry – the transport sector in this case. We also observed that some use cases have business or societal objectives in common, even if applied in substantially different sectors and situations. These use cases offer fertile ground for further applications and extension of AI usage. Businesses and policymakers that are interested in new AI-related business opportunities and applications are advised to monitor the deployment of these use cases very closely. Business opportunities, however, are only one side of the AI picture. As the influence of AI-driven predictions, recommendations and decisions is gradually affecting all dimensions of life, AI application can exert positive impacts on social welfare and actively contribute to social good. Our analysis has identified a very broad spectrum of AI applications for social good, which could range from high-quality healthcare in regions with few resources, to hunger prevention using machine learning to help farmers with irrigation schedules; from improving general public services such as waste management to supporting social welfare services by using AI-based natural language processing to better identify request of help and support social services in better allocating resources. A case in point of AI for social good, is its application in the healthcare sector. Here, our research has highlighted how specific AI applications are already at work to support healthcare systems, and hospitals in particular, to deal with the unprecedented challenges posed by the COVID-19 pandemic. Our research has found that AI is proving to be of paramount importance to improve epidemiologic surveillance through early identification of the virus outbreak and the tracking of the infection but is also contributing to better population screening through enhanced detecting and forecasting spread patterns. In this current phase of loosening of lockdown measures, AI is further helping authorities to trace contacts and enforce physical distancing, observing population movements and monitoring compliance to laws and guidelines.

Finally, we have focused on the ethical and trustworthiness-related challenges associated to the actual implementation of AI. In this context we have emphasised the importance of the European Commission guidelines for the deployment and application of a trustworthy Artificial Intelligence[50] and proposed a governance framework for trustworthy and ethical AI, which would serve as valuable guidance for European businesses, researchers and policy-makers in the near future.

[50] "Ethics Guidelines for Trustworthy AI: High-Level Expert Group on Artificial Intelligence", 18 April 2020 (https://ec.europa.eu/digital-single-market/en/news/ethics-guidelines-trustworthy-ai)

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Appendix B: Technology definitions

The advanced technologies covered in the 'Advanced Technologies for Industry' project include the following:

Advanced Manufacturing Technology

Advanced Manufacturing Technology encompasses the use of innovative technology to improve products or processes that drive innovation in manufacturing. It covers two types of technologies: process technology that is used to produce any of other advanced technologies, and process technology that is based on Robotics, automation technology or computer-integrated manufacturing. For the former, such process technology typically relates to production apparatus, equipment and procedures for the manufacture of specific materials and components. For the latter, process technology includes measuring, control and testing devices for machines, machine tools and various areas of automated or IT-based Manufacturing Technology.

Advanced Materials

Advanced Materials lead both to new reduced cost substitutes to existing materials and to new higher added-value products and services. Advanced Materials offer major improvements in a wide variety of different fields, e.g. in aerospace, transport, building and health care. They facilitate recycling, lowering the carbon footprint and energy demand as well as limiting the need for raw materials that are scarce in Europe.

Artificial Intelligence

Artificial Intelligence is a term used to describe machines performing human-like cognitive functions (e.g. learning, understanding, reasoning or interacting). It comprises different forms of cognition and meaning understanding (e.g. speech recognition, natural language processing) and human interaction (e.g. signal sensing, smart control, simulators). Artificial Intelligence is a heterogenous field in terms of its technology base. While some aspects like sensors, chips, robots as well as certain applications like autonomous driving, logistics or medical instruments refer to hardware components, a relevant part of AI is rooted in algorithms and software.

Augmented/Virtual Reality

Augmented Reality devices look to overlay digital information or objects with a person's current view of reality. As such, the user is able to see his/her surroundings while also seeing the AR content - Virtual Reality devices place end users into a completely new reality, obscuring the view of their existing reality.

Big Data

Big Data is a term describing the continuous increase in data, and the technologies needed to collect, store, manage, and analyse them. It is a complex and multidimensional phenomenon, impacting people, processes and technology. From a technology point of view, Big Data encompasses hardware and software that integrate, organise, manage, analyse, and present data. It is characterised by "four Vs": volume, velocity, variety and value. Big Data technologies are new generation of technologies and architectures, designed to economically extract value from very large volumes of a wide variety of data, by enabling high-velocity capture, discovery, and/or analysis.

Blockchain

Blockchain is a digital, distributed ledger of transactions or records, in which the ledger stores the information or data and exists across multiple participants in a peer-to-peer network. Distributed ledgers technology allows new transactions to be added to an existing chain of transactions using a secure, digital or cryptographic signature. Blockchain protocols aggregate, validate, and relay transactions within the blockchain network. 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.

Connectivity

Connectivity refers to all those technologies and services that allow end-users to connect to a communication network. It encompasses an increasing volume of data, wireless and wired protocols and standards, and combinations within a single use case or location.

Standard connectivity includes Fixed Voice and Mobile Voice telecom services to allow fixed or mobile voice communications, but also Fixed Data and Mobile Data services to have access and transfer data via a network.

Advanced connectivity that is in the focus of the ATI project refers to the rise of Internet of Things scenarios, where connectivity technology boundaries expand beyond wired and cellular (e.g. 4G, 5G,…) services to Low Power Wide Area Network (LPWAN), Satellite, and Short Range Wireless technologies.

The survey analysis encompasses all these three elements of the Connectivity definition mentioned above.

Cloud Computing

Cloud Computing includes the delivery of tools and applications like data storage, servers, databases and software based on a network of remote servers through the Internet. Cloud Computing services enable users to store files and applications in a virtual place or the cloud and access all the data via the Internet.

Public Cloud services that have been explored specifically by the ATI survey are available on public networks and open to a largely unrestricted universe of potential users. Public clouds are designed for a market, not a single enterprise.

Industrial Biotechnology

Industrial Biotechnology is the application of biotechnology for the industrial processing and production of chemicals, materials and fuels. It includes the practice of using microorganisms or components of micro-organisms like enzymes to generate industrially useful products in a more efficient way (e.g. less energy use, or less by-products), or generate substances and chemical building blocks with specific capabilities that conventional petrochemical processes cannot provide. There are many examples of such bio-based products already on the market. The most mature applications are related to enzymes used in the food, feed and detergents sectors. More recent applications include the production of biochemicals and biopolymers from agricultural or forest wastes.

Internet of Things (IoT)

The Internet of Things (IoT) refers to the network of smart, interconnected devices and services that are capable of sensing or even listening to requests. IoT is an aggregation of endpoints that are uniquely identifiable and that communicate bi-directionally over a network using some form of automated connectivity. Objects become interconnected, make themselves recognisable, and acquire intelligence in the sense that they can communicate information about themselves and access information that has been provided by another source. The Internet of Things relies on networked sensors to remotely connect, track and manage products, systems and grids. The Industrial Internet of Things (IIoT) – a subset of the larger Internet of Things – focuses on the specialised requirements of industrial applications, such as manufacturing, oil and gas, and utilities. IIoT systems connect non-consumer devices, used by companies, governments and utility providers in their service delivery.

Micro and Nanoelectronics

Micro and Nanoelectronics deal with semiconductor components and highly miniaturised electronic subsystems and their integration in larger products and systems. They include the fabrication, the design, the packaging and testing from nano-scale transistors to micro-scale systems integrating multiple functions on a chip.

Mobility

IT for Mobility

Mobility covers a large number of different technology areas and markets, which does not only encompass vehicles that take people from point A to point B, but also includes all kinds of technologies

that make people more mobile (like for example mobile phones etc.). These, however, consist of a large set of sub-technologies that are hard to capture at the same time. In this project, the patent, trade, prodcom, investment and skills analysis focus on a sub-section of mobility, which is related to vehicles only, e.g. satellite navigation and radio-location, which are also the core technologies that are necessary to make autonomous driving work.

Enterprise Mobility

The survey analysis captures mobility in terms of the workforce. The Enterprise Mobility market is made up of a conglomeration of mobile solutions and technologies, including hardware, software and services, empowering a borderless workforce to securely work anywhere, at any time and from any device. It does not include only the provision of smartphones or tablets to the workforce but also all the tools and applications for transforming key processes, from internal operations to operations with customers and suppliers, all the way from the shop floor to the top floor and from the back office to the end customers.

Nanotechnology

Nanotechnology is an umbrella term that covers the design, characterisation, production and application of structures, devices and systems by controlling shape and size at nanometer scale. Nanotechnology holds the promise of leading to the development of smart nano and micro devices and systems and to radical breakthroughs in vital fields such as healthcare, energy, environment and manufacturing.

Photonics

Photonics is a multidisciplinary domain dealing with light, encompassing its generation, detection and management. Among other things it provides the technological basis for the economic conversion of sunlight to electricity which is important for the production of renewable energy, and a variety of electronic components and equipment such as photodiodes, LEDs and lasers.

Robotics

Robotics is technology that encompasses the design, building, implementation, and operation of robots. Robotics is often organised into three categories: 1) Application specific. This includes Robotics designed to conduct a specific task or series of tasks for commercial purposes. These robots may be stationary or mobile but are limited in function as defined by the intended application. 2) Multipurpose. Multipurpose robots are capable of performing a variety of functions and movements determined by a user that programs the robot for tasks, movement, range, and other functions and that may change the effector based on the required task. These robots function autonomously within the parameters of their programming to conduct tasks for commercial applications and may be fixed, "moveable," or mobile. 3) Cognitive. Cognitive robots are capable of decision making and reason, which allows them to function within a complex environment. These robots can learn and make decisions to support optimal function and performance and are designed for commercial applications. When measuring production and uptake of Robotics, industrial applications will be taken into account.

Security

Security products are tools designed using a wide variety of technologies to enhance the security of an organisation's networking infrastructure — including computers, information systems, internet communications, networks, transactions, personal devices, mainframe, and the cloud — as well as help provide advanced value-added services and capabilities. Cybersecurity products are utilised to provide confidentiality, integrity, privacy, and assurance. Through the use of security applications, organisations are able to provide security management, access control, authentication, malware protection, encryption, data loss prevention (DLP), intrusion detection and prevention (IDP), vulnerability assessment (VA), and perimeter defense, among other capabilities.

Appendix C: Advanced Technology uptake

Figure 9: Advanced Technologies Uptake by European Industries - Question: Which of the following technologies is your organisation using or planning to use?

Technology	Finance	Gov/Edu	Healthcare	Manufacturing - discrete	Manufacturing - process	Professional Services	Retail, Wholesale	Telecom, Media	Transport/Logistics	Utilities, Oil, Gas	Agriculture
Public Cloud	56%	63%	76%	82%	68%	81%	84%	82%	81%	73%	78%
Big Data and analytics solutions	79%	44%	49%	45%	36%	61%	53%	63%	34%	47%	25%
Mobile solutions	53%	58%	40%	34%	32%	49%	56%	61%	32%	47%	38%
IoT	72%	48%	44%	58%	45%	58%	55%	73%	36%	64%	30%
AI	74%	33%	41%	45%	37%	60%	51%	70%	32%	60%	11%
Robotics	7%	1%	18%	72%	64%	7%	21%	7%	29%	53%	18%
ARVR	21%	38%	36%	10%	5%	10%	26%	48%	3%	13%	0%
Blockchain	62%	3%	1%	1%	1%	3%	4%	7%	1%	0%	0%
Security	88%	79%	78%	79%	73%	73%	75%	79%	68%	81%	51%
Advanced Manufacturing	0%	0%	0%	92%	79%	0%	0%	0%	0%	0%	0%
Advanced Connectivity	58%	63%	48%	37%	37%	54%	42%	82%	34%	63%	37%
Nanotechnologies	3%	0%	33%	37%	9%	3%	1%	6%	1%	19%	0%
Micro and nano electronics	2%	0%	4%	32%	5%	2%	1%	6%	1%	4%	0%
Advanced Materials	2%	0%	19%	24%	27%	2%	1%	3%	9%	13%	0%
Biotechnology	2%	0%	39%	0%	5%	2%	0%	0%	0%	14%	1%
Photonics	2%	1%	19%	24%	14%	1%	1%	12%	0%	19%	19%

Source: Advanced Technologies for Industry Survey, July 2019

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 Executive Agency for Small and Medium-sized Enterprises (EASME) by IDC, Technopolis Group, Capgemini, Fraunhofer, IDEA Consult and NESTA.

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